Environment Canada

Environnement Canada

ANNUAL REPORT

1972

FISHERIES RESEARCH BOARD

BIOLOGICAL STATION

ST. ANDREWS, N. B.

R. O. BRINKHURST, DIRECTOR

Environment Canada

Environnement Canada

ANNUAL REPORT

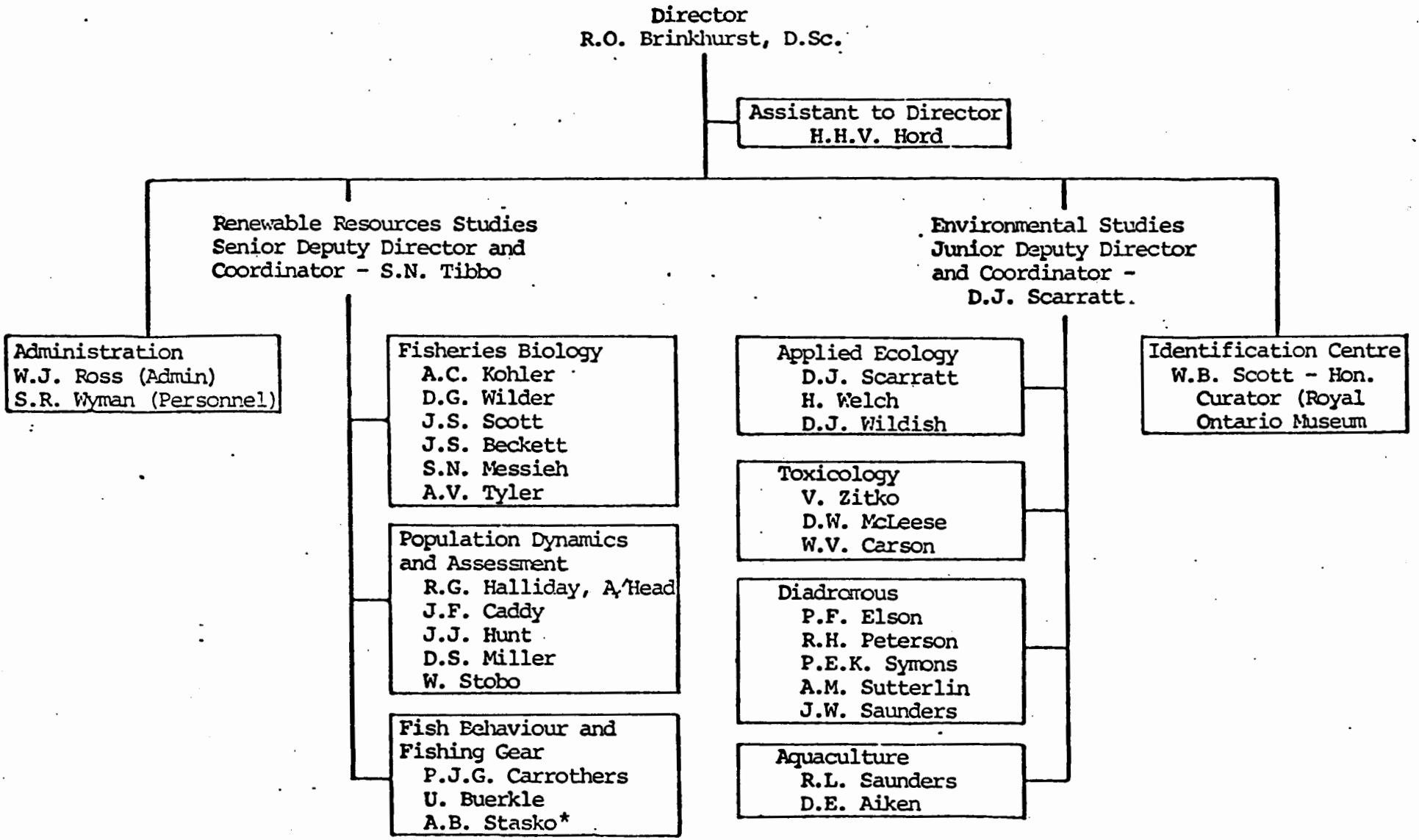
1972

FISHERIES RESEARCH BOARD

BIOLOGICAL STATION

ST. ANDREWS, N. B.

R. O. BRINKHURST, DIRECTOR



Seconded
To Halifax - F. D. McCracken
To HQ, Ottawa - T. D. Iles

*part time in Diadromous group

March 1973

DISCLAIMER

This Annual Report is not a public document and no quotation or citation of any material included herein may be made without previous written authorization of the Director or his appointed representative.

TABLE OF CONTENTS

SCIENTIFIC STAFF

(as of December 31, 1972)

R. O. Brinkhurst, D.Sc. (London), Director
F. D. McCracken, Ph.D. (Toronto), Assistant Director

1 D. E. Aiken, Ph.D. (Alberta). Physiology of lobster (moulting and growth)
2 J. S. Beckett, M.A. (Cambridge). Pelagic fishes (swordfish)
3 U. Buerkle, M.Sc. (McGill). Acoustics in fish
4 J. F. Caddy, Ph.D. (London). Invertebrates (molluscs)
5 P. J. G. Carrothers, S.M. (M.I.T.). Fishing gear engineering
6 W. V. Carson, B.Sc. (UNB). Chemistry
7 P. F. Elson, Ph.D. (Toronto). Salmon management
8 R. G. Halliday, Ph.D. (Glasgow). Groundfish (population dynamics)
9 T. D. Iles, B.A. (Wales). Herring
10 A. C. Kohler, Ph.D. (McGill). Groundfish (planktonic stages)
11 D. W. McLeese, Ph.D. (Toronto). Lobster behaviour and toxicology
12 S. N. Messieh, Dip. H.S. (Oceanog.) (Alexandria). Herring biology
13 D. S. Miller, B.A. (Saskatchewan). Herring
14 R. H. Peterson, Ph.D. (Carleton). Salmonid physiology
15 J. W. Saunders, M.Sc. (Laval). Trout
16 R. L. Saunders, Ph.D. (Toronto). Environmental physiology
17 D. J. Scarratt, Ph.D. (Wales). Lobster ecology
18 J. S. Scott, Ph.D. (St. Andrews). Fish populations and parasites
19 A. Sreedharan, M.S. (Massachusetts). Statistics
20 A. B. Stasko, Ph.D. (Toronto). Biotelemetry
21 A. M. Sutterlin, Ph.D. (Massachusetts). Physiology and behaviour
22 P. E. K. Symons, Ph.D. (Leiden). Salmonid behaviour
23 S. N. Tibbo, M.A. (Toronto). Tunas and billfishes
24 A. V. Tyler, Ph.D. (Toronto). Fish community ecology
25 D. G. Wilder, Ph.D. (Toronto). Lobster
26 D. J. Wildish, Ph.D. (London). Estuarine ecology
27 V. Zitko, C.Sc. (Slovak Academy of Sciences). Chemistry

Retired

28 J. C. Medcof, Ph.D. (Illinois) as of Sept. 29, 1972

Major Collaborators

29 D. D. Beatty, Ph.D. (Oregon State University)
30 M. N. Kutty, Ph.D. (Toronto)

DIRECTOR'S REPORT

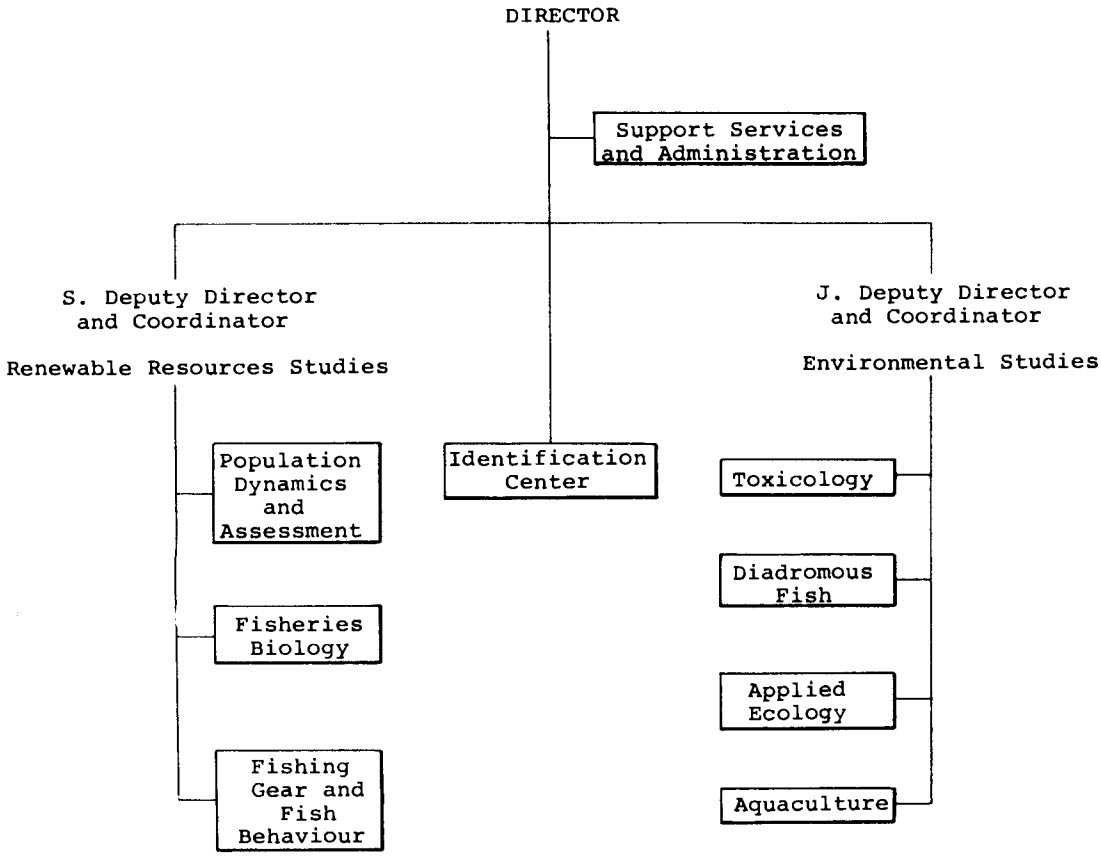
Organization

The preceding year has seen a number of changes at St. Andrews, beginning with the promotion of Dr. J. M. Anderson to the post of Director-General of Research and Development from February 20, 1972. Dr. F. D. McCracken, formerly Assistant Director, assumed responsibility for the Station until the appointment of Dr. R. O. Brinkhurst to the post of Director on October 2.

As the Fisheries Research Board and the Department of the Environment also underwent a series of changes in administrative structure, the scientific staff have had much to contend with in trying to carry out their work. The movement towards management by objectives should engender further changes in the coming year but if this leads to a clearer establishment of mandates, it should make sound long-range planning a helpful exercise. Two responses to the continuing stringency on man-year allocations are to operate on a teamwork basis and to reallocate manpower resources to new problem areas from time to time. These processes can be used to profit to a certain extent, especially where they lead to the termination of unprofitable lines of investigation, but if pursued too rigorously, they tend to lead to inflexibility and to an approach so pragmatic that future problems are not identified before they become crises. In order to ensure reasonable efficiency but to leave scope for ingenuity in research, the scientific staff at St. Andrews are being asked to identify a small number of problems which can be attacked on a teamwork basis, but an effort is being made to enable each investigator some time to pursue his own line of enquiry. The balance of these two activities will depend on the particular discipline involved, but most of our efforts will be devoted to the team projects.

The staff has been organized into two major teams, the Renewable Resource Study group and the Environmental Study group. The third unit (shown on the flow chart - text Fig. 1) is the Identification Center.

The Renewable Resource group was previously organized on a species basis, but we will adopt a function-oriented alignment in 1973-74. While species quotas are still needed and will probably remain one of our major management tools for some time to come, effort limitation may play an increasing role in the future. Our research to management work represents about 65% of the total effort. The greatest emphasis continues to be placed on groundfish and herring, with growing emphasis on other pelagic species (tunas, mackerel). The St. Andrews staff continue to play a major



Text Fig. 1. Administrative Flow Chart - St. Andrews Biological Station.

role in these fields, particularly in relation to ICNAF. Despite our involvement with lobster and scallop fisheries, the invertebrate group has been reduced by the transfer of Dr. J. Watson to the Editor's Office in 1971 and the retirement of Dr. J. C. Medcof in 1972. With Dr. J. F. Caddy on leave and the transfer of Dr. D. J. Scarratt to the Environmental Study group, Dr. D. G. Wilder has had to assume sole responsibility for the programme for some months. The Gear Research programme, for which St. Andrews has a special mandate, has been expanded by the inclusion of two of the aspects of fish behaviour (acoustics and biotelemetry) so as to interface the gear studies with those on fish responses to gear.

The Environmental Study team is made up of personnel from several former programmes so as to bring together a multidisciplinary team of scientists challenged with working within the broad mandate of management of resources for optimal human benefit in a maritime region. The interaction between forestry, industry and agriculture on the one hand and fisheries on the other has caused many problems, most obviously in relation to Atlantic salmon but also to species such as swordfish. A collaborative series of investigations involving Federal and Provincial agencies in Forestry, Agriculture, Fisheries and Pollution is needed in order to maximize the resource potential for both resident and tourist in areas such as New Brunswick, and we are making the first attempts at organizing this type of systems approach. The Applied Ecology section includes a marine biologist, a student of estuaries and we anticipate hiring a limnologist and a bio-oceanographer. Their work should tie in closely to that of the Toxicology group, the Diadromous fishery group and the Aquaculture group working with the physiology of salmonids and lobsters, with special reference to the future utilization of what are currently regarded as waste heat and sewage, and the rearing of stocks in captivity. The work of these teams should also be related to the Selective Breeding Study on Atlantic Salmon carried out by the International Atlantic Salmon Foundation near St. Andrews, and to research on the St. John River by the Huntsman Marine Laboratory.

Work on the field detection of pollution using the naturally occurring continuous monitors, i.e. the fauna, particularly the benthos, is becoming increasingly popular as its effectiveness becomes recognized in practice. Whilst slow to be adopted in North America, the increasing sophistication of statistical evaluation of the results of such studies is indicating its worth to non-biologists. These studies are only as good as the fundamental knowledge of the distribution and abundance of identified organisms will permit, so in order to improve the situation in Canadian marine science, we have reactivated the collection and identification of the local

fauna so as to produce simple, practical guides to the identity of the commonest organisms as a service to many on-going investigations. Such a center should attract competent systematists to contribute to the work through Huntsman Marine Laboratory so that our own staff do not get tied up in this work in depth.

Physical facilities

While we have completed plans for an extension to the main building, we continue to suffer from the need to use the substandard accommodation in the cottages, which are both unsound and remote from many of the essential services such as the computer, the library, the wet laboratories and fish-holding areas. Housing for additional biologists scheduled for 1973 and for summer students is a matter of considerable concern. On the positive side, we have completed an additional saltwater reservoir and installed a new freshwater line from the town reservoir so that our ideal position in regard to these essentials is now fully restored. A net shed on the wharf and a building housing a large flume and further fish-holding facilities have improved our operation. The aquarium was considerably expanded, adding greatly to its attraction to summer visitors, of whom some 30,000 registered in the visitor's book. Most of the laboratories were moved out of the old Residence building, which now houses practically nothing but administrative offices, including those of HML and IASF. The furnace room was also greatly improved.

Waste disposal problems attracted considerable attention, with the installation of sewage treatment plants and the inception of a site-cleaning operation and more careful attention to solid and chemical wastes.

Inordinate delays in the announcement of winter works funding create boom or bust conditions which do not allow for the smooth planning of such alterations which, while welcome, create particular strains in a laboratory set in a small rural community. Some mechanism that would allow phased building of projects such as the extension of the main building would be a much more profitable way to achieve mutual benefit to seasonal workers and ourselves.

Vessels

In 1972 the Station had partial use of the C.G.S. *A.T. CAMERON* (175 ft) and the C.G.S. *E.E. PRINCE* (130 ft) for investigations of the offshore fisheries in the Bay of Fundy, Nova Scotia Banks, and the Gulf of St. Lawrence. The former was used for six weeks, five on groundfish survey and one on gear research, while the latter was used for fifteen weeks on groundfish, herring, and scallop investigations. The M.V. *HARENGUS* (84 ft) was used for a total of eight weeks on

swordfish, tuna, herring, and ocean clam investigations. The C.G.S. *DAWSON* (196 ft) was used on loan from Bedford Institute for six weeks on swordfish investigations in the Caribbean area, and the M.V. *FRANCES GERALDINE* (131 ft) was used by St. Andrews on charter by the Nova Scotia government, to conduct tuna exploratory operations for ten weeks. At the local level, the M.B. *MALLOTUS* (54 ft) and the M.B. *PANDALUS* (50 ft) were used for investigations operating in the immediate area. The first steps were taken toward the eventual replacement of the *MALLOTUS*.

Statistical Services and Data Processing

The upward trend in the use of the IBM 1130 Computer continued in 1972, indicating the increased impact of electronic data processing on all aspects of the activities at the Station. There was a 30% increase in the use of the computing system in 1972 over the previous year.

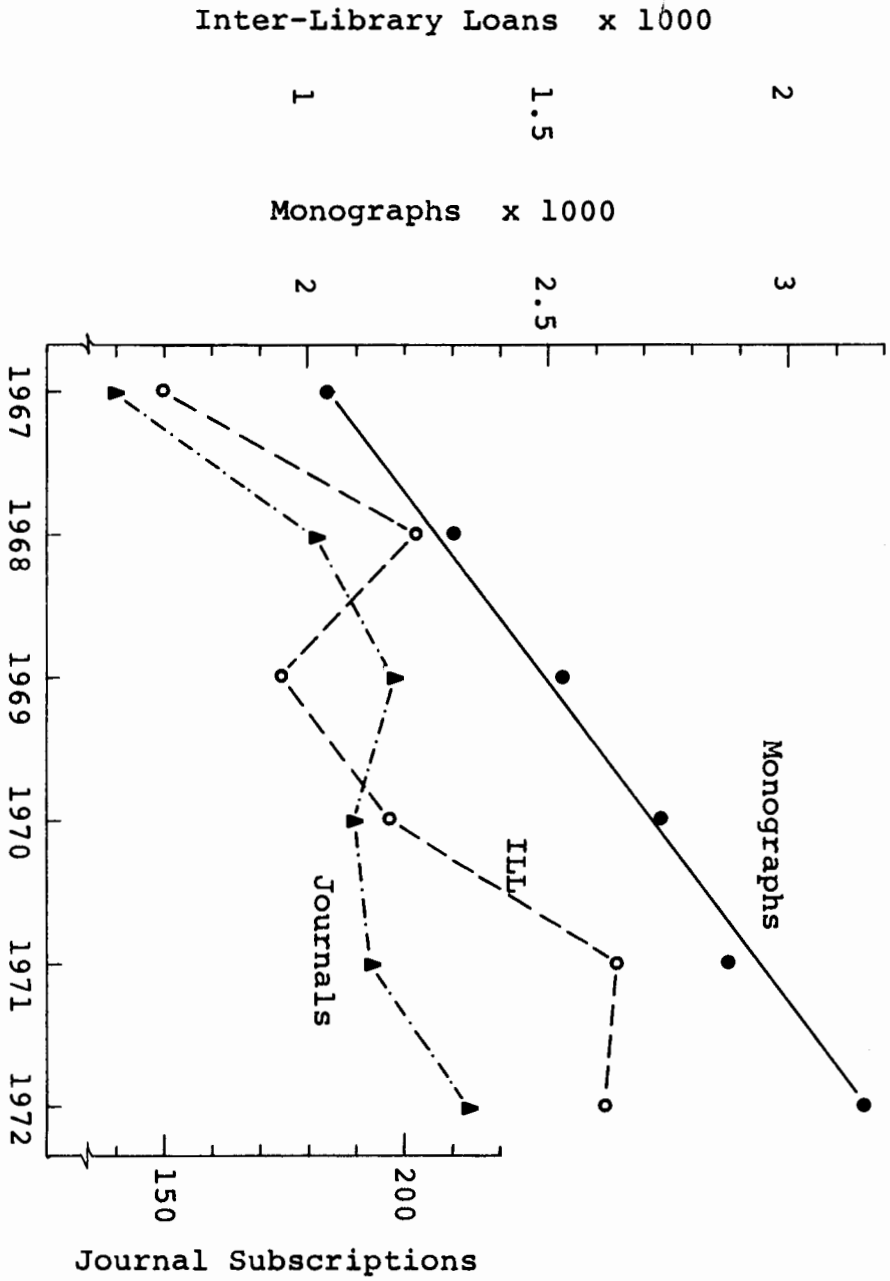
The statistician continued to provide advice and assistance in the fields of design and analysis of laboratory and field experiments, population dynamics problems and programming. The complete library of computer programs for fish stock assessment (FAO Fisheries Technical Paper No. 101) has been converted and adapted to the 1130 computing system.

Library

Our crowded library should gain considerable relief next year with expansion to fill the whole of the wing in which it is currently located. The staff have persevered despite conditions that are ridiculous in a modern scientific library.

Monograph holdings this year increased by 265 volumes. Twenty-one new journals were purchased, raising the number of subscriptions from 194 to 215. Outgoing interlibrary loans decreased from 1,105 in 1971 to 978, but incoming requests increased from 552 to 639, so that total business in this area remained approximately constant.

The growth, over the past six years, of monograph holdings, journal subscriptions, and interlibrary loans is shown in text figure 2. Compared with the year 1967, these items have increased by 37%, 54%, and 130% respectively, without any accompanying increase in staff. Over the years this has necessarily caused cuts in other areas, notably in indexing and in alerting services. We have already abandoned the process of updating the subject index due to pressure of immediate work, and the manpower shortage in this area is already at the critical phase.



Text Fig. 2. Growth of monograph holdings, journal subscriptions and interlibrary loans, 1967-1972.

Public Relations

During the year the Station, with the cooperation of the Huntsman Marine Laboratory, has continued the practice of providing visiting scientists with facilities for carrying on specialized research in marine biology. The Station is particularly suited to this type of investigation by the nature of the location and the facilities available, the library, the well equipped laboratories, and the marine equipment. However, the most important factor is the availability to the visitors of an experienced staff for consultation on research projects.

Postdoctoral Fellow

Dr. S. A. Rommel, University of Maine, migration and orientation of fish from July 1, 1972.

Graduate Students

Mr. M. Kamourdjian, University of Ottawa - endocrinological effect of photoperiod during smoltification of salmon, May 8 to August 31.

Mr. J. B. Sochasky, McGill University - physiology of crustacean growth, January 1 to December 31.

Mr. P. G. Wells, University of Guelph - oil toxicity to invertebrates, January 1 to September.

Guest Workers

Dr. David D. Beatty on sabbatical leave from the University of Alberta, spent eleven months from September 1971 to August 1972 working on visual pigments in salmon and eels.

Dr. R. O. Brinkhurst, Department of Zoology, University of Toronto, from June 1 to September 30 to establish a check list and reference collection of the invertebrate marine and estuarine fauna of Passamaquoddy Bay.

Dr. Daniel J. Faber, who is in charge of the Canadian Oceanographic Identification Centre at the National Museum of Natural Sciences in Ottawa, has been working at St. Andrews on an intermittent basis since October 1972 on the analyses of data from plankton tows collected during station research cruises in the Gulf of St. Lawrence.

Dr. W. B. Scott, curator of the Royal Ontario Museum's Department of Ichthyology and Herpetology, and honorary curator of the Station's Identification Centre, spent the period from July 1 to December 10 on a revision of "Fishes of the Atlantic Coast of Canada".

From overseas we have welcomed:

Dr. M. Kaczmarek from the Polish Sea Fisheries Institute in Gdynia during the period August 26 to October 10 for the purpose of familiarization with electronic aspects of specialized instruments and underwater cameras used in fishing gear engineering.

Dr. M. N. Kutty, a CIDA/NRC fellow from the University of Madurai, India, on the second of three annual three-month visits to study the respiratory metabolism of the Atlantic salmon.

The following paid visits of varying lengths to the laboratories during the year to carry out independent research projects:

Mr. T. Amaratunga, University of Guelph, biology of *Mysis stenolepis*.

Dr. G. A. Bartlett, Queen's University, ecology and marine geology of near-shore marine environments.

Dr. A. Brinkmann-Voss, University of Toronto, identification of hydrozoa and anthomedusae in the station reference collection.

Mr. R. Buchanan, McGill University, rates of settlement and growth of certain encrusting sessile animals.

Dr. S. Corey, University of Guelph, biology of cumaceans.

Dr. J. C. Fenwick, University of Ottawa, calcium metabolism in eels.

Dr. D. Fry, McGill University, study of cell surface of marine invertebrates during development and organogenesis.

Mr. M. H. Goodwin, University of Toronto, water chemistry (bentoquinones) of the St. Croix estuary.

Mr. W. Harvey, University of New Brunswick, chemotactic response in *Parorchis acanthus*.

Mr. W. Hollingshead, University of Guelph, growth, breeding and fecundity in *Meganyctiphanes norvegica*.

Miss J. Hum, McGill University, growth and metabolism of *Mytilus edulis*.

Dr. A. M. Kardos, Czechoslovak Academy of Sciences, Prague, methods of measuring Fenitrothion and metabolites in fish.

Dr. R. A. Khan, Memorial University, effects of protozoan blood parasites on sculpins.

Dr. W. R. Knight, University of New Brunswick, statistical studies of species association.

Dr. J. Machin, University of Toronto, volume regulation in the coclomic corpuscles of *Glycera dibranchiata*.

Mrs. A. Matthews, University of Guelph, collection of invertebrates for teaching purposes.

Mr. W. S. Oldham, London, Ontario, biology of Scotian Shelf cusk.

Dr. V. Pasztor, McGill University, origin and control of respiratory rhythm in lobsters.

Dr. J. D. Rising, University of Toronto, ornithology.

Dr. J. Roff, University of Guelph, plankton studies.

Dr. E. Roots, University of Toronto, lipids of the nervous system in a broad spectrum of species.

Dr. L. Smith, Queen's University, dispositional environment of carbonate rocks.

Dr. R. L. Spraggins, Stevens Institute of Technology, Hoboken, N.J., isolation and identification of lobster sex pheromone.

Dr. N. Watson, McGill University, effect of temperature and photoperiod on growth of *Diacyclops navus*.

Mr. R. Webb, York University, election histochemistry of the drilling mechanism of *Thais lapillus*.

Mr. K. A. Wilson, University of New Brunswick, helminths of flatfish intestines.

Dr. N. Wolfson, McGill University, study of cell surface of marine invertebrates during development and organogenesis.

Liaison and Acknowledgments

With manpower restrictions as they are, operations at St. Andrews depended heavily on cooperation and assistance received from many non-FRB agencies and individuals.

Various provincial and federal groups assisted our operations. Assistance in a number of areas was also received from the Inspection Branch and the Conservation and Protection Branch of the Fisheries Service. Good liaison was maintained with the Atlantic Oceanographic Laboratory of the Bedford Institute, the provincial fisheries departments of New Brunswick, Nova Scotia, Prince Edward Island, and Quebec, and also the Newfoundland and Prince Edward Island Travel Bureaus.

The Canadian Oceanographic Identification Centre of the National Museum of Canada and the Canadian Oceanographic

Data Centre of the Marine Sciences Branch, DOE, both provided us with ongoing service in processing some of our collections and data.

We continue to be indebted to individuals who return tags, bottles and drifters, maintain log records, and provide specific information about a variety of matters pertinent to our investigations. A number of companies provided assistance and facilities for our sampling programs, both ashore and at sea. Sport fishermen have provided assistance in tuna tagging.

This Station was involved in the work of the International Commission for the Northwest Atlantic Fisheries, International Commission for Conservation of Atlantic Tunas, Inter-American Tropical Tuna Commission and International Council for the Exploration of the Sea. In a number of programs we participated actively with the National Marine Fisheries Service Laboratories at Boothbay Harbor, Maine, Woods Hole, Mass., Miami, Florida, and with the Woods Hole Oceanographic Institution.

Many commercial fishermen provide an invaluable input through log records and tag returns, and the Fisheries Officers provide a great deal of field assistance in a number of programmes. We are deeply indebted to all of those who have made our work possible both ashore and at sea, and who have provided statistical information on their operations.

Personnel Changes

Professional Staff:

J. S. Beckett, M.A., was seconded to DOE Commercial Fisheries Secretariat, Ottawa, October 1.
R. O. Brinkhurst, D.Sc., taken on strength October 2.
J. F. Caddy, Ph.D., on professional development leave at the Centre for Quantitative Science, University of Washington, Seattle, Washington, from August 28.
J. C. Medcof, Ph.D., retired as of September 29.
R. H. Peterson, Ph.D., taken on strength April 1.
P. E. K. Symons, Ph.D., returned from professional development leave at Station d'Hydrobiologique, Biarritz, France, October 1.

Non-professional Staff:

W. H. Clarke resigned January 7.
Shirley W. DeLong retired November 1.
R. H. Merriam resigned February 4.

SUMMARIES OF INVESTIGATIONS

RENEWABLE RESOURCE STUDIES

Salmon (7)*

In 1971 the Greenland Atlantic salmon fishery increased 30% over that of 1970, and so, on the assumption that this fishery is in competition with that from the Maritimes, it would not be reasonable to expect any improvement in our region in 1972. Calculations based on returns from smolts tagged in the Northwest Miramichi suggest that 800 of the 1970 class were caught in Greenland in 1971 and about 100 in Newfoundland in 1972 before returning to their source; 453 fish of this smolt class were counted at the Board's fence in that year. The 1971 Maritimes catch of 0.34 million lb represented an all time low, showing a 48% decline over the 1970 harvest. Commercial fishing was banned in New Brunswick in 1972 because of the critically low stock levels determined from recruitment of young in the nursery rivers.

Angling, too, reached a nadir in 1971, with only 6,000 grilse and salmon reported from the Miramichi system, which is only 25% of the catches obtained during the early 1950's in the face of an intense commercial fishery, but the angling catch increased to about 21,000 fish in 1972. Over 30% of the 1972 run above the Board's Northwest Miramichi counting fence was taken by anglers, where angling in that year was only one third the intensity of that on other parts of the system, but the catch per rod day was similar, so that this proportion may be regarded as typical. Although the adult runs increased to 453 salmon and 2,323 grilse in 1972 as opposed to 50 salmon and 868 grilse in 1971, which represents the best run since 1961, this improvement will provide only one half to two thirds enough spawning for the stream to reach its natural potential of 950 salmon and 2,300 grilse (the average of the 1950-55 runs). It is possible that heavy angling pressure elsewhere has similarly limited the conservation effect of banning the commercial fishery.

Pollution of the Miramichi estuary with industrial effluents has been noticeably abated since 1970; pollution of the Northwest Miramichi from a base metal mine has been similarly abated. These factors as well as elimination of the commercial fishery must have contributed to improved adult runs in 1972. On the Northwest Miramichi, 200 salmon ascended after September 1, the best late run in 10 years. Restoration of this population, which appears to have a distinctive genetic component, is now feasible in view of abated base metal pollution in the lower river where they breed.

*Marginal enumeration indicates the scientific staff member responsible for all or part of the investigation concerned. Refer to list p. ii.

Juvenile populations were the lowest in 22 years, hence substantially improved production should not be anticipated before 1976 (grilse) and 1977 (salmon). Even this is one year earlier than would have been anticipated 5 years ago because smolts in 1972 were 80% 2-year-olds, whereas formerly 60-70% were 3-year-olds. The change may be associated with effects of forest harvesting which has been followed by minor widening and warming of the river, or with lack of competition in sparse populations.

(22)

The number of smolts leaving a river is dependent upon the rate at which smolt size (about 15 cm) is achieved, as well as on the number of fish present. The spread in ages of smolts around the mean age from a particular river appears to be caused in part by competition for food. Smaller socially subordinate salmon obtain a relatively small share of the food, grow more slowly and migrate a year or two later than those which are able to claim a territory and become dominant early in their lives. A change in the density of parr in a river may not result in a change in the number of smolts produced, but the cost of a lowered density is the loss of a "safety factor" which, in critical years, maintains smolt production at near normal levels.

Groundfish General (10)

The groundfish group continued to be deeply involved in studies related to the international management of offshore fisheries in 1972. A commitment to provide detailed and up-dated stock assessments for cod in ICNAF Divisions 4T-4Vn, 4Vn inshore, 4Vs-W, inshore 4W, and 4X, as well as haddock assessments for Divisions 4V-4W and 4X, was fulfilled. To provide data for these assessments on a continuing basis, an intensive field program of fish surveys on research vessels and sampling of commercial catches, in Maritimes ports, was carried out. Also a study of Canada's historical performance in the offshore groundfish fishery was completed to provide a bargaining basis for division of fish stock quotas among ICNAF member countries.

The section leader (A. C. Kohler) was one of a three-man task force charged with the mission of making a study on a management information system for fisheries on the Canadian Atlantic coast. A report was assembled after a series of interviews and meetings, and presented to the Management Committee of the Fisheries Service. One immediate result was the assignment of six new term positions for statistics and sampling collection to the St. Andrews field staff. These personnel will be transferred to the newly formed Management Information Service at the beginning of the fiscal year 1973-74.

Field studies continued with intensive surveys of adult groundfish stocks being carried out in the Bay of Fundy, on the Nova Scotia Banks, and in the Gulf of St. Lawrence, using the vessels *A.T. CAMERON* and *E.E. PRINCE*. Investigation of fish egg and larval distribution and abundance as related to adult stocks took place in the Gulf of St. Lawrence. Species association investigations were carried out, including a computer analysis of accumulated data for the Scotian Shelf, to determine assemblages found in the different environmental habitats on and off the banks.

Cod (8)

There are three major offshore stocks and a complex of inshore stocks between the Bay of Fundy and Cape Breton which support important cod fisheries in waters adjacent to the Maritime Provinces. Cod research has concentrated primarily on assessing current stock status and potential yield from these stocks.

In ICNAF Divisions 4T-4Vn (southern Gulf of St. Lawrence and Sydney Bight) two stocks are involved: (1) the major stock which inhabits Division 4T in the summer which migrates eastward to Division 4Vn in April-May; and (2) small inshore stocks in Division 4Vn which are independent from the much larger migrating stock, and on which an independent fishery is prosecuted mainly by longline in shallow water less than 50 fath in Division 4Vn during the summer and autumn.

Landings from the major stock declined from a high of 110,000 metric tons in 1956 to 41,000 tons in 1967 but have since increased, particularly in 1970, to over 64,000 tons, declining again in 1971 to about 57,000 tons. Current fishing mortality values on the bulk of the stock are lower than those of the early 1960's which apparently did not have a deleterious effect on stock production. A moderate increase in fishing effort to a level of fishing mortality of 0.40-0.45 may provide for a sustainable increase in future production. This is somewhat above the level of F giving the maximum yield-per-recruit in adjacent cod stocks.

The inshore fishery on minor stocks has been stable over the last 10 years with annual landings of 5,000-6,000 tons. Population abundance and recruitment have not fluctuated greatly, nor has fishing mortality. An average F of about 0.35 is probably close to that giving maximum yield-per-recruit.

There is a major offshore cod fishery in ICNAF Division 4Vs-W (Sable Island and Banquereau Banks) and a small inshore fishery in Division 4W, with some intermixing of the stocks on which they are based.

Landings of cod from Divisions 4Vs-W have fluctuated annually in recent years between 50,000 and 80,000 metric tons, averaging 62,000 tons in 1960-71. Canada and Spain were the main exploiters and over 90% of the catches were by otter and pair trawls. An increase in long-term yield-per-recruit is predicted to result from increase in the age at recruitment, and substantial economic benefits are predicted from a reduction in fishing mortality. In June 1972, ICNAF agreed to recommend to member governments a 1973 catch quota of 60,000 metric tons with the aim of preventing undesirable increases in fishing mortality on the stock.

The inshore cod fishery in Division 4W has yielded about 4,000 metric tons annually for the last 15 years. Fishing mortality rate is at a high level and is probably above that giving maximum yield-per-recruit.

There is only sufficient information at present to analyze the offshore stock in ICNAF Division 4X (southwestern Nova Scotia, Browns-LaHave Banks). The fishery expanded in the early 1960's with the introduction of otter trawling and landings reached about 19,000 metric tons in 1969. Landings were about half this in 1971. This fishery would benefit greatly from reduced effort and increased otter trawl mesh size.

(24)

Laboratory work on energy budgets of young cod at this Station has shown that daily ration estimates can be made by multiplying the mean quantity of food held in the stomach over a 24-hour period, by the instantaneous depletion rate specific for the ambient temperature. Before reasonable application can be made to a field situation, the effect of rate of swimming on the instantaneous depletion rate must be known. Ration estimates in the sea will have a large error term if activity strongly affects this depletion rate.

An experimental activity trough has been built to investigate this response. Preliminary work indicates that strongly exercised fish have reduced depletion rates.

Haddock (8)

There are two haddock stocks on the Nova Scotian Banks of importance to Canadians (1) that on Sable Island-Banquereau Banks, ICNAF Divisions 4V-W, and (2) that on Browns-LaHave Banks and in the Bay of Fundy, ICNAF Division 4X.

In ICNAF Divisions 4V-W, landings increased 43% from 9,300 metric tons in 1970 to 13,400 tons in 1971, due to a very high fishing mortality level of 0.9-1.2. In 1972, catches are predicted to be about 6,500 tons from an estimated stock of about 19,000 tons. With continuing poor recruitment,

stock abundance can be expected to continue to decline and future catches, if maintained at the 1972 level, will again result in increasing values of fishing mortality. The catch quota of 4,000 tons from the Division 4W part of the stock imposed by ICNAF in 1972, and likely to be imposed again in 1973, is not small enough to prevent continuing decline in stock abundance.

The Division 4X haddock stock was shown to be heavily exploited and declining in abundance in the late 1960's. Catch quotas of 18,000 tons were therefore imposed in 1970-71, and a reduced quota of 9,000 tons imposed in 1972, together with closed season-area regulations. Exploitation rate remains high, stock abundance continues to decline, and recruitment predictions indicate that no significant improvement in stock status can be expected prior to 1976. Thus, quota regulation in 1973 at the 1972 level of 9,000 tons as proposed by ICNAF will not prevent continuing deterioration of stock status.

Winter Flounders (24)

Stomach samples from winter flounders caught in the intertidal zone indicate that as much as 50% of the weight of items consumed is filamentous algae. Laboratory experiments have been started on the ration-growth relationships for flounders fed with the algae, to find whether this plant material may be assimilated. The discovery that a northern, edible fish is a facultative herbivore may be highly significant for aquaculture.

American Plaice (18)

Age-length curves of American plaice indicate that plaice growth rates off Cape Breton are lower than those to the south on the Nova Scotia Banks. Length-frequency compositions of research catches show little change over the past 5 years.

Underexploited Species (18)

Due to the considerable commercial interest in sand lance as a possible supplement to herring for fish reduction, an investigation of the biology of the northern sand lance *(Ammodytes dubius)* in the northwest Atlantic was carried out. The stock consists of local concentrations in sandy areas on top of offshore banks. Fish to the south are considerably larger than to the north. Meristic numbers showed clines from inshore to offshore and south to north but no distinct evidence of separate species. The fish feed largely on copepods and their planktonic diet plus their habit of burrowing into the sand during non-feeding periods, possibly in association with

tidal currents, partly explains the difficulty in catching them. Larval abundance and occasional very large catches support estimates of biomass which match these for some commercially important fish species.

Recurrent Ground Assemblages of the Scotian Shelf (24)

Data processing of research trawling records indicate that there are four or five areas of the Scotian Shelf that have different fish assemblages, and that within these areas the assemblages must be further categorized by at least three depth groupings of species. Certain fishes, such as plaice and medium-sized cod, seem to move between assemblages.

After studying existing methods of quantitative analysis of species clusters, a technique was evolved whereby groundfish collection data were arranged by environmental gradient and frequencies of co-occurrence of species tested for departures from randomness. Preliminary analysis over the western portion of the Scotian Shelf indicated that demersal fishes fell into three basic assemblages: a Sable Island assemblage characterized by yellowtail and longhorn sculpin, a Roseway Basin assemblage characterized by pollock, barndoor skate, thorny skate, and witch flounder, and a Deep Plains assemblage (> 75 fath) characterized by white hake, argentine, and cusk.

Herring (9)

Declining landings in the herring fisheries of the northwest Atlantic in the years 1971 and 1972 became so marked and over such a wide area as to precipitate a crisis requiring swift and effective management action at the national and international level. The St. Andrews herring programme was directed largely towards providing the information and scientific advice required to support management proposals put forward in bilateral discussions with the United States, at meetings of ICNAF and, in late 1972, at meetings of the newly formed Canadian Atlantic Herring Management Committee.

Statistical coverage of the Canadian Bay of Fundy fisheries allowed differentiation between 'landings' and 'catches' for juvenile and adult fisheries on both the New Brunswick and Nova Scotia sides of the Bay. Catches could then be more correctly allocated to the individual stocks allowing quantitative assessment. This served also as a basis for estimates of the numbers of herring removed by the juvenile fisheries, which in turn threw light on their parental origin.

An analysis of catch and effort information for the southwestern Nova Scotia fishery demonstrated a large decline

in abundance of stocks since the fishery expanded in the mid 1960's, but this had not, apparently, seriously affected their biological potential up to the early 1970's. This same study allowed more exact delimitation of the spawning areas and season for this major stock and indicated that three 'waves' of spawning activity occurred in most years, whose timing showed year-to-year variation.

The hypothesis of the separate identity of herring stocks on the New Brunswick and Nova Scotia side of the Bay, which was based largely on the retention of southwestern Nova Scotia spawned larvae in the upper Bay of Fundy, was confirmed to the extent that it was accepted as a basis for treating the Nova Scotia stock as a single management unit.

More information on the Gulf of St. Lawrence stock complex has been accumulated from tag returns and this and other studies have given a clearer picture of stock identities and migrations. Information on herring spawning areas and seasons in the Gulf was collated and used to help frame regulations to protect them by seasonal closure.

In early 1972, at a Special Meeting of ICNAF, quota regulations and size limits for the Bay of Fundy-Georges Bank-Gulf of Maine area were agreed upon. This was the first time that suballocation of an overall quota was applied to an international fishery.

In late 1972, as a result of the work of the new Atlantic Herring Management Committee, a set of consolidated regulations for Canadian Atlantic herring were promulgated and additional management proposals agreed to, including quota setting for the Gulf of St. Lawrence fisheries.

(12)

In a study of herring migration and stock identification, over 12,000 herring were used. Results showed that the herring population in Canadian Atlantic waters is made up of a number of separate unit stocks which do not intermingle to any great extent. They also indicate that the spring- and autumn-spawning herring are discrete populations, although in some cases inhabiting the same geographical area.

The ability to distinguish between otolith types characterizing local herring stocks and use them as natural tags enabled a study of the movements of herring between spawning, feeding and wintering areas to be made. It helped in a better understanding of the interrelationships between various stocks and mixing areas, and estimating rates of mixing. These results are of importance to fishery planning and policy because, from the point of view of management, it is essential to know if the progeny of a particular spawning recruit to the parent stock, and the extent to which the various elements of the population are mixed.

An analysis of data on larval herring distribution and dispersal in southern Gulf of St. Lawrence, collected over the last 5 years, showed large concentrations of herring larvae in spring and autumn. These coincide with the herring spawning seasons in the area.

On the basis of the distribution of these larvae, some still in the yolk-sac stage, and observations of adult fish in the ripe and running stages, the spawning grounds were located. The indications are that these spawning grounds are numerous and sporadic, probably an adaptive mechanism favouring survival. The dispersal pattern of herring larvae shows a general drift of the larvae with the prevailing counter-clockwise surface current. Neither metamorphosed larvae nor yearlings were found in large concentrations. The implications are that the nursery grounds do not overlap the adult spawning or feeding grounds, and so competition between larvae and adults is avoided.

Swordfish (2)

The swordfish fishery was abandoned early in 1971. Since then, research efforts have been concerned with an assessment of the impact of the longline fishery on swordfish stocks throughout the period of its operation. It is evident that by 1970 the stock was being overexploited. Effort (number of hooks fished) almost tripled over the 8-year period and while catch per day's fishing showed little change, hooking rates declined from 2.88 fish/100 hooks in 1963 to 1.03 in 1970. The most obvious effect of the longline fishery on the stock was a progressive and drastic reduction in average size of fish caught, from 228 lb in 1963 to 117 lb in 1970.

Studies of the early life history of swordfish were continued with research vessel surveys of the Caribbean and adjacent regions. Swordfish larvae have been found to have a discontinuous distribution during January-March, suggesting localized spawning areas in the northwest Caribbean, Windward Passage, Virgin Islands, Guinea current south of Trinidad and the Florida current.

Tuna (23)

High seas fisheries for tuna from east coast Canadian ports began in 1963 when two small tuna seiners were built to exploit bluefin and skipjack resources off the northeastern coast of the United States. These fisheries developed slowly but have now expanded to include other tuna species (yellowfin, bigeye and albacore) in both the Atlantic and Pacific Oceans. Preliminary estimates indicate that total catches of all species of tuna by Canadian flag vessels in 1972 amounted to about 12,000 short tons. Canada is a member of two international fisheries commissions (ICCAT and IATTC) that are

concerned with tuna, and Canadian research is directed towards meeting the needs of these commissions.

There is convincing evidence that all stocks of bluefin in the north Atlantic are small and heavily exploited. Bluefin are fast growing fish with a low natural mortality. The biomass of a year-class doubles in the second year of life and increases by similar amounts in the third and fourth years. Yield-per-recruit mathematical models strongly suggest that the capture of bluefin less than 5 kg (11 lb) round weight should be avoided, although fish below this size form a significant part of the landings from the west Atlantic purse seine fishery.

Surface fisheries for small bluefin almost certainly affect fisheries for moderately large (> 75 kg) and very large (> 200 kg) bluefin. In the northeast Atlantic no strong year-class has recruited to the large fish fishery since 1957 and a similar situation apparently exists in the northwest Atlantic. Trans-Atlantic migrations in both directions occur frequently, suggesting either a single stock of bluefin in the Atlantic or a very high degree of mixing between stocks.

For Atlantic yellowfin the recent declines in total abundance, and in the apparent population of older fish strongly suggest the deleterious effect of heavy fishing. Current information is inadequate for firm recommendations to management but consideration is being given to both quota controls and restrictions on size at first capture.

Invertebrates (25)

The United States offshore trawl and trap fishery for lobsters, which extends 500 miles along the continental slope, landed approximately 10 million lb of live lobsters in 1971. In August 1971, Canadian swordfish fishermen, unemployed because of unacceptable levels of mercury, were given special permission to fish lobsters with traps at least 50 miles offshore. During its first year of operation, the Canadian fleet of six boats landed about 1 million lb, partly from newly discovered grounds off Browns and Baccaro Banks. Surveys indicated poor commercial prospects east of Baccaro. Inexperience and inadequate storage facilities on some vessels resulted in heavy seasonal mortalities. Tag returns indicate that the rate of exploitation offshore is much lower than on the inshore grounds. High catches per unit effort necessary to offset high costs and heavy gear losses depend to a considerable extent on the supply of large lobsters which, in turn, depends on low fishing rates. The few tag returns to date give little information on movements or growth.

Lobsters were stored in a tidal pound for 2-5 months with and without tile cover, at densities of .6, 1, and 2 lb

per sq ft. They were fed a mixed fish diet at rates of 1 1/2, 3, and 6% of body weight per week. The feeding rate did not affect moulting frequency or growth per moult. Only the 6% rate was sufficient to maintain meat yield or to restore it 2 to 3 months after moulting. Lobsters in tiles survived better, developed less algal growth, and fewer resorbed eggs. Density had little effect on mortality. Most mortality occurred during the first week, reflecting initial condition of the lobsters rather than storage conditions.

(17)

An investigation into the effects on lobsters of raking the seaweed "Irish moss" was concluded. In some areas, significant damage can be caused to lobster stocks by this important harvest. It was recommended that strict control be imposed on Irish moss raking to minimize damage to lobsters and optimize profits from moss. It was also recommended that alternative, less damaging harvesting methods be evolved.

(4)

An 80-sq-mile bed of young scallops on Georges Bank was heavily exploited in 1971 and 1972. This led to an ICNAF agreement prohibiting the landing of scallops that on average yield more than 40 meats per lb or are less than 95 mm in shell diameter. In the inshore fishery off Digby, relative meat sizes vary so much that the feasibility of a meat size limit is open to question. This fishery was closed in the spring of 1972 when catch/day fell below a preset level.

(28)

Explorations with an hydraulic dredge, scuba divers and a submersible were made to study dense stocks of large, old, ocean clams *(Arctica islandica)* in harbours along southern Nova Scotia. The hydraulic dredge was 90% efficient in taking clams, whereas non-hydraulic rocker dredge on sandy soil harvested less than 1%, damaged half of those it caught, and killed 80% of those it failed to harvest. A new fishery landed 2 million lb, valued at $120,000, in 1971 but did not operate in 1972. Laboratory studies have confirmed that ocean clams grow slowly.

PHYSIOLOGY AND BEHAVIOUR STUDIES

Photoperiod Effects (16)

Salmon parr held in fresh water and subjected to reciprocal photoperiod (day length long in winter, decreasing in spring) showed more rapid development of the smolt characteristics (silvering and decrease in condition factor) than controls exposed to simulated natural photoperiod (day length short in winter, increasing in spring). Fish in reciprocal photoperiod developed lower condition factor, lower total body fat content and higher linear growth rate than controls. Pituitary histology revealed an increase in the number of growth hormone production cells in the fish exposed to long day length in winter.

Fish under reciprocal photoperiod became silvery in February; those under natural photoperiod silvered in April.

Biweekly injection of purified bovine growth hormone in parr held in fresh water at 11.5°C with reciprocal photoperiod for 4 weeks beginning in June resulted in a much higher linear growth rate than in saline-injected controls in fresh water and the same temperature-photoperiod conditions. Transfer to sea water (30‰) after 4 weeks' injection resulted in the death of all the controls and no deaths among the parr treated with growth hormone.

Salmon Retinal Physiology (16) (29)

Previous studies showed that pseudobranchectomy or injection of Diamox (an inhibitor of carbonic anhydrase) results in a decrease in intraocular O_2 tension in rainbow trout. The pseudobranch, a rich source of carbonic anhydrase, supplies arterial blood to the choroidal gland of the eye, the gland being the site of concentrating O_2 for the retina.

Bilateral pseudobranchectomy resulted in a significant decrease in the visual pigment concentration within 24 hours. The skin darkened and the fish were behaviourally blind within 24 hours. Unilateral pseudobranchectomy did not result in any significant difference in the visual pigment concentration in the right and left eyes. This suggests a crossover of blood from the intact pseudobranch to the opposite eye. The fish behaved normally and did not darken. Parr with the left eye and right pseudobranch removed had normal concentrations of visual pigment in the right eye after 24 hours and they did not darken or appear to be blind.

Parr injected with 5 mg of Diamox darkened and appeared to be blind within 24 hours. Normal colour and behaviour returned within 72 hours after injection.

Visual Pigments (29)

Visual pigments of Atlantic salmon parr, smolts and adults were examined to see if the rhodopsin:porphyropsin ratio changes during the life cycle. Spectrophotometric analyses of retinal extracts revealed that porphyropsin is the predominant visual pigment in parr and smolts. Adult salmon were not available for study. Adults might be expected to have mostly rhodopsin as is the case with adult Pacific salmon and steelhead trout taken in the ocean prior to and during the spawning migration.

Visual pigments of the yellow (juvenile) and silver (migratory) stages of the eel were studied to determine whether there is a change in the pigment composition during yellow to silver transformation. The data indicate a shift from a porphyropsin-rich retina to a rhodopsin-rich retina during this transformation with a further change to a deep sea rhodopsin as the silver stage proceeds to sexual maturity. This agrees with previous results from investigations with the European eel.

Respiratory Metabolism (16) (30)

Smolts exercised at low current velocities in a tunnel respirometer showed rates of 0_2 consumption little lower than those of fish swimming at higher speeds. The scatter of values at low swimming velocities is larger, suggesting that the level of excitement is high in salmon in slow currents. Continuous exercise up to 7 hours at a given swimming speed results in progressively reduced 0_2 consumption. Estimates of NH_3 excretion in salmon and relative protein utilization as judged from the ammonia quotient (proportion of ammonia excreted to 0_2 consumed) suggest that protein utilization increases with duration of exercise.

Effects of Ambient Temperature on Hatching Time of Young Atlantic Salmon (14)

About 120 eyed salmon eggs of Magaguadavic River origin were obtained on December 1, 1972. They were divided up and placed in 14 different temperature regimes to determine the effects of temperature on rates of development of eyed eggs through to the yolk-sac stage. The relationship between median hatching time and incubation temperature was linear with a slope of 5 days per °C. That is, for each degree decrease in ambient temperature, the hatching time is delayed 5 days. At the three highest temperatures (10.3-11.3°C), the fry are now free swimming and feeding. Egg mortality has been less than 10% at all temperatures, and no fry mortality has occurred.

Salmon Olfaction (21)

Adult Atlantic salmon employ olfactory cues during their spawning migrations in fresh water. Water quality in rivers therefore might be expected to influence the distribution of adults. Trapping data and water preference studies indicate that hatchery-reared salmon returning as adults select hatchery effluent and home to the hatchery, even though hatchery discharge contributes only 1/1000 of the river flow. Wild fish migrating up the main river are not diverted into the hatchery. Homing precision of hatchery fish differs during the various seasonal runs. The occurrence of well water alone in hatchery effluent does not account for its attractiveness to hatchery-reared fish.

Several classes of detergent-like compounds have been shown electrophysiologically to alter the sensitivity of salmon olfactory receptors. Preference studies performed in tanks indicate that sublethal levels of Cu^{++} added to hatchery effluent alters the preference of hatchery adults for this water.

Lobster Olfaction (11)

Lobster olfactory studies are important for a better understanding of trapping behaviour. Lobsters rely on taste for near detection of food and on olfaction for distant detection. They are not attracted to intact prey from a distance, only to injured prey or bait. They orient to a gradient across, rather than along, the path by turning toward the side of maximum stimulation.

Satiated lobsters respond to tank water from other lobsters, with the exception of intermoult female tank water. Males but not females respond to dilute urine from moulted animals. These observations indicate a general communication system, social rather than feeding, among lobsters. Chemical fractionation of tank water, urine, lobster tissues and fish (cod) extracts have shown partial activity to be retained in certain fractions but the classes of compounds that stimulate social and feeding responses have yet to be clearly identified. Social responses, stimulated by tank water and urines are blocked by traces of fish and lobster extracts in the test solutions. Because of this interference in behaviour, stimulating compounds must be identified from tank water or urine before the sites of origin in the lobster can be recognized.

Chemical comparisons showed that the amino acid content of lobster urines differs slightly between sexes, with only two amino acids that attract lobsters.

Electrophysical studies have shown that antennules contain chemoreceptor cells that respond to dilute solutions

of many chemicals indicating an olfactory function for the antennules. Male antennules have chemoreceptors that respond to urines from moulted not intermoult animals.

Lobster Culture (1)

Understanding and eventual control of the physiology of growth and reproduction is an essential part of lobster culture, and the environment and endocrine system interact to regulate these processes.

Light and temperature can influence lobster growth to a large extent, and growth rate of small lobsters has been accelerated 400% by manipulation of these parameters alone. Large individual variations in growth rate suggest that selective breeding of fast growing strains may be an effective culture technique.

Contrary to other reports, the moulting frequency of lobsters can be accelerated through surgical removal of the eyestalks, with good survival, excellent growth, and normal physical appearance being maintained through at least two moults.

An intensive search for the so-called "moult gland" of lobsters has revealed that the organ reported to function in this capacity actually is involved in reproductive control, and apparently has no direct influence on the moult cycle. Search for the actual moult gland is continuing.

A ciliate parasite has been discovered in lobsters obtained from commercial sources and held at St. Andrews. This parasite, which causes death by eating the blood cells of its host, has been found in crabs for several years but has not previously been reported in lobsters. Whether this will become a serious threat to commercial storage or culture is not yet known.

Groundfish Behaviour (21)

A variety of groundfish find food by chemical and visual means. Observations of flounder behaviour, using underwater TV situated below the intertidal zone, have revealed that amino acid solutions pumped to the bottom are highly stimulatory to flounders, causing upstream movement and aggregation at the odour source. *Fundulus* and Atlantic silversides are similarly attracted by such compounds.

(11)

Fish tend to aggregate on tracks left by otter trawl doors on the sea bed, presumably to feed on the plowed up prey. To test whether catches can be improved by dragging over the same area, repeat tows were made. In 42 comparisons, the mean

ratio of catch in repeat to initial tows was 1.1 (range 0.03-9.8). For the ratios exceeding 2 (eight instances), initial catches were small, 6-17 fish. Direct observations with a submersible were hampered by poor visibility, both before and after passage of the trawl.

FISHING GEAR, ACOUSTICS AND TRACKING

Fishing Gear (5)

The otter trawl engineering research project has continued with measurements at sea on the behaviour of four additional trawl designs, including work from a stern trawler for the first time. These studies have demonstrated that forces of water against the trawl increase with the square of the towing speed rather than with towing speed itself as claimed elsewhere.

The fundamental study on the fluid mechanics of netting has demonstrated the inadequacy of the Japanese theory widely used for fishing gear design in the past. The established theory for wire screens has been extended, with experimental verification, into conditions of low solidity and low angles of attack as found in trawls, and this will be further extended also to include the effects of knots, surface irregularities, etc., using experimental data already obtained.

In the field of underwater technology, development of an instrument package for measuring seven variables at the trawl doors has progressed well, including trials on full-scale trawls at sea. The hydraulic flume for studying the behaviour of salmon, scallops, underwater instruments, etc., in moving water under laboratory conditions, has been constructed. The diving sled and underwater camera sleds for studying the sea bed have been used successfully. Two efforts were made to observe the behaviour of trawl instruments and their possible effect on trawls from manned submersibles. The first effort had to be abandoned after damage to the sonar on the mothership, and the second effort was frustrated by inadequate visibility and submersible manoeuverability. Experience with these techniques for visual underwater observations indicates the need for an unmanned, towed, instrument vehicle which will maintain a fixed height above the sea bed without actually making contact.

Acoustics (3)

Analysis of underwater noise produced during fish dragging, and laboratory studies of hearing in cod have shown that cod can detect gear noise at a minimum distance

of one mile. The maximum detection distance ranges from 2-6 miles. The frequencies detected first are 160-200 Hz, and are likely produced by the dragger, not by the trawl.

Field experiments with cod harnessed to an instrument have shown responses to an approaching fish dragger. Most cod increase their activity in terms of tail beat amplitude and frequency, and in terms of direction change amplitude and frequency. Field work to determine the response of free-swimming fish is in progress.

Sonic Tracking (20)

The technology and techniques of tracking fish and other underwater animals with sonic transmitters are still at an early stage of development. Improved tracking equipment and field techniques of sonic tracking are being developed.

An inexpensive, directional hydrophone mounted inside a torpedo-shaped plastic housing (designed by Peter Ryan, Fisheries Service, Vancouver) reduces cavitation and permits movement of at least 10 knots with hydrophone immersed.

Further development in collaboration with the Electrical Engineering Department of the University of New Brunswick involved a sonic transmitter which can telemeter the swimming depth of the fish, a prototype being used successfully in tracking Atlantic salmon and American eels.

The Underwater Telemetry Newsletter is published jointly by FRB and the Huntsman Marine Laboratory. This newsletter, with a circulation close to 400, serves as a communications link among researchers in the rapidly expanding field of tracking aquatic animals.

Twenty mature Atlantic salmon fitted with sonic transmitters were tracked after returning to the Miramichi estuary. Those fish which progressed up the estuary did so mainly by bucking the ebb tide; there was much drifting and holding of position during both ebb and flood tides. In midsummer there was little movement up the estuary; most of the tracked fish did not progress beyond the industrialized area between Chatham and Newcastle. Two fish containing transmitters were angled as kelts in the spring, 8 and 10 months after release. Swimming depth for one fish, observed continuously for 29 hours, varied from around 5 m at night to mostly over 10 m in the daytime. One other fish tracked for 18 1/2 hours stayed mostly at around 18 m, while another tracked for 2 1/4 hours ranged from 1/2 to 12 1/2 m depth.

Prototype depth-sensing transmitters were tested on four salmon in Long Reach on the Saint John estuary in late fall, and five American eels, descending the St. Croix River in October. The results of both trials gave satisfactory indications of the patterns of movements of the fish.

ENVIRONMENTAL STUDIES

Pesticides

(15)
(7)

Brook trout were greatly depleted as a result of the aerial application of DDT in 1966 to control spruce budworm and have not yet recovered. It has not been determined whether this was due to the DDT or to the reduced insect population in ensuing years. However, pollution of stream environments with DDT still exists 5 years after the last application as a forest spray. Wild Miramichi parr collected in 1971 had a DDT residue content of 0.5-0.7 ppm. This was intermediate in value between that of smolts given a sublethal treatment of DDT (0.9-2.8 ppm) and control smolts (0.3 ppm). Smolts treated with DDT yielded only about 60% as many adult returns as control smolts.

(14)

Most metabolites and derivatives of p,p'-DDT had a similar effect to p,p'-DDT on selected temperature of young Atlantic salmon in a horizontal temperature gradient, namely a distributional shift to a temperature range 5-7°C higher than that of control fish (16°C). The order of effectiveness is p,p'-DDT $\geq$ p,p'-DDD > methyoxychlor > o,p'-DDT > p,p'-DDE. DDA, the most water soluble metabolite tested, had no effect at concentrations up to 8 ppm.

Aldrin, a chlorinated hydrocarbon insecticide of quite different molecular structure from p,p'-DDT, had a very dissimilar effect on selected temperature. Exposure to progressively higher concentrations resulted in a progressively greater decrease in selected temperature (to a maximum of 4°C) coupled with a decrease in the precision of temperature selection.

Aroclor® 1254, a polychlorinated biphenyl preparation, had no effect on selected temperature, even at concentrations approaching the incipient lethal level.

The effect of p,p'-DDT on selected temperature of young brook trout in a vertical temperature gradient was similar to the effects obtained with young Atlantic salmon in the horizontal gradient.

(15)

In four consecutive years (1969-72) the organo-(26) phosphate insecticide fenitrothion (= Sumithion) was sprayed over the drainage basin of Trout Brook, Miramichi system, in spring to control the spruce budworm after the use of DDT was discontinued. Following spraying, the densities of aquatic stages of insects important as food for young salmon and trout were below the levels established in 1966 after DDT spraying.

There was no evidence of immediate post-spray mortalities among fish following fenitrothion spraying but there were aberrant downstream movements of fish in spray years, particularly salmon parr in autumn. Fish which eat fenitrothion-contaminated insects do not reach an acutely toxic dose because of regurgitation. At 10 mg fenitrothion/g food, fish eating rations up to 3 g/day significantly alter social hierarchies. Whether these "sublethal" effects for salmonids significantly alter production must be determined in the field.

(14)

A series of experiments was begun to determine the effects of fenitrothion exposure on ability of brook trout to maintain position in water currents. In the initial experiments, trout (av. body length of 10 cm) were exposed to 1.5 ppm fenitrothion for 24 hours, then placed in an apparatus where they rested for 16 hours prior to experimentation. Average maximal swimming speed for dosed fish was 4.4 body lengths per sec as compared to 5.0 for controls - a decrease of 12%. In subsequent experiments, fish were allowed to rest only 2 hours prior to experimentation. In these latter experiments, the dosed fish swam at a maximum of 3.2 body lengths per sec, compared to 4.8 for controls - a decrease of 33%. It is considered probable that some recovery of dosed fish occurred during the longer rest period.

Industrial Chemicals (27)

Persistent industrial chemicals, discharged unintentionally into the environment, and heavy metals in surface waters in connection with mining activity in Northeastern New Brunswick, were the major areas receiving attention in 1972.

Increased levels of PCB were detected in hatchery-reared Atlantic salmon. The source of this contamination was an antifouling paint used in the hatchery tanks. Oral uptake of PCB by fish results in lower whole-body residues of PCB than uptake from water. Feeding experiments with isomerically pure chlorobiphenyls indicate that fish do not metabolize these compounds. Components of one peak of the commercial PCB preparation Aroclor 1254 are disappearing faster than components of the other peaks after the feeding of fish with PCB-contaminated diet had been discontinued.

Chlorinated dibenzofurans, possible impurities in commercial PCB preparations, are much more orally toxic than PCB to juvenile Atlantic salmon. Only octachlorodibenzofuran was detectable in dead fish and the fate of the less chlorinated dibenzofurans is not known. The present analytical method may not be sensitive enough to detect sublethal levels of di-, tri-, and tetrachlorodibenzofurans in fish. Analyses of yellow perch,

herring, and exchange samples for PCB and chlorinated hydrocarbon pesticides for the OECD "Toxic Chemicals in the Environment 1972-1974" program have been completed.

A method for the determination of phthalates in biological samples was developed. Dibutyl and di-2-ethylhexyl phthalate, used as plasticizers and additivies in a variety of products, were detected in eggs of double-crested cormorants and herring gulls, in the blubber of a common seal *(Phoca vitulina)* pup, in commercial fish food, and in hatchery-reared Atlantic salmon.

Heavy Metals (23) (2)

The official ban on the swordfish fishery stimulated a new research program to investigate various aspects of the broad problem of heavy metal contamination in large pelagic fishes with emphasis on mercury in swordfish. Results of work done in collaboration with the FRB Halifax Laboratory (210 swordfish examined) show total mercury levels ranging from 0.05-4.31 ppm with a mean value of 1.26 ppm. A number of tentative conclusions have been reached: (a) mercury levels are linearly related to size but regression coefficients vary with area; (b) males have higher mercury levels than females of the same size; (c) kidney and liver values are more variable than values for other tissues and are characteristic of particular localities; (d) mercury intake is less, and body levels decrease with time, in the northern part of the area of distribution and, (e) mercury levels in swordfish are related to mercury levels in locally important food species especially in areas where mercury-rich species form a significant part of the diet.

(27)

Methyl mercury may be removed from fish protein concentrate by washing with isopropanol acidified with hydrochloric acid.

The effect of humic acid on the acute toxicity of copper and zinc to juvenile Atlantic salmon was studied to provide data for the establishment of water quality requirements in northeastern New Brunswick. Humic acid, occurring naturally in surface waters, binds cupric ions strongly, thus decreasing their acute toxicity to juvenile Atlantic salmon, but has no effect on the acute toxicity of zinc. It is possible to predict the toxicity of copper to juvenile Atlantic salmon in the presence of humic acid by measuring the cupric ion activity with an ion selective electrode. Nitrilotriacetic acid (NTA), a synthetic chelating compound, even in quite low concentrations, releases heavy metals from sediments in streams receiving base metal mining effluents, and its use to protect fish from heavy metal toxicity is not recommended.

APPENDIX I

PUBLICATION LIST

PRIMARY PUBLICATIONS

Aiken, D. E., and E. H. Byard. Histological changes in lobsters *(homarus americanus)* exposed to yellow phosphorous. Science 176: 1433-1435.

Allen, K. R., R. L. Saunders, and P. F. Elson. Marine growth of Atlantic salmon *(Salmo salar)* in the northwest Atlantic. J. Fish. Res. Bd. Canada 29: 1373-1380.

Brinkhurst, R. O., K. E. Chua, and N. K. Kaushik. Interspecific interactions and selective feeding by tubificid oligochaetes. Limnol. Oceanogr. 17: 122-133.

Byrne, J. M., F. W. H. Beamish, and R. L. Saunders. Influence of salinity, temperature, and exercise on plasma osmolality and ionic concentration in Atlantic salmon. J. Fish. Res. Bd. Canada 29: 1217-1220.

Caddy, J. F. Progressive loss of byssal attachment with size in the sea scallop, *Placopecten magellanicus* (Gmelin). J. Exp. Mar. Biol. Ecol. 9: 179-190.

Das, N. Growth of larval herring *(Clupea harengus* L.*)* in the Bay of Fundy and Gulf of Maine area. J. Fish. Res. Bd. Canada 29: 573-575.

Denton, E. J., and R. L. Saunders. Some observations on the silvery layers in the skin of the Atlantic salmon *(Salmo salar)* during smoltification and on the regeneration of these layers under abnormal lighting conditions. J. Mar. Biol. Ass., U.K. 52: 889-898.

Osmotic properties of the epithelial layers covering scales of herring *(Clupea harengus)* and Atlantic salmon *(Salmo salar)*. J. Mar. Biol. Ass., U.K. 52: 899-902.

Fryer, Geoffrey, and T. D. Iles. The Cichlid Fishes of the Great Lakes of Africa. Oliver and Boyd, Edinburgh.

Hatfield, C. T., and J. M. Anderson. Effects of two insecticides on the vulnerability of Atlantic salmon *(Salmo salar)* parr to brook trout *(Salvelinus fontinalis)* predation. J. Fish. Res. Bd. Canada 29: 27-29.

Hutzinger, O., D. M. Nash, S. Safe, A. S. W. DeFreitas, R. J. Norstrom, D. J. Wildish, and V. Zitko. Polychlorinated biphenyls: Metabolic behavior of pure isomers in pigeons, rats, and brook trout. Science 178: 312-313.

Madison, D. M., R. M. Horrall, A. B. Stasko, and A. D. Hasler. Migratory movements of adult sockeye salmon *(Oncorhynchus nerka)* in coastal British Columbia as revealed by ultrasonic tracking. J. Fish. Res. Bd. Canada 29: 1025-1033.

McLeese, D. W. Effects of several factors on the growth of the American lobster in captivity. J. Fish. Res. Bd. Canada 29: 1725-1730.

Messieh, S. N. Use of otoliths in identifying herring stocks in the southern Gulf of St. Lawrence and adjacent waters. J. Fish. Res. Bd. Canada 29: 1113-1118.

Peterson, R. H. Electrical responses of goldfish cerebellum, responses to parallel fiber and peduncle stimulation. Brain Research 41: 67-79.

Tactile responses of the goldfish *(Carassius auratus)* facial lobe. Copeia 4: 816-819.

Peterson, R. H., and C. L. Prosser. The effects of cooling on electrical responses of goldfish *(Carassius auratus)* central nervous system. Comp. Biochem. Physiol. 42: 1019-1038.

Scarratt, D. J., and R. Lowe. Biology of rock crab *(Cancer irroratus)* in Northumberland Strait. J. Fish. Res. Bd. Canada 29: 161-166.

Scarratt, D. J., and V. Zitko. Bunker C oil in sediments and benthic animals from shallow depths in Chedabucto Bay, N.S. J. Fish. Res. Bd. Canada 29: 161-166.

Scott, J. S. Eggs and larvae of northern sand lance *(Ammodytes dubius)* from the Scotian shelf. J. Fish. Res. Bd. Canada 29: 1667-1671.

Morphological and meristic variation in northwest Atlantic sand lances. J. Fish. Res. Bd. Canada 29: 1673-1678.

Sochasky, J. B., D. E. Aiken, and N. H. F. Watson. Y organ, molting gland and mandibular organ: A problem in decapod crustacea. Can. J. Zool. 50: 993-997.

Tyler, A. V. Food resource division among northern, marine, demersal fishes. J. Fish. Res. Bd. Canada 29: 997-1003.

Watson, J. Mating behaviour in the spider crab, *Chionoecetes opilio*. J. Fish. Res. Bd. Canada 29: 447-449.

Wells, P. G. The influence of Venezuelan crude oil on American lobster larvae. Marine Pollution Bull. 3: 105-106.

Wildish, D. J. Acute toxicity of polyoxyethylene esters and polyoxyethylene ethers to *S. salar* and *G. oceanicus*. Water Research 6: 759-762.

Polychlorinated biphenyls (PCB) in sea water and their effect on reproduction of *Gammarus oceanicus*. Bull. Environ. Contam. Toxicol. 7: 182-187.

Post embryonic growth and age in some littoral *Orchestia* (Amphipoda, Talitridae). Crustaceana, Supp. 3. p. 267-274.

Zitko, V. Absence of chlorinated dibenzodioxins and dibenzofurans from aquatic animals. Bull. Environ. Contam. Toxicol. 7: 105-110.

Problems in the determination of polychlorinated biphenyls. Intern. J. Environ. Anal. Chem. 1: 221-231.

Zitko, V., and P. M. K. Choi. Halogenated hydrocarbons in the environment. J. Environ. Pollution Control 8: 39 (In Japanese).

PCB and p,p'-DDE in eggs of cormorants, gulls, and ducks from the Bay of Fundy, Canada. Bull. Environ. Contam. Toxicol. 7: 63-64.

Zitko, V., O. Hutzinger, W. D. Jamieson, and P. M. K. Choi. Polychlorinated terphenyls in the environment. Bull. Environ. Contam. Toxicol. 7: 200-201.

OTHER PUBLICATIONS

Brinkhurst, R. O. The role of sludge worms in eutrophication. Office of Research and Monitoring, U.S. Environmental Protection Agency. Ecol. Res. Series EPA-R3-72-004, August 1972.

Caddy, J. F. Size selectivity of the Georges Bank offshore dredge and mortality estimate for scallops from the northern edge of Georges in the period June 1970 to 1971. Int. Comm. Northwest Atl. Fish. Redbook 1972 Pt. III: 79-85.

Use of manned underwater vehicles in fisheries research. Proc. Oceanology Intern. Conf., Brighton, England. p. 278-281.

Caddy, J. F., and C. Radley-Walters. Estimating count per pound of scallop meats by volumetric measurement. Fish. Res. Bd. Canada MS Rep. 1202. 9 p.

Carrothers, P. J. G. Groundfish otter-trawl engineering research on a shoe string. Proc. Oceanology Intern. Conf., Brighton, England. p. 145-152.

Engineering research on commercial fish trawls in Canada. Proc. XII Convention of the Panamerican Federation of Engineering Associations, Lima, Peru. 18 p.

Carrothers, P. J. G., and T. J. Foulkes. Trawl measurements. How Canadian east coast otter trawlers behave. Fish. Res. Bd. Canada St. Andrews Sta. Cir. 57. 10 p.

Carson, W. V. Chemical conditions in the Northwest Miramichi River during 1971. Fish. Res. Bd. Canada MS Rep. 1180. 28 p.

Carson, W. G., and W. V. Carson. Toxicity of copper and zinc to juvenile Atlantic salmon in the presence of humic acid and lignosulfonates. Fish. Res. Bd. Canada MS Rep. 1181. 13 p.

Elson, P. F., J. W. Saunders, and V. Zitko. Impact of forest-based industries on freshwater-dependent fish resources in New Brunswick. Fish. Res. Bd. Canada Tech. Rep. 325. 26 p.

Foulkes, T. J. Design and performance of TUACS. Towed underwater automatic camera sled. Fish. Res. Bd. Canada Tech. Rep. 292. 9 p.

Foulkes, T. J., and J. F. Caddy. DUCCS - A collapsible underwater camera sled for sea-bed photography from a drifting support vessel. Fish. Res. Bd. Canada Tech. Rep. 310. 11 p.

Foulkes, T. J., and D. J. Scarratt. Design and performance of TURP - a diver controlled towed underwater research plane. Fish. Res. Bd. Canada Tech. Rep. 295. 15 p.

Gardella, E. S., and A. B. Stasko. A linear-array hydrophone for determining the swimming depth of transmitter-equipped fish. Underwater Telemetry Newsletter 2(2): 12-15.

Hutzinger, O., S. Safe, and V. Zitko. Photochemical degradation of chlorobiphenyls (PCBs). Environmental Health Prespectives Experl. Issue 1: 15-20.

Polychlorinated biphenyls. Analabs Research Notes 12: 1-11.

Iles, T. D., and J. F. Caddy. Submersible study on Georges Bank reveals vulnerability of Atlantic herring stocks. World Fishing 21(6): 14-16.

McLeese, D. W. Initial experiments on growth of the American lobster in captivity. Fish. Res. Bd. Canada Tech. Rep. 320. 22 p.

Medcof, J. C. The St. Lawrence rough whelk fishery and its paralytic shellfish poison problems. Fish. Res. Bd. Canada MS Rep. 1201. 38 p.

Messieh, S. N., and A. C. Kohler. Distribution, relative abundance and growth of larval herring (*Clupea harengus* L.) in the southern Gulf of St. Lawrence. Fish. Res. Bd. Canada Tech. Rep. 318. 31 p.

Pincock, D. G., D.M. Luke, and A. B. Stasko. A miniature pressure-sensing ultrasonic transmitter. Underwater Telemetry Newsletter 2(2): 6-7.

Scarratt, D. J. Investigations into the effects on lobsters of raking Irish moss 1970-71. Fish. Res. Bd. Canada Tech. Rep. 329. 34 p.

Canadian participation in New England Man in the Sea program. Phase I, May 21-June 13, 1972, Boothbay Harbor, Maine. Fish. Res. Bd. Canada MS Rep. 1191. 14 p.

Scott, J. S. Canadian Research Reports, 1971. B. Subareas 4 and 5. Int. Comm. Northwest Atl. Fish. Redbook 1972 Pt. II: 13-18.

Stasko, A. B. Bibliography of underwater telemetry in biological applications. Underwater Telemetry Newsletter 2(1): 20-24 and 2(2): 15-19.

Stasko, A. B., and S. M. Polar. Do-it-yourself hydrophone. Underwater Telemetry Newsletter 2(1): 15-17.

Watson, J., and P. G. Wells. Recaptures and movements of tagged snow crabs *(Chionoecetes opilio)* in 1970 from the Gulf of St. Lawrence. Fish. Res. Bd. Canada Tech. Rep. 349. 12 p.

Wilder, D. G. Cultivation possibilities for lobster conservation and management. Proc. Oceanology Intern. Conf., Brighton, England. p. 87-90.

Wildish, D. J. Acute lethality of some nonionic and cationic surfactants to *S. salar* and *G. oceanicus*. Fish. Res. Bd. Canada MS Rep. 1212. 7 p. + apps.

Wildish, D. J., W. G. Carson, W. V. Carson, and J. H. Hull. Effects of a neutral-sulphite, pulp effluent on some chemical and biological parameters in the L'Etang Inlet, New Brunswick. L'Etang Inlet Survey I. Fish. Res. Bd. Canada MS Rep. 1177. 18 p.

Wildish, D. J., and R. L. Phillips. Acute lethality of fenitrothion to freshwater aquatic insects. Fish. Res. Bd. Canada MS Rep. 1210. 7 p. + apps.

Wildish, D. J., and S. M. Polar. An actograph for laterally or ventrally compressed aquatic organisms of medium size. Fish. Res. Bd. Canada Tech. Rep. 341. 14 p. + apps.

Zitko, V. Determination, toxicity, and environmental levels of phthalate plasticizers. Fish. Res. Bd. Canada Tech. Rep. 344. 37 p.

Zitko, V., O. Hutzinger, and P. M. K. Choi. Contamination of the Bay of Fundy-Gulf of Maine area with polychlorinated biphenyls, polychlorinated terphenyls, chlorinated dibenzodioxins, and dibenzofurans. Environmental Health Perspectives Exptl. Issue 1: 47-50.

MANUSCRIPTS SUBMITTED FOR PUBLICATION

(to December 31, 1972)

Beckett, J. S., and S. N. Tibbo. The swordfish. Fisheries Fact Sheet.

Caddy, J. F. Underwater observations on tracks of dredges and trawls and some effects of dredging on a scallop ground. J. Fish. Res. Bd. Canada.

Caddy, J. F., and T. D. Iles. Underwater observations on herring spawning grounds on Georges. Int. Comm. Northwest Atl. Fish. Res. Bull.

Chua, K. E., and R. O. Brinkhurst. Evidence of interspecific interactions in the respiration of tubificid oligochaetes. J. Fish. Res. Bd. Canada.

Cook, D. G., and R. O. Brinkhurst. West coast invertebrates: Class Oligochaeta. *IN:* Light's Manual: Intertidal Invertebrates of the Central California Coast.

Carrothers, P. J. G., and W. D. Baines. Forces on screens of small solidity inclined to a fluid flow. American Society of Mechanical Engineers, Fluids Engineering Division.

Carrothers, P. J. G., and T. J. Foulkes. Measured towing characteristics of Canadian east coast otter trawls. Int. Comm. Northwest Atl. Fish. Res. Bull. (In press)

Elson, P. F., A. L. Meister, J. W. Saunders, R. L. Saunders, J. B. Sprague and V. Zitko. Impact of chemical pollution on Atlantic salmon in North America. Int. Atl. Salmon Found., Spec. Publ. 4(1). Proc. IASF Symposium, Sept. 1972. (In press)

Halliday, R. G. The fishery on the southern Gulf of St. Lawrence cod stock 1960-70. Int. Comm. Northwest Atl. Fish. Res. Bull. (In press)

A yield assessment of the eastern Scotian shelf cod stock complex. Int. Comm. Northwest Atl. Fish. Res. Bull. (In press)

Hutzinger, O., S. Safe, and V. Zitko. Analysis of chlorinated aromatic hydrocarbons by exhaustive chlorination: Qualitative and structural aspects of the perchloro derivatives of biphenyl, naphthalene, terphenyl, dibenzofuran, dibenzodioxin, and DDE. Intern. J. Environ. Anal. Chem.

Kutty, M. N., and R. L. Saunders. Swimming performance of young Atlantic salmon *(Salmo salar)* as affected by reduced ambient oxygen concentration. J. Fish. Res. Bd. Canada. (In press)

McLeese, D. W. Chemical communication among lobsters *(Homarus americanus)*. J. Fish. Res. Bd. Canada.

Orientation of lobsters to odour. J. Fish. Res. Bd. Canada.

Response of lobsters to odour solution in the presence of bleached kraft mill effluent. J. Fish. Res. Bd. Canada.

Morcos, S. A., and S. N. Messieh. Circulation and salinity distribution in the southern part of Suez Canal. J. Limnol. and Oceanogr. (In press)

Oldham, W. S. Biology of Scotian shelf cusk *(Brosme brosme)*. Int. Comm. Northwest Atl. Fish. Res. Bull.

Rommel, S. A., Jr. A simple method for recording fish heart and opercular beats without the use of implanted electrodes. J. Fish. Res. Bd. Canada.

Rommel, S. A., Jr., and D. M. Scott, Jr. Sensitivity to electric, magnetic, and mechanical forces related to charge distributions as a function of membrane morphology. Nature.

Rowe, V. Leslie., H. B. N. Hynes, and A. V. Tyler. The cycles of oogenesis and spawning of two Maldanid polychaetes in Passamaquoddy Bay, N.B. J. Fish. Res. Bd. Canada.

Saunders, R. L. Salmonid Aquaculture in Norway. Atlantic Salmon Journal.

Scott, J. S. Food and inferred feeding behaviour of northern sand lance *(Ammodytes dubius)*. J. Fish. Res. Bd. Canada. (In press)

Intestinal helminth parasites of northern sand lance *(Ammodytes dubius)*. J. Fish. Res. Bd. Canada. (In press)

Stasko, A. B., and P. F. Elson. Sonic tracking, a new tool in fisheries research.

Stasko, A. B., and S. M. Polar. Hydrophone and bowmount for tracking fish by ultrasonic telemetry. J. Fish. Res. Bd. Canada. (In press)

Stasko, A. B., R. M. Horrall, A. D. Hasler, and D. Stasko. Coastal movements of mature Fraser River pink salmon *(Oncorhynchus gorbuscha)*: ultrasonic tracking. J. Fish. Res. Bd. Canada.

Stasko, A. B., A. M. Sutterlin, S. A. Rommel, and P. F. Elson. Migration-orientation of Atlantic salmon *(Salmo salar* L.). Int. Atl. Salmon Found., Spec. Publ. 4. Proc. IASF Symposium, Sept. 1972. (In press)

Sutterlin, A. M., and R. Gray. Chemical basis for homing of Atlantic salmon *(Salmo salar* L.) to a hatchery. J. Fish. Res. Bd. Canada.

Symons, P. E. K. Behaviour of young Atlantic salmon exposed to or force-fed an organophosphate insecticide (fenitrothion). J. Fish. Res. Bd. Canada.

Tétreault, B., and P. E. K. Symons. Evidence that large male Baltic smolts *(Salmo salar* L.) return predominantly as grilse. J. Fish. Res. Bd. Canada.

Tibbo, S. N., and J. S. Beckett. Canadian research report, 1971-72. Int. Comm. for the Conservation of Atlantic Tunas, Madrid, Spain.

Tyler, A. V. Caloric values of some North Atlantic invertebrates. Marine Biology. (In press)

Wendt, C. A. G., and R. L. Saunders. Changes in carbohydrate metabolism in young Atlantic salmon in response to various forms of stress. Int. Atl. Salmon Found., Spec. Publ. 4. Proc. IASF Symposium, Sept. 1972. (In press)

Wildish, D. J., and D. Beatty. In vitro hydrolysis of polyoxyethylene esters by tissues of the American eel and Atlantic salmon. Bull. Environ. Contam. & Toxicol. (In press)

Zitko, V. Determination of phthalates in biological samples. Intern. J. Environ. Anal. Chem.

Zitko, V., and P. M. K. Choi. Oral toxicity of chlorinated dibenzofurans to juvenile Atlantic salmon. Bull. Environ. Contam. & Toxicol.

Zitko, V., W. V. Carson, and W. G. Carson. Prediction of incipient lethal levels of copper to juvenile Atlantic salmon in the presence of humic acid and cupric electrode. Bull. Environ. Contam. & Toxicol.

APPENDIX II

MEETINGS ATTENDED AND CONTRIBUTIONS

Jan. 4-6	CCFFR meeting, Ottawa	J. M. Anderson R. L. Saunders J. S. Scott A. V. Tyler
Jan. 5	Executive and Council Meeting, Canadian Society of Zoologists, Ottawa	J. M. Anderson
Jan. 13	Huntsman Marine Laboratory Board of Directors Meeting, Toronto	J. M. Anderson
	25th Annual Dinner of Canadian Sportsmen's Show, Toronto	J. M. Anderson
Jan. 14	1st Scientific Advisory Meeting, World Wildlife Fund Canada, Toronto	J. M. Anderson
Jan. 15-17	Meeting between Department and Industry representatives, Halifax, in preparation for the Special Commission Meeting of ICNAF in Rome	T. D. Iles
Jan. 16-20	3rd Technical Meeting, Organization for Economic Cooperation & Development, Berlin, Germany	J. M. Anderson
Jan. 21- Feb. 9	ICNAF Assessments Subcommittee Mid-term Meeting, Rome	T. D. Iles
	Contributions:	
	The seasonal and area distribution of herring spawning off the southwest Nova Scotia coast as indicated by logbook records - ICNAF Res. Doc. 72/10	
	'Landings' and 'catches' in the Canadian Bay of Fundy herring fisheries 1963-1971 - ICNAF Res. Doc. 72/12	
	Catch and effort data for the southwest Nova Scotia (4X) purse seine fishery - ICNAF Res. Doc. 72/11 - T. D. Iles and D. S. Miller	
Jan. 24-29	ICNAF Assessments Subcommittee Mid-term Meeting, Rome	R. G. Halliday
	Contributions:	

	4VW haddock: some implications of research vessel survey results - ICNAF Res. Doc. 72/17	
	The fishery on the southern Gulf of St. Lawrence cod stock 1960-70 - ICNAF Res. Doc. 72/18	
Jan. 27	Miramichi Salmon Management Advisory Committee Meeting, Newcastle	P. F. Elson
	Paper presented: Overfishing and depleted stocks of Northwest Miramichi salmon - ICES/ICNAF Salmon Doc. 72/19	
Feb. 7-9	Discussions of "Gulf Year" program with Bedford Institute scientists	A. C. Kohler
Feb. 11	Canadian Atlantic Fisheries Information Service Meeting, Halifax	J. M. Anderson T. D. Iles F. D. McCracken
Feb. 14-15	Meeting of Canadian Atlantic Fisheries Information Service Working Party and consulting with A/D Conservation and Protection Branch, Ottawa	T. D. Iles
Feb. 15-17	Field Technicians' Conference, St. Andrews	R. G. Halliday
Feb. 15-17	Gulf of St. Lawrence Program Meeting, Quebec City	T. D. Iles S. N. Messieh J. S. Scott
Feb. 17	Atlantic Salmon Association Annual Meeting, Montreal	P. F. Elson
Feb. 18-19	Annual Meeting of Association of Professional Engineers of the Province of New Brunswick, Moncton	P.J.G. Carrothers
Feb. 22	University of Waterloo to participate in examination of Ph.D. candidate	P. F. Elson
Feb. 24	Luncheon and Seminar, World Wildlife Fund, Toronto	J. M. Anderson
Feb. 24	Guelph University - talk to 4th year biology students on Atlantic salmon in a changing world	P. F. Elson
Feb. 24-26	SCITEC Council Meeting, 4th SCITEC Conference and 2nd Annual Meeting, Ottawa	J. M. Anderson

Feb. 28	Meeting with N.B. Electric Power Commission Engineers in Fredericton re aquaculture development at Lorneville	R. L. Saunders
Feb. 29-Mar. 1	Canadian ICNAF Scientific Advisers' Meeting, St. Andrews	R. G. Halliday
March-April	Work trip to University of Pennsylvania, Philadelphia, Pa.	A. M. Sutterlin
Mar. 18	Inshore Fisheries Seminar, Larry's River, N.S.	R. G. Halliday
Mar. 20-29	2nd Oceanology International Conference, Brighton, England	J. F. Caddy D. G. Wilder
	Paper presented: Cultivation possibilities for lobster conservation and management	D. G. Wilder
	Paper read by Dr. Caddy: Groundfish otter trawl engineering research on a shoe string by P.J.G. Carrothers	
Mar. 21-24	Committee Meeting of Inspectors and Administrators of North-East Atlantic Fisheries Commission, Lisbon, Portugal	F. D. McCracken
Mar. 22-23	Symposium on arthropod endocrinology, University of Western Ontario. Paper presented: Fractional analogies for the crustacean mandibular organ	D. E. Aiken
Mar. 27-28	5th Annual North American lobster workshop, Woods Hole, Mass.	D. E. Aiken D. W. McLeese D. J. Scarratt
Mar. 27-28	Meeting re aquaculture in Bras d'Or Lake, Ottawa	R. L. Saunders
Mar. 29	Visited National Marine Fisheries Service Research Station, Boothbay Harbor, Maine	D. J. Scarratt
Mar. 30	NOAA Workshop on mariculture of the New England lobster, Woods Hole, Mass.	D. W. McLeese
Apr. 5-8	"Gulf Year" program meeting at the Bedford Institute, Dartmouth, N.S.	T. D. Iles A. C. Kohler S. N. Tibbo

Apr. 10	Meeting with federal and provincial officers to discuss regulation of harvesting Irish moss, Charlottetown	D. J. Scarratt D. G. Wilder
Apr. 10-18	Meeting at Marine Laboratory, Aberdeen, Scotland, re inter-laboratory collaboration in fishing gear engineering research	P.J.G. Carrothers
Apr. 11	Interagency planning meeting for study of side effects of forest spraying, Fredericton	P. F. Elson J. W. Saunders
	Report: Impact of forest spraying on aquatic organisms - J. W. Saunders	
	Pesticides Ecology Research Group, Fredericton, reviewed ecological studies on Trout Brook, Miramichi	J. W. Saunders
Apr. 18-19	Program Working Party on Atlantic Anadromous Fish, Corner Brook, Nfld.	P. F. Elson J. W. Saunders A. B. Stasko
	Reports: P. F. Elson 1. Research at St. Andrews pertinent to salmon 2. Distant and home water utilization of salmon as shown by tag returns	
Apr. 19-22	ICES Working Group for Standardization of Scientific Methods for Comparing Catching Performance of Different Fishing Gear, Hamburg, West Germany	P.J.G. Carrothers
Apr. 21	Meeting of Board of Atlantic Region Directors, Halifax	F. D. McCracken
Apr. 23-24	Fisheries Service Aquaculture Meeting, Halifax	R. L. Saunders
Apr. 24	Preparatory hearing for the UN Conference on Human Environment, Fredericton	S. N. Tibbo D. G. Wilder V. Zitko
Apr. 24-27	Salmonid Workshop, Boston	R. L. Saunders
Apr. 25	Seminar: Lobster olfaction - on invitation at Stevens Institute of Technology, Hoboken, New Jersey	D. W. McLeese
Apr. 25-26	ICES Working Group for Data Collection and Processing in Fish Capture Research, Aberdeen, Scotland	P.J.G. Carrothers

Apr. 26	Meeting of ICNAF advisers to industry, Halifax	F. D. McCracken
	Fisheries Statistics Meeting, Halifax	R. G. Halliday
	Gulf of St. Lawrence Committee Meeting on "Tissue Banks", Halifax	V. Zitko
Apr. 27	Canadian industry meeting re ICNAF, Halifax	R. G. Halliday
	Meeting of the Technical Advisory Committee, Northeastern New Brunswick Mine Water Quality Program, Fredericton Also on June 27 and Oct. 11	V. Zitko
	Meeting with Fisheries Committee of Nova Scotia Legislature re lobster fishery, Halifax	D. G. Wilder
Apr. 30-May 2	Headquarters Management Committee Meeting re Management Information Service	A. C. Kohler
May 4	Lecture on salmon to UNB Saint John biology students at St. Andrews	P. F. Elson
May 10	Seminar on intertidal flounder ecology to UNB Marine Biology course, St. Andrews	A. V. Tyler
May 15-16	Eastern Pesticide Seminar - Determination of chlorinated dibenzodioxins and dibenzofurans in biological samples, Halifax	V. Zitko
May 15-26	ICNAF Herring Working Group and ICNAF Annual Meeting	T. D. Iles A. C. Kohler
May 15-June 2	Annual Meeting of ICNAF, Washington, D.C.	J. F. Caddy R. G. Halliday F. D. McCracken
	Papers presented:	
	An assessment of the Div. 4Vs-W cod stock complex - ICNAF Res. Doc. 72/111	R. G. Halliday
	Preliminary evaluation of trawls used for research vessel surveys by Canada, USA, and USSR on the Scotian Shelf, and some observations on the resulting biomass estimates - ICNAF Res. Doc. 72/134	M. D. Grosslein R. G. Halliday

	Some recommendations for conservation of Georges Bank scallop stock - ICNAF Res. Doc. 72/6	J. F. Caddy
May 16-17	ICES Working Group on Research on Engineering Aspects of Fishing Gear, Vessels and Equipment, IJmuiden, Holland Paper presented: Fishing gear engineering research in Canada	P.J.G. Carrothers
May 24-26	International Decade of Ocean Exploration (IDOE) Baseline Conference, "Determination of chemicals in the environment", New York	V. Zitko
May 28-31	Annual Meeting of Canadian Society of Zoologists, Toronto R. L. Saunders convened a session on fish physiology	R. L. Saunders J. S. Scott A. V. Tyler
June 1	Meeting of Board of Atlantic Region Directors, Moncton	S. N. Tibbo
June 4-6	Annual Meeting of Quebec United Fishermen, Mont Gabriel, Que. Paper presented: Prospects for Gulf of St. Lawrence fisheries	S. N. Tibbo
June 12-15	Meeting of Management Information Task Force, Ottawa	A. C. Kohler
June 13	Seminar on Canada National Water Quality Bank, Moncton	W. V. Carson
June 14-19	Canadian Atlantic Fisheries Information Service Advisory Committee Meeting, Halifax	T. D. Iles
June 16	Seminar on freshwater ecology for wildlife students from University of Maine visiting St. Andrews	J. W. Saunders
June 19-21	Meeting of Atlantic Region FRB Directors, Halifax	T. D. Iles F. D. McCracken S. N. Tibbo
June 20-23	Gulf of St. Lawrence and Statistics Task Force Meetings	A. C. Kohler

June 21-23	Gulf of St. Lawrence Program meeting	T. D. Iles S. N. Messieh S. N. Tibbo
June 26	Northeastern New Brunswick Mine Water Quality Program Meeting, Fredericton	W. V. Carson
June 26-28	First Meeting of Atlantic Herring Management Committee, Halifax	T. D. Iles
July 11	Meeting at ARD (Operations) office, Halifax, to discuss implementation of Management Committee decision on use of Canadian Atlantic Fisheries Information Service facilities in setting up full-scale herring log book system	T. D. Iles
	Talks presented to HML Marine Biology Course and Sunbury Shores Art and Nature Centre, "The richness of the intertidal zone"	A. V. Tyler
July 30-Aug. 4	Gordon Conference, Tilton, N.H.	A. M. Sutterlin
August	Paper submitted to ICES - International Atlantic salmon smolt tagging test in Canada May 1969 - 3rd Interim Report ICES Doc. C.M.1972/M:17	P. F. Elson Anne M. Williamson
Aug. 6-12	International Billfish Symposium, Kailua-Kona, Hawaii	J. S. Beckett S. N. Tibbo
	Papers presented:	
	Mercury in west Atlantic swordfish and other pelagic species - J. S. Beckett and H. C. Freeman	
	Swordfish biology - J. S. Beckett	
	Distribution of larval swordfish in the Northwest Atlantic - G. Markle	
	Further contributions to the food and feeding habits of swordfish, *Xiphias gladius* - W. B. Scott and S. N. Tibbo	
	The swordfish fishery - S. N. Tibbo and A. Sreedharan	
Aug. 8	Atlantic FRB Directors Meeting, Halifax	F. D. McCracken

Aug. 13-17	1972 Symposium on Biology of the Seal, University of Guelph, Guelph	H.H.V. Hord
Aug. 14-17	Fisheries Service Aquaculture Workshop, Ottawa	R. L. Saunders J. C. Medcof
Aug. 15-16	FAO Working Party on the Early Life History of Billfish, Honolulu, Hawaii	S. N. Tibbo
Aug. 15-18	Workshop on Fisheries Management on the Atlantic Coast, St. Andrews	R. G. Halliday A. C. Kohler J. S. Scott
Aug. 22-26	Meeting on assessment of swordfish, La Jolla, California	S. N. Tibbo
Aug. 23-25	Int. Symposium on Recent Advances in the Analytical Chemistry of Pollutants, "Determination of phthalates in biological samples", Halifax	V. Zitko
Aug. 27- Sept. 1	Division of Water, Air and Waste Chemistry, American Chemical Society 164th National Meeting, "Sources, levels, and toxicological significance of PCB in hatchery-reared Atlantic salmon", New York	V. Zitko
Aug. 28	Talk presented to church group, St. Stephen, Atlantic salmon in a changing world	P. F. Elson
Aug. 29	Talk presented to nature group, St. Andrews, Atlantic salmon in a changing world	P. F. Elson
Aug. 29- Sept. 1	Atlantic Herring Management Committee, Moncton	T. D. Iles
Aug. 30- Sept. 1	14th Atlantic Professional Engineers Conference, St. Andrews	P.J.G. Carrothers
Sept. 5-9	Policy Planning Meeting of Fisheries Service Directors, Ottawa	R. G. Halliday F. D. McCracken R. L. Saunders
Sept. 7	Annual Meeting, Miramichi Salmon Association, Doaktown	P. F. Elson
Sept. 11	Eastern Advisory Committee Meeting, St. John's, Nfld.	R. O. Brinkhurst S. N. Tibbo

Sept. 17-22	5th International Helgoland Symposium, Man in the Sea	D. J. Scarratt
Sept. 20-22	International Atlantic Salmon Foundation Salmon Symposium, St. Andrews	P. F. Elson S. A. Rommel J. W. Saunders R. L. Saunders A. B. Stasko A. M. Sutterlin V. Zitko
Sept. 23- Oct. 4	60th Statutory Meeting of ICES, Charlottenlund, Denmark	F. D. McCracken D. J. Scarratt
	Paper read by Dr. McCracken - Local differences in growth of northern sand launce *(Ammodytes dubius)* in the Northwest Atlantic by J. S. Scott	
	Paper presented to Shellfish and Benthos Committee - The effect on lobster *(Homarus americanus)* of raking Irish moss *(Chondrus crispus)*- D. J. Scarratt	
Sept. 24	IASF post-symposium field trip at Curventon - talk to visitors on significance and method of field studies	P. F. Elson
Sept. 25	Contribution to the Canadian Report for 1971 to ICES - Report to the Bluefin Working Group	J. S. Beckett S. N. Tibbo
Sept. 26	Board of Atlantic Region Directors, St. John's, Nfld.	S. N. Tibbo
Sept. 27	Seminar, CCIW - Research on polychlorinated biphenyls - Burlington, Ontario	V. Zitko
Oct. 2-4	Canadian Atlantic Fisheries Information Service Advisory Committee Meeting, Halifax	T. D. Iles
Oct. 16-18	N.S. Fisheries Service Meeting on Sea Pool Fishery, Lake Charlotte, N.S.	R. L. Saunders
	Pre-ICNAF meeting, Boothbay Harbor, Maine	D. S. Miller
Oct. 23	S.I.L. Organizing Committee 1974 Congress, Winnipeg	R. O. Brinkhurst

Oct. 20-23	Visit to salmonid aquaculture facilities, Harborside and Wiscassit, Maine	R. L. Saunders
Oct. 24-25	Salmon tagging workshop for Atlantic Chapter, Canadian Society of Wildlife and Fishery Biologists, Brudenell, P.E.I.	P. F. Elson J. W. Saunders
Oct. 29- Nov. 4	XII Convention of the Pan-American Federation of Engineering Associations, Lima, Peru Paper presented: Engineering research on commercial fish trawls in Canada	P.J.G. Carrothers
Nov. 3-12	Annual Meeting of Inter-American Tropical Tuna Commission (IATTC), Panama City, Panama	S. N. Tibbo
Nov. 5-8	Inspection of DEVCO aquaculture operations, Bras d'Or Lake, Cape Breton	S. N. Tibbo
Nov. 6-8	Meeting with Canadian Atlantic Fisheries Information Service and Management Information Service, Halifax	T. D. Iles D. S. Miller
Nov. 14	Seminar, Department of Biology, Dalhousie University, Halifax	R. O. Brinkhurst
Nov. 18- Dec. 11	Annual Meeting of International Commission for the Conservation of Atlantic Tunas (ICCAT), Madrid, Spain Paper presented: Canadian national research report 1971-72	S. N. Tibbo
Nov. 19	Meeting of Atlantic FRB Directors, Halifax	R. O. Brinkhurst
Nov. 23-25	Second Sport Fisheries Statistics and Valuation Workshop, Victoria, B.C.	P. F. Elson
Nov. 25- Dec. 4	Gulf and Caribbean Fisheries Institute & International Game Fish Meetings, Miami, Florida	A. C. Kohler
Nov. 26- Dec. 2	Meetings in Halifax on scallop industry	J. F. Caddy R. A. Chandler

Nov. 30-Dec. 1	Herring Management Committee Meeting, Halifax	T. D. Iles
Dec. 6-7	Working Group on Management of Atlantic Fisheries, Hull, Que.	R. G. Halliday
Dec. 7-8	Meeting of Board of Directors of Huntsman Marine Laboratory, Ottawa	R. O. Brinkhurst
Dec. 11-12	Discussions on scallop and lobster fisheries management with U.S. and Canadian officials, Washington, D.C.	D. G. Wilder
Dec. 11-14	Discussion on herring fishing regulations with U.S. and Canadian officials, Washington, D.C.	T. D. Iles
Dec. 12-14	Atlantic Fisheries Management Committee Meetings, Halifax	R. O. Brinkhurst
Dec. 14	Meeting with Fisheries Service personnel to discuss lobster and scallop management plans, Halifax	D. G. Wilder

APPENDIX III

LIST OF SEMINARS AND SPEAKERS

Speaker	Date	Subject
Mr. M. A. Carmichael Atlantic Weather Centre Halifax, N.S.	Jan. 13	Two films - cloud formation and weather radar; a discussion of weather observation and reporting techniques
Mr. Charles Grant FAO Accra, Ghana	Jan. 27	Fisheries on Volta Lake, Ghana
Dr. Vlado Zitko FRB Biological Station St. Andrews, N.B.	Feb. 25	Polychlorinated biphenyls and related compounds in the environment
Dr. C. Groot FRB Biological Station Nanaimo, B.C.	March 13	Migration of juvenile sockeye smolt in Babine Lake
Dr. W. H. Sutcliffe, Jr. Marine Ecology Laboratory Bedford Institute Dartmouth, N.S.	Apr. 26	Some relations of land drainage, nutrients, particulate matter and fish catch in two eastern Canadian bays
Dr. William H. Lenarz National Marine Fisheries Service LaJolla, California	May 15	Population dynamics of Atlantic yellowfin tuna
Dr. H. H. Wagner Division of Wildlife Research Oregon State Game Commission Oregon	June 2	Parr-smolt transformation in steelhead trout
Dr. Dietrich Schnach ICNAF Coordinator of Herring Larval Surveys Institute for Marine Research Kiel, Fed. Rep. Germany	June 6	Quantitative fish-larval surveying with special reference to herring larval ecology
Dr. C. D. Hickman Washington & Lee University Lexington, Virginia	June 29	Kidney function in teleost fish
Prof. Carl J. Walters Institute of Animal Resource Ecology University of British Columbia Vancouver 8, B.C.	July 27	Fisheries modelling: problems, directions, impact

Speaker	Date	Subject
Dr. A. V. Holden Department of Agriculture & Fisheries for Scotland Freshwater Fisheries Laboratory Faskally, Pitlochry, Perthshire	Aug. 11	The OECD international collaborative studies of environmental pollution
Mr. Stoebel Department of Biology Dalhousie University Halifax, N.S.	Aug. 14	Territoriality and breeding biology of the Ipswich sparrow
Dr. A. G. Huntsman Emeritus Professor Department of Zoology University of Toronto Toronto, Ontario	Aug. 21	Ectology: more salmon for angling
Dr. Robert L. Spraggins Stevens Institute of Technology Hoboken, New Jersey	Aug. 31	Prostaglandins from a marine organism
Mr. Kenneth Able Virginia Institute of Marine Science Gloucester Point Virginia	Sept. 15	Aspects of the life history and commensal behaviour of a new species of *Liparis* (pisces: Cyclopteridae)
Mr. Allan D. Michael Director of the Cape Cod Bay Census Marine Biology Laboratory Woods Hole, Mass.	Nov. 23	Numerical methods and the community concept in marine ecology
Mr. G. Hadoke, Secretary Foyle Fisheries Commission Londonderry, Ireland	Nov. 27	Fisheries management by the Foyle Fisheries Commission, Northern Ireland
Dr. D. D. Kristmanson Professor Chemical Engineering Faculty University of New Brunswick Fredericton, N.B.	Dec. 13	A study of mixing processes in the Northwest Miramichi River
Dr. P. E. K. Symons FRB Biological Station St. Andrews, N.B.	Dec. 20	Factors affecting growth of Atlantic salmon parr with an epilogue of comments on salmon in Europe

APPENDIX IV

STAFF LIST

(January 1, 1972 - December 31, 1972)

DIRECTORS

Director	J. M. Anderson, Ph.D. (to Feb. 20)
Director	R. O. Brinkhurst, D.Sc. (from Oct. 2)
Acting Director	F. D. McCracken, Ph.D. (Feb. 21 - Sept. 30)
Assistant Director	F. D. McCracken, Ph.D. (Jan. 1 - Feb. 20; and Oct. 2 - Dec. 31)
Acting Assistant Director	S. N. Tibbo, M.A. (Mar. 6 - Sept. 30)

SCIENTIFIC STAFF

D. E. Aiken, Ph.D.
J. S. Beckett, M.A. (seconded to Ottawa from Oct. 1)
U. Buerkle, M.Sc.
J. F. Caddy, Ph.D. (on professional development leave from Aug. 28)
P. J. G. Carrothers, S.M.
W. V. Carson, B.Sc.
P. F. Elson, Ph.D.
R. G. Halliday, Ph.D.
T. D. Iles, B.A.
A. C. Kohler, Ph.D.
D. W. McLeese, Ph.D.
J. C. Medcof, Ph.D. (to Sept. 29)
S. N. Messieh, Dip. H.S. (Oceanog.)
D. S. Miller, B.A.
R. H. Peterson, Ph.D. (from April 1)
J. W. Saunders, M.Sc.
R. L. Saunders, Ph.D.
D. J. Scarratt, Ph.D.
J. S. Scott, Ph.D.
A. B. Stasko, Ph.D.
A. M. Sutterlin, Ph.D.
P. E. K. Symons, Ph.D. (on professional development leave to Sept. 30)
S. N. Tibbo, M.A.
A. V. Tyler, Ph.D.
D. G. Wilder, Ph.D.
D. J. Wildish, Ph.D.
V. Zitko, C.Sc.

ADMINISTRATION

H. H. V. Hord, B.A.
W. J. Ross, M.Sc.
R. A. Silliker
S. R. Wyman, B.A.

IDENTIFICATION CENTER

W. B. Scott, Ph.D., Hon. Curator
Esther I. Lord
Janis A. Rommel (on contract)

DATA PROCESSING

A. Sreedharan, M.S.
G. E. Fawkes
Dayle V. Whiteside

LIBRARY

M. Beryl Stinson

ELECTRONICS & PHOTOGRAPHY

J. M. Babineau
S. M. Polar
F. B. Cunningham
P. W. G. McMullon

TECHNICIANS

H. P. Barchard
A. W. Brown
Cariene D. Burnett
W. G. Carson
R. A. Chandler, B.A.
C. A. Dickson
W. H. Dougherty
D. N. Fitzgerald
T. J. Foulkes
M. F. Fraser
E. K. Geldart
D. E. Graham
E. B. Henderson
J. H. Hull
I. M. Jones
L. R. MacFarlane

N. J. McFarlane
R. M. MacPherson
C. F. Monaghan
R. C. Murray
F. E. Purton
R. K. Robicheau
H. M. Sampson
E. J. Schofield
W. D. Smith
E. G. Sollows
R. J. Thurber
U. J. Walsh
C. Williams
A. J. Wilson
E. C. Tucker - Continuing Seasonal
(Apr. 1 - Oct. 27)

SECRETARIES

R. Marion Haley
Madelyn M. Irwin
Therese M. Parker
M. Barbara Stickney
Winifred E. Young

CLERKS

Shirley W. DeLong (to Nov. 1)
Dorothy M. Fawkes
C. Ruth Garnett
Charlotte A. Gibson
Myrna H. McConvey
Dorothy M. McLaughlin
D. Jacqueline Marraty
G. J. W. Sullivan
Irma I. Thompson
Anne M. Williamson, B.Ed. (from Jan. 4)

WORKS AND SERVICES

A. W. Carson (from Feb. 22)
W. H. Clarke (to Jan. 7)
F. M. Langley
H. E. Lee
M. S. Linton (from Feb. 14)
F. G. Lord
R. H. Merriam (to Feb. 4)
H. C. Small
C. E. Teakles
G. F. Wentworth

MARINE

A. W. Allen
F. R. Johnson
P. T. Ossinger

TERM AND CASUAL

D. Ann Belding (Jan. 6 - Mar. 3)
W. Chiasson (May 1 - Nov. 30)
T. B. Cox, B.Sc. (to Mar. 31)
Linda L. Cunningham
T. K. Decker, B.Sc. (from July 31)
P. A. DeMerchant (from July 31)
Nancy J. Del Monaco
L. A. Doucette (from July 31)
P. A. Gallop (from July 31)
A. L. Harvey (June 15 - Sept. 1)
J. J. Hunt, B.Sc.
B. S. Lord (to Mar. 31)
D. L. Lyon
Jessie E. MacDonald (from Sept. 5)
Lynn A. Mason, B.Sc. (from Nov. 6)
M. E. Mundie (to June 14)
J. S. Murphy (May 15 - Sept. 1)
R. B. McCartney (to Mar. 31)
M. B. McKibbon (Apr. 17 - Nov. 24)
R. H. Peterson, Ph.D. (Jan. 4 - Mar. 31)
J. G. Robichaud (from July 31)
D. C. Smith (to Mar. 31)
H. W. Stewart (Jan. 4 - Mar. 31)
D. S. Stuart (Jan. 4 - Mar. 31)
W. B. Stobo, M.Sc. (from Sept. 5)
R. C. Wood
T. A. Wright (to Mar. 31)

STUDENTS

P. T. Brennan (June 12 - July 10; Aug. 1-29)
P. A. R. Brown (May 2 - Sept. 1)
E. H. Byard, B.A. (May 8 - Aug. 25)
R. S. Cameron (May 29 - Aug. 18)
P. M. K. Choi (May 2 - Sept. 6)
A. J. Clarke (May 23 - Sept. 1)
A. G. Colodey (May 11 - Aug. 30)
E. J. Corby (May 2 - Aug. 21)
T. D. Cunningham (May 1 - Aug. 18)
Heather M. Daynard, B.Sc. (May 8 - Aug. 25)
P. G. Davis (May 15 - Sept. 5)
D. L. Fairbairn (May 15 - Sept. 1)

G. R. Farnham (May 15 - Sept. 1)
J. R. Forbes (May 8 - Aug. 25)
G. D. Harding (May 15 - Aug. 4)
C. A. Harvey (May 8 - Sept. 8)
B. L. Hawkes (May 10 - Aug. 29)
T. K. Henderson (May 15 - Sept. 1)
J. L. King (June 19 - Oct. 6)
Linda K. Lewis, B.A. (May 23 - June 30)
F. C. Libby (May 8 - Sept. 8)
N. A. Lister (May 1 - Aug. 18)
D. C. Lobban (May 26 - June 22; Aug. 1-29)
D. R. McBurney (Apr. 24 - Aug. 11)
Joan M. McGregor (July 3 - Sept. 8)
M. N. MacIntosh (May 23 - Sept. 11)
J. E. McRae (May 8 - May 19)
Gretchen E. Markle, B.Sc. (May 15 - Sept. 1)
J. B. Mawhinney (May 8 - Aug. 25)
L. J. Meagher (May 1 - Aug. 18)
Carol J. Moffatt (May 30 - Sept. 18)
M. G. Mullin (July 4 - Aug. 28)
J. P. O'Connor (May 8 - Aug. 25)
M. J. Oliver (June 7 - Aug. 25)
R. A. Paterson (May 15 - Sept. 1)
R. L. Phillips (June 5 - Sept. 22)
H. Bonita Pollard (June 30 - Sept. 8)
C. M. Radley-Walters (May 1 - Aug. 18)
P. A. S. Smith (May 8 - Aug. 25)
C. D. Sparrow (June 5 - Sept. 22)
G. L. Tranquilla (May 8 - Aug. 25)
Moira F. Walker (May 15 - Sept. 1)
J. G. White (May 15 - Sept. 1)
M. L. Wood, B.Sc. (May 29 - Sept. 15)