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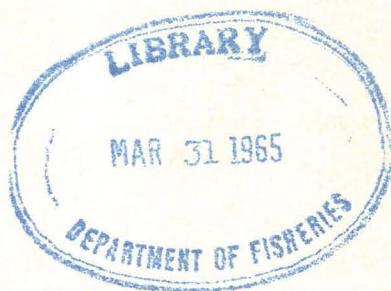


ANNUAL REPORT

1963-1964

RAPPORT ANNUEL

1963-1964



Fisheries Research Board of Canada
Office des Recherches sur les Pêcheries du Canada



The C.G.S. G. B. Reed

Operated through the Board's Biological Station
at Nanaimo, British Columbia, to
carry out fisheries research
in the Pacific

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ANNUAL REPORT

of the

Fisheries Research Board
of Canada

1963-64

For the Fiscal Year
ended March 31, 1964

RAPPORT ANNUEL

de

l'Office des recherches sur les
pêcheries du Canada

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Roger Duhamel, M.S.R.C.
Imprimeur de la Reine et Contrôleur de la Papeterie
Ottawa, Canada

1964

The Honourable the Minister of Fisheries,

Sir,—

I have the honour to transmit herewith the Report of the Fisheries Research Board of Canada for the period April 1, 1963, to March 31, 1964.

I am, Sir,

Faithfully yours,

W. E. RICKER,

Acting Chairman.

A l'Honorable Ministre des Pêcheries,

Monsieur,—

J'ai l'honneur de vous soumettre, ci-joint, le rapport de l'Office des recherches sur les pêcheries du Canada pour la période du 1^{er} avril 1963 au 31 mars 1964.

Votre tout dévoué,

W. E. RICKER,

Président intérimaire.

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Fisheries Research Board of Canada

Annual Report for the

Fiscal Year ended March 31, 1964

INTRODUCTION

From the standpoint of Canada's fisheries, the outstanding event of the year 1963-64 was the Federal-Provincial Conference on Fisheries Development, which assembled at the invitation of the federal Minister of Fisheries on January 24, 1964. The conference outlined a blueprint for new and augmented activity designed to increase the quantity and quality of fish landed, to raise fishermen's incomes, and to improve marketing. Research has played, and will continue to play, an important role in achieving these objectives. The staff of the Fisheries Research Board of Canada contributed extensively to the preparations for the Conference, and to the detailed planning by which its recommendations are being implemented.

During most of 1963-64 the Board operated within restrictions set by the government's economy program. This has reduced staff close to the temporary ceiling of 85% of approved strength—except for certain irreducible services such as boat crews. The attrition was mostly keenly felt among the ranks of our scientists, because elsewhere the demand for specialized trained manpower has continued to increase. Fortunately, in August 1963, the personnel restriction was relaxed so as to permit recruitment up to 93% of approved strength and further relief from recruitment restrictions is being sought.

Within these limitations, the Board in 1963-64 continued its researches on most aspects of Canada's marine and freshwater resources, as required by the Fisheries Research Board Act.

In 1963 the Board's membership was increased to its maximum legal complement of eighteen, exclusive of the Chairman. As of March 31, 1964, it included ten scientists from Canadian universities, seven industry representatives associated with one phase or other of fish capturing and processing operations, and a senior officer of the Department of Fisheries.

The Chairman of the Fisheries Research Board, Dr. J. L. Kask, tendered his resignation effective August 19, 1963, in order to take a challenging position in the United States. Dr. Kask was the Board's first full-time Chairman, and had held the position since 1954. On his resignation he reviewed the "exciting and rewarding experience" of his years of office, and referred to the flexibility in organization and administration of research provided by the Fisheries Research Board Act, which he

regarded as "a tribute to an enlightened parliament and people". The vacancy was filled temporarily by appointment of an Acting Chairman from the Board's scientific staff, Dr. W. E. Ricker of Nanaimo, B.C. On February 13, 1964, the Governor General in Council announced the appointment of a new Chairman, to take office August 1, 1964. He is Dr. F. R. Hayes, Vice-President of Dalhousie University, Halifax, N.S., and Director of its Institute of Oceanography.

The Members of the Board during the calendar year 1963 were as follows:

- *J. L. Kask, B.A.(British Columbia), PH.D.(Washington); Chairman (to August 19, 1963).
- *W. E. Ricker, B.A., M.A., PH.D.(Toronto), F.R.S.C.; Acting Chairman (from August 20).
- C. W. Argue, C.B.E., B.A., B.S.A.(British Columbia), M.S.(Iowa), D.SC.(New Brunswick); University of New Brunswick, Fredericton, N.B.
- J. M. R. Beveridge, B.SC.(Acadia), PH.D.(Toronto), M.D.(Western), D.SC.(Acadia), F.R.S.C.; Queen's University, Kingston, Ont.
- *T. W. M. Cameron, T.D., B.SC., M.A., PH.D.(London), D.SC.(Edinburgh), D.SC.(British Columbia), M.R.C.V.S., F.R.S.C.; McGill University, Macdonald College, Que.
- *D. B. DeLury, B.A., M.A., PH.D.(Toronto); University of Toronto, Toronto, Ont.
- *Yves Desmarais, B.A., B.S.A., PH.D.(Wisconsin); Montreal Botanical Garden, Montreal, Que.
- M. K. Eriksen, Esq., Prince Rupert, B.C. (representing the Fishing Industry),
- F. R. Hayes, M.SC.(Dalhousie), PH.D., D.SC.(Liverpool), F.R.S.C.; Dalhousie University, Halifax, N.S.
- Guy LeBlanc, Esq., Montreal, P.Q. (representing the Fishing Industry).
- I. McT. Cowan, B.A.(British Columbia), PH.D.(California), F.R.S.C.; University of British Columbia, Vancouver, B.C.
- *D. F. Miller, B.COMM., S.M.(M.I.T.), Vancouver, B.C. (representing the Fishing Industry).
- *A. H. Monroe, Esq., St. John's, Nfld. (representing the Fishing Industry).
- Edouard Pagé, M.B.E., B.S.A.(Montreal), PH.D.(Cornell), F.R.S.C.; Université de Montréal, Montréal, P.Q.
- G. L. Pickard, M.B.E., B.A., M.A., D.PHIL.(Oxon.) University of British Columbia, Vancouver, B.C.
- A. L. Pritchard, B.A., M.A., PH.D.(Toronto); Ottawa, Ont. (representing the Department of Fisheries of Canada).
- Sol Sinclair, B.S.A., M.SC., PH.D.(Minnesota), F.A.I.C.; University of Manitoba, Winnipeg, Man.
- R. G. Smith, Esq., Halifax, N.S. (representing the Fishing Industry).

*Members of the Executive Committee.

In recent years the Board has been fortunate in having as a member of its Executive Committee the Deputy Minister of Fisheries. Following the untimely death of Mr. G. R. Clark in February 1963, a new Deputy Minister was appointed on February 26, 1963, Dr. A. W. H. Needler. Dr. Needler was previously Director of the Fisheries Research Board's Nanaimo Station. Like his predecessor, he has agreed to act as an ex-officio member of the Executive Committee. A second ex-officio member is Mr. A. D. Wymbs, Chief Treasury Officer of the Department of Fisheries and Honorary Treasurer of the Board.

The Board met in Annual Meeting with the heads of its Stations, Laboratories and Units in Ottawa in early January 1964. At this time the Board's research policy and scientific programs were reviewed, and reports and recommendations from the standing regional Advisory Committees were heard. The Executive Committee met three times during the year to consider personnel and financial matters, and each of the three regional Advisory Committees met twice.

Research activities of the Fisheries Research Board of Canada are by design completely decentralized. Day-to-day administration and supervision of overall operations is carried out by the Chairman and his headquarters associates in Ottawa. This staff numbered eighteen in all, including one who was located outside Ottawa. In addition to the Chairman and Acting Chairman mentioned previously, the senior personnel in the Office of the Chairman during 1963 were:

W. R. Martin, B.A., M.A.(Toronto), PH.D.(Michigan), Assistant Chairman.

J. A. Rogers, A.C.B.A., Director of Administration and Executive Assistant to the Chairman.

J. C. Stevenson, B.A., M.A.(Saskatchewan), PH.D.(Toronto), Special Assistant to the Chairman and Editor.

E. G. Bligh, B.Sc., M.Sc.(Acadia), PH.D.(McGill), Special Assistant to the Chairman and Associate Editor.

H. B. Hachey, M.B.E., LL.D.(St. Thomas), F.R.S.C., Chief Oceanographer to March 31, then Special Assistant to the Chairman (Stationed at St. Andrews, N.B.).

Mr. J. A. Rogers and his associates Messrs. R. D. Willet and L. M. Morin served as Secretaries-general of the Board's Annual and Executive Committee meetings, and Mrs. Claire Duffy is Assistant Secretary to the Board.

The Fisheries Research Board had an approved staff establishment of 816 for the period covered by this report. Of these 196 were scientific positions, although the number actually on strength averaged about 159 because of recruitment restrictions and normal turnover.

The year 1963-64 was an active and productive one for the Board in all three areas of its scientific interests, namely aquatic biology with emphasis on fishery biology, fishery technology, and oceanography. Sixteen research vessels were operated for its biological studies. These vary from small inshore and lake craft to large sea-going ships specially built for the purpose.

During 1963 a new research barge, the *Velella* (76 feet overall; 269 registered tonnage) was added to the Board's fleet on the Pacific coast. The barge will serve as

a floating laboratory and will be used initially as a base for the study of young salmon in the sea.

Co-operative oceanographic programs were continued with the Royal Canadian Navy, the Department of Mines and Technical Surveys, and the Department of Transport, and close liaison was maintained with the Institute of Oceanography at the University of British Columbia, Vancouver, B.C., the Great Lakes Institute of the University of Toronto, Toronto, Ontario, and the Institute of Oceanography at Dalhousie University, Halifax, N.S. Co-operative programs were also carried out with Provincial Governments and with the International Pacific Salmon Fisheries Commission, New Westminster, B.C.

A large proportion of the Board's biological and oceanographic effort in research continues to be devoted to work carried out for the international fishery and sea mammal commissions to which Canada belongs and which do not have scientific staffs of their own. These include the International Commission for the Northwest Atlantic Fisheries, the Great Lakes Fishery Commission, the International Whaling Commission, the North Pacific Fur Seal Commission and the International North Pacific Fisheries Commission. The Board's widespread researches are carried out from five Biological Stations, two of which include oceanographic groups, and from three Technological Research Laboratories. Smaller stations and field establishments are maintained in places close to important operational areas.

BIOLOGICAL AND OCEANOGRAPHIC INVESTIGATIONS

The Board's main Biological Stations are situated at Nanaimo, B.C., London, Ont., St. Andrews, N.B., St. John's, Nfld., and Montreal, Que. The Nanaimo and St. Andrews Stations maintain associated oceanographic groups. A number of field stations and port observers stationed at key points are also maintained in the interest of operational efficiency.

ATLANTIC FISHERIES—NEWFOUNDLAND AREA

Total landings of the principal commercial *groundfish* species were about 4% higher than in 1962. Of these landings 79% were cod, 8% redfish, 8% plaice, 3% haddock, and 2% greysole, halibut, wolffish, and pollock. Cod, redfish, and plaice landings were, respectively, 4, 30, and 60% higher and haddock landings 60% lower than in 1962. The principal reason for the increase in landings of cod, redfish, and plaice is increased fishing effort for these species, whereas the low haddock landings are the result of decreased abundance.

In continued studies of the *inshore cod* fisheries of Newfoundland and Labrador, age and length compositions of samples reveal the dependence of traps and handlines upon the younger ages (4-7 years) whereas in the longline and gillnet fisheries cod of older ages (8 years and older) are important contributors to the catch when they are no longer being caught in large numbers by traps and handlines. In the Labrador area, cod of younger ages (4-6 years), which have contributed little to the catch in recent years, were present in abundance in 1963 and should contribute significantly to the success of the fishery for the next several years. In the annual shore survey for baby cod on the east coast of Newfoundland, designed to give useful predictions of

the supply of young cod to the commercial fishery, the relatively small numbers of cod of the year which were caught suggest only moderate survival and settlement of the 1963 year-class.

In *offshore cod* surveys by the *A. T. Cameron* great concentrations of cod, being fished by a large fleet of European otter-trawlers, were located at 120–180 fathoms on the southeast edge of Hamilton Inlet Bank in April and May. These fish were generally small, with a high proportion of 4- and 6-year-old cod occurring in the catches. About 20,000 cod were tagged during the year with the especial purpose of studying the interrelationships of inshore and offshore cod populations.

Extensive surveys by research ships in May and July failed to find any concentrations of *haddock*, and the Newfoundland landings were low. The basic cause is the poor survival of young; the last successful year-classes were those of 1955–56 and a new abundant year-class is not yet in sight. Heavy exploitation also has contributed to the present haddock scarcity.

Redfish surveys off Labrador and eastern Newfoundland in the spring indicated a general trend in the distribution of redfish to deeper water in spring and presumably in winter. This is the time of the greatest concentration of redfish in the Labrador area. In this area in April the shallowest catch of commercial quantities of redfish was at 250 fathoms. In the Gulf of St. Lawrence there is little evidence of the presence of large fish but in some areas large numbers of young fish (7 years and younger) were caught. These fish began to be recruited to the fishery in 1963 but their potential had been recognized from research vessel catches 4 years earlier.

Lobster research in Port au Port Bay centered around studies on growth, spawning times, and fishing rates.

From a planting of 2.5 million *pink salmon* eggs in North Harbour River, St. Mary's Bay, hatching was highly successful and about 2.2 million fry passed down river between May 7 and June 16. The survivors are expected to return to the river in 1964. The experiments on Atlantic salmon in the Little Codroy River have been completed.

ATLANTIC FISHERIES—SOUTHERN AREA

Population studies on *lobsters* have been continued at key points so as to follow natural changes and the effects of fisheries regulations. At Port Maitland, lobsters showed more movements and greater natural mortality than expected from previous work. The economic possibility of growing small lobsters in captivity to more valuable sizes was explored as a step toward lobster culture. No immediate advances are indicated. The behaviour of free-swimming lobster larvae in relation to taking up life on the bottom was investigated. The possibility of using larval abundance to forecast catches was examined and holds promise of providing an acceptable basis for short-term prediction. A comprehensive bulletin on the care and handling of lobsters was prepared to assist the industry in applying results from 10 years of research.

The fate of free-swimming *oyster* larvae was routinely followed and the time of spatfall accurately forecast. In general, efforts to rehabilitate mainland oyster populations wiped out during the 1950's by Malpeque disease were found to be going satisfactorily. Examinations revealed no new spread of the disease. Satisfactory

advances took place in co-operative work with other branches of government. An oyster hatchery has been built for co-operative use by the Fish Culture and Development Branch of the Department of Fisheries. Studies by the Department of Mines and Technical Surveys of bottom sedimentation confirmed suspicions of heavy silting on oyster beds and the consequent deterioration of productive grounds.

Fishery statistics that truly represent conditions of the fish stocks and the fishing effort are essential in research, management, and long-term planning. In association with the Economics Service of the Department of Fisheries and the Dominion Bureau of Statistics, *catch and effort data* are compiled for national use and to meet international commitments through the International Commission for the Northwest Atlantic Fisheries.

Important *fishing grounds* are surveyed annually to provide information on the conditions of the stocks and a basis for predicting abundance. Observations were continued on the distribution and abundance of cod in the Gulf of St. Lawrence and of haddock on the Nova Scotian Banks. On the Nova Scotian Banks no major changes in cod abundance are evident. Poor recruitment is anticipated for haddock during the next several years. The proportion of fish discarded after being caught, determined to meet obligations under the International Commission for the Northwest Atlantic Fisheries, showed that conservation measures are generally effective. A study of the life history and population dynamics of the American plaice was concluded.

The *behaviour* of cod and other groundfish is being studied to provide a basis for designing more effective fishing gear. Attention is being given to the levels of fatigue which can be sustained by fish without dying and to daily movements in relation to light intensity.

Catches of various *pelagic species* were sampled routinely and the conditions in the fisheries noted. Herring were sampled in the Bay of Fundy partly to meet international obligations. The spectacular upsurge in swordfish landings which accompanied introduction of longline fishing was fostered and followed by sea observations and shore sampling. New tuna enterprises based in New Brunswick are being followed and catches examined.

The *scallop* fishery is being studied by detailed analyses of catch statistics and observation trips at sea. Developmental stages of scallop larvae are being determined by laboratory rearing as a first step in studying factors influencing survival in nature. To assess the possibility of increasing the product from current catches, the wholesomeness is being examined of parts of scallops not now sold here but commonly used in other parts of the world.

As a preliminary step in having fishing gear designed specifically to recognize the behaviour of fish, *gear engineering* studies were begun to examine the forces on trawl nets while they are being towed.

Salmon populations in the Northwest Miramichi River and elsewhere are followed to detect natural changes in abundance and the effects of human interference in numerous ways including DDT spraying and mining pollution. In the Margaree River a major experiment is under way to determine whether the increase in smolt production resulting from control of merganser ducks is carried through to produce an increase

in available adult salmon. Information collected at herring weirs about salmon post-smolts showed their sources and distribution in the Bay of Fundy. Seven tagged Miramichi salmon have been captured in Greenland and it seems that many fish of Canadian origin may be caught there. The behaviour of salmon and *trout* in fresh water is being studied to find out the best ways of assisting natural reproduction.

Mathematical studies are undertaken to promote efficient design of experiments and observational routines, and to assess the pertinence of accepted methods of estimating stock size.

Great emphasis is given to *oceanography* in its relation to fisheries. Water circulation was studied by drift bottles, electrical analogue models, induction effects, and dynamic heights. Temperature conditions in the sea are being monitored on routine cruises and at shore stations. Other properties of sea water such as optical properties and chemical contents are likely to have a bearing on fish life and investigations on them are being initiated. To provide a more detailed exploration a geochemical description of the Gulf of St. Lawrence was undertaken. Studies of invertebrates on the bottom in the Gulf of St. Lawrence are showing relationships with fish concentrations and bottom conditions.

PACIFIC FISHERIES

During 1963–64 the Nanaimo Biological Station conducted many investigations largely related to the immediate national interest, providing scientific background for international problems and service, investigation, and advice for management of fisheries in coastal waters. The *marine commercial fisheries* investigations continued to provide statistical analyses, predictions, and other management information on groundfish, herring, shrimps, and crabs. In addition to conducting population studies of local stocks (*near-seas* groundfish investigation), new studies were initiated in the Gulf of Alaska (*distant seas*), particularly on ocean perch. The *herring* investigations continued a monitoring of populations, co-operated in studies of the incidence of salmon in herring catches, and undertook trials of new midwater trawl gear. Studies of the *scattering layer* which is an important area of concentration of juvenile fishes and food organisms, were continued. *Crustacea* studies on local species continued, and explorations were made in various areas, including the Gulf of Alaska.

Investigation of *marine invertebrates* was largely devoted to service in the day-to-day problems of the shellfish industry. Studies on the effects of pulp-mill effluent on oysters, diseases of oysters, shellfish poisoning, abalones, razor clams, and wood borers, spread the investigation over a wide field of invertebrate problems.

Staff responsible for studies on *marine mammals* worked closely with the Department of Fisheries on management, as well as carrying a heavy load of international commitments relating to the International Convention for the Regulation of Whaling, and the International North Pacific Fur Seal Commission.

Similar service to management problems was a major feature of the work of the Station on Pacific salmon. The group working on *salmon stock assessment* provided a continuing appraisal of the status of salmon stocks, undertaking whenever necessary to provide assessments of problems of particular concern. An important contribution

during 1963-64 was the part played by the Station in the production of a report concerned with pink salmon in the Strait of Georgia, under the auspices of the Pink Salmon Co-ordinating Committee appointed by the Governments of Canada and the United States.

A particularly large management-type of activity is embodied in the *Skeena River salmon* investigations, which support the participation of the Station in every aspect of Skeena salmon research management. All routine observations required for management were continued, including collection and analysis of commercial statistics, test fishing, escapement estimation, and sampling for age and size composition. Studies of sockeye at Babine Lake continued to provide information on growth and abundance of young from spawnings of known size and distribution. Pink salmon fry production (13% survival) was estimated in the Lakelse River.

The investigations on *salmon propagation* and *lake sockeye*, though less concerned with matters of day-to-day management, are concerned with questions which have applicability to current work of the Fish Culture and Development Branch of the Department of Fisheries, and liaison with the Department is maintained at a good working level. The salmon propagation study at Lakelse is attempting an assessment of an artificial sockeye hatchery in conjunction with studies on critical aspects of early life-history biology. The lake sockeye studies on Babine Lake have encouraged the setting up of a "Babine Development Program" aimed at strategic location of artificial spawning channels to ensure better utilization of lake-rearing potentials. The work of Dr. W. Johnson and Mr. C. Groot on the migrations of young sockeye was awarded a prize as paper-of-the-year in fish ecology and management, by the North American Wildlife Society.

The work on *early sea life of salmon* in Burke Channel has produced further valuable data on growth and mortality of young pink salmon, as well as estimates of total marine growth and survival. The latter findings are particularly significant to international problems, supporting the view that high-seas fishing for pink salmon is less productive of total yield than shore-based fisheries on mature fish.

Stream ecology studies, largely concerned with underyearling coho salmon at Chef Creek, Vancouver Island, confirmed and extended previous work. Production of young coho is at a rate of 50 pounds per surface acre and is enhanced by small pools in the system.

During 1963 *chinook and coho salmon* studies were re-established to provide information apropos of new problems arising from sport fishing and the international aspects of the fisheries for these species. In addition, this investigation will undertake the Canadian commitment for participation in the program for evaluation of Columbia River hatcheries for chinook salmon.

Pollution investigations were, to a very large extent, concerned with monitoring existing marine pollution and with research aimed at answering specific applied questions posed by the complex chemistry of pulp-mill effluents. This investigation has been considerably overworked, with the expanding pollution problem on the Pacific Coast.

Tolerance studies provided consultation and bioassay services for the Department of Fisheries. The more fundamental aspects of this work were concerned with the

difficult problems of bioassay technique—another field of potentially important application.

Physiology and behaviour investigations continued to provide valuable understanding basic to evaluation of situations created by man-made obstructions such as power dams and water diversions. Appreciation of effects of these kinds of developments has greatly increased, and is proving valuable in planning adequate protection for salmon in proposed projects. Work on respiratory metabolism has been summarized in a comprehensive publication. Studies of behaviour have been chiefly concerned with the mechanisms of migration and navigation.

As in previous years, the Station has been heavily committed to conduct research related to the problems before the International North Pacific Fisheries Commission (INPFC). The investigation concerned with *salmon on the high seas* was perhaps most directly involved, and the large expenditures on fishing for salmon far offshore are an indication of the work being done. In 1963, extensive tagging in the Gulf of Alaska confirmed the general picture of distribution of North American salmon stocks in the eastern part of the North Pacific, allaying concern that Japanese high-seas fishing was taking large numbers of salmon of Canadian origin. Other investigations have been involved, and though not engaged in extensive field work, were nevertheless committed to large expenditures of time in the preparation of INPFC reports. Much of the work of the *parasitism and disease* investigation for the past decade has been concerned with techniques of stock identification by parasite loads. A comprehensive publication concerning the parasites of salmon in the North Pacific was completed. Studies have continued on the biology of many parasites which may prove of significance. The herring group in early 1964 began an investigation of Queen Charlotte Island herring stocks—an investigation considered desirable in view of the recent release of these stocks from abstinence. Scientists engaged in *salmon stock assessments* have been called on to prepare arguments documenting the Canadian viewpoint that salmon should not be harvested on the high seas, and are at present being rationally exploited to their biological capacity. Similarly, staff working on *marine commercial fisheries* participated in the documentation of the case for abstinence for halibut and herring.

The *Pacific Oceanographic Group* has also been involved in INPFC activities, invaluable contributing to the collection, synthesis, and presentation of the oceanographic material as background to understanding of North Pacific fisheries problems. The general program of the Pacific Oceanographic Group covers a wide range of oceanographic researches, reflecting that the group currently undertakes the Canadian requirements in oceanography on the Pacific. The projects in 1963 included continued monitoring at Ocean Station "P", daily seawater observations at 15 stations, study of physical oceanography of Dixon Entrance, assessment of coastal structure, publication of weekly charts for the Canadian Oceanographic Information Service, development of the airborne radiation thermometer, collaboration (with Scripps Institution of Oceanography) in publication of mean monthly OCEAN charts, definition of models of temperature and salinity structure for the North Pacific, studies of the intermediate water in the subtropical Pacific, and collaboration with the early-sea-life-of-salmon group on oceanography and pink salmon migration in Burke Channel.

An important new development in the Pacific Oceanographic Group has been a re-orientation in the first part of 1964 to new objectives in *fisheries oceanography and*

marine ecology. A program has been established, to work in co-operation with existing fisheries investigations, to assess the existing state of knowledge of the environment and fisheries, to derive correlations where possible, to define what information is lacking and how it may be obtained, and to provide systems of monitoring the environment that will aid assessment of the fisheries. Some transfers of staff have been effected in the Station as a whole, and further developments in this area will be reported in 1964-65 as the program gains in momentum.

INLAND FISHERIES

The *population study* at Heming Lake has produced evidence that in the course of several years a surprisingly large proportion of tagged fish lose their tags, even when carefully applied. Evidence continues to accumulate that a program to control the parasite *Trienophorus crassus* in Heming Lake, which terminated in 1960, succeeded in eliminating the pest completely; apparently it has not become re-established. A study of the *Great Slave Lake* fishery is now almost completed and preparations for reporting on results are almost completed. In *Lake Superior*, the Canadian catch of lake trout again increased as did average size of individual fish and catch per net. These are encouraging signs of improvement in the condition of the lake trout population, an improvement attributed to a recent sharp decline in sea lamprey abundance.

The Board again acted as Canadian agent for the Great Lakes Fishery Commission with respect to a program designed to control landlocked *sea lampreys*. The Commission's 1963 program required chemical treatment of 15 Lake Superior streams, and surveys on 630 streams in the Great Lakes watershed. In 1963, as in 1962, counts of spawning-run sea lampreys were much lower than counts for several years prior to 1962. Apparently there has been a dramatic decrease in lamprey abundance as a result of control efforts.

ARCTIC FISHERIES

An aquatic biological survey of *Great Bear Lake*, devoted principally to limnology in its initial year, found primary production to be generally very low with a maximum occurring in the shallowest southern arm. Fish abundance paralleled primary production findings.

Catch per unit of effort of *char* in Frobisher Bay continued to decline and results indicated the fishery continued, in part, on the accrued capital stocks. An investigation carried out on a land-locked population on Victoria Island suggested a useful untouched resource exists in the many small lakes of this area.

The feasibility of a fishery on the west coast of *James Bay* was investigated and found unprofitable; western coastal arctic fishery exploration found Greenland cod to be abundant and worth further study.

Life-history studies of the *narwhal* were started in the Pond Inlet area, and sampling and censusing of the *white whale* population of the Churchill area was completed.

Aerial censusing of moulting and breeding *harp seals* and breeding *grey seals* was carried out, and young harp and grey seals were tagged and/or branded in order to determine exploitation rates and migration patterns.

Planktonic studies to determine arctic water masses and currents were carried out and the Station actively participated in an international program designed to study the drift of fish larvae and eggs in relation to plankton distribution and hydrographic conditions on west Greenland waters.

TECHNOLOGICAL INVESTIGATIONS

The Board's integrated technological research program for the Atlantic coast is carried out in laboratories located at Halifax, N.S., Grande-Rivière, Que., and St. John's, Nfld. Technological investigations on freshwater fish are centered at London, Ont., and are co-ordinated with those concerning Pacific coast fisheries which are conducted at the Board's research laboratory in Vancouver, B.C.

ATLANTIC COAST

The co-ordination of technological research in the Atlantic Provinces has been completed by linking the program of the Grande-Rivière Technological Station with that of the Newfoundland Technological Unit and the Halifax Technological Research Laboratory to form the Atlantic Technological Research Program.

A commonly employed diet for commercially pounded *lobsters* has been shown to be little better than starvation in maintaining lobster blood cell counts at the level found in a natural environment. Supplementation of the diet with liver corrected this situation. The tolerance of lobsters to various woods and fluoridated water has been assessed. Western cedar is extremely toxic and should not be used for construction of pounds.

A diluting media for *salmon* sperm has been found which does not cause inactivation during the process of incorporating glycerol in the cell. This is a prerequisite to successful freezing of the sperm.

Malpeque-resistant *oyster* stocks have been shown by serological tests to possess an antigen which is absent in susceptible Cape Breton oysters, but it is still to be determined whether this is associated with resistance.

Dimethyl sulphide has been identified as the substance responsible for the off-odour of fillets from *Labrador cod* feeding on the pteropod *Limicina helicina* ("black-berry").

Sample thickness is indicated to be an important variable in determining texture characteristics of *freeze-dried cod*. A mascerated muscle residue from commercial filleting operations in Newfoundland has been shown to produce a freeze-dried product with much better texture than similar products prepared from fillets.

Very low dose *radiation pasteurization* of haddock and scallop meat has resulted in products with excellent storage characteristics in ice.

Fish protein concentrate (flour) has been prepared from filleting scraps and whole fish and the process has been modified for application to oily species such as herring. Nutritional and aesthetic characteristics of all products have been very good.

Considerable progress has been made towards defining the influence of *physiological and environmental factors* on quality and shelf-life of fishery products, particularly in the studies on Newfoundland trap cod and non-bacterial deterioration of groundfish.

PACIFIC COAST AND INLAND

In former years research and its logical development in these laboratories has resulted in large-scale applications of the findings in the fishing industry. In keeping with these previous successes the present year has seen significant progress in devising novel *equipment* for unloading comparatively large fish, such as salmon, by either the air-lift principle or by employing an ingenious device using alternate suction and pressure cycles. Useful applications of existing knowledge have been made in the engineering of refrigeration systems on vessels, which may engage in tuna or halibut freezing at sea, in use of a vacuum principle in tuna canning, and in bulk handling of herring meal.

Previous *general investigations* which have been continued or modified with new objectives include: attempts to prevent "belly-burn" in non-eviscerated salmon by holding them in sea water at about 25°F; studies on development of oxidative and hydrolytic rancidity and its significance and control in frozen fish; the value of tetracycline antibiotics in shrimp preservation; control of drip formation in thawed fish; and the effect of sugar removal on browning of heated fish flesh.

Much research effort has been expended on *biochemical problems* associated with live fish. Thus significant progress has been made in elucidating the nature of food and home stream odour attractants for salmonid fish, in the assay and purification of salmon pituitary gland hormones, and in investigations of the post-spawning survival of Pacific salmon. A number of modified techniques have been applied to separation of certain of the muscle, blood, and serum proteins of fish, and there is now no doubt that this method will prove an invaluable addition to existing methods of fish classification. Several fish enzymes have been studied with respect to their ability to form rare chemical compounds, and basic chemical studies have been made of novel marine invertebrate and fish nucleic acids and nucleotides.

In the *London laboratory*, progress has been made in implementing new programs concerned with improvement in quality of lake fish and the possible use of rapid spray chilling as one means of effecting this. Research on speciation of freshwater fish by use of protein patterns has been initiated.

Further details of the above and other investigations by the Board's various establishments during the fiscal year 1963-64 are given in the reports that follow. Localities of the laboratories and of their principal field work during the year are shown on the map facing page 86. A roster of the scientific staffs, and a list of publications issued during 1963, are appended.

Rapport annuel de l'Office des recherches sur les pêcheries du Canada pour l'année budgétaire finissant le 31 mars 1964

INTRODUCTION

Du point de vue des pêches du Canada, l'événement marquant de l'année 1963-1964 a été la Conférence fédérale-provinciale relative à l'expansion des pêches, convoquée sur l'invitation du ministre fédéral des Pêcheries, le 24 janvier 1964. La conférence a esquissé un programme d'activité nouvelle et augmentée, visant à accroître la quantité et la qualité du poisson débarqué, à relever le revenu des pêcheurs et à améliorer la commercialisation du poisson. La recherche a joué et continuera de jouer un rôle important pour la réalisation de ces objectifs. Le personnel de l'Office des recherches sur les pêcheries du Canada a largement contribué aux préparatifs de la conférence, ainsi qu'à l'organisation détaillée, grâce à laquelle ses recommandations sont mises en œuvre.

Durant la majeure partie de l'année 1963-1964, l'Office a fonctionné sous le coup de restrictions imposées par le programme d'économie du gouvernement, ce qui a eu pour effet de réduire le personnel à près du plafond temporaire de 85 p. 100 des effectifs approuvés, sauf dans le cas de certains services irréductibles, comme par exemple les équipages de bateau. C'est dans les rangs de nos investigateurs scientifiques que cette mesure a été le plus durement ressentie car, ailleurs, la demande de main-d'œuvre formée et spécialisée a continué d'augmenter. Heureusement, au mois d'août 1963, la restriction visant le personnel a été mitigée de manière à permettre d'employer jusqu'à 93 p. 100 de l'effectif approuvé, et les autorités cherchent à obtenir un nouvel adoucissement des restrictions visant le recrutement du personnel.

Dans le cadre des limitations imposées à son action, l'Office a continué en 1963-1964 à étudier la plupart des aspects des richesses de la mer et de l'eau douce du Canada, ainsi que l'exige la Loi sur le Conseil de recherches.

En 1963, le nombre de membres de l'Office a été porté à son maximum réglementaire de 18, sans compter le président. Au 31 mars 1964, l'Office comptait 10 savants d'universités canadiennes, 7 industriels intéressés à une phase quelconque des opérations de capture et de traitement du poisson, et un fonctionnaire supérieur du ministère des Pêcheries.

Le président de l'Office des recherches sur les pêcheries, M. J. L. Kask, PH.D., a remis sa démission le 19 août 1963, pour se charger d'une tâche difficile aux États-Unis. M. Kask a été le premier président à service continu de l'Office, et il a rempli cette fonction depuis 1954. En donnant sa démission, il a passé en revue les années de son mandat, qui ont été pour lui «une aventure scientifique stimulante et rémunératrice». Il a aussi souligné la flexibilité de l'organisation et de l'administration de la

recherche prévue par la Loi sur le conseil de recherches, qui, selon lui, est un instrument qui «fait honneur aux vues éclairées du parlement et du peuple». Le poste laissé vacant par le départ de M. Kask a été comblé provisoirement par la nomination d'un président suppléant détaché du personnel scientifique de l'Office, M. W. E. Ricker, PH.D., de Nanaïmo (C.-B.). Le 13 février 1964, le gouverneur en conseil a annoncé la nomination d'un nouveau président, dont l'entrée en fonctions était fixée au 1^{er} août 1964. Il s'agit de M. F. R. Hayes, PH.D., vice-président de l'Université Dalhousie, Halifax (N.-É.), et directeur de son Institut d'océanographie.

Les membres dont les noms suivent étaient en fonctions durant l'année 1963:

- *M. J. L. Kask, B.A.(Colombie-Britannique), PH.D.(Washington); président (jusqu'au 19 août 1963).
- *M. W. E. Ricker, B.A., M.A. PH.D.(Toronto), F.R.S.C.; président suppléant (à compter du 20 août).
- M. C. W. Argue, C.B.E., B.A., B.S.A.(Colombie-Britannique), M.S.(Iowa), D.SC.(Nouveau-Brunswick); Université du Nouveau-Brunswick, Fredericton (N.-B.).
- M. J. M. R. Beveridge, B.SC.(Acadia), PH.D.(Toronto), M.D.(Western), D.SC.(Acadia), F.R.S.C.; Université Queen's, Kingston (Ontario).
- *M. T. W. M. Cameron, T.D., B.SC., M.A., PH.D.(Londres), D.SC.(Edimbourg), D.SC.(Colombie-Britannique), M.R.C.V.S., F.R.S.C.; Université McGill, Collège Macdonald, (Québec).
- *M. D. B. DeLury, B.A., M.A., PH.D.(Toronto); Université de Toronto, Toronto (Ont.).
- *M. Yves Desmarais, B.A., B.S.A., PH.D.(Wisconsin); Jardin botanique de Montréal, Montréal (Québec).
- M. M. K. Eriksen, Prince-Rupert (C.-B.); (représentant de l'industrie de la pêche).
- *M. F. R. Hayes, M.SC.(Dalhousie), PH.D., D.SC.(Liverpool), F.R.S.C.; Université Dalhousie, Halifax (N.-É.).
- *M. Guy Le Blanc, Montréal (Québec); (représentant de l'industrie de la pêche).
- *M. I. McT. Cowan, B.A.(Colombie-Britannique), PH.D.(Californie), F.R.S.C.; Université de la Colombie-Britannique, Vancouver (C.-B.).
- *M. D. F. Miller, B.COM., S.M.(M.I.T.), Vancouver (C.-B.); (représentant de l'industrie de la pêche).
- *M. A. H. Monroe, Saint-Jean (T.-N.), (représentant de l'industrie de la pêche).
- M. Edouard Pagé, M.B.E., B.S.A.(Montréal), PH.D.(Cornell), F.R.S.C.; Université de Montréal, Montréal (Québec).
- M. G. L. Pickard, M.B.E., B.A., M.A., D.PHIL.(Oxon.) Université de la Colombie-Britannique, Vancouver (C.-B.).
- M. A. L. Pritchard, B.A., M.A., PH.D.(Toronto); Ottawa, Ont.; (représentant du ministère des Pêcheries du Canada).
- M. Sol Sinclair, B.S.A., M.SC., PH.D.(Minnesota), F.A.I.C.; Université du Manitoba, Winnipeg (Man.).
- *M. R. G. Smith, Halifax (N.-É.); (représentant de l'industrie de la pêche).

*Membres du comité exécutif.

Au cours des dernières années, l'Office a eu la bonne fortune de compter le sous-ministre des Pêcheries parmi les membres de son comité exécutif. Après la mort prématurée de M. G. R. Clark, au mois de février 1963, un nouveau sous-ministre, M. A. W. H. Needler, D.P.H., a été nommé le 26 février 1963. M. Needler était antérieurement directeur de la Station de l'Office des recherches à Nanaïmo. Comme son prédécesseur, il a consenti à agir d'office à titre de membre du comité exécutif. M. A. D. Wymbs, délégué en chef du Trésor au ministère des Pêcheries et trésorier honoraire de l'Office est aussi membre de droit de son comité exécutif.

La réunion annuelle de l'Office avec les directeurs de stations et les chefs d'unités a été tenue à Ottawa au début de janvier 1964. C'est à ce moment que les programmes scientifiques et la ligne de conduite de l'Office visant la recherche ont été étudiés en même temps que les rapports et les recommandations des comités consultatifs permanents régionaux. Le comité exécutif s'est réuni trois fois durant l'année pour étudier les questions de personnel et de finance, et chacun des trois comités consultatifs régionaux s'est réuni deux fois.

Les entreprises de l'Office dans le domaine de la recherche sont, à dessein, complètement décentralisées. L'administration quotidienne et la surveillance des opérations sont assurées par le président et ses collègues à temps continu au siège administratif à Ottawa. Le personnel, y compris un fonctionnaire en dehors d'Ottawa, comptait dix-huit employés en tout. Outre le président et le président suppléant mentionnés antérieurement, voici les noms des hauts fonctionnaires du bureau du président en 1963:

- M. W. R. Martin, B.A., M.A.(Toronto), PH.D.(Michigan), président adjoint.
- M. J. A. Rogers, A.C.B.A., directeur de l'administration et adjoint exécutif du président.
- M. J. C. Stevenson, B.A., M.A.(Saskatchewan), PH.D.(Toronto), adjoint spécial du président et directeur de la publication.
- M. E. G. Bligh, B.Sc., M.Sc.(Acadia), PH.D.(McGill), adjoint spécial du président et directeur adjoint de la publication.
- M. H. B. Hachey, M.B.E., LL.D.(St. Thomas), F.R.S.C., océanographe en chef au 31 mars, et ensuite adjoint spécial du président affecté à la Station de St. Andrews (N.-B.).

M. J. A. Rogers et ses collègues, MM. R. D. Willet et L. M. Morin ont rempli les fonctions de secrétaires-généraux à la réunion annuelle de l'Office et aux réunions du comité exécutif, et Mme Claire Duffy est la secrétaire adjointe de l'Office.

L'Office des recherches sur les pêcheries comptait un effectif approuvé de 816 employés durant la période envisagée dans le présent rapport. Cet effectif comprend 196 emplois de nature scientifique, bien que le nombre des emplois figurant effectivement au contrôle n'ait été que d'environ 159, par suite du mouvement normal du personnel et des restrictions visant le recrutement.

L'année 1963-1964 a été active et productive pour l'Office dans chacune des trois disciplines scientifiques qui retiennent son attention, notamment la biologie aquatique, surtout en ce qui a trait à la pêche, l'océanographie et la technologie de la pêche. Seize vaisseaux de recherche ont été utilisés pour la poursuite de ses études biologiques. Ces unités varient des petites embarcations côtières et de lac aux grands bâtiments de mer construits spécialement à cette fin.

En 1963, une nouvelle barge de recherche, la *Velella* (76 pieds hors tout; 269 tonnes de jauge nette) a été ajoutée à la flottille de l'Office sur la côte du Pacifique. Ce bâtiment, qui est un laboratoire flottant, servira d'abord de base pour l'étude du jeune saumon en mer.

Des programmes coopératifs de recherches océanographiques ont encore été exécutés avec la collaboration de la Marine royale du Canada, du ministère des Mines et des Relevés techniques et du ministère des Transports. Des relations étroites ont été entretenues avec l'Institut d'océanographie de la Colombie-Britannique, Vancouver (C.-B.), l'Institut des Grands lacs de l'Université de Toronto, Toronto (Ont.), et l'Institut d'océanographie de l'Université Dalhousie, Halifax (N.-É.). L'exécution d'autres programmes coopératifs a aussi été poursuivie de concert avec les gouvernements provinciaux et la Commission internationale de la pêche du saumon du Pacifique, New-Westminster (C.-B.).

Les investigations poursuivies par un certain nombre de commissions internationales sur la pêche et sur les mammifères marins, commissions dont le Canada fait partie et qui ne disposent pas de leur propre personnel scientifique, représentent une proportion considérable des entreprises de l'Office en matière de biologie et d'océanographie. Les commissions en cause sont: La Commission internationale des pêches du nord-ouest de l'Atlantique, la Commission de la recherche sur les pêches des Grands lacs, la Commission internationale de la chasse à la baleine, la Commission du phoque à fourrure du Pacifique et la Commission internationale des pêches du Pacifique nord. Cinq stations de biologie, dont deux comportent des groupes océanographiques, et trois laboratoires de recherche technologique, assurent l'exécution des vastes travaux de recherche de l'Office. Des stations de moindre importance et de petits établissements sur les lieux facilitent l'exécution du travail dans les principaux secteurs d'opération.

ENQUÊTES BIOLOGIQUES ET OCÉANOGRAPHIQUES

Les principales stations de recherche biologique de l'Office sont situées à Nanaïmo (C.-B.), London (Ont.), St. Andrews (N.-B.), Saint-Jean (T.-N.), et Montréal (Québec). Des groupes océanographiques associés relèvent des Stations de Nanaïmo et de St. Andrews. Pour assurer le fonctionnement efficace des opérations, l'Office entretient un personnel d'unités sur place et d'observateurs portuaires aux endroits stratégiques.

PÊCHES DE L'ATLANTIQUE—RÉGION DE TERRE-NEUVE

Le total des apports des principaux *poissons de fond* du commerce a été d'environ 4 p. 100 supérieur à celui de 1962. Ces apports comprenaient 79 p. 100 de morue, 8 p. 100 de chèvre, 8 p. 100 de plie, 3 p. 100 d'aiglefin, et 2 p. 100 de plie grise, de flétan, d'anarrhique-loup et de colin. Les apports de morue, de chèvre et de plie ont été respectivement de 4, de 30 et de 60 p. 100 plus élevés que ceux de 1962, tandis que les apports d'aiglefin ont été de 60 p. 100 inférieurs à ceux de l'année précédente. L'augmentation des apports de morue, de chèvre et de plie s'explique principalement par un accroissement de l'effort de pêche de ces espèces, tandis que la diminution dans les apports d'aiglefin est le résultat d'un déclin dans l'abondance de ce poisson.

Dans la continuation des études sur la pêche de la *morue côtière* de Terre-Neuve et du Labrador, la composition d'âge et de longueur des échantillons révèle que la

pêche aux trappes et aux cordeaux compte sur les jeunes classes d'âge (de 4 à 7 ans), tandis que la pêche aux palangres et aux filets maillants s'appuie sur la morue plus âgée (8 ans et plus) qui contribue de façon importante à la prise lorsqu'elle n'est plus capturée en grand nombre par les trappes et les cordeaux. Au Labrador, la jeune morue (de 4 à 6 ans), qui a peu contribué à la prise au cours des dernières années, était abondante en 1963 et sans doute devrait-elle contribuer de façon marquée à la réussite de la pêche pour plusieurs années. L'étude annuelle de la petite morue sur la côte est de Terre-Neuve, dont l'objet est de fournir des prédictions utiles quant à l'abondance de jeune morue dans la pêche de commerce, a révélé qu'un nombre relativement faible de sujets de l'année avaient été capturés, ce qui n'indiquerait qu'un taux modéré de survivance et d'établissement de la classe annuelle de 1963.

Les études sur la *morue hauturière* faites par le navire de recherche *A. T. Cameron* révèlent que d'importantes concentrations de morue, exploitées par un flotte considérable de chalutiers européens, se trouvaient entre 120 et 180 brasses à l'extrémité sud-est du banc de l'anse Hamilton aux mois d'avril et de mai. D'une manière générale, ces poissons étaient petits, et les captures renfermaient une proportion élevée de sujets de 4 à 6 ans. Environ 20,000 morues ont été étiquetées durant l'année dans le dessein particulier d'étudier la corrélation entre les populations de morue côtière et hauturière.

Les grandes explorations poursuivies par les navires de recherche aux mois de mai et de juillet n'ont révélé aucune concentration d'*aiglefin*, et les apports de Terre-Neuve ont été faibles. La raison fondamentale de cette situation est la mauvaise survivance des jeunes sujets; les dernières bonnes classes annuelles ont été celles de 1955 et de 1956, et aucune nouvelle classe annuelle abondante n'est en perspective. L'intensité de l'exploitation a aussi contribué à la rareté actuelle de l'*aiglefin*.

Les études sur la *chèvre* poursuivies au large du Labrador et de la partie est de Terre-Neuve au printemps révèlent une tendance générale à la distribution de la chèvre en eau plus profonde au printemps et, vraisemblablement, en hiver. C'est l'époque où l'on trouve les plus grandes concentrations de chèvre dans la région du Labrador. Au mois d'avril dans ce secteur, la prise de chèvre en quantités commerciales faite à la plus faible profondeur a été réussie à 250 brasses. Le golfe St-Laurent ne donne que peu d'indices de la présence de gros poissons, mais dans certains parages des quantités considérables de jeunes sujets (7 ans et moins) ont été capturées. Ces poissons sont apparus dans la pêche en 1963 mais les perspectives qu'ils offraient avaient été reconnues d'après les captures faites par les navires de recherche quatre ans auparavant.

La recherche sur le *homard* dans la baie de Port-au-Port a été concentrée sur des études ayant trait à la croissance, au temps du frai et au taux de pêche.

Le déversement de 2.5 millions d'œufs de *saumon rose* dans la rivière North-Harbour, baie St. Mary, a donné lieu à une éclosion bien réussie, et environ 2.2 millions d'alevins ont descendu la rivière entre le 7 mai et le 16 juin. On prévoit que les survivants remonteront ce cours d'eau en 1964. Les expériences portant sur le saumon atlantique dans la rivière Little-Codroy ont été complétées.

PÊCHES DE L'ATLANTIQUE—RÉGION DU SUD

Les études sur les populations de *homard* ont été poursuivies à des endroits stratégiques de manière à suivre les changements naturels et les effets du règlement

de pêche. A Port-Maitland, le homard accuse un taux de déplacement et de mortalité naturelle plus élevé que les travaux antérieurs ne permettaient de le prévoir. La culture du homard a été abordée par une exploration de la possibilité économique d'élever du petit homard en captivité jusqu'à ce qu'il atteigne une taille ayant plus de valeur marchande. Pour le moment, aucun progrès immédiat n'est à signaler. Le comportement des larves de homard libres en rapport avec le moment où elles s'apprêtent à s'installer sur le fond a été étudié. La possibilité de se fonder sur l'abondance des larves pour prédire les captures a été examinée et promet de fournir une base acceptable pour des prévisions à brève échéance. Un bulletin complet sur le soin et la manipulation du homard a été préparé dans le dessein d'aider l'industrie à appliquer les résultats de 10 années de recherche.

Le sort des larves d'*huîtres* libres a été suivi comme d'habitude et l'époque de la chute du naissain a été prédite avec exactitude. D'une manière générale, les tentatives faites pour restaurer les populations d'*huîtres* du continent, anéanties durant les années 50 par la maladie de Malpèque, se poursuivent de façon satisfaisante. Les examens effectués ne révèlent aucune nouvelle propagation de la maladie. Des progrès satisfaisants ont été réalisés dans les travaux coopératifs avec d'autres directions du gouvernement. Un établissement d'élevage des *huîtres* a été construit pour l'usage conjoint de l'Office et du Service de l'expansion de la pisciculture du ministère des Pêcheries. Les études poursuivies par le ministère des Mines et des Relevés techniques sur la sédimentation de fond ont confirmé que les gisements *huîtres* étaient fortement colmatés et que, en conséquence, des fonds productifs se trouvaient détériorés.

Les données statistiques qui représentent réellement l'état des stocks de poisson et l'intensité de l'effort de pêche sont essentielles à la recherche, à la gestion et à la planification à long terme. De concert avec le Service de l'économie du ministère des Pêcheries et le Bureau fédéral de la statistique, des données sur les *captures et sur l'effort de pêche* sont rassemblées pour l'usage du pays, ainsi que pour répondre aux engagements de caractère international pris par l'entremise de la Commission internationale des pêches du nord-ouest de l'Atlantique.

Chaque année, d'importants *fonds de pêche* sont étudiés afin de fournir des renseignements sur l'état des stocks et une base pour des prédictions d'abondance relative. La répartition et l'abondance de la morue dans le golfe St-Laurent et de l'aiglefin sur les bancs de la Nouvelle-Écosse, continuent d'être l'objet d'observations. Sur les bancs de la Nouvelle-Écosse, aucun changement important n'a été observé dans l'abondance de la morue. Il est prévu que le recrutement de l'aiglefin durant les années prochaines sera médiocre. La proportion de poissons rejetés après la capture, déterminée pour répondre aux besoins de la Commission internationale des pêches du nord-ouest de l'Atlantique, révèle que les mesures de conservation sont généralement efficaces. Une étude des mœurs et de la dynamique des populations de plie du Canada a été terminée.

Le *comportement* de la morue et autres poissons de fond est à l'étude dans le dessein de fournir des renseignements pour la conception d'engins de pêche plus efficaces. Les niveaux de fatigue susceptibles d'être soutenus par le poisson sans mourir et ses mouvements quotidiens en rapport avec l'intensité de la lumière, retiennent l'attention.

Les prises de diverses *espèces pélagiques* ont été échantillonnées de façon courante, et l'état de la pêche a été noté. Le hareng de la baie de Fundy a été échantillonné, en partie pour répondre aux obligations internationales. La montée en flèche des apports d'espadon qui a accompagné l'introduction de la pêche aux palangres a été encouragée et suivie au moyen d'observations en mer et d'échantillonnage à terre. De nouvelles entreprises de pêche du thon installées au Nouveau-Brunswick sont suivies et les prises sont examinées.

La pêche des *pétoncles* est à l'étude au moyen d'analyses détaillées des données statistiques de prise et de voyages d'observation en mer. Les stades de développement des larves de pétoncles sont déterminés par l'élevage en laboratoire comme premier pas dans l'étude des éléments qui influent sur la survivance de l'espèce dans la nature. Pour évaluer la possibilité d'accroître le produit des captures courantes, certaines parties des pétoncles qui ne sont pas vendues ici, mais dont l'usage est répandu dans d'autres parties du monde, sont examinées afin de savoir si elles sont de nature saine.

Des études techniques d'*engins de pêche* ont été entreprises en vue d'examiner les forces qui agissent sur les chaluts lorsqu'ils sont remorqués. L'objet de ces travaux préliminaires est d'arriver à créer des engins de pêche conçus particulièrement pour reconnaître le comportement du poisson.

Les populations de *saumon* de la Miramichi du nord-ouest et d'autres cours d'eau sont suivies afin de déceler les changements naturels dans leur abondance et les effets des diverses formes d'intervention humaine, y compris les vaporisations au DDT et la pollution minière. Dans la rivière Margaree, une expérience de grande envergure est en cours afin de savoir si l'augmentation dans la production de tacons résultant de la répression du harle se continue de manière à produire un accroissement du nombre disponible de saumons adultes. Les renseignements recueillis aux pêcheries à fascines de hareng sur le saumon ayant dépassé le stade de tacon révèlent son origine et sa distribution dans la baie de Fundy. Sept saumons de la Miramichi marqués ont été capturés au Groenland, et il semble que plusieurs poissons d'origine canadienne peuvent être capturés en ce lieu. Le comportement du saumon et de la *truite* en eau douce est à l'étude afin de découvrir les meilleurs moyens de favoriser la reproduction naturelle.

Des *études mathématiques* sont entreprises afin d'encourager l'élaboration de plans efficaces pour la conduite des expériences et des observations, ainsi que d'évaluer le bien-fondé des méthodes acceptées d'estimer l'importance des stocks.

On accorde beaucoup d'importance à l'*océanographie* dans ses rapports avec la pêche. La circulation de l'eau a été étudiée au moyen de bouteilles dérivantes, de modèles électriques analogues, d'effets d'induction et de hauteurs dynamiques. Les conditions de température de la mer sont contrôlées au cours de croisières courantes et aux stations terrestres. D'autres propriétés de l'eau de mer, notamment ses propriétés optiques et sa teneur chimique, peuvent avoir une influence sur les poissons, et l'investigation de ces propriétés a été commencée. Afin de fournir une exploration plus détaillée du golfe St-Laurent, la description géochimique de cette «mer» a été entreprise. L'étude des invertébrés de fond du golfe St-Laurent indique des rapports entre ces organismes, les concentrations de poisson et les conditions du fond.

PÊCHES DU PACIFIQUE

Durant l'exercice 1963-1964, la Station de Nanaïmo (C.-B.) a poursuivi plusieurs investigations se rattachant surtout à l'intérêt national immédiat, elle a fourni des données scientifiques pour la solution de problèmes internationaux, ainsi que des services, des investigations et des conseils pour la gestion des pêches dans les eaux côtières. Les investigations portant sur les *pêches de commerce maritimes* ont continué de fournir des analyses de données statistique, des prédictions et autres renseignements utiles à la gestion des poissons de fond, du hareng, des crevettes et des crabes. En plus de poursuivre l'étude des populations de stocks de la localité (investigations sur les poissons de fond des *mers rapprochées*), de nouvelles études ont été entreprises dans le golfe d'Alaska (*mers éloignées*), particulièrement sur la perche de mer. Dans le cadre des investigations sur le *hareng*, le contrôle des populations, l'étude de l'incidence du saumon dans les captures de hareng, et l'essai de nouveaux engins de chalutage pélagique ont été continués. Les études portant sur la *couche de dispersion* qui est un important secteur de concentration de jeunes poissons et d'organismes alimentaires, ont été continuées. Des études sur les *crustacés* de la localité ont été poursuivies, et des explorations ont été faites dans divers secteurs, y compris le golfe de l'Alaska.

L'investigation sur les *invertébrés marins* a été surtout consacrée au service pour la solution des problèmes quotidiens de l'industrie coquillière. Des études sur les effets de l'effluent d'une usine de pâte à papier sur les huîtres, sur les maladies des huîtres, sur l'intoxication causée par les coquillages, sur les ormers, les couteaux et les perce-bois, ont fait porter l'investigation sur une gamme étendue de questions ayant trait aux invertébrés.

Le personnel chargé des études sur les *mammifères marins* a travaillé en liaison étroite avec le ministère des Pêcheries en rapport avec la gestion de ces animaux, tout en portant la lourde charge de s'acquitter d'engagements internationaux ayant trait aux besoins de la Commission internationale de la chasse à la baleine et de la Commission internationale du phoque à fourrure du Pacifique nord.

Un service analogue pour la solution des problèmes de gestion a été la principale caractéristique du travail accompli à la station sur le saumon du Pacifique. Le groupe affecté à l'évaluation des stocks de saumon a fourni une estimation constante de l'état de ces stocks, se chargeant, chaque fois que la chose était nécessaire, de fournir une évaluation des problèmes d'intérêt particulier. A titre de contribution importante durant l'exercice 1963-1964, signalons le rôle joué par la station dans la production d'un rapport ayant trait au saumon rose du détroit de Georgie, sous les auspices du Comité de coordination de la recherche sur le saumon rose, nommé par les gouvernements du Canada et des États-Unis.

Une forme particulièrement considérable d'activité du type gestion se concrétise dans les investigations sur le *saumon de la rivière Skeena*, qui nécessitent la participation de la station à tous les aspects de la recherche sur la gestion du saumon de ce cours d'eau. Toutes les observations courantes nécessaires à la gestion ont été continuées, y compris le rassemblement et l'analyse des données statistiques commerciales, les essais de pêche, l'estimation du passage des géniteurs, et l'échantillonnage en vue de déterminer la composition d'âge et de taille. Les études sur le sockeye poursuivies au lac Babine ont continué de fournir des renseignements sur l'accroissement

et l'abondance de saumoneaux provenant de frais dont l'importance et la répartition sont connues. La production de frai de saumon rose (survivance de 13 p. 100) a été estimée dans la rivière Lakelse.

Les investigations sur la *propagation du saumon* et du *sockeye de lac*, tout en se rattachant un peu moins aux affaires de gestion quotidienne, portent sur des questions applicables aux travaux courants de la Direction de l'expansion de la pisciculture du ministère des Pêcheries et la liaison avec le Ministère est maintenue à un bon niveau de fonctionnement. L'étude sur la propagation du saumon à Lakelse comporte l'évaluation d'un établissement pour l'élevage artificiel du sockeye, conjointement avec d'autres études sur les aspects critiques de la biologie du saumon au début de sa vie. Les études sur le sockeye de lac poursuivies au lac Babine ont favorisé la mise au point d'un «Programme d'expansion du secteur de Babine» visant à créer des chenaux de frai artificiel à des endroits stratégiques pour en arriver à une meilleure utilisation de la capacité biogénique du lac. Le travail de M. W. Johnson, D.P.H., et de M. C. Groot, sur les migrations du jeune sockeye a mérité le prix décerné par la «North American Wildlife Society» à la meilleure étude de l'année sur l'écologie et la gestion du poisson.

Le travail sur les *premières phases de la vie du saumon en mer* dans le chenal Burke a produit d'autres données précieuses sur la croissance et la mortalité du jeune saumon rose, ainsi que des estimations de la croissance et de la survivance totales en mer. Ces dernières constatations revêtent un sens particulier quant aux problèmes internationaux, en ce qu'ils étayaient l'opinion que la pêche hauturière du saumon rose est moins productive dans son rendement total que la pêche côtière portant sur le poisson adulte.

Les études sur l'*écologie des cours d'eau*, portant sur le saumon coho de moins d'un an au ruisseau Chef, île Vancouver, confirment et amplifient le travail antérieur. La production de jeunes cohos se réalise à raison de 50 livres par acre de surface et elle est favorisée par les petites fosses qu'on trouve dans le régime de ce cours d'eau.

En 1963, les études sur les *saumons quinnat et coho* ont été reprises afin de fournir des renseignements relatifs aux nouveaux problèmes découlant de la pêche sportive et des aspects internationaux de la pêche pour ces espèces. En outre, cette investigation servira à remplir les obligations du Canada visant la participation au programme d'évaluation des piscicultures du Columbia pour le saumon quinnat.

Dans une très grande mesure, les investigations sur la *pollution* ont porté sur le contrôle des pollutions marines en existence et sur la recherche visant à répondre à diverses questions précises touchant la complexité chimique des effluents d'usines de pâte à papier. L'expansion du problème de la pollution sur la côte du Pacifique a considérablement augmenté la tâche des investigateurs chargés de ce travail.

Des études sur les *tolérances* ont permis de fournir des services de consultation et d'analyse biochimique au ministère des Pêcheries. Les aspects fondamentaux de ce travail portent sur les problèmes difficiles de la technique d'analyse biochimique, autre domaine susceptible d'importantes applications.

Les investigations sur la *physiologie et le comportement* ont continué de fournir des éléments de compréhension précieux pour l'évaluation de situations résultant d'obstructions créées par l'homme, notamment les barrages d'énergie hydroélectrique et de dérivation d'eau. L'appréciation de l'effet des aménagements de cette nature s'est accrue considérablement et se révèle précieuse quant à la mise au point de

mesures de protection satisfaisantes pour le saumon dans la construction des installations projetées. Le travail sur le métabolisme respiratoire a été résumé dans une publication très complète. Les études sur le comportement se rattachent surtout aux mécanismes de migration et de navigation.

Comme par les années antérieures, la Station s'est vue lourdement chargée de travaux de recherche ayant trait aux problèmes qui confrontent la Commission internationale des pêches du Pacifique nord (INPFC). L'investigation sur le *saumon dans les mers hauturières* est peut-être plus directement en cause, et les dépenses considérables qui ont été faites pour pêcher le saumon loin au large sont un indice du travail en cours. En 1963, l'étiquetage pratiqué en grand dans le golfe de l'Alaska confirme le tableau général de la répartition des stocks de saumon nord-américains dans la partie est du Pacifique nord, ce qui dissipe l'idée que les pêcheurs hauturiers du Japon prenaient un nombre considérable de saumons d'origine canadienne. D'autres investigations sont en cause, et, bien qu'elles n'aient pas donné lieu à des travaux étendus sur place, elles ont quand même entraîné une dépense considérable de temps pour la préparation de rapports destinés à l'INPFC. Une grande partie du travail occasionné par l'investigation sur le *parasitisme et la maladie* au cours des dernières années a porté sur la technique d'identification des stocks par les parasites portés. Une étude détaillée sur les parasites du saumon dans le Pacifique nord a été terminée. Les études portant sur la biologie de plusieurs parasites qui peuvent avoir de l'importance se continuent. Au début de 1964, le groupe chargé du hareng a entrepris une investigation des stocks de ce poisson dans les îles de la Reine-Charlotte, cette investigation étant considérée désirable du fait que les stocks en question ont récemment été soustraits à l'abstention. Les investigateurs scientifiques chargés de l'*évaluation des stocks de saumon* ont été invités à préparer des raisonnements pour étayer la thèse canadienne selon laquelle le saumon ne devrait pas être pêché dans les mers hauturières, et qu'il est à l'heure actuelle exploité rationnellement dans la pleine mesure de sa capacité biologique. De même, le personnel chargé de l'étude sur les *pêches maritimes de commerce* a participé à la documentation des mesures pour la défense de l'abstention de pêcher le flétan et le hareng.

Le *groupe océanographique du Pacifique* a aussi été mis à contribution en rapport avec l'activité de l'INPFC, et il a fourni une importante contribution au rassemblement, à la synthèse et à la présentation de documentation océanographique devant servir de base à la compréhension des problèmes de la pêche dans le Pacifique nord. Le programme général du GOP s'étend à une gamme étendue de recherches océanographiques, ce qui indique que ce groupe s'occupe couramment des besoins du Canada en fait d'océanographie dans le Pacifique. Le programme de 1963 comportait les travaux suivants: continuation du contrôle à la station océanique «P», observation quotidienne de l'eau de mer à 15 stations, étude de l'océanographie physique de l'entrée de Dixon, évaluation de la structure côtière, publication de tableaux hebdomadaires pour le service d'information océanographique du Canada, mise au point du thermomètre à radiations aéroporté, collaboration (avec l'Institut d'océanographie Scripps), à la publication mensuelle de tableaux d'observations océaniques moyennes, définition de modèles de structure de la température et de la salinité pour le Pacifique nord, études sur l'eau intermédiaire du Pacifique semi-tropical, et collaboration aux travaux du groupe chargé des études sur les premières phases de la vie du saumon en mer, l'océanographie et la migration du saumon dans le chenal Burke.

Au début de 1964, les travaux du groupe océanographique du Pacifique ont été orientés vers de nouveaux objectifs dans le domaine de l'*océanographie de pêche et de l'écologie marine*. Cet important changement a donné lieu à l'établissement d'un programme de collaboration aux investigations de pêche en cours, pour l'évaluation de l'état actuel des connaissances du milieu et de la pêche, en vue d'en tirer, si possible, une corrélation qui permettra de préciser les renseignements qui manquent et le moyen de les obtenir, aussi bien que de fournir les systèmes de contrôle du milieu qui aideront à l'évaluation des pêches. Des mutations de personnel ont été effectuées dans l'ensemble de la station, et le compte rendu des progrès nouveaux accomplis dans ce secteur sera donné en 1964-1965, alors que l'exécution du programme sera accélérée.

PÊCHES DE L'INTÉRIEUR

L'étude des populations au lac Heming a fourni la preuve que, au cours de plusieurs années, un nombre surprenant de poissons marqués perdent leurs étiquettes, même lorsqu'elles sont posées avec soin. Les preuves de réussite du programme de répression du parasite *Triaxophorus crassus*, terminé en 1960 au lac Heming, s'accumulent et semblent établir que cet organisme nuisible a été complètement éliminé; du moins, il ne paraît pas s'être rétabli. Une étude sur la pêche au *Grand lac des Esclaves* est presque achevée, et les travaux préparatoires à la rédaction du rapport sur les résultats obtenus sont sur le point d'être terminés. Dans le *lac Supérieur*, la prise canadienne de truite grise a encore augmenté, de même que la taille moyenne du poisson et la capture par filet. Ces indices encourageants révèlent que l'état de la population de truite grise s'améliore, et ce progrès est attribué à une diminution récente et marquée dans l'abondance de la lamproie marine.

L'Office a de nouveau rempli les fonctions d'agent canadien de la Commission de la recherche sur les pêches des Grands lacs relativement au programme visant à réprimer la *lamproie marine* de l'intérieur. Le programme dressé par la Commission pour l'année 1963 comportait le traitement chimique de 15 cours d'eau du lac Supérieur et l'étude de 630 cours d'eau du bassin hydrographique des Grands lacs. En 1963, aussi bien qu'en 1962, le dénombrement des remontes de frai des lamproies marines s'est révélé bien inférieur au dénombrement portant sur plusieurs années antérieures à 1962. Il semble que les tentatives de répression ont abouti à une diminution sensationnelle dans l'abondance de la lamproie.

PÊCHE DES RÉGIONS ARCTIQUES

Une étude de biologie aquatique au *Grand lac de l'Ours*, consacrée dans sa première année surtout à la limnologie, a révélé que la production primaire était généralement très faible, et que les meilleurs résultats étaient obtenus dans le bras sud qui est la partie la moins profonde du lac. L'abondance du poisson va de pair avec les constatations relatives à la production primaire.

La prise d'omble, par unité d'effort, dans la baie Frobisher, continue à décliner, et les résultats de la recherche indiquent que la pêche se poursuit, en partie aux dépens des stocks primitifs accumulés. Une investigation portant sur une population de l'intérieur de l'île Victoria, donne à croire qu'il existe dans les nombreux petits lacs de cette région une richesse intacte qui pourrait se révéler très utile.

D'après une étude poursuivie sur la côte ouest de la *baie James*, la pêche dans ce secteur ne serait pas rentable; d'autre part une exploration de la pêche côtière dans l'ouest du secteur arctique révèle que la morue du Groenland est abondante et qu'elle mérite d'être étudiée plus à fond. Des études sur les mœurs du *narval* ont été commencées dans le secteur de Pond-Inlet, alors que le prélèvement d'échantillons et le recensement de la population de *bélugas* dans le secteur de Churchill ont été complétés.

Le recensement aérien des *phoques du Groenland*, en phase de mue et de reproduction, et des *phoques gris*, en phase de reproduction, a été effectué; des jeunes des deux espèces ont été étiquetés ou marqués dans le dessein de déterminer le taux d'exploitation et les parcours de migration.

Des études sur le plancton visant à déterminer la situation des masses d'eau et des courants arctiques ont été pratiquées, et la station a participé activement à l'exécution d'un programme international conçu en vue de l'étude de la dérive des larves et des œufs de poisson, relativement à la distribution du plancton et aux conditions hydrographiques dans les eaux de l'ouest du Groenland.

ENQUÊTES TECHNOLOGIQUES

Sur la côte de l'Atlantique, le programme intégré de recherche technologique de l'Office est mis en œuvre à des laboratoires situés à Halifax (N.-É.), Grande-Rivière (Québec) et Saint-Jean (T.-N.). Des enquêtes technologiques sur les poissons d'eau douce se font à London (Ontario), et ces travaux sont coordonnés avec des études correspondantes ayant trait aux pêches de la côte du Pacifique qui se poursuivent au Laboratoire de recherche de l'Office à Vancouver (C.-B.).

CÔTE DE L'ATLANTIQUE

La coordination de la recherche technologique dans les provinces atlantiques a été complétée par la réunion du programme de la Station technologique de Grande-Rivière à ceux de l'Unité technologique de Terre-Neuve et du laboratoire de recherche technologique d'Halifax, pour former le Programme de recherche technologique de l'Atlantique.

Un régime courant de nourrissage du *homard* gardé en vivier aux fins de vente s'est révélé à peine meilleur que la privation de nourriture pour maintenir le dénombrement des cellules sanguines du homard au niveau trouvé dans un milieu naturel. L'addition de foie au régime en question a corrigé cette situation. La tolérance du homard en présence de certaines essences de bois et d'eau fluorée a été évaluée. Le cèdre de l'Ouest s'est révélé extrêmement toxique et ne devrait pas être employé pour la construction des viviers.

On a trouvé pour le sperme de *saumon* un milieu de dilution qui ne rend pas le sérum inactif durant le procédé d'incorporation de glycérol à la cellule. Cette condition préalable est nécessaire à la réussite de la congélation du sperme.

Des épreuves sérologiques ont montré que les stocks d'*huîtres* résistantes de Malpèque possèdent un antigène qu'on ne trouve pas dans les huîtres susceptibles du Cap-Breton, mais il reste encore à savoir si la résistance dépend de cet antigène. On a

reconnu que l'éthane sulphuré était cause de la mauvaise odeur des filets de *morue du Labrador*, se nourrissant du ptéropode *Limicina helicina* (connu en anglais sous le nom de «blackberry»).

Il semble que l'épaisseur des échantillons soit un élément variable de grande importance lorsqu'il s'agit de déterminer les caractéristiques de texture de la *morue cryo-desséchée*. On a constaté qu'un résidu de muscle macéré provenant d'opérations de filetage commercial à Terre-Neuve donnait un produit cryo-desséché dont la texture était bien supérieure à celle de produits semblables préparés avec des filets. La *pasteurisation par radiation* de la chair d'aiglefin et de pétoncles à très faible dose a donné des produits dont les caractéristiques d'entreposage en glace sont excellentes.

Un *concentré de protéine de poisson* (farine) a été préparé avec des parures de filetage et des poissons entiers, et le procédé a été modifié de manière à permettre l'emploi d'espèces huileuses comme le hareng. La valeur nutritive et les caractéristiques de tous les produits sont très bonnes.

Un progrès considérable a été réalisé en vue de définir l'influence des *éléments physiologiques et des facteurs de milieu*, sur la qualité et la durée de conservation en magasin des produits de la pêche, particulièrement en rapport avec les études sur la morue de Terre-Neuve prise aux trappes et sur la détérioration non bactérienne des poissons de fond.

INTÉRIEUR ET CÔTE DU PACIFIQUE

La recherche poursuivie au cours des années passées dans ces laboratoires et son aboutissement logique a donné lieu à plusieurs applications des découvertes sur une grande échelle dans l'industrie de la pêche.

En accord avec ces succès antérieurs, l'année courante a été témoin d'un progrès marqué dans la conception d'*outillage* nouveau pour le déchargement de poissons relativement gros, comme le saumon, soit par l'application du principe de sustentation pneumatique, soit par l'emploi d'un dispositif ingénieux faisant usage de cycles alternés d'aspiration et de pression. Les connaissances actuelles ont donné lieu à d'utiles applications dans la technique des systèmes de réfrigération à bord des vaisseaux susceptibles de pratiquer la congélation du thon ou du flétan en mer, dans l'usage du vide pour la mise en conserve du thon et dans la manutention en vrac de la farine de hareng.

Les *investigations générales* commencées antérieurement et continuées ou modifiées en vue d'atteindre de nouveaux objectifs comportent les travaux suivants: tentatives de prévenir le «ventre-cuit» dans le saumon non éviscéré en le gardant dans de l'eau de mer à 25°F. environ; études sur l'évolution de la rancidité due à l'oxydation et à l'hydrolyse, ainsi que sur son importance et sur la manière d'en refréner les manifestations dans le poisson congelé; valeur des antibiotiques à base de tétracycline pour la conservation des crevettes; manière d'enrayer le dégouttage du poisson décongelé; et effet de la suppression du sucre sur le brunissement de la chair de poisson chauffée.

Les *problèmes biochimiques* qui se rattachent au poisson vivant ont donné lieu à de nombreuses recherches. Ainsi, un progrès marqué a été réalisé dans l'élucidation de la nature des substances alimentaires et des éléments des cours d'eau de naissance

qui attirent les salmonidés, dans l'épreuve et la purification des hormones de glandes pituitaires du saumon, et dans les investigations de la survivance du saumon du Pacifique après le frai. Un certain nombre de techniques modifiées ont été appliquées à la séparation de diverses protéines tirées du muscle, du sang et du sérum de poisson, et il n'est pas douteux que cette méthode constituera une addition précieuse au procédé courant de classement du poisson. Plusieurs enzymes de poisson ont été étudiés relativement à leur aptitude à former des composés chimiques rares; et des études fondamentales ont été faites à l'égard de nouveaux acides nucléiques et de nucléotides tirés d'invertébrés marins et de poissons.

Au *laboratoire de London*, des progrès ont été accomplis dans l'exécution de nouveaux programmes ayant trait à l'amélioration de la qualité du poisson de lac et à l'usage possible du refroidissement par vaporisation rapide comme moyen d'arriver à ce résultat. La recherche sur la spéciation du poisson d'eau douce par l'emploi de diverses structures de protéine a été entreprise.

Des détails supplémentaires sur les études indiquées ci-dessus et sur les autres travaux effectués aux divers établissements de l'Office durant l'année financière 1963-1964, figurent dans les rapports qui suivent. La carte qui se trouve en regard de la page 86 permet de voir la situation de chacun de ces établissements et leurs principaux champs de travaux durant l'année à l'étude. Une liste des membres du personnel scientifique et un répertoire des publications parues en 1963 sont annexés.

BIOLOGICAL STATION, ST. JOHN'S, NFLD.

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The responsibilities of the St. John's Biological Station are mainly for research on the groundfishes and additionally on Atlantic salmon, lobster, the introduction of Pacific salmon, and hydrography. Almost half the effort is devoted to researches on cod with special attention to the cod of the inshore area.

The Station is on Water Street East in St. John's but a field station for pink salmon introduction is located at North Harbour River, St. Mary's Bay and investigations of cod are carried out on many parts of the Newfoundland and Labrador coasts.

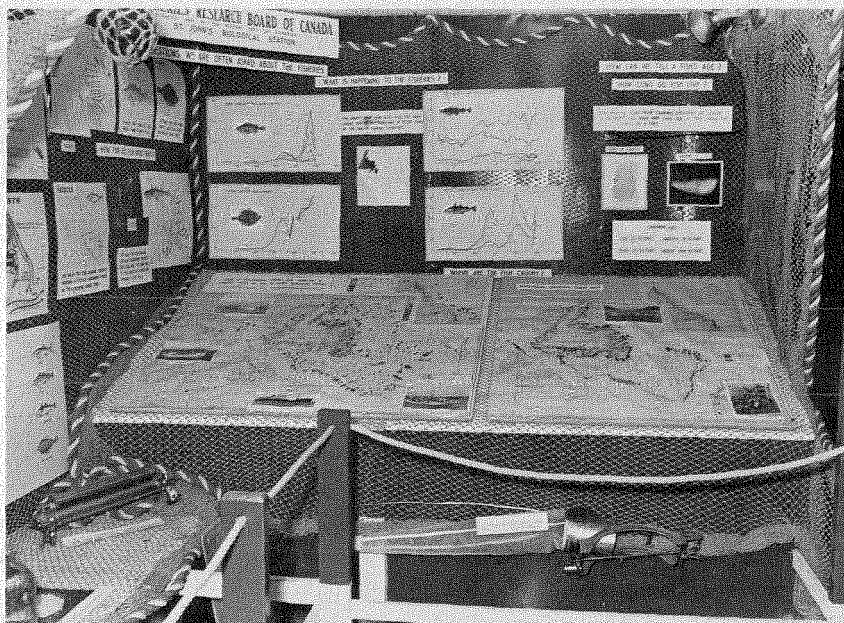
The Station operates the *A. T. Cameron* for two-thirds of the year and is responsible for administrative matters relating to this ship. The Station also operates the 82-foot *Investigator II*, the 62-foot *Marinus*, and the 50-foot *Parr* mainly in the ground-fish investigations.

The Station's investigations are chiefly concerned with the study of the biology and dynamics of the populations of commercial fish especially in relation to the effects of nature and the fishery on these populations. The objective is to build up and add to a body of fisheries knowledge which will be adequate for long- and short-range advice to government and industry.

COD

OBSERVATIONS ON THE CODFISHERY IN THE INSHORE NEWFOUNDLAND AND LABRADOR AREAS. Routine sampling of the inshore codfishery by various gears was carried out in the spring, summer, and fall in regular sampling centres at 15 separate localities on the Labrador coast and at St. Anthony, La Scie, Twillingate, Bonavista, St. John's, Trepassy, Burin, and Port-aux-Basques on the Newfoundland coast. Special emphasis is being placed on improvement in sampling techniques while information is collected for age and growth studies and on catch and fishing effort; about 87,000 fish were measured with more detailed examination made on 10,500.

In Labrador sampling was carried out between the Strait of Belle Isle and northern Labrador. The fishery in the Strait of Belle Isle was found to be based on younger and smaller fish than on the remainder of the Labrador coast. In all areas, however,



Display exhibited by the Biological Station, St. John's, at the Agriculture and Homecrafts Exhibition in St. John's, October 1962.

there was a marked decline in fish sizes due to large numbers of young cod entering the commercial fishery for the first time. These were mainly of ages 5 and 6 along most of the coast, but large numbers of 4-year-old fish were present in the Strait of Belle Isle. Cod of such young ages have contributed little to the Labrador inshore catch in the past several years, but their presence in quantity in 1963 indicates that these age-groups must be fairly abundant, and should contribute significantly to the success of the fishery for the next several years.

On the east coast of Newfoundland, although the trap fishery in 1963 at St. Anthony, Twillingate, and St. John's was fairly successful compared with the 1962 fishery, it was considered to be poor at La Scie and Bonavista. On the south coast, at Burin, the trap fishery was moderately good, at about the same level as in 1962, but at Trepassey it was generally poor mainly because of adverse weather conditions. The handline fishery at St. Anthony, Twillingate and Bonavista was considered to be reasonably good, but at St. John's this fishery was very poor. Except for the fishery at Twillingate, which was considered to be fairly good, the linetrawl fishery was very poor in all areas with the result that many fishermen turned almost entirely to using gillnets. The gillnet fishery began in autumn at St. John's with good results while in the Trepassey area catches with gillnets were high all season with 510 pounds per net per haul being realized. At Burin and Twillingate, however, the gillnet fishery was only moderately successful for most of the season, 150 pounds per net per haul being obtained at Burin. The longline fishery was generally poor at Bonavista and Trepassey but was good at Twillingate.

More detailed information on catches is available for Bonavista and Burin. At Bonavista the total catch in 1963 by all gears was 9.8 million pounds, 20% lower than

in 1962. Of this total 42% was landed by baited handlines and jigger, 31% by traps, 24% by longlines, and 3% by linetrawl. At Burin the 1963 total catch by all gears was 3.6 million pounds, 20% higher than in 1962, with 47% from trap, 45% from gillnet, 5% from linetrawl, and 1% from jigger.

In the trap catches cod 4 to 6 years of age were the most abundant numerically along the east coast and at Burin on the south coast, and cod aged 7 and 8 years were present in varying numbers in different localities. At Trepassey, however, large numbers of older fish up to 10 and 11 years of age were common in trap catches, although the majority were 5 to 8 years old. In the handline catches fish of ages 5 and 6 years were the most abundant with ages 4, 7, and 8 also being represented. In the linetrawl catches cod of ages 4, 5, and 6 years were the most important contributors. In longline catches fish aged 5 to 10 years were the most abundant in all areas sampled, although fish older than 10 years contributed significant numbers to the catches in most areas. Along the northeast coast area and in the Trepassey area 8-year-old fish dominated the longline fishery while in the southwest coast area 9-year-old fish were dominant. In Bonavista the average size of longline cod decreased because of the increased abundance of 6- and 7-year-old fish. In the gillnet fishery there was an abundance of 8-year-old cod and fish aged 7, 9, and 10 were well represented.

The age and length compositions of samples of cod caught by the various gears reveal the dependence of the trap fishery upon the younger ages of cod, whereas in the longline and gillnet fishery cod of older ages are important contributors to the catch after they are generally no longer available to the traps.

THE INSHORE COD FISHERY WITH NYLON GILLNETS. The use of nylon gillnets in the inshore cod fishery in Newfoundland was begun as a result of a joint program of the Industrial Development Service of the Department of Fisheries of Canada and the Newfoundland Fisheries Development Authority of the Department of Fisheries of Newfoundland. In 1960 a 55-foot boat fished fleets of nylon gillnets in the Trepassey-St. Mary's Bay-Placentia Bay area and a 45-foot longliner fished gillnets in the Bonavista area. In addition nylon gillnets were distributed to a number of selected fishermen. Although the Bonavista experiment yielded inconclusive results because of scarcity of fish in the area, there was extremely good fishing in the Trepassey area, with much higher daily catches being obtained by the gillnets than by longlines in the same locality.

By 1961 many fishermen had procured nylon gillnets and were using them either in conjunction with other gears or as their principal fishing gear. Nets, generally of Japanese or English manufacture, were usually 50 fathoms long, 25 meshes deep, twine size 210d/15, and mesh sizes ranging from 6 to 7½ inches. By 1963, when it is estimated that about 13,000 nylon gillnets were used in the codfishery, the main concentrations were in Trepassey, St. Mary's, and Placentia Bays on the south coast and Notre Dame and Trinity Bays on the east coast.

Observations are being taken on the gillnet fishery at Twillingate, Trepassey, and Burin. The nylon nets were fished in quantity at Trepassey in 1961, but at Twillingate and Burin not until 1962. The number of nets used per boat continues to increase each year as fishermen become more experienced in their use. Gillnets are used throughout the season in Burin, but at Twillingate mainly in the spring, late summer and fall, and at Trepassey chiefly in the spring and summer.

Catches at Twillingate and Burin were low in the gillnet fisheries in 1963 but with low total yield from the inshore fishery in these areas the daily catch from nylon nets was above those obtained with other gears fishing at the same time. At Trepassey, the longline boats equipped with gillnets have been very successful, with average catch per net per haul for the fleet amounting to 770 pounds (round) in 1961, 660 pounds in 1962, and 510 pounds in 1963. The average catch per net per haul has decreased each year as the number of nets has increased.

Large cod were caught by nylon gillnets in all areas, with about 90% ranging from 60 to 100 cm (24-40 inches). The fish were mainly of ages 7 to 14, with fish of the 1955 year-class (age 8 in 1963) contributing heavily to the catches.

BABY COD SURVEY, 1963. The annual survey designed to obtain information on the inshore distribution and relative annual abundance of small cod up to 2 years of age was carried out from September 19 to October 31. Beaches in areas selected in previous surveys were seined using a small-meshed Danish seine with the codend lined with fine-meshed nylon.

During the survey 141 successful sets were made on beaches from St. Mary's Bay to the northern part of Notre Dame Bay, and from 1 to over 600 small cod (total 5366) were taken in 89% of the sets. Cod-of-the-year (zero cod) occurred in 71% and were in the majority in 40% of the successful sets. Zero cod made up 39% of the total cod catch from all areas. Cod of age 1 and older (1+) occurred in 88% and were in the majority in 48% of the successful sets. Of the total cod catch from all areas 1+ cod made up 61%. From St. Mary's Bay to Conception Bay the 1+ cod were generally more abundant than the zero cod whereas from Trinity Bay to Notre Dame Bay zero cod were somewhat more abundant in the catches. The numbers of 1+ cod taken in the northern areas were not consistent with reports of large numbers of these fish seen in harbours and around fish plants during the summer as was anticipated from the relatively large catches of zero cod during the 1962 survey. The numbers of zero cod caught in 1963 suggest only moderate survival and settlement of the 1963 year-class of cod.

COD SURVEYS OFFSHORE, 1963. Surveys of cod distribution and abundance were carried out by the *A. T. Cameron* and *Investigator II*, and included the shallowest depths available to 400 fathoms over the whole area between southern Labrador and St. Pierre Bank, with the exception of Flemish Cap. Great concentrations of cod, being fished by a large fleet of European trawlers, were located in 120 to 180 fathoms in April and May on the southeast edge of Hamilton Inlet Bank. These were fairly small fish, with a high proportion of the catch consisting of 4- and 6-year-old fish. In September moderately large concentrations were found in 160 fathoms on the southwest edge of Hamilton Inlet Bank, and again in October at 75-95 fathoms.

On the Northeast Newfoundland Shelf several good catches of cod were obtained in April and May between 120 and 175 fathoms, and a good catch was taken at 95 fathoms on the northern Grand Bank in June. Length frequencies of fish from the Northeast Newfoundland Shelf indicate the presence of significant numbers of 3- to 5-year-old fish.

Catches in the Halibut Channel in January, on St. Pierre Bank in June, and on the Grand Bank in January, May, June, and July were usually less than 1000 pounds per 30-minute tow at all depths.

Maturity examinations in April–June revealed that spawning occurred progressively later from north to south, and that the largest fish were the last to spawn.

COD TAGGING. Cod tagging was continued to study the interrelationships of inshore and offshore cod populations. About 20,000 cod were tagged off the coast of Labrador, the northeast, southeast, and southwest coasts of Newfoundland, the Grand Bank and the north shore of the Gulf of St. Lawrence.

COD GROWTH. Analysis of cod growth on an area basis for the years 1960–62 has shown that there is a progressive decline in average size at age proceeding from south to north. Also, fish from different areas, but inhabiting similar latitudes, exhibit similar patterns of growth. The differences between the area of slowest growth (northern Labrador) and fastest growth (southern Grand Bank) are so great that a fish from the latter area is 30% longer than the former at age 5, increasing to 75% greater length at age 15. Differences in weight at age are even more striking. These growth differences are considered to be related mainly to variations in temperature and food supply between areas.

HADDOCK

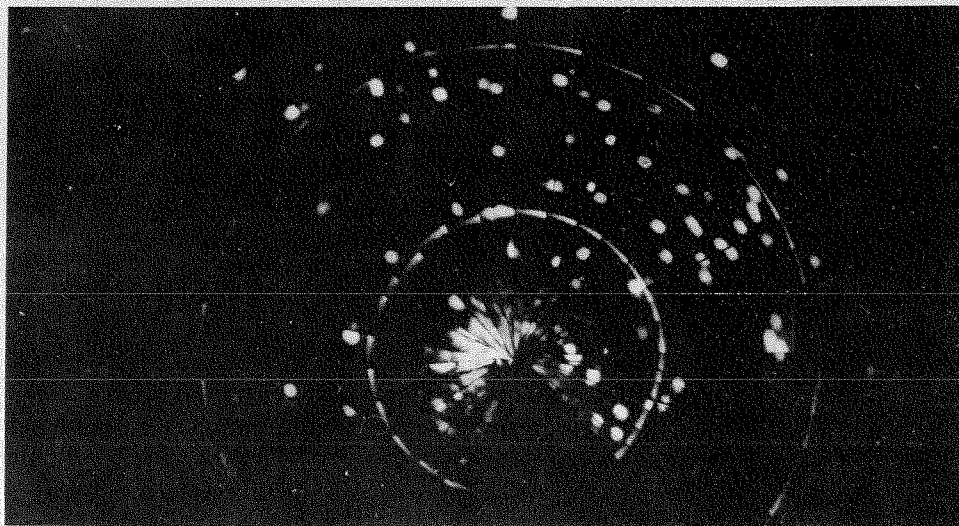
HADDOCK SURVEYS IN 1963. Otter-trawling surveys over the southern half of the Grand Bank were carried out in May and July. During the May cruises, from a total of 75 drags in depths ranging between 25 and 150 fathoms only one drag produced more than 300 pounds of haddock. This catch of 1500 pounds was taken in 80 fathoms at 3.6°C on the western part of the southwest slope. At most of the fishing stations on the slope and adjacent bank areas water temperatures were favourable for haddock.

The survey in July resulted in even poorer catches throughout the entire area. The best catch of 430 pounds was obtained in 65 fathoms at 4.6°C near the station where the best catch was taken earlier in the spring survey. A number of exploratory drags was made on the Southeast Shoal, where in past years large concentrations of haddock were often found feeding on capelin eggs and capelin, but no significant quantities were taken. An interesting feature of the July survey was the presence of capelin in most of the drags, coincident with the scarcity of cod and haddock.

On St. Pierre Bank an otter-trawl survey in June once again produced very little haddock. In most of the drags no haddock or just a few individuals were caught, the best catch being 170 pounds. Haddock fishing has been insignificant on this bank since the large fishery on the very abundant 1949 year-class came to an end in 1956.

LENGTH AND AGE COMPOSITION OF THE GRAND BANK STOCK. From the length and age frequencies of samples taken during the May survey, haddock of the 1955 and 1956 year-classes which were dominant in the catches during the surveys of 1959–61 were outnumbered in 1963 by 1- and 2-year-old fish of the 1961 and 1962 year-classes. However, when it is considered that the catch per unit effort was considerably lower than those of previous years both in number and weight, the apparent abundance of these 1- and 2-year-old fish may be only in relation to the presently reduced year-classes of earlier years. For example, the average number of haddock per 30-minute drag was 70 in 1963 and 80 in 1962, while in 1960 it was 590.

TRENDS IN THE COMMERCIAL FISHERY AND PROSPECTS FOR THE FUTURE. The commercial haddock fishery, which began in 1945, rapidly increased and by 1949 the total haddock landings was 173 million pounds. After a decrease to 94 million pounds in



Above, composite photograph, made from movie film, of part of the *A. T. Cameron's* radar screen showing part of concentration of trawlers on the southeastern slope of Hamilton Inlet Bank, May 3, 1963. (The photograph represents a circular area of radius 5 nautical miles with the *A. T. Cameron* at the centre. In the missing sector, now blank, the ships were also abundant. At this time there were 90-100 trawlers within a radar range of 10 nautical miles.) Below, 2 groups, each showing traces of about 15 trawlers in the original photograph. Photograph taken at the same time as those of the radar traces. (Photo by A. W. May.)

1953, an increase to 230 million pounds occurred in 1955 as a result of the recruitment to the fishery of a very abundant 1949 year-class. However, by 1959 total landings had declined to a low of 77 million pounds. In 1960 and 1961 a very successful 1955 year-class, a moderately successful 1956 year-class, and the additional USSR exploitation of the haddock stock increased the landings to 147 million and 176 million pounds, respectively.

Up to 1959 the haddock fishery was carried on almost exclusively by Canadian and Spanish trawlers, with the Spanish vessels particularly in the early years taking about three-quarters of the annual yields. However, Spanish landings declined in the late 1950's and early 1960's when the stock consisted mostly of small haddock.

In 1962, while Canada maintained an annual landing of 63 million pounds from the winter and spring concentrations, the summer concentrations either did not occur or were not heavily fished and only small quantities were taken by other countries, the total landings being 77 million pounds.

In 1963, after much effort in searching, Newfoundland trawlers were able to take only 17 million pounds as compared with nearly 50 million pounds the year before. Also, extensive surveys by Canadian research vessels in May and July failed to find any concentrations of haddock.

Although heavy exploitation has played its part in the present scarcity of haddock, the basic cause is the lack of successful survival of young. The last very successful year-class was that of 1955, which dominated the catches during 1960-62. Since 1955-56, survival has been relatively poor and consequently the haddock fishery must inevitably continue to be at a low level until a good brood occurs and is recruited to the stock.

REDFISH

Spring cruises to the southern Labrador and Northeast Newfoundland Shelf areas, occasioned by the recent exploration of spawning stocks of cod, have served to emphasize our lack of knowledge of the redfish stocks during this season when changes in distribution are likely because of the reaction to winter conditions and of larval extrusion by the females. Rather limited data from April for the southern Labrador area indicate that in this area there is a general deeper trend in the distribution of *mentella* redfish in the spring and presumably in winter. *Marinus* redfish showed an even greater trend to deeper water coupled with a change in sex ratio and maturity distribution which suggest a rather close relationship between distribution and larval extrusion. In the Labrador area in April, redfish were almost all below 200 fathoms and the shallowest catch of commercial quantity was at 250 fathoms, 75-100 fathoms deeper than in summer-autumn.

A cruise was made to the Gulf of St. Lawrence in November to examine the redfish distribution and abundance in the area and in particular to follow the progress of the new year-classes which were noted in 1959 and later. The usual survey pattern was carried out with 30-minute sets being made at depths of 100, 120, 140, 160, 180 fathoms and deeper in each of the 6 areas examined. No good catches of large redfish were obtained and it seems that, with the possible exception of a few isolated pockets, very little remains of the virgin population of large fish which supported the fishery in the middle 1950's. In spite of this scarcity of large fish, some excellent catches

were obtained, particularly in the vicinity of St. George's Bay where catches greater than 2300 pounds were obtained in sets from 140 to 200 fathoms. These catches consisted almost entirely of fish about 7 years old and younger and the abundance of the group is emphasized by the catch of over 15,000 fish in 30-minute tows in this area. The young fish (modal size 25-27 cm; 10-11 inches) were not so abundant in the northern or western parts of the Gulf.

AMERICAN PLAICE

A fairly large proportion of the American plaice population on the northern half of the Grand Bank is below the 50% selection point of the 4½-inch mesh otter trawl. The extreme northern part of the Grand Bank in particular has a very large proportion of small plaice so that the possibility of using a larger-sized mesh should be explored.

The plaice populations from the Grand Bank are composed of a large number of relatively successful year-classes.

The catch per unit effort for plaice for the whole of the Grand Bank showed a decline in 1962. At the same time there was a marked overall increase in the total effort.

From the analysis of the logs of two commercial trawlers it appears that the catch per unit effort for American plaice is greater for daylight fishing than it is at night.

EFFECT OF CATCH SIZE ON THE SELECTIVITY OF HADDOCK AND COD BY OTTER TRAWL

Selectivity experiments on haddock in ICNAF Subarea 3, and cod in Subarea 2, were carried out by the *A. T. Cameron* between 1959 and 1962. These have been analysed on a catch-size basis. In all cases the selection factor was lowered with increase in size of catch. However, it is not indicated that the selection factors are reduced to the extent that escapement through the meshes of the net is drastically decreased with large catches.

GROUNDFISH STATISTICS AND SAMPLING

The collection of catch and effort statistics and the sampling of landings from the commercial fishing fleet are a continuing program for the offshore fisheries and a seasonal one for the inshore cod fisheries. The information collected is necessary in the assessment of the status of the commercial groundfish stocks in the Newfoundland area and, in addition, forms the basis of our annual statistical submissions to ICNAF. In many phases of the statistical collection we work in co-operation with the Economics Branch, Department of Fisheries of Canada (Nfld. Area).

During the 1963 fishery the total weight of the principal commercial groundfish landed was about 4% higher than in 1962. Of the 1963 total 79% was cod, 8% redfish, 8% plaice, 3% haddock, and 2% greysole, halibut, wolffish, and pollock.

The cod fishery was moderately good, with landings 4% higher than in 1962. Redfish landings were 30% higher than 1962, chiefly because of increased fishing effort for small redfish on the eastern Grand Bank and in the Gulf of St. Lawrence. Plaice landings were 60% higher than in 1962, mainly because of greatly increased

fishing effort. Haddock landings were 60% below the 1962 total because of scarcity of fish. Greysole landings were 20% less than in 1962, mainly because of the smaller effort for haddock; quantities of greysole are generally taken during the haddock fishery. Halibut, wolffish, and pollock are generally caught as incidental species during other fisheries and the landings are small as a consequence. A significant development was an upward trend in the Labrador fishery with an additional 12 schooners and longliners prosecuting the fishery and the operation of a floating freezing plant in the Labrador area. In addition, three new freezing plants commenced operations in Newfoundland and the otter trawling fleet increased by six.

In the sampling of the commercial landings about 87,000 cod were measured and 10,500 pairs of otoliths collected from the inshore fishery. From the offshore fishery about 3000 cod, 8000 haddock, 9000 plaice, and 2000 redfish were measured, with otoliths collected from about 10% throughout the year.

HYDROGRAPHY

The usual six hydrographic sections across the Labrador Current and continental shelf from southern Labrador to the southern Grand Bank were taken by the *Investigator II* between July 27 and August 22. Station 27, 2 miles off Cape Spear near St. John's, was occupied once to several times monthly throughout the year.

LOBSTER

In studies on growth of lobsters in Port au Port Bay the growth on moulting ranged from 12.1 to 11.5% for male lobsters in a carapace range from 77 to 102 mm (3.0–4.0 inches) and from 10.9 to 9.5% for female lobsters ranging from 77 to 100 mm (3.0–3.9 inches) in carapace length. Twenty-six per cent of the recaptured punched lobsters had not moulted.

All egg-bearing female lobsters examined from Port au Port Bay and Bay of Islands possessed eyed eggs in spring. Hatching of larvae occurred mostly in late July and early August, although a few hatched in early September. In October and November most external eggs had eyed embryos showing that embryonic development had progressed during the warm summer period.

In Port au Port Bay, length measurements and growth increments of the lobsters landed in the fishery in 1962 and 1963 showed that the proportion of first-year recruits remained fairly constant at about 58%. The estimate of fishing rate from tagging and recaptures in 1962 was 50%. This estimate could be low because of tagging mortalities.

PINK SALMON

Investigations in 1963 were centred around the fry resulting from the planting of 2.5 million eggs of British Columbian pink salmon supplied by the Nanaimo Station in November 1962.

From replaceable egg samples it was found that hatching began around February 15 and was completed by March 22. The fry run extended from May 7 to June 16 with the peak day being May 24. In the two days May 23 and 24 over a million fry, which was half the total run, passed through the fence. The estimated number of fry at the fence was 2,150,000 which is 87% of the number of eggs planted. Scarcity

of silt and moderate winter conditions favored a good survival. In a rearing experiment fry were fed beef liver, tinned horse meat and liver, redfish larvae, herring eggs, cod eggs, capelin eggs, lumpfish eggs, and fish food pellets. They ate all the various foods except the fish pellets but appeared to prefer the beef liver and redfish larvae.

An attempt was made to follow the fry as they migrated seaward but of several methods used only visual observation proved successful. Thirty sightings were made and with few exceptions all the fry were near the surface and within 1 to 10 feet of the shore. Fry were seen in the river from May 20 to June 4, in the pond from May 20 to July 7, in the arm from June 24 to July 9, and in St. Mary's Bay from July 2 to July 31. The last sighting was on July 31 over half-way out St. Mary's Bay approximately 22 miles from the mouth of the river. Most of the fry in the arm and in the bay were seen in coves where capelin had spawned and were feeding on capelin eggs.

Only moderate predation on pink salmon fry was found. In the river, sampling of brook and brown trout moving downstream indicated that 12% of the brook trout and 11% of the brown trout were feeding on fry. In the arm, standard gillnets were fished at various places from June 10 to August 22 and only 4 or 0.5% of the 875 fish of all kinds caught were feeding on fry; also 261 herring from a fisherman's seine were examined and no fry were found in their stomachs. Commercial catches of cod outside the arm, in St. Mary's Bay, were sampled from June 18 to August 30 and no fry were found in 3795 stomachs.

ATLANTIC SALMON

A total of 159 mature adult salmon was recorded moving upstream on the Little Codroy River in 1963. This is the largest escapement since 1957. The run consisted of 1 adolescent, 118 grilse, 34 small salmon, and 6 large salmon.

The rate of return of 2 sea-year salmon in 1963 was 0.4%. This is higher than average. In 1963, the Little Codroy appears to have been cooler and deeper than in 1960-62, and the high return may have been the result of these better conditions.

Twenty of the 117 non-fincipped grilse were considered by their appearance to be stray, that is, not native to the Little Codroy. The remainder represent a 1.3% return of the 1962 smolts. The average rate of return of fincipped grilse to the counting fence between 1955 and 1962 was 0.5%.

Some of the increase in the number of grilse may have been the result of the better conditions in the river in 1963 or in the sea life of the fish. Many rivers of the Maritime Provinces had unusually good grilse runs in 1963. Also there was one major difference in the environment of the 1962 smolts of the Little Codroy and the previous runs studied; the 1962 smolts were counted without being handled. Lack of handling, therefore, may have contributed to the high return.

A total of 7326 smolts was counted in 1963. This is the smallest run recorded since the investigations began in 1954 and is probably the result of the small numbers of adults in 1959 and 1960.

About 2% of the freshwater area of the river was quantitatively sampled to estimate the parr population. The population was below average—about half the 1959-62 level. The lowered salmon parr production may be the result of the small numbers of adult salmon that have entered the river since 1958.

Regular field work ceased in September 1963. No further research is planned for the Little Codroy River.

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The research program of the St. Andrews Biological Station is intended to increase knowledge of fishery resources available to Maritimes fishermen. Knowledge can be used in a variety of ways. The most important and fundamental use is to increase understanding of aquatic life. The only basis for application is understanding—understanding of factors controlling reproduction, growth, concentrations, migrations, and interrelations of the animals constituting the resource. On knowledge should depend our actions: to seek new resources; to find fish concentrations; to improve methods of catching; to increase stocks; to exploit known resources wisely; and, to use fully and efficiently catches that are made. It is only through understanding that we can predict catches and fishery trends of the future. The Station's programs are designed toward providing knowledge that can be applied toward these objectives. In general research effort on offshore fisheries is planned to increase efficiency of catching methods. For inshore fisheries more attention is directed toward conserving and increasing stocks.

In carrying out programs, Station scientists have enjoyed help and co-operation from many sources. Most co-operating agencies are acknowledged in the appropriate context. Special mention should be made of the Department of Fisheries whose various Services have augmented, supplemented, and used research results in many ways; and the Department of Mines and Technical Surveys which has not only made vessels and specialized techniques available but has provided accommodation to the Atlantic Oceanographic Group (AOG) at the Bedford Institute of Oceanography.

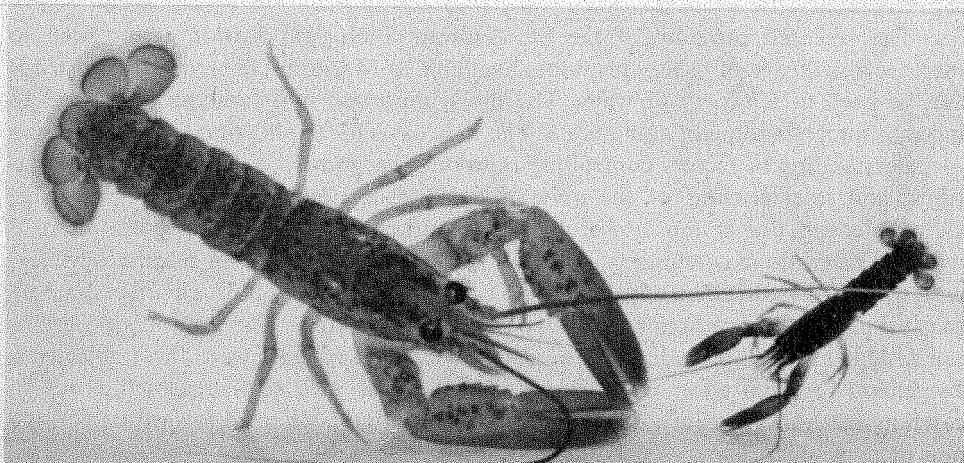
The International Commission for the Northwest Atlantic Fisheries (ICNAF) strongly influences research programs at St. Andrews. Its Research and Statistics Committee provides specialist criticism of programs and results and frames ways for pooling records from the thirteen participating countries. Special projects initiated through ICNAF in 1963 were: the Environmental Survey—an International survey involving two Canadian vessels to study the cod environment in the Labrador Sea;

and, the Environmental Symposium—a scientific meeting in Rome to bring together information on the relationship between fisheries and the environment.

Work on fishes and their environment requires the use of sea-going vessels. For oceanographic work, AOG has use of CNAV *Sackville*, and less regularly CSS *Baffin* and MV *Theta*. Biologists use the MV *Harengus* and still smaller vessels. In recognition of the need for a larger ship specially equipped for fishery research plans are being drawn for a 130-foot vessel.

LOBSTER

The lobster is the most valuable single species marine resource in Canada. In 1963 the Canadian catch was 44.2 million pounds valued at 21.2 million dollars and the Maritimes catch was 36.0 million pounds valued at 17.9 million dollars. It is aggressively exploited and regulations of several kinds apply to the fishery. Investigation is aimed at guiding conservation of the resource and to developing economical handling methods. Possibilities for actually increasing lobster production are being explored.



The effect of temperature on the growth of lobsterlings. The larger lobster was hatched on July 27, 1963, and was reared at a constant temperature of 18°C. The smaller lobster was hatched on August 4, 1963, and has been maintained at normal seawater temperatures. Both have been fed a mixed diet of squid, herring, and flounder flesh together with live crustaceans. Both lobsters are shown natural size, March 1964.

COMMERCIAL FISHERY. Field studies of the commercial fishery have been continued at Fourchu and Gabarus, N.S., Port Maitland, N.S., and Miminegash, P.E.I.

At Port Maitland the 1963 total catch rose by 12% over the previous year but was still 25% below the 1945-63 average. As the number of boats has dropped to half since 1951 and the price has risen markedly, gross landed value per boat in 1963 was the highest on record.

In Northumberland Strait off Miminegash the exploitation rate as shown by the recovery of tagged lobsters reached 90% for the second successive year. Since 1945 the larger, older, more valuable lobsters have declined from 19% by number to 3%.

GROWTH AND SURVIVAL. Of 40 lobsters marked off Miminegash in 1961 and captured 2 years later, 5 had moulted twice, 30 once, and 5 had not moulted at all. The average growth per moult was $\frac{1}{3}$ inch. During 2 years Miminegash fishermen took only 25% of all the marked lobsters on the grounds. Similar experiments off Port Maitland yielded less than 10% of the marked lobsters. These experiments indicate high mortalities not associated with the regular fisheries.

Tagging from Port Maitland showed lobsters in that area to move farther than those liberated elsewhere. Fishermen from other ports returned 28% of the tags recovered. Almost 10% of tags recovered within 8 months of time of release showed movements between 10 and 40 miles. The rest were recovered closer to home.

WOLFFISH. Wolffish were suspected of being responsible for natural mortality among lobsters. Accordingly, the food, both in nature and in captivity, was studied. The principal foods in the Port Maitland area were mussels, whelks, sea urchins, and hermit crabs, with crabs, starfish, etc., in lesser roles. Lobsters were found in 12% of the stomachs.

GROWING LOBSTERS IN CAPTIVITY. The feasibility of growing small lobsters in captivity to more valuable sizes was explored. Trials involved holding groups of 50 animals in individual cells at three temperatures and three feeding rates. All combinations showed net losses in weight resulting from the excess of deaths over growth by moulting. The best result showed a loss of 28% in weight with animals held at 63°F and fed 3% of their weight weekly. Work so far indicates possibilities for improving techniques in later trials.

LARVAL STUDIES. Studies involving larvae have been intensified. Final (fourth) stage larval abundance in Northumberland Strait as found by systematic towing was related to estimated parent stock and allowed an acceptable forecast of the commercial catch.

Experiments involving capture and holding of natural fourth-stage larvae, and observations of these larvae at different ages gave indications that they start settling to the bottom before they are half through the fourth stage.

Larvae reared in the laboratory fed well and survived. They grew but not as well as those in nature. Other laboratory experiments showed that at about one third through the fourth stage larvae changed habits and were prepared to pass from warm surface water into a cooler layer.

Surveys of the lobster population by scuba divers showed a different size distribution of lobsters from that found by bottom dragging. Highest abundance of lobsters was encountered in areas of boulders and deeply creviced rock.

HISTOCHEMISTRY. During the moulting cycle, glycogen, lipids, and calcium accumulate in the hepatopancreas of early post-moult lobsters. These materials subsequently decrease and calcium builds up in the integument. The rate of deposition apparently depends upon temperature and possibly upon kind of food.

OYSTER

The oyster lends itself to culture, and it is only through positive cultural practices that an industry of significant proportions may be maintained. The general requirements for culturing a marine animal are rather obvious. A sufficient quantity of early

young must be obtained and raised to a size where they can be set out to grow independently. Suitable food must be available. Harvesting has to be practical. Effects of disease in reducing profits should be minimized. There must be assurance that the product is wholesome. Work is progressing on all of these subjects and some of the results are dealt with below.

Oyster work is based at Ellerslie, P.E.I., where facilities and space are shared co-operatively with the Fish Culture Development Service of the Department of Fisheries. During 1963, noteworthy assistance was provided by the Department of Mines and Technical Surveys which applied its specialized resources to joint investigations of bottom conditions in Malpeque Bay.

Interests in public health and in making full use of the shellfish resource are reconciled through the Interdepartmental Shellfish Committee involving the Department of National Health and Welfare and both the Research and Management divisions of the Fisheries Ministry. The Committee is advisory to both departments and receives United States observers who participate usefully.

An oyster hatchery has been designed and constructed at Ellerslie by Department of Fisheries engineers. In it cool or warmed sea water clarified by centrifuges is supplied to culture rooms through chemically inert piping. All special facilities that can be anticipated as necessary for culturing oyster larvae and their food are provided. A first trial at commercial scale larvae rearing and spat production will be made in 1964. Other early projects will deal with hatchery techniques, breeding European oysters for introduction to the Maritimes, and selecting good genetic strains of oysters.

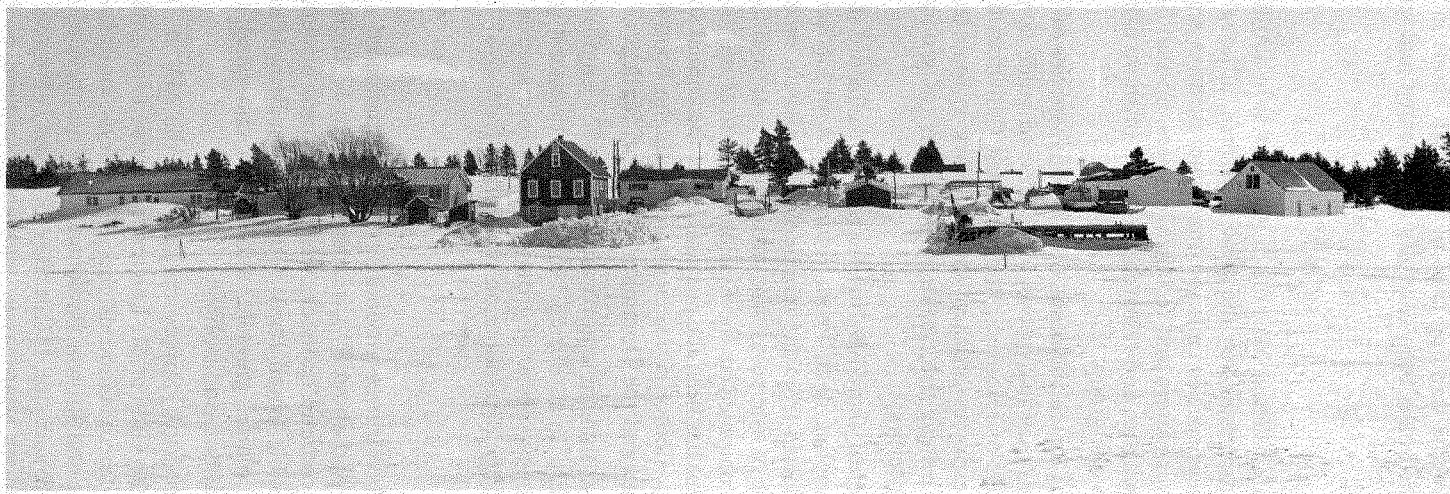
Preliminary results from studies of bottom deposits in Bideford River, P.E.I., show many feet of silt, and deposition at the rate of about $\frac{1}{2}$ inch a year. Oyster shell beds buried deep in unproductive silt give evidence of progressive degeneration of productive bottom. Changes include the replacement of oysters by mussels and other valueless forms.

Growth rates of oysters were found to vary significantly between areas in the Maritimes and from year to year. Within a year, growth rate was fastest when water was warm.

As among land animals, disease increases in apparent importance with domestication, and mortalities require study and control. Mortalities among oysters at Orangedale, N.S., are now confidently ascribed to low salinities. Recent mortalities in Malpeque Bay are associated with poor condition and a trematode parasite. A protozoan, *Hexamita*, associated with poor oyster condition and mortalities, is being studied under contract. There has been no spread of Malpeque disease. Monitoring of rehabilitation transfers has shown them to be succeeding except in the Shippegan region where introduced stock has not bred successfully.

CLAM

An important project to provide fresh water to the town of Dalhousie, N.B., involves a dam close to clam beds at the outlet of the Eel River. The local Indian band that controls the site would not approve alterations to develop water use unless guaranteed compensation for any future loss of revenues resulting from clam digging.



Biological Station, St. Andrews, N.B.

A general view from Bideford River of the Biological Sub-Station, Ellerslie, and the Department of Fisheries Oyster Culture Station. The buildings and facilities shown, from left to right, are: Oyster Hatchery (1963); F.R.B. Laboratory (1961), original F.R.B. Laboratory (1931); office building of Oyster Culture Station (1955); small building housing fire pump and standby generator; wharf and research vessels on slip, and behind this large outdoor tanks; Department of Fisheries warehouse (1959); original warehouse (1932). In the foreground is the snow-covered ice of part of the oyster reserve. Ice usually forms in the first week of December and persists till the third week in April, an average period of 140 days, with a range of 100–170 days. The ice thickness reached varies somewhat with weather conditions, 30 inches is an average figure and 42 inches the maximum observed. Water temperatures fall to 0°C at the time of freeze-up and remain at or below this figure until break-up. Salinities are generally high through the winter but a layer of fresh water collects under the ice in spring which may completely replace salt water if snow accumulation is high and run-off rapid.

The data above are based on observations made since the station opened in 1932.

To provide a baseline for judging losses, the Station made a careful estimate of the size and composition of the standing crop of soft-shell clams in the area. Methods used and results obtained have been carefully documented and supplied to all interested parties.

OFFSHORE FISHERIES

The several offshore fisheries have much in common in addition to fishing areas. They use the same boats manned by the same fishermen, although gear may change. Research on the different species calls for one comprehensive statistical system and flexible direction of investigators and technical services. So that Station organization may reflect industrial practice and research needs, all offshore fisheries investigations were confederated into one group.

Research programs match the needs of individual species or species groups, and vary widely. In general, they follow two objectives: to guide conservation and thus assure advantageous use of resources, and, to assist Canadian fishermen in getting a good share of the resources off their shores. Work is reported under five major headings: groundfish, pelagic fish, scallops, behaviour (of groundfish in relation to fishing), and gear engineering.

An important interest shared by investigators of offshore fisheries is obtaining catch statistics and sampling data. From voluntarily kept logbook records sufficient catch statistics are collected from the mobile fleet to allow a breakdown of the total landings by species, size of fish, vessel size, area fished, gear, and fishing effort exerted. Catch and effort are computed at the Station's statistical unit in Halifax. A major responsibility of this unit has been the preparation of the annual statistical submission to ICNAF. This responsibility has been shared with the Economics Service of the Department of Fisheries and the Dominion Bureau of Statistics.

Selected landings at some nine ports are sampled for length as well as for species composition and weights. In all during 1963, over 56 thousand commercially caught fish in 432 samples of eight species of groundfish and four species of pelagic fish were measured. Otoliths for age determination were taken from 6961 fish.

GROUNDFISH

During 1963 total Maritime groundfish landings increased about 2% in weight to 397 million pounds and about 8% in landed value to 17½ million dollars. Catches of traditional species, cod and haddock, were maintained by replacing fishing effort on Grand Bank and Sable Island Bank with effort on Browns and Georges Banks. Increased landings of plaice, greysole, and redfish countered slight decreases for pollock, hake, cusk, halibut, and wolffish.

SURVEY AND PREDICTION. Survey cruises with the *MV A. T. Cameron* on the Scotian Shelf and in the Gulf of St. Lawrence provided information on groundfish distribution and recruitment. Good catches of haddock, both large and small, were made on Little LaHave and Browns Banks and large numbers of small haddock were taken on the Nova Scotian side of the Bay of Fundy. However, on Sable Island Bank strength of haddock year-classes with the exception of 1959 seemed below average.

The 1959 year-class of haddock on Sable Island Bank may provide a temporary increase in recruits during 1964 but, with later year-classes weak, subsequent recruitment is expected to continue below average for several years. Comparative survey data off western Nova Scotia is not available. Migration patterns of haddock in that area are not fully understood. With such uncertainties no prediction on haddock abundance in that area is attempted.

Cod were taken in small numbers throughout the survey area and offered no indications of marked changes either in sizes available or in recruitment.

Pollock catches were light and these fish tended to be absent at depths less than 50 fathoms on the top of banks.

Argentines and a few silver hake were taken in a few hauls in deeper water along the slope of the Shelf.

DISCARDS. Knowledge of fish caught but not landed is desirable to judge fishing practices from the point of view of conservation, to meet Canadian international commitments through ICNAF, and to estimate the possible future use of kinds and sizes of fish not currently used.

Changes in trawl mesh-size regulations and changing fishing practice involving use of smaller fish have all but eliminated discards of cod in the Gulf of St. Lawrence, but substantial amounts of flatfish are still wasted. On the Nova Scotia Banks discards of both haddock and cod were significant. The higher rate of discarding may arise from the growth and recruitment of new year-classes to the fishery.

All skates, silver hake, anglers, herring, and sharks caught were discarded.

PLAICE. A thorough study of the American plaice in the Gulf of St. Lawrence was completed. Tagging and meristic data show two main groups of plaice in the Gulf, a Miscou-Magdalen group and a Cape Breton group between East Point, P.E.I., and Sydney Bight. The investigation covered migrations, growth rates, variations in year-class strength, food, the effects of various fishing practices, resistance to exposure, and total and natural mortality rates.

GREYSOLE. A study of the greyscale was begun and includes preliminary observations on preferred habitat, movements, growth rates, food, and recruitment.

HALIBUT. During 1963 halibut observations were continued. Age-length relationships were studied. Trawl and longline catches were sampled for comparison. Maturity, food, and parasites were examined. Returns from tagging near the 100-fathom edges of St. Pierre Bank, Green Bank, and the Grand Banks in February were mainly to the westward of release points, some as far as Scatari and Banquereau.

OTHER PROJECTS. Because of increasing interest in food relationships, groundfish food and feeding habits are being analysed making use of IBM data storage and computer methods.

General studies of the fisheries and biology (sizes, populations, maturity, food, and parasites) of wolffish and cusk were started.

A theoretical examination of trends in recent cod and haddock landings emphasizes the difficulty in using landing data without supplementary information of the intention of fishing captains and additional detailed information on the way in which fish are distributed on fishing grounds.

PELAGIC FISHES

The pelagic fishes including the coastwise herring and mackerel, and the offshore swordfish, tunas, and sharks constitute the greatest known but unused resource on the Canadian Atlantic coast. In 1963 Canadian fishermen landed 277 million pounds of pelagic fish worth $6\frac{1}{2}$ million dollars. Still the potential can only be guessed.

Increasing research effort is being directed to the larger offshore pelagic fishes with their exciting possibilities for exploitation and strong established markets. Biological observations are being continued on herring and mackerel.

HERRING. The Canadian Atlantic catch of herring in 1963 was about 260 million pounds, up about 8% from the previous year. Increased catches were recorded in the Gulf of St. Lawrence and in Charlotte County, N.B. Catches in Digby and Yarmouth Counties were down.

To meet ICNAF commitments the size composition of herring in the Bay of Fundy, its approaches, and on Georges Bank was followed. In general, sizes and seasonal variations followed those of previous years.

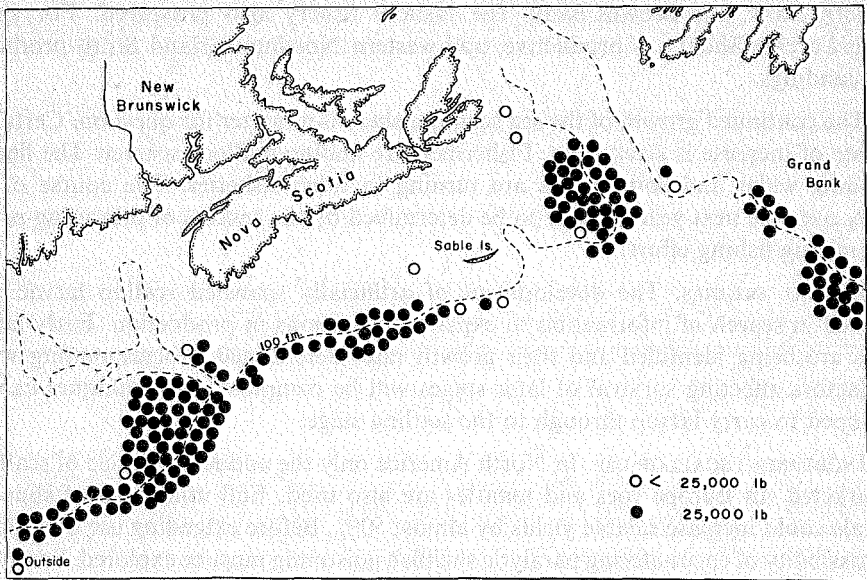


Hake on the ocean floor. Submarine photography is a new and powerful tool in fisheries research. This illustration shows how hake in nature work with their sensory pectoral fins extended beside the head.

Collections for the study of the production and distribution of herring larvae were continued in 1963, both in the Bay of Fundy and in the Gulf of St. Lawrence.

MACKEREL. Total Canadian mackerel landings in 1963 at 16.4 million pounds were practically unchanged from the preceding year. There was considerable change in the location of the landings, with the Gulf of St. Lawrence catches increased by about 70%.

SWORDFISH. In 1963, swordfish landings increased to 12.4 million pounds from 3.5 million pounds in 1962. The increase was a result of a change in fishing methods



Distribution of swordfish catches during 1963. Plotting difficulties partly hide the well marked tendency of catches to be concentrated along the 100 fathom line. In 1963 the new use of floating longlines led to an increase of about 300% in the production of swordfish. Harpooning apparently took only mature females and was effective only under favourable conditions of sea and light. Longlining is effective day and night under most weather conditions and catches adult swordfish of both sexes and immatures.

from harpooning to longlining. The new fishing method was generally more effective. It could be used in poor weather. It can be used at night. The fishing season is longer. In addition the method extends the resource base as it takes both male and female swordfish. Only females are taken by harpooning.

Biological observations on lengths and weights of landed swordfish were supplemented by observations at sea. Length records give clear indications that in 1963 the fishery depended on a diverse population rather than a single homogeneous one as previously believed.

TUNAS. A new Canadian Atlantic fishery made its appearance in 1963 with the landing of over half a million pounds of bluefin tuna and skipjack. Most of the fish were caught by two new large purse seiners, fishing from Cape Cod southward to Long Island, N.Y. A sampling of these fish was a first step in a biological study of the fishery.

Eighteen bluefin tuna weighing 400–600 pounds each were tagged from traps in St. Margaret Bay, N.S., but no recoveries have yet been reported.

SCALLOP

The sea scallop fishery continued to grow during 1963. Total landings were 16.2 million pounds of shucked meat, a 19% increase over the record catch of 1962. Most of the 15 million pounds caught by offshore vessels came from Georges Bank.

The Bank was utilized more thoroughly than in previous years. In addition fishing by offshore vessels extended to quite a few other areas, such as Lurcher Shoal, St. Pierre Bank, and Browns Bank. The inshore fishery also prospered. For small vessels Lurcher Shoal was productive, and western Northumberland Strait produced good landings.

The continued growth of the sea scallop fishery is a matter for question. Certainly the rate of increase is slackening. Fishermen are finding scallops scarcer. The fleet is spreading wider and some boats are turning to other fisheries. The course of the fishery over the next year is likely to be determined by the success of prevailing prices in attracting fishing effort.

LARVAL STUDIES. The development of artificially spawned scallop larvae was followed in search of information to explain fluctuations in production. Early larval stages are being identified and their growth rates determined. Corresponding work and factors affecting survival of later stages will be completed as techniques can be developed to carry larvae through to the settling stage.

INCREASING SCALLOP USE. In North America only the adductor muscle of scallops is marketed. In Europe roes and mantles are also used. Full utilization of shucked animals could increase salable yields by almost 50%. Before extending use of scallops the possibility of encountering paralytic shellfish poisoning must be explored. Sampling showed both roes and mantles from Georges Bank and the Gulf of St. Lawrence to be safely usable. Roes from the Bay of Fundy were also usable but mantles remain toxic throughout the year. More study and special precautions would be necessary there.

FISH BEHAVIOUR

The reasoned way to develop fishing methods is to study how different kinds of fish act in the presence of gear and then to design gear to exploit fish behaviour. A start along these lines is being made.

FATIGUE. Ordinarily fish swim or struggle when in contact with fishing gear. This can affect their capture, their survival if they escape through net meshes, and their quality as food if they are landed and processed. Effects of muscular fatigue are being measured in terms of the accumulation of lactate in the blood. Exercising fish for half an hour caused some to die. Lactate continued to accumulate in the blood for an hour after exercise.

DIURNAL MOVEMENTS. Analyses of echo-sounder records showed that cod and haddock stayed close to bottom by day but move up into the water with the onset of darkness. With cod this movement is more marked in deep water than in water less than 70 fathoms. Large fish seem to rise in darkness more than small ones.

OFF-BOTTOM FISHING NETS. An off-bottom trawl to take research samples was constructed so as to fish up to 6 feet from the bottom. It made catches of about the same size as a standard trawl of similar size. As the off-bottom trawl sustained less damage it has promise for commercial as well as research use. More critical tests are planned.

GEAR ENGINEERING

Engineering study of performance of fishing gear was undertaken with the object of promoting for Canadian fishermen the most efficient fishing methods. These studies are accompanied by others on the behaviour of fish in relation to gear. It is believed that taken together these investigations can give information for developing fishing methods that will provide catches at reduced unit costs.

Work in this new investigation was directed to comparing existing scallop gears and improving present otter trawl gear. In addition to working on research projects, advice on gear engineering, instrumentation, and textile technology was made available to the Department of Fisheries and industry. Liaison has been maintained with the International Standards Organization Subcommittee on Fishing Gear Materials.

Trials with existing scallop gear compared performances of standard offshore drag, tumbler gear, and calico scallop otter trawl nets. In general the current standard offshore drag proved most efficient. Tumbler drags caught fewer scallops and dug into the bottom and filled with trash. Calico scallop drags did not perform well on offshore grounds. However, preliminary trials in the Gulf of St. Lawrence were promising and these trawls may prove effective there.

The engineering study of groundfish otter trawls is planned to provide a basis for designing trawls which match the towing conditions of given vessels and which assume shapes predetermined by the behaviour of the fish sought.

Since the trawl is a flexible structure, its shape is determined by the equilibrium of the forces acting on it. The forces include tensions in lines and twines, and hydrodynamic forces between gear and water created by the motion of the gear passing through the water, as well as friction against the sea floor, gravity, and buoyancy.

Although some measurements have been made of nets in action, investigating trawl nets is largely in the instrumentation phase. Good advances have been made in developing the following instruments: hydraulic dynamometers for recording warp tension at the vessel; cable inclinometers for recording the angles of the warps in the water; underwater pitotmeters for recording the hydrodynamic pressure at the net; underwater dimension meters for recording headline head and wing spread of the net while fishing; underwater dynamometers for recording tensions in lines at the net; and underwater cameras as tools in behaviour studies. Other needs are being met by purchased instruments. A preparatory step in research will be to establish for both research and industry use the towing characteristics of trawls now in commercial use in the region.

ANADROMOUS FISH

Salmon and trout studies at St. Andrews were reorganized during 1963 in one group, the Anadromous Fish Investigation, in recognition of common problems and overlap in locality of investigations.

In addition to doing research on salmon and trout the course of the Miramichi smelt fishery was followed.

Research on anadromous fish is planned to provide a basis for obtaining full potential from the resource. It is recognized that stocks of freshwater fishes are

threatened by destruction of their habitat in several ways. In response to this, information is being collected both to guide repair of impaired habitats and populations, and to improve production in unaffected waters. Specifically, studies are being directed to: (1) laboratory and field investigations of young salmon, particularly hatchery-reared smolts; (2) the relation of merganser control to commercial and angling catches of salmon; and (3) ecological relations of young salmon and trout in small streams that are potential nursery grounds.

The regular advance of research has been interrupted by urgent threats to salmon stocks by aerial spraying of DDT on the watersheds and by poisonous mine effluents in streams. It is hoped gradually to turn over all management responsibilities to the appropriate branches of the Department of Fisheries.

Assessment of the situation recognizes the need for a fish culture establishment jointly operated by research and application personnel to develop and test means for maintaining salmon and trout stocks under rapidly changing environmental conditions.

The research program was originally designed by the Federal-Provincial Co-ordinating Committee on Atlantic Salmon. Recently progress has been followed through the succeeding Salmon and Trout Research and Management Section of the Federal-Provincial Atlantic Fisheries Committee. Co-ordination of research and management in the region was promoted with the Fish Culture and Development Branch and with provincial departments through annual meetings of a Scientific Advisory Group.

CATCH STATISTICS AND EXPERIMENTAL FISHING. Catch statistics collected by the Department of Fisheries are analysed to indicate conditions of fish stocks. As commercial and angling catches are independently important they are considered separately. Commercial landings in 1963 were up about 5% to 3.86 million pounds. This was entirely due to the increased production in Newfoundland by 13% to 2.51 million pounds. New Brunswick and Quebec catches were down by 12 and 19%, respectively. Grilse (1-sea-year salmon) were unusually common throughout the Atlantic area. These comprise a large part of the catch by commercial fishermen in Newfoundland but not in the Maritime Provinces. This may explain the difference between Newfoundland and other observations.

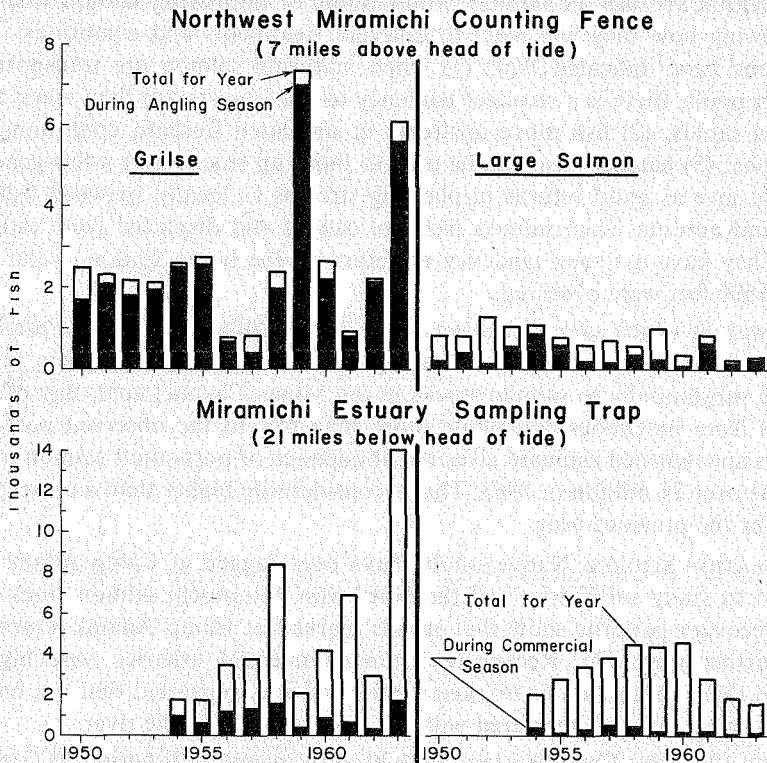
Angling catches were up throughout the Atlantic area except along the outer coast of Nova Scotia and the east coast of Newfoundland. They increased in the Gulf of St. Lawrence area by 164% and in the Bay of Fundy area by 207%. The increases are associated with the large numbers of grilse. Angling along the outer coast of Nova Scotia was off by almost half.

Experimental fish trapping was carried out at three sites in the Miramichi system: in the estuary 21 miles below the head of tide at Millbank, in the Northwest Miramichi 7 miles above the head of tide at Curventon, and 33 miles further up the same branch at Camp Adams. The figure shows the high abundance of grilse in 1963. It also illustrates that regularly most of the salmon run through the estuary after the August 30 closure of commercial fishing but are available in the river before the close of the angling season.

RELATION OF FOREST SPRAYING TO SALMON. The good run of grilse in 1963 has been a subject for satisfaction to anglers. This has led to a careful consideration of the

relationship between salmon abundance and aerial spraying of DDT to control spruce budworm outbreaks in the watersheds of salmon streams. It is evident that the increase in salmon enjoyed in 1963 is part of a general increase in salmon stocks throughout the region. In river systems where DDT was not a factor as on the south and west coasts of Newfoundland, and in streams unaffected by DDT spraying in 1958, improvement was evident in 1962 and continued into 1963. For the Miramichi River which is the greatest contributor to angling catches, the first year of release from severe spraying effects was 1959. The fry of that year are the grilse of 1963.

Surveys of young salmon in parts of streams having different applications of forest insecticides have been made and reported each year since 1954. Censuses were made by electroseining. Censuses covered areas subjected to different kinds of applications of DDT and to experiments with a systemic insecticide, phosphamidon. It is



Salmon runs in the Miramichi River. In the Miramichi River system, New Brunswick, the St. Andrews Station has maintained a salmon counting fence across the Northwest Miramichi tributary since 1950, and a sampling trap in the estuary since 1954. Generally no ascending adults are found before angling and commercial seasons open, but the seasons close well before runs cease in the fall. The figure shows total annual counts of grilse (1-sea-year fish) and large salmon (mostly 2-sea-year), also the proportion of the total run entering the Northwest Miramichi before the end of the angling season (Sept. 30 in this area) and entering the estuary before the end of the commercial trap-net season (August 31). It illustrates the comparatively high abundance of grilse in 1963. Also, in any year, most of the salmon run through the estuary after the close of commercial fishing but are available in freshwater areas before the close of angling.

concluded that DDT sprays, as currently used for controlling budworm, damaged young salmon populations seriously and in relation to the amount of DDT applied. Adult stocks from sprayed year-classes of young were affected. Phosphamidon as used alone did not reduce fish populations. Similarly tests showed no short-term effects on the populations of aquatic insects that serve as food for young salmon.

EFFECTS OF CONTROLLING MERGANSERS. A large-scale experiment is under way to determine whether increasing smolt production by controlling merganser ducks will increase the stock of maturing salmon. The experiment has continued for two years and satisfactory control of ducks has been attained. This work has had the active support of the Canadian Wildlife Service and of the Nova Scotia Department of Lands and Mines and has been carried out in co-operation with the Fish Culture and Development Branch.

BEHAVIOUR STUDIES ON SALMON. Maintaining or improving salmon stocks relies upon knowing how they will react to different treatments and conditions. Various observations have indicated that: (1) when maturing salmon are transported and released in pools, there is a stronger tendency to move upstream than when they are released in rapids; (2) fish move upstream in simulated freshets, confirming earlier observations; (3) hatchery fish can be used to build up stocks over a few generations but do not give as good returns in planting streams as locally spawned fish; (4) in summer and autumn when salmon parr are caught and displaced from established territory they have a strong tendency to return to the home section—returns from as far as 1500 feet were observed.

The way in which salmon behave in the sea is difficult to observe directly but deductions from salmon caught in herring weirs imply that: (1) rivers in Maine contribute substantially to salmon stocks in the Minas Channel area, Bay of Fundy; (2) smolts from hatcheries contribute more than 6% to the observed post-smolts; and (3) an unconfirmed estimate gives the abundance of post-smolt salmon in Minas Channel as over 2½ million in 1963. This is considerably higher than a corresponding estimate for the previous year.

POPULATION STUDIES. Native smolts have been tagged at Camp Adams and at Curventon to study subdivisions of the Northwest Miramichi salmon stock. Differences in recovery patterns show that smolts marked at Camp Adams return earlier and go farther upstream. Recaptures from commercial fisheries were higher for Curventon than Camp Adams marked smolts and it is suggested that the migration of late-returning fish was interfered with by mine effluents in the river.

During 1963, five Canadian tags have been recovered in fisheries off Greenland, bringing the total to seven. These recoveries and the accounts of the commercial fisheries for salmon there suggest a substantial concentration of salmon in Davis Strait during late summer and autumn.

A release of tagged ordinary and fast-growing hatchery stock in 1961 in the Miramichi River has allowed comparison among two kinds of hatchery stocks and wild stocks. Returns averaged 0.6% from the two hatchery stocks with the ordinary Miramichi Hatchery stocks producing more returns than the selected fast-growing stock of the Saint John Hatchery. This may arise from lack of homing in the introduced fish. In general, returns from wild stocks tagged in previous years were higher than those from hatchery stocks.

CONTROLLING THE ENVIRONMENT FOR TROUT. Formation of a pond by damming Ellerslie Brook, P.E.I., close to the outlet stopped fish in their downstream migrations and held them available to anglers. There was an early improvement in total annual catch in fresh water but production has now returned to pre-dam values.

Various artificial alterations to increase the amount of cover in Ellerslie Brook and its tributary, Hayes Brook, have been installed in an effort to increase carrying capacity. Unfavourable natural conditions adversely affecting recruitment made interpretation of results uncertain in Ellerslie Brook but there is evidence both of increased carrying capacity and of improved availability of trout to angling as a result of the changes.

Brook trout have been planted in the estuary of Ellerslie Brook to compensate for recruits cut off by the dam. Fingerlings grew and survived to capture well and remained in the area. Yearlings failed to grow effectively. They too survived well and were effective in stocking nearby streams. Estuarial planting is a promising fish cultural technique.

COMPARISON OF BROOK TROUT AND RAINBOW TROUT. Field tests comparing the two species gave conflicting results and further trials with greater control of environmental conditions are necessary to demonstrate the respective advantages for planting the two species.

SMELT IN THE MIRAMICHI RIVER. The fate of the commercial smelt fishery of the Miramichi River is followed through catch statistics and logbook records. In 1963 the catch was the best since 1958 although nets were fewest in 17 years. Catch per net was highest in the 17 years of observation. Weather conditions were favourable to good spawn survival.

POLLUTION

Increasing population and industrialization are intensifying pressure to use natural waters to receive domestic and industrial wastes. The extent to which this can be tolerated and still preserve fisheries for salmon and other freshwater and estuarial species must be thoroughly understood if both material advances and fishing are to be enjoyed. In the Maritimes mining pollution is one of the major threats to fish life in rivers, and it has been the main object of research effort during 1963.

Effects of pollution on migrating adult salmon were clearly shown in the Northwest Miramichi River. Since 1954 migrations of salmon have been observed and the numbers of salmon going up the river on their spawning migration recorded at Curventon. Fish returning downstream without spawning are also noted. From 1954 to 1959, the percentage of ascending salmon that returned downstream was never more than 3%. In 1960, pumping operations on a zinc and copper mine began adding mine-water to a tributary stream a short distance above Curventon. The proportion of descending fish rose to 22% and has not fallen below 10% in any year since. Of the fish that fell back, 31% re-ascended the river and 62% were never reported again.

The effect of mining pollution depends on the concentrations of both zinc and copper and on water hardness. Strength of pollution can be usefully described in relation to incipient lethal level (ILL)—the concentration which doesn't quite kill a fish. Young salmon in the laboratory are shown to avoid minute concentrations of

metals and to discriminate between ordinary water of 0.05 ILL and treated water of 0.07 ILL. In the Miramichi River migrating salmon started to move downstream when metal pollution exceeded about 0.35 ILL.

Surveys by electroseining made it evident that populations of young salmon are severely depressed in the parts of the Miramichi River affected by mine effluents.

An object of research is to anticipate problems other than mining pollution and to accumulate knowledge for application. ILL's for phenol and detergent were determined. Chlorine was lethal in any concentration that could be measured.

The incidence of highly alkaline fresh water from a new cement pipeline was studied and is being described for the interest of other users of laboratory water.

MATHEMATICAL STATISTICS

Mathematical statistics are applied at the Station in three ways. Statisticians provide professional supervision of data collecting and processing. Critical examination of data and of data collection advance sound interpretations as well as efficient design of experiments and routines in observation. Finally, studies are carried out on statistical problems related to fisheries and on mathematical aspects of biological fish population problems.

A critical study of current sampling methods for groundfish shows that uneven mixing within cod and haddock stocks on the fishing banks seriously impairs the effectiveness of sampling methods in revealing stock composition. Indications are that reliable estimates of stock composition can only be obtained by greatly increasing the number of samples.

Theoretical studies relating food, metabolism, and growth of fish showed a logarithmic relationship (0.8) between metabolic expenditure and total weight. The relationship is maintained at different levels under various feeding regimes.

The justification of using catch and effort statistics in measuring changes in fish stocks has been critically examined in the light of new and realistic assumptions concerning fish distribution. It is shown that current methods require supplementing by special research vessel data from echo sounders and fishing surveys.

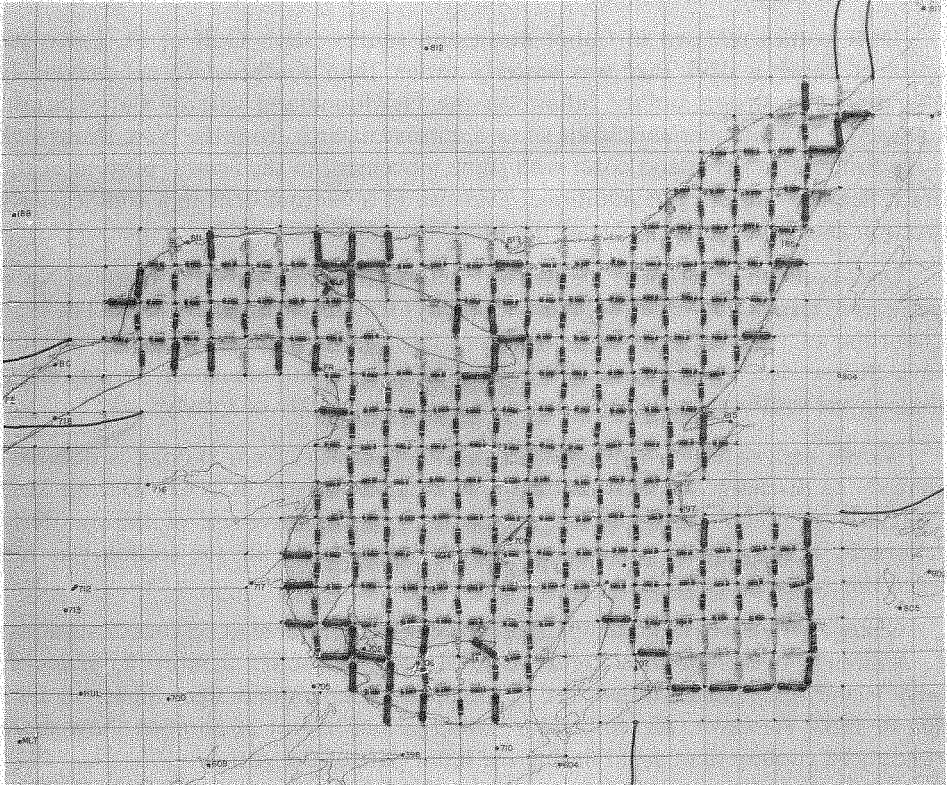
Examination of the results of systematic collection of lobster larvae with towed nets showed the methods to be adequate. As the relationship between larval abundance and subsequent production of adults in the fishery is neutral, it is concluded that variations in mortality beyond the so-called larval stages obscure the effects of larval production and survival.

Examination of data collected in surveys of scallop abundance showed the sampling to be about adequate on favourable grounds. There they could demonstrate a 25% annual mortality. Elsewhere more extensive sampling would be required. There is evidence that small scallops are distributed in quite small pockets. This is of significance both to assessment methods and to concepts of the biology of the species.

OCEANOGRAPHY

The Station's work in oceanography is in a state of transition. Until recently the Fisheries Research Board, through its Atlantic Oceanographic Group then at St. Andrews, tried to meet the ever-expanding national needs in Atlantic oceanography.

Now, satisfying general needs is accepted as a responsibility of the Department of Mines and Technical Surveys. To an increasing extent even fisheries requirements in physical oceanography, especially those involving monitoring, will be assumed by that Department. At present, work by the Board's oceanographers on the Atlantic coast is concentrated on studying the physical and chemical properties of the water and sea bottom, and the movements of the sea itself as these may affect energy exchanges and the production of fish.



Electrical analogue model of the Gulf of St. Lawrence. The network of resistors in the figure forms part of an electrical analogue model designed to study wind-driven circulation in the Gulf of St. Lawrence. In essence it is a specialized analogue computer which gives a solution to the simplified equations governing the water movements under the action of the wind. From a knowledge of the prevailing winds, the corresponding wind-driven circulation pattern may be derived from the model.

Oceanographic work in the Maritimes is based at two centres. At Dartmouth, N.S., in the Bedford Institute of Oceanography, the Atlantic Oceanographic Group is currently carrying out work in physical oceanography, geology and geochemistry, benthic fauna, and chemistry. It is expected that biological work there will be increased. At St. Andrews a smaller group investigates variations in properties and circulation of the sea in relation to the biology of commercial fishes.

CIRCULATION. Circulation in the Gulf of St. Lawrence has been actively studied in several ways. Field studies in the Strait of Belle Isle undertaken in co-operation

with the Department of Mines and Technical Surveys determined boundary conditions among water masses for use in mathematical modelling.

An electrical analogue model for calculating wind-driven circulation is being developed and in preliminary tests gives promising results.

An electric cable across the Strait of Belle Isle allows estimates of flow there as voltage generated in it is proportional at all times to the net instantaneous flow of water through the Strait. There are indications that the flow responds markedly to meteorological disturbances.

Drift bottles released in Cabot Strait and southwestern Gulf of St. Lawrence indicated either a drift that was easterly rather than southeasterly as previously observed, or a strong surface inflow on the Newfoundland side of Cabot Strait. Releases in Northumberland Strait show a consistent drift from the New Brunswick to the Prince Edward Island coast with some movement to the central portion of the Strait. Sea-bed drifters give additional evidence of a bottom drift in a southeasterly direction along the western edge of the Magdalen Shallows.

Drift-bottle monitoring of the Bay of Fundy and around the outer coast of Nova Scotia gave results that differ only in minor ways from earlier observations. The high proportion of recoveries of sea-bed drifters released in the Bay of Fundy and off Nova Scotia along with drift-bottle recoveries gives clear indication of upwelling all along the southwest coast of Nova Scotia and in the Bay of Fundy.

WATER PROPERTIES. A hydrographic section southeast from Halifax is occupied quarterly to discharge an international commitment through ICNAF. During 1962 and 1963 an attempt was made to assess the representativeness of the quarterly sections by occupying the stations at monthly intervals. In all, the section was run eleven times. Results of the analysis will be available shortly.

Changes in surface water temperature have been monitored at six coastal stations: St. Andrews, N.B.; Lurcher Lightvessel; Halifax Harbour; Sambro Lightvessel; Entry Island, P.Q.; and Borden, P.E.I. In general temperatures were higher in 1963 than in 1962. However, all temperature observations except at Sambro show more pronounced cooling than usual during the latter part of the year.

Analyses of long-term temperature variations based on all data available for the Maritimes area were prepared for an ICNAF symposium. In general temperatures were warm around 1900, mid 1930's and mid 1950's and cooler around 1920 and early 1940's.

Examination of temperature and salinity conditions within the Halifax section show different salinity distributions in warm and cold years implying that water masses are really different in composition, not merely different in temperature or thickness.

An analysis of observations on surface temperatures over a 42-year period provided a basis for forecasting various components of the temperature regime and the fiducial limits of forecasts. At St. Andrews forecasts of average temperatures based on temperature regime in previous years are within 0.4°C of the observed temperature 78% of the time.

The optical properties of water including turbidity have potential value in surveying water masses and in determining habitats. They are accordingly being made the subject of special study. Preliminary trials have shown a definite relationship between bottom type and water clarity.

GEOLOGY AND GEOCHEMISTRY. A preliminary study of the southwestern Gulf of St. Lawrence has shown a shallow undulating plain gently sloping toward the northwest. Shallow gullies leading from the edge of the Laurentian Channel have accumulations of fine silt and clay sediments. On the Magdalen Shallows various types of bottom are encountered with the bottom type apparently influenced to a large extent by depth.

A critical study of the sediments in the estuarial section of the Gulf of St. Lawrence indicates that the major part of the chemical composition of the bottom layer is a direct reflection of minerals in the sediments. However, a minor but significant fraction of the bottom substance has been brought to the site in solution and deposited there through chemical precipitation, reaction with pre-existing solid phases, absorption, and biological activity.

BIOLOGY. A study of the benthic fauna in the Gulf of St. Lawrence has been begun to determine the relationship between bottom biomass and fisheries. Preliminary results of samples along one line showed a significant gradation in biomass. High biomass was found in the region of concentrated commercial fishing but no ecological explanation is immediately evident.

An examination of the relationship between surface sea temperatures and the arrival of herring on the fishing grounds of the Magdalen Islands showed that on the average herring first appeared when temperatures reached 2.1°C. Thereafter the intermittent movement of herring to the spawning grounds paralleled the irregular pattern of temperature increases.

CHEMISTRY. Studies of the chemistry of sea water are part of the present program in physical oceanography. The solubility product of calcium carbonate at low temperatures and the activity coefficient of the sodium ion in relation to temperature and dilution were examined in 1963.

BIOLOGICAL STATION, LONDON, ONT.

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The Biological Station at London is concerned with freshwater fisheries problems in central Canada. Its basic overall objective is to help develop, through research, appropriate guidelines for managing Canadian inland fisheries. Also, in fulfilment of a contractual arrangement between the Fisheries Research Board and the Great Lakes Fishery Commission, the Station carried out work on sea lampreys in the Canadian waters of the Great Lakes during 1963.

The administrative headquarters of the Station is in a rented two-storey building at 539 Richmond Street, London, Ontario, which is shared with the London Technological Unit. To expedite the analysis of data and the conduct of experimental work, facilities include: a library, IBM equipment to punch and sort cards, equipment for determining the ages of fish from their scales, laboratory space suitable for experimentation with live fish, a dark room, and a workshop. The building serves, too, as a base of operation for field parties; all projects at the Station require considerable field work. Field work is carried out either from permanent sub-stations or from mobile camps. The largest sub-station is at Sault Ste. Marie, Ontario, where a new building 40 by 80 feet was built in 1963 to replace a building lost by fire in 1962. Most of the staff on the lamprey project are permanently stationed at Sault Ste. Marie. There is also a small sub-station in Port Arthur. A sizeable sub-station at Heming Lake in northern Manitoba is occupied seasonally for research on fish populations. A sub-station at Hay River, N.W.T., is permanently occupied by two men in connection with research on Great Slave Lake. Destructive floods in Hay River during 1963 caused no appreciable damage to the sub-station.

In addition to a number of small boats, the Station has two 45-foot steel-hulled diesel-powered motor vessels. The *Cottus* is used on Lake Superior and the *Stenodus* is used on Great Slave Lake.

HEMING LAKE

POPULATION STUDIES. Fishery scientists often use mathematical models of fish populations as an aid to developing rational plans for managing fisheries. These models are essentially equations whose terms are manipulated to represent various sets of conditions which might influence a fish population, so that the theoretical effect of various changes may be studied. The desirability of testing the validity of such mathematical models by attempting to apply them to a controlled fish population has long been recognized. Since 1960 a project to test their validity has been carried out at Heming Lake in northern Manitoba.

During 1963 the principal activity at Heming Lake continued to be a tagging and recapture program. A total of 5971 fish was tagged and 2966 tagged fish were recaptured: 1191 tagged in 1963; 1410 in 1962; 348 in 1961, and 17 in 1960. A large proportion of the fish tagged three and four years ago had lost their tags, in spite of extreme care taken originally to attach the tags securely. Also, survival was better among small perch and medium-sized suckers that bore inconspicuous clear tags than among comparable fish with conspicuous yellow tags. The difference is attributed to heavier predation by pike on those fish which carried the more conspicuous mark.

Heavy fishing prior to 1960 had greatly reduced the average size of pike, perch, and suckers in the lake. Lighter fishing recently has resulted in a considerable increase in the average size of these species.

TRIAENOPHORUS. Until 1960 the pike of Heming Lake were fished intensively in an effort to control *Triaienophorus*, a tapeworm for which whitefish is the intermediate host and for which pike is the final host. As a result of the heavy fishing, the percentage of pike in which *Triaienophorus* occurred declined steadily to zero by 1958. Examination of the usual number of pike in 1963 revealed zero infection for the seventh successive year. Examination of a limited number of whitefish and ciscoes in 1963 also showed zero infection for the fourth successive year. These results serve to further strengthen a conviction that *Triaienophorus* was completely eliminated from Heming Lake by heavy fishing for pike and to indicate that it has not re-invaded the lake.

GREAT SLAVE LAKE

The commercial fishery of Great Slave Lake has been studied continuously since it first began in 1945 and has served to document the effect of fishing on the fish populations and the effect of changes in the populations on the fishery. The main source of information has been, and remains, the commercial fishery through examination of samples from the fishermen's catches and through daily interviews with selected fishermen.

Collection of data from both the summer and winter commercial fisheries continued in 1963. Both an angling study at Taltheilei Narrows and a survey of commercial fishing vessels were completed. New conversion factors were derived for the relationship between dressed fish and fish in the round. Data processing techniques were developed for handling the immense amount of information that has been accumulated in the 19 years that the fishery has been studied. Techniques were perfected for processing the data through computing machines and an appreciable quantity has been made ready for processing. Current progress indicates that preliminary analyses of all the data back to 1945 will be completed by the end of 1965.

The results of a study of tagged fish in Great Slave Lake are now available. A total of 3629 fish were marked and 505 were recovered, some as much as 7 years after the date of marking. Although most of the fish tagged were whitefish and lake trout in about equal numbers, a few individuals of 8 other species were also tagged. The tagging study demonstrates that Great Slave Lake fish tend to be sedentary rather than mobile. The median distance between point of tagging and point of recapture was 5 miles, although a few individuals moved considerably greater distances.

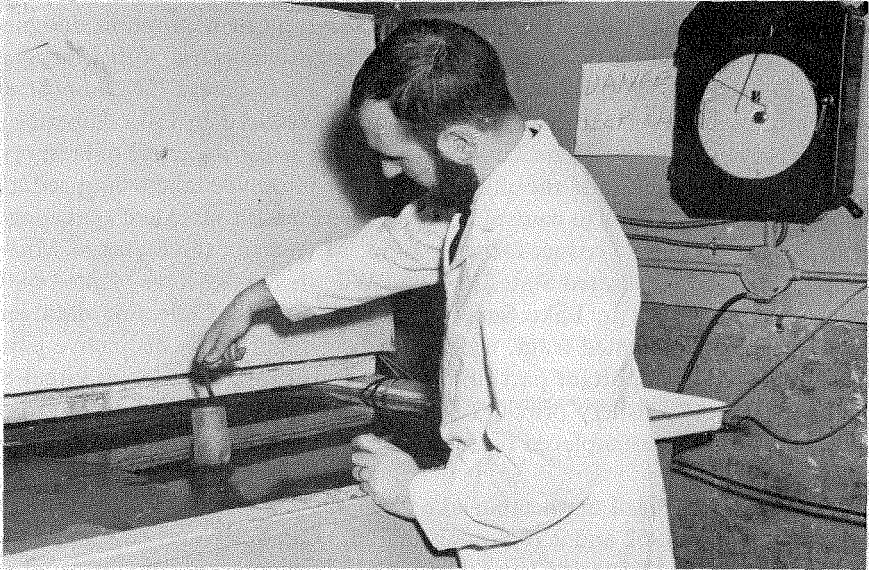
LAKE SUPERIOR

The Great Lakes Fishery Commission is carrying out a program designed to control sea lampreys in the upper Great Lakes. The basic purpose of their program is to enable the re-establishment of lake trout which sea lampreys have almost exterminated in Lakes Huron and Michigan and greatly reduced in Lake Superior. The immediate purpose of research on Lake Superior is to assess the effect of lampreys on the lake trout populations and the effect, in terms of improved lake trout production, of the Commission's efforts to control lampreys. Because the stocks of spawning lake trout have been so greatly reduced, the Province of Ontario, the States of Michigan and Wisconsin, and the United States Fish and Wildlife Service have planted millions of hatchery-reared trout in Lake Superior in recent years. Collecting data on the contribution of these planted trout, which may be recognized by distinctive patterns of fin clipping, is an important part of the Lake Superior study. As on Great Slave Lake, the commercial fishery provides the major source of data. In Lake Superior, however, more emphasis is placed on sampling aboard fishing vessels than on Great Slave Lake.

The average weight of marketable lake trout was 2.43 pounds in 1963, compared with 2.34 pounds in 1962 and 2.18 pounds in 1961. Catch per unit effort was 12.1 in 1963, compared with 11.1 in 1962 and 9.8 in 1961. The increased catch per unit effort and the larger size of fish encouraged more fishing with the result that fishing effort was about 35% greater than in 1962. Because of the greater average size, greater catch per net, and more fishing effort, the lake trout catch in 1963 was approximately 112,000 pounds, compared with 70,000 pounds in 1962 and 44,000 pounds in 1961, in spite of considerable restriction on the fishery as a conservation measure. These signs of improvement in the lake trout population are attributed to a recent decline in abundance of sea lampreys in Lake Superior (see below). It should be noted, however, that, although there has been some improvement, restoration of the lake trout of Lake Superior to the pre-lamprey condition is far from being achieved.

On fishing grounds where hatchery-produced trout had been planted, they constitute a major part of the commercial catch. Hatchery-produced trout have become increasingly important in the commercial catches in some other areas as well. In inshore waters, in general, catch per unit effort of hatchery-reared trout has increased from 1.3 in 1961 to 4.5 in 1962 and 8.4 in 1963. At the same time, catch per unit effort of naturally-produced trout in inshore waters has declined from 10.0 in 1961 to 8.4 in 1962 and 5.9 in 1963. The decline in abundance of naturally-hatched trout is attributed to almost complete lack of natural spawning for several years prior to the recent decline in lamprey abundance. Survival rate among approximately 500,000 per year of hatchery-reared trout planted in Canadian waters in recent years has been phenomenally high, probably because of lack of competition from naturally-hatched fish. The percentage of hatchery-reared trout in offshore catches is negligible; natural spawning appears to be adequate for maintaining offshore populations at a satisfactory level.

The incidence of lamprey-wounded trout in the catches in 1963 was about the same as in 1962 and 1961, and considerably lower than the incidence for several years prior to 1961. A puzzling feature was a higher-than-average incidence of wounding on certain grounds towards the west and a lower-than-average incidence on certain grounds towards the east.



Adding ammocoetes to depth burrowing experimental unit, London Biological Station.



Collecting ammocoetes in depth burrowing experiment London Biological Station.

LAMPREY CONTROL EXPERIMENT

LAMPREY BARRIERS. Electrical barriers were operated continuously from May 15 to July 31 on 8 streams tributary to Lake Superior. The main purpose of barrier operation is to assess the size of the lamprey runs. It is assumed that approximately

the same proportion of the run is killed, recovered, and counted each year at the electrical barriers, so that comparisons of counts from year to year should give a rough idea of the relative number in the spawning run. The size of the spawning run is in turn probably closely related to the number of lampreys which have preyed on lake trout and other fish during the preceding year. In 1963 a total of 1056 adult sea lampreys was counted at the 8 Canadian barriers, slightly more than the 788 counted in 1962, but considerably less than the 2895 counted in 1961.

Since most streams where large spawning runs occur are on the south shore of Lake Superior, an assessment of lamprey abundance by barrier counts is much more meaningful if values from the barriers in the United States are included. The accompanying table shows recent counts in the United States and Canada in round numbers. The same 8 barriers are used in Canada and, except in 1956, 1957, and 1958, the same 26 were operated in the United States. The U.S.A. figures for 1956, 1957 and 1958 are weighted to make them comparable with later counts.

	1956	1957	1958	1959	1960	1961	1962	1963
Canada.....	2,000	2,000	1,400	2,300	3,900	2,900	800	1,100
U.S.A.....	45,000*	53,000*	58,000*	45,000	37,000	67,000	9,000	11,000

*Estimated.

It is evident from the table that both in Canada and in the United States the counts in 1963 were roughly comparable with those in 1962 and considerably smaller than earlier counts. The low counts in 1962 and 1963 compared to previous years indicated that there has been a recent sharp decline in lamprey abundance. It is attributed to the recent use of lampricide, a chemical, as a lamprey control measure.

STREAM SURVEYS AND TREATMENTS. Surveys were conducted on 351 Lake Superior streams, 66 Lake Huron streams, and 213 Lake Ontario streams. Sea lamprey ammocoetes were found for the first time in 7 Lake Superior streams and in 17 Lake Ontario streams.

Most Lake Superior lamprey streams have now been treated at least once and lampricide is applied to them according to a regular schedule, which provides for re-treatment at least once every 4 years. Those streams which appear to be responsible for lake-dwelling ammocoetes are re-treated annually in order to dry up recruitment to the lake-dwelling populations. Nine Lake Superior streams were re-treated on schedule in 1963, and 6 new streams were treated. Four of the 6 were small streams in which lamprey populations were discovered for the first time in 1963; the kill in each was small to moderate. Two, the Big Pic and White Rivers, were of considerable size and in each of them the kill was large. A synergist, "Bayer 73", whose use was first proposed by United States investigators in 1963, was mixed with the usual lampricide during the Big Pic and White River treatments, with the result that about half the usual amount of lampricide was sufficient for control purposes, thereby reducing the cost appreciably.

LAKE-DWELLING AMMOCOETES. Although sea lamprey ammocoetes usually complete their life cycle in the streams where they are hatched, a few individuals are carried or swim out of their native streams and are found in the open lake. Since these lake-dwelling forms are not affected by the lamprey control technique that is used, it is important to assess their contribution to the adult lamprey population.

One of the best-known lake-dwelling populations is in Batchawana Bay, which is maintained by immigrant ammocoetes from the Chippewa, Batchawana, and Sable Rivers. A recent analysis of data obtained during several treatments of each of these three rivers indicates a much greater reduction in populations of sea lamprey ammocoetes upriver than in the estuaries or in the lake immediately off the river mouths. These data suggest a constant interchange of ammocoetes between the estuaries of these rivers and the open lake.

An electrified beam trawl has been developed for collecting lake-dwelling ammocoetes in order to study them. The 110 hauls made with the trawl in 1963 indicated a concentration of ammocoetes in the inshore areas which was comparable with the concentration found during an early study when a different technique was used. In offshore areas the concentration was found to be only about one-tenth as great as in the immediate inshore area. These are preliminary estimates and they require confirmation.

AMMOCOETE BURROWING. When chemical is applied to lamprey-producing streams for the first time, the kill of ammocoetes is usually spectacular. During second treatments a short time later small numbers of sea lamprey ammocoetes have been found in some of the more complex watersheds, even though theoretically there should be none. In an effort to improve the treatment technique so that all ammocoetes are killed during the first treatment, the burrowing habits of ammocoetes are being studied through experiment.

Studies in the field and in the laboratory have shown that sea lamprey ammocoetes may burrow into the stream bottom as much as 2 feet. When water levels drop enough to leave the stream bottom exposed, ammocoetes survive for a surprising length of time in burrows in the exposed substrate. These results have considerable significance for the perfecting of stream treatment techniques.

BIOLOGICAL STATION, NANAIMO, B.C.

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The investigations of the Biological Station at Nanaimo are concerned primarily with obtaining the necessary background of scientific information for the successful protection, management, and improvement of Canada's Pacific marine fisheries. Research on the oceanography of the Pacific and its application to fisheries is the responsibility of the Pacific Oceanographic Group, working in close association with the Biological Station.

During 1963 a major development has been the implementation of the Board policy that the work of the Pacific Oceanographic Group should be directed more toward fisheries problems, now that there is the prospect of an expanded oceanographic program for purposes other than fisheries, in the Department of Mines and Technical Surveys.

Research programs in fisheries oceanography have been initiated in connection with early life history of pink salmon, year-class strength in groundfish, and high-seas distribution and migration of salmon.

The broad program of research on salmon has been maintained, because of the value of the salmon fisheries, their vulnerability to over-exploitation, and the prospects for artificial enhancement of production. Particular attention has been paid to aspects of the biology of salmon that pertain to the international problems of conservation, which in recent years have greatly accelerated scientific knowledge. The early completion of a number of manuscripts for publication in the Bulletin series of the International North Pacific Fisheries Commission is noteworthy. Participation in the applied research required for management of salmon has continued not only with

respect to the many domestic problems, but in connection with coastwise international problems. Liaison with the Department of Fisheries in Vancouver, and with the industry, is close and effective.

Fisheries for species other than salmon (including groundfish, herring, shellfish, crustaceans, and marine mammals) are equally well attended in so far as contact with the Department and industry are concerned. However, their lesser economic importance at present is reflected in the smaller staffs involved in research, and the proportionately large commitment of these staffs in management activities. This situation is aggravated by the growing importance of international competition, particularly for groundfish stocks of the Gulf of Alaska. It is significant that much of the first year of work by the *G. B. Reed* was concerned with initial assessments of these resources.

Maintenance of an active program in experimental biology (and the growth in related fields at the Vancouver Technological Research Laboratory), significant developments in the study of behaviour, steady progress in pollution investigations, and some commendable contributions to the knowledge of the biology of our Pacific coast fauna, continue to round out the broad approach of the Station's work.

EARLY LIFE OF SOCKEYE

MIGRATION OF SMOLTS THROUGH BABINE LAKE. This was the concluding year of extensive study of the sockeye smolt migration through the Babine Lake system. Major effort was placed on tagging (and recovery) at two sites (the head of Morrison Arm and Halifax Narrows, plus recovery at the outlet of Nilkitkwa Lake), extensive transplanting of marked smolts from all three of these sites to various parts of the system, and general air observations. Although the data are yet in process of analysis, it appears the results will generally confirm the findings of previous years.

ABUNDANCE, DISTRIBUTION, AND GROWTH RATE OF UNDERYEARLING SOCKEYE. During the July–October period, tow-netting was carried on throughout the lake system. Analysis has been pursued far enough to make some general statements on abundance and distribution. The total lake population of underyearlings in 1963 appears considerably greater than the previous year, even though it was produced by a spawning escapement which was only slightly more than half the size of the escapement parent to the previous year's population. This was evident in the earliest samplings and suggests a much better survival in the egg-to-fry stage than in the previous year (of the order of three times better). Population estimates for the various lake basins indicate a greater than usual uplake dispersal of fish from the spawning grounds; this may be related to the unusually strong uplake (NW) winds prevailing during the late June period. In connection with growth studies, periodic sampling of the zooplankton in the various lake basins was continued.

OTHER. A preliminary examination of circulation in Babine Lake, using the dynamic height method, was undertaken.

Testing of the pump-type sampler used in Alaska for sampling eggs and alevins from spawning grounds was carried out. Preliminary sampling using this method was carried out.

Work continued toward completion of manuscripts dealing with the ecology of young sockeye during their lake phase of life.

SALMON PROPAGATION, EXPERIMENTAL HATCHERY

INCUBATION AND RELEASE OF 1962 EGG-TAKE. An estimated 9,000,000 eggs were taken in 1962 and incubated throughout the winter months, representing about 50% of the total egg deposition potential of the adult run to Lakelse Lake. A slime-mold which disrupted the flow pattern through the hatchery trays caused suffocation and a higher-than-normal incidence of "cripples". After the first occurrence, further loss was minimized by frequent cleaning of the 900-odd baskets and trays.

In the spring approximately 6,500,000 fry were released into the stream. A new release technique was used in which the fry were allowed to remain in a 6-inch-deep bed of gravel, relatively undisturbed by other fry. Most fry were nearer complete development than those of the year before when no gravel was supplied. Further modifications of the release technique are likely when more of the natural behaviour and its requirements become known.

YOUNG SOCKEYE IN THE LAKE. Tow-netting was carried out as in 1962. The data indicate a higher average mortality rate in 1963 than those established for wild fish for previous years; and possibly a decrease in the mortality rate as the season progressed, implying a higher daily mortality rate for hatchery-reared fish than for wild fish.

SMOLT ESTIMATE OF 1961 BROOD. The April and May tow-netting catches supply an index of abundance of the number of smolts (mostly age I, a few age II). A tag-and-recovery method was employed similar to the method in use at Babine fence, making use of colour-coded staples for short duration tagging. A total of 9893 fish was tagged and released, of which 3181 were recovered in a total sample of 144,642, indicating a smolt run of 449,840.

ADULT RUN AND EGG-TAKE, 1963. Diversion fences were operated on Williams and Scully Creeks which between them absorb about 95% of the total Lakelse sockeye run. Stream surveys established the number of fish spawning naturally. The total run was 11,600 large and 1300 jack sockeye.

The numbers of eggs now developing are 2,000,000 naturally and 12,000,000 in the hatchery. The expectation is thus a five-fold increase in fry production over what would have been produced naturally under average conditions and without the protection of the hatchery.

EXPERIMENTAL WORK. Experimental work on the 1962 brood was limited to bio-assay tests on alevins and eggs and performance tests on migratory fry. The bio-assays concerned the maximum tolerance levels for various compounds which could possibly be used in the control of the slime-producing organism; the results were very discouraging. The performance tests (swimming against fast currents) have established that performance is related to size and that naturally propagated fry and hatchery-reared fry of similar length perform equally well. However, since there is a distinct size difference between the average wild and the average hatchery fry, the hatchery population as a whole compares unfavourably with the natural population. Studies on the factors responsible for the size difference are under way.

SKEENA SALMON

Work on Skeena salmon, particularly sockeye and pink, was continued in 1963 to meet the present requirements for management of the stocks. Routine projects such

as the collection and analysis of commercial catch-effort data, test gill-net fishing, estimation of escapement size and distribution, and sampling for age and size composition of the runs were carried out.

Studies of sockeye at Babine Lake continued to provide information on the growth and abundance of the young from spawnings of known size and distribution. An estimate of the number of smolts (14,300,000) resulting from the large 1961 spawning revealed a poor level of production to this stage.

A large-scale test of a photo-electric technique of counting migrating sockeye smolts was carried out following successful initial tests in 1962. The technique continued to show promise of increasing the accuracy of the smolt estimate with reduced effort. Scuba diving and gill-netting in 1962, and again this year, demonstrated that lake spawning occurred in Babine Lake. However, little progress has been made so far in determining the numbers involved or the effectiveness of the spawning.

Studies were also continued to better define the individual stocks contributing to Babine sockeye production. Sampling for age composition was carried out again this year to confirm 1962 results and to determine whether differences in the age composition of the various stocks were consistent.

An estimate of pink fry production from the very large spawning of 635,000 in the Lakelse River in 1962 was made to indicate the level of production at relatively high spawning densities. Moderate production was indicated by an egg-to-fry survival of 13%.



Seining for salmon for tagging in the Skeena River.

SALMON STOCK ASSESSMENTS

ASSESSMENT OF CONDITION OF SALMON STOCKS. To provide an aid to salmon management and to follow changes in size composition, the Station has sampled catches in all important fisheries for all five species of salmon, the first complete coverage being achieved in 1960.

The total 1962 British Columbia catch of 3,500,000 sockeye was considerably lower than the catch of 4,600,000 in 1961 and well below the average catch of 4,900,000 sockeye for the previous 10-year period. A good part of this decline in the sockeye catches was due to the poor return of Adams River sockeye on the Fraser River. At Rivers and Smith Inlets, 4-year-olds from the 1958 brood composed more than 85% of the 1962 catches. In 1963, 5-year-olds from this brood were approximately 50% of the catches. Assessment of the strength of the runs to these areas in 1963 was made difficult by the strike of fishermen during the latter half of July, just prior to the entry of the major portion of the runs into the fishing areas.

There was a poor return of 4-year-olds from the 1958 brood to the Skeena in 1962, followed by an equally poor return as 5-year-olds from the same brood in 1963. The 4-year-olds from the 1959 brood year were more than half of the catch of approximately 137,000 sockeye to the Skeena River in 1963.

The 1962 catch of 1,500,000 chum salmon was only slightly better than the record low catch of 1,200,000 in 1961. The 1963 catch (up to the end of September) of 1,100,000 suggests that this also will be a poor year for chum salmon. In the Central Area catches, 3-year-olds from the 1960 brood were the most abundant in most of the catches from these areas. In Johnstone Strait the catches, which include a large proportion of chums bound for the Fraser River, were composed of slightly more than 50% 4-year-olds from the 1959 brood. Three-year-olds from the 1960 brood were almost as abundant, making up about 46% of the catches. Catches from the west coast of Vancouver Island were composed mostly of 3-year-olds from the 1960 brood.

In 1963 the catch of 11,700,000 pink salmon was approximately one-half the all-time record catch of 23,400,000 in 1962, but despite a reduction in fishing due to the strike, it was considerably better than the catch of 8,300,000 made in the parent year of 1961.

The 1963 coho catch of 3,200,000 was slightly less than the catch of 3,600,000 made in 1962, and ranks as the third highest annual catch made since 1951. The catch of slightly more than 700,000 springs in 1963 was poor, about the same as the catch made in 1962.

AGE DETERMINATIONS OF SOCKEYE SALMON FROM THEIR OTOLITHS. For the first time in 1962, otoliths from spawning sockeye at Babine Lake were examined. The otoliths showed that 4-year-old fish predominated among the early, south-end fish while those which entered the system late and spawned largely in the Upper and Lower Babine rivers were predominantly 5-year-olds. The examination of otoliths of spawning sockeye from Rivers Inlet in 1963 suggests some segregation by age on the spawning grounds. Most of the sockeye samples from rivers tributary to upper Owikeno Lake were 5-year-olds; 4-year-olds predominated in samples from rivers tributary to the lower lake region.

STUDIES OF SOCKEYE SCALES IN 1963. Studies to identify the origin of sockeye taken by longlining in the Gulf of Alaska during April and May were conducted again in 1963 in an attempt to throw light on the probable sizes of runs to coastal areas later in the season.

The general level of catch-per-unit effort was considerably smaller in 1963 than in 1962, which was reflected in smaller coastal runs in 1963 than in 1962 (preliminary catch figures indicate that North American sockeye maturing in 1963 were about two-thirds as abundant in 1963 as in 1962). As in 1962, scale studies indicated that Alaskan sockeye (mainly those bound for Bristol Bay) formed about two-thirds of the sockeye in the Gulf of Alaska. Among sockeye bound for British Columbia, half were identified as individuals bound for the Rivers and Smith Inlets area, reflecting the strength of that run, which accounted for perhaps one-third of the run of maturing sockeye to British Columbia in 1963. The scale studies correctly indicated that the vast majority of 5-year-old sockeye returning to British Columbia in 1963 were bound for the Rivers and Smith Inlets area. More detailed interpretations regarding the abundance of the runs of maturing fish returning in 1963 were not possible because the 1963 samples contained large fractions of immature sockeye (the exact fractions of immatures in the various samples were not known, because most sockeye were tagged and released alive).

STUDIES OF SALMON MOVEMENTS—INTERNATIONAL MANAGEMENT PROBLEMS. Management problems posed by the intermingling of salmon bound for United States and Canadian streams have stimulated the formation of a number of international committees composed of representatives of management and research agencies of the two countries whose main function has been to review available information and arrange for research on the movements of the stocks involved.

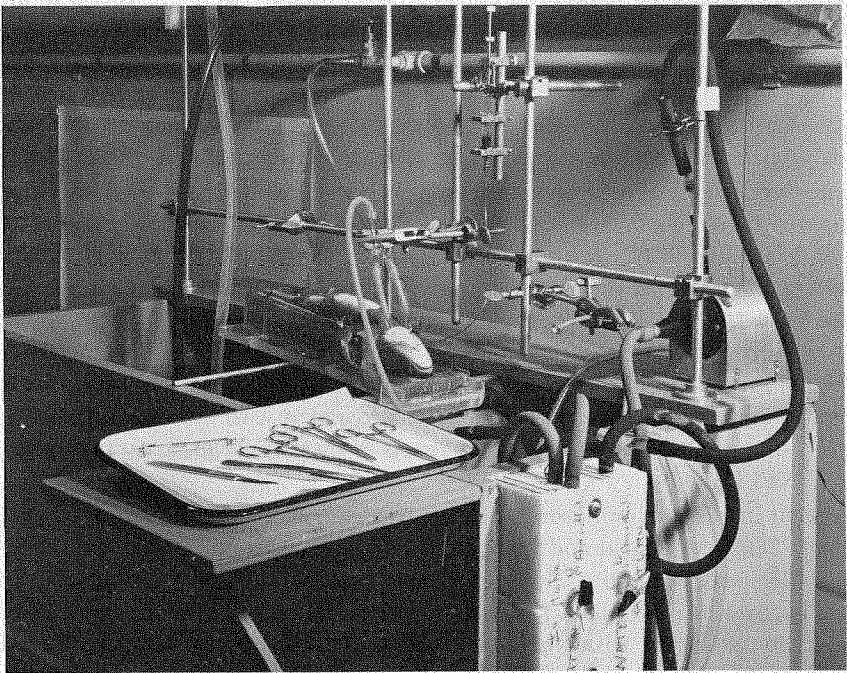
Intensive studies on the movements of pink salmon which passed through waters of the Fraser River Convention area were carried out by the two countries in 1959 and 1961 under the auspices of an international co-ordinating committee. The final reports of these studies, which provided thorough descriptions of the abundance, migration routes, and times of passage of pink salmon migrating through Fraser Convention waters, have been almost completed for submission to the two governments early in 1964.

Reviews of information on the movements of pink and sockeye salmon in the northern British Columbia-southeastern Alaska region were arranged through an international committee. Members of this Station's staff prepared the major part of the Canadian submission. The final report of the Committee, which revealed that in some years at least, United States fishermen make large catches of British Columbia-bound pinks and sockeye, will be submitted to the two governments soon and will form the basis for any future considerations of mutual management problems in this area.

An international committee was established in November 1963 to arrange for reviews of information on the migration and exploitation of chinook and coho along the Pacific coast with particular emphasis on determining where and when, and to what extent, intermingling between fish bound for the United States and Canada occurs. It is anticipated that Department of Fisheries personnel will be mainly responsible for this review but that staff of this Station will assist.

EARLY SEA LIFE OF SALMON

Continuing progress was made on studies of the juvenile ecology of pink salmon in the coastal waters of Central British Columbia. The 1962 brood-year Bella Cooola fry were observed during the movement into the estuary and through the length of Burke Channel. In co-operation with the Pacific Oceanographic Group, many of the physical and chemical features of the environment were recorded and correlated with movements of the small salmon. Growth is being studied from changes in length frequency with time; however, these data are difficult to interpret. A second approach was tried in 1963 by marking 180,000 fry and releasing them as a group on April 29. These were found in subsequent sampling to June 11. Factors associated with growth, i.e. feeding and condition factors, were obtained for the period April 21 to June 11, and in co-operation with the Vancouver Technological Research Laboratory, changes in fats and protein nitrogen were documented. The effects of limiting food supplies and diurnal changes in condition, stomach weights, fats, and protein nitrogen were also studied.



Operating table for fish with anaesthetic in water circulating across gills. The operation in progress is a cannulation of the dorsal aorta.

Preliminary observations on behaviour, and plankton and its distribution were made. Studies on the effects of the copepod parasite *Caligus* sp. are in progress.

A second lot of 140,000 fingerlings was marked and released the end of May and early June. By this time fish had become relatively scarce and it is proposed this was due to a severe mortality rate in Burke Channel.

Catches of adult pinks were sampled and many 1961 brood-year marks recovered. Observations were extended to the Bella Coola River spawning ground where the escapement was measured.

Analysis of survival data from the 1960 brood year of Hook Nose Creek pinks is now complete and ready for publication. The main findings are that survival from natural sources of mortality in the sea was about 22%. The rate of exploitation of the fishery was about 95%. The Hook Nose stock was shown to be more exposed to fishing than other stocks in the area; the rate of exploitation on the Bella Coola stock was about 70–80%. Similar data are now on hand for the 1961 brood-year Bella Coola stock.

MARINE SALMON

Investigation of the high-seas distribution of salmon was extended to the winter season through operation of the newly-commissioned *G. B. Reed* from January to February 2, 1963. Both longline and gill-net gear were used. An initial cruise southward to latitude 43°N, longitude 129°W yielded only a single salmon (sockeye) and 2 steelhead. A second cruise, northwestward to latitude 55°N, longitude 150°W, showed the presence of sockeye in considerable numbers west of 140°W, in an area where large numbers of this species had also been caught in the previous spring (April–June). A few pink salmon were also caught. In this operation the longline outfished the gill-net by a wide margin. Total catches consisted of 305 sockeye, 11 pinks, 6 chums. From the release of 206 tagged sockeye, 4 recoveries have been reported at widely separated localities from Bristol Bay to Southeastern Alaska.

The distribution of salmon throughout the Gulf of Alaska in April and May was investigated by the *G. B. Reed* and three chartered vessels operating between latitude 43°N and latitude 58°N, westward to longitude 160°W, using longlines. Sockeye in April were concentrated in the central part of the Gulf. In later weeks movements of fish northward and westward from this concentration were evident. Pink salmon in April were mainly located in the southern and eastern parts of the region examined. Northward movement occurred during subsequent weeks. Chum salmon were widely scattered. These findings are in good general agreement with those reported for 1962. However, the catch per unit of effort for each of these three species was considerably lower in 1963.

A total of 8733 salmon and steelhead was caught during the spring operations. Of these, 7266 were tagged and released. Tag recoveries reported to October 24 are: sockeye 146; pink 30; chum 24; coho 3; steelhead 3. The geographical distribution of these recoveries is similar to that found in 1962, with the important addition of pink salmon associated with the large "odd-year" runs of East Kamchatka and the region comprising southern British Columbia and Puget Sound. The presence in May of Asian pinks as far east as 155°W in the Gulf of Alaska has now been demonstrated. Chum salmon tags have again shown the presence in the central and western Gulf of numerous fish destined for Asian and northern Alaskan localities.

STREAM ECOLOGY

The study of underyearling coho at Chef Creek, Vancouver Island, confirmed and extended previous work. Smolts were produced at a rate of 50 pounds per acre. The total number was 14,709, with average length 8.5 cm, average weight 8.06 g.

Two areas of the stream have been studied—18,000 feet of stream in the upper forested section and 2700 feet of swampy area above tide level. The adult return to the stream of 700–800 fish produces fry in excess each year. The upper area has 166 pools, the swampy area about 10. The upper area produced altogether more smolts in 1963 than in 1962 and in proportion to the area occupied. The swampy area produced approximately the same number.

Both areas produced smolts of the same five size groupings. The upper area had more individuals in the upper three size groups—12, 11, and 9.5 cm—than the swampy area. The difference appears to be related to hierarchies established in pools. The underyearlings feed mostly on drifting insect larvae and the dominant fish have a greater food supply. A greater number of small pools gives more ecological opportunities for growth than a few large pools.

Differences in light intensities below 0.01 ft-c are important to the behaviour of insect larvae and fish.

PARASITOLOGY

Studies have continued on the identification and taxonomy of all salmon parasites collected during the research program associated with the International North Pacific Fisheries Commission studies to determine the origin of salmon on the high seas by means of their parasites. The objective is to produce a detailed account, with illustrations, of all parasites occurring in salmon throughout the North Pacific region.

As reported last year, data obtained in the INPFC studies on the geographical distribution of two marine species of adult trematodes (*Hemiurus levinsoni* and *Tubulovesicula lindbergi*) in sockeye suggest that they may be useful in describing the general oceanic areas occupied by North American and Asian sockeye. To assess the value of these parasites as indicators of the continental origin of sockeye on the high seas, it is necessary to know their life spans in salmon. Experiments in progress for the past 5½ months indicate that *T. lindbergi* probably lives considerably longer than that time period because there has been no reduction in the rate of infection in the experimental fish, the parasites are still growing and at present they are considerably smaller than their known maximum length in salmon. A second species of trematode (*Lecithaster gibbosus*) initially present in the experimental fish is disappearing, indicating a life span of approximately 6 months.

Studies have been carried out to identify a species of *Caligus* (Copepoda) parasitic on young pink salmon which may play a part in the mortality of these young fish shortly after they enter the sea.

REPORTING OF INPFC RESEARCH

Results of the extensive INPFC investigations on the high seas and the oceanographic background are being summarized in a series of reports being prepared jointly by scientists of the three countries. Preparation of these reports has formed an important part of the work of a number of this Station's scientists over the past 2 years. The report on the oceanography of the Subarctic Pacific was completed in 1962. Reports on the results of high-seas fishing for salmon on the origin and distribution of coho on the high seas, and background sections on the life history of the

various species were completed in 1963. Reports on the origin and distribution of sockeye, pink, and chum, and a background section on the distribution of spawners in Canadian waters, are near completion.

PHYSIOLOGY AND BEHAVIOUR

PHYSIOLOGY STUDIES. To facilitate studies on circulation, nitrogen metabolism, and detoxication mechanisms in salmon, methods have been developed for continuous intra-arterial injection, long-term blood sampling, and for continuous collection of urine from free-swimming fish. The successful cannulation of the dorsal aorta has permitted the application of angiographic techniques providing the first really clear picture of large sections of the vascular system and demonstrating the presence of a coronary artery, previously unsuspected. Preliminary determinations of blood volume in yearling pink salmon amounted to 10% of body volume, an unusually high level.

Results of plasma transaminase assays (glutamic-oxalacetic acid) on normal and kidney-diseased sockeye juveniles suggest that increased enzyme levels are directly related to the presence of the disease.

Fatigue studies on the swimming speeds of 70 adult sockeye and 60 pinks were individually conducted in the 10-inch diameter tunnel at Robertson Creek. Critical 10-hr sustained speeds occurred at about 1.7 mph for both species (66–69°F). At higher velocities, pink salmon fatigued faster than sockeye of the same length. The average speed maintained for 10 min was approximately 2.6 mph for pinks and 3.3 mph for sockeye.

The frictional drag on a towed, freshly killed 50-g sockeye salmon was 2.2 times that expended by the fish when alive and swimming in minutely turbulent water, despite assuming 100% efficiency of conversion of chemical to mechanical energy. This remarkable advantage in favour of the live fish occurred at the critical sustained swimming speed of about 4 lengths per second. At higher and lower velocities the ratio diminished, the power requirements becoming equal at 1.3 and 8.2 lengths per second at 15°C. The effect of environmental temperature on swimming speed was greatest at low velocities, decreasing to minor significance at about the maximum sustained speed.

Established rates of power developed agree reasonably well with estimates derived from man and dog, confirming for the first time a general similarity in muscle energetics.

An intensive investigation into the methods and interpretation of biological assay analyses has been completed. Research has been directed toward the general methods of estimating the effect of water quality alteration within multivariable environmental domains. Results indicate that the response of coho juveniles to a particular water pollutant (sodium pentachlorophonate) may be highly related to associated environmental conditions (temperature, oxygen, and salinity) as well as to age. The inference to be drawn is that no single estimate of safe level of pollutant concentration is acceptable *unless* that level is based on maximum stress conditions as a function of levels of pertinent environmental entities and age, over the time period of natural exposure involved.

BEHAVIOUR STUDIES. During 1963, these studies were, as in the 2 previous years, concentrated on two problems: (a) where, when, and in which way does the migration of sockeye smolts in lakes from the nursery areas to the outlet occur, and (b) how do sockeye smolts find their way about in lakes during this migration. Three projects were pursued during 1963. A technique has been developed for recording sockeye smolt migration in lakes by using a *horizontal echo-ranger* (sonar) and *time-lapse photography*. Thus the happenings of a 24-hr period can be viewed in $2\frac{1}{2}$ min. Analysis of the movies with a time-motion projector revealed information on the density and relative size of the schools, and on the depth, speed, and direction of migration or movements over 24-hr periods at different places in Babine Lake.

Experiments in previous years on *celestial orientation* of sockeye smolts during daylight and twilight hours strongly suggested the existence of a cue (or set of cues) in the blue sky other than the sun.

Tests in which the plane of polarization of the sky light was changed by rotating polaroid filters in many cases resulted in predictable shifts of preferred direction during the dusk period. The results of tests done during the noon and afternoon periods are so far difficult to interpret. Analysis of the data is complicated by the fact that sockeye smolts readily switch from one type of orientation mechanism to another.

Experiments during the 1962 season have clearly shown that sockeye smolts can orient themselves in the appropriate migration directions under conditions without a view of the sky and horizon and only diffused artificial lighting. Two hypotheses have been proposed by workers on bird and mammal orientation as possible explanations for this non-visual compass (Type-X) orientation: (a) Animals might accomplish orientation in the original preferred direction in the absence of any external sensory cues, including celestial ones, by means of a memory of every twist and turn made during transportation to the experimental set-up. Sockeye smolts which were anaesthetized before introduction into the orientation tanks showed similar preferred directions as untreated controls. (b) Animals may be able to perceive cues as yet not considered in orientation studies. Experiments with birds in steel plate chambers in which Type-X orientation disappeared have focussed attention on electro-magnetic waves from outer space as possible cues. Sockeye smolts tested in a $\frac{3}{8}$ -inch steel plate box under diffuse lighting conditions showed good orientation in the usual compass direction. On a number of occasions deterioration of orientation with time was apparent.

Thus, neither one of the hypotheses mentioned seems to apply to the Type-X orientation of sockeye smolts.

MIGRATION AND BEHAVIOUR STUDIES. These studies started off from a need to know what salmon are actually doing from hour to hour and mile to mile as they migrate (descriptive), and to develop means of analyzing behaviour, particularly the environmental cues and drives involved (analytical).

Studies of the detail of choice in pattern of upstream migration have revealed cyclic patterns of daily movement with the most active periods at dawn and dusk. Nocturnal migration does take place but *not* through sections of difficult passage. River entry from the sea is influenced by cloud-cover, being delayed by clear, relatively high-pressure weather.

During September and October, adult chum salmon entered two small coastal streams in a series of nightly pulses lasting for only a few hours each night. The largest pulse was associated with heavy cloud-cover.

Observations of other species (sockeye, coho, pink, spring) in two fishways in the Stamp River revealed types of premature reproductive behaviour (e.g. quivering in the male), and fighting which were intensified under low flow and prolonged blockage. These patterns, observed for the first time, are both energy consuming and potentially damaging.

GROUND FISH

In 1963 the investigation was divided into two units because of the emergence of two more or less separate lines of endeavour. A "near seas" unit, with emphasis on the population dynamics of groundfish stocks off the British Columbia coast, is concerned with assessment of changes in stock size and of the need for management of the Canadian and United States trawl fishery. A "distant seas" unit is involved in exploitation and biological investigation of potentially important groundfish resources of the Gulf of Alaska, where concern is growing regarding the rapidly developing fishery by foreign nations (USSR and Japan).

NEAR-SEAS INVESTIGATIONS. As in past years a large part of the research effort was spent on routine tasks associated with maintaining a watching brief on the trawl fishery off the British Columbia coast. These included collection and processing of current catch statistics, sampling of commercial landings and analysis of changes in size and age composition. A continued important role was played in the work of the International Trawl Fishery Committee which has co-ordinated and published up-to-date catch statistics on the trawl fishery along the west coast of Canada and the United States. A leading role has been taken in the similar treatment of statistics of fishing effort.

Laboratory work, aside from analysis of statistics and studies of age and growth, consisted of the completion of a report on the dynamics of the rock sole of Hecate Strait. Similar work on the brill (petrale sole) is still in progress. Results of laboratory experiments on the hatching of Pacific cod eggs were completed and submitted for publication.

Field work consisted of two trips to grounds off the west coast of Vancouver Island to obtain information on the distribution of juvenile brill and to obtain additional information, through tagging, on stock relationships. In addition, further sampling of rock sole was conducted in Hecate Strait and of lemon sole in the Strait of Georgia. In the latter area an attempt is being made to assess the effects of the recently imposed regulation on trawl mesh size.

DISTANT-SEAS INVESTIGATIONS. Activities in 1963 were centred primarily around three cruises of the new research vessel *G. B. Reed*. The first of these (February–March) took place in Queen Charlotte Sound where emphasis was placed on testing of fishing gear and development of deck sampling techniques. These were initial steps in the development of a research program on Pacific ocean perch (*Sebastes alutus*), a species of considerable economic potential off British Columbia and also farther to the north where it is currently the main object of fishing by foreign fleets. Following further gear trials and explorations in Queen Charlotte Sound and Dixon Entrance

in the early stages of the second cruise (July–August), extensive explorations for ocean perch were conducted in the eastern Gulf of Alaska (Cape Spencer to Seward). The third cruise (August–September) extended farther west, covering grounds in the vicinity of Kodiak Island (Portlock Bank to Chirikof Island). On that occasion further studies were made on the distribution of ocean perch, in addition to investigation of local shrimp populations.

During the Gulf of Alaska cruises, large catches of ocean perch were of common occurrence (as much as 16,000 lb per 30-min drag). Approximately 57,000 specimens were measured and a lesser number sampled for sex ratio and age.

Laboratory studies, so far restricted largely to ocean perch, consist of developing a valid method of age determination, analysis of within-area and between-area differences in size composition, sex ratio and length–weight relationship. Some morphometric differences have been detected and these are being examined with the view to differentiating stocks. In addition, hydrographic data from various sources are being assembled for the purpose of defining the physical environment of ocean perch throughout its range in the North Pacific.

PELAGIC FISH

HERRING. In 1962–63, 189 miles of spawn was deposited following a record catch of 263,240 tons, a decrease of 8% in spawn but an increase of 22% in catch over the previous year. Studies by the Herring Management Unit showed that herring were unusually abundant in the northern and middle east coast populations and at least of average or above-average abundance in the lower east coast, lower west coast, lower central, and upper central populations. In the last-named population the catch of 34,850 tons, the largest since 1944–45, was, however, followed by a drastic reduction in spawning. The generally high level of abundance in most populations resulted from the unusually strong contribution of 4-year-old fish from the 1959 year-class and the above-average numbers of 3-year-olds from the 1960 year-class.

Laboratory studies using naturally spawned herring eggs showed that there was a definite relationship between the density of spawn deposition and hatching success and larval malformation. When eggs were one or two layers deep, 80–87% hatched, but when they were four or five layers deep, only 15–21% hatched and the number of malformed larvae increased. These findings suggest that extensive light spawnings may be more desirable and yield more larvae than heavy spawnings.

MID-WATER TRAWL STUDIES. Studies of widespread echo-scattering layers were continued in two areas in the Strait of Georgia to determine the importance of these layers as a source of food for commercial fish and their relationship to pelagic fish. Some differences in species composition were found between the two areas, and between winter and spring catches in an area. Catches included juvenile herring, adult hake, whiting, dogfish, eulachon, lanternfish, and smooth-tongue smelt. Invertebrates such as euphausiids, amphipods, squid, and glass shrimp apparently formed an important part of the layer.

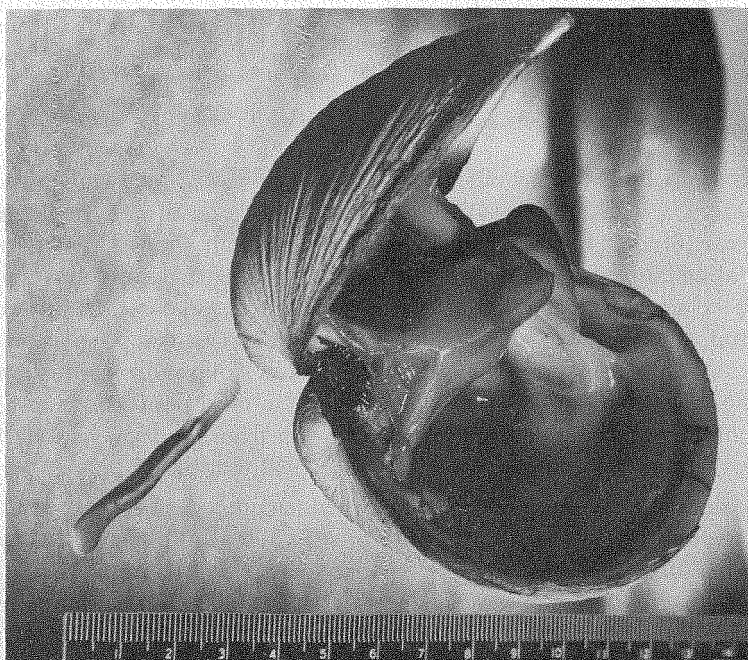
Preliminary tests were made of the practicability of 2-boat surface trawling for young salmon. Methods of handling the trawl were developed and it was shown that young coho of 7–10 inches could be caught in fair numbers (up to 60 per set). The net

used was of $1\frac{1}{2}$ -inch mesh and opened approximately 70 ft by 40 ft. It could be towed at a maximum of $2-2\frac{1}{2}$ knots. There were indications that a faster towing speed of possibly 4-5 knots would have yielded larger catches. The loss of a smaller-sized, larger-meshed net unfortunately prevented the gathering of data on this point.

CRUSTACEA

A trawl and trap survey with *A. P. Knight* in July and August resulted in the sampling of 6889 crabs. On the basis of this survey, poor fishing is expected in Hecate Strait in 1964; fair fishing for the 1963 fall season in McIntyre Bay, and improvement for the Naden Harbour area in the fall of 1963 and spring of 1964.

Testing to find a suitable metal as a "weak link" in crab traps was continued. The most promising corrodible material so far is No. 430 stainless steel wire made as a lid hook in the trap.



A butter clam with excised crystalline style.

Compilation of an annotated bibliography on the biology and technology of the commercial crab was continued.

Experimental shrimp fishing was conducted during three cruises of the *G. B. Reed* in 1963. Trawling during the first cruise in March in Queen Charlotte Sound and Smith Inlet did not yield shrimps in commercial quantities. The age structure of the above shrimp collections is uncertain. In August and September the vessel operated in Alaskan waters off Kodiak Island. Catches to 2600 pounds of shrimps were taken, but because tows were of short duration no assessment of commercial prospects was feasible. Over 3100 shrimps of 2 species were sampled from 56 tows; also, small samples of "king" crabs (*Paralithodes*) and "tanner" crabs (*Chionoecetes*) were taken.

A survey of areas adjacent to the Strait of Georgia revealed the intermingling of two species of pink shrimps, *Pandalus borealis* and *P. jordani*. The former has a range northward into Alaskan waters and the latter species flourishes from British Columbia south to California. The proportion of each of these two species on a ground may serve as a biological indicator of trends in seawater temperatures.

A comprehensive study of the age and growth of several species of shrimps in the Strait of Georgia has been completed and submitted for publication.

MARINE MAMMALS

Three groups of marine mammals were the principal subjects of study in this investigation. Two of these, whales and fur seals, are regulated and investigated according to terms of international agreements. The third group, sea-lions and hair seals, involves domestic problems pertaining to the relationship of these species to local fisheries and methods of control or utilization. Work in 1963 was devoted almost entirely to whales and fur seals.

A special working group on North Pacific whale stocks, comprising scientists from Canada, USA, Japan, and USSR, was set up in 1962 to co-ordinate biological research for the purpose of stock assessments based upon catches of major species, and the related catching effort. Preliminary work of the group includes a review of existing knowledge and the organization of procedures for the collection of necessary data for stock assessments.

WHALES. The 1963 whaling operation from Coal Harbour began on May 1 and ended on October 3. The catch of 147 sperm whales, 274 baleen whales and 3 Baird's beaked whales produced a better yield of oil than the 1962 catch.

A seasonal assistant spent the season at Coal Harbour to collect statistics required by the International Whaling Agreements and biological specimens required for studies of age and growth, feeding habits, and reproductive condition. Special log-books have been placed aboard whale-catchers for the purpose of calibrating effort as a reliable index of availability with respect to selection of whales, weather, visibility and efficiency of catchers.

FUR SEALS. Seals were hunted in 1963 from April 16 to May 20 off the west coast of Vancouver Island and from May 28 to July 15 in the Gulf of Alaska off Kodiak Island, using a chartered vessel, the *T. W. Islander*. A total of 260 seals was taken during the period; exceptionally poor weather resulted in the failure to take the required 500 seals.

An attempt to test the applicability of aerial observation and photography to the estimation of fur-seal abundance in Hecate Strait in March was unsuccessful because of poor weather.

Tagging returns indicate that seals taken in the eastern Pacific originate almost entirely on the Pribilof Islands but those taken in the western Pacific are of mixed origin from Robben Island, Commander Islands and from the Pribilof Islands. Special samples of reproductive tracts of tagged seals of Robben Island origin taken pelagically off Japan and all females taken on the Robben Island breeding grounds were requested and received from Japan and the USSR in 1963. Comparison of these samples with Canadian samples taken pelagically in the eastern Pacific shows that

the early growth of Robben Island seals is faster and that females from Robben Island mature and bear their first pup one year earlier than do those from the Pribilof Islands.

MARINE INVERTEBRATES

Marine invertebrate studies in a broader aspect were continued with four collecting trips, mainly in the depth range between 50 and 130 fathoms.

OYSTERS. Spatfall forecasting was again conducted in Ladysmith Harbour and Pendrell Sound. No commercial-scale spatting occurred at Ladysmith, but in Pendrell Sound two major spatfalls produced well over 1000 spat per shell.

The Harmac oyster-pollution experiment has been completed and it is apparent that fatness in Pacific oysters is adversely affected by kraft mill effluent (KME) in concentrations between 10 and 40 ppm of Harmac KME. The condition of commercial oysters at Crofton continues at a very low level.

Observations on the Denman oyster disease were continued. Incomplete annual harvesting, coupled with somewhat haphazard replanting, makes infection rate and mortality assessment difficult. The 1963 level of infection was 20% as compared with a previous maximum of 33%.

STUDIES ON PARALYTIC SHELLFISH POISONING. These studies continue as circumstances permit. The rise in toxicity at Cape Mudge suggested transplanting of non-toxic clams and oysters there to compare rates of uptake, if any. Monitoring coloured plankton blooms in the Strait of Georgia indicated a low level of occurrence as compared to 1962. Toxicity of butter clams above the allowable level at several sampling stations necessitated the closure of 7 fishery areas to the taking of this species.

COPEPOD PARASITES. Observations on the seasonal occurrence of the parasitic copepod *Mytilicola orientalis* in *Mytilus edulis* and *Crassostrea gigas* were continued.

ABALONE. Studies have been largely concerned with attempts to learn the exact time of breeding by seasonal gonad changes, plankton and spat collecting. So far the best lead has come from a mass spawning of abalones in the laboratory aquarium in August.

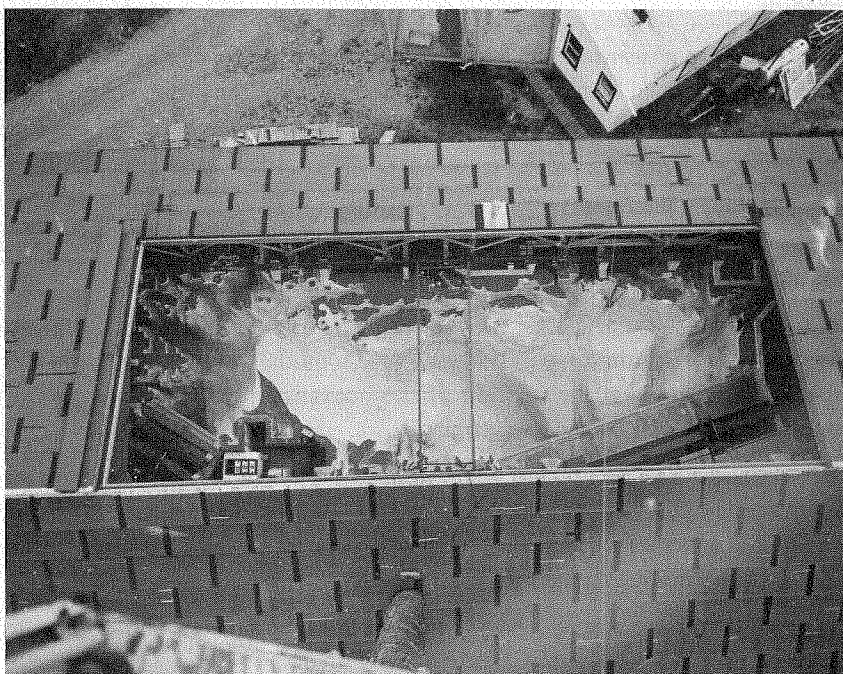
RAZOR CLAM INVESTIGATIONS. These investigations showed a continuation of the moderate but regular annual seeding on the Masset beaches. An occurrence of 3 or 4 spat/ft² with a mean length of about 5 mm in April was unexpected. No breeding occurred at Long Beach for the second successive year.

LIMNORIA. Further studies on the distribution of *Limnoria* show the creosotophile species *Limnoria tripunctata* to be widespread in Barkley Sound as well as in the Strait of Georgia. This will entail extension of the distributional studies into other west coast inlets. Another problem identical to that raised by the discovery of *L. tripunctata* is that occasioned by our recent finding of the Atlantic shipworm *Teredo navalis* in Pendrell Sound.

GEAR DEVELOPMENT. Extensive use of the modified Petersen grab has demonstrated the value of the alterations. Work is going forward in modifying the Knudsen bottom sampler, testing the efficiency of the 8-ft running integrative plankton sampler, and the manual hydraulic clam digger.

POLLUTION

Oceanographic-pollution surveys of a monitoring nature during 1963 were confined to waters of Northumberland and Stuart Channels, the Fraser River estuary, Burrard Inlet, and Howe Sound. Some effort was devoted to the analysis of oceanographic data collected in Northumberland Channel and in the Prince Rupert area during the past 8 years. A program of collecting sediments at selected stations in Alberni Harbour during monthly periods was initiated in the spring of 1963. Sampling and analysis of gases evolved by the sediments in Alberni Harbour were also carried out, and experimental studies are under way.



The Hecate Strait Model from the observation tower. Queen Charlotte Islands at the bottom, Masset Inlet at the top, northern tip of Vancouver Island to the right.

Investigations on the foaming characteristics of kraft pulp and newsprint effluents have been continued. Green liquor dregs have excellent foam-suppressing qualities, even when present in the comparatively small volume available in a kraft mill. Black liquor from kraft pulp digestors foams heavily in sea water but produces much less foam in fresh "tap" water and very little foam in distilled water.

As in previous years, consultation was rendered on various pollution problems through the Area Director of the Department of Fisheries. Meetings were attended on waste disposal problems concerning (1) proposed new pulp mills at Prince George, Kitimat, Kamloops, and Squamish, (2) pulp-mill expansions at Port Alberni, Crofton, and Prince Rupert, and (3) an electrochemical, chlorine, and caustic plant at Nanaimo.

PACIFIC OCEANOGRAPHIC GROUP

The Pacific Oceanographic Group is a section of the Nanaimo Biological Station. Under this direction and in co-operation with the Canadian Committee on Oceanography, the Group carries out research and co-ordinates all possible resources to fulfil the Canadian requirements (fisheries, military, and industrial problems) for oceanography in the Pacific area. The following projects were undertaken in 1963.

Ocean Station "P" (lat 50°N , long 145°W) and *Line "P"* (6 to 10 stations en route to and from Station "P") were maintained to monitor oceanographic conditions (structure, transport, and productivity) in the eastern Subarctic Pacific. Reference tables are being compiled to show the depth and standard deviation of features of the structure.

Daily seawater observations (at 15 stations) are made to monitor oceanographic conditions in the coastal waters. A graphical catalogue of the 7-day running averages and the statistical classification of monthly mean values are being prepared for publication.

The accumulated data of the *physical oceanography of Dixon Entrance* have been assessed with the aid of the Hecate Model. This research is being prepared for publication.

Previous research on the *assessment of coastal structure* has defined the structure models and their relation to wind stress. These models are being applied to the accumulated data to show the relation of the oceanographic situations to the daily weather and coastal seawater observations.

The *Canadian Oceanographic Information Service* publishes weekly charts of (1) sea surface temperature, (2) potential layer depth, and (3) magnitude of, and the bottom of, the seasonal thermocline. (Daily charts of sea surface temperature and potential layer depth are planned if data input permits.)

Five new *airborne radiation thermometers* will be completed and tested this year and are to be used by the Royal Canadian Air Force.

Bathythermograms collected in the eastern North Pacific since 1945 have been grouped by 1° squares and have been analysed according to the OCEAN system of assessment. These are issued as *Mean Monthly Ocean Charts* (with the Scripps Institution of Oceanography). The charts show the mean monthly values, occurrence of transient thermoclines, potential layer depth, and depth of bottom of thermocline.

Regional models of temperature and salinity structure in the seasonal zone of the Pacific from the Tropics to the Arctic have been defined.

Salinity structures in the eastern subarctic with their standard deviations are being deduced from accumulated data.

The source and mechanics of generation of the salinity minimum of the *intermediate water in the Subtropic Pacific* between 200 and 800 m depth are being investigated.

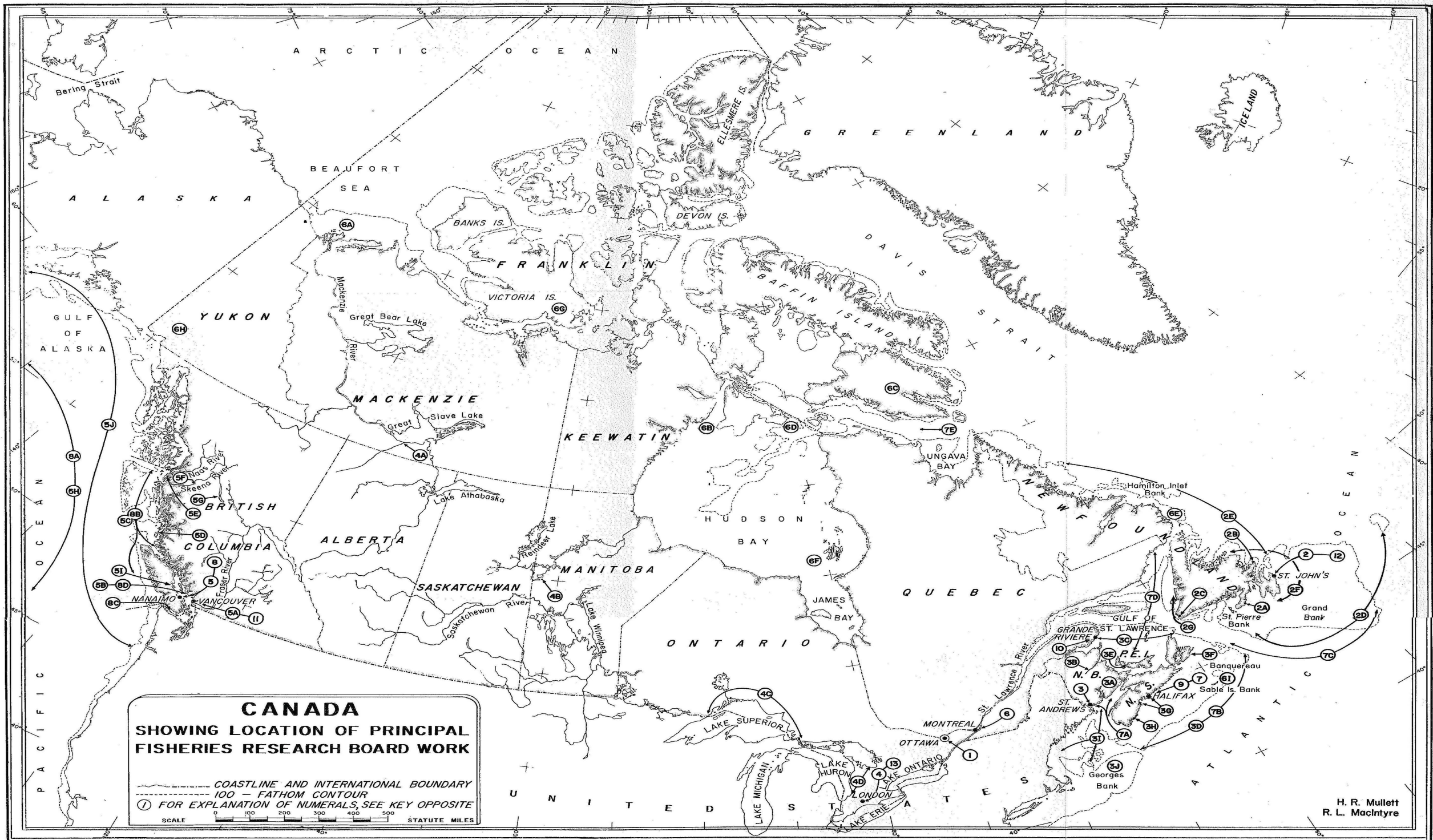
The *ecology of young salmon* in the estuarine waters of the central British Columbia coast (Burke Channel and adjoining regions) is being studied.

A program has been established, to work in co-operation with existing fisheries investigations, to assess the existing state of knowledge of the environment and fisheries, to derive correlations where possible, to define what information is lacking and how it may be obtained, and to provide systems of monitoring the environment that will aid assessment of the fisheries.

KEY TO MAP

1. HEADQUARTERS (ADMINISTRATION), OTTAWA, ONT.
2. BIOLOGICAL STATION, ST. JOHN'S, NFLD.
 - 2A. Burin, Nfld. (groundfish statistics)
 - 2B. Bonavista, Nfld. (groundfish, longlining)
 - 2C. St. Andrews, Nfld.—Little Codroy River (salmon)
 - 2D. St. Pierre Bank to Flemish Cap (cod, haddock, redfish, plaice studies)
 - 2E. North Harbour River (pink salmon introduction)
 - 2F. East Newfoundland (baby cod survey)
 - 2G. Port au Port Bay (lobster tagging)
3. BIOLOGICAL STATION, ST. ANDREWS, N.B.
 - 3A. Pollett River, N.B. (salmon)
 - 3B. Miramichi River, N.B. (salmon, DDT effects, zinc pollution)
 - 3C. Southern Gulf of St. Lawrence (groundfish census, plaice and scallop studies)
 - 3D. Nova Scotia Banks (groundfish survey)
 - 3E. Prince Edward Island and adjacent waters (oyster, lobster, and trout studies)
 - 3F. Eastern Cape Breton Island, N.S. (lobsters)
 - 3G. Halifax and Lunenburg, N.S. (groundfish statistics)
 - 3H. Lockeport, N.S. (cod, haddock)
 - 3I. Bay of Fundy and Gulf of Maine (sardine herring, haddock, pollock, lobsters)
 - 3J. Georges Bank (scallop studies)
4. BIOLOGICAL STATION, LONDON, ONT.
 - 4A. Hay River, N.W.T. (Great Slave Lake fishery study)
 - 4B. Heming Lake, Man. (fish population dynamics)
 - 4C. Lake Superior (lamprey surveys and control, commercial fishery)
 - 4D. Lake Huron streams (lampreys)
5. BIOLOGICAL STATION, NANAIMO, B.C.
 - 5A. Vancouver, B.C. (commercial statistics)
 - 5B. Strait of Georgia (herring, groundfish, salmon, oysters, pollution studies)
 - 5C. Hecate Strait and offshore (herring, groundfish, salmon stocks)
 - 5D. Fitz Hugh Sound (ocean life of young salmon)
 - 5E. Prince Rupert, B.C. (commercial statistics, salmon management, pollution study)
 - 5F. Terrace, B.C. (Kleanza Creek experimental hatchery)
 - 5G. Babine Lake, B.C. (adult and smolt salmon censuses; lake production of sockeye)
 - 5H. Pacific Ocean (high seas salmon fishing, tagging, and stock identification)
 - 5I. Great Central Lake, Vancouver Island (salmon behaviour and tolerance)
 - 5J. Columbia River to Kodiak (fur seal sampling, sea-lion study)
6. ARCTIC BIOLOGICAL STATION, MONTREAL, QUE.
 - 6A. Herschel Island to Tuktoyaktuk (fish and beluga exploration)
 - 6B. Northwestern Hudson Bay (plankton, benthos)
 - 6C. Frobisher Inlet (char survey, Ogac Lake study)
 - 6D. Coats and Southampton Islands (walrus)
 - 6E. Labrador—Newfoundland "Front" (harp seal assessment)
 - 6F. Belcher Island (seal netting)
 - 6G. Cambridge Bay (lake trout and char studies)
 - 6H. Yukon Lakes (commercial fisheries)
 - 6I. Sable Island (seal stocks)
7. ST. ANDREWS BIOLOGICAL STATION (ATLANTIC OCEANOGRAPHIC GROUP, DARTMOUTH, N.S.)
 - 7A. Bay of Fundy and Passamaquoddy Bay
 - 7B. Scotian Shelf
 - 7C. Off southern Newfoundland
 - 7D. Gulf of St. Lawrence
 - 7E. Hudson Strait
8. NANAIMO BIOLOGICAL STATION (PACIFIC OCEANOGRAPHIC GROUP)
 - 8A. North Pacific Ocean and Gulf of Alaska
 - 8B. British Columbia coastal waters and inlets
 - 8C. Strait of Juan de Fuca
 - 8D. Strait of Georgia
9. TECHNOLOGICAL RESEARCH LABORATORY, HALIFAX, N.S.
10. TECHNOLOGICAL STATION, GRANDE-RIVIÈRE, QUÉ.
11. TECHNOLOGICAL RESEARCH LABORATORY, VANCOUVER, B.C.
12. TECHNOLOGICAL UNIT, ST. JOHN'S, NFLD.
13. TECHNOLOGICAL UNIT, LONDON, ONT.

Note: Areas of research for 1963.



H. R. Mullett
R. L. MacIntyre

ARCTIC BIOLOGICAL STATION, MONTREAL, QUE.

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The primary objectives of the Arctic Biological Station are to assess the aquatic biological resources of the arctic regions and the marine mammal resources of the Atlantic coast.

The importance of the aquatic resources of the Canadian Arctic are second to none in terms of local economy. Dependence on these resources is already high and is increasing rapidly as organized commercial, domestic, and sport fisheries develop and expand. This increased utilization has emphasized the need for greater knowledge for the management of these low productive stocks.

Seals in both the Arctic and Atlantic have gained importance through recent increases in pelt prices and studies have been continued toward providing data for the establishment of sound management policies.

FISHERIES INVESTIGATIONS

GREAT BEAR LAKE. A limnological and fisheries survey of Great Bear Lake was started in June 1963. Vessel facilities consisted of the 113-ft M.V. *Radium Gilbert*, chartered from the Northern Transportation Company, and other small craft. In the first year of this planned 3-year study, emphasis was on limnological factors such as bathymetry, temperature regime, plankton, bottom fauna, nutrient status, and primary productivity. Some fisheries studies were carried out but the main phase of this work is planned for the final stages of the program when the limnology is better known.

In the course of the work during the season, McTavish, the deepest and coldest arm of the lake was investigated most intensively. The deepest region was found to be approximately 8 miles west of Port Radium where a maximum depth of 1404 ft was recorded. Further to the north and completely separated from the first deep region another area of near similar depth (1392 ft) was discovered. This consisted of a flat-bottomed trench about a mile wide and running in a north-south direction for a distance of about 6-7 miles. From the deepest region McTavish Arm slopes gradually upwards to the west where the bottom of the centre of the lake lies at a depth of 240-300 ft.

The depths of Keith and McVicar Arms, both shallower than McTavish Arm, were also investigated.

Water temperatures varied in the different regions of the lake. McTavish was very cold reaching a maximum of 6°C at the surface, and falling to 4°C at 75 ft. Below this depth the temperature shows a gradual reduction in the temperature of maximum density until at the bottom (1400 ft) the temperature at the height of the summer is 3.6°C. McVicar Arm was considerably warmer than the rest of the lake

with temperatures as high as 15°C being recorded from the surface waters in the southern part. Keith Arm was intermediate in character between McVicar and McTavish Arms.

The nutrient status was low as were total dissolved solids. Transparency in the deepest part of the lake showed a maximum reading of the Secchi disc of 90 ft. In some of the sheltered waters of the inlets maximum readings were reduced to 24 ft.

Fish were found distributed throughout all parts and depths of the lake investigated. Bottom trawls at 600 ft yielded sculpins, *Myoxocephalus quadricornis*, while two lake trout, *Salvelinus namaycush*, were caught in gill nets at 1350 ft. At the head of the bays in McTavish Arm, whitefish, *Coregonus clupeaformis*, were plentiful although total numbers would be restricted on account of the limited suitable area available to them. McVicar Arm where the water was relatively warm and shallow appeared to have greater potential for whitefish production than the other two arms of the lake.

Primary production data are still in the process of being analysed but in most areas production is manifestly low.

JAMES BAY. Investigation of a summer gill-net test fishery conducted on the west coast of James Bay by the Indian Affairs Branch of the Department of Citizenship and Immigration showed little likelihood of the development of a profitable commercial fishery. Adverse winds and abundance of drifting seaweed made fishing difficult and time-consuming while restricted benthic food items and low catch per unit of fishing effort indicated a real scarcity of fish in the area.

CHAR STUDIES. Keyhole Lake. A limnological survey and an intensive fishing, tagging, and sampling program was carried out on an unfished population of land-locked arctic char in a 48.6-hectare lake near Cambridge Bay, Victoria Island. Preliminary analysis of the data indicates a population of approximately 6500 char over 10 cm in length occupy the lake. During the winter months these fish are sometimes restricted to less than 20% of the volume of the lake through build-up of the ice cover. Further analyses are required to outline details of life history and productive capacity.

Results show that short-term intensive fishing on these virgin stocks can be an efficient and profitable method of utilizing this presently unused resource. Long fallow fishing periods would be required for stock recovery and build-up.

Ferguson River. The commercial gill-net fishery of Ferguson Lake arctic char was followed this year when the location of the fishery was extended from the river migratory stock to the summer residents in the sea. The change in fishing location and increase from 4½–5½-inch mesh nets resulted in a continuous summer supply of fish of a larger average size than previously taken. Approximately 35,000 pounds of char were caught in the sea by the commercial fishery while another 30,000 pounds were taken by the Eskimo domestic fishery in the mouth of the river.

Frobisher Bay. The commercial catch of arctic char in Frobisher Bay, Baffin Island, continued to show a decline in catch per unit of effort from 212 pounds in 1959 to 70 pounds in 1963. Average weights and ages during this period have remained relatively constant indicating the fishery is maintaining itself largely at the expense of the accrued capital stock. Total catch is composed of a 10,000-pound commercial fishery, a 15,000-pound domestic fishery, and a 15,000-pound sports fishery.

MARINE FISHERIES. Exploratory fishing in Darnley and Franklin Bays of the western Arctic was continued from the M.V. *Salvelinus*. Large numbers of Greenland cod, *Gadus ogac*, were encountered and sampled for life-history studies. None of these fish was found to have developing gonads but cod larvae were plentiful in the surface waters from first break-up until the third week of July indicating that spawning probably occurred in late winter or early spring. Subsequent cod fishing in mid November at Cambridge Bay showed all samples to have maturing gonads. Only minor domestic cod fisheries presently exist in the Canadian Arctic and a relatively large population of older and larger fish are to be found. Cod taken by jig line in Cambridge Bay averaged 5.1 pounds in weight with a maximum record weight of 11.0 pounds.

MARINE MAMMALS

NARWHAL. Narwhal studies started on Bylot Island in June resulted in the capture of 26 animals, 22 of which were taken by nets in Milne Inlet in the period August 7-19. Of the net captures four animals were calves. All animals were measured and weighed and sampled for future age, maturity, and food analysis. Both the tusks and lower jaws show laminae useful for age determination. Average weight of the adult animals was 1685 pounds. Of this weight 750 pounds (45%) represented skin and blubber, and 430 pounds (25%) edible meat.

The netting of these animals was an innovation which proved very successful over the conventional hunting techniques so long in vogue. Relatively large numbers of narwhal were seen with a maximum herd size of 150 animals being observed.

Utilization is confined to a few settlement areas with the major catch of about 125 animals being taken at Pond Inlet. Smaller numbers are reported taken from Pangnirtung, Clyde, Repulse Bay, Arctic Bay, and Spence Bay. The maximum utilization of 200 narwhal can probably be increased without depleting the present stocks.

WHITE WHALES. Numbers of white whales, *Delphinapterus leucas*, in the area between Cape Churchill, Man., and Eskimo Point, N.W.T., were estimated through aerial surveys on July 27-29, 1963. The resultant total of 3000 animals represents as high a count as found for the same stretch of coast in any previous year and indicates that the stock is in good shape following reduced catches in the period 1961 to date. Prior to 1961 catching took place only at Churchill and the mean number taken was about 450 animals annually.

HARP SEALS. A second aerial photographic survey of moulting harp seals on the Front (east of Labrador and Newfoundland coasts) made with two aircraft in the second half of April 1963 gave an estimate of between 250,000 and 300,000 for the population of immature and adults. In the Gulf of St. Lawrence a total of only 20,000 seals on the ice confirmed that most seals of the Gulf herd must moult in the water. Catch statistics also show that the Front survey also missed 50% or more of the seals, which are presumed to have been in the water at the time of the survey.

The heavy fishery for harp seals in the Gulf of St. Lawrence in the past few years has had no effect on either the age of sexual maturity or the percentage of non-pregnant females in the herd. From samples gathered at Harrington Harbour on the north shore of the Gulf of St. Lawrence in early January 1964 it was found that the mean age of sexual maturity of 5 years of age and the 10% level of non-pregnant females remains the same as found in the period 1949 to 1953.

An aerial photographic survey of the breeding stocks of harp seals was made on the Front and in the Gulf during the period February 27 to March 12, 1964. Faster shutter speed cameras with improved Tri-X film gave excellent photographic results in which the difficult-to-discern young whitecoats were readily observable particularly when photographs were taken at noon when a minimum of shadow existed. Final results with estimates of numbers based on counts in the photographs are expected by late May 1964.

Early aerial photographic reconnaissance of harp seals in the Gulf of St. Lawrence located whelping patches for a helicopter-equipped tagging party. A total of 2791 young seals were tagged during the period March 1-11 in the vicinity of the Magdalen Islands. Intensive hunting by ship and helicopter sealing crews restricted all further tagging after this date. Vessel tag recoveries have not yet been fully reported but already over 30% of all tags applied have been received from Canadian sealers and additional tags are being received daily.

GREY SEALS. Studies on winter distribution of breeding grey seals in the Gulf of St. Lawrence along with a tagging and branding program in the breeding colony of the Basque Islands, Michaud Point, N.S., and a branding program on Sable Island stocks were continued. All 187 pups on the Basque Islands were tagged, 21 of which were branded, while on Sable Island 253 pups were tagged and 45 of these were branded. During 1963 nine recoveries of branded and tagged animals were made in the Maritimes, Newfoundland, and Labrador.

BIOLOGICAL OCEANOGRAPHY

ZOOPLANKTON. The M.V. *Salvelinus*, while principally engaged in fishing operations, sampled 14 stations for hydrographic data and made benthos and plankton collections at a number of these locations. Although most of the material awaits examination, several range extensions have been noted in the material especially in collections from deep (150-180 m) water at the mouths of Franklin and Darnley Bays. These appear to be the deepest collections of bottom fauna yet made in the Beaufort Sea region, and they have provided the first records from the western arctic of several relatively deep-water North Atlantic species indicating the probability of continuous deep-water distribution north of the Canadian arctic islands.

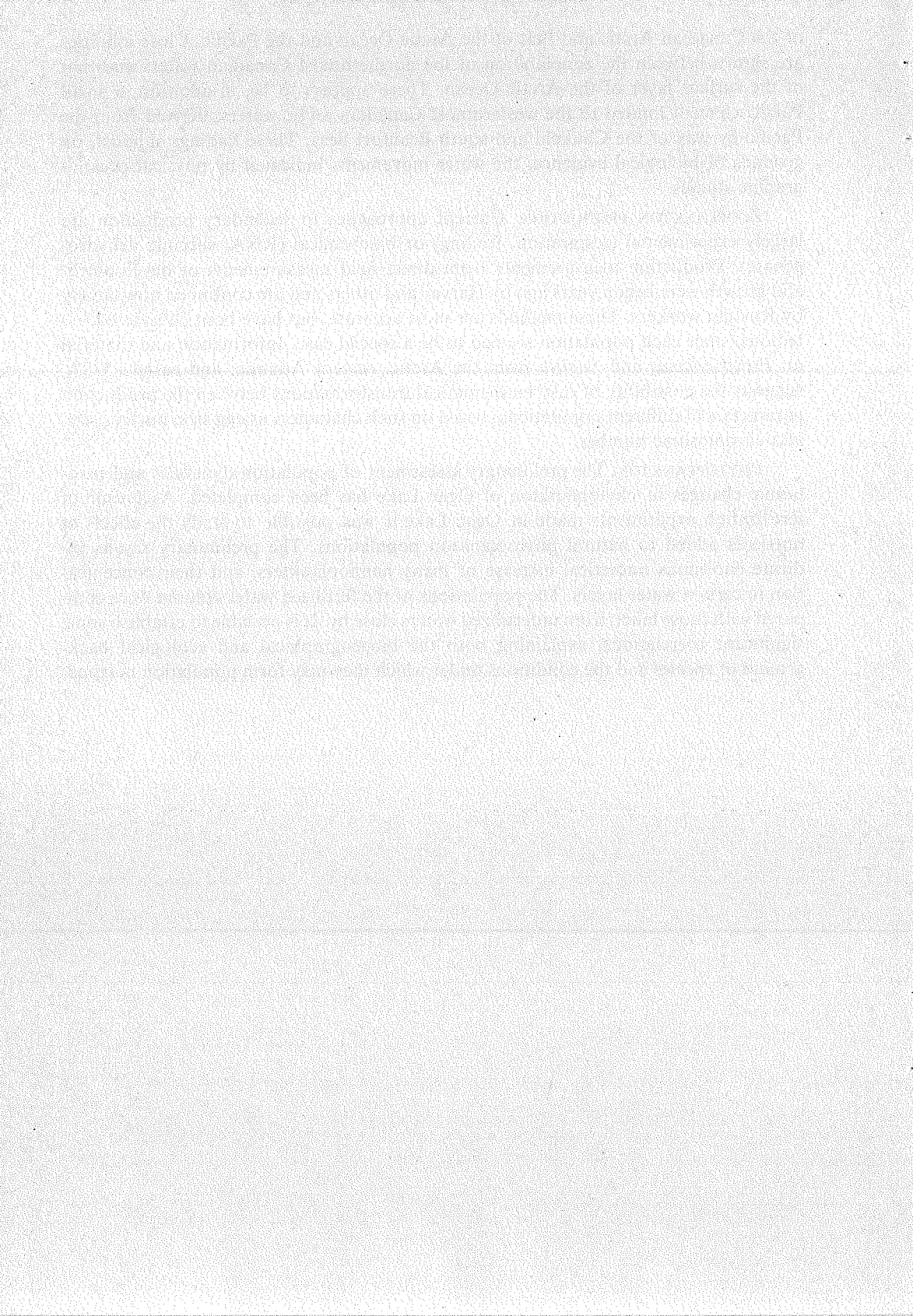
Participation in the "Northwestlant 2" part of the 1963 Environmental Survey of Greenland Waters planned by the International Commission for the Northwest Atlantic Fisheries resulted in the collection of a large amount of zooplankton and phytoplankton material. Analysis of about 75% of the zooplankton collections has been made to date and a number of standing crop estimates have been calculated. About 50 zooplankton species have been identified in the collections which are dominated by copepods (16), followed by amphipods (10), medusae (5), euphausiids (4), chaetognaths (3), and pteropods (3).

Zooplankton material taken on the 1962 Archipelago Survey in M'Clure Strait and in the vicinity of Cambridge Bay was studied during the year. The considerable material now identified from the southeast Beaufort Sea, Amundsen Gulf, M'Clure Strait, Prince Gustaf Adolf Sea, Peary and Sverdrup Channels, Nansen Sound, and from the Arctic Ocean immediately offshore from the northwest islands is being analysed as part of a study of the relationships between the zooplankton of the waters

of the Canadian Arctic and that of the Arctic Ocean and the Pacific. Close affinities are shown between the zooplankton of the northernmost Canadian waters and that of the surface layer of the Arctic Ocean. There appears to be, in addition, a small Pacific element limited to the westernmost Canadian arctic waters, derived from the Pacific by way of the Chukchi and south Beaufort Seas. These findings support, on grounds of biological evidence, the water movements indicated by physical oceanographic studies.

ZOOPLANKTON PRODUCTION. Current approaches to secondary production are largely experimental (respiration, feeding) or biochemical (RNA, succinic dehydrogenase). Production measurements from direct field measurements of development and growth were begun years ago by Harvey and others and are continued now largely by Russian workers. These methods are most accurate, but have been considered too tedious, since each population seemed to be a special case. Information and material on *Pseudocalanus* and *Sagitta* from the Arctic, eastern Atlantic, and eastern USA, suggests the possibility of easy mathematical transformations between the production parameters of different populations, based on such characters as egg size, nucleus size, and chromosome number.

PHYTOPLANKTON. The preliminary assessment of population dynamics and taxonomic changes in phytoplankton of Ogac Lake has been completed. As a result of fertilization experiments made in Ogac Lake it was possible to study the effects of nutrients added to natural phytoplankton populations. The preliminary results indicate enormous numerical increase of many nanoplankters, and their concentration in certain water layers. The populations of the fertilized water column were compared with those taken from unfertilized waters close by. It is possible to establish some significant correlations, explaining both the biogeographical and ecological background of species and the conditions under which they form population maxima.



TECHNOLOGICAL RESEARCH LABORATORY, HALIFAX, N.S.

(including the St. John's Unit and the Grande-Rivière Station)

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The activities of these laboratories are directed towards increasing the scope and value of Canadian fisheries and all living aquatic resources through scientific research.

Emphasis has continued to increase in those research areas concerned with enlarging the fisheries resource through scientific manipulation of live animals. Studies on cold storage, freezing of sperm, and on lobster and oyster diseases, are typical examples.

QUALITY OF FRESH AND FROZEN COD

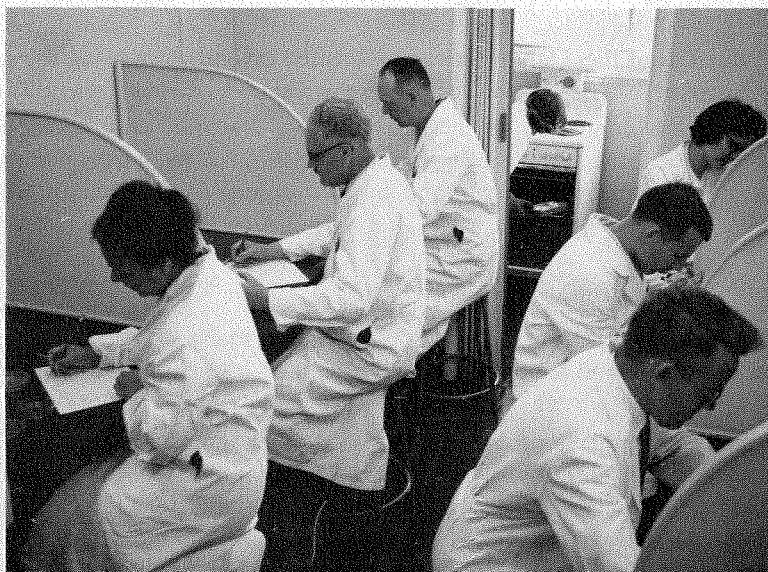
Radiation pasteurization has been demonstrated to extend markedly the storage life of scallop muscle and haddock fillet at ice temperature. Similar studies are now in progress with cooked lobster meat.

Non-bacterial spoilage problems in cod and other species are already of concern to industry, and the adoption of radiation pasteurization and other advanced processing methods will increase the significance of these studies. The physical and chemical relationships between the lipids and non-lipid portions of the muscle, and the physiological condition of the fish at the time of catching, are fundamental to an understanding of non-bacterial spoilage. Studies on metal-induced rancidity show that there are seasonal variations in the susceptibility of fish in this regard. Thus, the effect of added salt varies with the season and may be either beneficial or deleterious, but the addition of small amounts of free fatty acids, such as are normally liberated during frozen storage, inhibits rancidity.

The proteolytic enzymes of cod have been detected in the muscle, blood, and skin of cod and current isolation procedures suggest that the level of activity in blood and skin may be higher than in muscle. The optimum conditions for the activity of these enzymes have been determined and studies are being carried out to correlate proteolytic activity and some of the conditions of the fish before and after death. Starved and fed fish, for example, differ in a number of physiological aspects. These physiological variations are particularly important in areas such as the Gulf of St. Lawrence where summer water temperatures tend to be higher than in other fishing

areas, but the same effects may also significantly influence the quality of Newfoundland trap cod.

In trawled fish, the energy reserves in the muscle were found to be exhausted or nearly so, whereas in trap cod, as brailed into the boat, considerable energy reserves remained. Even in aquarium-held cod, netted and killed quickly by stunning, some glycolytic activity had occurred. Levels of glycolytic metabolites under conditions which closely approach those in the living, rested animal have been determined. Only traces of lactic acid were present; very high glycogen levels, up to 700 mg/100 g, along with a high content of high-energy phosphate compounds, were found. The concentration of these metabolites varied greatly throughout the musculature, as did the degree of stiffening during rigor mortis as measured by a penetrometer technique. The severity of the death struggle influenced the time to development of maximum rigor.



Taste panels play an important role in determining the quality of frozen or irradiated fish after various storage periods.

In collaboration with the Gloucester Technological Laboratory of the U.S. Bureau of Commercial Fisheries it has been shown that water thawing of frozen fillet blocks is as effective as microwave thawing. There was no difference in the quality of refrozen fillets from cod frozen either in the prerigor or postrigor states, or by brine or plate freezing methods, with 12 months' storage at -18°C . Protein extractability decreased gradually over the storage period, and quality as assessed by taste panels had fallen to borderline acceptability at 12 months. As previously found in refrozen trap cod fillets there was a very rapid increase in free fatty acid formation in the 2-month period following refreezing.

In a collaborative series of tests with the Information and Consumer Service of the Department of Fisheries, Ottawa, the cooking method greatly influenced the

palatability of cooked frozen fillets. Frying improved the acceptability of products of poor or doubtful quality. Quality differences due to deterioration in frozen storage were readily detected in baked or steamed samples by a taste panel, whereas differences in prefreezing quality of the fillets were less readily apparent. Thus, for taste testing by an analytical taste panel, baking or steaming cooking procedures are preferable to frying.

A commercial electric fish tester shows promise for appraising the total storage life of fall-caught, Newfoundland cod independently of days storage in ice at time of examination. The tester confirmed organoleptic assessment of worsening quality with storage.

The "blackberry" odour in Labrador cod has been identified as dimethyl sulphide. This material, and a precursor, dimethyl- β -propiothetin, are formed in marine algae and invertebrates. In some species of Pacific salmon the precursor accumulates and may liberate additional dimethyl sulphide on cooking. Investigation of the precursor-sulphide relationship in cod will be necessary to determine possible remedial measures.

NEWFOUNDLAND COD

The possibility of benefits from handling trap cod alive for a few hours to ensure controlled conditions of killing, processing, and freezing has been suggested. However, data obtained in 1963 as the result of freezing, storing, and taste testing fillets of fish held alive for $2\frac{1}{2}$ – $5\frac{1}{2}$ hr would suggest that live carrying contributed little to improved storage quality. The taste panel has evaluated frozen fillets prepared from trap fish held alive for two weeks before processing and those prepared from fish killed at the traps. Live holding at 42°F resulted in significantly better textured frozen, stored fillets, followed by live holding at 32°F, no holding at all (fish killed at trap), and live holding at 52°F. Fall fish of initial high quality and possessing good frozen storage potential yielded fillets of equal quality on live holding at either 35°F or 52°F.

In an attempt to appraise the relative merits of pre-rigor, in-rigor, and post-rigor freezing, the taste panel, trained to distinguish texture and taste characteristics, has examined frozen fillets of iced and uniced fish killed at the traps and from live holding tanks (trap- and fall-caught fish). These investigations, which will be the subject of a published report, show close agreement in grades given trap fish frozen in the three states of rigor. Mealiness is prevalent in pre-rigor samples and chewiness in the others. Appreciably better grades were given to in-rigor as compared to pre-rigor frozen fall fish. Long-term storage (8½ months) indicated somewhat better characteristics for the fillets frozen pre-rigor.

During 1963, methods of exhausting cod prior to killing were examined tentatively, since in the freezing industry there would appear to be some merit in using very fresh fish in which the pH is near neutrality. Methods used for exhausting the fish were adequate to provide exercised fish for small-scale experimental work only. The pH of exercised fish did not drop after the fish were killed, in contrast to the drop in normally killed fish. The glycogen level in exhausted fish was only 40% of that in the control.

A continuation (1963) of earlier work conducted on fillets treated with sodium tripolyphosphate prior to freezing and storage has shown that treated fillets of trap

cod could have greater market acceptance than the untreated pack, having a better texture.

Tests were conducted to check the suitability of the technique used by the Board on the east coast for measuring thaw drip. The drip-time curves for polyphosphate-treated and untreated fillets assumed the same form, the drip collected rising rapidly in initial stages of storage at 2–3°C and then tapering off. Thus, the technique for collecting drip over a 48-hr period may be used in comparing drip from treated and untreated samples without in any way prejudicing the case of the treated as against the untreated pack. The density of polyphosphate-treated and untreated cod fillets was found to be essentially the same, thus assuring the block producer that density of the flesh in itself is not an important factor in underpacked and overpacked cartons. Little difference was found in the amount of thaw-drip from frozen cod when two laboratory methods of thawing were compared—the Gloucester method, samples thawed in contact with drip at 70°F, and the Board method (East Coast) where fish is not in contact with drip and thawing is carried out at 2–3°C for 48 hr.

Two large producers of frozen cod blocks and fillets received assistance in training personnel to enable them to set up taste panels in their respective plants. However, concrete results can be expected only if industry itself has capable people on staff, or outside, to set up, to operate, and to check panels periodically.

DISEASES, NUTRITION, AND PARASITISM

Epidemics of Gaffkaemia (a fatal bacterial infection of lobsters) occur periodically. This investigation is concerned with the prevention, prediction, and/or control of this disease. One phase of the study concerns the natural and inducible defences against diseases possessed by the lobster.

Lobster haemocytes (blood cells) are thought to be a part of these defence mechanisms. Thus it is important to know the lobster blood cell counts and the effect of captivity, feeding, starvation, infection, immunization, and other factors on the numbers of cells. Suitable conditions have been found to allow the use of an electronic counter for obtaining rapid and accurate lobster haemocyte counts. This method was applied to a study of lobsters held captive, starved, and fed. The results show that a spectacular reduction in cell numbers accompanied starvation or a poor diet. The blood proteins followed the same pattern. This study emphasized the important role that nutrition plays in the prevention of excessive bleeding after the animal has been wounded and in non-specific resistance to infection.

The lobsters from this experiment were boiled, the meat removed from the tail and large claws and weighed. The well-fed group had a meat yield of approximately 25% of the live body weight, while the starved group had 10%. This is a 60% loss and again points up the importance of nutrition, especially for lobsters held captive.

Western red cedar was shown to contribute to sea water materials toxic to lobsters, while Douglas fir, black spruce, eastern fir, redwood, and Tennessee cedar did not. The highly coloured extracts from redwood and Tennessee cedar would militate against their use in lobster tank construction. Western red cedar very definitely should be avoided.

Collaborative work with the lobster investigation at St. Andrews consisted of making blood cell counts and blood protein measurements on a group of lobsters

held for moulting temperature studies. Conclusions from this study cannot be drawn until the work is completed.

The outstanding disease of oysters is commonly called "Malpeque" disease and has had disastrous effects on oyster stocks. This disease could interfere greatly with the oyster farming which is expected to develop as a direct result of the oyster hatchery at Ellerslie, P.E.I. Studies are directed toward gathering sufficient information on this disease so as to be able to predict, prevent, or control outbreaks.

Information on the infective agent is lacking. One of the best tissues for propagating the infective agent should be oyster tissue or tissue from other cold-blooded animals. Rainbow trout gonadal (RTG) cells have been grown for this purpose and a study of the nutritional requirements necessary for producing normal RTG cells was made. Similar work with oyster tissue has not as yet been as successful, but reasonable proliferation of new cells has occurred.

Serological studies made on Malpeque disease-resistant and susceptible oysters show that there is at least one antigenic difference between them. Further work is in progress to determine whether resistant and susceptible oysters can be distinguished one from the other routinely on this basis or whether this characteristic stems from population differences.

Although the presence of parasites in fish has been recognized for a long time, no attempt has been made to evaluate the effect that they might have on the host. This study is an attempt to first establish the normal physiological conditions as found in the cod, especially in reference to blood. Secondly, to evaluate the changes that may occur in the case of a parasitized fish, and whether these changes are harmful or beneficial. Thirdly, to correlate these changes with the future behaviour of the host.

The normal blood pattern has been established on an inshore population of cod. This has included the erythrocyte count, packed cell volume, haemoglobin level, mean corpuscular volume, mean corpuscular haemoglobin concentration, total blood volume, and acid-base value.

Controlled bleeding of cod to simulate the blood losses that may occur under high levels of parasitism have indicated that it is possible to remove over 100% of the total volume of blood in a cod in a 30-day period. Fed fish are more capable of replacing blood than starved ones. The spleen maintains an important haemopoietic function in these vertebrates. The acid-base volume of the blood is maintained even at extremely low levels of cell counts.

BIOCHEMISTRY OF COD

The original one year program of sampling Terence Bay cod at monthly intervals has been extended slightly to permit an overlapping period for confirmation of initial results obtained in this study. Supplementary samples of large sexually mature cod were obtained by trawling in the same area. The data obtained by the various groups studying these fish is currently being processed.

Electrophoretic patterns of albumin and blood sera are specific for different fish species but the identification of populations within a species appears to be complicated by factors such as sex or state of maturation. "Standard" cod antisera have been prepared for examination of a variety of cod to establish if particular precipitin bands are characteristic of different populations.

Procedures have been established for the rapid separation of certain nucleotides and nucleosides of cod muscle. These will be examined in connection with post-mortem changes.

MARINE HORMONES

The problem of maintaining stocks of salmon sperm continues to be actively investigated. Although varying results were obtained, possibly dependent on the original state of maturity of the sperm cells, it was established that stored samples of salmon sperm require free access of oxygen for optimum fertility. Attempts to hold sperm in frozen storage continue to be unsuccessful, but an inactivating diluent saline has had some success.

Adult spawned female Atlantic salmon held in sea water resumed feeding as the water temperature increased in summer and gonad development was noted. Attempts at artificial induction of sexual maturation through hormone treatment led to the death of the fish, probably due to the effect of one hormone, although lack of knowledge as to when water salinity should be changed may also have been a contributing factor.

Hormone analyses in the blood of Atlantic salmon have been successful in eliminating previously reported discrepancies in such analyses and this work is being extended to cod and other marine life.

MARINE LIPIDS

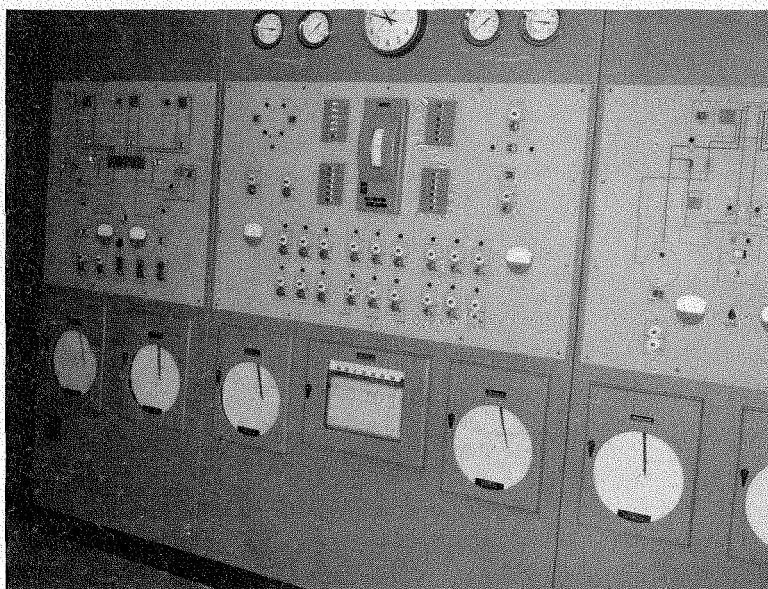
The introduction of the longer-chain highly unsaturated fatty acids characteristic of marine life into the oceanic food chain has been shown to occur in at least one important species of phytoplankton, *Skeletonema costatum*. Previously it had been considered that zooplankton synthesized these acids from shorter-chain precursors. Furthermore, the triglycerides of this diatom had the characteristics postulated for fats in the marine food chain in that these "essential" fatty acids occurred in the β -position. This postulate was also verified by feeding radioactively-labelled fats to lobster, cod, and trout and through zooplankton analyses.

Other investigations in progress include those on the stereochemical structure of marine fats and on lipases of marine species including the phospholipases of cod flesh. Analyses of the depot fats of local teleost fish suggest that the fatty acid compositions are remarkably similar with minor variations in the proportions of polyunsaturated fatty acids largely accounting for changes in iodine value, etc.

PROCESS AND PRODUCT RESEARCH

The use of less expensive raw materials such as cod trimmings (eviscerated cod after the fillets have been removed), whole cod, eviscerated cod, press cake, and oily fish such as herring, for making fish protein concentrate has been studied. These materials also yield an excellent product, although the colour is slightly off-white (cream coloured). The presence of bones causes a slight reduction in the percentage protein. The use of the above low-cost raw materials for fish protein concentrate makes available a source of fish protein concentrate of excellent nutritional quality at a lower cost where the white colour and soft texture of the cod fillet concentrate is not required.

The successful application of freeze drying in other types of foods has not been paralleled in marine products. Active investigations in this field have determined some of the limiting variables, such as maximum allowable temperature and sample thickness. Efforts are now being concentrated on means of increasing the efficiency of heat transfer, since economic operation of this relatively high cost process will require maximum output commensurate with a good quality product.



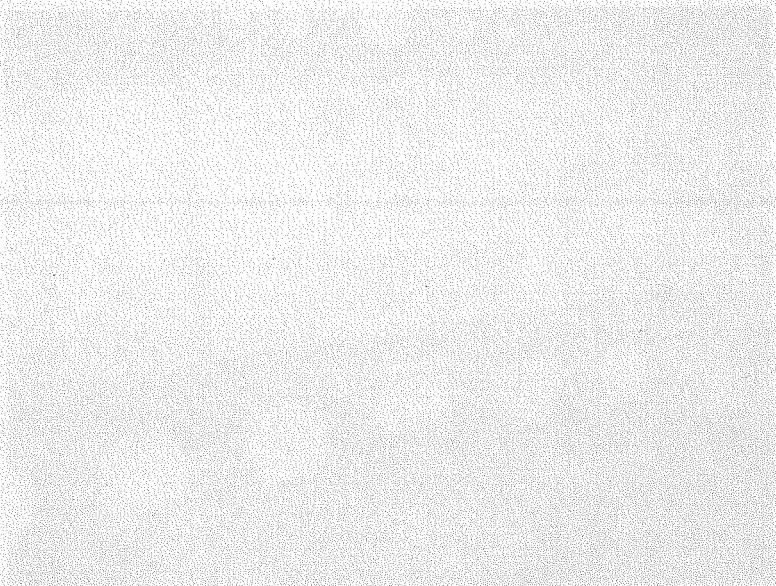
Instrument panel for controlling and recording temperatures in experimental storage facilities.

LIVE FISH AND SHELLFISH HOLDING AND OTHER FACILITIES

Experience gained over the past two years showed how deficiencies in the live holding facilities could be corrected and a greater demand for space has resulted in several modifications and additions in the live fish and shellfish holding facilities at Halifax. Three additional sea water intakes were added along with high-capacity pumps to increase the flow of water. Three large sand and gravel filters were installed permitting all of the water used to be filtered before use. The sea water piping has been extended to include the main building. Filters with accompanying equipment have been acquired for the purpose of supplying clean, chlorine-free fresh water for freshwater species and maintaining brackish water conditions for work with all species. In addition, a large concrete outdoor tank has been built and will be supplied with running sea water for holding and working with a variety of marine species.

Improvements have also been effected in the live holding facilities at Grande-Rivière and St. John's. In all three laboratories the installation or improvement of walk-in refrigeration facilities will greatly assist work with heat-labile materials.

The experimental cold storage equipment at Halifax has been completely modernized and the facilities include standby equipment capable of protecting long-term experiments against both equipment breakdown and any reasonable failure in outside electrical power supply.



TECHNOLOGICAL RESEARCH LABORATORY, VANCOUVER, B.C.

(including the Technological Unit, London, Ont.)

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ENGINEERING INVESTIGATIONS

Rapid progress has been made in development of two original fish unloading systems. The first of these employs alternate suction and pressure cycles without passing the fish through the centrifugal pump which provides the necessary water velocity required to lift them. A full scale model of this unloader was built by a local company and successfully used for unloading cannery salmon. The second unloading device employs the "air-lift" pumping principle and appears to offer great promise for "low-lift" transfer of fish. Successful field tests of an 8-inch model have been made. Public service patent protection for these devices is being sought.

Plant tests on vacuum cooling of precooked tuna were initiated this year. A 10-car retort in a local plant was reinforced for vacuum service and equipped with devices for steam condensation, removal of non-condensable gases by vacuum, and ejection of condensing water. Tests were conducted over a 3-week period. Bursting of some fish during rapid cooling was overcome by use of vacuum during a 185°F precook. An important finding was that the tuna could be cleaned and further processed immediately after cooking with consequent significant time saving.

This year refrigeration systems developed in this Laboratory have been installed on many Canadian fishing vessels. Thus B.C. salmon packers with combined capacities of 1,250,000 pounds of fish were equipped with refrigerated sea water systems, and brine spray tuna freezing systems were installed on two New Brunswick tuna seiners. The *Royal Pacific*, the largest fishing vessel built in British Columbia in recent years, has also been equipped with the brine spray freezing system and with dry cold storage space. A sister ship in course of construction will be similarly equipped, and it is expected that these vessels will employ this equipment to freeze halibut at sea next year.

The possible use of larger containers for packaging herring meal is being investigated. Bin-bags of $\frac{1}{2}$ - and 1-ton capacities were filled with antioxidant-treated and untreated meals and the temperature rises recorded during storage. Heating of the

meals was not excessive in either series, perhaps partly due to cool storage temperatures, the good quality of the meal and the use of winter-caught herring. Some difficulty was encountered in unloading the bags. The investigation is continuing and it is expected that trials will be made involving bunker railway cars.

PRESERVATION OF FRESH FISH

The findings described in last year's report regarding possible relations between post mortem metabolism and changes in sodium, potassium, and magnesium concentrations in the muscle of fish stored in refrigerated sea water (RSW) have been confirmed. In addition experimental evidence has been obtained that post mortem metabolic activity influences the course of the weight changes observed when either whole fish or skinned fish muscle are immersed in RSW.

Storage of fish at -4°C in RSW fortified with 4% salt has been investigated as a possible means of preventing "belly-burn" (proteolysis of the visceral cavity) in fish intended for canning. The procedure partially freezes the fish and has been found to prevent "belly-burn" and also putrefaction of gut contents for periods up to 2 weeks. However, although the method has also proven to be satisfactory from the point of view of weight changes, development of drip, denaturation of protein and salt penetration into the flesh, it has been found that rancidity develops very rapidly particularly in the lipids of the red lateral muscle. The results of preliminary experiments have indicated that if air can be excluded from the storage tanks this difficulty can be overcome.

A request from the fishing industry has prompted an investigation into the cause of "chalky halibut". With the support of the International Halibut Commission and the co-operation of a fishing company, samples for histological and biochemical studies have been obtained. It appears the condition may develop post mortem and may be related to the pH of the muscle. This requires confirmation.

An extensive investigation of the bacterial spoilage of raw shrimp meat has been completed. Certain cultural and biochemical characteristics of several typical bacteria responsible for shrimp spoilage have been determined, and great variations in the sensitivity of the organisms to four tetracycline antibiotics have been recorded. The effect of sea water and of magnesium ions in overcoming the desirable bacteriostatic qualities of antibiotics of the chlortetracycline group has been confirmed. Extracts of shrimp shells have a similar effect. Attempts to overcome the above undesirable effects which lessen the value of antibiotic treatments have met with some success in that the simultaneous use of an agent (ethylenediaminetetracetic acid) which inactivates ions such as magnesium greatly improves the effectiveness of antibiotics in preservation of raw shrimp.

PHYSICAL AND CHEMICAL CHANGES IN FROZEN FISH

Methods already available for determination of development of toughness in stored frozen fish are useful within certain limitations, and moreover certain of them are not applicable to cooked fish. Last year an apparatus was designed to measure the shear force required to cut small bundles of muscle fibres. Fairly extensive tests with samples of frozen fish stored at different temperatures have indicated that measurements with this equipment are unlikely to prove reliable as an indication of

development of toughness in the raw or cooked samples. Other tests have shown that hydrolytic rancidity develops as rapidly in frozen fish stored in nitrogen as in that stored in air, and that results of peroxide value determinations and taste tests suggest that oxidative and not hydrolytic rancidity is largely or entirely responsible for rancid off-flavour development in frozen fish.

Fairly extensive trials have been made in order to assess the value of certain polyphosphates and of sodium or potassium citrate in retarding exudation of free liquid (drip) which so frequently occurs in fillets of fish such as sole and cod. The gain in weight following treatment usually averaged about 2.5% and was thus very little more than that usually experienced in a brief dip in water or in dilute salt solutions. In most instances the polyphosphate and sodium citrate treatments reduced "thaw drip" considerably, and there was some evidence of control of oxidative rancidity in polyphosphate-treated samples. Polyphosphates have advantages over ordinary salt as agents for retarding drip in frozen fish in that salt normally accelerates oxidative rancidity development and contributes a somewhat salty flavour.

As a result of certain requests fairly extensive trials are being made to ascertain the comparative effectiveness of several newer and more economical types of packages in preventing desiccation during storage of frozen fish.

PROTEIN PATTERNS AND SPECIATION

Factors influencing the overall electrophoretic muscle myogen and hemoglobin patterns of the genus *Oncorhynchus* have been extensively investigated. This study of 650 adult sockeye salmon from 27 racial stocks in the Pacific Northwest ranging from the State of Washington, the Province of British Columbia, and the State of Alaska, has established that the electrophoretic patterns of muscle myogens and hemoglobins are essentially invariable and specific properties of this species, and are not affected by differences in sex or maturity during the period of spawning migration or by the slight differences in environmental conditions at their spawning grounds. A single analysis from one fish suffices to establish identification. The chum and pink salmon also display the same phenomenon. During these studies the number of natural "hybrids" encountered may suggest that hybridization occurs to an extent greater than formerly believed.

Muscle myogen and hemoglobin analyses of the fishes of the Pacific West Coast have also been studied. One hundred and fifty seven samples of muscle myogens and blood proteins representing 35 species from three (*Elasmobranchii*, *Holocephali*, *Teleostomii*) of the four living classes of fishes from the superclass, *Gnathostomata*, each showed species specific patterns. Familial and generic similarities in their myogen patterns compared roughly with Berg's classification of fishes. Evidence for the existence of at least three variations of black cod (sablefish) were found. The relationship indicated one of natural hybridization. Fairly widespread differences in the myogen patterns of other species also indicate a degree of variation which suggests the occurrence of several variants in these species of fishes. These variations cannot be reconciled with the remarkable uniformity observed in 650 individual sockeye salmon.

STUDIES USING LIVE FISH

Collection of the glands necessary for the study of the pituitary hormones of Pacific salmon is now a routine procedure. About 20,000 chinook salmon glands were collected at the Green River and Spring Creek Hatcheries in the State of Washington. Gonadotropic hormone activity has been partially purified using the technique of starch gel electrophoresis with the frog gametokinetic response as bioassay. The partially purified fraction induced spermatogenesis when injected into immature steelhead trout. More recent experiments have been directed at the purification of salmon corticotropin using as bioassay changes in the blood levels of corticosteroids in rainbow trout induced by injected hormones.

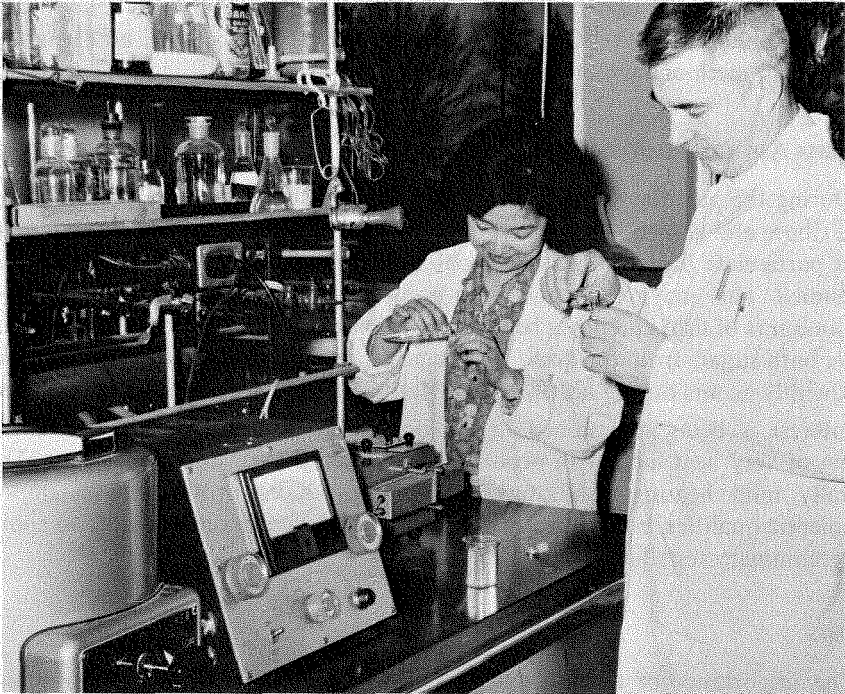
Studies on the attractants present in food (marine zooplankton) and in home stream waters have continued. An improved bioassay system for the food attractant has been developed. Using paper chromatography a partial purification of this attractant has been achieved. Experiments with the home stream attractant for sockeye present in the water of Great Central Lake suggest there are two components of differing volatility.

The possibility that pre-spawning sockeye salmon will feed voluntarily in fresh water has been investigated. Great Central Lake "green" sockeye were tagged, weighed, and divided into two groups. One group was offered marine zooplankton as food a few days after capture. At the end of 6 weeks about 60%, and by the end of the third month, virtually all of the fish were feeding. The second group is serving as unfed controls. A few spawned, feeding fish are still alive at the time of writing, but it is too soon to be able to say whether any will survive the effects of spawning. It is hoped this study may help to clarify the role of starvation in the post-spawning death of Pacific salmon under natural conditions. Histopathological examination of several organs and tissues of fish from both groups is in progress. These and related studies will continue. The occurrence of jaundice in some mature sockeye has been confirmed by tests which show a very marked increase in plasma bilirubin levels (from 0.01–0.39 to 3.52–8.65 mg/100 g) in the jaundiced fish.

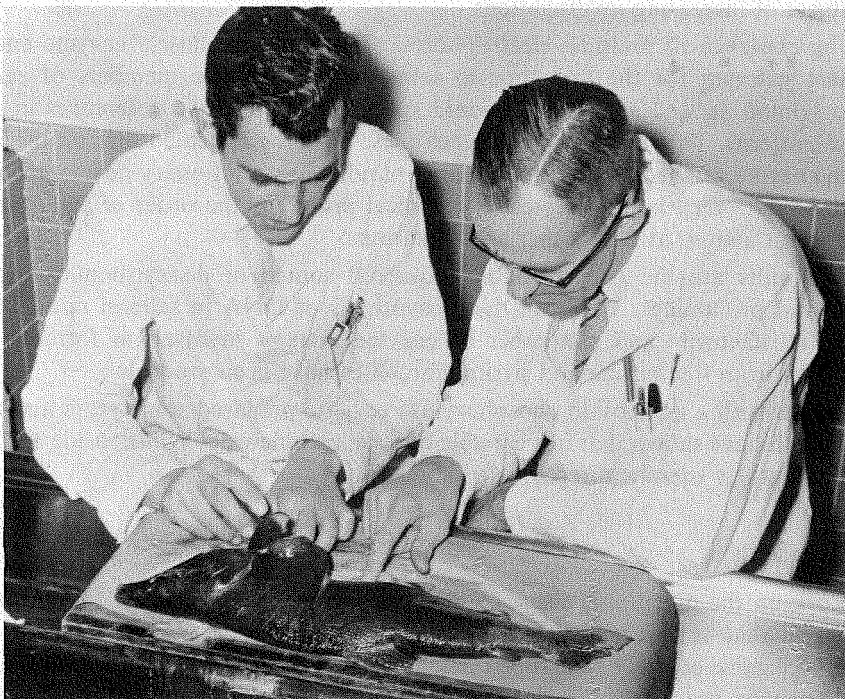
An investigation of the biochemical changes accompanying the parr-smolt transformation in Pacific salmon was initiated. It was found that a new group of hemoglobins ("adult" hemoglobins) are synthesized during this transformation and that both "adult" and "fry" hemoglobins are present during the remainder of the life cycle of coho and sockeye salmon. It has also been shown that the live weights, body protein nitrogen, moisture and lipids of pink salmon increase for the first 5 weeks after they enter the sea and then decrease for the following 2 weeks prior to their emigration from coastal waters.

In continuing the work on lipid metabolism in fish it has been shown that the fatty acid oxidizing system of the mitochondria from the dark lateral line muscle of salmon resembles that of mammals. The fatty acid oxidizing system in tissues of juvenile sockeye salmon has been found to have a wide spectrum of activities in different tissues similar to that observed previously in the tissues of adult salmon. A study of non-esterified fatty acids and ketone bodies in fish blood is in progress.

In continuation of studies of possible precursors of trimethylamine, choline has been found to be a much better precursor than other compounds examined. Very



Performing a salmon hormone assay using a fluorimeter.



Post mortem examination of a spawned male sockeye salmon.

limited formation was observed from γ -butyrobetaine-methyl- C^{14} , betaine-methyl- C^{14} , and methionine-methyl- C^{14} . Choline was converted to betaine, and betaine was labelled from methionine-methyl- C^{14} .

PROBLEMS ASSOCIATED WITH FISH CANNING

During the past few years extensive studies have demonstrated the origin of the sugars ribose and glucose which arise in chilled fish flesh during post-mortem storage. Also a particulate bacterial enzyme capable of degrading these sugars was prepared and studied. This enzyme has now been prepared in quantities sufficient to apply to small amounts of fish, and it has been found that in a day or two at 32°F it will largely remove both sugars from the flesh. This removal severely curtails the browning which so frequently occurs during heating of the flesh of certain species of fish as in canning.

Interest is being maintained in the possibility of using certain antibiotics in canning of very heat labile fish products such as crab meat and oyster stew. Use of unusually mild heating conditions definitely produces products with improved organoleptic qualities, but naturally may render the products more liable to spoilage. Only preliminary tests have been made so far.

ENZYMES

The importance of enzymes in mediating vital biochemical reactions and in producing new and interesting biochemical compounds is well recognized, but it is only in recent years that the occurrence and properties of these agents in fish has been the subject of increasing investigations.

The existence of multiple electrophoretic forms of the muscle enzyme enolase was demonstrated for the first time in salmon flesh. All five members of eastern Pacific salmon as well as other salmonid species showed slight differences in their enolase patterns. The relationship between these patterns indicated that a functional protein enzyme can also evolve in a manner parallel to evolutionary development. In fact, these data may be interpreted as chemical proof for the order of evolutionary development arrived at from other considerations.

Fish milts are the best available industrial source of deoxyribonucleic acids (DNA) and protamines. Work on the biosynthesis of DNA in salmon milts is proceeding satisfactorily and a number of enzyme systems involved in formation of nucleotides from free purine and pyrimidine bases have been studied.

Studies with a nucleoside phosphorylase enzyme prepared some years ago from lingcod flesh have shown that it is capable of forming a new deoxynucleoside and also that it can utilize adenine directly as a substrate.

MISCELLANEOUS

Work on the nutritional value of B.C. herring meals has proceeded, and it has been found that antioxidant treatment has several advantages. Thus it assures that the metabolizable energy of the meals is higher, the oils are better utilized by poultry, and the protein nutritive value is superior. Studies concerning the effects of herring meal on egg hatchability are in progress.

Use of a new chromatographic technique for the characterization of nucleotide derivatives has demonstrated a rapid increase in inosinic acid in Pacific oysters immediately after they are removed from the shell, and other nucleotides have also been characterized. Studies on chemically synthesized nucleoside-3',5' cyclic phosphates, a class of compounds which are involved in glycogen metabolism, have shown that they have unusual stability to acid and also that an enzyme in brain tissue rapidly hydrolyses the purine nucleotides.

The resignation of a scientific staff member forced severe curtailment of a flavour research program. However, one study of volatile compounds in Pacific oysters has been completed. It has been found that methyl sulphide is a predominant component of the characteristic odour of fresh oysters, and that as spoilage occurs methyl mercaptan and, to a lesser extent, other mercaptans and hydrogen sulphide form.

Two analogs of coenzyme B₁₂, containing deoxyribose, were prepared. They were subjected to chemical and enzymatic studies and the results are being published. Photolysis studies of methylcobalamin indicated that in the presence of excess oxygen this coenzyme B₁₂ analog, through a series of postulated free-radical reactions, decomposed to produce formaldehyde in 80% yield while under strict anaerobic conditions methyl cobalamin was stable to light. When oxygen uptake was measured one mole of oxygen was consumed per mole of cobalamin photolyzed.

TECHNOLOGICAL UNIT—LONDON, ONTARIO

The past year saw implementation of a joint plan of programming in which the Vancouver Laboratory assumed overall responsibility for the research of the Unit. Existing programs were terminated in favour of new programs, and progress is being made in preparing existing data for publication.

Suitable techniques were developed for canning of inconnu, suckers, smelt, alewife, and burbot livers, but not for burbot flesh which does not give an acceptable product. Changes were made in design of the Unit's smokehouse in order to reduce labour requirements and yield products with improved external appearance. It is hoped that this smokehouse may eventually be developed into a large-scale industrial unit.

Work in connection with a program that has as its general objective improvement in quality of freshwater fish has commenced, and initially studies are concentrated on yellow perch. The effect of location, food, sexual development, exhaustion, and other factors on subsequent keeping quality of fresh and frozen fish is being assessed. Since no really reliable objective tests are available, organoleptic tests are presently used as general criteria of quality. Perch caught on different days and held live in a large tank proved to differ in appearance and disease resistance. Fish held 3 weeks without feeding kept satisfactorily 15–18 days in ice after killing and evisceration. Holding such fish 8 hr at 80°F after death, a treatment which could arise under certain fishing conditions, reduced this "shelf life" to about 3 days. With trap net fish it was found that the "shelf life" of fish which were eviscerated after killing was 18–21 days, and only 10–13 days for non-eviscerated fish. An experiment designed to determine the effect of season on keeping quality of perch frozen and stored at -10°F is in progress.

Experiments to determine the comparative effects of chilling of perch by a 32°F water spray and of icing on quality of the fresh and frozen product are in progress.

With appointment of a biochemist to replace a bacteriologist who resigned early in the year, an investigation on speciation of certain freshwater fish using the protein pattern technique referred to previously has been initiated and considerable progress has already been made.

PUBLICATIONS AND REPORTS

The publications and reports of the Board for 1963 were as follows: (1) the *Annual Report* for the fiscal year ended March 31, 1963; (2) No. 137-141 of the series of informative *Bulletins*; (3) Vol. 20, No. 1-6 of the scientific *Journal*; (4) No. 38-41 of the *General Series of Circulars* of the Biological Station, St. Andrews, N.B.; (5) No. 6 of the *Circulars* of the Biological Station, and Technological Unit, London Ont.; (6) No. 67-71 of the *Circulars* of the Biological Station Nanaimo, B.C.; (7) No. 11-12 of the *Statistical Series of Circulars* of the Biological Station, Nanaimo, B.C.; (8) No. 1963-1 to 1963-6 of the *Circulars* of the Pacific Oceanographic Group, Biological Station, Nanaimo, B.C.; (9) No. 27-29 of the *Circulars* of the Technological Research Laboratory, Vancouver, B.C.; (10) No. 12-13 of the *Circulars* of the Technological Research Laboratory, Halifax, N.S.; (11) No. 776-817 of the *Studies* series (articles published in other journals).

The Annual Report, Bulletins and Journal are available to anyone by purchase. Issues as they appear are listed, with prices, in the Daily Checklists published by the Queen's Printer, and also in the Monthly and Annual Catalogues of Canadian Government Publications. Applications for purchase of publications should be made to:

THE QUEEN'S PRINTER,
OTTAWA, CANADA.

Circulars may be obtained from the Board establishment which issues them, while the supply lasts. Separates of articles (*Studies* and others) not printed by the Board are not for sale, but may sometimes be obtained from the authors.

Enquiries concerning exchange of publications should be addressed to the Editor, Fisheries Research Board of Canada, Sir Charles Tupper Building, Confederation Heights, Ottawa 8, Canada.

The lists that follow will indicate the individual articles contained in the above publications, as well as other articles related to the Board's work that were published or distributed in 1963 (plus a few from 1962 that were not previously reported).

In addition to publications for sale or distribution, the Board prepares *Manuscript Reports* primarily for its own use. These are not available for distribution outside the Board, but may be consulted at the libraries of the Board's Stations by interested individuals who have made prior arrangement with the Director of the Station. A list of these Manuscript Reports and certain other manuscripts is included.

PUBLICATIONS ET RAPPORTS

En 1963, l'Office faisait paraître les publications et les rapports qui suivent: (1) le *Rapport annuel* pour l'année budgétaire finissant le 31 mars 1963; (2) les numéros 137-141 de la série des *Bulletins* d'information; (3) Vol. 20, les numéros 1-6 du *Journal* scientifique; (4) les numéros 38-41 de la «General Series of Circulars» de la Station biologique de St. Andrews, N.-B.; (5) le numéro 6 de la série des «Circulars» de la Station biologique et de l'Unité technologique de London, Ont.; (6) les numéros 67-71 de la série des «Circulars» de la Station biologique de Nanaïmo, C.-B.; (7) les numéros 11-12 de la «Statistical Series of Circulars» de la Station biologique de Nanaïmo, C.-B.; (8) les numéros 1963-1 à 1963-6 de la série des «Circulars» du Groupe océanographique du Pacifique de la Station biologique de Nanaïmo, C.-B.; (9) les numéros 27-29 de la série des «Circulars» de Laboratoire de recherche technologique de Vancouver, C.-B.; (10) les numéros 12-13 de la série des «Circulars» de Laboratoire de recherche technologique, Halifax, N.-É.; (11) les numéros 776-817 de la série des «Studies» (articles parus dans d'autres journaux).

Le Rapport annuel, les Bulletins et le Journal se vendent au public. Au fur et à mesure de leur parution, l'Imprimeur de la Reine inscrit ces publications sur les listes de vérification qu'il émet quotidiennement et elles figurent aussi aux catalogues mensuels et annuels des publications du gouvernement canadien. Les demandes d'achat doivent être transmises à:

L'IMPRIMEUR DE LA REINE,
OTTAWA, CANADA

On peut se procurer les circulaires aux établissements de l'Office qui les émettent tant que le tirage n'est pas épuisé, mais on ne peut se procurer des tirés à part d'articles (Études et autres) que l'Office ne publie pas lui-même; toutefois, on peut parfois se les procurer chez l'auteur même.

La correspondance au sujet de l'échange de publications devrait être transmise au Rédacteur, Office des recherches sur les pêcheries du Canada, Édifice Sir Charles Tupper, Confederation Heights, Ottawa 8, Canada.

Dans la liste qui suit, on trouvera les titres des articles contenus dans les publications précitées de même que d'autres articles qui ont trait aux travaux de l'Office publiés ou distribués depuis 1963 (et quelques-uns de 1962 qui n'ont pas été mentionnés plus tôt).

En plus des publications qu'il vend et distribue, l'Office rédige des «Manuscript Reports» (*Rapports manuscrits*) pour son propre usage et qui ne sont pas distribués à l'extérieur; on peut, toutefois, consulter ces ouvrages aux bibliothèques des Stations de l'Office après entente avec le directeur de l'établissement.

Une liste de ces Rapports manuscrits et de certains autres manuscrits est incluse.

ABBREVIATIONS:

ABRÉVIATIONS:

J. Fish. Res. Bd.—Journal of the Fisheries Research Board of Canada.

Bull. Fish. Res. Bd.—Bulletin of the Fisheries Research Board of Canada.

MS Rept. Biol.—Manuscript Reports, Biological Series, of the Fisheries Research Board of Canada.

MS Rept. Technol.—Manuscript Reports, Technological Series, of the Fisheries Research Board of Canada.

MS Rept. Oceanogr. and Limnol.—Manuscript Reports, Oceanographic and Limnological Series, of the Fisheries Research Board of Canada.

FRB No. — Refers to the Studies Series of the Fisheries Research Board of Canada.

PUBLICATIONS

ANON. Obituary: Donald Johnston Milne, 1916–1961. *J. Fish. Res. Bd.*, Vol. 20, No. 1, pp. 239–242.

ANON. J. R. Dymond—An appreciation. *J. Fish. Res. Bd.*, Vol. 20, No. 2, pp. 255–256.

ANON. [Compiled by J. L. Hart.] First supplementary list of useful publications for oyster farmers of the Maritimes. *Fisheries Research Board of Canada, St. Andrews Biological Station Circular, General Series*, No. 41, 1 p.

Premier supplément à la liste des publications utiles aux ostréiculteurs des Provinces Maritimes. *Office des Recherches sur les Pêcheries du Canada, St. Andrews station biologique, Circulaire, Série Générale*, No. 41, 1 p.

ANON. Progress in 1961 in Canadian research on problems raised by the Protocol. *Annual Report of the International North Pacific Fisheries Commission* for 1961, pp. 29–47, 1963. [Based on material from A. W. H. Needler.] [FRB No. 859]

ANON. [Prepared by A. M. Fleming.] [Canada (Newfoundland) statistics of fishing efforts and landings from the ICNAF Convention Area for 1961 by Divisions, months and years.] *International Commission for the Northwest Atlantic Fisheries, Statistical Bulletin* for 1961, Vol. 11, 90 pp., 1963.

ANON. [Compiled and edited by C. J. Kerswill and M. W. Smith.] Investigation and management of Atlantic salmon and trout. The research program. *Department of Fisheries of Canada, Trade News*, Vol. 16, No. 1, pp. 5–12, 1963.

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BIOLOGICAL STATION, ST. JOHN'S, NFLD.

Wilfred Templeman, O.B.E., PH.D.(Toronto), F.R.S.C., *Director*.

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NEWFOUNDLAND INSHORE COD, GROUNDFISH SAMPLING AND STATISTICS

A. M. Fleming. (*See above*.)

A. T. Pinhorn, M.SC.(Memorial).

LABRADOR, NORTHERN NEWFOUNDLAND AND OFFSHORE COD

A. W. May, B.SC.(Memorial).

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HADDOCK AND MATHEMATICAL STATISTICS

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LOBSTER

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OFFSHORE

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R. A. McKenzie, M.A.(Toronto).

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A. C. Kohler, PH.D.(McGill).

P. M. Powles, M.SC.(Western Ontario).

J. S. Beckett, B.A.(Cambridge). From February 17.

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R. L. Saunders, PH.D.(Toronto).

POLLUTION

J. B. Sprague, PH.D.(Toronto).

MATHEMATICAL STATISTICS

J. E. Paloheimo, M.A.(Toronto).

E. L. Cadima, LIC.MATH.(Lisbon).

NON-STAFF

Vivien M. Brawn, M.SC.(Dunelm). Volunteer Investigator.

W. B. Scott, PH.D.(Toronto). Volunteer Investigator.

Irené Scarratt, M.A.(Mount Holyoke). Volunteer Investigator.

ATLANTIC OCEANOGRAPHIC GROUP

N. J. Campbell. (*See above.*)

R. W. Trites. (*See above.*)

D. H. Loring, PH.D.(Manchester).

R. F. Platford, PH.D.(Saskatchewan).

G. P. Cant, M.SC.(McMaster).

B. L. Blackford, M.SC.(M.I.T.).

J. R. Chevrier, B.SC.(Laval).

D. L. Peer, M.SC.(Saskatchewan).

BIOLOGICAL STATION, LONDON, ONTARIO

W. A. Kennedy, PH.D.(Toronto), *Director*.

A. H. Lawrie, M.A.(Toronto), *Assistant Director*.

POPULATION DYNAMICS

G. F. M. Smith, PH.D.(Toronto).

G. H. Lawler, PH.D.(Toronto).

GREAT SLAVE LAKE

J. J. Keleher, M.A.(Toronto).

LAKE SUPERIOR

A. H. Lawrie (*See above.*)

LAMPREY

J. J. Tibbles, PH.D.(Wisconsin).

D. P. Dodge, B.S.A.(O.A.C.).

S. M. Dustin, M.S.(Michigan)

B. G. H. Johnson, M.SC.(Western Ontario).

Aarne Lamsa, M.SC.(Western Ontario).

EXPERIMENTAL GENETICS PROGRAM

D. P. Scott, PH.D.(British Columbia), on secondment to Great Lakes Institute.

SPECIAL CONSULTANT

F. E. J. Fry, PH.D.(Toronto). Term June 1 to 30.

BIOLOGICAL STATION, NANAIMO, B.C.

(including Pacific Oceanographic Group)

P. A. Larkin, D.PHIL.(Oxon), *Director*. From July 1.

F. C. Withler, M.A.(British Columbia), *Acting Director* to June 30.

A. S. Hourston, PH.D.(California), *Assistant Director* to December 31.

K. S. Ketchen, PH.D.(Toronto), *Assistant Director*. From January 1.

J. P. Tully, M.B.E., PH.D.(Washington), A.R.I.C., F.C.I.C., *Oceanographer-in-Charge*.

BIOLOGICAL CONSULTANT

W. E. Ricker, PH.D.(Toronto), F.R.S.C. To August 1.

SALMON AND EXPERIMENTAL INVESTIGATIONS

F. C. Withler. (*See above.*)

MARINE SALMON INVESTIGATION

F. Neave, PH.D.(British Columbia), F.R.S.C.

J. I. Manzer, M.A.(British Columbia).

H. Godfrey, M.A.(British Columbia). To December 5.

R. J. LeBrasseur, M.A.(British Columbia). To October 31.

SALMON STOCK ASSESSMENT

M. P. Shepard, PH.D.(Toronto).

A. S. Hourston. (*See above.*)

H. T. Bilton, B.A.(British Columbia).

EARLY LIFE OF SOCKEYE

W. E. Johnson, PH.D.(Wisconsin). To September 30.

SKEENA SALMON

J. McDonald, M.A.(British Columbia).

K. V. Aro, B.A.(British Columbia).

H. W. D. Smith, M.SC.(Washington).

P. J. McCart, M.A.(British Columbia). From September 23.

YOUNG SALMON IN THE SEA

R. R. Parker, PH.D.(British Columbia).

CHINOOK AND COHO

H. Godfrey. (*See above.*) From December 6.

EXPERIMENTAL HATCHERY

R. A. Bams, PHIL.DOCTORANDUS(Leiden).

STREAM SALMON

W. P. Wickett, M.A.(British Columbia). To October 31.

RESPIRATORY METABOLISM

J. R. Brett, PH.D.(Toronto), F.R.S.C.

G. R. Bell, PH.D.(Western Ontario).

D. V. Ellis, PH.D.(McGill). To June 28.

W. E. Vanstone, PH.D.(McGill). Transferred to Vancouver Laboratory, July 1.

BIOASSAY OF ENVIRONMENTAL CHANGES

D. F. Alderdice, PH.D.(Toronto)

BEHAVIOUR OF SALMON

C. Groot, PHIL.DOCTORANDUS(Leiden).

PARASITISM AND DISEASE

L. Margolis, PH.D.(McGill).

N. P. Boyce, B.SC.(British Columbia).

POLLUTION

M. Waldichuk, PH.D.(Washington).

MARINE COMMERCIAL FISHERIES

K. S. Ketchen. (*See above.*)

PELAGIC

F. H. C. Taylor, PH.D.(California)

W. E. Barraclough, M.A.(British Columbia).

D. N. Outram, B.A.(British Columbia).

DEMERSAL

S. J. Westrheim, M.SC.(Washington).

J. A. C. Thomson, M.SC.(McGill).

CRUSTACEA

T. H. Butler, M.A.(British Columbia).

MARINE MAMMALS

G. C. Pike, M.A.(British Columbia).

D. J. Spalding, B.A.(British Columbia). To August 8.

Allison M. Craig, B.Sc.(McGill). (Part-time to September 30—stationed at Vancouver Laboratory.)

MARINE INVERTEBRATES

D. B. Quayle, PH.D.(Glasgow).

PRIMARY PRODUCTIVITY

J. D. H. Strickland, PH.D.(London). To May 31.

C. D. McAllister, M.A.(British Columbia). On educational leave from July 1.

N. J. Antia, PH.D.(Zurich). Transferred to Vancouver Laboratory, September 1.

PACIFIC OCEANOGRAPHIC GROUP

J. P. Tully. (*See above.*)

A. J. Dodimead, M.Sc.(British Columbia).

L. F. Giovando, PH.D.(British Columbia).

S. Tabata, M.A.(British Columbia). On educational leave from April 1, 1962.

P. B. Crean, M.A.Sc.(Toronto).

F. W. Dobson, M.Sc.(Dalhousie). To September 24.

W. H. Bell, B.A.Sc.(British Columbia).

N. E. H. Boston, M.Sc.(Texas A. & M.). Term from April 22 to September 30.

G. H. Jung, PH.D.(Texas A. & M.). Term from May 1 to September 15.

A. Acara, PH.D.(Istanbul).

MARINE ECOLOGY

W. E. Johnson. (*See above.*) From October 1.

W. P. Wickett. (*See above.*) From November 1.

R. J. LeBrasseur. (*See above.*) From November 1.

NON-STAFF

C. J. Berkeley, F.C.I.C., Volunteer Investigator.

H. P. Arai, PH.D.(California).

Mary Needler Arai, PH.D.(California).

ARCTIC BIOLOGICAL STATION, MONTREAL, QUE.

H. D. Fisher, PH.D.(McGill), *Scientist-in-Charge*. To July 15.

J. G. Hunter, M.A.(British Columbia), *Acting Scientist-in-Charge*. From July 16.

FISHERIES

J. G. Hunter. (*See above*.)

L. Johnson, PH.D.(Leeds).

D. Y. E. Perey, M.D.C.M.(McGill). Term, June 16 to July 15.

MARINE MAMMALS

D. E. Sergeant, PH.D.(Cantab.).

A. W. Mansfield, PH.D.(McGill).

I. A. McLAREN, PH.D.(Yale). To September 30.

BIOLOGICAL OCEANOGRAPHY

E. H. Grainger, PH.D.(McGill).

A. S. Bursa, M.SC.(Krakow).

TECHNOLOGICAL RESEARCH LABORATORY, HALIFAX, N.S.

(including the St. John's Unit and Grande-Rivière Station)

D. R. Idler, D.F.C., PH.D.(Wisconsin), *Director*.

C. H. Castell, M.S.A.(Toronto), *Assistant Director*.

QUALITY OF FRESH AND FROZEN FISH AND POSTMORTEM BIOCHEMISTRY OF FISH

W. J. Dyer, PH.D.(McGill), F.C.I.C.

J. R. Dingle, PH.D.(Toronto), F.C.I.C.

D. G. Ellis, B.SC.(Queen's).

Doris I. Fraser, B.SC., B.ED.(Acadia).

J. A. Hines, B.SC.(St. Francis Xavier).

J. T. Lauder, B.SC.(Dalhousie). Transferred to St. John's Unit, June 15.

MARINE LIPID RESEARCH

R. G. Ackman, PH.D.(London).

H. Brockerhoff, PH.D.(Cologne).

P. M. Jangaard, B.SC.(California).

J. C. Sipos, M.A.(Toronto).

Michael Yurkowski, M.SC.(Saskatchewan). From October 1.

R. J. Hoyle, M.S.(Cambridge).

R. D. Burgher, B.SC.(Acadia). To June 15.

MARINE BACTERIA

H. S. Shieh, PH.D.(McGill). From July 1.

NON-BACTERIAL DETERIORATION OF FISH AND SHELLFISH

C. H. Castell. (*See above.*)

N. Dambergs, ING.CHIM.(Nancy).

Jill E. MacLean, B.SC.(Dalhousie). To March 17.

DISEASES AND NUTRITION OF SHELLFISH

J. E. Stewart, PH.D.(Iowa).

M. F. Li, PH.D.(Alberta).

J. W. Cornick, M.S.A.(O.A.C.). From January 15.

ENDOCRINOLOGY AND PHYSIOLOGY OF FISH

D. R. Idler. (*See above.*)

M. S. Mounib, PH.D.(Aberdeen). From March 20.

Beryl Truscott, M.S.(Queen's).

H. C. Freeman, M.SC.(Acadia).

BIOCHEMICAL INDICATORS OF FISH SPECIES AND POPULATIONS

P. H. Odense, PH.D.(Oklahoma).

C. W. Shinnars, B.SC.(St. Dunstan's).

PATHOLOGY OF FISH

K. Ronald, PH.D.(McGill).

Heather C. Macnab, B.S.A.(O.A.C.). From August 12.

PROCESS AND PRODUCT RESEARCH

P. M. Townsley, PH.D.(California). To August 31.

A. L. Wood, B.SC.(Dalhousie), B.E.(Nova Scotia Technical College).

H. E. Power, B.E.(Nova Scotia Technical College).

Mary Lou Hughes, B.SC.(New Brunswick). To June 5.

TECHNOLOGICAL STATION, GRANDE-RIVIÈRE, QUEBEC

Rosaire Legendre, M.ENG.(McGill), *Director.*

H. P. Dussault, M.SC.(McGill).

Michael Yurkowski, M.SC.(Saskatchewan). To October 1.

F. Maltais, B.SC.(Montreal). To October 1.

TECHNOLOGICAL UNIT, ST. JOHN'S, NEWFOUNDLAND

W. A. MacCallum, B.E.(Nova Scotia Technical College), M.SC.(Dalhousie), *Scientist-in-Charge*.

H. S. Shieh, PH.D.(McGill). To July 1.

J. T. Lauder, B.SC.(Dalhousie). Transferred from Halifax, June 15.

Dorothy A. Chalker, B.SC.(Memorial).

NON-STAFF

Lydia A. Buyco, B.SC.(San Agustin). Co-investigator under grant from U.S. National Institutes of Health. To October 31.

J. W. Cornick, M.S.A.(O.A.C.). On loan from Nova Scotia Research Foundation. To January 15.

Fumio Nagayama, DR.AGRIC.(Kyushu University). National Research Council Post-doctorate Fellowship. From August 27.

Toshitake Tamura, M.SC.(Nihon University). Co-investigator under grant from U.S. National Institutes of Health. To October 31.

TECHNOLOGICAL RESEARCH LABORATORY, VANCOUVER, B.C.

(including the Technological Unit, London, Ontario)

H. L. A. Tarr, PH.D.(McGill; Cantab.), F.R.S.C., *Director*.

BIOCHEMISTRY

Neil Tomlinson, PH.D.(California).

Hiroshi Tsuyuki, PH.D.(Wisconsin).

Edward Bilinski, D.SC.AGR.(Louvain).

William E. Vanstone, PH.D.(McGill). Transferred from Nanaimo Station, July 1.

J. R. McBride, M.A.(British Columbia).

R. E. E. Jonas, B.A.(Madras).

Eve Roberts, B.SC.(Manitoba).

Shirley E. Geiger, B.A.(British Columbia).

CHEMISTRY

Michael Smith, PH.D.(Manchester).

P. J. Schmidt, B.E.(Saskatchewan).

U. H. M. Fagerlund, M.SC.(Abo).

T. G. Oikawa, M.SC.(British Columbia). Transferred from Nanaimo Station, June 1.

Barbara S. Findlay, B.A.(British Columbia). To June 19.

MICROBIOLOGY AND FOOD TECHNOLOGY

H. L. A. Tarr. (*See above.*)

N. J. Antia, PH.D.(Zurich). Transferred from Nanaimo Station, September 1.

J. W. Boyd, B.S.A.(British Columbia).

Burnett A. Southcott, B.S.A.(British Columbia).

Alan G. Comer, M.S.A.(O.A.C.). From October 15.

H. P. C. Hogenkamp, PH.D.(California). To November 12.

ENGINEERING

S. W. Roach, B.A.SC.(British Columbia).

F. G. Claggett, B.A.SC.(British Columbia).

NON-STAFF

Robert P. Klett, PH.D.(Heidelberg). Working under grant from National Institutes of Health, Bethesda, Maryland. From November 1.

Todor Todoroff, PH.D.(Aachen). Working under grant from International Pacific Salmon Fisheries Commission.

G. H. Berry, B.S.A.(British Columbia). Working under grant from International Pacific Salmon Fisheries Commission.

TECHNOLOGICAL UNIT, LONDON, ONTARIO

L. C. Dugal, PH.D.(Laval), *Scientist-in-Charge*.

A. W. Lantz, B.SC.(Alberta).

J. F. Uthe, M.A.(Saskatchewan). From September 3.

A. S. Bogoslawski, B.S.A.(O.A.C.). To June 29.