FISHERIES RESEARCH BOARD OF CANADA

BIOLOGICAL STATION
ST. ANDREWS, N.B.

ANNUAL REPORT

and

INVESTIGATORS' SUMMARIES

1965

J. L. HART, DIRECTOR

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BIOLOGICAL STATION, ST. ANDREWS, N.B.

The object of the St. Andrews Station is to provide information useful in promoting good management and full utilization of fisheries resources available to the Maritimes. Most work is of direct pertinence; some is basic and is applicable only secondarily; some is routine observations of commercial catches, fisheries stocks, or physical conditions, necessary for the work and not otherwise available in a satisfactory way.

Major objectives are continuing but there are frequent shifts in emphasis as work progresses or conditions change. In general, priorities are based upon demands for information, needs for scientific understanding, opportunities for applying biological principles to increasing the value of fisheries, and upon availability and interest of scientific talent.

Most projects are selected in recognition of national interests. Control and exploitation of freshwater and inshore resources are largely national responsibilities and research emphasizes needs of culture, conservation, management, and preservation of habitat. For offshore resources, research recognizes the need to find and exploit fish stocks. Here too there is great interest in conservation but the interest is expressed through international commissions.

A substantial part of the Station's work goes on from year to year adding vital knowledge and understanding as it continues. The following studies have been carried forward without major change in intensity and some will go on for some time before sufficient data are collected to justify definitive reporting:

The lobster fishery was assessed at Miminegash, P.E.I., and Port Maitland, N.S. Studies of lobster larvae and ecology were continued.

Oyster growth in different stocks was studied on several grounds.

Work on oyster environment and eel-grass control made good progress.

Catch and fishing effort data are still collected for the mobile fishing fleet.

Egg and larva and life-history studies for various groundfish species were continued in the Gulf of St. Lawrence and on the Scotian Shelf.

Herring populations were sampled in the Bay of Fundy and south of Newfoundland.

Studies of the biology of swordfish and tunas were carried forward.

Salmon runs were monitored in the Northwest Miramichi River and in the Miramichi estuary.

Effects of merganser control on production of adult salmon in the Margaree River, N.S., remained under study.

The value for trout of stream improvement was explored further.

Special studies of ocean circulation were again undertaken, and monitoring of hydrographic conditions was continued.

During 1965 some projects were expanded and some new ones were started. New emphasis was given

to the implications of our findings to the economics of the lobster industry,

to reducing losses in holding and shipping lobsters,

to the possibility of transplanting lobsters to the Pacific coast,

to following up initial successes in hatchery production of oyster spat as a preliminary to application in industry,

to exploring and assessing under-used shellfish resources,

to studies of species association among groundfishes,

to relating reflected echo sounder impulses with the abundance of fish near the bottom,

to studies of behaviour of fishes for application to design of fishing gear,

to investigating distribution and biology of silver hake and argentines, until now little used in the Canadian fishery,

to broadening exploratory fishing for large pelagic fishes such as swordfish, tunas, and sharks,

to developing instrumentation for studying engineering principles involved in operating towed fishing gear,

to studying the effects of salinity on survival and growth of salmon and trout,

to learning about the exploitation in the Labrador Sea of salmon produced in Canada, and to accumulating information on lethal limits and sublethal effects of polluting substances likely to be added to Maritimes waters.

Some projects were reduced or suspended.

A contraction in scallop work resulted from the transfer of the scientist in charge.

Less emphasis has been given to work on oyster disease.

The highly productive Pollett River project was closed out since it had reached a point of diminishing returns.

Other changes in the Station's programs are regarded as desirable.

Currently the Station is collecting catch information from the mobile fleet fishing for groundfish, swordfish, tunas, and sharks. It is the hope that this responsibility may be taken up by another responsible agency.

The upsurge in exploitation of salmon on the west coast of Greenland gives urgency to a study of sea life of Atlantic salmon.

Because of the possibility of using parasites as biological tags in this salmon work and for many other reasons, studies in marine parasitology and pathology are contemplated.

Application of research to practical problems of culture and management of anadromous fishes has led to the idea of expanding experimental facilities so that principles of behaviour and survival can be explored, and application tested in pilot-scale trials. Participation by Departmental personnel in this work is to be encouraged and planning is in progress.

ACCOMMODATION

The St. Andrews headquarters consists of one fire-proof main building and a variety of secondary structures. The main building houses in 48 rooms 58 of the 73 people now based at St. Andrews. The other 15 must find accommodation elsewhere as must expected recruits and some 16 student seasonals. The 15 people now on staff are housed in inflammable former dwelling structures provided with sprinkler systems. Plans are under way to rig up accommodation for recruits. Six wet laboratories provide adequate facilities for present experimental work but increasing demands are anticipated. Holding space now (1966) being added has released space for laboratory construction and will meet anticipated requirements for several years if expanded facilities for salmon are to become available elsewhere.

Laboratory and office buildings at the Ellerslie, P.E.I., Substation accommodate two oyster scientists and a supporting staff of five. Reconstruction is planned to eliminate dripping condensation and improve heating. Special arrangements are required to increase wet lab space necessary for large-scale experiments.

A base for processing statistical information is maintained in the Federal Building in Halifax, N.S., through the courtesy of the Department of Fisheries. Space is insufficient for current needs and more is being sought. Adequate office space for local headquarters at Chatham, N.B., Lockeport, N.S., Lunenburg, N.S., Sydney, N.S., and Yarmouth, N.S., is provided in Federal buildings. A summer office is supplied by the New Brunswick School of Fisheries at Caraquet. Depots for field operations were maintained at Curventon, N.B., Richibucto, N.B., Ellerslie Brook, P.E.I., and Millbank, N.B. The Millbank installation and with it responsibility for monitoring runs of adult Miramichi River salmon is being turned over to the Resource Development Service of the Department of Fisheries.

VESSELS

The Station operates four vessels and obtains others by agreements. The M.V. Harengus (78 feet, registered length) was kept on a wide variety of tasks throughout the year from the Gulf of St. Lawrence to the Bay of Fundy. The M.B. Mallotus (54 feet) was duty boat at St. Andrews and it too served a wide variety of investigations. The M.B. Pandalus II (46 feet) was used in the Gulf of St. Lawrence, principally in the lobster investigation. The M.B. Ostrea (36 feet) was used as a service boat at Ellerslie. The C.G.S. A. T. Cameron (168 feet), considerately provided for 18 weeks by the Board's St. John's Station, allowed work on such subjects as: distribution of greysole, studies of the distribution of under-utilized species, testing research gear, species association and food of fishes, fish eggs and larvae, and exploration for large offshore pelagic fishes. These tasks would otherwise have been impracticable. Chartered vessels supplemented the fleet for specific operations. The M.V. Louise P. (107 feet) was used for exploration studies with trawls. The M.V. Beinir (111 feet) was used for corresponding work with long lines and lobster traps. The M.V. Reliance (118 feet) was chartered for gear testing operations. A new 128-foot research vessel, designed to set and haul all kinds of gear from the stern, is being built.

The current mixed policy for vessels for the Station works well. Essentially research projects are carried on by specially equipped research vessels. Charters are resorted to for operations simulating commercial fishing operations and for exploratory work not calling for special equipment or specially qualified crews. There is still need to acquire vessels. Most of the Station's boats are now reaching the end of their dependable lives and replacements must be scheduled soon. There is a long-term need for a large offshore vessel to carry Canadian fishery research into distant seas.

STAFF

The St. Andrews Station is still affected by the loss during the last four years of five scientists with administrative talent--three of them by transfer. In addition, we have had regrettable but normal losses at intermediate and junior levels. We have repaired some losses by fortunate recruiting. Senior members of the staff who have remained at St. Andrews are much to be commended for their efforts in maintaining Station scientific output. They have also borne much of the burden for making the Board's work available to industry and other agencies of government through correspondence, reports, conferences, and consultation. The number and sources of requests for advice are evidence of the applicability to regional and national needs of the programs these scientists have fostered.

The establishment during 1965 was 28 scientists and 108 support staff.

LIAISON AND ACKNOWLEDGEMENT

The interests of the St. Andrews Station cover many subjects and a broad territory. Obviously programs could not be carried out without active co-operation of many agencies and individuals. In most cases advantages have accrued to both the Station and the other agencies in rather complicated ways, and it would be rash to try to distinguish between our benefactors and those we have helped. Some of those with whom we have enjoyed cordial relations are mentioned below.

We have had profitable exchanges of personnel, visits, and ideas with most of the Board's other stations. Mainly through the Ottawa and Halifax offices we have had close working relationships with several services of the Department of Fisheries, including resources development, protection, economics, statistics, information, and inspection. We provided a training course for protection officers of the Department.

The Industrial Development Service of the Department of Fisheries by providing funds has made possible offshore lobsters surveys, surveys of eels and their utilization in the Maritimes, and engineering studies on towed fishing gear. Recommendations of the Federal-Provincial Fisheries Development Conference directed support to studies of lobster losses during storage and shipment, offshore exploration for large bottom and pelagic fishes, studies of unused shellfish resources, and gear research.

We have worked closely with scientists of the Department of Mines and Technical Surveys in physical oceanography, preparation of charts for fishermen, studies of the sea bottom, and in arrangements for the hydrological decade. Officers of the Department of Transport have co-operated most helpfully at lightships and lighthouses by obtaining hydrographic data and by releasing drift bottles and sea-bed drifters. They have also assisted with the design of a large vessel and in inspecting its construction. We have enjoyed the co-operation of officers of the C.N.S.S. Bluenose and Wm. J. Carson and the C.P.S.S. Princess of Acadia in collecting oceanographic data. The National Research Council helped by modelling vessels by assigning a postdoctorate fellow to the establishment, and in other ways. The Department of Public Works has been generous with advice on a variety of construction matters and has made office space available in several Maritimes ports. The Naval Research Establishment has provided valuable advice in specialized areas. We have continued in profitable working relationship with the Department of National Health and Welfare on shellfish sanitation and have provided the Atlantic Regional Development Agency with technical information.

Our offshore fisheries exploit fish stocks in international waters. As a result we share conservation problems with other fishing countries around the North Atlantic basin. The International Commission for the Northwest Atlantic Fisheries and more recently, the International Council for the Exploration of the Sea have provided foci for co-operative action. They have nurtured co-operation with many foreign scientists, especially those of the United Kingdom, the United States, and Denmark. FAO also promoted international scientific co-operation. Other profitable international contacts involved gear specialists of the U.K. White Fish Authority and the United States Fish and Wildlife Service.

At a more local level we exchanged benefits with scientific colleagues at several Canadian universities and have co-operated with extension departments. We co-operated also with departments of fisheries of the five Atlantic Provinces. The Province of New Brunswick generously allowed use of its electronic computer.

It would have been quite impossible to relate our scientific work to commercial operations without co-operation of the fishing industry. This has been generously given and we are deeply indebted to the fishing companies and to vessel captains and to fishermen who have provided us with information and in many cases inconvenienced themselves so as to assist our efforts.

STAFF LIST BY INVESTIGATIONS - 1965

Director, Scientist 6	J. L. Hart, Ph.D.
Assistant Director, Scientist 4	J. C. Medcof, Ph.D.
Assistant to Director, Scientist 1	A. Weinsieder, M.S. (from Aug. 30)

LOBSTER

Scientist 4	D. G. Wilder, Ph.D.
Scientist 3	D. W. McLeese, Ph.D.
Scientist 2	D. J. Scarratt, Ph.D.
Technician 3	R. C. Murray
Technician 2	D. E. Graham
Technician 2	U. J. Walsh
Technician 1	A. J. Wilson
Technician 1	G. E. Raine, B.S.A. (from May 25)
Casual - Student	Gail S. Storey, B.Sc. (May 11 - Sept. 7)
Casual - Student	I. S. Rote (May 7 - Sept. 10)
Casual - Student	W. H. Kydd, B.Sc. (May 17 - Sept. 10)

OYSTER

Scientist 3	R. E. Drinnan, B.Sc.
Scientist 2	M. L. H. Thomas, M.S.A.
Technician 3	S. E. Vass, B.Sc. (to Aug. 6)
Technician 2	L. L. MacLeod, B.Sc.
Technician 1	S. J. Hazelden (from Sept. 1)
Casual	W. B. Stallworthy, Ph.D. (June 21 - July 16)
Casual - Student	Wai-Ming Cheung, B.Sc. (June 1 - Sept. 3)
Casual - Student	R. R. Cattley, B.Sc. (June 11 - Aug. 31)
Casual - Student	Catherine R. Dobson (May 17 - Aug. 31)
Casual - Student	D. L. Waugh (May 3 - Sept. 24)

GROUNDFISH

Scientist 4	F. D. McCracken, Ph.D.
Scientist 3	L. M. Dickie, Ph.D. (to July 1)
Scientist 3	A. C. Kohler, Ph.D.
Scientist 2	P. M. Powles, Ph.D.
Scientist 2	A. V. Tyler, M.A.
Scientist 1	A. R. Emery, M.Sc. (to Feb. 2)
Technician 4	D. N. Fitzgerald
Technician 4	G. J. W. Sullivan

GROUNDFISH (Continued)

Technician 3	R. G. Dowd
Technician 3	M. F. Fraser
Technician 3	R. M. MacPherson
Technician 2	N. J. McFarlane
Technician 1	R. J. Thurber
Assistant Technician 3	R. K. Robicheau
Assistant Technician 3	W. D. Smith (from Feb. 3)
Assistant Technician 2	Irma I. Thompson
Assistant Technician 2	H. M. Sampson (from Nov. 1, previously seconded to Anadromous)
Assistant Technician 2 - Term	D. L. Lyon (from April 1)
Assistant Technician 2 - Term	U. J. Chiasson (May 25 - Nov. 30)
Casual - Student	W. S. Oldham, B.Sc. (May 6 - Sept. 2)
Casual - Student	L. D. Doran, B.Sc. (May 4 - Sept. 11)
Casual - Student	S. J. Nepszy, B.Sc. (May 10 - Sept. 21)
Casual - Student	D. C. Blair, B.Sc. (May 10 - Sept. 1)
Field Observer - Part-time	R. C. MacMillan - Lockeport

PELAGIC

Scientist 4	S. N. Tibbo, M.A.
Scientist 1	J. S. Beckett, B.A.
Scientist 1	R. D. Humphreys, M.A.
Technician 3	E. G. Sollows
Technician 2	A. W. Holt
Technician 2	C. F. Monaghan
Assistant Technician 3	C. A. Dickson
Assistant Technician 2	Cariene D. Burnett
Assistant Technician 2	W. H. Dougherty
Technician 1 - Term	D. G. MacDonald, B.Sc. (from Sept. 1)
Assistant Technician 2 - Term	D. L. Lyon (from Jan. 22)
Assistant Technician 2 - Term	E. A. McCullough (July 23 - Nov. 19)
Assistant Technician 2 - Term	L. M. Spires (Aug. 11 - 27)
Casual - Student	C. R. Wyman, B.Sc. (May 5 - Aug. 23)
Casual - Student	K. T. MacKay, B.S.A. (May 6 - Sept. 3)
Casual - Student	R. J. Beamish (May 10 - Aug. 23)
Casual - Student	D. G. Robinson (May 3 - Sept. 2)
Casual - Student	D. G. MacDonald, B.Sc. (May 10 - Aug. 31)

GEAR RESEARCH

Scientist 3	P. J. G. Carrothers, S.M.
Technician 3	T. J. Foulkes
Casual - Student	S. R. Burgoyne (May 11 - Aug. 19)

FISH BEHAVIOUR

Scientist 2	F. W. H. Beamish, Ph.D. (to Dec. 2)
Technician 2	Udo Buerkle, B.S.A. (educational leave from Oct. 20)
Casual - Student	E. D. Ralph (May 12 - Sept. 2)
Casual - Student	Brenda R. Moffitt (May 10 - Sept. 10)

SCALLOP

Scientist 3	N. F. Bourne, Ph.D. (to June 16)
Technician 1	R. A. Chandler, B.A. (on loan to Groundfish from Sept. 1)
Assistant Technician 3	Esther I. Lord
Casual - Student	T. W. Rowell, B.Sc. (Apr. 26 - Sept. 2)

FISHERIES OCEANOGRAPHY

Scientist 3	L. M. Lauzier, D.Sc.
Technician 4	J. G. Clark
Technician 3	J. H. Hull
Technician 1	A. W. Brown
Casual - Student	H. S. Douglass (May 12 - Sept. 10)
Casual - Student	H. M. Akagi (May 3 - Sept. 15)
Field Observer - Part-time	J. R. McLean - Entry Island
Field Observer - Part-time	R. A. Doucette - Lurcher Lightship
Field Observer - Part-time	M. R. MacKenzie - Borden
Field Observer - Part-time	G. B. Hadley - Yarmouth

SALMON & TROUT

Scientist 4	K. R. Allen, M.A. (from Nov. 1)
Scientist 4	M. W. Smith, Ph.D. (in charge to Oct. 31)
Scientist 3	P. F. Elson, Ph.D.
Scientist 2	J. W. Saunders, M.Sc.
Scientist 2	R. L. Saunders, Ph.D.
Scientist 2	P. E. K. Symons, Ph.D. (from Sept. 1)
Technician 4	E. J. Schofield
Technician 2	E. B. Henderson
Technician 2	C. R. Hayes
Technician 1	I. M. Jones
Technician 1	Cyril Williams

SALMON & TROUT (Continued)

Technician 1	W. G. Irving
Assistant Technician 3	H. P. Barchard
Assistant Technician 3	L. R. MacFarlane
Assistant Technician 2	E. K. Geldart
Assistant Technician 2	Mary Holmes
Asst. Tech. 3 - Continuing Seasonal	G. W. Cooper (April 1 - Nov. 30)
Asst. Tech. 2 - Continuing Seasonal	W. R. Currie (April 1 - Nov. 30)
Asst. Tech. 2 - Continuing Seasonal	J. H. King (April 1 - Nov. 30)
Asst. Tech. 2 - Continuing Seasonal	E. C. Tucker (April 1 - Nov. 30)
Casual - Student	G. M. Hare (May 10 - Sept. 24)
Casual - Student	M. G. Forsythe (May 14 - Sept. 13)
Casual - Student	M. J. Dadswell (May 10 - Sept. 9)
Casual - Student	F. L. Swan (May 14 - Sept. 13)
Casual - Student	J. M. Byrne, B.A. (May 3 - Sept. 10)
Casual - Student	Maureen E. Day (May 6 - Sept. 15)

POLLUTION

Scientist 3	J. B. Sprague, Ph.D.
Technician 3	W. V. Carson, B.Sc.
Technician 2	W. G. Carson (from Jan. 1)
Casual - Student	Delphine C. Maclellan, M.Sc. (May 6 - Oct. 31)

MATHEMATICAL STATISTICS

Scientist 3	J. E. Paloheimo, M.A. (educational leave from Oct. 1)
Technician 3	G. S. Mann, B.Sc. (to Sept. 30)
Electronic Data Processor 2	G. E. Fawkes
Casual	W. R. Knight, Ph.D. (May 17 - Aug. 18)
Casual - Student	P. D. M. Macdonald (May 31 - Sept. 15)

ADMINISTRATION

Administrative Officer 5	W. J. Ross, M.Sc.
Administrative Officer 3 (Buildings & Grounds Supervisor)	H. Y. Brownrigg
Administrative Officer 1	D. A. Wood

Clerical and Stenographic

Clerk 4	Winifred E. Young
Clerk 4	Frances L. Stinson
Clerk 4	B. H. Foster
Clerk 3	Shirley W. DeLong
Clerk 3	M. Beryl Stinson
Clerk 2	Dorothy M. McLaughlin
Clerk 2	Dorothy M. Fawkes
Stenographer 3 (Secretary)	C. Ruth Garnett
Stenographer 3 (Secretary)	Charlotte A. Gibson
Stenographer 3 (Secretary)	M. Barbara Stickney
Stenographer 3	R. Marion Haley
Stenographer 3	Frances J. Armstrong
Stenographer 2	Therese M. Parker
Stenographer 2	Joanne M. Maxwell (to Jan. 12)
Stenographer 2	Donna E. Grant (Jan. 5 - Sept. 9)
Stenographer 1	Eleanor L. Hutchinson
Storeman 1	G. F. Wentworth (from Nov. 1)
Clerk 1 - Term	Thora L. O'Brien (from Aug. 16)
Clerk 1 - Term	Pamela A. Stuart (from Sept. 27)
Casual - Student	Elizabeth J. Millar (May 10 - Sept. 3)
Casual - Student	Sandra M. Barr (May 17 - Sept. 3)

Technical Services

Technician 2	P. W. G. McMullon
Technician 1	F. E. Purton
Assistant Technician 3	F. B. Cunningham

Maintenance

Maintenance Supervisor 1	F. M. Langley
Maintenance Supervisor 1	K. R. Oatway
Maintenance Craftsman 1	P. M. Green
Maintenance Craftsman 1	J. F. Johnson
Maintenance Craftsman 1	F. G. Lord
Caretaker 4	K. W. Johnston
Caretaker 4	G. F. Wentworth (reassigned to Stores Nov. 1)
Caretaker 3	D. A. Stinson
Caretaker 3	H. E. Lee
Cleaning Service Man	C. E. Teakles
Maintenance Helper - Continuing Seasonal	J. L. Ellis (May 3 - June 30)
Assistant Technician 1 - Term	Clarence Cook (May 17 - June 30)
Assistant Technician 1 - Term	H. P. Millar (Aug. 16 - Oct. 15)

M/V "Harengus"

Captain	H. H. Butler
Chief Engineer	Harvey Yarn (to Nov. 30)
Chief Engineer	L. R. Parks (from Nov. 24)
2nd Engineer	Stanley Evans
Mate	E. A. Mason
Boatswain	W. J. Horne
Cook-Steward	Phillip Comeau
Twinehand	E. B. Fevens
Twinehand	L. V. Richard
Deckhand	Theador Richard

M/B "Mallotus"

Technician 1 (Captain)	C. S. Tucker
Deckhand	F. R. Johnson

M/B "Pandalus II"

Captain	P. T. Ossinger
Engineer - Term	A. D. Roberts (Apr. 21 - Oct. 28)
Cook-Deckhand - Term	G. E. O'Brien (Apr. 21 - Oct. 25)

M/V "E. E. Prince"

Chief Engineer	Harvey Yarn (from Dec. 1)

SCIENTIFIC STAFF - 1965

Biological Station, St. Andrews, N. B.

J. L. Hart, Ph.D. (Toronto), F.R.S.C., Director.

J. C. Medcof, Ph.D. (Illinois), Assistant Director.

A. Weinsieder, M.S. (Vermont), Assistant to Director. From Aug. 30.

Lobster

D. G. Wilder, Ph.D. (Toronto).

D. W. McLeese, Ph.D. (Toronto).

D. J. Scarratt, Ph.D. (Wales).

Oyster

R. E. Drinnan, B.Sc. (London).

M. L. H. Thomas, M.S.A. (Toronto).

W. B. Stallworthy, Ph.D. (Toronto). Casual, June 21 - July 16.

Groundfish

F. D. McCracken, Ph.D. (Toronto).

L. M. Dickie, Ph.D. (Toronto). To July 1.

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

P. M. Powles, Ph.D. (McGill).

A. V. Tyler, M. A. (Toronto).

A. R. Emery, M.Sc. (Toronto). To February 2.

Pelagic

S. N. Tibbo, M.A. (Toronto).

R. D. Humphreys, M.A. (British Columbia).

J. S. Beckett, B.A. (Cambridge).

Gear Research

P. J. G. Carrothers, S.M. (M.I.T.).

Fish Behaviour

F. W. H. Beamish, Ph.D. (Toronto). To Dec. 1.

Scallop

N. F. Bourne, Ph.D. (Toronto). To June 16.

Fisheries Oceanography

L. M. Lauzier, D.Sc. (Laval).

Anadromous

K. R. Allen, M.A. (Cambridge). From Nov. 1.

M. W. Smith, Ph.D. (Toronto).

P. F. Elson, Ph.D. (Toronto).

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

J. W. Saunders, M.Sc. (Laval).

P. E. K. Symons, Ph.D. (Leiden). From Sept. 1.

D. P. Dehadrai, Ph.D. (Delhi). Post Doctoral Fellow.

Pollution

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

Mathematical Statistics

J. E. Paloheimo, M.A. (Toronto). Educational leave from Oct.1.

W. R. Knight, Ph.D. (Toronto). Casual, May 17 - Aug. 18.

PUBLICATIONS

(January 1, 1965, to December 31, 1965)

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FILMS

1965

The films listed below were added to the collection in 1965 at the Board's St. Andrews Station:

SALMON SMOLT TAGGING	10 min. colour silent 16 mm (project at sound speed)
ANTI-POLLUTION TESTS WITH FISH	15 min. colour silent 16 mm (project at sound speed)

INDEX TO SUMMARY REPORTS

LOBSTER SUMMARIES

No. A-1

LOBSTER INVESTIGATIONS

During 1965, the lobster investigation staff was fully occupied with an interesting variety of projects. Studies of the commercial fishery were continued at two ports and serious thought was given to controlling fishing effort at one of these ports on an experimental basis. A half-acre artificial reef was made under our supervision off Richibucto, N.B., and systematic observations of its developing flora and fauna were carried out by our divers. This work was done in conjunction with studies of the ecology of larvae and older lobsters and observations on the behaviour of larvae in the laboratory. A survey to determine the extent and causes of lobster losses during commercial storage and shipment provided interesting new information but was seriously handicapped by a lack of fully qualified staff. Small lobsters grew in captivity to more valuable sizes better than in 1964 but commercial application is not yet economically feasible. An offshore survey for lobsters with a trawler met with some success but a complementary survey with conventional traps was hampered by heavy gear loss. Studies of the growth, survival and long-term movements of lobsters in nature suffer from the lack of a satisfactory tag that would be retained through several moults. New types of tags have shown considerable promise in laboratory tests. Possible effects of the N.B.-P.E.I. crossing on nearby lobster stocks have stimulated considerable thought and discussion. A brief preliminary survey of the area has been made. Interest by our staff in the attempt of the Nanaimo station to establish lobsters in British Columbia waters remains keen. During the year, old relations were renewed and new relations established with lobster research workers in the New England States through a series of meetings and co-operative field work.

D. G. Wilder

No. A-2

THE COMMERCIAL FISHERY

Systematic observations on the commercial lobster fishery were continued at Port Maitland, Yarmouth County, N.S., and at Miminegash, Prince County, P.E.I.

Landings at Port Maitland during the December 1, 1964, to May 31, 1965, season were 12% below the average for the previous 10 years. The landed price, which in recent years had remained quite steady averaging 55¢, suddenly jumped to 76¢. Consequently the landed value of the catch was the fourth highest in 21 years.

Of 54 cod caught on hand lines or line trawls among the lobster traps off Port Maitland, about 6% contained remnants of sublegal lobsters.

From May 14 to 24, 1963, 2,201 sublegal lobsters were marked and released off Port Maitland. During the December 1963 to May 1964 season, only 66 of these were recovered although 95% of the lobsters landed at Port Maitland were carefully examined for marks. This extremely low return is explained in part by the fact that over 500 of the lobsters were too small when marked to be expected to grow to legal size during the 1963-64 season. However, if they survived they would be expected to contribute to the 1964-65 landings. Although 34% of the 1964-65 catch at Port Maitland was examined, only 4 marked lobsters were found. The conclusion that sublegal lobsters released off Port Maitland in May suffer heavy mortalities is confirmed.

Surface water temperatures off southern Nova Scotia during the last half of 1965 were unusually low. In the Halifax area, temperatures in August were 12°F below the long-term average, and off Yarmouth in September 6°F below average. Low summer temperatures would be expected to delay and inhibit moulting and so increase the proportion of soft-shelled lobsters in the catch and reduce the number of recruits. Low temperatures during the fishing season would be expected to reduce the lobsters' activity and catchability. During December 1965, landings in Halifax, Lunenburg and Queens Counties averaged about 40% below December 1964 landings. Shelburne County was about 10% lower, whereas Yarmouth and Digby County landings averaged 30% higher than 1964. Shell condition and meat yield were unusually poor throughout December. The poor condition of the lobsters is of particular significance in view of fishermen's meetings this year that debated earlier lobster fishing in southern New Brunswick and southern Nova Scotia. There is no full explanation for the striking regional differences in December 1965 landings, although differences in the distribution of cold water undoubtedly played a part. It will be interesting to see how landings for the full 6-month season compare. December 1965 landings at Port Maitland were more than twice the previous 5 years' average and with landed prices steady at the all-time December high of 90¢, the landed value was more than three times the 5-year average. The average gross income per boat for December was nearly $4,000.

Landings at Miminegash, P.E.I., were 25% below 1964 and 22% below the average for the previous 10 years. Since the fleet was near an all-time high, the catch per boat was the third lowest on record. Although the total landed value was 24% below the record 1964 value, it was the second highest on record. Total landings in the northern half of Northumberland Strait initially reported as extremely poor were about 22% below 1964 in weight and 27% below in value.

The extremely high rate of exploitation in the lobster fishery (Miminegash 1965 tag returns 88%) has focussed attention on the possibility of reducing fishing effort through trap limits and licence restriction to effect a substantial increase in net profits. There has been considerable thought and discussion to decide how effort control might be introduced in the Miminegash area on an experimental basis. Some assistance was given to Mr. M. C. Cormier of the Economics Branch in a preliminary survey of the Miminegash area. The situation is, however, further complicated by a strong general interest in the industry for some form of effort control that has been confirmed by recent surveys of fishermen's opinions. If effort control is to be generally introduced soon, the proposed Miminegash experiment would have less significance.

In 1964, 20 new lobster traps at Miminegash were dipped in a solution of TBTO in Varsol as a treatment against shipworms (Teredo). Shipworm settlement during the 1964 season was extremely light so the results were inconclusive. When the same traps, without further treatment, were re-examined after the 1965 season, the treated traps averaged 10 worm holes per lath, the untreated 175 holes. The tests confirm those of the Ellerslie sub-station in relation to oyster rearing equipment and indicate that TBTO can be used effectively and inexpensively to control shipworm damage to lobster traps.

The field studies at Port Maitland were carried on by D. E. Graham with some assistance from U. J. Walsh and P. T. Ossinger. U. J. Walsh made the field observations at Miminegash.

D. G. Wilder

No. A-3

OFFSHORE LOBSTER INVESTIGATIONS

In recent years, U.S. trawlers operating along the continental slope at depths of 50 to 250 fathoms, principally south of Georges Bank, have landed over 2,000,000 pounds of lobsters annually. To learn more about the abundance and distribution of lobsters, particularly in areas more accessible to Canadian fishermen, two projects were started in 1965 in co-operation with the Industrial Development Service. The Louise P., a chartered stern trawler, made 192 ¾- to 1-hour tows with a #41 Yankee trawl from July 17 to August 27. This fishing was done at 50 to 200 fathoms along the continental slope from south of Georges Bank to Sable Island. The M.V. Beinir, a chartered longliner, fished conventional wooden traps from August 20 to September 7 at depths of 25 to 55 fathoms off southern Nova Scotia from Grand Manan Bank to Roseway Bank. A total of 985 trap hauls were made.

A total of 196 lobsters were caught trawling, with 90% of these being taken off eastern Georges Bank. They ranged in weight from ¼ to 22¼ pounds and averaged 5.7 pounds. Best fishing was found south of Georges Bank at 100 to 110 fathoms at 9°C. Of these lobsters, 182 were tagged with yellow spaghetti tags and released close to the point of capture. Six tags have been returned to date, 3 from the United States, 2 from Canada and 1 from Russia. Reasonably complete data for 4 of the tags indicate movements of 4 to 60 nautical miles in 1 to 5½ months. Two Stage II larvae were caught on eastern Georges Bank during the third cruise and two Stage IV larvae between Browns and LaHave during the fourth cruise.

Only 10 lobsters were caught trap fishing. Five of these, caught on Grand Manan Bank at 30 to 40 fathoms, ranged from 2.4 to 2.9 inches carapace length and averaged less than a pound in weight. The other 5 caught on the Tongue Ground at 35 fathoms ranged from 3.2 to 5.4 inches carapace length and averaged about 2 pounds in weight. All 10 lobsters which were females were tagged and released approximately where caught. None of these tags have been returned to date. A striking feature of this project was the heavy gear loss, 78 of our 100 traps being lost in about 2 weeks. Most of the loss resulted from chafed lines but a significant number of traps were lost in thick fog. Unless gear losses can be greatly reduced, trap fishing at these depths would not be economically feasible. General lack of experience and ignorance of the fishing grounds undoubtedly contributed to the poor catches.

R. A. McKenzie, who was in overall charge of the Louise P. operations, was assisted at sea by R. J. Beamish, D. N. Fitzgerald, W. H. Kydd, D. G. Robinson, E. G. Sollows, L. Spires, D. G. Wilder and A. J. Wilson. D. E. Graham supervised the operations of the M.V. Beinir, assisted by A. J. Wilson and E. McCullough.

D. G. Wilder

No. A-4

LARVAL TOWING

Our main purpose this year was to determine whether Stage IV lobster larvae in the surface waters were more abundant at night than in the daytime. A series of ½-hour tows made at 2-hour intervals over four separate 24-hour periods was made in August 1965. This time of year was chosen as one when Stage IV larvae would be most abundant. The following results were obtained:

Catch/tow of larvae, means of 8 daytime and 5 nighttime tows in each of 4 series.

	Stage I		Stage II		Stage III		Stage IV	
Series	day	night	day	night	day	night	day	night
Aug. 9	49.1	27.6	17.2	20.4	4.6	5.0	0.6	1.6
Aug. 11	24.5	18.2	11.9	5.8	3.5	2.0	1.1	0.8
Aug. 17	23.7	5.1	36.6	25.6	24.0	26.6	5.9	2.8
Aug. 31	13.0	3.0	2.8	0.8	0.9	0.2	2.9	2.2
Mean of means	27.25	13.5	17.09	13.1	8.25	8.45	2.61	1.85

In general the catch per tow of Stages I and II was higher in the daytime, which is in agreement with earlier findings, and Stage III daytime and nighttime abundances were about equal. Stage IV larvae were more abundant during the daytime although statistical comparison of means does not indicate that the values are different,

$$p = .4,$$

consequently nothing can be inferred about a diurnal rhythmic behaviour in Stage IV lobster larvae.

D. J. Scarratt

No. A-5

LABORATORY WORK ON LARVAL LOBSTERS

The first item of interest this year was the establishment of a bulk rearing technique. Our previous trials have not been effective for a variety of reasons. Firstly, lobster larvae are cannibalistic and mortality is high unless they are separated by barriers or turbulence. Turbulence created by a continuous-flow system causes problems when food has to be provided on a continuous basis. Mr. J. T. Hughes of the Lobster Hatchery, Martha's Vineyard, kindly lent us one of his rearing chambers which we were able to adapt to a recirculatory system using a reservoir and electric pump. Live *Artemia salina* nauplii provided as food lived in the recirculating water and passed through the pump satisfactorily. New *Artemia* were added once every 24 hours and feeding at 2-hour intervals (as practised at Martha's Vineyard) was eliminated. This chamber was used as a repository for newly hatched surplus larvae and no record was kept of the numbers of animals put in or taken out. Nevertheless, several larvae developed to Stage V and many others were used in Stages II, III, and IV.

The main experimental items concerned the behaviour of larvae in response to light changes and to an artificially established thermocline in an 8-ft tall plexiglass column filled with sea water. Stage IV lobsters in particular were considered, although tests were made with other stages including Stage V. Observations comprised the vertical distribution of larvae under constant conditions of illumination, the direction of movement, if any, following a change in illumination, and the rate of settling of larvae of different ages.

Usually larvae remained in warmer water above the thermocline (say above 13-15°C). Once in the cooler water they rarely rose above it but continued to the bottom.

In bright light conditions, the percentage of larvae (Stage IV) settling within ½ hour of introduction to the column rose from 4 of 101 larvae in the first week of Stage IV to 47 of 101 between 22 and 28 days in Stage IV. Similarly the number of Stage IV lobsters which did not settle during the course of a test run (6-8 hours) fell from 77 of 101 larvae in week 1 to 49 of 101 larvae in week 4. An "eye" test on the data suggests that the change from the tendency to remain planktonic to the tendency to settle soon after introduction to the column takes place at about day 21 in Stage IV.

The vertical distribution of swimming larvae in constant conditions of illumination likewise changes with the age of the larva: 2 Stage IV larvae on the 1st day after moulting remained in the upper 1 ft of water for 62.5% of the time they were observed; 11 larvae 16 days in Stage IV occupied the upper 1 ft layer only 9% of the times they were observed and of 10 larvae in day 20 of Stage IV, 8 went to the bottom within 5 minutes and none were observed in the surface layer.

The reaction of Stage IV larvae to changes in illumination is somewhat more complex and was only demonstrable at low levels of illumination. A change in illumination from almost pitch dark to a dim light (60 ft candles at the surface) was followed by an upward movement of the larvae. Change from dim light to dark was followed by a downward movement. Following light changes between dim and bright (270 ft candles) illumination, these patterns appeared to be reversed.

To test the results the following procedure was adopted. Following a change in illumination a lobster was deemed to have moved if its subsequent position was 6 inches or more above or below its starting position. Thus a table was obtained showing upward, downward or no movement for larvae of all ages for all light changes. These observations could be summed, i.e. +1 for each upward move, -1 for each downward move and 0 for no movement, and the sum divided by the total number of observations to give a net value for each day. These values can then be ranked in ascending order and tested for their departure from zero, using the Walsh test (Seigel, 1956, Non-parametric statistics).

Movement of Stage IV larvae, 1-7 days old, following increase in illumination from dark to dim light.

	Day	1	2	3	4	5	6	7
Up	+	28	32	4	3	15	22	4
No movement	0	18	5	5	8	17	3	2
Down	-	0	0	2	0	2	3	1
Resultant		28	32	2	3	13	19	3
No. of observations		46	37	11	11	34	28	7
Mean resultant d		.608	.864	.181	.272	.382	.678	.428
Rank		5	7	1	2	3	6	4

for $N = 7$

$d_1 = .181 > 0$

$p = .008$

This assumes that in the absence of specific stimuli the larvae would, over a short period of time, move up or down in a random fashion, and on the average give a resultant of zero. The existing resultants in effect measure the departure from random up or down movement.

The following table displays the results to date. The words, sink or rise, indicate a difference significant at .05 level. A + or - indicates the direction of movement if the result is not significant.

Light change	Week 1	Week 2	Week 3	Week 4
Dark - dim	Rise	Rise	+	+
Dim - dark	Sink	Sink	-	Sink
Dim to full	-	Sink	-	-
Full to dim	-	+	+	Rise
Dark to full	-		+	
Full to dark	-		+	

No conclusions are offered.

D. J. Scarratt

No. A-6

DIVING SURVEY FOR LOBSTERS

This year 26 stations were sampled. As in previous years the technique consisted of a close search by divers of a 25 sq yd area of sea bed, surrounded temporarily by a net which delimited the area and reduced the chance of lobsters escaping. The stations were confined to a rocky area off the mouth of the Richibucto river at depths of 3 to 10 fathoms. The stations were about ¼ mile apart and the "net" was set four times on each, making a total of 2,600 sq yd (2,175 sq m) of sea bed examined. Samples were also taken with a "vacuum cleaner" type sampler (working on the air-lift principle) of the fauna in and around lobster burrows. These are awaiting analysis. The lobsters taken were brought aboard the boat, sexed, measured, and preserved. Later the lobsters were weighed and the stomach contents analysed.

The size distribution of the 221 lobsters taken is similar to that obtained in 1964. The total weight of these lobsters was 14.733 kg which gives an average of 6.8 g/sq metre of sea bed surveyed.

The stomachs of these lobsters were examined. Among the diet were tunicates, polychaetes, echinoderms, shrimps, amphipods and crabs, and occasionally molluscs and fish. In most cases only hard parts were left. In the early part of the season only lobsters taken early in the day had food in the stomach. Later on, most specimens had full stomachs, regardless of the time of day.

D. J. Scarratt

No. A-7

ARTIFICIAL REEF

The site for the reef was selected on the basis of a survey performed for us by Miss Kate Kranck of the Geological Survey of Canada in the summer of 1964. The area was also examined carefully by our divers during the spring of 1965. Work began on the reef on June 27, 1965, when we placed six small plastic buoys marking the boundaries of the reef area. These buoys acted as guides to the contractor who placed large spar buoys at the site that same afternoon. Fill was taken from the sea cliff about ½ mile SW of Richibucto Cape, trucked to the Cape and towed to the reef site in steel dumping scows. The first load was delivered on June 30 and examined by me that afternoon. The depth of water at the site is approximately 9 fathoms. Loads of up to 40 cubic yards will spread out fairly evenly over a diameter of about 40 feet in that depth of water. Larger loads seem to leave a less even pile having a crater-like appearance, bare in the centre with a circular ridge around the periphery. For this reason the loads did not exceed 40 cubic yards with the scows only two-thirds full each trip. The tug was able to make two or three trips each day. The weather generally was favourable and the last load was dumped on July 9.

The marker buoys were subsequently removed from the site. The mooring stones, however, were left since they form useful points for attachment of guide lines marking the boundaries of the reef. A lighter spar buoy has been rigged by a chain bridle to two of these stones as a semi-permanent mark. Two shore transects have been established and several sextant bearings taken to ensure that the reef will not be lost. The centre of the reef is at:

Lat. 46°45'42.434"N.
Long. 64°44'59.792"W.

The reef is in approximately 60 feet of water and covers one-half acre. Approximately 1,000 cubic yards of rock were used. The reef material comprises pieces of sandstone ranging from 2 inches to 3 feet in diameter. There are abundant hiding places for lobsters and the rocks are small enough to be moved by divers under water.

There was one detailed examination during the latter part of August and further examinations in September and October. Seventeen lobsters between 2¼ and 2¾ inches in carapace length have been seen on the reef and tagged under water with a suture-type tag. Only one tagged lobster has been seen again. Several lobster burrows have been established on the reef; however, these were not continuously occupied. There is no indication of movement in of smaller lobsters.

By October, bryozoa and hydroids were beginning to grow on the rocks and some small starfish and a few brittle stars were seen. There were also a few hippolytid shrimps and a few fish. There was little for lobsters to feed upon on the reef and I do not expect to see a resident population before such a food supply is established.

D. J. Scarratt

No. A-8

BIOLOGICAL SURVEY OF N.B.-P.E.I. CAUSEWAY SITE

With construction of the N.B.-P.E.I. causeway commencing this fall, it was deemed desirable that an investigation of the biology of the crossing area should be made. D. L. Peer of the Bedford Institute of Oceanography and I visited Cape Tormentine October 12-15. We had kindly been presented with a topographical map of bottom sediments in the area by Miss Kate Kranck of the Bedford Institute of Oceanography. Fourteen samples were taken with a Van Veen Sampler in the immediate vicinity of the proposed crossing.

The sea bed for the most part consists of a glacial till, with sand and gravel predominating. Gravel and small stones are lying at the surface, as evidenced by bryozoa, sponges, tunicates, etc., growing on them. Some of the deeper areas have pockets of mud among the pebbles. Inshore on either side the bottom is of sand.

It seems that there are no areas where concentrations of lobsters occur. Rather they appear to be randomly distributed over the whole area exclusive of the sandy, shallow areas. Local fishermen do not recognize specific lobster reefs but claim equal fishing potential over the whole area lying deeper than 5 or 6 fathoms.

The causeway and pier foundations will cover existing sea bed which is producing lobsters. Since final designs for the crossing are not published, the total area to be buried cannot yet be calculated. The most "open" design yet suggested would bury approximately 87 acres of sea bed, the most closed design about 200 acres. The better lobster grounds in Northumberland Strait produce lobsters at an average approximate rate of 20 pounds per acre per year. There could therefore be an immediate loss of from 1,750 to 4,000 pounds of lobsters in the path of the crossing. Undoubtedly many would escape being covered by rock fill.

Increased currents resulting from the constriction of the passage will have two effects: Firstly, the time during which fishermen may haul traps will likely be reduced. Secondly, there will probably be an increase in the scouring effects in the passage and possibly a deposition of sediment elsewhere. It is unlikely that scouring will affect lobster productivity unless sufficient overburden is removed to expose the bedrock. This bedrock appears to be sandstone and I doubt whether, once exposed, this rock will support many lobsters, unless the surface proves to be broken or littered with boulders. Deposition of this sediment elsewhere could cover existing lobster producing areas.

D. J. Scarratt

No. A-9

GROWTH IN CAPTIVITY

Experiments to explore the feasibility of growing lobsters in captivity were continued. A total of 178 immature lobsters (av. weight 1 lb) from the Bay of Fundy area were held in fibreglass tanks at densities of ¼, ½, 1, and 2 lobsters/sq ft of bottom area. To maintain the density, any lobsters that died were replaced. The lobsters were provided with separate wire or aluminum shelters which as a rule they occupied except when they came out to obtain food. They were fed 2% of their weight three times a week. The diet was varied to approximate a natural one and consisted of molluscs, fish, miscellaneous invertebrates and on occasion beef liver. Water temperature was maintained at 15°C. The results at 6 months (May 22 to Nov. 22) are summarized in the following table:

Density lob/sq ft	No. lob.	No. dead	No. moulting	No. intact moults at 8 weeks	Av. % growth 8 weeks after moult Length	Weight
2	54	7	48	36	9.1	28.9
1	54	17	45	16	9.7	32.6
½	55	6	52	29	10.1	33.5
¼	15	2	15	6	12.2	43.3
	178	32	160	87	9.7	32.1

Mortality amounted to 32 (18%) of which 30 were moulted lobsters. Twenty-four of the 30 had been partly eaten by other lobsters. Maximum growth in weight for an individual lobster was 56.3% at a density of ¼ lobster/sq ft. The average growth in weight for all 87 intact lobsters was 32.1%. In two previous growth experiments the best average growth in weight was 20% for a group of 19 lobsters fed cod fillets and beef liver at 15°C. The better growth in the current experiment is thought to result mainly from the varied diet. However, most if not all of these Bay of Fundy lobsters were immature and these may normally grow faster than the smaller but earlier maturing lobsters from Northumberland Strait used in the 1964 experiments.

The average growth of the small sample at ¼ lobster/sq ft was greater than at the other densities. Experiments should be continued to investigate further the effects of maturity and density on growth.

On February 23, meat yield (claw and tail meat) of 40 lobsters that had moulted 4 to 6½ months earlier in the experiment averaged 25.9% with a range from 16.5 to 30.1%. This average meat yield is slightly better than that from 10 freshly caught lobsters in May 1963 (23.0%), in July 1964 (24.6%) and about equal to the yield from 11 freshly caught winter lobsters, 1953 (25.8%).

D. W. McLeese

No. A-10

COMMERCIAL LOSSES OF LOBSTERS

Lobster landings in Canada are about 42 million lb a year, of which 17 million lb are processed into fresh, frozen and canned meat soon after capture and 25 million lb are marketed alive. During handling, shipping and storage of these 25 million lb, losses from weakening and deaths occur. In most cases weak and dead lobsters that are promptly detected are processed but usually at a lower profit. Those dead lobsters that are not suitable for processing are a total loss. During the latter part of 1964 a study was started to provide reliable figures for commercial losses during all phases of storage and shipment and to determine the causes.

We have made direct observations on about 1.8 million lb of lobsters in fishermen's catches, in shipments and in storage and have obtained commercial storage and shipping records from about 17 million lb. From these it is estimated that of the 25 million lb of live lobsters, 2 million lb (8%) of weak and freshly dead lobsters are processed and 660,000 lb (2.6%) of dead lobsters are a total loss. These estimates are somewhat low because the quantities of lobsters that are handled repetitively have not yet been accurately determined. Based on current retail prices of $1.38 to $1.67 a pound for live lobsters and $3.75 to $4.50 a pound for meat (4.5 lb lobsters convert to 1 lb meat), loss in retail value is estimated to be between $1.1 and $1.3 million from weak and freshly dead lobsters and between $0.9 and $1.1 million from unsalvageable dead lobsters.

A total of 50,000 lb (6.7%) of lobsters discarded as weak or dead from a total of 750,000 lb in fishermen's catches, in shipments and in storage were examined in detail. Of these, 3,000 (6%) were injured, 35,000 (70%) were weak with no visible signs (handling and environmental), 9,250 (18.5%) were vigorous but lacked both claws (some regenerating), 450 (0.9%) were soft-shelled and 2,300 (4.6%) were dead or rotten. There was no indication of blood disease. From tidal pound storage in winter, up to about 1.7% may be processed as weak lobsters because of severe erosion from shell disease.

In fishermen's catches, 5.1% of the lobsters had only one claw; about half of these were new injuries. In some shipments, up to 13% of the lobsters had one claw. Unbiased sampling from shipments is difficult because of commercial culling for 1-clawed lobsters. These usually sell for 12-25% less.

At inland storage areas, delay in transportation is generally blamed for poor shipments, except in late fall when lobsters are soft-shelled and are not expected to ship well. Because of frequent shipments from the coast and a rapid turnover, lobsters are usually not held inland for more than a few days. Most dealers reported negligible losses in their artificial seawater storage units.

There are certain areas where rapid improvement in storage and shipment could be realized. In Northumberland Strait during May to October, 3 to 40% of the daily shipments from the fishing areas to the major processing and storage plants are weak on arrival. Losses increase with distance and as the days grow warmer. Much of the weakening is related to poor facilities for temporary storage at the fishing ports and to lack of refrigerated transportation. The magnitude of the loss is masked because relatively small quantities of market-sized lobsters are handled each day at each collection port. However, the total is over 4 million lb with over 400,000 lb weak.

The biggest total loss occurs in lobster pounds where lobsters are stored for maximum periods of 4 months in summer and 5 to 6 months in winter. Considerable effort has been expended on the study of pounds, where the overall unsalvageable loss is estimated at about 400,000 lb a year. Most of the 21 tidal pounds have been surveyed and area, water depth, flooding and stagnant periods determined. The pounds enclose a total of 3 million square feet. Environmental conditions, temperature, salinity and oxygen have been measured in some and over 2,000 lobsters have been tagged as they were put in pounds.

Records for the 6-year period 1960-65 show that average winter losses are higher than average summer losses in 11 of 12 pounds. The difference is not simply related to longer storage in winter since the average loss per month is also higher in winter. Over the 6-year period, for the 12 pounds, winter losses ranged from 2.7 to 34% and summer losses ranged from 1.2 to 19%. Preliminary analysis of data has failed to show consistent relationships between stagnant period, water depth, crowding or maximum time in storage and losses in pounds. Sampling of environmental conditions has not coincided with heavy losses. Losses during 1965 were close to the minimum losses recorded over the previous 5 years in 17 of 21 possible comparisons.

The Economics Branch of the Department of Fisheries plans to undertake an economic study of storage and shipment of lobsters. Such a study would allow us to focus attention on the causes of losses and on methods for reducing them. An economic study would be a tremendous aid in the realistic appraisal of improvements the industry might introduce.

D. W. McLeese

No. A-11

TREATMENT OF BLOOD DISEASE WITH AN ANTIBIOTIC (VANCOMYCIN)

In a recent growth experiment, the number of lobsters was maintained by replacing those that died. Blood disease (Gaffkaemia) was apparently introduced after October 28, near the end of the growth experiment proper. From November 18 to January 6, 37 of 178 lobsters died. Blood smears were obtained from 29 of which 22 showed the presence of blood disease bacteria. On January 6, each of 54 lobsters was injected with 1 cc of the antibiotic Vancomycin (50 mg/cc) and 53 others were each injected with 1 cc of sterile sea water as a control. Fifty-eight lobsters in another group had shown no evidence of blood disease and were not treated. Between January 6 and February 14, 8 deaths occurred, 4 in the antibiotic-treated group (no infection), 3 in the seawater control (3 infected) and 1 in the untreated group (no infection).

The single injection with the antibiotic appears to have eliminated bacteria from the blood. The potential value of the antibiotic in reducing mortality was not shown since the treatment apparently was given when heavy mortalities from blood disease had ceased. The dosage was suggested by Mr. Phillip Goggins, Maine Department of Sea and Shore Fisheries.

D. W. McLeese

No. A-12

TOXICITY OF WESTERN RED CEDAR TO LOBSTERS

Stewart and Cornick (J. Fish. Res. Bd. Canada, 21(6): 1549-1551, 1964) showed that a substance toxic to lobsters could be extracted with warm (24°C) sea water from western red cedar sawdust. For this reason they recommended against the use of this cedar in the construction of lobster storage tanks.

To determine whether western red cedar would cause significant losses under commercial storage conditions, further experiments were conducted. A fibreglass tank, 38" x 18" x 12", was completely lined with new cedar shingles and filled to a depth of 8 inches with 20 imperial gallons of sea water. The tank was placed in a cold room where the water was aerated and maintained at 3.6°C. Twenty pounds of lobsters were placed in this tank and in a similar unlined control tank. This storage density is within the range of inland commercial practice.

In the lined tank, half of the lobsters died in 16.5 days, in the control in 28 days. This confirms the presence of a toxic substance but mortalities to 10 days did not differ significantly in the two tanks and were only 4% in the lined tank. This suggests that significant losses would be unlikely to occur during inland storage, the lobsters normally being held for only a few days.

Both tanks were then thoroughly cleaned and refilled with 17 gallons of sea water and 17 pounds of lobsters. In this test half of the lobsters in the lined tank died in 23 days, in the unlined tank in 28 days. Mortalities to 20 days did not differ significantly and were only 3.8% in the lined tank. Apparently a significant fraction of the toxic material had leached out of the cedar during the first test. This suggests that the danger from western red cedar declines with use and could to quite an extent be avoided by a thorough soaking and flushing. A firm using western red cedar tanks reports normal storage mortalities.

In the first test, water in the lined tank became fairly heavily stained within a few days. Staining was appreciably less in the second. A 15-member taste panel could not detect any difference in the flavour of test and control lobsters on the 18th day.

D. W. McLeese

No. A-13

SHALLOW WATER STORAGE FOR LOBSTERS

Experiments to investigate a more efficient storage method for lobsters using less space and water were initiated. Groups of 20 lobsters were stored in fibreglass tanks (3' x 3') with water depths of 1 inch, 2 inches and 8 inches (control). Over the 22 days of the experiment, water temperature ranged from 0 to 3.8°C and room temperature ranged from about 15 to 20°C. Of 60 lobsters in shallow water 4 died, 3 of which were killed as they moulted. None of the 20 in the control died.

Large-scale experiments to test a variety of water and air temperatures and a variety of water flows are planned.

D. W. McLeese

No. A-14

INVESTIGATION OF PERMANENT TAGS

Two experiments have been performed; the first tested the original type sphyrion tag (Scarratt and Elson, J. Fish. Res. Bd. Canada, 22, 1965) against a branding technique and the conventional carapace tag. Eighty-eight animals were used in each category.

Thirty-two lobsters carried the sphyrion tag successfully through one moult; one lost the tag during moulting. Forty-one tags were lost of which 19 were not accounted for. Subsequent dissection of the stomachs of several dead lobsters has yielded a few of these tags and the likelihood is that most of the tag losses were due to other lobsters holding the tags in their mouthparts, resulting in the tag being torn off or dislodged. In many cases the labels of remaining tags were illegible due to repeated chewing by other lobsters.

Thirty-seven carapace-tagged lobsters carried their tags until the moult and 39 tags were lost or not accounted for. Mortality in both cases was about the same: 12 sphyrion-tagged animals, 11 carapace-tagged animals. The remainder (2 and 1) were unmoulted when the experiment terminated.

Of 48 branded animals known to have moulted, only 22 showed a recognizable mark after moulting. The number of branded lobsters not accounted for was high since consumption of the old shell of a lobster which showed no brand mark after moulting results in a completely unidentifiable lobster. This is a direct consequence of the experimental conditions, where the lobsters were free to wander in large shallow tanks furnished with "stalls" for cover and protection. The ensuing confusion was unforeseen.

In the second experiment we attempted to minimize this confusion by subdividing the tanks and providing thin-wall, aluminum tubes 9 inches long x 4½ inches diameter. Since lobsters crawl into these, it was hoped to reduce the number of tags lost by chewing, yet still give the lobsters some freedom of movement. The stock remaining from the first experiment was used again. The existing sphyrion tags were retained on the original animals and new tags applied to the remainder. Three modifications of the sphyrion tag were tested, each made with different lengths of "spaghetti" replacing the vinyl label: a short version with a label c. 1¼ inches long was inserted under the carapace; a medium version with a label c. 2½ inches long and a short (¼ in.) filament was similarly inserted under the carapace; a long version with label 4 inches long was inserted in the abdominal musculature dorsally between abdominal segments 2 and 3.

This experiment is still in progress at the time of writing but to date there have been 20 successful moults by 19 lobsters. The state of the experiment is as follows:

	Sphyrion tag	Sphyrion-spaghetti tag short	medium	long
No. animals	40	30	30	30
Successful moults	7*	12**	2	0
Tags lost before moult	1	4	7	15
Mortality	3	11	4	8
Tags left in experiment	25	22	17	6

* Two of these tagged animals had already moulted successfully in the previous experiment.

** One of these animals moulted twice in this experiment.

In spite of more effective shelters, there is still evidence of lobsters chewing the tags off their neighbours. The amount of chewing a tag receives seems to be a function of its length. In nature it is doubtful if such effects will occur. The tags will therefore be tested once more in the lab - the lobsters being isolated from one another - before a field experiment is run.

D. J. Scarratt

No. A-15

BRITISH COLUMBIA LOBSTER TRANSPLANT

In connection with the current attempt to establish lobsters in British Columbia waters, T. H. Butler and R. J. Ghelardi of the Nanaimo Station visited the Atlantic coast from May 26 to June 10. Their itinerary included visits to Board stations at St. Andrews, Halifax, and St. John's for general lobster discussions and diving surveys off Richibucto, N.B., and in Bay of Islands, Newfoundland, to observe lobsters under a variety of natural conditions.

In June 1965, 184 immature, Bay of Fundy lobsters averaging 1 pound in weight were obtained locally. These were carefully culled to reject those that were weak or injured. In co-operation with Dr. J. E. Stewart of the Halifax Laboratory, the remainder were carefully checked twice to see if they were carrying Gaffkya homari, the bacterium that causes blood disease. The 96 lobsters that appeared to be disease-free were flown to Vancouver, all arriving there alive on June 23. Half of these were held under observation at Nanaimo and half were held in cages at the proposed transplanting site on the west coast of Vancouver Island.

D. G. Wilder

OYSTER AND CLAM SUMMARIES

No. B-1

GENERAL INTRODUCTION AND SUMMARY

In 1965 the programme was largely a continuation of established investigations designed to allow the development and management of the huge shellfish production potential of inshore areas.

The hatchery programme is designed to provide the basic essential for development of the oyster fishery--seed. We have established the feasibility of such hatchery production, made progress in the necessary engineering and gained experience in the biological requirements. Additional facilities which will be necessary for further development are under design for construction in 1966. We are now at the stage of assessing the potential of Maritimes areas for exploratory commercial hatchery development.

Our programme of general benthic ecology is concerned with describing the dynamics of the estuary, physical and biological as a basis for developing techniques of control. The initial descriptive phase is virtually complete, and the more difficult study of the dynamic interplay between organisms and their environment is beginning. This work has been extended to include a study of fouling organisms, shown to be important in hatchery development. A beginning was made in 1965 to a study of the effects of the addition of fertilizers to an estuarine area.

The under-exploited species programme is a new one. Designed to assess the potential for development of currently under-exploited inshore molluscan species, and develop a biological basis for their management, it will complement the more basic work on benthic ecology.

We are continuing to monitor the basic biology of the oyster, growth, biology, etc., throughout the Maritimes. The response of the organism to variations, physical and biological, in its environment is an important prerequisite to intelligent exploitation.

The control of pests is important in cultured species. The eel grass control programme has progressed to the stage of pilot commercial scale tests. A method of shipworm control has been tested thoroughly and its effects on oysters investigated.

The work is not carried out in isolation. We maintain a very close contact with the Fish Culture Branch of the Department of Fisheries, not only in the joint Oyster Hatchery project but also in all phases of our work through the Oyster

Culture Stations throughout the Maritimes. Without its constant assistance and co-operation much of our work would be impossible.

Enquiries, requests for advice and liaison with agencies of provincial and federal governments and private individuals continue to increase. We believe that this is a measure of the identification of our programme with the needs of the industry.

R. E. Drinnan

No. B-2

HYDROGRAPHY

Changes in technical staff and responsibilities have delayed the complete analysis of the 1965 data. In general the summer was warm and dry in the Maritimes.

An analysis of water temperatures at the Oyster Culture Stations was made as part of an assessment of Oyster Hatchery potential throughout the Maritime Provinces. The periods in days above 5°, 10°, 15°, and 20°C are shown below:

	Days above			
Location	5°C	10°C	15°C	20°C
Shippegan, N.B.	187	133	83	26
Neguac, N.B. (mean of 3 sites)	176	131	80	16
Ellerslie, P.E.I.	191	153	110	56
Malagash, N.S.	198	158	112	62
Crowdis Bridge, Cape Breton	184	141	99	41
Gillis Cove, Cape Breton	187	153	112	58

The specific sites and methods used to obtain these temperatures may have affected their relative values to some extent but the general trend is clear. There are striking differences between the stations and these are clearly reflected in the growth of oysters, reported elsewhere in this report. Ellerslie, Malagash and Gillis Cove show very similar figures and very similar oyster growth. Shippegan, marginal for oyster growth and survival, shows typically low figures for the higher temperatures. Temperatures are surprisingly low at Neguac, N.B., and must reflect considerable exchange with offshore waters.

R. E. Drinnan
L. L. MacLeod

No. B-3

OYSTER MORTALITY

Malpeque Disease

No spread of the disease was detected in 1965. Monitoring of the development of resistance has continued in New Brunswick. The recovery of the commercial fishery south of and including the Miramichi estuary, reported last year, has continued. The high ratio of undersized to market-sized oysters reported from commercial fishing operations suggests that this trend will continue. However tray stocks of native spat in these areas continue to show mortalities above normal, intermediate between susceptible and resistant oysters, suggesting that a fully resistant oyster population is not yet established. This is particularly true of the upper reaches of the Miramichi estuary. Oysters moved from here to Shippegan show mortalities very similar to those of completely susceptible Cape Breton oysters.

At Shippegan native oysters continued to show mortalities typical of completely susceptible stocks. The failure of spatfall in this area in recent years has prevented the planned monitoring of mortality in spat caught on collectors. To replace this, in 1965 small native oysters were collected from as many areas as possible and placed on trays for monitoring of mortality.

Mortalities in tray stocks at Gillis Cove, Bras d'Or Lakes

Abnormal mortalities have occurred in year-classes held on trays at Gillis Cove over the past several years.

Heavy mortalities were observed in the spring of 1965. Year-classes on trays showed 10-25% mortality in the period May 11-June 15. This is less than in the comparable period of 1964 but high compared to the normal monthly rate for the open-water season, of 1-5%. Again the effect was more marked in the older year-classes.

A study of our data since 1959 shows a general correlation between low salinity and mortality. The heavy spring mortality may be a result of the practice of suspending trays just below the ice all winter where they are exposed to the maximum effect of freshwater accumulation in the spring run-off.

Comparisons of mortalities in stocks held on surface and bottom trays at Gillis Cove and nearby Crowdis Bridge in the River Denys Basin support this. At both sites surface trays showed heavy mortalities in 1965, while bottom trays showed normal rates.

R. E. Drinnan
L. L. MacLeod

No. B-4

EXPERIMENTAL OYSTER HATCHERY

The co-operative Department of Fisheries-Fisheries Research Board oyster hatchery program has continued the development of techniques for the commercial rearing of seed oysters.

Oyster larval rearing

The first large-scale test of the complete seed production process was begun in February 1965. Larvae were reared on cultured food in the hatchery and set on cement-coated wood veneers. The spat were held in the hatchery and fed on cultured food until conditions outside were suitable for their survival. By this time they had reached a mean size of 1/4-3/8 inch. Subsequently they were suspended from floats in the river, until they reached 1 inch and then separated and held on floating trays. They reached a size of up to 2 inches in length in October, 6 months after they set. This represents a very high growth rate for eastern Canadian waters. Unfortunately it is difficult to know whether this may be regarded as typical. Fertilization studies may have affected the growth rates observed, though the growth rates of adult oysters were not unusual.

Subsequent spawnings were not so successful and planned experimental programmes were seriously incapacitated. Larvae showed poor growth, high mortalities and abnormal setting behaviour. Fouling of intake lines and bacterial contamination of distribution lines appeared to be responsible. The use of stricter sanitation procedures remedied the situation.

Hatchery design

As a result of our experience to date, some changes have been made in design. We have now completed the change to a low-flow water storage type operation. This allows the use of lower capacity heat exchangers.

Heat exchangers still present a problem. We are presently exploring the possibility of using lead coils, which have given satisfactory results in other laboratories. These have proved to be quite satisfactory physically but we have experienced difficulties in spawning oysters conditioned in water from them. We are now investigating which components in our system are responsible for this. Plastics are alternative materials for heat exchangers. These are being investigated and look promising.

We still have no really satisfactory water filtering system. We are investigating the use of viscose filter bags and sand filters.

Bacterial recontamination of the sea water from distribution lines after passing through ultra-violet sterilizers appeared to give us trouble in 1965 and has been shown to be a serious problem in Britain. We have redesigned our sterilizing system and now use mobile units which discharge directly into our tanks.

Additional facilities are required to carry out, on a large scale, a step not envisaged in the original design, the rearing of spat to ¼ inch in controlled surroundings. A building to accommodate this is now in the late stages of design by Department of Fisheries engineers for construction in 1966. This will be a two-storey building with observation galleries for visitors. The upper floor will house mass cultures of algae for food, gravity fed to tanks containing oyster spat on the lower floor.

Algae culture

We have continued the development of mass open-culture techniques. The most satisfactory tanks tested to date are the conical fibreglass tanks used in larval rearing. These are now in regular use for feeding.

Collector materials

Supplies of a plastic mesh spat collector in commercial use in France have been obtained for testing. For use, these are coated with a sand-lime mixture and are reusable, the spat breaking off with the coating on flexing. This coating should be less toxic than cement and the basic material does not have the lack of durability of wooden veneers. The collector looks most promising and will be tested on a large scale in 1966.

Future programme

In the coming year the present programme of developing large-scale techniques of seed production will continue. We will continue to develop physical equipment and basic techniques. Important needs for the future are the investigation of spat settlement and growth in both laboratory and field conditions. This will include the observations on larval behaviour at settlement and the dynamics of spat feeding and growth.

The basic feasibility of mass rearing of oyster larvae has been demonstrated. We are now in a position to carry out exploration of likely areas for their potential suitability for pilot commercial development.

R. E. Drinnan

No. B-5

OYSTER SPATFALL IN 1965

In 1965, larval sampling in the field was limited to the minimum number of samples necessary to predict spatfall at Ellerslie. The samples taken were not quantitative so no figures for larval density are available. The timing of spatfall was as predicted but the actual settlement of spat was very light and survival poor.

The monitoring of spatfall was carried out as in earlier years. Clean, aged, scallop shells were exposed for 2-week periods, adjacent periods overlapping by 1 week, at all the Department of Fisheries Oyster Culture Stations. At Ellerslie such series were obtained from both the creeks in the reserve and a series of shells at 1 foot, 4 feet, and 7 feet exposed daily.

Ellerslie, P.E.I. In Paugh's Creek, the daily shells showed a light variable set from August 5 to 18, with a peak August 13 to 16. Weekly shells showed a similar period of setting but a heavier set.

In Smelt Creek daily shells showed a very light set August 5 to 18 with no detectable peak. Weekly shells showed the same period and a heavier set.

In both creeks the deep (7-ft) shells again showed a heavier set than that obtained at 1 foot or 4 feet.

Shippegan, N.B., Neguac, N.B., and Malagash, N.S. No set on experimental collectors.

Cape Breton. In the Bras d'Or Lakes two stations were monitored with weekly shells. Single shells were used at Gillis Cove and a vertical series of three at Crowdis Bridge.

Gillis Cove showed a continuous heavy set from July 12 to August 20, with a peak July 23 to August 13 of 300-400 spat/scallop shell.

Crowdis Bridge showed a continuous heavy set July 12 to August 27 with a peak July 23 to August 13 of 700-1,000 spat/scallop shell.

Again, at Crowdis Bridge spatfall increased with depth. The set at 7 feet was up to fifty times that at 1 foot.

Set on commercial collectors

Staff of the Oyster Culture Stations report setting similar to that on experimental collectors. Shippegan, Neguac, and Ellerslie showed no surviving spat. Collectors at Malagash had a light set. The set at Gillis Cove and Crowdis Bridge was heavy and grew well. They also report a light set in parts of Kent County, N.B., and P.E.I.

R. E. Drinnan
R. Cattley

No. B-6

BENTHIC STUDIES

Faunal survey of Ellerslie Reserve

This survey was started in 1962 with the intention of gaining a better knowledge of benthic conditions in the Ellerslie Reserve, and to provide a basis for future development and management work. The survey has proceeded through several stages including general subtidal benthic surveys, intertidal benthic surveys, general sedimentary surveys and a survey of the flora and fauna of the shore area covered by extreme high tides. The analysis of data from these surveys is not yet complete.

Although cores of the bottom have shown that the area was once mainly oyster bed, there is now relatively little true oyster bed left. Most of the area is now soft mud harbouring a fauna characterised by the bivalve, *Yoldia limatula*. This community has a low biomass averaging about 2 g/m^2 (dry wt.) and presumably a low productivity. By way of contrast, mussel beds established in the reserve have a biomass of over 100 g/m^2 and certainly a much higher production. Oyster beds may never have had the biomass of present mussel beds but those remaining have a biomass between 50 and 100 g/m^2. At present, sedimentary conditions favour a transition from oyster bed to mussel bed and then to *Yoldia* or other less productive communities. There is thus a reduction in the benthic productivity of the estuary. Since most commercially harvested estuarine species are part of the benthos this change is a direct loss to man. However, estuarine areas are essentially highly productive and proper utilization and management could restore favourable conditions.

Long-term changes in the benthic fauna of Bideford Reserve

The series of stations established in 1963 to study long-term changes at selected sites in Ellerslie Reserve were sampled in May, July and November 1965. Conditions at most of the stations appear to be reasonably stable; one station on the Sand Bed however, has shown a steadily diminishing biomass. The Sand Bed used to be a good oyster bed but at present appears to be in transition to a different fauna. Table 1 shows the general characteristics of the eight stations.

Table 1. General characteristics of eight long-term benthos sampling stations in Ellerslie Reserve.

Station	Name or Area	Type of Community	Mean faunal biomass g/m^2 dry wt.
R1	Upper Smelt Cr.	*Mytilus edulis* - *Macoma balthica* - *Zostera*	73.02
R2	Fred England Bed	Oyster bed with encroaching *Mytilus edulis*	91.62
R3	Upper Paugh's Cr.	*Macoma balthica*	15.64
R4	Confluence	*Yoldia limatula*	3.59
R5	Martin Bed	*Mytilus edulis* (old oyster bed)	138.53
R6	Totten Bed	Oyster bed	46.94
R7	Sand Bed	Transitional (recent oyster bed)	20.03
R8	Off Martin Bed	*Mytilus edulis* - *Yoldia limatula*	26.91

The productivity of these areas has not been established but those with a biomass below 50 g/m^2 certainly have a relatively low productivity.

Faunal settlement

The settlement of the natural fauna of the Ellerslie Reserve on three typical substrata (mud, sand and shell) at the eight long-term benthic sampling stations was again studied in 1965 by means of trays containing initially abiotic bottom material. Results are not yet fully worked up but some preliminary findings are of interest.

During the 2-year study not a single oyster has settled on any substratum in any tray. Blue mussels settled at most stations, particularly on shell.

Macoma balthica, a mud-living bivalve, typical of low salinity areas, settled heavily in mud and sand at all stations except the deepest one (R8). Individuals grew larger in mud than in sand, reaching a mean length of 8.1 mm by late October.

Tellina agilis, another bivalve of similar habitat to M. balthica, but preferring higher salinities, also settled heavily at all stations but one. It did not settle at the most upstream station (R1) and like M. balthica grew larger in mud than in sand. A few T. agilis were able to colonize the silt layer accumulating in shell trays.

Yoldia limatula, the bivalve typical of the deeper, muddy parts of the reserve, settled almost exclusively in mud at six of the eight stations.

The settlement of the soft-shell clam Mya arenaria was of particular interest in that it settled and grew well in sand trays at all but two stations including some in fairly deep water. At one station it also settled and grew well in mud. Mean size of individuals in each tray at the end of October was up to 23 mm long weighing (wet with shell) 1.2 g.

Cumingia tellinoides, a bivalve typical of good oyster bed, settled sparsely, being abundant only in the shell tray on the Totten Bed.

The razor clam Ensis directus was notable in that it settled exclusively in sand but at all stations.

In summary, these studies appear to show that the biotic environment in the Ellerslie Reserve favours the spread of fauna associated with mud and to a lesser extent sand. These species appear able to colonize small areas of suitable substrata set in an unsuitable area, whereas the reverse is not true of the shell bed fauna. The reasons for this are not understood but the future trend is clear.

Biology of major species

Most commercially or potentially important local species of shellfish occur in Bideford Reserve and special studies have been begun on several of these as well as on several numerous noncommercial species. Data on growth, abundance and biometrics are being gathered. The following species are under study: Mytilus edulis, Volsella demissa, Ensis directus, Mya arenaria, Yoldia limatula, Macoma balthica, Cumingia tellinoides, Nassarius obsoletus and Tellina agilis. Analysis of data gathered so far is underway.

General faunal surveys

A start has been made on a general Malpeque Bay survey but so far only a few samples have been collected.

Brief surveys have been made in Grand Etang and South Harbour, Cape Breton Island, both of which have unique oyster beds.

Conway Narrows benthos

During eel grass control studies many benthic samples have been gathered from the Conway Narrows Reserve. In addition a repetitive benthos sampling station has been maintained during 1965.

The benthos of Conway Narrows is rich and varied, having faunal constituents typical of both warm, estuarine conditions and of the cool Gulf of St. Lawrence.

The mean total dry weight of benthos in the area studied was about 360 g/m^2 (dry wt.) of which 300 g was comprised of eel grass. The fauna averages over 50 g/m^2, a moderately high biomass. Other evidence suggests a fairly high productivity. The benthic community is characterised by Mytilus edulis, the blue mussel, and by Littorina littorea, the common periwinkle. L. littorea is not a usual constituent of mussel beds in this general area and is taken to indicate a real difference in the Conway Narrows area. In addition blue mussels in the "narrows" are much smaller than average.

The third major constituent of Conway Narrows benthos is the polychaete Nereis virens. This worm is supposedly predatory but our evidence suggests that it is at least in part a deposit feeder. The mean abundance of this worm at the "narrows" was $280/m^2$ with a dry weight of 8.6 g/m^2.

These three species together comprise about 90% of the benthic biomass. Other small species with short life histories may well contribute significantly to production.

Studies on *Thracia conradi*

Thracia conradi, a deeply burrowing pelecypod, has previously been recorded only rarely in Canadian waters. The species is common in parts of Malpeque Bay. Evidence gathered so far shows a unique mode of life and suggests an interesting life history.

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No. B-7

UNDER-EXPLOITED SPECIES

This is a new investigation which was begun late in the summer of 1965. Its aim is to investigate the development potential of fisheries for currently unexploited or under-exploited species of inshore molluscs in the Maritimes. This will involve testing of gear, exploration and establishment of a biological basis for effective management.

Work in 1965 was largely exploratory, gear development, planning, etc. Some observations were made on two species, the bar clam (*Spisula*) and the blue mussel (*Mytilus*).

Bar clam

The present fishery for this species is largely restricted to hand fishing in shallow water. The distribution of this species in deeper waters is largely unknown. In recent years there has been some development of mechanized gear. An escalator harvester was used and demonstrated a large population in deeper water. There is an active interest in such development.

Our explorations in 1965 were made with the escalator harvester, M.V. *Cyprina*. We worked in three areas, Malpeque Bay, Cascumpeque Bay and Hardy's Channel, in the lagoon area between the two bays.

Bar clams were found only in sand and in commercial concentrations only off the flats where hand digging was already taking place. The greatest concentrations occurred below levels fishable by hand. Low concentrations were found over a wide area, including some offshore areas.

Though the fishing was largely exploratory and to familiarize the crew with techniques, many samples were collected for growth studies, measurement of length-weight relationships, etc.

Exploration was severely limited by the gear. The escalator harvester can fish only to a limited depth and in relatively calm conditions. A hydraulic dredge would have much greater versatility and depth range. This is important in establishing the depth range of the bar clam and in exploring for other species. Several potentially exploitable species were found in relatively heavy concentrations during this work, especially razor clams and false quahaugs (Pitar).

Some observations were made on spawning. Bar clams were ripe in early June and were seen to spawn in the field. Spawning was easily induced in the oyster hatchery and eggs developed to the larval stage.

Blue mussels

The stocks of this species in the Maritimes are enormous but the present rate of exploitation is very low. As a first step in assessing the potential, samples of mussels were collected, in October and November, from seven areas in Prince Edward Island, three in New Brunswick and one in Nova Scotia. Indexes of condition measurements were made using a volumetric method. Values found ranged from 25 to 50, low in comparison with Europe where this species is fished in large quantities for food.

Future programme

The development of gear for exploration and sampling is an important first step. The programme will include exploration to locate and survey stocks and studies on growth, mortality, recruitment and size and age distribution of natural stocks.

An important part of the development programme will be liaison with the industry and agencies involved in regulation of the fisheries, technology and marketing.

R. E. Drinnan
L. L. MacLeod

No. B-8

FERTILIZATION OF A MARINE AREA

In 1965, observations were made on the effects on phytoplankton production and oyster growth of the application of commercial fertilizer* to a marine area.

Paugh's Creek, one of the two creeks at the head of Bideford River, was fertilized, the other creek, Smelt Creek, acting as a control. Observations on oyster larval populations in earlier years suggested that these two water masses were reasonably discrete.

Fertilizer was added weekly in five applications from July 26 to August 23. A highly soluble concentrated fertilizer was used and added in solution in sea water from a moving boat.

Water samples were taken weekly through June, July and August from surface and bottom from two sites in Paugh's Creek (fertilized) and one in Smelt Creek (control). These were analysed for phosphate, nitrate, chlorophylls a, b and c and dissolved carbohydrate. During the period of fertilization samples were taken immediately before and 24 hours after the addition of fertilizer and analysed for phosphate and nitrate.

Observations in the reserve in previous years suggest that in the average year there is a steady rise in chlorophyll through June and July to a peak of 8-12 mg/m^3 in August, and that phosphate rises at the same time to a peak of 0.03 mg/l.

Samples taken after fertilization showed the effects on nutrient concentration. There was a 5-6 times increase in phosphate and a 50% increase in nitrate in the fertilized creek. Values were back to normal a week later.

The total chlorophyll content of both creeks was normal until fertilization began. In Paugh's Creek all stations showed a rise in August to 18-22 mg/m^3, two to three times normal values, followed by a sharp decline before the last application of fertilizer. In Smelt Creek surface samples showed relatively normal chlorophyll values throughout the sampling period, perhaps slightly above normal. The bottom samples showed a dramatic increase in total chlorophyll in mid August to 31 mg/m^3.

*The fertilizer used was Prima Aero 18-46-0 (N-P-K).

The effect of fertilization on oyster growth is difficult to assess, as Smelt Creek obviously cannot be used as a control. Growth in adult oysters was monitored and growth increments were not unusual. However, oysters on bottom trays were unusually fat in the fall, with a higher index of condition than has been recorded in the reserve for many years. Also hatchery-reared spat suspended from floats showed very high growth rates. Unfortunately as newly set spat have never been available before in early summer, this is a unique observation and its significance impossible to assess.

Eel grass growth was monitored in both creeks throughout the fertilization period. No increase in growth was observed.

The detailed analysis of the observations, including relevant hydrographic and meteorological factors is not yet complete but the results are encouraging enough to warrant further investigation. In 1966, the detailed chemical monitoring will not be repeated but the effects of continuous fertilization on oyster growth will be studied.

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No. B-9

EEL GRASS STUDIES

Chemical control trials

During 1964, nine herbicides were tested for their possible use in the control of eel grass (Zostera marina) in Maritime oyster growing areas. As a result of these tests, all but two herbicides were abandoned for possible use. The two chemicals showing promise were 2,4-D butoxy ethanol ester and dichlorobenil. The 1965 trials were devoted to a thorough testing of these two pesticides on 1,000 m^2 plots at Conway Narrows, P.E.I., and Neguac, N.B. At both sites careful controls for eel grass were maintained and sampled at regular intervals along with the treated plots. At Conway Narrows additional samples of benthos were collected and analysed from a control station and from treated plots. It was intended that oysters from treated plots be analysed for herbicide residues repeatedly after application, but unfortunately no laboratory willing or able to carry out such analyses could be located.

Results may be summarized as follows:

(1) The action of dichlorobenil has been most erratic. Complete eel grass kill has never been achieved and in most cases mortality was limited to small areas on the plots, where presumably, the herbicide fell more heavily. It is concluded that dichlorobenil is not suitable for use in eel grass control.

(2) 2,4-D shows promise for control. Complete mortality of eel grass followed herbicide application on two plots and high mortalities occurred on others. Under conditions such as prevail at Neguac where water currents are relatively slight it is concluded that control on large plots could be achieved by an application of 150 lb of a 20% 2,4-D equivalent herbicide per acre, costing at U.S.A. prices about $50.00. Up to twice this amount would be required where tidal currents are faster. The nature and mode of action of 2,4-D suggest application during the period of vigorous growth extending from May to August.

(3) These tests have not shown any mortality of benthic fauna caused directly by 2,4-D or dichlorobenil at the concentrations used. Evidence was collected that showed a decline in one member of the fauna associated directly with eel grass. Decline of an eel grass associated fauna is an inevitable result of the removal of eel grass. Such a decline cannot be considered undesirable as such a fauna would not normally occur on eel grass-free oyster bottom.

(4) The main problems in the use of 2,4-D lie in the field of residue accumulation by food shellfish. Problems in the analysis of such residues in shellfish prevent critical studies of this problem. Further critical work in this field must await the development of reliable analytical methods.

Mechanical control

Eel grass has been cut off just above the sediment on several plots at different seasons. The results indicate that cutting off eel grass during the period from May to August results in only a temporary shortening, regrowth to normal conditions being fairly rapid and complete. Cutting during the fall, however, appears to cause some over-winter mortality of eel grass which results in a less dense growth the following year. Cutting for possible harvest would best be done during July and August when biomass is greatest. Cutting for control would have to be carried out during the fall. Studies on this aspect of control are continuing.

Biology

Eel grass growth, abundance and general biology have been followed at all field stations and at Ellerslie and Conway Narrows, P.E.I.

Growth and abundance patterns were similar to those observed in 1964, except at Neguac, where there was a reduction in eel grass density during the summer. This was due to the floating away of entire plants which were then swept ashore. Observations indicated that this was caused by extra floatation resulting from dense epiphytic growths of filamentous green algae which entrapped respiratory gases. The same phenomenon was observed at other locations where eel grass samples are not collected.

Manuscript reports describing eel grass control trials in 1964 and 1965 have been prepared.

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No. B-10

SHIPWORM CONTROL

For the past 3 years, bis(tri-n-butyltin)oxide in its proprietory form bioMet TBTO (M and T Chemicals Inc.) has been tested at Ellerslie as a treatment for unpainted wood to prevent shipworm attack and reduce fouling and rot.

Treatment

The tests have checked the effectiveness of concentrations of TBTO from 0.2-2.0% dissolved in mineral spirits (Varsol, Irsol) and light oil (kerosene). There was no evidence that the solvents used affected the action of TBTO.

The percentage of TBTO in the solvent did, however, affect results. The lowest concentration used, 0.2%, gave effective protection over a 2-year exposure. Test blocks even when somewhat "green" dipped in a 2% solution were completely protected for 2 years. The tests showed the importance of using at least fairly dry wood. Since TBTO is insoluble in water and solvents also insoluble in water are used as carriers, contact with the wood cellulose could not be expected with wet wood. This contact with cellulose is vital if the unique property of affinity for cellulose by TBTO is to be exploited. Two-year exposures at low concentrations indicate that there is some loss of TBTO from the wood surface. In such blocks minute shipworm burrows were made in the surface of the wood. These burrows did not materially affect structural strength and deep penetration was evidently stopped by TBTO within the block. Some of the blocks, trays, etc., treated with TBTO have suffered moderate mechanical abrasion and still retained protection against shipworm. Penetration of the preservative is evidently enough to afford this advantage.

In summary the results indicate that a 1-2% solution of TBTO dissolved in mineral spirits or light oil, applied to reasonably dry wood affords shipworm protection for at least 2 years. Dipping wood is more effective than brushing but brushing is adequate under normal conditions.

Our tests have also shown that TBTO applied as recommended above does materially reduce general fouling on the wood and can also be expected to retard rot.

The use of TBTO as an ingredient in anti-fouling paints evidently shows promise. Future tests of such paints are planned. The action of TBTO recommends the use of preservatives incorporating it on wooden hulls prior to painting to give protection when the paint film is damaged. For such use a preservative based on mineral spirits would be best as a light oil film might affect paint adhesion.

Toxicity of TBTO

The effectiveness of TBTO relies at least in part on its toxicity to various organisms. The acute oral LD_{50} (dose required to kill 50% of test animals) for rats is about 250 mg/kg and for rabbits 11,700 mg/kg. Thus the chemical is quite poisonous and could be fatal if swallowed.

As indicated in last year's report, oysters from trays, the wood of which was treated with TBTO, showed peculiar shell morphology. It was considered possible that some combined action of the tin compound (TBTO) and the zinc of the galvanized wire could be responsible for the results. To test this hypothesis and to check for possible toxic effects of solvents and the TBTO itself, a complex series of experimental trays and blocks was set up. Oysters on trays were measured at the start and finish of the test which ran throughout the summer.

The results of this test showed that: (1) Growth of oysters was not affected by any treatment of trays involving galvanized wire and TBTO. Growth was reduced where plastic mesh was used instead of galvanized. This effect was probably caused by the reduced water circulation through the small plastic mesh which fouled badly. (2) Oysters in trays treated with TBTO did show thickened shells. This effect was much greater on trays with TBTO plus galvanized wire than on trays with TBTO and plastic mesh. (3) Condition index of oysters on trays treated with TBTO was much higher than controls or other tray-held stocks in the area. (4) Fouling was reduced where TBTO was used but was further reduced with the combination of TBTO and galvanized wire.

In summary, oysters on TBTO-treated trays did show differences from controls in that condition index and relative shell thickness were both increased. The fact that growth was also good on most treated trays prompts the conclusion that changes that did occur were not harmful. On the contrary, we may draw the tentative conclusion that better oysters were produced on TBTO-treated trays than on control trays. There remains some evidence that there is some biological interaction between galvanized wire and TBTO; this effect should be further investigated.

A circular describing the use of preservatives containing TBTO is planned for the near future.

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No. B-11

OYSTER GROWTH IN THE MARITIMES

General

In 1965, one hundred oysters from each year-class were measured in spring (May) and fall (October) at each Oyster Culture Station. The increments in millimetres shown by the 1961 and 1963 year-classes are shown below.

At Shippegan, N.B.

Stock	Gillis Cove (Susceptible)	Native	Ellerslie (Resistant)	Malagash
1961	-	6.4	10.1	-
1963	7.6	-	10.9	12.4

At Malagash, N.S.

Stock	Gillis Cove (Susceptible)	Native	Ellerslie (Resistant)	Malagash
1961	-	14.2	14.3	
1963	10.4	19.6	22.5	

At Gillis Cove, Cape Breton, N.S.

Stock	Native
1961	11.2
1963	19.7

These figures show the variation in growth throughout the Maritimes and the differences in growth between susceptible and resistant oysters.

Growth was good at Malagash and Gillis Cove. We have no strictly comparable figures for Ellerslie but observations here suggest very similar increments.

Gillis Cove oysters show a lower growth rate than the resistant Ellerslie oysters at both Malagash and Shippegan. This is typical of susceptible oysters. Native oysters at Shippegan also show growth rates characteristic of susceptibles in contrast to oysters from Malagash, where a resistant population is now established.

Growth rates are generally lower at Shippegan in accordance with the climatic differences between this and the other stations.

Oyster growth at Ellerslie

At Ellerslie the effect of tray bottom material and position in the water column on oyster growth was investigated. Oysters were held on trays at three levels, surface, mid water and bottom and on three types of tray bottom, solid wood, ¼-inch mesh and ½-inch mesh. The increments (mm) (June-October) measured in oysters at the three levels are shown below. Each figure is the mean of three observations.

Surface	Mid water	Bottom
15.3	18.5	11.6

The best growth occurred at mid water, least on the bottom.

There was no significant difference in size increment between oysters grown on ¼-inch and ½-inch mesh. Oysters grown on a solid wood bottom showed virtually no growth.

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R. R. Cattley

No. B-12

INDEX OF CONDITION AND GILL WORMS

In 1965, three beds in the oyster reserve at Ellerslie were monitored for gill worms and index of condition. One of these was off the laboratory at the head of the estuary, one midway down the estuary and one at its mouth, in the open bay. Gill worms were counted and index of condition measured, on samples of oysters from the bottom, monthly throughout the open-water season. Observations were also made on oysters on bottom trays on the two up-river beds and on oysters on floating and bottom trays in the two creeks at the head of the estuary.

The worm counts showed the usual seasonal variation in numbers, with a major peak in July and a lesser one in October. The counts were much lower than normal on the lowest bed. Counts on the up-river beds were much higher than normal but still far less than normally seen on down-river beds. Oysters held on bottom trays, which are held approximately 6 inches above the bottom by concrete legs, showed only 20-50% of the worm counts in oysters on adjacent bottom. Oysters on surface trays showed no gill worms.

The index of condition was generally low in oysters from the beds throughout the season. The only exception was the down-river bed where oysters showed an increase in the fall and entered the winter in moderately good condition.

An unusual situation was encountered in the comparison between surface and bottom trays in the creeks. In both areas oysters from surface trays were thin, resembling oysters on the beds. In contrast, oysters on bottom trays were consistently fatter and entered the winter in good condition. These results are in direct contrast to the usual observation that oysters suspended at the surface grow faster and are fatter than oysters on the bottom. The unusually heavy fouling which occurred in 1965 and which is largely confined to the surface, may have been responsible for the anomaly and the results of fertilization of these waters, reported elsewhere, may have had an effect.

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L. L. MacLeod
R. R. Cattley

No. B-13

MUSEUM AND TOURISTS

At Ellerslie the number of visitors has been increasing steadily. Coping with tourists became such a problem that the necessity of having special staff to deal with them was obvious. In 1965, commissionaires to provide 24-hour-a-day watchmen and guide services were hired. This arrangement has worked out very well and interruptions to the scientific staff have been kept to a minimum.

The number of visitors continues to increase at an alarming rate. In 1965, 2,177 visitors signed the visitors' book; 1,484 of these were from Canada, 688 from the United States, 2 from England and 1 each from France, Sweden and Denmark.

The station co-operated with Mr. D. Denbeigh of the Information and Consumer Service, Canada Department of Fisheries, to set up a major exhibit featuring oysters at the Tyne Valley Oyster Festival.

Scientific collections in the museum are being expanded as time allows.

M. L. H. Thomas

OFFSHORE INVESTIGATIONS SUMMARIES

continued

OFFSHORE INVESTIGATIONS SUMMARIES

continued

OFFSHORE INVESTIGATIONS SUMMARIES

No. CA-1 Groundfish

GROUNDFISH — ANNUAL SUMMARY

Competition for groundfish stocks in the Northwest Atlantic continues to grow with increases in the Canadian fleet and greater activity by other countries in the area. Between 1960 and 1964 groundfish landings from the Northwest Atlantic increased about 27% to reach 5.2 billion lb. In 1960, only about 30% of the landings were taken from the southern region, off the Maritime Provinces and New England. By 1964, landings from this region had increased to 40% of the total, principally by addition of previously unutilized species. Provision of good landing and effort statistics has been a major accomplishment of the International Commission for the Northwest Atlantic Fisheries (ICNAF).

At the 1965 ICNAF meeting, members of the Commission again considered effects of various regulatory actions. At the request of the Commission, the Chairman of the Research and Statistics Committee and the Chairman of the Assessments Subcommittee had prepared a document in which their conclusions were: that some increase in catch from various stocks might be obtained by protecting small fish (i.e., large mesh size), but that if this is followed by further fishing expansion, stocks would again be decreased with little or no increase in landings; that there must be some direct control of the amount of fishing and that, to this end, a quota system presents least difficulties.

With such conclusions being considered, it is clear that Canadian groundfish research must continue to be able to provide advice to Canadian Industry and Commissioners as to whether the basic concepts underlying such conclusions are sound.

It is also clear that studies on both utilized and unutilized species should be extended to provide information leading to greatest possible use of available stocks.

During 1965 work at St. Andrews has been directed to meeting part of the Canadian research responsibilities in these fields. Particular attention was paid to studies of stocks of cod, haddock, and flatfish in the Gulf of St. Lawrence and Nova Scotia banks areas. Studies on a number of underexploited species were continued by investigating life-history and distribution of such species as the common hake, cusk, silver hake and argentine. Relationships between aggregations of demersal species within specific areas were studied both on inshore and offshore fishing grounds.

Fish behaviour studies on groundfish were mainly related to capabilities and behaviour aspects of commercial species which might be utilized in developing fishing methods. They included laboratory work on swimming endurance for various groundfishes, auditory thresholds for cod, and fatigue and mortality in cod and haddock. In addition, during 1965, a camera attached to the headrope of a trawl was used extensively to observe reactions of fish in the mouth of the trawl during fishing operations.

Preliminary experiments with counting fish echoes as obtained from the ship's echo sounder produced favourable results.

As a result of our advice about charting needs, two large-scale fishermen's charts with well defined soundings and contours for offshore banks have been produced by DM & TS and these have been well received. During 1965 we continued to provide advice about possible improvements and the need for outlining bottom type.

By end November 1965 groundfish landings in the three Maritime Provinces had increased by about 8% in weight and 12% in value over a like period in 1964.

Increased cod, redfish, and flatfish landings offset decreases in landings of pollock and haddock. While total cod landings increased, it is likely that cod catches in the Gulf of St. Lawrence region will be considerably lower than in 1964 as effort was directed to redfish. Redfish landings more than doubled as otter trawlers exploited good new year-classes in the Gulf. Landings of such incidental species as cusk and catfish increased; those of the common hake decreased.

The considerable increase in fleet that is occurring and the opening of new plants in various ports have increased the work load and difficulties in measuring landings and in obtaining log records from the fleet. During 1965, large Canadian otter trawlers continued to expend more effort in the Browns-LaHave and Georges Banks region than on the traditional grounds of Emerald and Sable Island Banks. Canadian effort on concentrations of cod along the Laurentian Channel in winter and spring appears to have increased.

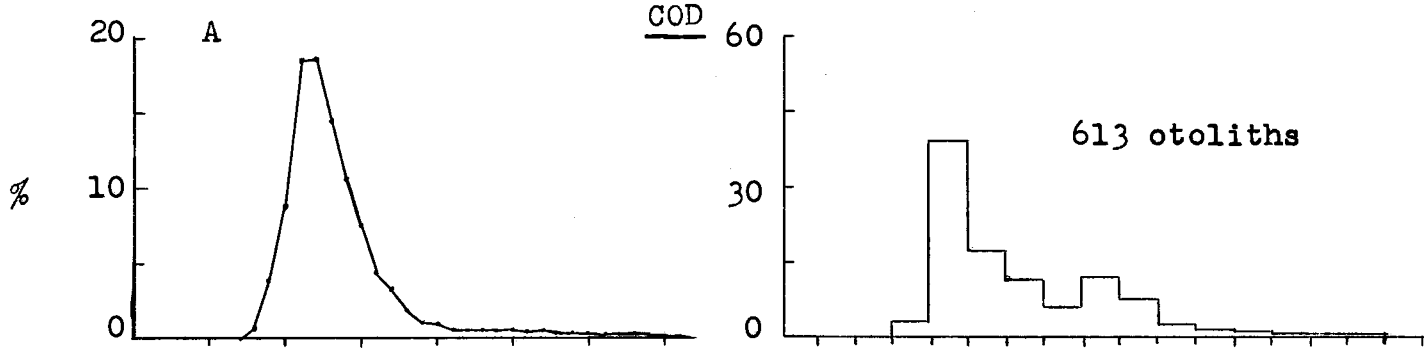
F. D. McCracken

No. CA-2

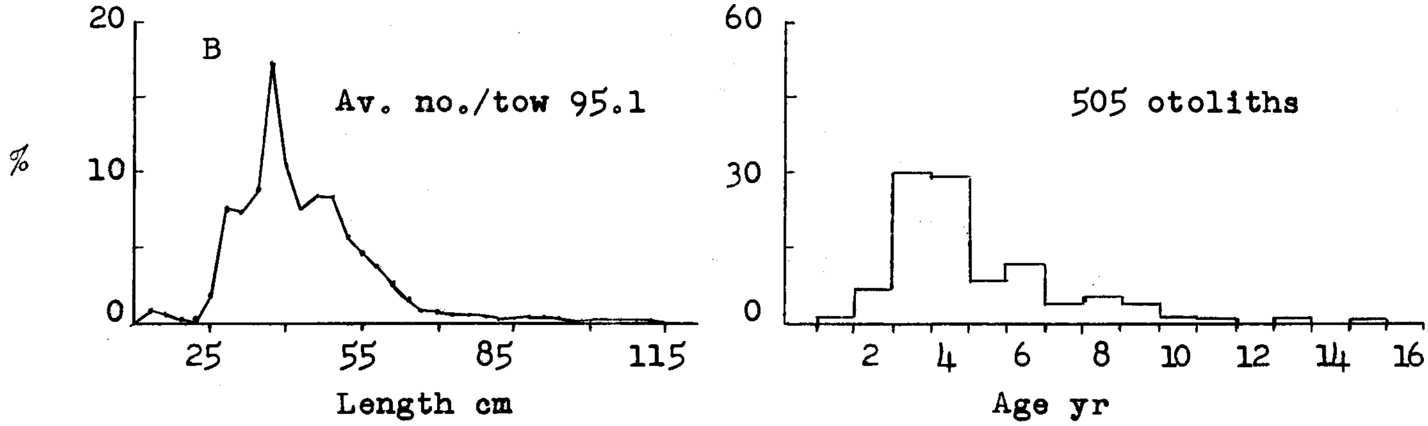
STUDIES OF GULF OF ST. LAWRENCE COD STOCKS

Research on commercial and pre-commercial sizes of cod in the Gulf of St. Lawrence was continued in 1965. The main field effort consisted of the regular survey cruise conducted on the M.V. Harengus in September, and the continued sampling of landings of cod at northern New Brunswick ports.

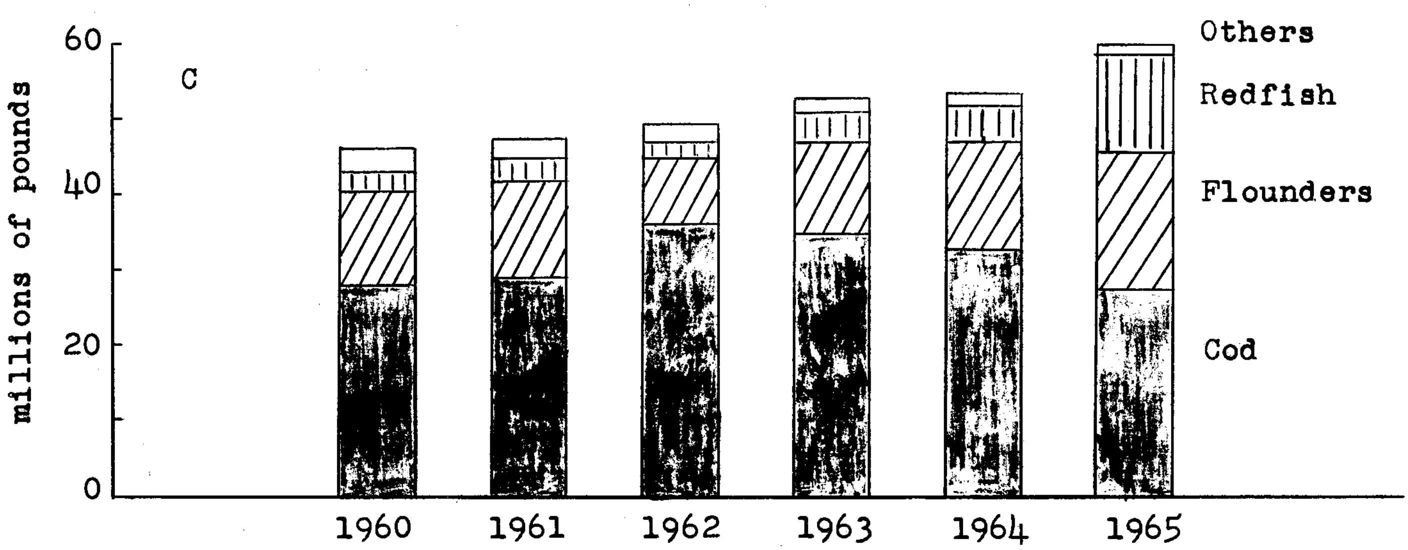
COD



ICNAF Division 4T commercial landings, 3rd quarter 1965.



Survey, ICNAF Division 4T, 3rd quarter 1965.



Landings at major ports in Gloucester County, N. B.

One of the functions of the survey is to predict what sizes and ages of cod will be available to the commercial fishery in subsequent years. Section A of the accompanying figure shows size and age composition of landings by the commercial fishery in the summer of 1965. Over the past few years size composition has remained almost constant. The figure shows peak sizes are at 43 to 46 cm with most of the fish landed being between 34 and 70 cm. Looking at the age composition of the landings, last year's prediction of a large 1961 year-class dominating the landings has proved correct. Referring to the age composition for the 1965 survey (Section B of the figure), the 1961 year-class is still as strongly represented among the younger fish as the 1962 year-class. This indicates that the 1961 year-class will remain important in the commercial fishery in the summer of 1966.

The length composition of survey-caught fish does not differ significantly from that found for 1964. However, the catch per tow for the survey has changed considerably from an average of 170 fish per tow in 1964 to 95 fish per tow in 1965, a drop of 44%. This lowered availability of cod in the 1965 Gulf survey is also reflected in preliminary statistics of landings for the southwestern part of the area. Part C of the figure shows landings at major ports in Gloucester County from 1960 to 1965. A downhill trend in cod landings for the 4 years since 1962 is evident.

The lower availability of cod is apparently being reflected in greater landings of other species from the Gulf each year. Section C shows that landings of flounder and redfish have increased each year for the last 4 years. Also, it indicates that total landings of demersal species for the area are increasing each year, and in 1965, for Gloucester County ports, reached a new high of 60 million lb.

Monitoring changes in the commercial groundfish fishery of the Gulf of St. Lawrence will be continued by research-vessel and port sampling. Current research will be concentrated on problems of recruitment to this fishery.

A. C. Kohler

No. CA-3

GULF OF ST. LAWRENCE EGG AND LARVAL SURVEY

The fish egg and larval survey program in the Gulf of St. Lawrence is aimed at relating drift and settling of eggs and larvae of commercial species to spawning concentrations and nursery areas in the Gulf. The work is being carried out with the aid of one summer student who will use part of the data for an M.Sc. thesis at McGill.

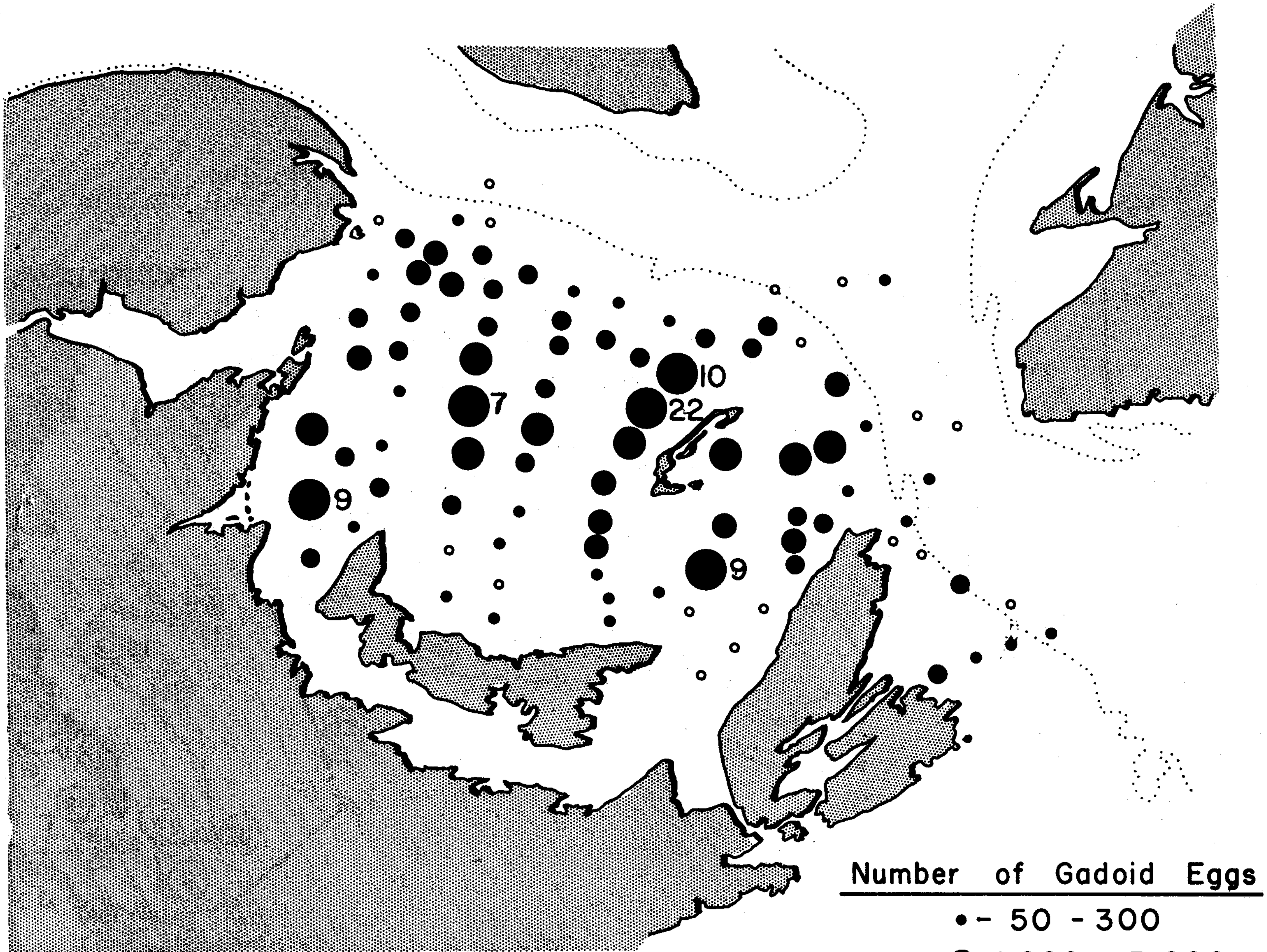


Fig. 1. Concentrations of gadoid eggs in the southern Gulf of St. Lawrence, May 27–June 6, 1965.

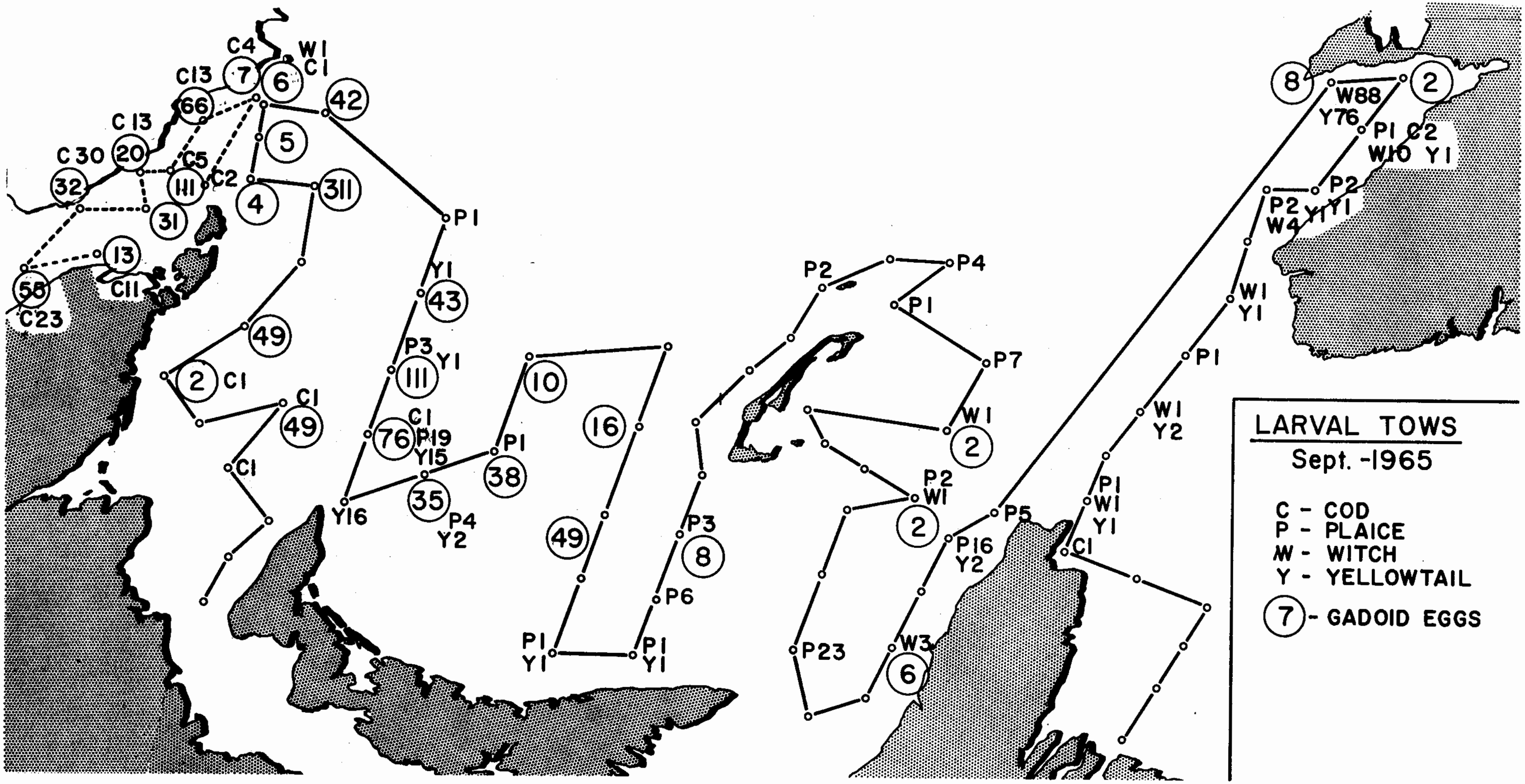


Fig. 2. Preliminary data on catches of groundfish eggs and larvae in the Gulf of St. Lawrence, Sept. 8-20, 1965.

In 1965 two survey cruises were carried out with the C.G.S. A.T. Cameron. Various types of plankton gear were used to determine which was the most efficient for catching eggs and which for larvae. Types of gear included a 1-metre net with #0 mesh; a 2-metre net with #0 mesh; a Gulf V sampler; an Isaacs-Kidd midwater trawl; a Neuston net; and a net originally designed for catching lobster larvae at the surface. The 1-metre net with #0 mesh consistently caught most gadoid eggs. The Isaacs-Kidd trawl lined with a small-mesh nylon liner caught most pelagic larvae. For catching small fish and larvae at the surface, the Neuston net was very efficient.

Ninety-five stations in the southern Gulf were occupied during the first survey from May 27 to June 6. Catches of the metre net on the stations were identified as mainly gadoid eggs and American plaice eggs. Figure 1 shows the concentrations of gadoid eggs per half-hour tow on the stations. In order to identify gadoid eggs as cod or haddock, they have to be brought to a stage where the pigment spots congregate. For this reason, each sample of eggs taken on a station was put into a separate hatching jar on the ship and the eggs were held until the pigment groups were identifiable. All eggs hatched from these Gulf stations proved to be cod eggs. The figure shows that areas of concentration of cod eggs at this time were between Cape Breton and the Magdalen Islands, between the Magdalen Islands and Gaspé, and at the western end of P.E.I.

To provide an estimate of drift of the surface waters carrying the eggs at this time, surface drifters were dropped on these stations. Earlier work on surface water movements in the Gulf had shown that the dominant movement was from the Gaspé area between the Magdalens and P.E.I., then between the Magdalens and Cape Breton. In this region the surface drift splits with one component going north into the northern Gulf and the other going out Cabot Strait. On this basis, the search for larvae on the second cruise was planned.

The second survey on the A.T. Cameron in the Gulf took place between September 9 and 20. Sixty-nine stations were occupied in almost the same area except that the survey was extended into St. George's Bay on the west coast of Newfoundland at the beginning of the trip. Figure 2 shows the catches of larvae made on this cruise. Flatfish larvae were predominant, especially in the St. George Bay area. Few cod larvae were taken except in Chaleur Bay; and these were taken by the M.V. Harengus on a cruise about a week later.

To find out what becomes of the large numbers of gadoid eggs taken in the Gulf early in the summer, more survey time is planned for the summer of 1966. This will bridge the 3-month gap in surveys in 1965, and it is hoped to follow concentrations as they drift, hatch, and settle.

Details of sampling procedures, gear, hatching and counting techniques, etc., are contained in a report by summer assistant, Lee Doran, which is on file in Groundfish Investigations.

A. C. Kohler

No. CA-4

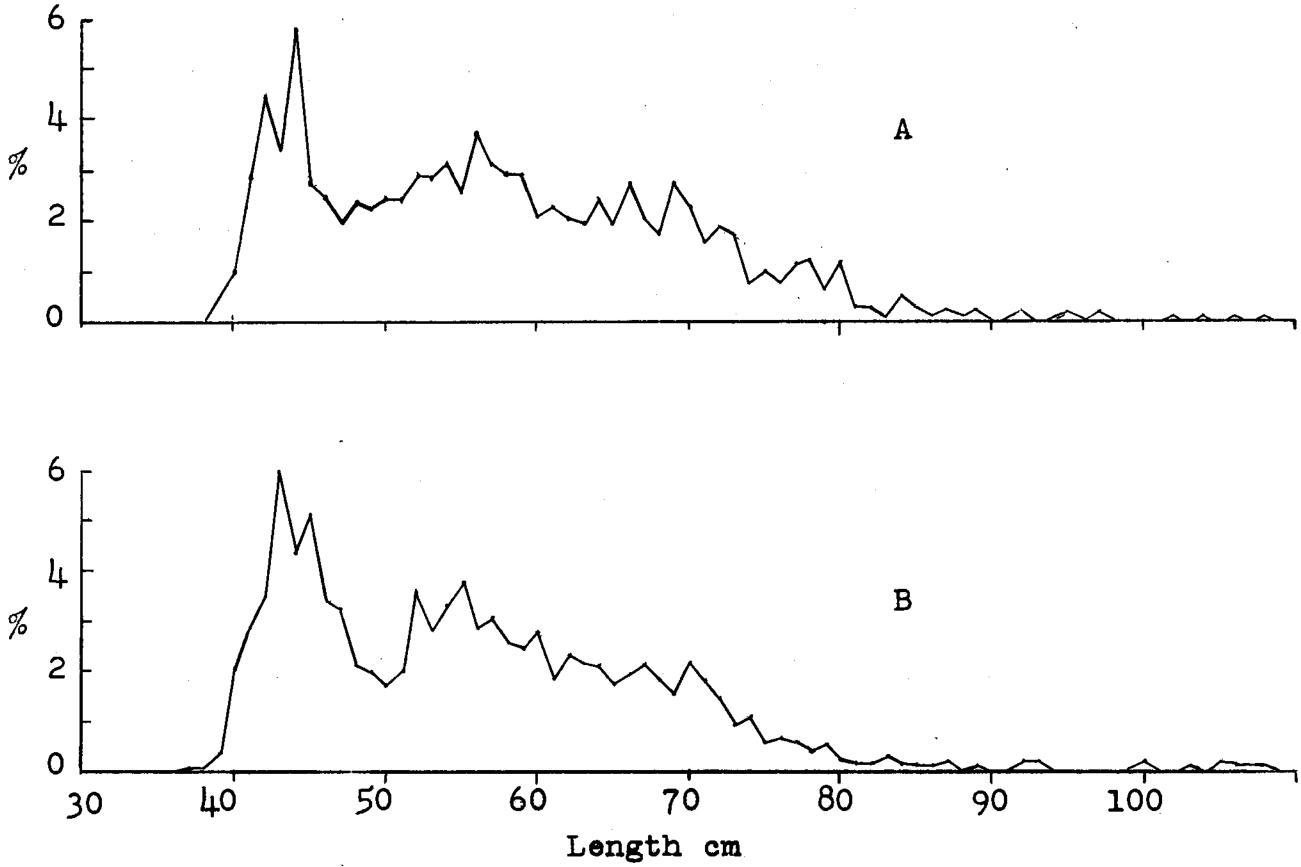
HAKE INVESTIGATION

Research into the life-history of the hake (*Urophycis* sp.) was started in the summer of 1965 because of its growing importance as a commercial species in both the southern Gulf of St. Lawrence and southwestern Nova Scotia. Preliminary investigations were concentrated in the southern Gulf and most of the field work was carried out by a summer assistant who plans to use part of the data for an M.Sc. thesis at McGill. Shore samples of commercial landings were taken in P.E.I., mainly at the port of Souris. Both otter trawlers and longliners land hake here during the summer and fall months. The otter trawlers fish the extreme southeast corner of the Gulf of St. Lawrence, in the area between Cheticamp and Wood Island. Hake landed at Souris by longliners come from small boats that fish inshore off eastern P.E.I.

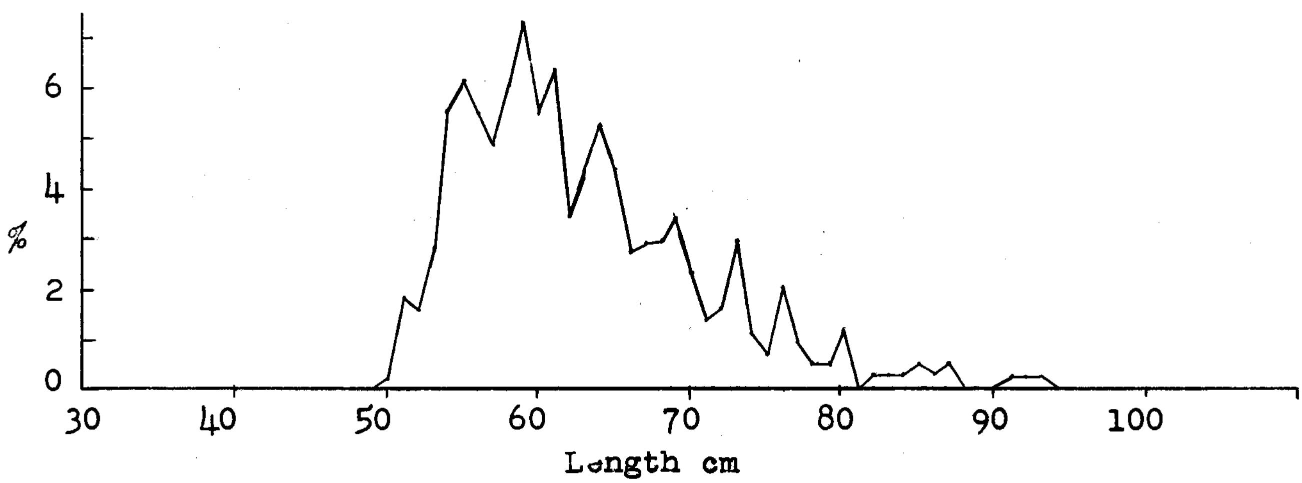
An example of the lengths of fish landed can be seen in the accompanying figure. The bulk of the fish landed from the line fishery measure between 39 and 90 cm, with a peak group of small fish between 40 and 45 cm in length. The figure also shows that the otter-trawl fishery lands fish of a different overall size. The range here is about 49 to 81 cm, with a modal size at 59 cm.

Otoliths were collected from these fish for ageing studies and they were found to be very difficult to read. Investigation of other hard parts in the hake is continuing to try to find something else that shows more definite annual zones.

Studies of catches at sea on a commercial vessel and studies of round fish landed at the wharf were carried out to determine spawning sizes and times. A preliminary analysis of these results indicated that the main spawning



Length of inshore line-caught hake, 3-4 mi off Souris, P.E.I.
A. 1122 hake caught from July 26 to Aug. 13, 1965.
B. 1320 hake caught from Aug. 14-31, 1965.



Length of 3 samples of otter-trawled hake caught in area 4Tg and landed at Souris, P.E.I., on Oct. 5-7-9, 1961 (422 hake).

of the hake in the Gulf occurred in June in 1965, with some sporadic spawning spread out later in the summer.

The program of research on the hake will continue in the Gulf in 1966. Survey cruises on the M.V. Harengus to better determine factors affecting distribution of hake in the area are planned. A special study of fecundity will be carried out as part of this work for an M.Sc. thesis. A report of details of the work done on hake during the summer of 1965 by summer assistant, Stephen Nepszy, is on file in Groundfish Investigations.

A. C. Kohler

No. CA-5

GREYSOLE AGE VALIDATION STUDIES

Seasonal deposition of opaque and transparent material on the outer edges of greysole otoliths was described in last year's annual summary. Opaque edges in Nova Scotian greysole otoliths were found from June through September, and transparent edges from October through May. The samples of otoliths examined were mainly from commercial sizes of fish. Validation of the ageing technique as applied to pre-commercial sizes of greysole was investigated in 1965. Prior to this, very few small greysole from any one area had been captured.

Length modes

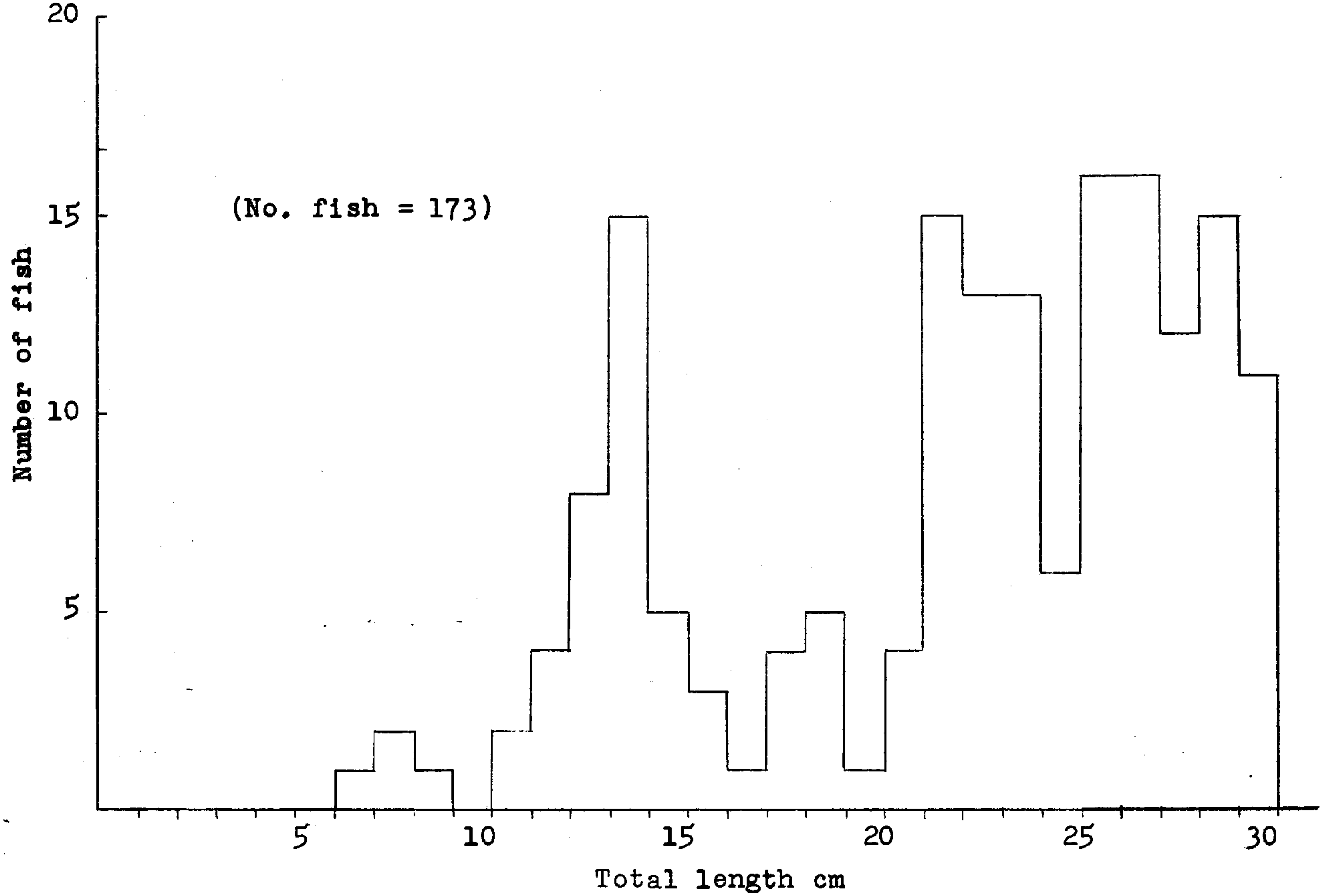
In April 1965, 955 greysole were taken by shrimp trawl and otter trawl in one area east of Middle Ground. Of these, 173 taken by shrimp trawl were below commercial size (less than 30 cm in length). Modes in the length frequency of this sample occurred at 8, 14, 19 and 22 cm (accompanying figure). Otoliths of these fish showed an opaque centre plus 1, 2, 3, and 4 hyaline zones respectively at the outer margin. Since hyaline zones are annual (see para. 1), these fish were aged 1, 2, 3, and 4 respectively, although they had not quite reached their actual birthdays (June).

Back-calculation of total lengths from otoliths

A sample of 42 greysole otoliths was measured from the nucleus to the outer median edge on the long half of the left otolith. Otolith "half-length" and total length of fish when plotted were related according to the formula

$$L = 1.52O^{1.55}+2.00$$

Size composition of greysole taken by shrimp trawl, April 1965, Middle Ground.



CA-11

Groundfish

where L = total fish length in cm, and σ = otolith "half-length" in eye-piece units. Because this relationship was constant for greysole ranging between 3 and 48 cm, back-calculations were deemed valid. Suitable corrections for allometry were made as in Frost and Kipling (The determination of the age and growth of pike (Esox lucius L.) from scales and opercular bones. J. Conseil, XXIV, No. 2, 1959, Fig. 6).

Below is a tabulation by sex of the mean lengths-at-age obtained by back-calculation of 42 greysole otoliths from the Middle Ground region. The otolith back-calculations were arranged by age groupings because of the possible occurrence of Lee's phenomenon.

Table I. Mean lengths (cm) of Middle Ground greysole computed by back-calculation of otolith rings; based mainly on greysole taken by otter trawl.

Age (yr)	1-4 yr Male	1-4 yr Female	5-8 yr M	5-8 yr F	9 & over M	9 & over F	Overall mean (cm)	No. measurements
1	10.8	8.3	6.4	7.8	6.1	6.7	7.7	36
2	19.2	14.8	11.8	13.2	11.0	12.0	13.7	36
3	24.8	18.5	16.1	18.5	16.4	15.9	18.4	39
4	27.5	22.3	20.2	23.0	21.4	20.2	22.4	42

There is some suggestion of Lee's phenomenon in the above data. Usually the mean lengths computed from the otoliths of younger fish are greater than the mean lengths computed from the otoliths of older fish (Lee's phenomenon). The overall mean lengths, however, correspond very closely to the length-frequency modes of small greysole taken by shrimp trawl (compare 7.7, 13.7, 18.4, and 22.4 with 8, 14, 19, and 22 of the figure). This is good evidence that the ageing techniques used for commercial sizes are also valid for younger greysole.

P. M. Powles

No. CA-6

GREYSOLE AND PLAICE TAGGING EXPERIMENTS

During the period October 1963 to April 1965, 2637 greysole were tagged in various regions from the southern Gulf of St. Lawrence to Middle Ground (Table I). The number of recaptures has been disappointingly low. In all except one area (lot 6) at least moderate fishing has occurred since the date of tagging. Taggings of other flatfish such as American plaice have provided good tag returns. Therefore poor reporting of recaptured fish is not considered to be a reason for low returns. It is

Table I. Summarized results of greysole tagging experiments carried out from October 1963 to April 1965. All tagging was done from research otter trawlers.

Lot #	Av. %/yr recovered	Month, year tagged	No. tagged	No. recovered to Jan./66	Av. surf. temp. °C	Av. bottom temp. °C	Av. depth fathoms
1	3.2	10/63	111	7	11.9	3.28	48 North Bay
2	1.0	10/63	103	2	11.3	3.88	89 Cape North
3	5.0	10/63	110	16	10.8	2.70	72 Sydney Bight
4	0.4	02/64	724	6	1.1	4.12	147 S. Scatari Bk.
5	0.4	02/64	703	6	0.8	3.84	199 Greysole Hole
6	-	10/64	191	-	12.3	1.67	106 Little Hole
7	1.5	03/65	204	3	0.4	2.32	106 Canso Bank
8	5.7	04/65	491	28	0.19	4.32	71 E. Middle Ground
			2637				

suspected that greysole returns are falsely low. Although no experiments have been performed to test the various factors involved, it is believed that tag shedding and post-tagging mortality are probably the most important factors.

Emigration

Plots of tag recaptures have thus far shown no evidence of extensive greysole movements. All reliable locations of returns have been within 20 to 30 miles of the release area. Emigration therefore does not account for reduced tag returns. Research and commercial catch data indicate limited but general seasonal movement to and from deep water in winter and summer respectively.

Tag shedding

Several reports of greysole tags (without fish) in the meshes of trawls have been received. Tag shedding may be a small contributing factor, since greysole flesh and skin are more tender than plaice, winter flounder or halibut, all species which have been tagged with moderate success using similar tags.

Post-tagging mortality

Exposure to sudden changes in depth and temperature probably has the most pronounced effect on survival. The best recaptures were obtained from lots 1, 3, and 8, where depths ranged from 48 to 72 fathoms (Table I). Greysole kept in tanks for 6 hours from deep water (lot 7) appeared to develop symptoms of popeye (opaque retina). Greysole from shallow fall and spring taggings appeared normal.

When plaice and greysole were tagged and released together, plaice appeared to show better survival, assuming both species were equally prone to capture by Danish seiners and others operating in the area (Table II).

Table II. Comparison of plaice and greysole tag returns to January 1966 from lots 1, 2, and 3 of Table I.

Lot	Plaice		Greysole	
#	Returns	No. tagged	Returns	No. tagged
1	60	217	7	111
2	3	9	2	103
3	1	10	16	110

Late spring taggings, when surface and bottom temperatures were not widely different (see lot 8, Table I), and the fish were not too deep, appear to be the most successful for greysole. At this time also, the air temperature to which the fish were exposed was not as extreme as in the summer or winter months.

Other means of improving survival such as injection of adrenalin inhibiting substances (to prevent popeye) should be considered for future taggings for this species.

Until tagging survival of greysole can be improved, the returns should not be used in estimations of fishing rates. The studies have been useful however in showing that greysole movements are probably of a limited nature.

P. M. Powles

No. CA-7

HADDOCK STOCK SURVEY

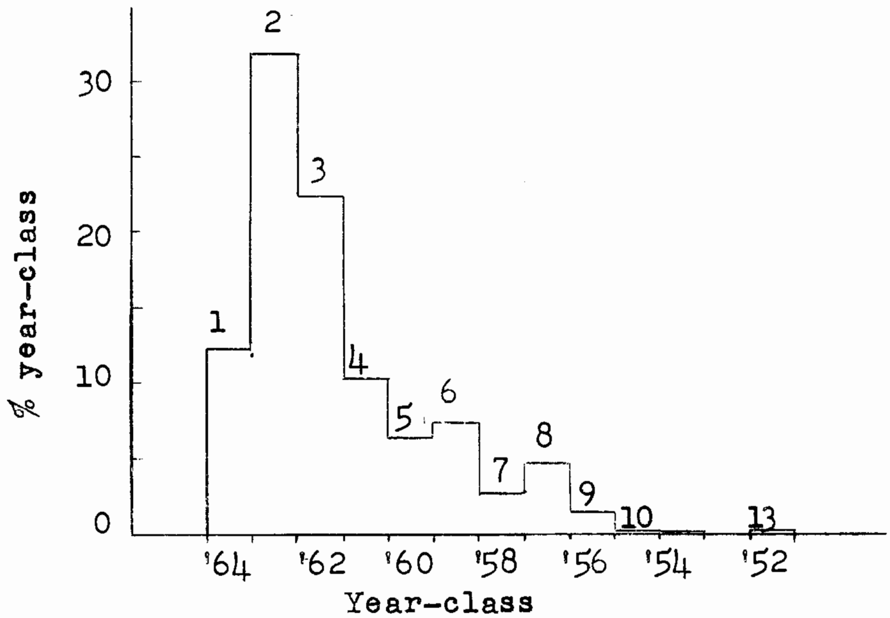
During 1965 a short (6-day) cruise of the A.T. Cameron to the central Scotian Shelf area in March and early April was aimed at surveying pre-recruit haddock stocks. Moderately good but sporadic catches of commercial sizes of haddock were obtained, especially in the area south of Emerald Bank.

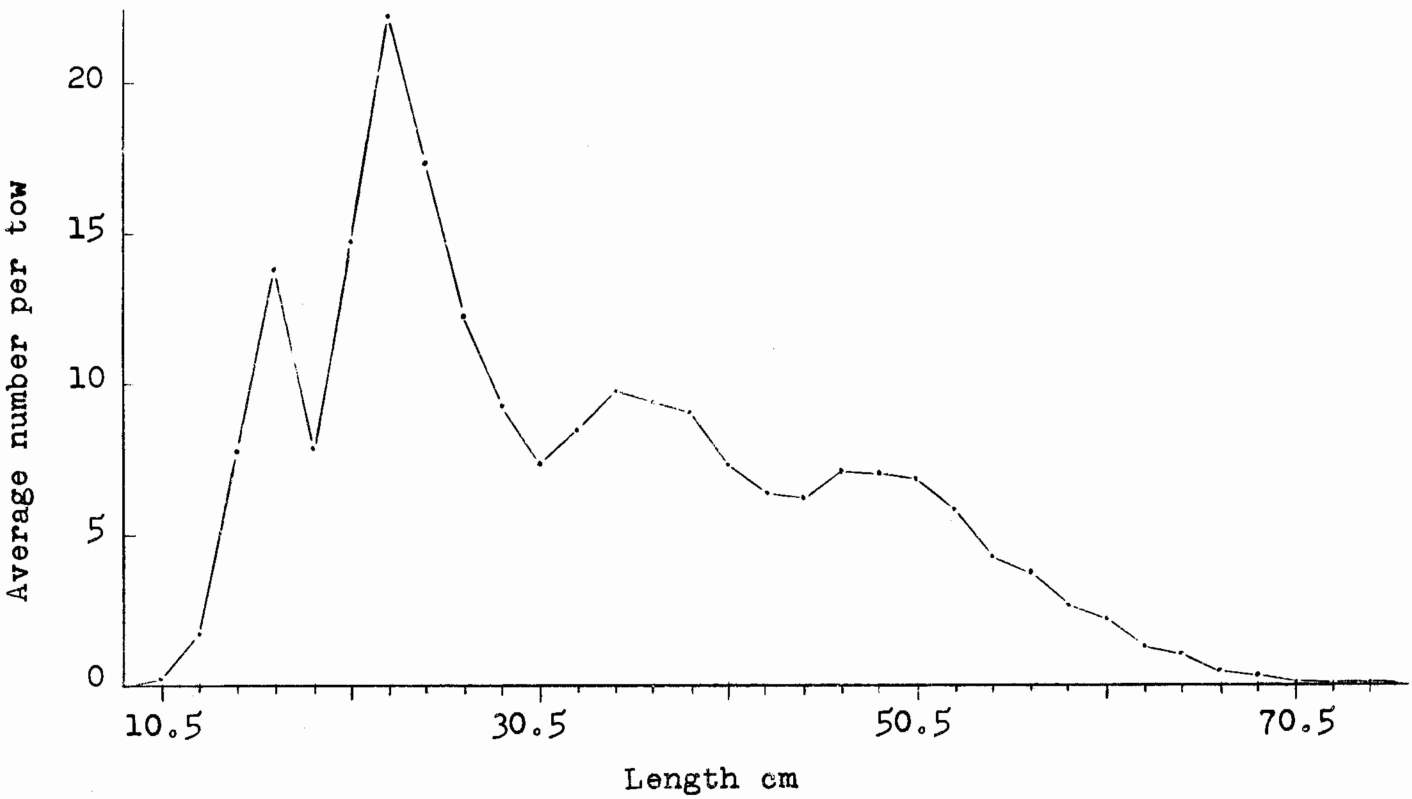
Average size composition and age frequency of the haddock catches are shown in the accompanying figure. Previous predictions of poor year-classes seem to have been confirmed. None of the year-classes from 1958 to 1961 appear to have been outstanding. Current commercial landings are relying mainly on the 1959 year-class. Year-classes of 1958 and 1960, which should also be influencing the fishery, seem particularly weak.

In our survey data (from a limited cruise) the 1963 year-class seems relatively strong. This year-class is also strong on banks to the westward where, on Georges Bank, it has now entered the fishery, and on Browns Bank it is outstanding among the pre-recruit sizes of haddock.

From about 1958 to 1963 haddock stocks off central Nova Scotia were at a high level. The data obtained from the 1965 survey along with those from surveys in 1962 and 1963 suggest that haddock stocks will be at relatively low levels for the next 3 or 4 years, at least.

F. D. McCracken





Lengths and ages of haddock in survey hauls, Emerald Bank region, March-April 1965.

No. CA-8

FOOD RESOURCE DIVISION AMONG SYMPATRIC FISHES

The aim of this work is to determine which species might be feeding competitors and to illuminate the action of piscivorous species. Localities selected for this study are Passamaquoddy Bay and LaHave Bank on the Nova Scotian shelf.

In Passamaquoddy Bay, fishes were collected by otter trawl on a station 2 mi long located between 20 and 30 fath depth contours. Each month, a sub-station 1/2 mi wide and 1 mi long was sampled with 5 half-mile trawl sets. Radar buoys are set out to outline the sub-station and to determine distance towed and towing velocity relative to the ground. From March 1965 to February 1966 the station was sampled 17 times in this manner. Trawling will continue to July 1966.

Usually all fishes caught were measured for length but occasionally when large numbers of fish were caught individuals were counted and a sample measured. Samples of 25 fish per 10-cm length group were injected with formalin and brought back to the laboratory where food organisms in their stomachs were weighed and identified.

Extra trips were made to collect fishes for length-weight measurements so that relative abundances of fishes caught on regular sampling dates could be worked up in terms of weight. Otoliths were taken on some of these trips.

Sampling methods had to be modified for the work carried on at sea. The station on LaHave Bank was circular with a diameter of 4 mi. To sample the station, the vessel was positioned by Decca bearing at the centre of the station and 30-min sets were made radially at 45° intervals on the compass. Sixteen sets were made in this way so that the circle was fished twice around in 24 hr. The vessel moved about 2 mi during each set (1/4 mi shooting away, 1 3/4 mi after hook-up).

Examination of the fishes at sea was similar to that made of Passamaquoddy fishes except that the work was done aboard ship and estimated volumes, not weights, of food items were recorded. Volume to weight conversion factors will be determined.

The station on LaHave Bank was sampled in April, June, August, October, 1965, and February 1966.

A. V. Tyler

No. CA-9

FEEDING OF FISHES IN DIFFERENT AREAS WITHIN FISH AGGREGATIONS

This project aims to discover whether fish are consuming food rapidly enough so that in the densest part of their aggregations they deplete the food supply. Aggregations of haddock were located on the east slope of LaHave Bank in an area about 12 mi square in April, June, August, and October 1965. These aggregations were sampled by making consecutive otter-trawl sets along transects running across the bank depth-contours from at least 80 fath to 50 fath. From each 30-min tow haddock and other fish caught were stratified into 10-cm length groups and where available the stomachs of 20 individuals were examined from each length group.

The haddock aggregations appeared to be 3 to 5 mi wide (accompanying figure). Preliminary analysis (Table I) indicates that, as the temperature of the sea bottom at the 50-fath contour increased from April to October, the haddock aggregations moved to less deep and warming areas on the bank.

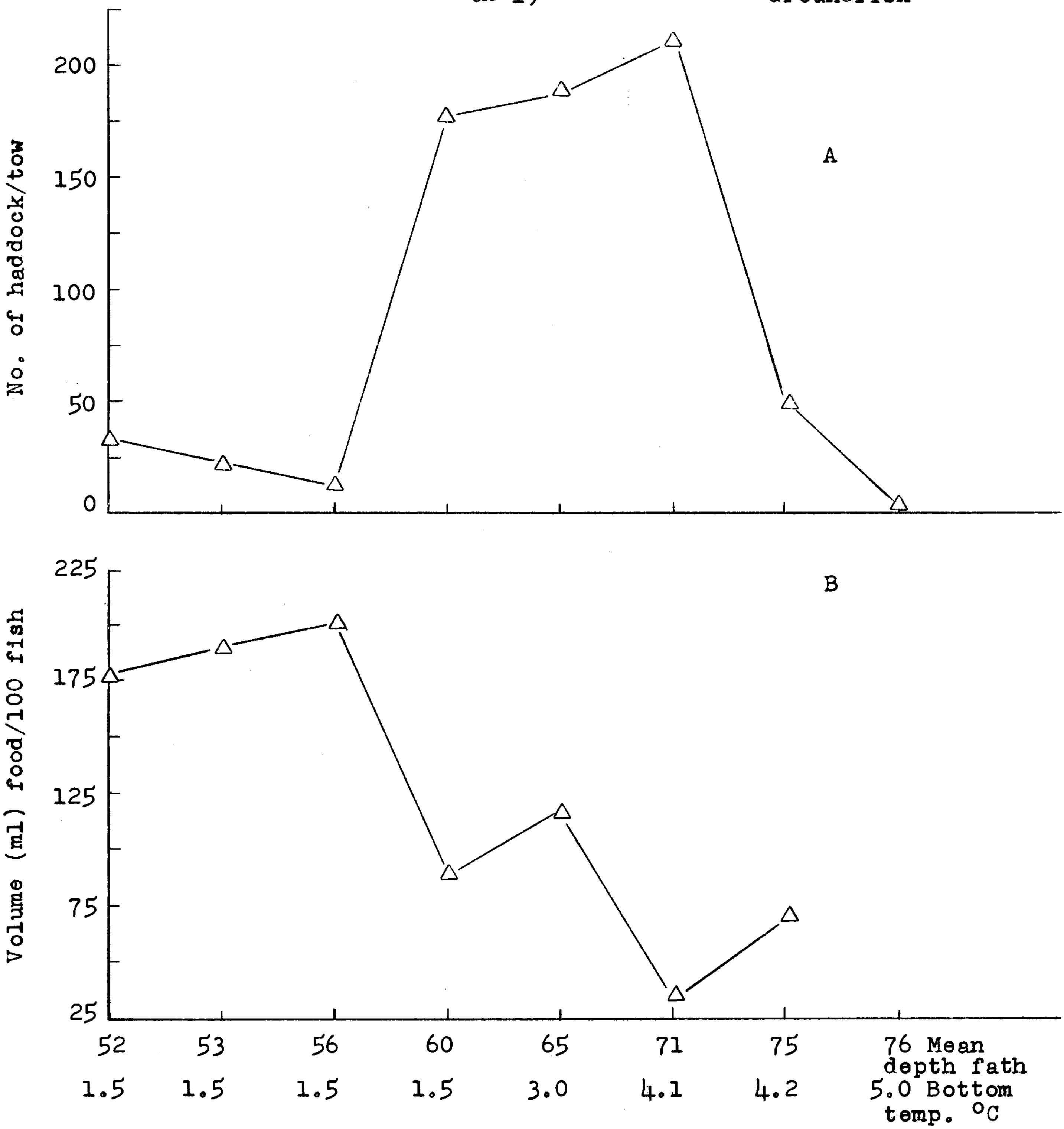
The stomach content data of haddock and other fishes are being analyzed in relation to their position in the haddock aggregation, other environmental factors, and season.

The data shown in the figure indicate that food volume was high in the less deep areas that most haddock had not yet penetrated in August. Until all data have been considered, it is a tentative conclusion that the haddock within aggregations in August were living under diminished food supply.

Table I. Sea bottom temperatures and depths associated with haddock aggregations.

Date	Temp. range over entire transect °C 50 fath	≥80 fath	Temp. range at aggregation site °C	Depth range at aggreg. site (fath)
April	0.2	4.3	0.2 to 0.8	65-87
June	0.7	5.5	1.4 to 4.9	70-75
August	1.5	5.0	1.5 to 4.1	60-70
October	2.4	5.6	2.6 to 3.7	53-73

A. V. Tyler



Relative abundance of haddock (A) and volume of food found in haddock stomachs (B) from consecutive otter-trawl sets on a transect running from the top of LaHave Bank to deeper water off the bank. Data from August 1965.

No. CA-10

LABORATORY STUDIES ON GROUNDFISH FEEDING

Laboratory studies were begun on the feeding rates and food conversion efficiency in groundfishes. Estimates of these functions are necessary for evaluation of rates at which fishes at sea utilize their food resources.

Experiments were conducted with young cod (80-250 g). The cod were held for a month or more after capture in 6-ft diameter, fibreglass tanks in groups of 15 to 20 individuals. They were fed on alternate days to satiation on a diet of liver and herring.

During the experiments the fish were kept in fibreglass tanks (14" x 78" with 12" water depth), one fish to a tank. After being transferred to the experimental tanks, the fish were acclimated to selected temperature levels (2, 7, 12, 17 C). Fish were allowed one day to acclimate to each Centigrade degree increase or two days for each Centigrade degree decrease from acclimation to test temperature. Water temperature was controlled to ± 0.5 C. Water flowed quietly into each tank at a rate of one liter per minute. Aeration was carried out in header tanks only. The fish were weighed after acclimation was completed and experimental feeding began the day after weighing.

Each fish was given a weighed amount of shrimp daily. Food which remained from the previous day was siphoned onto a fine screen and weighed. Shrimp for the feeding studies were caught by research trawler and fresh frozen in capped plastic cups. Before use, the shrimp were soaked in the cup for 24 hr. The shrimp abdomens were diced into 1/4-in. pieces and then weighed out for each fish by dropping the chunks into a dipper which was suspended from the pan of an electric balance and submerged in a beaker of water.

Factors for conversion of submerged weight to fresh moist weight and to dry weight were determined.

Shrimp pieces were placed in the experimental tanks without fish in control experiments. At least 10 trials were made at each temperature to which fish were acclimated. Correction factors for shrimp weight change were calculated from these trials.

While in the experimental tanks, most of the cod were quiet and would usually come to the edge of the tank when fed.

Young cod of the size used in these experiments feed almost exclusively on small crustaceans in the Passamaquoddy Bay.

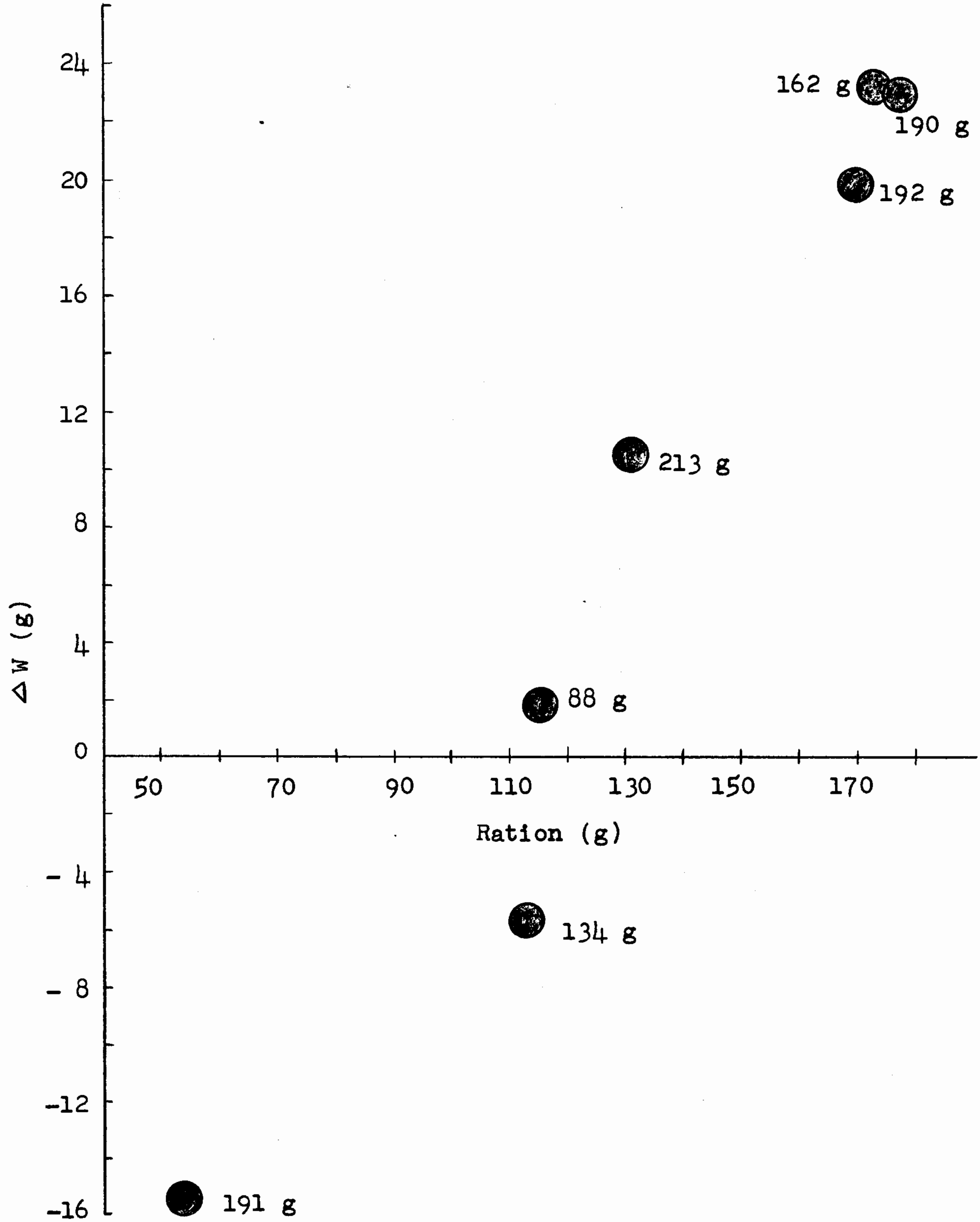


Fig.1. Weight change (ΔW) and ration consumed for 7 young cod acclimated to 7 C. Ration is given as wet weight (g) of shrimp consumed, weight change in terms of wet weight of cod, both calculated to a 30-day period. Final fish weight (wet) is given for each ΔW-ration point.

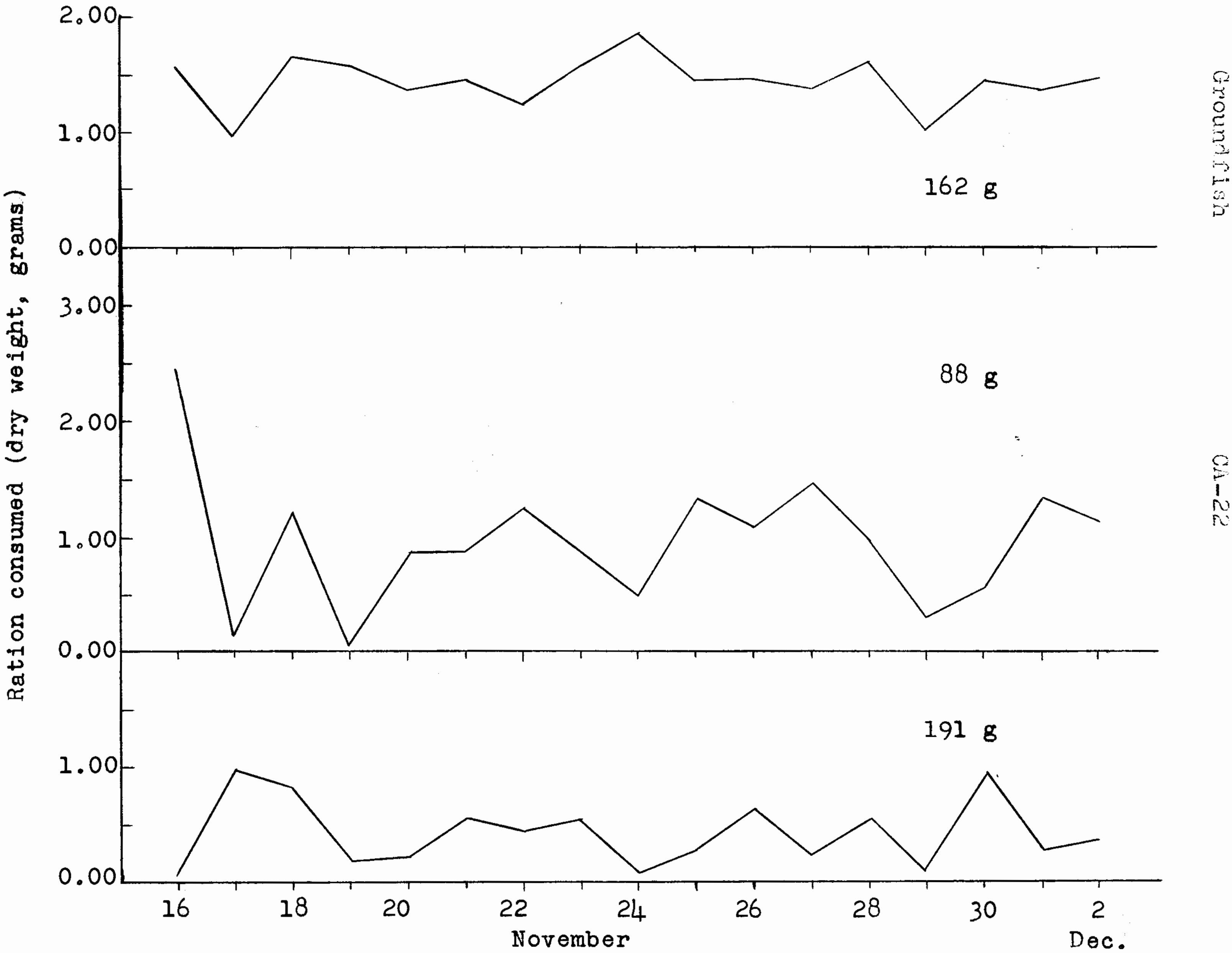


Fig. 2. Daily food consumption (dry weight of shrimp) of three fish from Fig. 1. Final fish weight (wet) is included within the figure.

Experiments have not yet been completed and comparisons between acclimation levels cannot be made at this date. Figure 1 is a plot of weight change against ration consumed for young cod acclimated to 7 C. For this group of fish, the maintenance ration was about 4 g of shrimp per day (fresh moist weight).

Chart of daily food consumption of three individual cod from Fig. 1 is shown in Fig. 2.

A. V. Tyler

No. CA-11

STUDIES ON THE CUSK (BROSME BROSME MÜLLER)

In 1965 Canadian landings of cusk reached about 9 million lb, a fivefold increase from 10 years earlier. Studies on the fishery and biology of the cusk were initiated in 1963 and continued through 1964 and 1965 as a project by summer student, W. S. Oldham, who is using some of the material obtained for a M.A. thesis.

Examination of the fishery statistics shows that about 75% of the cusk currently taken from the ICNAF Convention Area come from Subarea 4. Of these, about 98% are taken by Canadian vessels, and practically all came from the western and central Scotian Shelf region. About 98% of the cusk catch was by hook and line.

Most of the study on cusk has relied upon sampling commercial landings since few cusk have been taken in research-vessel otter-trawl hauls. The studies therefore relate to cusk of about 40 cm and over, since smaller and younger cusk are not taken by the commercial fishery and were uncommon in all research-vessel surveys.

Along the western Scotian Shelf cusk are taken from depths of about 40 to 200 fath. Those from the shallower areas on top of the shelf ranged in length from 40 to 70 cm. Cusk taken along the edge of the shelf, in deeper water, were generally from 60 to 90 cm in length.

Studies on the otoliths of cusk showed that opaque zones predominated on their outer edge from June to October, with hyaline zones predominant from November to May. On this basis, an opaque and hyaline zone was assumed to be a record of each year. From these age determinations it was found that most male cusk landed were between 5 and 9 years and females between 6 and 11 years of age. At 5 years of age, mean length of fish was about 46 cm. By age 9, the mean length was 63 cm with females slightly smaller than males.

At Lockeport, where sampling was carried out, most cusk are landed round, and thus maturities and seasonal changes in gonad condition could be determined. It was found that 50% of males were mature at around 44 cm and 50% of females at 51 cm. The peak spawning period occurred in late June; however, some ripe and spawning fish were taken earlier (May) and later (up to mid August) when intensive sampling was terminated.

Studies of fecundity, length/weight relationships and growth rates are being pursued as part of the M.A. thesis problem at the University of Western Ontario.

F. D. McCracken
(abstracted from season's report
by W. S. Oldham)

No. CA-12

GROUNDFISH STUDIES UTILIZING COMPUTER PROGRAMS

Food studies

With the completion of analyses of cod feeding covering the period 1959 to 1964 (Orig. MS 1008, 1965), attention is now being focussed on haddock and flatfish food studies. Print-outs were made of the stomach volumes and types of organisms for haddock and greysole-plaice cruises from 1959 to 1964. IBM summary feeding cards have been punched for haddock, and are ready for analyses by size, area, depth, and season.

New programs

Age-length key-commercial data-trip weighted program: This program computes the mean length-at-age, age frequency (%), standard deviation and standard error of the mean lengths for each age. The program has been tested and a sample problem for Gulf of St. Lawrence cod samples has been run. The 1964 data for commercial samples of Gulf cod have been punched and verified. The program will be used for haddock and cod from other areas, and it is planned to use the program in place of the former preliminary hand computations for commercial data.

Length-weight program I: This program has been used for summarizing groundfish length-weight data covering the period 1946 to 1965. Print-outs have already been made for length-weights of cod, haddock, plaice, halibut, yellowtail, greysole, hake, and flounder. The data include round, gutted, and gutted-gilled weights for cod, haddock, and halibut. The program computes a and b in the formula $W = a\ell^b$, and prints out weights for lengths 1 to 99 cm and 1 to 250 cm by incorporating the Doolittle forward solution. It may also be used to obtain a polynomial equation as well as the straight-line relationship, $W = a\ell^b$.

An age-length key program for research vessel data is almost completed. Print-outs summarizing research-vessel survey catches by tow and species are being planned, as is a head-length, total-length regression for halibut. Two Bertalanffy growth equation programs (Allan's and Abramson's) are in the process of translation from FORTRAN IV to FORTRAN II.

P. M. Powles

No. CA-13

FISH ECHO COUNTING

During late 1964 and early 1965 a system was designed to count fish echoes, using a ship's echo sounder. Preliminary experiments were conducted during April 1965 on the A.T. Cameron, with reasonable results, to establish the validity of the principles. From the information gathered on this cruise, electronic logic circuits were designed and constructed for the control and shaping of the varying echoes.

On an October cruise on the A.T. Cameron, attempts were made to calibrate the system by simultaneously making tows and obtaining counts. Though the fish concentrations encountered at that time of year were small, they enabled the investigator to obtain a correlation between the counts and the catch for small numbers of fish. Future experiments must be conducted to obtain correlation between all sizes of catches.

In June, a related experiment was begun on M.V. Harengus to obtain data on size-echo relationships and also to establish the source of the strongest echo in fish. For this the echo amplitudes from live cod were measured at different depths. The swim-bladder was then removed and the amplitudes were measured at the same depths. The latter yielded an echo strength over the depth range of 60 to 140 m of one-half to one-quarter power of the former.

F. D. McCracken
(abstracted from a report
by R. G. Dowd)

No. CA-14

EXPLORATORY FISHING (FEDERAL-PROVINCIAL PROJECT)

Previous analysis of research-vessel catch records has shown that two species of unutilized groundfish, silver hake, Merluccius bilinearis Mitchill, and argentine, Argentina silus (Ascanius) provide a possible Canadian fisheries resource. This assessment has been confirmed by Soviet operations in catching these species. Investigations of their biology and distribution, begun in 1964, were continued in 1965, although hampered by the loss of the biologist carrying out these studies.

Four summer cruises (July-August) with the charter vessel Louise P were carried out between Sable Island and the southeast part of Georges Bank in depths and areas where these species are likely to be found. In addition, part of a winter cruise of the A.T. Cameron to the central Scotian Shelf was devoted to the study of argentines. From these partially analysed data and those of previous cruises, the following preliminary results may be presented:

Argentines

This species was found in many localities along the edge of the continental shelf from Banquereau to the south-eastern part of Georges Bank. Best catches were made between 100 and 200 fath. Argentines are found also in the deep-water basins of the Scotian Shelf, but do not extend into either the Gulf of St. Lawrence or Bay of Fundy.

Along the edge of the continental shelf off Nova Scotia, argentines were mainly 2 to 7 years of age and 8 to 10 in. long; off Georges Bank they were 10 to 15 in. long; and in the Emerald Basin region about 6 to 11 years of age and 12 to 15 in. long. Argentines are slow growing and late maturing and it seems likely that intensive fishing could rapidly reduce stocks. There is some evidence that the incidental catches by the USSR may already have done so.

Silver hake (Whiting)

This species was taken in most tows on Georges Bank and sporadically from the Scotian Shelf during exploratory fishing in 1965. Catches were generally not large enough to be considered of commercial interest. Near the west bar of Sable Island in depths around 20 fath somewhat larger catches (average 700 lb per hour's tow) of 10- to 15-inch silver hake were taken in early August. In the same region a fleet of about 40 Soviet vessels was operating and appeared to be catching the same species. Information on the biology of silver hake from the Scotian Shelf has not been analysed, principally because of lack of personnel and difficulties encountered in age reading. Our data and observations of the Soviet fleet suggest the seasonal nature of fishable silver hake concentrations throughout the region. Mid summer seems the most opportune time in the Sable Island region.

During these cruises a standard groundfish otter trawl lined with small-mesh netting was used. It seems likely that more specialized gear would be desirable. Small-mesh, light, high-rising herring trawls were not received in time for trials during 1965. Such gear should be used in continuing explorations. Future explorations should emphasize more detailed biological aspects, such as changes in seasonal distribution, diurnal behaviour, segregation of stocks, and sizes of fish, age and growth, etc.

F. D. McCracken
(abstracted from a report by
R. A. McKenzie)

No. CA-15

STATISTICS AND SAMPLING FOR OFFSHORE INVESTIGATIONS

Collection of catch and effort statistics and sampling of commercial fish landings continued to be a responsibility of the St. Andrews Station during 1965. Most of the work is carried out by a staff of field technicians with headquarters in various ports in the Maritimes area. Besides the six permanent staff stationed at Sydney, Halifax, Lunenburg, and Yarmouth, two term positions were created in 1965, one full time at Lockeport, N. S., and one seasonal at Caraquet, N. B. These positions were required to keep up with research requirements for statistics and sampling from the rapidly expanding offshore fleet in the Maritimes. It is apparent that a further position will be required for the fishing season in P.E.I. in 1966.

The accompanying table shows types of species sampled and number of fish handled. Sampling submissions to St. Andrews increased again in 1965, with 68,710 pelagic fish and groundfish measured and over 10,000 otoliths taken for ageing studies. The sampling of sizes and ages of fish landed and the recording of where the fish were taken and the effort required to make the catch are essential to the scientists studying these populations of fish.

Each year there is a joint meeting of the Fisheries Research Board, the Economics Service of the Department of Fisheries, the Quebec Bureau of Statistics, and the Dominion Bureau of Statistics to work out policies and details for production of fisheries statistics for the Maritimes and Quebec. In 1965 the meeting was held in August in Halifax. Many details of production of statistics were discussed; among them, the problem of computer print-out of catch and effort statistics for the International Commission for the Northwest Atlantic Fisheries, and new methods of preparing effort statistics for IBM punching.

The negotiations reported last year for Departmental take-over of routine statistics and sampling work from the Fisheries Research Board have not progressed far. Responsibility for supervising the group that collects this routine information will continue to be borne by Board scientists until a competent organization for take-over of this work is set up within the Department.

Samples of commercial landings of offshore species in 1965

Species	No. of samples	No. of fish measurements	No. of otoliths
Groundfish			
Cod	58	21303	3209
Haddock	64	22134	3345
Halibut	9	1426	612
Redfish	11	2775	0
Pollock	5	1242	90
Hake	5	922	176
Cusk	7	751	398
Plaice	5	1019	49
Witch	10	1867	433
Yellowtail	2	400	80
Winter Flounder	4	991	100
Sub-total	180	54830	8492
Pelagic Fish			
Herring	36	5435	1000
Swordfish	56	5622	—
Mackerel	21	2690	590
Tuna	15	115	--
Shark	4	18	--
Sub-total	132	13880	1590
TOTAL	312	68710	10082

A. C. Kohler

No. CB-1

PELAGIC FISH INVESTIGATIONS 1965

The pelagic fishes within range of Canadian Atlantic fishermen constitute the greatest of our known but incompletely utilized marine resources. Our research is therefore directed towards surveying stocks of various species to determine their biological characteristics and the locations of aggregations that can be exploited profitably. Herring is the best used and most intensively studied member of the group, but there is still a great need for knowledge of the factors that control the abundance and availability of various sizes both seasonally and throughout the area of distribution. Information on mackerel and tuna resources is rudimentary and badly needed for guidance in the development of a Canadian fishery. Swordfish utilization has increased threefold in recent years and there are already signs of decreases in mean size, catch-per-unit effort and total catch. This emphasizes the need for more knowledge of the life history of swordfish and of the factors that control its occurrence not only off the Canadian coast, but throughout the area of distribution in the North Atlantic.

Landings of pelagic fish from the northwest Atlantic have increased rapidly during the past decade and now amount to more than 750 million lb annually. There has been substantial growth in the Canadian fishery, but most of the increase has resulted from new fisheries by Europeans. Because of the increasing international use of pelagic fish resources, more and more attention is being paid to research and management of these resources by the International Commission for Northwest Atlantic Fisheries (ICNAF).

Canadian landings of herring, mackerel, swordfish, tuna and sharks during 1965 amounted to 442 million lb (round weight) valued at 8.4 million dollars. The total catch was made up of 404 million lb of herring, 24 million lb of mackerel, 12 million lb of swordfish, 1.4 million lb of tuna and 120 thousand lb of shark.

The 1965 herring catch was 91 million lb (29%) greater than in 1964. Most of the increase occurred in the Bay of Fundy region where an all-time record catch of 255 million lb was made. This was 70 million lb (38%) greater than the record of 185 million lb taken the previous year. Presumably the increase in landings was due entirely to new markets that became available for the first time in 1965. Herring landings also increased in Newfoundland (48%); off the Atlantic coast of Nova Scotia (18%); and in the Gulf of St. Lawrence (9%).

The Canadian mackerel catch (24 million lb) was virtually the same in 1965 as it was the previous year. There were slight increases in Bay of Fundy and Nova Scotia coast landings, but these were offset by smaller landings in the Gulf of St. Lawrence and in Newfoundland. Swordfish landings which amounted to 11.7 million lb (round weight) were down sharply (34%) from the 17.6 million lb taken in 1964. However, the landed value (3.3 million dollars) was only 8% less than in 1964. Tuna landings (1.4 million lb) were less than half what they were in 1964, while shark (chiefly porbeagle) landings increased threefold to 120 thousand lb.

S.N. Tibbo

No. CB-2

HERRING SIZE AND AGE COMPOSITION--1965

Routine sampling of the southern New Brunswick "sardine" herring landings was continued throughout 1965. Between January and December, 141 samples were obtained covering landings from Saint John County to Grand Manan. A total of 18,410 fish were measured for total length and otoliths from 2,300 fish were removed for age determination. Three per cent of the 2,300 fish had opaque otolith nuclei (spring-spawned). Of the autumn-spawned fish, 4% were of the 1964 year-class, 77%--1963, 9%--1962, 7%--1961, and 3%--1960. Total lengths ranged from 7.5 to 38.0 cm.

Herring samples containing a total of 1,297 fish were obtained during September and October by Dutch herring trawl on the northern edge of Georges Bank. Total lengths ranged from 19.6 to 35.4 cm. Four hundred and fifty-three (453) sets of otoliths were used for age determinations. Of these, 3% were spring-spawned fish. The year-class composition of the autumn-spawned fish was as follows: 1%--1963, 23%--1962, 66%--1961, 8%--1960, 2%--1959.

From March 24 to November 11, a total of 58 herring samples were obtained from purse-seiners, weirs, and gill nets on the Trinity to Cape St. Mary spawning grounds. Seven thousand, eight hundred and fifty-three (7,853) herring were measured, ranging in total length from 8.0 to 39.5 cm. Ages were determined from 2,009 sets of otoliths. Of these, about 4% were of the spring-spawned type. The autumn-spawned fish consisted of 18%--1963, 4%--1962, 56%--1961, 16%--1960, 5%--1959, and 1%--1958 plus 1957.

R.D. Humphreys

No. CB-3

FATNESS OF HERRING

Herring from the southwest Nova Scotia pre-spawning and spawning stocks were obtained between June 15 and August 3, 1965, for fatness determinations. Whole fish were ground to a smooth paste, dried in anhydrous sodium sulphate, and the fats extracted with ether. Values were expressed as per cents of the total body weights of the fish and ranged from a low of 9.7% for the June 15 sample to a high of 17.3% for the July 8 sample. The increased fat content in July appeared to be associated with the maturation of the gonads as spawning season approached.

It is proposed that this study be continued and that a complete range of herring sizes, fishing localities, and seasons be sampled.

R.D. Humphreys

No. CB-4

EXPERIMENTAL HERRING FISHING ON THE SOUTH COAST OF NEWFOUNDLAND

In past years, the herring fishery on the south coast of Newfoundland was based on aggregations of pre-spawning fish that appeared in inshore areas during the late fall and early winter. Fishing was carried on close to shore with small purse-seines, shore seines, traps and gill nets.

In November 1964, the M.V. Lavallee, a Pacific coast purse-seiner, was introduced to the herring fishery on the south coast of Newfoundland to supply herring to a new reduction plant at Harbour Breton, Newfoundland. The seine used by this vessel is 300 fathoms long and 45 fathoms deep. Therefore, it was necessary to fish further offshore in deeper water to avoid fouling the gear on the bottom. The fishery is still executed within the sheltered waters of the bays, but in depths of 50 to 150 fathoms, setting the gear on schools swimming at depths of between 7 and 18 fathoms.

Previously, commercial catches on the south and west coasts consisted chiefly of large and old herring with mean lengths of 34.4 to 36.1 cm and mean ages from 10.9 to 13.0 years. In contrast, a mean length of 33.0 cm and a mean age of 8.2 years was recorded for samples taken from Baie de Vieux-La Hune Bay catches during the winter of 1965.

The high proportion (84.0%) of immature herring occurring as late as March in the catches of 1965 is the first record of such a large proportion of immature fish in winter catches on the south coast. Also, there was a noticeable increase in the proportion of immature fish and a decrease in maturing individuals as the season progressed, indicating that as the fish matured they left the area being fished by the purse-seine gear. It is suggested that the use of the larger seine gear has resulted in the earlier exploitation of fish that previously did not enter the fishery until later in the season, after they had reached the inshore spawning areas.

R.D. Humphreys

No. CB-5

EXPERIMENTAL HERRING FISHING IN SOUTHWEST NOVA SCOTIA

A Pacific coast purse-seiner, the Quadra Isle, was brought to Nova Scotia in the spring of 1965. It was equipped with a western seine to determine the efficiency of the larger and deeper seine in the inshore herring fishery of southwest Nova Scotia.

During the period August 1 to October 21, the Quadra Isle landed an estimated 1,163 tons of herring. These herring were from spawning and recently spawned concentrations.

The seining operation was successful only at night. Usually the fish are closest to the surface just before the moon comes up and immediately after it goes down. Herring schools deeper than 30 fathoms are outside the effective range of the gear.

Herring schools were located in two ways: (1) with a Simrad echo sounder, and (2) by listening for whales "blowing." The latter method appears to work well in providing a rough indication of productive waters.

The number of tons of herring per set varied from 3 to 120. Sets of less than 5 tons were usually not taken aboard. As many as three sets were made in a night, each taking 2 or 3 hours.

There is a pronounced difference in behaviour between "spawning" and "spent" herring schools with respect to the seine. Spawning concentrations have a tendency to orient themselves downward when enclosed by the seine. This particular behaviour pattern causes considerable difficulty in handling a large set. The combined force of the school swimming downward often resulted in the submersion of the buoys of the seine and the consequent loss of a portion of the school. To combat this situation, the seine was retrieved more rapidly to confine the fish so that they were unable to swim. However, this procedure was frequently unsuccessful since the seine would not accommodate the additional tension and often ripped.

The movement of "spent" herring schools within the seine was usually horizontal. This behaviour pattern did not impede the recovery of the seine and the set was completed more quickly.

R.D. Humphreys

No. CB-6

HERRING TAGGING IN THE BAY OF FUNDY

A preliminary attempt was made this year to tag herring in their third year of life or older on the New Brunswick side of the Bay of Fundy. The object of the experiment was to determine the origin of these fish by tag recoveries on the spawning grounds.

A total of 2,086 herring were tagged with yellow spaghetti tags during the latter part of July. These fish were taken from weirs in the Wolves Islands, the outer coast of Campobello Island, and from Bliss Island. All were released near the site of capture.

A total of 86 (4.1%) recoveries were made between the first date of release (July 20) and November 30. None had travelled more than a few miles from their place of tagging and none were recovered on a known spawning area.

R.D. Humphreys

No. CB-7

OFFSHORE EXPLORATIONS FOR HERRING

Canadian herring fisheries are all carried on within a few miles of the coastline and no attempt has yet been made to harvest offshore stocks. In recent years USSR vessels have fished for herring on Georges Bank and have landed as much as 160,000 metric tons in a single season (1962). The total Canadian herring catch in 1962 was only 112,000 metric tons. In an attempt to encourage exploitation of offshore herring stocks by Canadians and to learn more of the distribution of these stocks, four exploratory fishing cruises were carried out during July and August 1965 with the chartered vessel Louise P. using a standard No. 41 Yankee trawl with a 1¼" liner.

Most of the tows were made in the Georges Bank area, but in areas other than where the USSR fleet was operating. Some fishing was also done along the 100-fathom contour from Browns to Sable Island Bank. The information sought concerned distribution, abundance and size composition of herring in relation to depth and temperature conditions.

The total catch of herring for the four cruises amounted to 19,248 lb for an average catch of about 100 lb per tow (there were 192 tows altogether). Practically all of this catch was made on Georges Bank during Cruises I and III. The total catch during Cruises II and IV which were carried out east of the Fundian Channel was only 250 lb (77 tows). The most successful fishing was in the vicinity of Corsair Canyon where several tows exceeded 2,300 lb.

Herring were caught in depths ranging from 19 to 200 fm, although more than 90% of the total catch was taken between 30 and 80 fm. Average lengths varied from 28.8 cm to 32.4 cm. Individual lengths varied from 19 cm to 39 cm with an over-all average of 29.7 cm. In depths greater than 55 fm, the fish were slightly larger (30.3 cm) than they were in shallower depths (29.2 cm). The few specimens taken east of the Fundian Channel were smaller than those taken on Georges Bank. Herring were taken in temperatures that ranged from 1.6 to 14.9 C, although most (> 90%) of the catch was made at temperatures between 6.0 and 9.4 C. Mr. R.A. McKenzie was responsible for these exploratory fishing projects and this summary has been extracted from his original report.

S.N. Tibbo

No. CB-8

SWORDFISH FISHERY 1965

The greatly reduced commercial catch of swordfish in 1965 was offset by a substantial increase in the value of the fish. The total catch of 7,831,000 lb (dressed) was only 66% of the 1964 figure, but the total value was down only 8.2% to $3,266,200.

Log book returns, which increased slightly during 1965, showed longlining from the area of Cape Lookout (North Carolina) to the eastern Grand Bank. Data from these records are summarized in the accompanying table with comparable figures from the other two full seasons of longlining since its introduction in 1962, and for 1959--the record year for the traditional harpoon fishery.

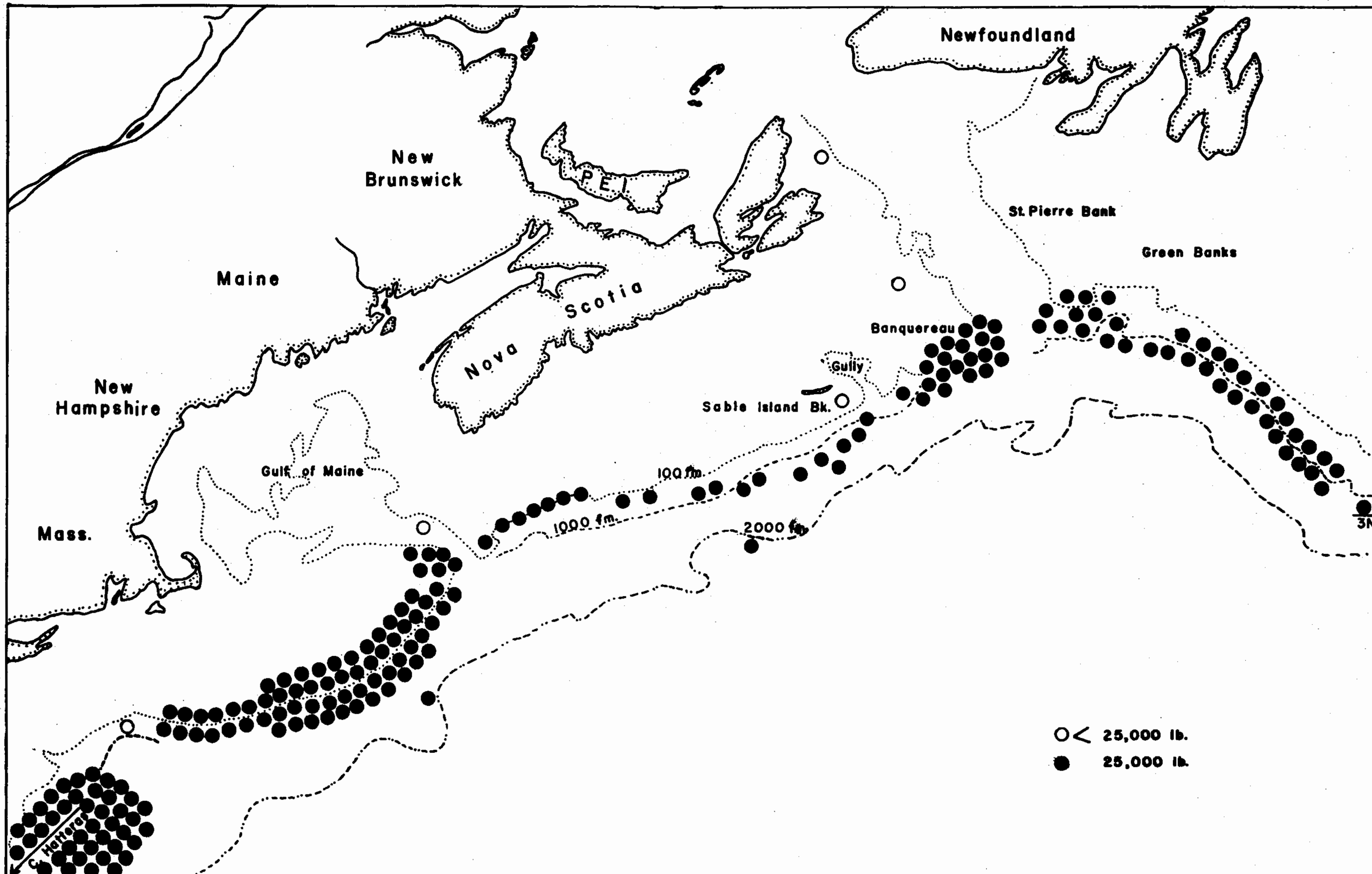


Fig. 1 Distribution of Swordfish Catches, 1965

Summary of swordfish log records 1959 and 1963-65

	1959	1963	1964	1965
Total no. trip records	40	205	329	354
Av. no days at sea per trip	13	10	13	15
Av. no. fishing days per trip	10	7	9	10
Av. no. fish caught per trip	73	121	99	95
Av. wt. individual fish per trip (lb)	200	172	156	143
Av. landing per trip (lb)	14,510	20,827	15,432	13,631
Av. gross stock per trip	3,004	4,290	4,568	5,684

The increase in the non-fishing days spent at sea is due to an increased percentage effort in the more distant parts of the fishery such as the Grand Banks and all Cape Hatteras.

Analysis of the landings by time and area show marked changes from 1964. No landings were made during January 1965 as compared to 51,000 lb in January 1964. The November catch increased by 34% whilst the small landings of February and May were similar in both years. Major decreases occurred during July and August when landings fell 1.07 and 0.94 million lb (38% and 30%) respectively. The landings from Georges Bank and Banquereau fell 25% and 32%, probably correlating with the reduced July and August catch as these have been the main areas fished during these months in the past. By contrast the landings from St. Pierre and the Grand Banks rose by 20%, partly due to displaced effort, and those from the area between Cape Hatteras and Hudson Canyon by 28%. Fishing during November was almost exclusively in the latter area.

The actual catch-per-unit effort (number of fish/100 hooks longline gear) for both Georges Bank and the area to the west was 0.9%, whilst that from the Grand Banks was 0.6%. These figures conceal considerable temporal fluctuations with the catch rates at the better times running about double the average. The highest catch recorded, 68 fish (3.9%), was taken over the Grand Banks in early September. The decline in the catch rate to the east is compensated by an increase in the size of the fish.

Considerable harpooning is still carried out, both by the longliners and by small inshore vessels from Cape Breton. The first fish was boated at the end of May, but significant numbers were not taken from S.W. Georges until early July, and from the eastern part of Georges until early August. The highest recorded one-day catch by harpoon was 20, taken in mid-July near Lydonia Canyon.

J.S. Beckett

No. CB-9

SWORDFISH FOOD AND FEEDING HABITS

Continuing analysis of the contents of swordfish stomachs resulted in 413 being examined in 1965, during five cruises. The contents of the 396 containing food were measured volumetrically and identified, where possible, to the family if not to species.

The food items fall into three categories--bait (found in 61% stomachs), other fish (69%) and squid (55%). All mackerel have been considered as bait since there was always damage consistent with being torn off a hook. There were, however, up to 12 mackerel in any one stomach, whilst one or more odd halves were frequently found. This suggests that swordfish may bite several times without being hooked, whilst the unmatched halves indicate that these baits were probably off the hook before being swallowed. Examination of relatively undigested food-fish for slash marks is inconclusive, some fish have definitely been hit by the sword whilst others are completely free of damage. Size appears to play little part in the frequency of slashing, although long fish may be in several pieces.

The incidence of food-fish ranged between 1 and 1.8 (average 1.25) times that of squid on different cruises, whilst 21% of the stomachs showed no trace of squid. The volumetric ratio of fish to squid in 45 stomachs was 3.5:1. However, an unknown factor is the persistency of the hard parts both as regards resistance to digestion and frequency of evacuation. Squid beaks, but no flesh, were found in an additional 10% of the stomachs, and have been disregarded in the above, whilst the general 'soup' of well-digested fish has been included.

The food-fish reflect the geographical area of capture with bottom fish occurring only in catches near the 100-fathom contour and bathypelagic species forming the bulk of the food elsewhere. Bottom fish such as hake and redfish usually predominate in the stomachs of swordfish taken in water less than 500 fathoms deep. Groundfish, such as flatfish, are occasionally found in large swordfish, indicating that one use of the sword may be to sweep along the bottom, and possibly explaining the numerous notches and general abrasion seen on the swords.

J.S. Beckett

No. CB-10

SWORDFISH SIZE COMPOSITION

Information on the size of swordfish is gathered both from research cruises and from commercial trips. Of 354 log records received during 1965, individual fish weights were available for 72 and in these dressed weights ranged from 9 to 560 lb. As in previous years, average weights varied markedly with area, the smaller fish being to the west and larger fish to the east, some values being 112 lb from the area between Cape Hatteras and Cape Cod, 137 lb from Georges, 187 lb from Banquereau and 192 lb from the Grand Banks.

The over-all average size in 1965 was 143 lb, continuing the approximately 9% decrease that has occurred annually since the introduction of longlining in 1962. Initially the decrease in size was due to exploitation of a wider section of the population than was available to the harpoon fishery when larger females only were taken. This fall in size is seen in most areas, with that for the area between Cape Hatteras and Cape Cod being the most marked (22.4% from 1964) whilst elsewhere the fall was between 2.5 and 12.3%. The figure for Georges (2.5%) is the over-all value of changes ranging between a loss of 21% and an increase of 50%. This latter, and a smaller increase of 16% occurred in the catches from the northeast part of Georges and were apparently due to a stock of large fish in August and September, particularly exploited by harpooners, that were either absent or not harvested during 1964. In the area showing the 50% increase in size, there was virtually no successful, if any, fishing during 1964, and in both areas the number of trips averaging over 180 lb fish increased greatly. Analysis of the size composition of the landings from the more southern parts of Georges shows that whilst the centre of the peak frequency (80 lb) did not change, the peak was sharper than that for the previous year (75-95 lb compared to 50-110 lb) and that the curve falls off more rapidly on the larger side. This is particularly noticeable above 200 lb. The observed changes on Georges can be partly explained if the larger fish moved farther north during 1965. The drastic size reduction in the western zone (west of 70°W longitude), the area fished between late fall and spring, was largely due to unusually heavy landings of very small fish during November and December. One trip of 426 swordfish was reported to have landed 225 fish under 50 lb, whilst another trip of 103 fish contained 59 under 50 lb for an over-all average of 63 lb. This is the lowest trip average recorded in the logs for any year (71 lb was the minimum in 1964). The size frequency at this time showed a strong peak in the 35-45 lb range with heavy representation above 15 lb. These catches appear to have been made in an area of concentration of such small fish since large fish were caught, in contrast to the normal pattern, further off shore during the same months--one trip of 79 fish averaging 225 lb.

Attempts to trace growth or movement of size groups from the size frequency graphs have been unsuccessful, largely because no modes are shown or because each trip contains a different mode that falls into no pattern yet considered. On Georges Bank, a mode around 150 lb is occasionally seen in addition to that at 80 lb.

There is some evidence of a movement of larger fish onto the most easterly edge of Georges Bank in July as the average fish size/trip from a one-degree square increased from a range of 91-144 lb to 123-204 lb, whilst in the adjoining square to the northeast the averages were 129-186 lb, changing to 166-258 lb. Such a movement, which is not seen in weekly average weight tabulations, might be correlated with the increase in fish size on the northeast part of the bank.

J.S. Beckett

No. CB-11

LARGE PELAGIC FISH TAGGING EXPERIMENTS

The 606 fish tagged during 1965 included the first successfully marking of free-swimming fish--a swordfish, a blue shark and a sunfish, being tagged by using a modified light harpoon. This is of particular interest as a potential method for marking "finning" swordfish because the great majority of longline-caught fish are dead on hauling.

The species and numbers tagged, and the dates and localities of marking are summarized below:

Dates	Locality	Swordfish	Bluefin	Skipjack	Tuna	Dolphin	Sunfish	Sharks Blue	Sharks Mackerel	Sharks Others
Feb. 1-28	Cape Hatteras to Caribbean								3	16
May 20-June 3	71-73°W off Virginia	7	4			4			4	
June 7-22	Off New Jersey	3	3							
July 2-16	South Georges	6					1	1	4	
July 8-12	St. Margarets Bay, N.S. (traps)		52							
July 18-Aug.16	Off New Jersey		146	6						
July 21-Aug. 5	Off New Jersey		90		60					
July 26-Aug.16	Grand Banks	4						109		
Sept.25-Oct. 7	South Georges	3	1					64	3	12
	Total	23	296	6	60	4	1	174	14	28

A total of 27 recoveries were received during the year--2 from mackerel sharks and 25 from tuna. One of the mackerel sharks was released the previous October south of Browns Bank and recaptured in June, reportedly 301 miles away well south of the Gulf Stream in an area where no longlining is known. The other shark, released near Veatches Canyon (Georges Bank) in October 1965 was recaptured 30 miles N.E. of Cape Hatteras in December, a distance of 353 miles after 83 days at liberty.

The bluefin tuna tagged in St. Margaret's Bay, all giants over 350 lbs, tended to remain in the same locality, several being retagged in the same trap on later occasions, and two being recaptured nearby within a week of release. The other tuna returns were from fish released from purse seines south of Cape Cod, 5 being 1964 releases and the remaining 18 being bluefin released in 1965. All the recaptures, except one, illustrated the movement of the tuna (bluefin and some skipjack) schools north along the coast of Virginia and New Jersey, from the point where they became available to the seiners off Delaware Bay, to the area of Cholera Bank (some 20 miles S.E. of New York). The schools ceased to be available to the purse seines in mid-August, but several fish were taken up to a month later by other methods. The exception showed a reverse movement from the Cholera Bank, towards the end of the season, and was caught on a trolled line. The greatest distance travelled by a 1965 tagged fish was 110 miles (71 days) and the fastest was 4.2 miles/day (14 days).

The rates of return are high, the 1966 releases recaptured the following year were all from one set (mixed skipjack and bluefin), a return of 12.5%, or 5.7% for the year. The recapture rate of the 1965 releases was 7.6% discounting the mixed skipjack/bluefin release from which there are no recaptures to date.

J.S. Beckett

No. CB-12

DISTRIBUTION OF POST-LARVAL SWORDFISH (*Xiphias gladius* L.) IN RELATION TO WATER MASSES

In February 1965, 47 post-larval swordfish, ranging in length from 1.8 to 11.1 cms, were caught in three general regions of the western North Atlantic: off Cape Hatteras near the southern edge of the Gulf Stream; in Florida Strait along the western edge of the Florida current; and in the northeast part of the Caribbean Sea both east and west of the Virgin Islands.

These young swordfish were caught in waters with a relatively narrow range of temperature and salinity and in areas near a steep horizontal gradient of either temperature or salinity. Temperatures ranged from 23.7 to 25.6 C and salinities from 35.81 to 36.36‰.

Identification of the various water masses that contained swordfish larvae might be expected to provide clues to the location of spawning areas and the means of transport for the young. The water masses in the Virgin Islands area are probably of southern Sargasso Sea origin. Since no swordfish were caught in the western Sargasso Sea, it is probable that those caught in the eastern Caribbean were either produced there or in the southern Sargasso Sea where, unfortunately, no observations were made. In Gulf Stream waters from the Florida Straits to Cape Hatteras there was an apparent drift of swordfish larvae across the current downstream. They were caught on the left-hand side of the stream off Florida and on the right-hand side off Cape Hatteras. The larvae caught off Cape Hatteras were larger than those taken off the coast of Florida and this should be expected if they were of common origin from somewhere in the Gulf of Mexico. The known circulation pattern, however, will not explain the presence of larvae in the northeastern Caribbean that are larger than those in the Florida Strait area. Hence, there are almost certainly two or more spawning areas for swordfish in the western Atlantic, although precise locations still have to be established.

L.M. Lauzier
S.N. Tibbo

No. CB-13

EXPLORATIONS FOR SWORDFISH

The M.V. Beinir was chartered for a cruise to the Grand Banks July 26-August 12 to study the distribution and abundance of swordfish in relation to the environment. The major part of the program involved the use of commercial-style surface longline gear, and the collection of hydrographic data using BTs and Knudsen reversing bottles.

The longlines, set at last light and hauled in the morning, were fished on 10 occasions and caught 42 swordfish (130-600 lb round), 83 blue sharks (90-200 cm fork), 7 common hake and 1 anglerfish. Four swordfish and 109 sharks were tagged and released whilst the remainder were boated--the swordfish for detailed morphometric studies and analysis of both stomach contents and gonad maturity, and the sharks for measurement and sexing. In addition, a Neuston surface plankton net with large mesh was towed at the end of each set, the catches included lanternfish, flyingfish and halfbeaks.

Swordfish were taken in all surface temperatures (13.5-17 C) and over all depths (75-1500 fm) fished. Three main areas were fished, two over water less than 500 fm and one several miles beyond the 1000-fm edge. The first inshore area produced swordfish at between 0.4 and 2.2 fish/100 hooks whilst catch rates in the second were 0.0 to 0.6. Temperatures were similar or a little colder in the second area. The only difference that appeared significant was the water depth, in the more productive area there was rapid fluctuation between 75 and 350 fm, whereas in the other one the bottom was fairly level. This may affect the bottom fauna and hence the food species--largely redfish and hake.

In the outer area, which was selected because of a rapid temperature change (15-16 C) catches of 1.6 and 1.0 fish/ 100 hooks were obtained. These fish were much smaller than inshore where few specimens under 250 lb were taken, and are of interest as the commercial fleet generally only takes large fish from the eastern banks. Part of the fleet subsequently fished this area with substantial success and confirmed the size differences. The depth of the warm water layer appears to be important as the inshore areas had comparable surface temperatures, but were very much colder comparatively close to the surface.

Only 4 of the 38 swordfish examined were male, and these, as is usual, were small, the largest being 240 lb and the others considerably less. Of the sharks examined, 319 were male and 109 were female, there being no discernible size differences. Neither ratio is unusual, although that for swordfish is more normally 3:1, the preponderance of larger fish inshore (3 of 12 were male offshore), however, might explain this.

J.S. Beckett

No. CB-14

TUNA FISHERY AND SIZE COMPOSITION

The decrease of over 50% in the Canadian tuna landings (down from 2.3 to 1.1 million lb) was reflected in both the purse seine (-55%) and assorted (-45%) fisheries. Included in the latter class are the incidental landings of various tunas by the swordfish fleet. Swordfish fishermen retain only part of their tuna catch. However, there is no evidence of any change in the proportion of the catch landed in 1965.

Longline catches of tuna are almost exclusively bluefin and bigeye, but identification is difficult as the fish are landed with the head, tail and fins dressed off. The average size of 412 fish recorded in the log records, at 150 lb, was similar to that of the previous year (148 lb).

Analysis of the dressed weight frequencies for 144 tuna, size range 52-600 lb, caught during April-July inclusive, shows no significant modes or changes with time or area. However, there is no trace of the very strong 40-80 lb (dressed) class seen in May 1964. The catch follows the movement of the swordfish fleet and hence is not a true representation of tuna distribution. The general pattern was for higher catches (largest number recorded for a trip was 28) during the spring and fall off the United States coast south of Cape Cod; smaller catches in the early summer on the southern edge of Georges Bank; and very few fish during the rest of the summer from the Nova Scotia and Newfoundland Banks.

The purse seine fishery started in mid-July, a month later than in the two previous years, off Delaware and, as in 1964, initially exploited bluefin of 74-84 cm fork length (Age Group III). This size class had apparently left the fishery by the end of June in 1964. Similarly the catches during August in '65 were mostly comprised of fish 130-158 cm (Group VI-VII) which were caught only in July the previous year. Skipjack, which formed 42% of the purse seine landings the previous year, were almost completely absent and comprised less than 3% of the total. Those fish that were landed (August), however, were also of a size range (50-60 cm) that were taken earlier in 1964, although in this case only by two weeks.

The general tendency in 1965 was for the apparent waves of tuna to be considerably later than in the previous year. The absence of the small longlined tuna may be an expression of the same delay as the swordfish fleet may have moved north before the tuna arrived off the coast between Virginia and New Jersey. To what extent the observed tardiness was due to the late seasonal warming of the water in this area, is uncertain.

J.S. Beckett

No. CB-15

MACKEREL INVESTIGATION 1965

In May of 1965, a preliminary survey of mackerel was instigated. The general purpose of this survey was to study the biology of the mackerel including size and age composition, food and feeding, spatial and temporal distribution of eggs and larvae, sex and maturity, evidences of migration and a study of meristic characters to attempt a separation of the northern and southern contingents. In the course of the survey, mackerel fishing ports from Yarmouth to Ingonish on the Atlantic coast of Nova Scotia, P.E.I., Magdalen Islands, and the Bay of Chaleur were visited.

Length frequencies were plotted for the individual samples and also bimonthly for the different areas (Gulf of St. Lawrence and Atlantic coast of Nova Scotia). These results showed a definite decrease in size composition of the fish caught on the Atlantic coast of Nova Scotia as the season progressed. Samples obtained in the last week of May from Yarmouth to Lunenburg had a mean length of 364 mm. Mean lengths decreased to 350 mm (June 1 to 15); 346 mm (June 15 to 30); 311 mm (July 1-15) and 270 mm (July 15 to 30). This change in size composition was due to a migration up the coast and into the Gulf of St. Lawrence with the larger fish leading the way. The length-frequency data for the Gulf of St. Lawrence showed that the same size mackerel which appeared off the coast of Nova Scotia in May and early June were found in the Gulf in July.

From an examination of the age and length frequency data, it is apparent that there was a preponderance of age-class IV or 1961 year-class fish. Interviews with fishermen indicated that this year-class had been dominant for the past two years at least.

The gonads of all mackerel sampled on the Atlantic coast of Nova Scotia between May 26 and July 30 were either immature or maturing. Samples from the Gulf of St. Lawrence obtained between July 12 and July 20 contained 24% ripe fish and 72% spent fish. All mackerel sampled at Caraquet in the Bay of Chaleur on August 10 were spent.

The more successful meristic counts made were of the second dorsal fin rays and anal fin rays. The mean second dorsal fin ray count varied from 11.5 to 11.9 and the mean anal fin ray count from 11.7 to 11.8. No comparison has yet been made between these samples and mackerel captured in more southerly regions.

R.D. Humphreys

No. CB-16

PELAGIC FISH RESEARCH IN TROPICAL WATERS

During February 1965, the C.S.S. Hudson, on loan from the Department of Mines and Technical Surveys, was used in the area between Cape Hatteras and the eastern Caribbean Sea to study distribution, size, food and spawning areas for swordfish, tuna and sharks and temperature, salinity and oxygen conditions under which they live.

Fishing with longlines resulted in the capture of seven species of sharks. Forty-one (41) specimens were taken on board and examined in detail for size, body proportions, sex and stomach contents. Nineteen (19) others were tagged and released for studies of migrations. Other longline captures included barracuda (Sphyraena barracuda), amberjack (Seriola dumerili) and snappers (Lutjanus sp.). Only one adult swordfish was captured, but this was of special interest because it was a sexually mature male.

Plankton tows provided a great variety of small fishes. Among these, substantial collections of lanternfishes (Myctophidae), dolphins (Coryphaenidae) and flyingfishes (Exocoetidae) were of special interest either because they are poorly known scientifically or because they constitute important items of food for swordfish and tuna. Another important collection was 95 specimens of larval eels belonging to three families (Anguillidae, Congridae and Muraenidae). The collection of greatest interest, however, was 47 post-larval swordfish ranging in size from 17.9 to 110.6 mm. The captures were concentrated in three general areas: off Cape Hatteras; in the Florida Straits; and in the northeast part of the Caribbean Sea. It may be significant that young swordfish were found only in waters warmer than 74 F.

S.N. Tibbo

No. CB-17

AN OCCURRENCE OF CAPELIN (Mallotus villosus) IN THE BAY OF FUNDY

Sporadic occurrences of capelin in the Bay of Fundy have been recorded since 1850. The last official record, however, was reported by Bigelow and Schroeder as having occurred in May 1915 with capelin being frequently taken in the vicinity of Passamaquoddy Bay from then until March 1919.

Between March 23 and May 12, 1965, more than 80,000 pounds of capelin were caught and landed in the Bay of Fundy. The catches were made in Passamaquoddy Bay and along a short stretch of coast between Deadman's Harbour and Seeley's Cove (a straight line distance of about 10 nautical miles). All of the catches were made in herring weirs.

Samples of capelin for length and age studies were obtained from catches made at Deadman's Harbour on April 12 and at Seeley's Cove on April 20. The mean lengths of the sample from Deadman's Harbour were 14.6 cm for males and 13.5 cm for females. In the sample from Seeley's Cove, the mean length for males was 14.9 cm and for females 14.0 cm. The size range for both samples was from 12.5 to 17.3 cm for males and 12.3 to 15.6 cm for females.

Age determinations using scales and otoliths showed that males ranging in length from 14.0 to 16.5 cm were 2+ years of age (1962 year-class) while those from 12.5 to 13.5 cm were 1+ years old (1963 year-class). Most of the females were 1+ years old (1963 year-class) with a size range of 11.5 to 13.0 cm. The remainder were 2+ years old (1962 year-class) with a size range of 13.5 to 16.0 cm.

Referring to capelin in Newfoundland waters, Templeman noted that during the spawning season there is a partial division of the maturing female schools from the roving schools of males and that the percentage of male capelin spawning on the beaches increases as spawning gets under way.

Capelin captured in Deadman's Harbour on April 12 were approximately 69% males and those sampled in Seeley's Cove on April 20 approximately 75% males. It would appear, therefore, that these fish were partially segregated, as if on a spawning migration.

Normal water temperatures for the first quarter of the year are 4.4 C in the Lurcher Lightship Vessel area and 3.1 C along the N.B. side of the Bay of Fundy. Records at the St. Andrews Station of the Fisheries Research Board show that during the first quarter of 1965 water temperatures were lower than normal by as much as 1.8 C at the Lurcher Lightship and 0.8 C along the N.B. side of the Bay. It may be that the capelin's avoidance of warmer waters prevents its entrance into the Bay of Fundy except during an abnormally cold season.

S.N. Tibbo

No. CC-1

REVIEW OF THE SCALLOP FISHERY

The scallop investigation was seriously reduced in 1965 due to the loss of the investigator in charge who has now been replaced by Dr. J. F. Caddy. During 1965 this Station continued to follow the fishery through collection and compilation of log records. A survey planned for the southern Gulf of St. Lawrence was carried out and information about results was communicated to fishermen and the industry.

Commercial fishery

Sea scallop landings in 1965 reached 19 million lb which is well above the 1964 level and about 90% of the landings came from the offshore fishery. Fishing effort on Georges Bank was distributed widely over the bank with some effort in deeper water where no Canadian fishing had occurred previous to 1964. In June the offshore fleet began fishing grounds off the Virginia coast which had not been fished previously by Canadian vessels. The bottom is smooth and depth is 20-30 fath. Although some problems in keeping scallops were encountered during the warm weather, the fleet continued to fish there until November and catches accounted for 40% of the offshore landings. Apparently these grounds have been known to U.S. fishermen but only sporadically have scallops been abundant enough on them to support a fishery.

Scallop landings from Browns Bank and St. Pierre Bank were less than in 1964 but a few good trips came from Middle Ground. Although some new vessels were added to the scallop fleet, total numbers remained about the same as in 1964 because some vessels converted to other fisheries.

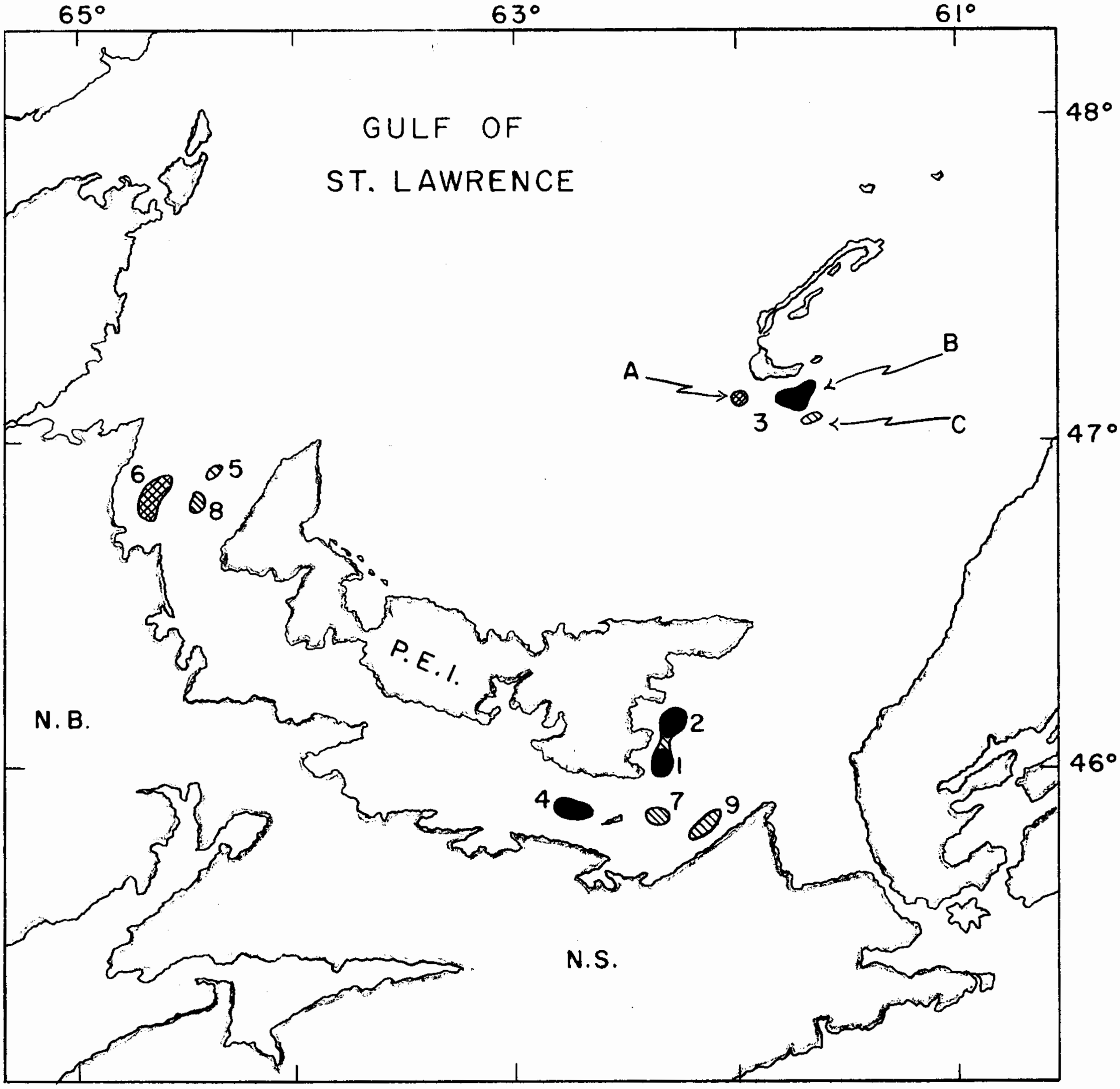
Landings from the inshore scallop fishery increased slightly over the previous year. Fair fishing continued in the Bay of Fundy and good fishing on local beds in the Gulf of St. Lawrence.

Esther I. Lord
F. D. McCracken

No. CC-2

SCALLOP SURVEYS

The main scallop areas in the southern Gulf of St. Lawrence were resurveyed in July 1965. Areas and catches are shown in the accompanying figure. Beds off Cape Bear were judged to have the best possibilities for commercial exploitation. Six exploratory tows here caught



Location of areas in the southern Gulf of St. Lawrence surveyed in 1965: 1. Cape Bear; 2. Boughton Island; 3. Magdalen Islands (Beds A, B and C); 4. Pictou Island (West); 5. Miminegash; 6. Richibucto; 7. Pictou Island (East); 8. Cape Wolfe; 9. Arisaig. The abundance of scallops is indicated by "solid black" denoting areas of commercial quantity, "cross-hatched" for borderline, and "lined" for sub-commercial quantities.

an average of 2.1 bu and all tows yielded more than a bushel. The bed has good fishing bottom. Eight tows were made just north of this on the Boughton Island bed and catches here averaged 1.8 bu and ranged from 0 to 6 bu. Results from the Cape Bear survey aroused fishermen's interest and in late summer a profitable and intensive fishery developed in this general area.

Good populations were again found on small beds off the Magdalen Islands. Bed B averaged 1.6 bu for 11 tows and one catch was 4.5 bu. Bed A catches were slightly less. The meats from here are considerably larger than those from other areas surveyed and a small fishery prospered there this year.

Pictou Island (West) bed averaged 1.6 bu for 10 tows which is considered to be of borderline abundance.

Other areas covered in 1965 were not considered likely to support any commercial fishery for at least another year.

Esther I. Lord
F. D. McCracken

No. CD-1

SWIMMING ENDURANCE OF GROUNDFISHES

Endurance was determined in relation to swimming speed and temperature for cod, *Gadus morhua*, redfish, *Sebastes marinus*, winter flounder, *Pseudopleuronectes americanus*, and to swimming speed at 8 C for longhorn sculpin, *Myoxocephalus octodecimspinosus*, sea raven, *Hemitripterus americanus*, and ocean pout, *Macrozoarces americanus*.

At swimming speeds of 4 body lengths per second (BL/sec) and greater, cod swam for similar periods at 5 and 8 C, and redfish and winter flounder each about equally long at 5, 8, and 11 C. At swimming speeds less than 4 BL/sec, all species swam longer at higher temperatures. At the common test temperature of 8 C, endurance at comparable swimming speeds was greatest for winter flounder, followed by cod, redfish, longhorn sculpin, ocean pout, and sea raven.

F. W. H. Beamish

No. CD-2

FATIGUE IN COD

Cod were exercised in an activity chamber and levels of muscle and blood lactic acid and muscle glycogen used as a measure of fatigue. At comparable swimming speeds between 30 and 90 cm/sec, similar lactic acid and similar glycogen levels were obtained after 15 or 30 min exercise periods. Above 90 cm/sec, lactic acid concentrations were appreciably higher, and glycogen lower, after 30 min exercise.

Following 30 min exercise at 130 cm/sec, lactic acid values (in recently fed cod ?) reached a maximum after 90 min recovery and returned to unexercised levels after 8 hr. For cod starved 48 hr prior to an experiment, peak lactic acid was lower than that for recently fed cod, and was reached after 60 min. Again, lactic acid values subsided to unexercised levels after 8 hr.

F. W. H. Beamish

No. CD-3

FATIGUE AND MORTALITY IN OTTER-TRAWL-CAUGHT HADDOCK

Severe fatigue and sometimes death of haddock followed capture in an otter trawl towed for 30 min at 150 cm/sec. Blood lactic acid was taken as a measure of fatigue. Lactic acid concentration in haddock surviving required about 12 hr to return to unexercised levels. Mortality attributable to fatigue varied from 2 to 77% in different hauls. The difficulty in maintaining haddock in tanks prevented a laboratory study as in cod.

F. W. H. Beamish

No. CD-4

AUDITORY INTENSITY THRESHOLDS OF COD

Perception of sound was measured by conditioned response using heart rate as an indicator. Intensity thresholds, in decibels (db) with reference to one microbar (μ bar) were determined between 17.6 cycles per second, the lowest frequency possible with the transducer available, and 400 cps, beyond which no response could be established. The lowest threshold, -4.9 db, was recorded at 17.6 cps. Between 17.6 and 70.7 cps the threshold increased to +2.0 db and remained about the same at 141 cps. From 141 to 283 cps, the threshold decreased markedly to -4.1 db, but rose to +19.0 db at 400 cps.

F. W. H. Beamish

No. CD-5

ACTIVITY PATTERNS IN REDFISH AND COD

Spontaneous activity of redfish and cod kept under two different photoperiods was measured in the laboratory with a Spoor (1941) type meter. In one case, 16 hr of light was alternated with 8 hr of darkness, and in the other 9 hr of light with 15 hr of darkness. Temperature was 5 C.

Redfish were generally more than twice as active in darkness as in light for both photoperiods. Cod were about equally active during light and dark periods regardless of their duration.

F. W. H. Beamish

No. CD-6

UNDERWATER OBSERVATIONS AHEAD OF AN OTTER TRAWL

Photographic observations on fish behaviour immediately ahead of the footrope of an otter trawl have been made on a number of species by day and by night. The camera is a multisequential 35 mm variety designed to automatically take one photograph every 12 sec. Results have not been thoroughly analysed, particularly for observations made at night. However, by day, there is some suggestion that Atlantic cod, haddock, winter flounder, and plaice swim against the direction of stream but that endurance is probably less than 30 sec at a towing speed of 5 ft/sec.

F. W. H. Beamish

No. CE-1

GROUNDFISH TRAWL PROJECT

During 1965 most of the special instruments required for this study (and described in principle in previous annual reports) were brought to a working level of competence. The prototypes were proven on a #36 Courlene trawl in 12 fath of water off Pictou, N. S. Then, after minor modification, these same instruments were used to obtain data from a #35 Courlene trawl, a #36 Courlene trawl, and a #36 manila trawl in 21 fath of water off Souris, P.E.I., with M.V. Harengus, and from a #41 nylon trawl in 34 fath of water on Sable Island Bank with M.V. Reliance. In all cases, for these basic data, a smooth, level sea floor was chosen, and the nets were operated with normal rigging. Taking these data usually requires long tows which could result in excessively large catches. Therefore, for most of this work, the codend was left open to preclude the possibility of such catches adversely affecting the data or damaging the net.

The recording, hydrostatic, warp tension meters worked reliably and with a minimum of special attention. This time, the cylinders were mounted on the gallows with the chain wrapped around the warp outside the gallows block rather than at a fair-lead bollard on the deck as previously. We believe this new location gives more accurate results by avoiding bearing friction in the blocks. On Reliance, two 25-ft lengths of hydraulic hose were used from each cylinder to its respective recorder to provide damping of vibration, even though these lengths were not required for reach. One of the recorders required repair which we were able to effect in our own shop.

As was expected, the warp tension is more a function of the towing characteristics of the vessel than of the drag characteristics of the net. For example, with the three different trawls towed by Harengus, the warp tensions were very nearly the same for all nets at similar engine r.p.m., the differences in trawl drag being ramified more in differences in towing speed than in differences in warp tension. Therefore, it is essential that towing speeds also be measured accurately whenever warp tension data are expected to have significance in a study of trawl behaviour. Also, a knowledge of ocean currents at the time and place of warp tension and towing speed measurements is a necessary part of the analysis of trawl behaviour.

The records from our warp tension meters show both the distribution of the towing load between the two warps and the magnitude of the total load on both warps to fluctuate appreciably as conditions vary during the course of a tow. The recorders provide a very useful means for following these changes. With the usual, indicating-type tension meters (dynamometers), readings would have to be taken frequently, and vibration of the pointer makes such meters very difficult to read under most towing conditions.

With M.V. Harengus (240 SHP) towing loads rarely exceeded 3,000 lb per warp, and with M.V. Reliance (600 HP) towing loads rarely exceeded 10,000 lb per warp.

The effective piston areas of the warp tension meter cylinders were determined carefully through displacement measurements. The areas of the two special cylinders respectively averaged 10.007 and 10.011 sq in. with cumulative errors possibly as high as 0.063%. These errors are well within the accuracy of the pressure recorders, permitting a direct calibration of the recorders in pounds tension (1,000 psi pressure = 10,000 lb tension). The areas of the standby stock cylinders averaged 11.427 and 11.416 sq in. respectively.

For the Saunders-Roe warp angle meters, which we purchased in 1965, we designed and constructed the necessary circuitry for calibrating the units and for feeding their signals onto our Honeywell, 2-channel, Electronik 17, 10 mvdc recorders. In place of the automobile-type, lead-acid accumulator recommended by Saunders-Roe for the sensor supply voltage, we used a size "D" mercury cell with considerable saving in space and weight and with completely satisfactory service. Under the electrical loads imposed by this equipment the mercury cell can be used as a standard reference voltage, and, even over an 8-hr period, drift caused by changes in cell voltage was well within the accuracy of the equipment.

Three modifications to the Saunders-Roe equipment were required for service under our conditions. The eye to which the main securing line was fastened repeatedly came adrift, particularly on Reliance. The method for securing the equipment has been changed. The air breathers for the telescopic members permitted sea spray to enter the mechanism and cause internal corrosion. These breathers have been replaced by a totally enclosed breathing system which should now exclude sea spray and prevent further corrosion. Originally, the equipment was capable of measuring warp divergences up to 1.2 ft per fathom, which is less than prevails on our vessels on the shallower banks. We modified the equipment to take readings up to 2.0 ft per fathom. Mechanically, the Saunders-Roe equipment measures the warp divergence angle rather than the sine of the angle as represented by the "feet per fathom" scale. However, under our calibration procedure, the scale error at 2 ft per fathom is only 0.34% so that the "feet per fathom" scale has been retained for its greater convenience in the interpretation of results. With occasional, routine-type servicing these units performed satisfactorily.

The Saunders-Roe warp angle meters suffer from two inherent disadvantages for our studies. First, by measuring the angle between the two warps rather than the angles of each warp to the direction of motion, they force us to assume that the geometry of the two warps is symmetrical. In the presence of the ocean currents which prevail on our fishing grounds, this assumption is not valid. Second, because the warp angle sensor must be mounted on both warps at once, this instrument cannot be used on stern trawlers. Therefore, we are continuing with the development of the FRB-NRC warp angle meter.

As described in previous reports, the FRB-NRC warp angle meters work very satisfactorily for measuring the angles of incidence of the warps to the direction of motion, but difficulties have been experienced in measuring the roll angle of the warp/velocity plane from horizontal. The tail assembly, which was intended to provide a vertical, "gravity" reference for this angle, tended to align itself with the support rod during calibration trials in the NRC tow tank. NRC Ship Laboratory staff undertook a development project to correct this defect and supplied two, considerably modified units. After further modification in St. Andrews for greater structural integrity, these units were tried at sea. They produced a satisfactory trace of the angle of incidence, but changes in roll angle are apparently slight and were completely masked by an instrument fluctuation of more than 10 degrees. Either the stability of the unit must be improved, or damping of the roll angle mechanism must be increased. Structural inadequacies of the earlier prototypes have been overcome, but we still have difficulty removing all the sea water from bearings for storage. Further development of this instrument will be required before satisfactory performance is realized, but progress is being made.

The vessel echo sounder proved to be completely adequate for determining the depth of the trawl on level bottom and we are confident that it will be satisfactory for determining trawl depths when working on more irregular sea floors.

So far, we have used the commercial markings for determining the length of warp between the towing block and the doors. Even intermediate lengths have been determined quite readily by additionally taking a few measurements, e.g., gallows separation, on the vessel. However, we expect to have to use our Olympic warp meters during our study of the effect of changes in warp length on trawl behaviour.

The Ott current meter has served very well for measuring the speed of the vessel relative to the water. In replicate measurements the coefficient of variation was less than 1% under good experimental conditions and exceeded 2% only under extremely adverse conditions.

Our normal procedure for taking engineering data from the trawls was to tow under constant conditions for periods of 5 min. By establishing our position at the beginning and end of each 5-min period, our average velocity relative to the sea floor during that period can be calculated. For this, we took readings from the Decca navigator at the beginning and at the end of each test period and, as a check, took distance and azimuth and data from the radar and magnetic bearings from the ship's compass for triangulating our position relative to a moored radar buoy. These data have not been reduced and coordinated with data from the ocean current meters, pitotmeter, and Ott meter so that this procedure cannot be evaluated here. However, all seemed to go well.

Ocean currents at the test site were monitored by two, Braincon, Type 316, histogram current meters, one suspended near the surface below the radar buoy, and the other suspended from the radar buoy mooring line, near the anchor. These units proved to be dependable and relatively easy to service. They take a photographic record, averaging the conditions (direction and speed) of the ocean currents over sequential, 20-min periods. We are having some difficulty establishing precisely to what 20-min period each data record refers, even though times of setting and hauling the meters have been carefully recorded. The first data record is usually a triple image, and it is difficult to determine whether this represents one, two, or three 20-min periods. Also, even with mercury switches to start the meters as they are set, it is difficult to know just when the film advances for the next data record. However, except at the change of tide, the ocean currents change slowly so that we should be able to coordinate these current data satisfactorily with our trawl data.

The battery packs for the underwater instruments, which we built using nickel-cadmium penlight cells, worked exceedingly well. There was no obvious adverse result from the effect of temperature on cell voltage, and we had no difficulty keeping these battery packs in a good state of charge from the ship's batteries, using the special charger we built for this purpose.

Mercury switches were installed in the battery circuits of all the underwater instruments so that the instruments could be switched on automatically as the trawl is set. With them, the instruments can be set up with sufficient leisure to avoid mistakes, recorder chart paper is not wasted while the trawl and instruments are being rigged for setting, and the times of setting and hauling can be marked on the charts with an accuracy of ± 1 min. On one occasion, the setting of the instrumented trawl was delayed by bad weather for 4 days after the instruments had been set and their cases closed, yet, thanks to the mercury switches, a complete set of data was recovered when the tow was finally completed.

The cases for the underwater instruments could be handled with facility. They were easy to open and close, and they gave ready access to the instruments within for setting, calibrating, and checking. There was no evidence of leakage at any place or at any time. However, each unit weighs 15 lb in water. Three extra floats were attached to the headline at each instrument to prevent the headline from being depressed, but this undoubtedly increased the drag on the headline.

The Rustrak recorders presented no problems despite anticipation of charts becoming jammed and pointers becoming misaligned as a result of occasional blows. The half-inch-per-minute chart speed to which the recorders were finally converted is completely adequate for our work, and the one-second chopper bar timing gives a trace which is easy to follow. The unregulated chart drive, whose speed can be set manually by a variable resistor in the battery circuit before each tow, is constant enough for this work and draws about half the current of the regulated chart drive, with correspondingly longer battery life. Some inconvenience resulted from having to open the recorders whenever a note was required on the chart. Therefore, special access doors are being fitted in place of the usual windows to make the charts more readily available for notes. This will make the recorders more subject to damage in the event of flooding, but indications are that this will rarely, if ever, occur. Various possibilities for internally increasing the buoyancy of these units were explored on paper, and we concluded that the best answer is to have the endplates fabricated in epoxy-fibreglass instead of aluminum as at present. The manufacture of these new endplates is being investigated at the present time.

The pitotmeters, for measuring hydrodynamic pressure at the trawl, were calibrated against the Ott current meter over a wider range of speeds than is planned for trawl observations, with the water density measured directly by hydrometer both before and after each calibration run. During subsequent trawl observations one of the pitot tubes became damaged (the only casualty during three cruises at sea on this work) and two spares were obtained. These spare tubes were also calibrated in a similar manner, and the results will be published in a paper on the pitotmeter to be written in 1966. Some non-linearity at the top of the 100 psf range in the static vs recorded pressure relation results from the relatively low load impedance imposed on the pressure transducer by the 0 to 1 milli-amp Rustrak recorder. Correction for this non-linearity can be made quite readily, but it involves an extra step in the reduction of the data. Therefore, we have purchased 0 to 10 micro-amp, taut-band, Rustrak recorders for these instruments. With these recorders, the load impedance on the pressure transducer can be increased two orders of magnitude, assuring a more linear output and, according to the recorder manufacturer, without loss of ruggedness.

The net dimension meters (for measuring wing spread and headline height) were plagued with electronic unreliability of the basic echo sounder units. Of three units, only one performed consistently, so this was fitted to measure wing spread as being the more important dimension for our engineering analysis. The other two units were fitted to measure headline height and the one most likely to produce results at the time was used. In this manner, sporadic headline height data were obtained. Special precautions with these instruments included servicing, modification, and checking on the dock by the electronics technician at this Station before each trip, and the purchase of a portable oscilloscope for servicing these meters at sea.

Just before transferring to Halifax, the electronics technician serviced these echo sounders very carefully, replacing several parts, and the gear research technician rebuilt the control and calibration circuitry with superior components to make doubly sure that the trouble did not lie in our own part of the instruments. At last trial they all gave satisfactory results while measuring the headline height of the 3/4 - 35 trawl from M.B. Mallotus. At present, negotiations are under way with the echo sounder manufacturer for stand-by units of greater reliability than those supplied in the past, with the objective of always having at least two functioning units on board at all times while at sea.

Problems with transducer floats have been worked out very nicely. A cellular mortar, consisting of 4 parts by weight of phenolic micro-balloons to 10 of epoxy resin matrix gave a structurally competent material with specific gravity of 0.45. The floats easily withstood our 600 psi test pressure (equivalent to 400 m depth) and absorbed negligible moisture, even after half an hour at this pressure.

Our streamlined float wings were made of this material in two halves, cemented together, and covered with epoxy-fibreglass for additional protection. For trawl spread measurements, these float wings were secured to aluminum webs, held vertical by lead weights and cellular mortar floats on their lower and upper edges respectively. The floats and their transducers were balanced to have a slightly positive buoyancy so they floated clear of the trawl during setting, and a trim tab was added to each float to provide hydrodynamic lift during towing so the ultrasonic signal could travel between the two transducers over the square of the net. This equipment is relatively easy to handle, during both setting and hauling, and brought back wing spread data, without fail, on every tow.

For headline height measurements, the echo sounder transducer is mounted in two of these float wings. However, in this case, the function of the float wings is to streamline and protect the transducer rather than to provide buoyancy. This unit is secured to the headline of the net and under the square to preclude the presence of netting in the acoustic path. Three meshes of the square have to be cut to let the transducer and float wings through, but these are easily repaired.

The FRB, underwater, cable tension meters worked consistently. As these must be given primary calibration on the test bed in the shop, they were set up prior to each cruise and checked for accuracy on our return. The largest drift during a whole cruise was just over 6% and all other drifts were less than 5%, which is considered adequate for this study. The electric cables between the load cells at the wings and the control/recorder unit on the headline were a bit of a nuisance, but there were no real problems, and operation was reliable.

The underwater load cells we purchased from Saunders-Roe were a bit disappointing. They arrived during our second period at sea, but required servicing, particularly to the batteries, that could not be accomplished on board. However, we put them on the net in the "as received" condition to reveal any other problems, but without any real hope of obtaining useful data at that time. The springs in the "starter" bolts proved to be far too weak for their job, and these are now being replaced by solid bolts. During our last cruise, the instruments provided bridle tension data, but their operation was still far from satisfactory. They are originally equipped with lead-acid "dry accumulators" for the hot stylus, but we found it impossible to avoid corrosive fumes during charging of these batteries, and some spillage of electrolyte occurred in transit to the boat. Further, with the current-limiting resistor supplied on the scribers by Saunders-Roe, the trace with the "hot" stylus was very little better than when the stylus was cold. Therefore, we are dressing the stylus tips so that they give a good trace on lower electric current, and we are replacing the lead-acid accumulators with nickel-cadmium, size "D", 4 ampere-hour, rechargeable cells. Of course, the size of the current-limiting resistor has to be reduced to correct for the lower cell voltage (1.3 for the nickel-cadmium cells as compared with 2.0 for the lead-acid accumulators) but we are able to get 4 to 6 hr of readable trace before recharging. After this experience, we feel very strongly that instrument manufacturers should supply their equipment in "ready to go" condition, particularly if they are late on delivery.

Most of the time since our last period at sea has been required to make the indicated modifications to the instruments. This timing assures that they will be ready for action in 1966 and allows for unexpected delays. As soon as this instrumentation work is complete, we will start the primary reduction of the engineering data we have already obtained from the four styles of commercial trawl mentioned at the beginning of this summary. We plan to combine these data with similar data to be obtained from a Courlene #41 trawl, a Courlene Skagen trawl, and possibly from an Atlantic Western III trawl, to be released without analysis late in 1966.

P. J. G. Carrothers

No. CE-2

MATERIALS STUDIES

During 1965, most of our work on fishing gear materials was related to the deliberations of ISO/TC38/SC9, the Subcommittee on Textile Products for Fishing Nets of the International Standards Organization.

The membership of the Canadian group on SC9 has been increased to 10 with the addition of three representatives of the fishing industry. The presence of these men should help to maintain proper perspective in an organization that tends to be dominated by the textile industry.

There was an international meeting of SC9 at The Hague, Netherlands, in November 1965, during which documents on "Basic Terms and Definitions", and on "Designation of the Fineness of Netting Twines in the Tex System" were brought into the final stages of development.

Also considered were: basic manufacturing terms for knotted netting, commercial designation of knotted netting, designation of taper cuts for shaping machine-made netting, and terms and definitions relative to the hanging of netting on lines. More work has to be done on these subjects before generally acceptable documents evolve, but basic terms of reference for this work have been developed.

The meeting also agreed that the SC9 Secretariat should prepare draft proposals for methods for testing knot strength of twine, extension of twine at knot breakage, mesh sizes in netting, mesh strength of netting, and changes in mesh length on wetting with water. It is proposed that the revived FRB activity in fishing gear materials research will first be directed toward determining what materials properties primarily determine the performance of the materials in fishing gear and how these properties are best measured. Thus, the timing of these projects is very opportune.

During 1965, our participation in SC9 deliberations, through chairmanship of the Canadian group, consisted of: a reportedly well-received, constructive criticism of Documents 39 to 42 inclusive, prepared with the help of written comments submitted by Canadian members on SC9; discussion in Montreal of Documents 43 to 50 inclusive with the Canadian delegate to the SC9 meeting at The Hague; constructive criticism of Documents 51 to 65 inclusive, as an aid to the preparation of the final SC9 recommendations on "Basic Terms and Definitions" and on "Designation of Fineness of Netting Twines in the Tex System". Whereas the subject matter of these deliberations has not yet been developed into final recommendations, space will not be devoted to repeating details here.

P. J. G. Carrothers

FISHERIES OCEANOGRAPHY SUMMARIES

No. D-1

FISHERIES OCEANOGRAPHY

GENERAL SUMMARY

"Knowing the environment and its effects on fish" is one of the four major areas of research conducted by the Fisheries Research Board. The program of this investigation is directed towards the description of the environment and of its variations as they are related to fisheries, and towards the understanding in the processes involved. The effects of the environment on fish is programmed by other investigations.

Three aspects of the ocean environment related to fisheries research were investigated: circulation, properties of water masses and environmental factors in relation to biological studies. Two systems of observations have been maintained: repeated observations in particular areas from fixed points and those carried out either during an oceanographic cruise or simultaneously with biological observations pertaining to a specific fishery.

Circulation

An increased effort was directed to the study of bottom non-tidal drift. In the Bay of Fundy-Gulf of Maine area, releases of sea-bed drifters at six fixed stations were carried out throughout the year. The sea-bed drifter coverage of the Continental Shelf from the Laurentian Channel to the Bay of Fundy has been completed during 1965. Two large scale releases of drift bottles and sea-bed drifters were characteristic of the support given to the study of groundfish eggs and larvae in the southern Gulf of St. Lawrence between May and September. Study of bottom circulation in Northumberland Strait has been extended from the northern sector to the central area where the N.B.-P.E.I. causeway will be constructed.

Analysis of bottom non-tidal drift on the Scotian Shelf and the Gulf of Maine-Bay of Fundy area completed a preliminary study of the bottom circulation over the Continental Shelf area from the southwestern Gulf of St. Lawrence to the Bay of Fundy. Some of the main features of the bottom circulation were: a) continuity of a southerly drift, between 50 and 100 fathoms, from the Magdalen Shallows to the eastern Scotian Shelf, bringing about westward "flooding" of at least the area between the coast and Banquereau; b) a large scale convergence over the eastern Gulf of Maine related to upwelling all along the coast from Cape Sable to St. Mary Bay; and c) a two-way circulation at the entrance of the Bay of Fundy.

In 1965 the surface non-tidal drift in the Bay of Fundy and the northern Gulf of Maine indicated **very little** movement out of the Bay and an off-shore component of the usual coastal drift, along the Maine coast. It is suspected that the Gulf of Maine eddy was smaller in size than usual. The "close" circulation in the Bay of Fundy and the changes in the Gulf of Maine eddy seemed to be associated with the low run-off from rivers along the Atlantic seaboard. In the Gulf of St. Lawrence and Cabot Strait, relative weakening of the circulation in 1965 also seems to be related to the effect of low run-off (high salinity). This weakening of the surface drift as compared to that of previous years is indicated by a relative decrease of the usual northeasterly component north of the Magdalen Islands and also by the decrease of the southerly component of the drift along the Cape Breton side of Cabot Strait. Similarly the usual northerly surface drift along the Newfoundland side of Cabot Strait had somewhat weakened during the same period.

Analysis of 1963 and 1964 drifter data indicate that the predominant surface drift from west to east in the northern Northumberland Strait is associated with a reverse (east to west) drift along the bottom.

Properties of water masses

Analysis of sea water temperatures from coastal stations in 1965 indicates that the surface waters were generally colder than 1964, except around Magdalen Islands. A similar variation in temperature of bottom waters was observed in the Bay of Fundy-eastern Gulf of Maine area. Observations carried out by other agencies along the south-western coast of Nova Scotia also indicate large negative anomalies during the summer. Compilations by the Canadian Oceanographic Services were most useful in delineating the extent of the cold coastal zone. The cooling trend started in the fifties along the Canadian Atlantic coast continued during 1965. The Bay of Fundy temperatures were the lowest since the early forties.

A study of the daily temperature records at St. Andrews showed that the "fixed time" method of sampling introduced complications in estimating day-to-day temperature variations. It is a case of aliasing which originates in the relation of water temperature to tidal phase. However, the twice-monthly and monthly averages based on 30 and 60 observations respectively may be considered as truly representative.

Two surveys over the Magdalen Shallows indicated that the surface salinities in 1965 were generally higher than in the two previous years. It seems then that the 1965 salinities were the highest salinities ever observed in the area during the summer. Out of 150 samples scattered between Gaspé peninsula and Cape Breton, only 4 had a salinity lower than 29.5‰ . An unusually small horizontal gradient of salinity between the mainland and the Magdalen Island was associated with the general level of surface salinities.

Environmental factors

Extensive observations of the physical environment were conducted simultaneously with biological observations during three cruises. During the Caribbean cruise for large pelagic fishes, with C.S.S. Hudson in February, operational information was continuously supplied and valuable data were obtained for the combined analysis of the results. The relationship between the distribution of post-larval swordfish and the water masses provided some preliminary clues to a number of general spawning areas.

During the Gulf of St. Lawrence cruises for groundfish eggs and larvae with C.G.S. A.T. Cameron in June and September, pertinent information was obtained on surface and bottom circulation, properties of water masses and their variations from late spring to late summer.

Miscellaneous

All oceanographic data collected by the various investigations at the Station are processed here. A rigid control of quality is applied to temperature and salinity data as well as BT data before they are coded for submission to C.O.D.C. The new system of processing BT slides by C.O.D.C. brings us another load of routine work. This was previously undertaken by AOG and DM&TS' staff at BIO.

Liaison and co-operation with outside agencies and other investigations is always increasing. The flow of data and information, either one way or both ways, was maintained with: Station de Biologie marine, Grande Rivière; Atlantic Oceanographic Group, Dartmouth; Bedford Institute of Oceanography, Dartmouth; Institute of Oceanography, Dalhousie University; Meteorological Branch; Canadian Oceanographic Services for Defence, Halifax; U.S. Bureau of Commercial Fisheries, Woods Hole and Boothbay Harbor Laboratories; all investigations at the Station in St. Andrews and several firms in the Maritimes, either directly or indirectly.

During the year, the personnel of this investigation participated in four cruises. The balance sheet for 1965 shows: 8 papers published, 3 papers in press and one Original Manuscript.

Acknowledgments

Many of the releases of drift bottles and sea-bed drifters were carried out by the various investigations at the Station. The masters and officers of CPR Princess of Acadia, CNR Bluenose and William Carson, of Sambro and Lurcher Light-vessels have co-operated in the task of daily releases of drift bottles and sea-bed drifters. Oceanographic data have been collected by the various investigations at the Biological Station.

L.M. Lauzier

No. D-2

DRIFTER PROGRAM - 1965

The total effort in the circulation study has increased again in 1965 over previous years. The total number of releases, drift bottles, sea-bed drifters and tubes amounted to 13,790, roughly 2,000 more than in 1964. The total number of recoveries processed during the year, 2,662, exceeds last year's number by 626. The breakdown of releases and recoveries is given in Tables I and II for drift bottles and sea-bed drifters respectively. Not accounted for in the Tables were 798 recoveries in 1965 from previous years' releases.

Main features

The releases of sea-bed drifters at six fixed stations in the Bay of Fundy-Gulf of Maine area were continued throughout 1965. They had been initiated in the summer of 1964. Two large scale releases of both drift bottles and sea-bed drifters were characteristic of the support given to the study of groundfish eggs and larvae in the southern Gulf of St. Lawrence, between May and September 1965. In previous years, only one such large scale release was ever made within a year. Until 1965, the releases of sea-bed drifters on the Scotian Shelf have been concentrated in the central and western sectors from Emerald to Brown's banks. In 1965, a special effort was made to cover the entire Scotian Shelf from Banquereau to Brown's banks and from the coastal regions to the continental slope. It was only an attempt to obtain a sparse coverage, leading to more

Table I. Drifter program, 1965 - Fixed Stations

Area	Stations	Period	Drift bottles: Releases	Drift bottles: Recoveries	Drift bottles: % of Recoveries	Sea-bed drifters: Releases	Sea-bed drifters: Recoveries	Sea-bed drifters: % of Recoveries
Bay of Fundy	Princess of Acadia 1 & 2	Jan-Dec.	1155	257	22.3			
		Jan-Oct.				600	206	34.4
Gulf of Maine	Bluenose 1 & 2, Lurcher L.V.	Jan-Dec.	1980	277	14.0	972	136	14.0
Passamaquoddy	Prince 5	Jan-Dec.	288	87	30.2	288	20	6.9
	Prince 6	Jan-Dec.	288	125	43.4			
Scotian Shelf	Sambro L.V.	Jan-Dec.	618	21	3.4			
Cabot Strait	Carson 1,2&3	Jan-Feb., May-Dec.	1332	71	5.3			
			5661	838	14.8	1860	362	19.4

Table II. Drifter program, 1965 - Cruises

Area	Cruise	Period	Drift bottles: Releases	Drift bottles: Recoveries	Drift bottles: % of Recoveries	Sea-bed drifters: Releases	Sea-bed drifters: Recoveries	Sea-bed drifters: % of Recoveries
Gulf of St.Lawrence	ATC-104	May-June	(528	165	31.3	510	20	3.9
			(380 (1*)	61	15.8			
Gulf of St.Lawrence	ATC-106	Sept.	609	50	8.2	612	16	2.6
Scotian Shelf:								
Eastern Sector	ATC-98	March				168	4	2.4
" "	ATC-99	March				204	7	3.4
Central Sector	ATC-100	March) April)				168	1	0.6
" "	ATC-101	April				120	2	1.7
" "	LP-2	July) August)				192	0	0
Coastal Area	HS-50	April	276	23	8.3	270	20	7.4
Western Sector	LP-4	August				126	1	0.8
Bay of Fundy	HS-51	May	288	88	30.6	102	47	46.0
" " "	ATC-107	Sept.) Oct.)				162	4	2.5
Bay of Fundy-Gulf of Maine and Western Scotian Shelf	HS-52	May	642	97	15.1	642	57	8.9
Northumberland St.	Pan-16	October				270	1	0.4
			2723	484	17.7	3546	180	5.1

(1*) Golf Tubes

concentrated coverage in the future. The effort spent in the Gulf of Maine-Bay of Fundy area was aimed at the study of regions of upwelling mainly along the southwestern coast of Nova Scotia. A network of 106 stations between the entrance of the Bay of Fundy, Georges bank and LaHave bank area was designed for the simultaneous releases of drift bottles and sea-bed drifters. The work in northern Northumberland Strait has been curtailed in 1965. However bottom circulation studies were initiated, during October, in central Northumberland Strait (Borden-Tormentine area).

A.W. Brown
J.G. Clark
L.M. Lauzier

No. D-3

HIGHLIGHTS OF DRIFTER RECOVERIES- 1965

A. Drift bottles

The total number of recoveries in the Bay of Fundy has reached its peak in 1965, from releases made outside the Bay as well as inside. The spring and summer escapement from the Bay of Fundy to the outside waters in 1965 has been the second lowest in the last seven years. The "close" circulation regime during the summer of 1965 is related to the low run-off from the rivers into the Bay of Fundy. In the Passamaquoddy area, the number of recoveries from outside releases was relatively low but the percentage of recoveries from releases within the area was high indicating, in a scale smaller than that of the Bay of Fundy, a "close" circulation regime or less exchange with the outside this year as compared to other years.

The lack of recoveries along New England coast including the Maine coast indicate a strong offshore component of the usual coastal branch of the Gulf of Maine eddy. It is suspected that this eddy was smaller in size than usual and that it had shifted slightly to the east. The number of recoveries along the west coast of Nova Scotia and in St. Mary Bay was relatively high, implying an easterly component stronger than usual for the waters of eastern Gulf of Maine. This may be to a certain point related to the strength, or weakness of the Gulf of Maine eddy.

In the coastal areas of the Scotian Shelf the low percentage of recoveries, the lowest in six years, is indicative of offshore surface movement which has been suspected from the unusually low surface water temperature along at least the western half of Nova Scotia south coast.

The surface circulation in Cabot Strait area showed some peculiarities in 1965, mostly on the Cape Breton side. The usual southerly flow, from spring to autumn, had apparently weakened to the point of leaving room mostly to an easterly and northeasterly flow towards the south coast of Newfoundland. The northerly flow along the Newfoundland side of Cabot Strait had somewhat weakened during the same period.

In the southern Gulf of St. Lawrence, the cyclonic circulation was predominant. The analysis of recoveries of drift bottles, across the Laurentian Channel, implies an easterly component somewhat stronger than in previous years, at the expense of the usual northeasterly component. This seems to be associated with the conditions in Cabot Strait area. Both of these sets of conditions might be related to the weakening of the estuarial type of circulation as reflected in the unusual high surface salinity in the Gulf during the summer of 1965, and to the relative strengthening of wind circulation.

B. Sea-bed drifters

In the lower Bay of Fundy, the inferred bottom circulation in the deeper areas is generally to the northeast (upstream) except in the Grand Manan area. In the shallower areas the main component is generally towards the coast. A small gyre seems to be located over the 50-fathom contour. In the upper Bay of Fundy, from Saint John-Digby line eastward, the general drift is to the east and "up to" the shores. A large number of sea-bed drifter recoveries, and the lack of drift bottle recoveries along the eastern Bay of Fundy shore of New Brunswick indicate a fairly active process of upwelling.

In the eastern Gulf of Maine, the 1965 observations confirm the previous results: a west and northwest drift in the northern segment is separated by a sheer zone or a front from easterly drift in the deeper waters. Over the shallower segment, off western Nova Scotia the drift varies gradually between northeast and southeast, generally converging towards the coast. Finally in the southernmost segment, over Brown's banks and in the gully towards the coast, the bottom drift is mostly north and northwest, approximately the same as the surface drift.

The few recoveries over the Scotian Shelf are pertinent to the western and eastern sectors. The bottom drift in Roseway and LaHave banks area is generally to the west and northwest. In the Banquereau area, the inferred westerly drift is fairly general, it seems to be "fed" by a southerly drift along the Laurentian Channel. There are still three areas of which little is known regarding the bottom drift: Emerald and LaHave Basins (previously called Scotian Gulf), Sable Island Bank, and the coastal regions.

In the Gulf of St. Lawrence, few recoveries indicate a northerly component of the deep waters of the Laurentian Channel. Recoveries along the western 100-fathom contour of the Laurentian Channel are always indicating a southeasterly drift. The bottom drift in the eastern half of Northumberland Strait, between Tormentine and Pictou area is estimated to be between 0.2 and 0.4 mile per day in the east southeast direction.

L.M. Lauzier
A.W. Brown
J.G. Clark

No. D-4

BOTTOM NON-TIDAL DRIFT FROM THE GULF OF ST. LAWRENCE TO THE BAY OF FUNDY

Compilation of over 2,500 sea-bed drifter recoveries from 14,400 releases is used as a basis for a description of bottom circulation over the Continental Shelf from the Gulf of Maine to the Laurentian Channel, including the southwestern Gulf of St. Lawrence. The recovery pattern, in time and in place, and the types of recovery, at sea or along the shores, are characteristic in each of the four areas: Gulf of St. Lawrence, Cabot Strait, Scotian Shelf proper, and Gulf of Maine-Bay of Fundy. Figure 1 is an attempt to represent the inferred drift in these four areas.

In the southwestern Gulf of St. Lawrence the predominant features are: 1) the southerly drift at the entrance of Bay of Chaleurs with branching to the west into the Bay along the Quebec side; 2) an elongated semi-circular drift near the 30-fathom line east of Miscou and Shippigan Island, with a "return" drift along the western and northern edges of Orphan Bank; 3) a southerly drift along the 50 and 100 fathom contours of the western slopes of the Laurentian Channel; and 4) a northeasterly drift along the Cape Breton shores. The circulation around the Magdalen Islands is not well defined even with a convergence area around the southwest tip of the Islands. There are two areas of upwelling in the Gulf, the eastern coast of New Brunswick between the Miramichi and Miscou Island and the New Brunswick side of northern Northumberland Strait.

In the Cabot Strait area, between the Gulf of St. Lawrence and the Scotian Shelf proper, the bottom drift is definitely southerly along the western edge of the Laurentian Channel. This drift, a continuation of the fairly consistent current observed between 50 and 100 fathom contours in the Gulf, has apparently widened and is now covering a greater range of depths. Along the eastern side of the Laurentian Channel, a northerly drift is indicated originating from the deeper waters of the Channel.

On the Scotian Shelf, the coastal drift is known only at the two extremes where there is strong indication of upwelling. These are the northeast corner adjacent to the Cabot Strait area and the southwestern corner adjacent to the Gulf of Maine. The southerly drift out of Cabot Strait and eastern Cape Breton shelf continues as far south as Banquereau, however some of it seems to fan out and to turn to the right in the gully between southern Cape Breton and Misaine Bank. The bottom drift over Banquereau is generally westward while the conditions in the region of Middle Bank and Canso are rather ill-defined. The inferred drift over Emerald Bank is clockwise while the drift over Western Bank is generally easterly or northeasterly. The deeper areas of the Scotian Shelf, between Emerald Bank, LaHave Bank and the coast, have not yielded information on the bottom drift despite the numerous releases. From LaHave Bank to the Gulf of Maine, the bottom drift is generally to the west, with a northerly component in the coastal regions and a southerly component, mostly in the very southern part of Brown's Bank area. There seems to be an area of divergence in the Fundian Channel between Georges Bank and Brown's Bank.

Over the eastern Gulf of Maine from Brown's Bank to the entrance of the Bay of Fundy, the inferred drift seems to be that of a large scale convergence area. The bottom drift, consistently towards the north from most of Brown's Bank to the latitude of Seal Island, gradually veers towards the coast north of Seal Island. This inshore bottom drift is associated with offshore surface drift, bringing about upwelling all along the coast from Cape Sable to St. Mary Bay. In the deep trough penetrating into the Bay of Fundy, an easterly drift into the Bay of Fundy is sharply separated from a westerly drift out of the Bay. This boundary or "front" is given an average position on the chart. On the south side of the front, the easterly drift is relatively wide and unidirectional while on the north side of the front, the westerly drift seems to diverge mostly to the right (towards the coast of Maine). Further to the west in the deep waters of the Gulf of Maine, as the front disappears, this westerly drift seems to diverge even more.

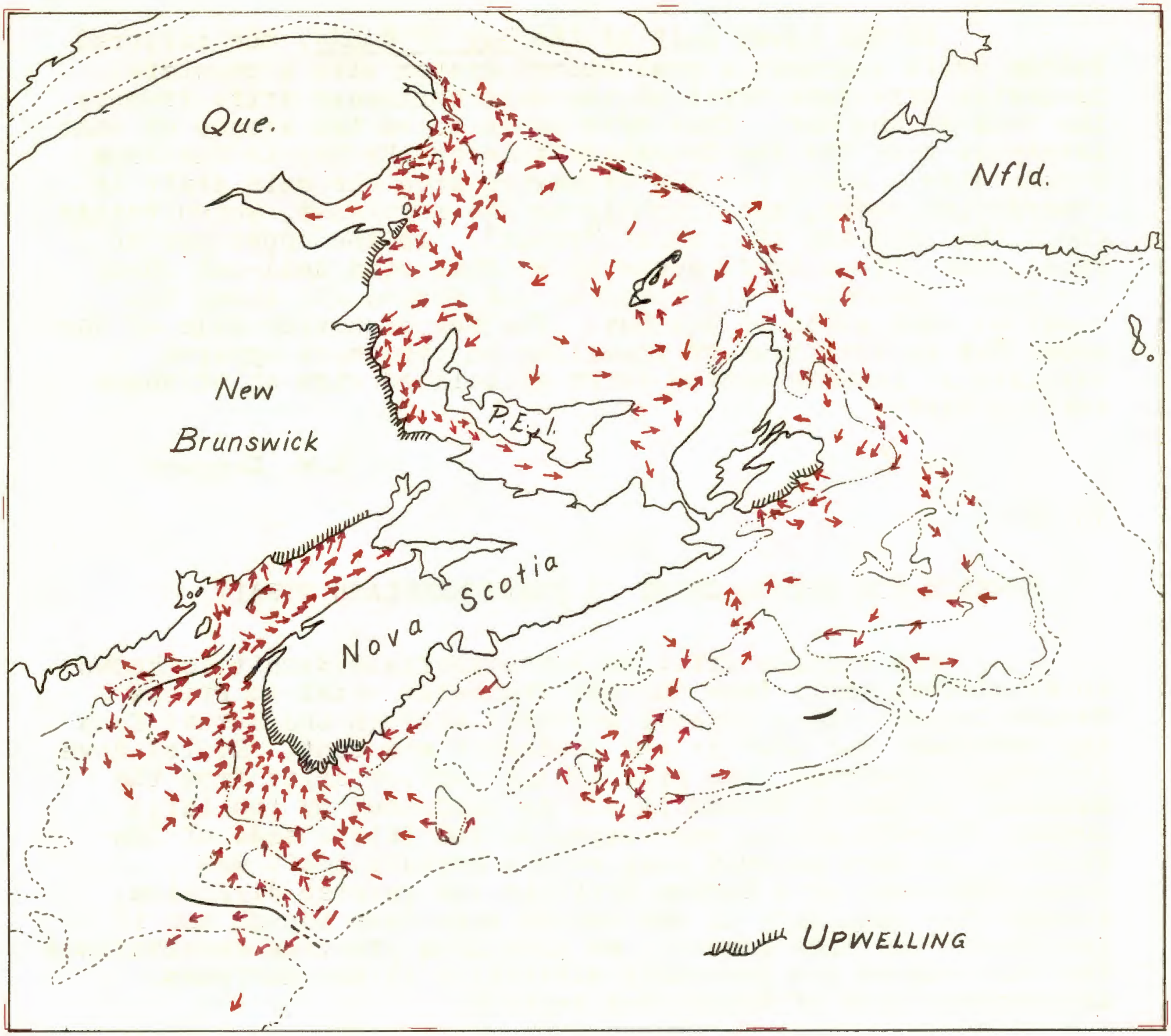


Fig. 1. Bottom drift from the Gulf of St. Lawrence to the Bay of Fundy.

In the lower part of the Bay of Fundy, the inferred bottom drift suggests a semi-closed system with a counter-clockwise gyre just north of the main northeast drift towards the head of the Bay. This gyre seems to be the avenue of some transport from the New Brunswick side of the Bay to the Nova Scotia side. Along the New Brunswick side the main drift is towards the coast, and slightly to the northeast, which brings about the presence of a short "front". In the upper Bay of Fundy, the bottom drift seems to be that of a dead-end where the shore recoveries are numerous and spread all along the coast on both sides of the Bay. The New Brunswick side of the upper Bay is the locus of upwelling in the sense applied earlier, an inshore bottom drift associated with an offshore surface drift.

L.M. Lauzier

No. D-5

SURFACE AND BOTTOM DRIFT IN NORTHUMBERLAND STRAIT

The surface drift in Northumberland Strait is known to be predominantly from the New Brunswick coast to Prince Edward Island with a general movement through the Strait from the northwest and west to the southeast and east. Eddies have also been observed. The predominant surface drift from the mainland to Prince Edward Island is indicated by the large number of drift bottle recoveries on the Island side of the Strait. We have assumed that such a surface drift was counterbalanced by a bottom drift in the reverse direction, towards the mainland, if the waters were deep enough and if the Strait was wide enough. We know from previous observations that the waters are generally stratified in the northern segment and part of Egmont Bay segment.

During 1963 and 1964, over 650 drift bottles and sea-bed drifters were released simultaneously during five cruises in the northern half of Northumberland Strait to verify this assumption of a return bottom drift. The numbers of coastal recoveries by sections are given in Figure 2. The percentage of recoveries is less for sea-bed drifters than for drift bottles, 26.9 and 49.5% respectively. It is interesting to note the concentration of sea-bed drifters near three headlands: Pointe Sapin, Richibucto Head on the New Brunswick side, and West Point on the Prince Edward Island side. The relative deficiency of drift bottle recoveries and the relative abundance of sea-bed drifter recoveries on the New Brunswick side associated with the reverse conditions on the Prince Edward Island side are the basis for the verification of the assumption put forward previously. The predominant surface drift from the west to east is associated with a bottom drift from east to west.

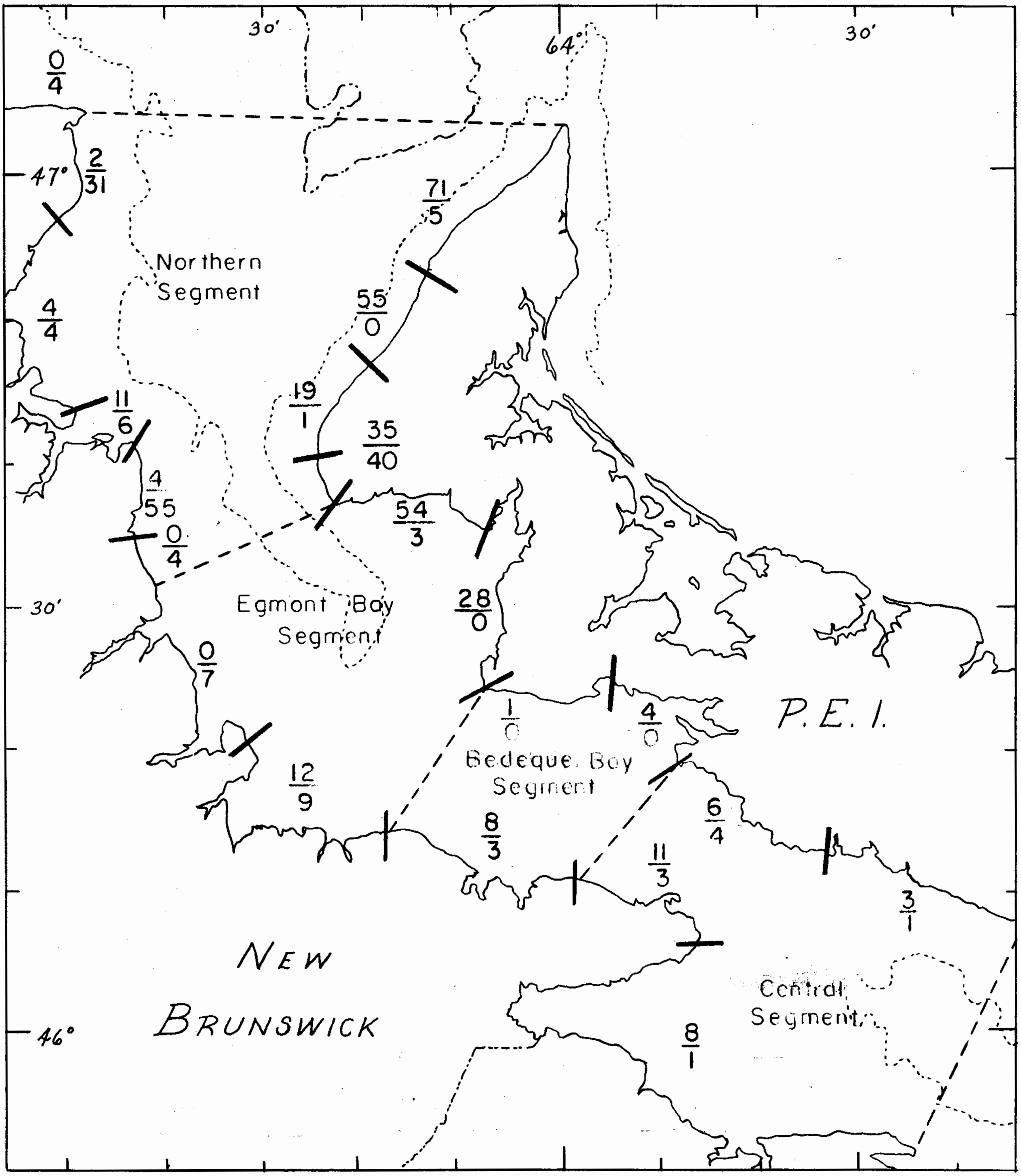


Fig. 2. Distribution of drift bottle and sea-bed drifter recoveries along the shores of northern Northumberland Strait.

$\frac{4}{55}$ means $\frac{\text{4 drift bottles}}{\text{55 sea-bed drifters}}$

This two-layer circulation is most noticeable in the Northern and Egmont Bay segments but almost non apparent in Bedeque and Central segments. The bottles and drifters have been released only in the former two segments. The recoveries of either type, bottles or sea-bed drifters, southeast of Egmont Bay segment indicate the general movement through the Strait with an unexplained predominance on the New Brunswick side.

The speed of the bottom drift seems to be generally one-tenth to one-fifth of the surface drift.

L.M. Lauzier

No. D-6

COMPARISON OF SURFACE DRIFTERS: DRIFT BOTTLES AND PLASTIC TUBES

For the second year, ballasted plastic tubes (86 x 3.3 cm) have been used in the Gulf of St. Lawrence simultaneously with drift bottles. In 1965 the open Gulf was chosen for this experiment and a modification of the tube in the method of ballasting made it easier to prepare and to handle. It is also expected that its longevity has improved.

From 380 drift bottles and tubes released at 63 stations, 118 bottles and 61 tubes have been recovered after seven months at sea. The inferred drift patterns from analysis of the two sets of recoveries are generally the same. However the following are the main differences. The tubes have a stronger tendency to drift further away over longer distances than the drift bottles do. Along the west coast of Newfoundland, the tubes drift further north resulting in a greater proportion of tubes being recovered in the Strait of Belle Isle region as compared to bottles. Similarly, along the south coast of Newfoundland more tubes than bottles are recovered as far east as Placentia Bay. The bottles have a tendency to drift slightly faster than the tubes. Representative figures for the average speeds of drift are: 4 to 7 miles per day for bottles and 4 to 6 miles per day for tubes, depending of the area of drift.

L.M. Lauzier
J.G. Clark

No. D-7

TRENDS OF TEMPERATURES AT ST. ANDREWS

The long-term variations or trends of water temperatures have been represented so far as variations of a moving average, or with similar smoothing processes. In order to show the variability of water temperatures at St. Andrews,

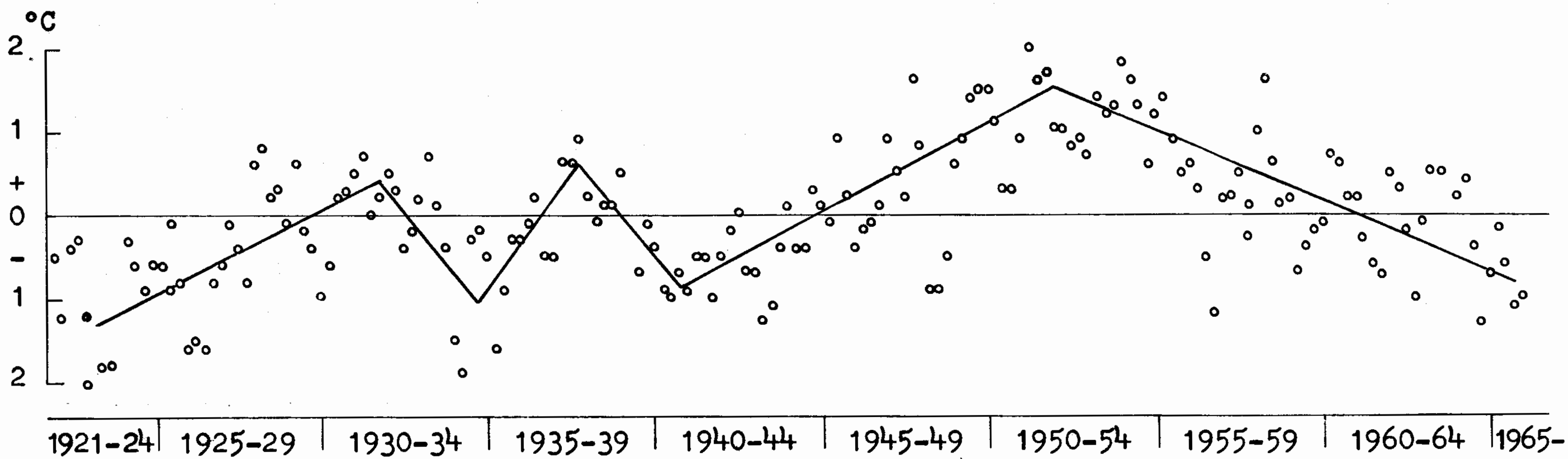


Fig. 3. Quarterly deviations and trends of surface temperatures at St. Andrews, N.B. from 1921 to 1965.

quarterly deviations have been compiled and plotted against time in Figure 3. The maximum range of deviations is 4.7°C. The standard deviation is the highest, 0.98°C, for the first quarter, and lowest, 0.76°C, for the second quarter. The straight lines indicate the warming and cooling trends in the last 45 years. As the result of the cooling trend in the last 13 or 14 years, the marine climatic conditions, in 1965, were similar to those of the early forties.

L.M. Lauzier

No. D-8

SURFACE SALINITY DISTRIBUTION OVER THE MAGDALEN SHALLOWS, 1965

Observations of salinities over the Magdalen Shallows have been made in May-June and in September of 1965 as part of an environmental study of the distribution of groundfish eggs and larvae, and for comparison with salinity conditions of other years. During the last two summers, 1963 and 1964, the salinity distributions indicated a much higher level of surface salinity than usual. Then, waters of relatively low salinity, lower than 28.5‰, occupied a small area as compared to previous years. In late spring 1965, the waters of this same area had salinities between 29.5‰ and 30.0‰. The area between the mainland and the Magdalen Is. especially in the western regions, is subjected to large salinity variations from one year to another. It may also be an area of relatively steep salinity gradient, depending on the occurrence of low salinity waters along New Brunswick and Prince Edward Island coasts. In late summer 1965, the minimum salinities observed near the mainland and Prince Edward Island were all greater than 29.5‰ and the salinities around Magdalen Islands between 30.1‰ and 30.5‰, indicating a small horizontal gradient of surface salinities. This unusually small gradient is associated with the general level of surface salinities, the highest ever observed during the summer.

L.M. Lauzier

No. D-9

MARINE CLIMATE AT GRANDE-RIVIERE (BAY OF CHALEURS)

Temperature variations of surface waters at Grande-Rivière have been studied in order to describe the marine climate of the region and to point out anomalies between 1938 and 1962. Local variations of the climate in various parts of the Gulf of St. Lawrence are indicated and an explanation for such variations is offered. Long-term variations of surface water temperature at Grande-Rivière are compared with those observed at other points along Canada's east coast.

This study, published in the Journal of the Fisheries Research Board, 22(6): 1321-1334, was co-authored by A. Marcotte of the Station de Biologie marine at Grande-Rivière.

L.M. Lauzier

No. D-10

COASTAL SURFACE AND BOTTOM TEMPERATURES - 1965

Twice-daily observations of surface temperature was continued last year at six stations along the Canadian Atlantic coast. Observations at St. Andrews marked the 45th year of a continuous series. Monthly averages are given in Table I.

The temperatures for the year 1965 generally showed a decrease from the 1964 level providing large deviations from long-term averages. Temperatures at St. Andrews and Entry Island showed the least variation from the 1964 temperatures. Most pronounced was the variation in the latter half of the year at Sambro Light-vessel and the annual deviation from long-term averages at both Sambro and Lurcher Light-vessels.

The unusually low temperatures along the south-western coast of Nova Scotia have been well illustrated in the temperature charts issued periodically by the Canadian Oceanographic Services. Temperature data collected during an environmental survey of Albatros IV of the Bureau of Commercial Fisheries, Woods Hole, Mass., are very pertinent. They are indicative of a very cold coastal zone during the first weeks of September near Cape Sable, N.S. We wish to thank Mr. J.B. Colton, Jr. for supplying us with these data.

Lurcher Light-vessel and Prince 5 Station at the entrance to Passamaquoddy Bay again provided monitoring of bottom temperatures. The bottom temperatures at Lurcher Light-vessel showed a slight decrease from the 1964 temperatures with the exception of a short period in the late winter and early spring. Bottom temperatures at Prince 5 Station were generally the lowest observed since the early forties.

L.M. Lauzier
J.H. Hull

Monthly surface water temperatures
along the Canadian Atlantic Coast - 1965

	St. Andrews N.B.	Lurcher L.-V.	Halifax Harbour	Sambro L.-V.	Entry Is. Que.	Port Borden P.E.I.
Jan.	1.1	3.4	1.7	1.5	-	-1.3
Feb.	0.5	2.1	0.1	-0.2	-	-1.3
March	1.2	1.6	0.7	-0.9	-	-1.0
April	3.2	2.7	2.1	-0.1	0.2	0.3
May	6.2	3.6	4.7	2.7	5.0	5.6
June	8.7	5.7	8.8	5.9	9.4	13.7
July	10.9	7.9	10.8	10.0	15.1	17.0
August	12.1	9.1	13.0	9.9	17.2	18.0
Sept.	11.7	8.8	13.2	14.6	13.7	15.5
Oct.	9.5	7.8*	10.3	11.2	8.6	10.4
Nov.	6.4	6.3*	6.1	-	3.2	3.6
Dec.	3.8	5.0*	4.1	4.1	0.3	-0.6

Average monthly temperature variations from 1964 to 1965

	St. Andrews N.B.	Lurcher L.-V.	Halifax Harbour	Sambro L.-V.	Entry Is. Que.	Port Borden P.E.I.
Jan. to June	-0.4	-0.6	-0.4	-0.4	0.0	-0.7
July to Dec.	0.0	-0.7	-0.6	-2.2	+0.1	-0.3
Jan. to Dec.	-0.2	-0.6	-0.5	-1.0	0.0	-0.5

Average monthly temperature deviation from long-term averages

	St. Andrews N.B.	Lurcher L.-V.	Halifax Harbour	Sambro L.-V.	Entry Is. Que.	Port Borden P.E.I.
Jan. to Dec.	-0.7	-2.3	-1.4	-2.8	-0.6	-0.9

* Estimated

No. D-11

SHORT-TERM TEMPERATURE VARIATIONS AT ST. ANDREWS

Daily average surface temperatures at St. Andrews computed from twice daily observations (8:00 am and 4:00 pm) yield an apparent variation which is related, among other factors, to the phase of the tide. This is shown by periods of maxima and minima associated with neap and spring tide periods respectively. The differences between pm and am temperatures also vary similarly. Such variations in temperature usually occur between May and October, being more pronounced in some years than in others.

Our immediate concern was to determine how long a series of daily observations (8:00 am and 4:00 pm) should be in order to minimize the aliasing introduced by our sampling.

Temperature recorders were installed in a cove near the Station, on the bottom (at 5 feet below the lowest low water level) and near the surface. The bottom recorder yielded very good results for the period May 13 to Sept. 9 with few interruptions. The surface recorder went out of commission towards the end of the period damaging all previous records. Twelve daily readings from continuous temperature recordings were used as the basis for computation of "true" average daily temperatures. Discrete or fixed-time samplings, such as 8:00 am and 4:00 pm, were extracted from the records of bottom temperatures to assess the error introduced. The following table gives some of the results.

Periods	No. of series	Difference between "true" averages and fixed-time sampling averages	
		mean	maximum
5 days	12	0.12°C	0.37°C
10 "	6	0.08	0.16
15 "	4	0.06	0.08
30 "	3	0.04	0.07

According to this table monthly and twice monthly averages of fixed time sampling may be considered as truly representative.

Statistical analysis was carried out on previous years data. Assistance from the statistics group of the Station is acknowledged. Harmonic analysis of continuous records of temperatures has been carried out on part of the 1965 data and will be continued in 1966.

L.M. Lauzier
from H.S. Douglass' report

No. D-12

OCEANOGRAPHIC DATA: CONTROL AND PROCESSING

In 1965 data from approximately nine hundred hydrographic stations were coded for submission to Canadian Oceanographic Data Centre for processing. These included some data from cruises taken in 1963 and 1964. An up to date cruise file of hydrographic and BT stations has been maintained.

A total of 845 bathythermograph slides were taken on cruises by vessels operating from this Station during 1965. Prior to July 1st, 1965, BT slides and data were forwarded to the Atlantic Oceanographic Group for final processing. After this date the processing of all BT slides and accompanying data was transferred in its entirety from AOG to CODC in Ottawa.

As a result of this change over, the necessity of acquiring new equipment and the coding of all relevant data, some delay in the processing of BT slides was inevitable. Before any data submitted by investigations at the Station is coded, a rigid control of quality has to be applied. However, the coding and processing of this data is well under way and it is anticipated that subsequent BT slides will be processed as soon as possible after receipt.

During 1965, cruises from the various investigations including Fisheries Oceanography yielded a total of 647 stations and 1,765 salinity samples from these stations were processed here in the laboratory.

J.H. Hull

ANADROMOUS FISH SUMMARIES

No. E-1 INTRODUCTORY STATEMENT

These investigations have continued to be concerned mainly with the maintenance and development of Atlantic salmon and brook trout stocks. They have been concentrated mainly on various aspects of the freshwater life and on physiological studies of some of the problems associated with the transfer from a freshwater to a marine environment.

Transfer of the operations monitoring the effects of the forest-spraying operations on the survival of young salmon in streams from the Board to the Fisheries Department will leave the St. Andrews Station staff more time to concentrate on the basic problems underlying salmon production, and to revert to the policy which prevailed before the serious situation resulting from the widespread use of DDT in forest spraying brought about an emergency change in policy.

A more recent development which may be expected to lead to some change in the research program has been the appearance of a major Atlantic salmon fishery on the coast of Greenland. This, as is shown elsewhere in the present and earlier Annual Reports, is drawing a significant proportion of its catches from Canadian stocks. Lines of investigation which will enable the effects of this fishery to be assessed are now being considered and they are being planned to include high-seas exploratory fishing operations aimed both at plotting the distribution of salmon at sea and at marking fish before they enter the various fisheries. It is hoped that, unlike the situation which arose from the use of DDT, it will be possible to undertake this work without any diversion of effort from projects already under way.

Further consideration has been given to the proposal, which has been under discussion for several years, for the construction in the Maritimes area of an experimental establishment where work can be done requiring more space and greater volumes of water than can be available at the St. Andrews Station, and where relatively large quantities of fish can be handled. Such a facility could be either operated jointly by the Board and the Fisheries Department or by the Board independently. It has now been suggested that it could include not only provision for experimental fish culture operations, but also a laboratory stream installation for use in experimental work on the effect of ecological and behaviour factors on the production of young salmon.

Close liaison with the Resource Development Service of the Fisheries Department has continued during the year. Two full meetings were held of the Program Working Party which had been established to facilitate liaison between the two organizations in the Maritimes and Newfoundland areas; these were in Halifax, N.S., and St. John's, Nfld. In addition, a sectional meeting concerned only with Maritime problems was held in Halifax.

K.R. Allen

No. E-2

SALMON STATISTICS, 1965

Catches in Maritimes area

The generally increasing trend of salmon catches in the Maritimes area which has been apparent in the last few years has continued to be evident in both commercial and angling catches as is shown by the following figures obtained from the Department of Fisheries:

Table I. Commercial and angling catches in the Maritimes area in pounds.

	Commercial catch	Angling catch
1962	1,029,000	211,000
1963	1,010,000	371,500
1964	1,310,000	296,900
1965	1,567,000	325,000

Miramichi River system, New Brunswick

As a background to the detailed studies of the number of fish leaving and returning to the Northwest branch of the Miramichi River, statistics on the commercial and angling catches in the area are of interest.

The commercial catch in Northumberland County contains a high proportion of fish of Miramichi River origin, although earlier work showed that the drift-net catches, which have been high in recent years, also included a high proportion of Restigouche River fish; in the last four years the quantities of fish caught in this fishery, as shown by Fisheries Department returns, have been as shown below:

Table II. Commercial catches in pounds in Northumberland County.

1962	364,000
1963	375,000
1964	627,600
1965	635,900

The large increase in the catch of these fish, which was noted last year, has been sustained at almost the same level.

The angling catch has shown an increase over 1964, but is still less than that of 1963. It should be noted that commercial and angling catches are not strictly comparable since the commercial catch does not include grilse which are, however, dominant in the angling catches.

Table III. Angling catches in the Miramichi River.

	Number of fish	Weight of fish (lb)	Rod-days of fishing	Catch per rod-day	% Grilse
1962	19,784	112,312	49,706	0.4	72
1963	58,182	265,392	57,060	1.2	88
1964	40,352	176,277	62,592	0.6	-
1965	50,328	201,178	62,465	0.8	92

In recent years the run of fish in the Northwest Miramichi has shown a diminishing proportion of large salmon both in the angling catches and at the Curventon trap. This trend continued in 1965 in the angling catch, but at Curventon there was a rise in the proportion of large salmon; this was, however, due to a strong decline in the number of grilse reaching the trap, and the actual number of large salmon taken was also lower than in previous years although the decrease was proportionally less.

Table IV. Catches of grilse and older salmon in the Curventon up-trap in the last four years.

	Grilse	Large salmon
1962	2,285	224
1963	6,088	309
1964	5,127	146
1965	1,689	120

In view of the well sustained catches in the Miramichi system as a whole, the decrease in the numbers of grilse at the Curventon trap appears to be a local effect in the Northwest Miramichi which may well be associated with the effects of pollution from the Tomogonops tributary.

K.R. Allen

No. E-3

GREENLAND SALMON FISHERY

Since 1959 there has been an Atlantic salmon fishery of growing importance along the shore of west Greenland. Prior to 1959, salmon were taken occasionally near several localities between Cape Farewell and Holsteinsborg (60-67°N) but not in sufficient numbers to establish a commercial fishery. The catch of salmon has increased from a modest 13 metric tons in 1959 to over 1400 tons in 1964. Figure 1 shows the trend of the fishery. Although the final figures for 1965 are not yet available, it has been estimated that the catch has amounted to 700 tons which is only about one-half of the catch in 1964. Fishermen are said to be returning their attention to cod which have been the mainstay of Greenland fisheries. Cod were scarce in 1963 and 1964. This scarcity and the high price of salmon led to an increased salmon fishery. Cod were more abundant in 1965 and the price of salmon was reduced. It is not known whether these factors alone accounted for the reduced catch in 1965 or if salmon were less abundant. It is interesting that only in Egedesminde, at the northern end of the fishing area, was the catch higher in 1965 than in 1964 and that larger fish were caught there than in the other districts to the south.

The record catch of 1400 metric tons of salmon in Greenland in 1964 did not appear to have a serious effect on Canadian commercial landings in 1965 (Figure 2). The Greenland catch is known to be composed largely of fish which have spent 1½ years at sea. Such fish would be 2-sea-year salmon the year following. Two-sea-year salmon in Canadian waters usually weigh between 6 and 12 lb and make up a large part of the commercial catch. The catch in New Brunswick is mostly of salmon of 2-sea-years and older since regulations prohibit the landing of fish weighing less than 5 lb. The Newfoundland catch is composed partly of grilse which are unaffected by the Greenland fishery. Therefore, any marked effect of the 1964 Greenland fishery should be evident in the 1965 New Brunswick catch but not necessarily in the Newfoundland catch. Despite any possible effects of the Greenland fishery, 1965 landings for both the New Brunswick and the total Atlantic area were the highest in 10 years. We do not know how much (if any) higher the 1965 landings might have been in the absence of the Greenland fishery.

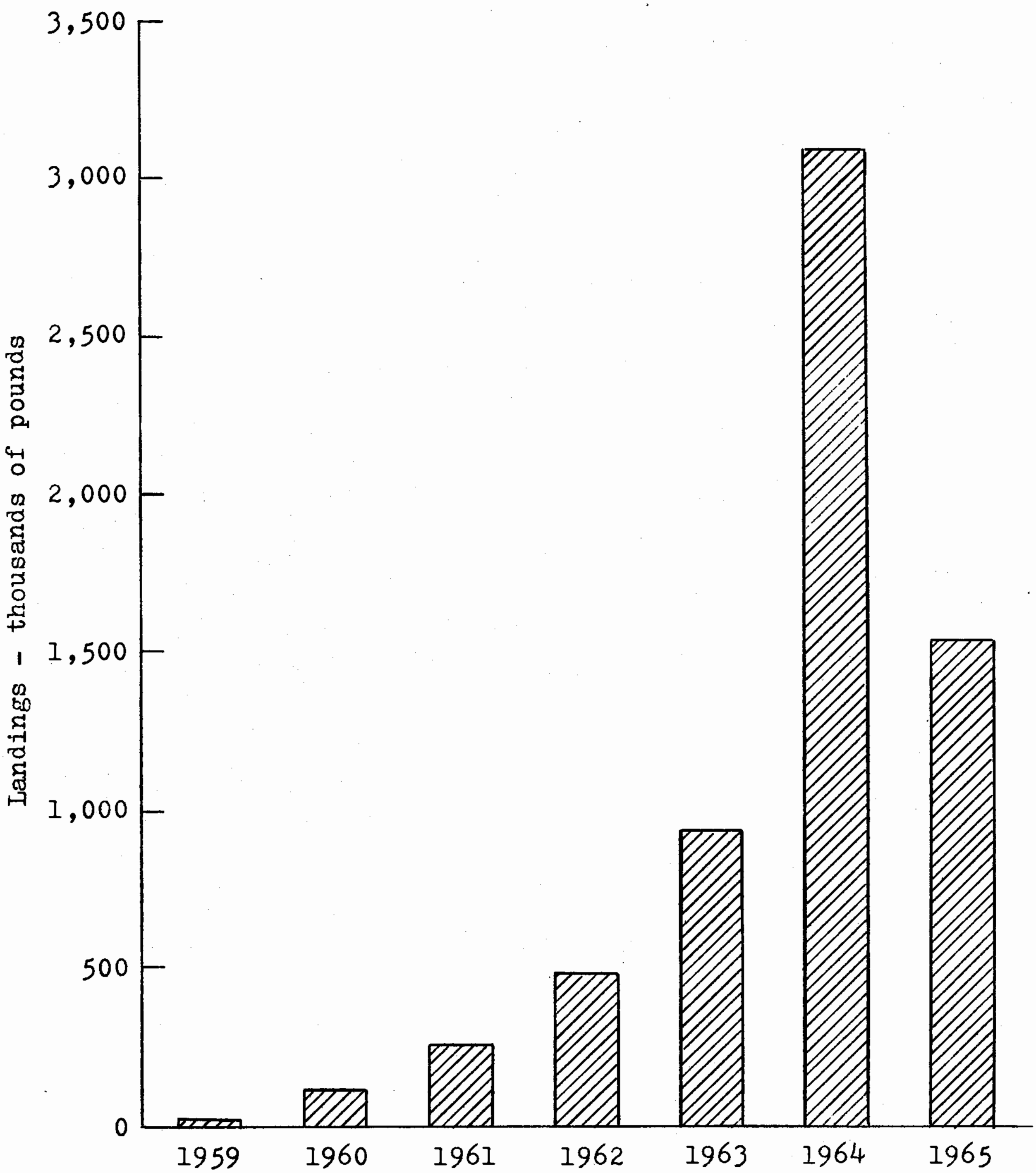


Figure 1. Catches in the Greenland salmon fishery, 1959 to 1965.

Twelve new recaptures of Canadian tagged salmon have been reported from Greenland. The details of tagging and recapture of these are given in Table I. Notice that 3 of these were taken in 1964 and the remainder in 1965. The total number of Canadian tagged salmon taken in Greenland now stands at 32. Two tagged salmon from Maine, U.S.A., and over 50 from Europe (Scotland, England, Ireland and Sweden) have also been taken in Greenland.

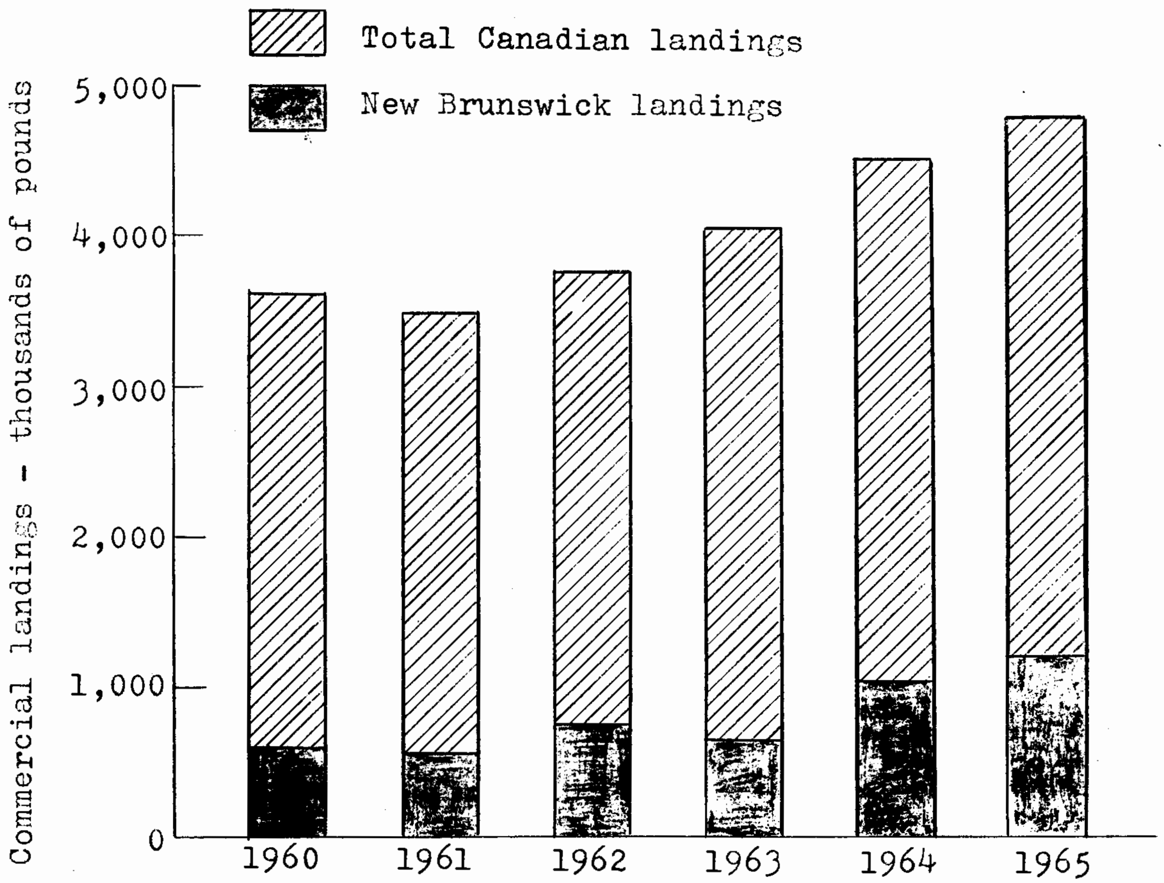


Figure 2. Commercial Atlantic salmon landings in Canada.

The Greenland salmon fishery is now included in the considerations of both the International Council for Exploration of the Sea and International Commission for the Northwest Atlantic Fisheries. A joint ICES/ICNAF working group has been formed with representatives from the various salmon-producing nations. Proposals have been made to learn more about the biology of salmon in Greenland, their origins, size of stock, rates of natural mortality at different times during their sojourn at sea, and degree of exploitation by the fishery.

Table I. Tag returns during 1965 from Canadian salmon caught in the west Greenland fishery.

Tagging data			Recapture data		
Stock origin (parentage, rearing place)*, place released	Stage, length	Date	Place	Length sex	Date
Chaleur Bay stock, Miramichi Hatchery, Northwest Miramichi R.	Smolt –	May 30, 1963	Off Napassoq	67 cm –	Sept.17, 1964
Northwest Miramichi R., New Brunswick	Smolt –	June 6, 1963	Eqalugarssuit, Julianehaab District	68 cm –	Oct.12, 1964
"	Smolt –	June 5, 1963	Off Fiskenaesset	69 cm ♀	Nov.3, 1964
"	Smolt –	May 25, 1964	Off Ravns Storø	– –	Sept.9, 1965
"	Smolt –	May 22, 1964	Off Arsuk	65 cm –	Sept.16, 1965
"	Smolt –	May 23, 1964	Sukkertoppen	65 cm ♂	Sept.18, 1965
"	Smolt –	June 3, 1964	Off Kangâmiut	– –	Oct.–Nov., 1965
"	Smolt –	May 26, 1964	Off Sydprøven	69 cm ♀	Oct.2, 1965
Late-run Miramichi stock, Florenceville Hatchery, Northwest Miramichi R.	Smolt –	May 20-21,1964	Off Qagssimiut, Julianehaab District	65 cm –	Aug.29, 1965
"	Smolt –	May 21-22,1964	Off Frederikshaab	– –	Aug., 1965
Mill River, Prince County, P.E.I.	Smolt –	June 7, 1963	Amerdloq Fjord, near Holsteinsborg	– –	Sept.16, 1965

Table I. (continued)

Tagging data			Recapture data		
Stock origin (parentage, rearing place)*, place released	Stage, length	Date	Place	Length sex	Date
Millbank, Miramichi R. estuary	Salmon 89 cm	Oct.11, 1964	Greenland	91.5 cm -	Sept.-Oct., 1965

*Unless otherwise noted, fish were tagged as naturally-produced smolts or adults.

I made a brief visit during September 1965 to some of the salmon fishing centers in west Greenland. A special report describing these observations has been circulated. I visited Scottish and Danish biologists who were starting a program of tagging adult salmon in the Godthåb district. They tagged 223 salmon. These were taken in a Norwegian kilenot (a trap-net) or in gill-nets. These methods of capture were not entirely satisfactory because many salmon were killed and others badly wounded. It is planned that more tagging be done in 1966 and that Canada and other interested nations participate in this work. One of the main Canadian objectives will be to find the best way of catching salmon in suitable condition for tagging. Longlines with baited hooks are used to catch Pacific salmon for tagging and will be used in our Greenland work to catch feeding Atlantic salmon in good condition for tagging. It is tentatively planned that Canadian biologists attempt to catch and tag salmon on the high seas off west Greenland during late summer and early autumn 1966.

An important new development in the fishery is the start of drift-netting in international waters off Greenland. Two vessels (from Norway and Faeroe Islands) made small catches during August, September and October (up to a ton per day) on the banks off Sukkertoppen and Holsteinsborg. One of the vessels had moderately good fishing in Disko Bay in October. This development may be a potentially greater threat to salmon stocks than the onshore fishery carried out by Greenlanders.

R.L. Saunders

No. E-4

NORTHWEST MIRAMICHI SMOLT RUN - 1965

Daily samples of smolts were taken throughout the 1965 run. The sample amounted to 1000 fish or about 3.7% of the total number counted at Curventon fence. The largest, oldest smolts were taken early in the run. Scales showed no plus growth from May 10 to 18. After June 9 all showed plus growth. Average lengths were lowest during the middle of the run and then increased thereafter. The mean length and weight for the whole sample were 14.6 cm and 21.8 g.

Three-year-olds comprised 87.8%, two-year-olds 11.1% and four-year-olds 1.1% of the sample. The proportion of two-year-olds increased during the run. This age composition is in striking contrast with that in the 1962 smolt-class wherein nearly half were two-year-olds.

The ratio of females to males was about 2 to 1. Over 79% of two-year-olds, 65% of three-year-olds and only 37.5% of four-year-olds were female. The ratio of females to males was greatest during the early part of the run and decreased slightly thereafter. Mean lengths of males and females for the entire sample were nearly identical.

The mean condition factor for all smolt samples was 0.7.

It seems worth while to continue this survey for two or three more seasons to get an idea of any yearly changes in composition of smolt run with respect to size, age, sex ratio, and condition factor. Such data may have some bearing on the success and age at maturity (grilse versus larger salmon) of various smolt-classes.

M.G. Forsythe and
R.L. Saunders

No. E-5

FATE OF PRINCE EDWARD ISLAND SALMON SMOLTS

There is no commercial fishery for Atlantic salmon in Prince Edward Island waters and, with the exception of a few of the larger streams, adults enter fresh water too late in the autumn to provide a sport fishery. However, it is quite possible that Island-reared salmon enter commercial fisheries in other areas of the Canadian Atlantic coast.

A kelt-tagging program (carried out by the Department of Fisheries prior to 1930) at the Morell River, P.E.I., has provided some information on the oceanic movements of adults from Island streams. Morell fish were recaptured along the entire east coast of Newfoundland.

Three recent recaptures of salmon, which had been tagged as smolts at Mill River by FRB personnel, have provided our first information on the fate of Island smolts. The salmon bore Carlin-type tags. One fish, tagged in the spring of 1962, was recaptured at Snug Harbour, Labrador, in early summer 1965;

another, tagged during the spring of 1963, was taken in Amerdloq Fjord, Greenland, September 16, 1965. One was recaptured as a grilse (3 lb ♂) in October 1964 in a cod net off the mouth of Mill River, Cascumpeque Bay, P.E.I. It had been tagged the previous spring.

J.W. Saunders

No. E-6

PLANTING BROOK TROUT AND SALMON PARR IN ESTUARIAL WATERS

Brook trout

Plantings at Ellerslie

To explore a method to compensate for the loss of native Ellerslie trout to the estuary, which occurred after a pond was formed on the brook, and to increase the trout stocks for angling in the Ellerslie system (stream, pond and estuary) as a whole, hatchery-reared trout were planted directly into the estuary. Plantings were made in autumn in four different years (1961-64).

Results

The Ellerslie estuarial plantings are summarized in Table I. Returns from the planted yearlings were good.

Table I. Recaptures of hatchery-reared trout in the season after planting in the Ellerslie estuary.

Date of planting	Stock	Number planted	Number recaptured: Within Ellerslie system	Number recaptured: Outside Ellerslie system	Total returns	% returns
Dec.1, 1961	Finger-lings age 0	1,978	553	Nil	553	28
Dec.4, 1962	Year-lings age 1+	1,973	541	144	685	35
Dec.2, 1963	Finger-lings age 0	2,000	118	Nil	118	6
Nov.23, 1964	Finger-lings age 0	2,000	160	Nil	160	8

Compared to the returns (28%) from the 1961 fingerlings, stocking returns from the 1963 and 1964 plantings were low, 6 and 8% respectively, and appeared to be associated with small runs of fish up the estuary in the springs following the two latter plantings. The small runs were associated with low spring runoff from the brook in 1964 and 1965. However, the returns from the fingerling plantings in 1963 and 1964 compare favourably to returns (2 and 6%) from fingerling plants made into the freshwater parts of the Ellerslie system in the same years.

Plantings at Cains Brook (Mill River)

To evaluate estuarial stocking in an estuary from which trout are free to move into fresh water, autumn plantings of hatchery-reared fingerlings (2,500) were planted in the Cains estuary in 1962. Yearlings (1,000) were planted in 1963 and 1964. In each of the years, similar numbers of trout were planted up in the stream.

Results

It was not possible to mount a creel census on Cains Brook in 1963 until the end of May. Accordingly, no catch records are available for the period (April-May) when the majority of estuarial fish are usually caught. From June to September 2.4% (60 fish) of the estuarial-stocked fingerlings and 3.4% (85 fish) of those planted into the stream were angled.

In 1964 anglers caught 23% of the yearlings that had been planted into the estuary in 1963 - 173 were angled in salt water and 41 in the stream. Anglers caught 20% of the stream-planted fish - 138 were taken in the stream and 55 in salt water.

Of the 967 yearlings that were planted in the Cains estuary in 1964, anglers caught 81 (8.4%) during the next season. As was the case at Ellerslie, there was little spring runoff from the stream to attract fish, either natives or hatchery stock, to the head of the estuary.

The catch from 1,004 stream-planted fish was 164 (16%). It was known, however, that at least 76 fish in the reported catch from the stream stock were taken by poachers a short time after the fish were planted.

Estuarial stocking by other agencies

Resource Development Service, Maritimes area, Canada Department of Fisheries, is now evaluating the estuarial stocking of trout as a management procedure in a number of Atlantic Coast areas, including the Bay of Fundy.

Atlantic salmon

It was known, from observations made at Ellerslie, that salmon parr could winter successfully in an estuary and transform into smolts there in spring. To explore the possibility of increasing salmon production in a system through the introduction of pre-smolts into the estuary, parr were introduced into the estuary of the Northwest Miramichi in November 1964 and into the Margaree estuary in December 1965.

Northwest Miramichi plantings

Approximately 2,000 tagged parr were introduced into the Miramichi estuary - 1,000 were planted about a mile upstream from the Anderson Bridge at Newcastle; the remainder about ½ mile above the Bridge. At the time the tide was high and salinities in the area ranged from 5 to 10‰. The water temperature was approximately 0.5°C; ice covered a good part of the estuary.

The planted parr, young-of-the-year (average length 14.6 cm), were the progeny of early-run Atlantic salmon. They had been raised at Kejimkujik and brought to the Miramichi hatchery in late November for tagging.

Results to date

Five of the planted parr were recaptured in the spring of 1965 - 3 were angled near the planting sites, 1 was taken in the down-trap in the Curventon counting fence, and 1 entered the estuarial trap at Millbank.

Margaree plantings

The parr planted in the Margaree estuary were yearlings that had accomplished most of their growth at the Yarmouth hatchery. They were the progeny of Margaree salmon. The average fork length at planting was 13.1 cm. The parr were divided into two lots for tagging. Tags (Carlin-type) were applied to the fish in one lot after they were anaesthetized (amylene hydrate). Fish in the other lot were tagged while they were restrained in a wooden tagging boot through which water flowed.

The estuary was ice-covered when the fish were planted. At the time the tide was low and only a trace of salt water could be detected.

If the estuarial plants of parr prove successful, then a logical extension of this program would be the introduction of smolts near the mouths of estuaries.

J.W. Saunders

No. E-7

THE IMPORTANCÉ OF APPROPRIATE STOCK FOR PLANTING SMOLTS

Accumulating results from several small plantings of tagged, hatchery-grown smolts point forcefully to the importance of using fish of a kind which will best meet the objective. Some of the factors which have emerged as warranting more study are stock origin, time of planting, and size at planting. The results reported here concern a series of small, comparable plantings made in 1963 and 1964 on the Margaree, Miramichi, and Big Salmon Rivers.

Similar plantings of three groups of 1,000 smolts were made in both the Margaree and Miramichi in 1963 and in the Margaree and Big Salmon respectively in 1964. Points of liberation were about 7 miles above tidehead in the Miramichi and around 20 miles above tide in the other two rivers.

Stocks of three different origins were involved: (1) early-run grilse from the Miramichi, taken no later than July well up in fresh water; (2) late-run salmon (possibly some had spawned in previous years as grilse) taken in the upper Miramichi estuary in October; (3) Bay of Chaleur stock, taken on the Bay of Chaleur coast about 35 miles from the Restigouche River and at one time considered to be an early-run stock of large salmon. All smolts used were reared by the Resource Development Service of the Canada Department of Fisheries. Bay of Chaleur stock was reared in the Miramichi Hatchery; Miramichi stocks were reared in hatcheries on the Saint John River.

Parentage and time of river entry

Table I gives the time, by months, of recapture either well up in fresh water reaches or still in the sea, including tidal parts of estuaries, for each of the three stocks. Returns as 2-sea-year fish of the 1964 plant have still to come. For the early-run stock, more fish were taken in the rivers than in the sea while for the late-run stock, more were caught at sea. Relatively few fish of Chaleur stock were caught either in the rivers or at sea.

Age at maturity in relation to parentage and rivers

Only the 1963 plantings have had the opportunity to return either as grilse or as older salmon. About 90% of the fish of both groups of Miramichi origin were recaptured as grilse, whether their parents were early-run grilse or late-run salmon. Of 9 Bay of Chaleur fish recaptured from the 1963 planting, only 5 were taken as grilse.

Table I. Time of recapture, by months, in fresh water (angling and government counting installations) and in brackish or salt water (commercial and government nets) of tagged hatchery-reared smolts of different stock origin. Numbers liberated given under stocks.

Month of recapture	Early-run 3,980		Late-run 3,983		Bay of Chaleur 3,914	
	river	sea	river	sea	river	sea
May	0	1	0	0	0	0
June	9	13	2	4	0	2
July	57	16	4	11	1	3
August	2	3	4	7	0	2
September	2	1	2	5	0	1
October	0	0	7	0	1	1
Total numbers	70	34	19	27	2	9
% of total recaptures for each stock	67	33	41	59	18	82

Regardless of parentage, recaptures from these 1963 plantings in the Margaree yielded 41 grilse and 8 salmon (85% and 15%), and the similar groups liberated in the Miramichi yielded 95 grilse and 9 salmon (92% and 8%) - considering numbers involved, scarcely an important difference.

Time of liberation and size at liberation

In 1963, all fish were liberated in the last few days of May or the first few days of June, at about the height of natural smolt runs for the rivers. In 1964, liberations were in the last few days of April, a month before smolt runs and with much snow water still running off. Total recaptures as grilse from the 1964 early-spring planting amounted to only 0.3%, but for the 1963 late-spring planting to 2.1%.

Size, i.e., total length, and color are convenient criteria for selecting hatchery-reared young salmon as smolts. The essential smolt characteristics are, however, physiological. Earlier planting experiments have indicated that a high proportion (upwards from 90% of the plant) is likely to migrate downstream only if the fish average 15 cm or more in length by April or May.

Table II summarizes the returns as grilse from the 1963 and 1964 plantings.

Table II. Recaptures as grilse from stock of different origin compared with size at planting.

	No.	Size at planting: Mean length	Size at planting: S.D.	Number of recaptures: 1963 Late May	Number of recaptures: 1964 Late April
Early-run	1990	15.0	2.6	80	-
	1990	17.7	3.2	-	16
Late-run	1992	19.8	2.7	42	-
	1991	11.2	0.6	-	0
Chaleur	1926	14.3	1.0	3	-
	1988	12.9	0.6	-	2

Returns from the early-run stock show a lower production of grilse from the late-April planting than from the late-May planting. If this indicates a lower survival rate from the early-spring planting, it is in line with previous findings on success of smolt migration in relation to time of liberation. It could also have resulted from less favourable conditions at sea for the 1964 planting, although the good general run of grilse in 1965 does not point strongly to such an explanation.

The complete lack of returns as grilse from the 1964 late-run stock could also reflect poor survival at sea. It seems more likely, again on the basis of previous findings for hatchery stock, that it may be closely linked with small size at liberation. Among wild fish in the Maritime region, hardly any smolts as small as these fish have been recorded. These data seem to further support the existence of a critical size for successful smolt migration.

The Chaleur fish produced few grilse from either planting. While in both years they were of relatively small size, the difference between Chaleur and early-run stock liberated in 1963 seems insufficient to account for the great difference in relative returns. Possibly the Chaleur stock had some additional characteristic which contributed to their low rate of recapture as grilse.

Conclusions

The results reported here thus seem to support some of the conclusions reached on earlier data regarding factors affecting the efficient utilization of hatchery smolts. At least some of them also have connotations for management of natural production. With present data they can only be presented as very tentative conclusions.

Time of entry into rivers appears to have genetic as well as environmental components. Management for best utilization may require both early and late stocks for both angling and commercial use.

Some stocks may be more prone to develop as grilse than others, but there may be a vague suggestion also of a component here that is associated with specific rivers or the environment which their smolts meet at sea (as suggested by Huntsman and White for Apple River).

The time of liberation of hatchery smolts should be as close to the time of natural peak smolt run in the river of liberation as is commensurate with time requirements for implanting required homing tendencies.

Size at liberation should be at least 15 cm total length when liberation is near the time specified above.

P.F. Elson

No. E-8

GROWTH OF SALMON SMOLTS IN RELATION TO SALINITY

This is a continuation of a growth study of salmon smolts started in June 1964. A report of the work to January 1965 is given in Original Manuscript No. 1005 of the Biological Station, St. Andrews. A description of experimental methods is given there. In general, the work was carried on in the same way this year.

A preliminary finding in 1964 was that inclusion of herring in the diet is detrimental to salmon. After several months on a herring-rich diet, fish lost equilibrium; many eventually died. This condition is believed to be owing to a high content of thiaminase (which breaks down vitamin B_1) in herring. The diet was changed accordingly in 1965 but provision was made to gather more information about the supposed ill effects of a herring diet. Accordingly, two groups were held at the same salinity and one group was fed on a mixture of liver (42.5%, by weight), herring (42.5%) and Purina trout chow (15%). This was the same diet used in 1964. Four other groups were fed a mixture of liver (42.5%), cod fillets (42.5%) and trout chow (15%).

Water temperatures varied seasonally but at any time were the same for all experimental groups. The salt water, being colder, was heated so that the temperature corresponded to that of the fresh. The summer of 1965 was unusually hot and dry and water temperatures were about 2° above the 1964 level for the three months - July, August and September. This, as shown below by a comparison of growth and temperature, was an important factor.

Smolts used in this year's experiment were supplied by the Saint John Fish Culture Station. Stock origin was late-run Miramichi (Curventon), hatched in May 1963. The experiment began on April 1 and smoltification was still in progress during the first two and part of the third months. Growth during this period was comparable in all groups with no advantage apparent in any one salinity.

Results and discussion

Six groups of smolts used in this year's experiment were measured for the first time on April 1. Salinity levels were full salt (30-32‰), 22‰, 15‰, 7‰, and fresh water. Temperatures rose from 4°C in April to a maximum of 18°C in August and dropped to 7°C by December 7 when the experiment was terminated.

The fish were measured five times from April 1 to July 8. All groups showed similar growth for this period with no advantage apparent in any particular salinity. Between July 8 and August 12, a pattern emerged which held for the duration of the experiment. The freshwater fish took the lead and held it until the terminal date, December 7. The other groups followed in order of increasing salinity; the smallest group being those in full salt water.

The accelerated rate of growth of the fish in fresh water and decreased rate in full salt coincided with high water temperatures. Relative growth rates calculated for the fresh and full salt groups show that (a) they were the same from April to July 8; (b) that the freshwater fish grew faster than the full salt group from July 8 to September 23; (c) that the full salt group grew faster than the freshwater group from September 23 to November 10.

The period of rapid growth of freshwater fish and slow growth of full salt fish coincides with the highest temperatures of the year. Temperatures were above 16°C for 59 days from July 12 to September 9. For 17 days of this period, they were 18°C. Thus it appears that the optimum temperature for salmon smolts in sea water is a few degrees below that for smolts in fresh water.

A comparison of food consumption of the full salt fish with temperature shows that consumption dropped when temperatures went above 15°C, was at its lowest at 18°C, and began to increase when temperatures dropped below 16°C.

It is apparent that the food consumption of the freshwater fish also dropped when the temperature rose above 17°C. Here, though, the drop was less pronounced and lasted for a shorter period.

Prior to and following this period, food consumption was close to the same in both groups with the salt group taking a slight lead with falling temperatures in the fall.

Although low oxygen levels (4-5 p.p.m.) may have suppressed growth at these levels, it appears to be less important than temperature. As soon as temperatures began to decrease, food consumption and growth increased while oxygen levels stayed low beyond this period. It is concluded that the growth of salmon smolts is not greatly affected by oxygen levels as low as 4-5 p.p.m.

As stated above, one group of fish, salinity 7‰, were fed on the liver, herring and Purina trout chow and in all other groups cod was substituted for the herring. Growth of the herring-fed group was very good, equalling or exceeding that of all other groups, for most of the period, April through September. However, it became obvious in early October that they were being adversely affected by the herring. The first sign of the 'sickness' is loss of balance and swimming ability of the fish. They first become very wobbly, swimming partly tipped over on their sides and eventually are seen lying on their sides on the bottom of the tank. Death is not sudden, usually taking several weeks.

The groups on the cod, liver and meal mixture remained healthy throughout the 8-month period, April 1 to December 7.

E.B. Henderson and
R.L. Saunders

No. E-9

OSMOTIC CONCENTRATIONS OF SALMON BLOOD

Freezing point depressions (Δ's) of blood plasma were determined for post-smolt salmon acclimated at various salinities and in fresh water. It is planned that these measurements be used to determine whether or not fish in various salinities are in osmotic balance. Figure 1 summarizes some preliminary observations made for fish held at salinities of 7, 15, 22 and 31‰ and in fresh water. The Δ values for salmon fed a mixture of ground liver, cod fillets and Purina trout chow were from -0.77 to -0.90°C with means from -0.80 to -0.83°C. The Δ values for a group of salmon fed ground herring in place of cod in the diet mixture were from -0.70 to -0.78°C (mean -0.74°C). It appears that diet can have a marked effect on the osmoregulatory abilities of post-smolt salmon.

The Δ values in the literature for Atlantic salmon of various sizes and stages of development are lower than those

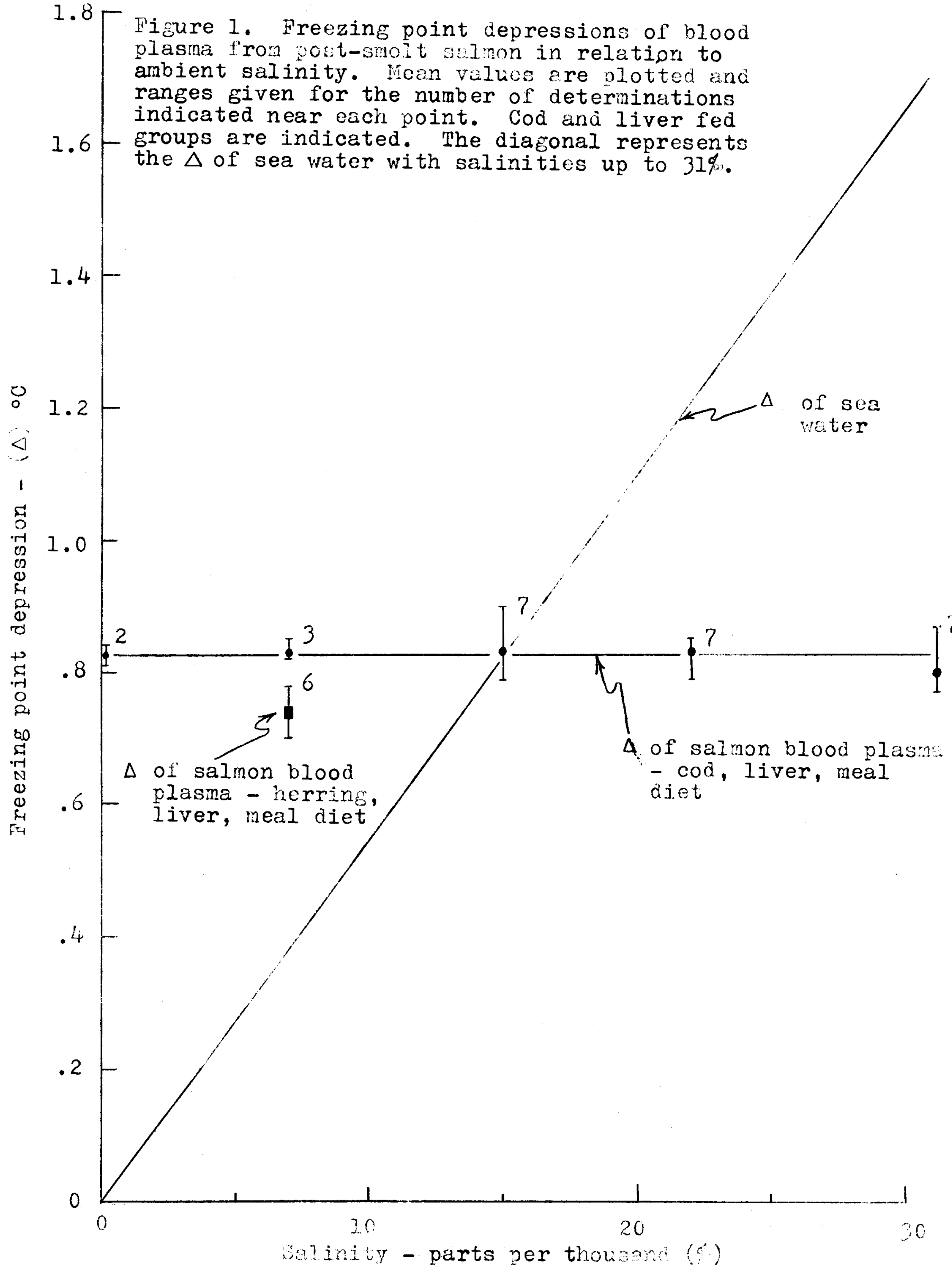


Figure 1. Freezing point depressions of blood plasma from post-smolt salmon in relation to ambient salinity. Mean values are plotted and ranges given for the number of determinations indicated near each point. Cod and liver fed groups are indicated. The diagonal represents the Δ of sea water with salinities up to 31‰.

found by us. They are: -0.59°C for alevins; -0.61°C for parr; -0.58°C to -0.65°C in smolts; -0.77°C in adults in dilute sea water (15‰) and -0.65°C for adults in fresh water. It is interesting that the present results are higher than those in the literature and that Δ values of cod-fed salmon are about the same at ambient salinities from 0 to 31‰.

In view of the apparent effect of diet on the osmotic concentration of the blood, these findings should be followed up because of the important implications for fish cultural practices.

R.L. Saunders and
J.M. Byrne

No. E-10

SOME EFFECTS OF REARING SALMON FRY IN DILUTE SALT WATER

In a preliminary experiment in 1964 it was found that salmon fry which had recently absorbed their yolk sacs tolerated salinities as high as 12‰ and grew slightly faster in dilute salt than in fresh water. Moreover, there appeared to be some benefit of salt water (even as low as 2‰) in preventing accumulation of fungus which was apparently the cause of many deaths of fry in fresh water.

A similar experiment was done in 1965 to consolidate the preliminary findings and to find out if salinity influences the known harmful effect of a diet rich in herring. Two groups of 300 salmon fry were held in each of the following conditions: fresh water, 6‰ salinity and 12‰ salinity. Up to July 6, during which time all fish had been held in fresh water, the mortality reached 45%. At this time the fish had been feeding three weeks. Salinities were increased to the levels indicated on July 6. Between this date and August 17, there was a significantly lower mortality in the four saltwater groups than in the two freshwater groups. These were as follows: fresh water, 56.9 and 60.0%; 6‰, 27.0 and 19.6%; 12‰, 25.1 and 28.3%. It is indicated that low levels of salinity have a therapeutic effect in reducing mortality in salmon fry during the first two months of active feeding, a time during which many small fish usually die in hatcheries.

The surviving fry were used for a study of growth with two different diets in relation to salinity between August 18 and November 24. Six groups of 100 fry each were used in two series. Each series consisted of groups of fish in salt water of 6 and 12‰ and a third group in fresh water. The diet of one series was ground liver only; the other series received a mixture of ground liver and herring. The fish were individually weighed and measured at the start and monthly thereafter.

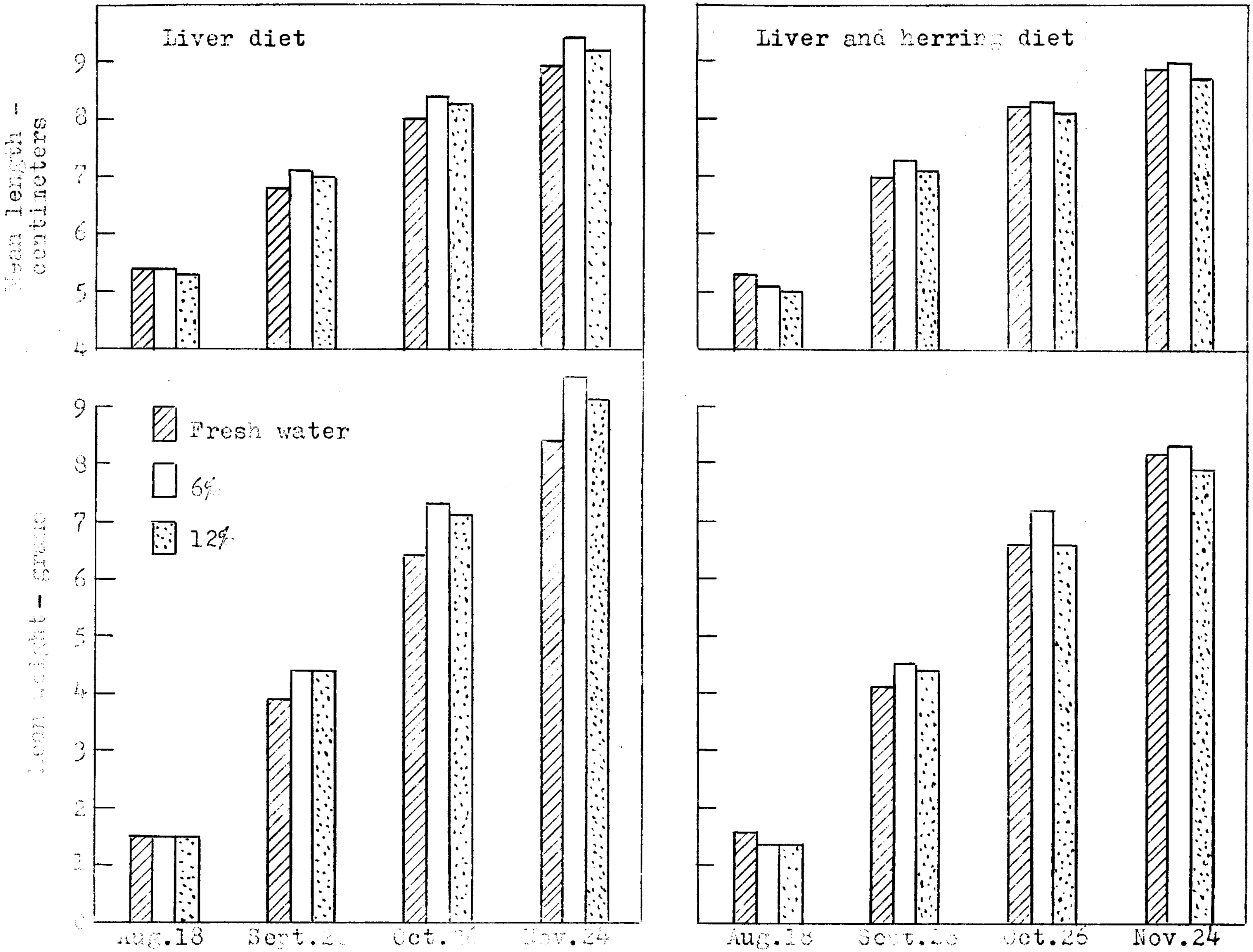


Figure 1. Growth of salmon fry at different salinities and on two diets.

Figure 1 shows the mean weights and lengths of each group of fry at four times during the experiment. Considering first the liver-fed series, the saltwater groups are larger, both longer and heavier from September 28 onward. However, statistical tests show that the differences are only significant between the freshwater and 6‰ groups. A comparison of weights and lengths of these two groups for November 24 shows them to be different at the p = .01 level. Differences between weights and lengths of 6‰ and 12‰ and between 12‰ and freshwater groups failed to reach the 0.05 level of significance. The growth of fry in the herring-fed series was comparable in length and weight to that in the liver-fed series until late October. Between late October and late November there was a smaller increase in weight in the herring-fed series than in the liver-fed series. Between November 1 and January 12 there were many deaths in the herring-fed series. There was not a single mortality in the liver-fed series between August 18 and January 12. The lower rate of growth in the herring-fed series between October 26 and November 24 probably reflects a moribund condition in many fish. It is known that herring is rich in thiaminase, an enzyme which destroys vitamin B_1 or thiamin. It appears that salt water aggravates the harmful effect of the herring diet. To date, the rate of mortality is higher in the saltwater groups than in the freshwater group. It is possible that the shortage of thiamin may increase the susceptibility of the fish to the osmoregulatory imbalance when in salt water and so produces a high mortality rate.

R.L. Saunders and
E.B. Henderson

No. E-11

DEVELOPMENT OF PRACTICAL MERGANSER CONTROL

Experimental control of mergansers on the Margaree River is designed to provide protection to five successive annual smolt runs over the last two years of pre-smolt life. Control started in August 1962. The 1964 smolt run was the first to receive approximately this amount of protection. While population densities and survival rates of Margaree young salmon are receiving study, the final criterion of success or failure as a management procedure will hinge on the identification of commensurate increases in associated fisheries. Most Margaree salmon go to sea as 3-year-olds and return after two or three years at sea, so 1971 catches will terminate this experiment.

Residual predation

The immediate objective of control operations is to restrict merganser activity on the system to a level between about 5000 and 7000 duck-days per year. Development of a working measurement to express residual predation is more complex for a system requiring several days for complete patrol coverage than for an area that can be patrolled in a single day. Treatment of data brought in by Margaree patrols is still under study. One simple measurement is the average number of birds (1) seen but not killed in the preceding week, and of (2) birds seen in the current week. Multiplying this average figure by the number of days in the second period gives a value for residual predation. Such measurements for the period of merganser control on the Margaree are diagrammed in Figure 1.

Another method of deriving a duck-day value for residual predation is to treat each section of the river separately and in relation to successive patrols on that section. While possibly yielding a more accurate figure for scientific evaluation, this method is more cumbersome than the first. It does yield a lower value and may be more accurate for investigational purposes, whereas the first seems more adaptable as a tool for assisting field personnel to do their job effectively. A comparison of the two different measures as worked out by field personnel on the one hand and by Canadian Wildlife Service on the other is given in Table I.

Table I. Residual predation by mergansers, in duck-days, on the Margaree River system as calculated (1) on a weekly* basis by field crews and (2) on a day-to-day basis by the Canadian Wildlife Service.

Year	(1) Weekly basis	(2) Day-to-day basis
1962 (Sept.-Dec.)	3036	2195
1963	5082	3900
1964	4108	3090
1965	4407	1975 (to Nov.30)

*Separate computations were made for each part of a week in which a month ended.

Either method involves some not easily checked assumptions about behaviour of the birds. For use as an operational tool, a fairly simple method which can be calibrated against a more accurate, even if more complex, system may have advantages.

By either of the above methods, residual predation has been below the 5000-7000 duck-days believed necessary to achieve full practical benefits from control.

The incidence of mergansers on the Margaree may be decreasing somewhat as local breeding stock is affected by control. With fewer birds reported per patrol from April

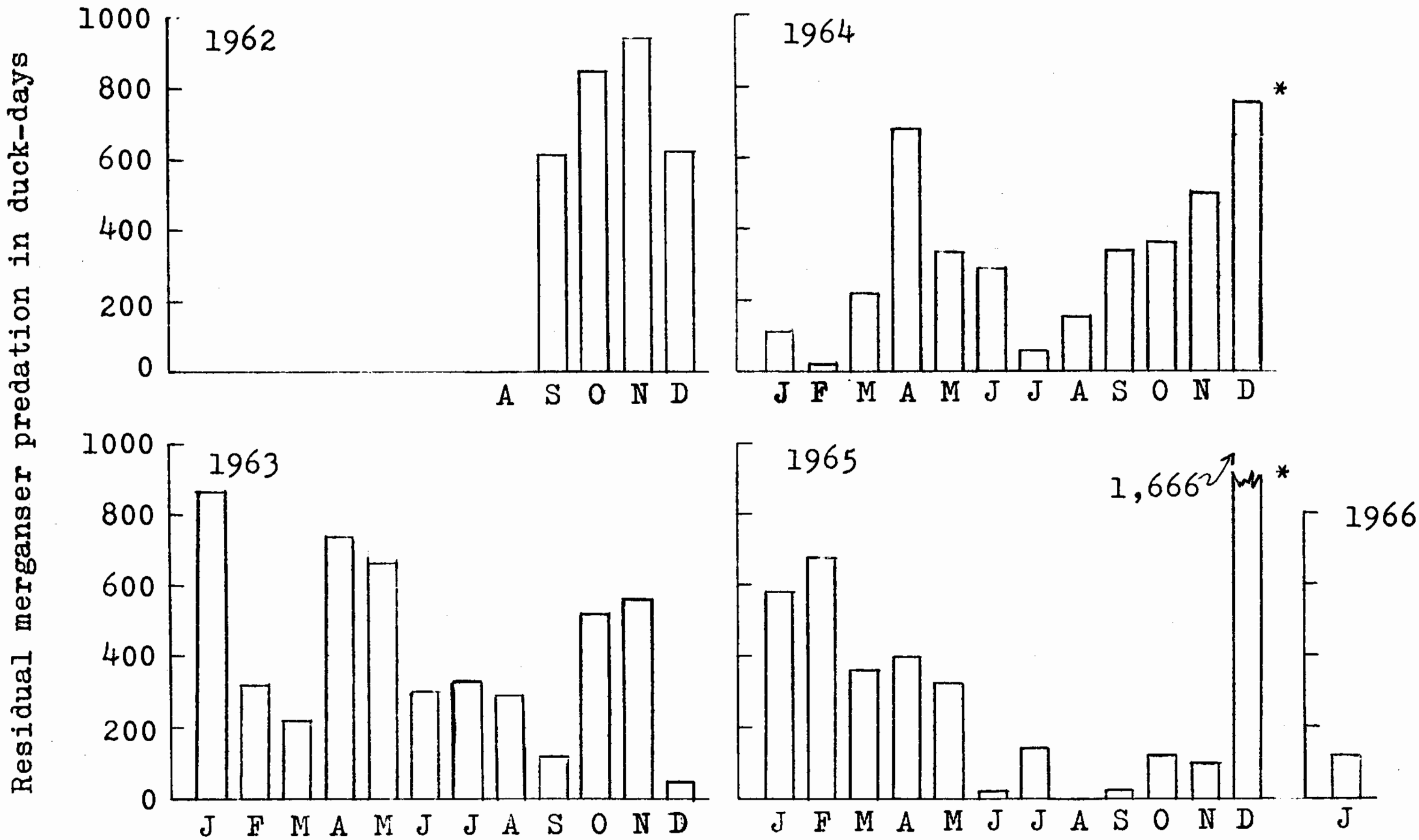


Figure 1. Residual merganser predation, in duck-days, on the Margaree River system as derived from patrol records of birds seen and killed, calculated on a weekly basis usually, but on a part-weekly basis at month-ends. *In December of 1964 and 1965, 500 to 1000 additional duck-days were recorded on Lake Ainslie just at freeze up.

through December in 1965 (2.1 as compared to 2.9 in 1964) patrols were reduced in number (95 against 152 in 1964) to permit ancillary investigational operations. Residual predation (weekly basis) for these periods was calculated as only 2780 duck-days against 3530 in 1964.

Young salmon populations

Beginning in 1957 there has been some evaluation of young salmon populations in established areas each August by electroseining. Since merganser control started, this seining has been hampered by high water and other circumstances including control operations so that planned schedules have not been fully met. There has, however, been enough such study to suggest an increase in survival rates from underyearlings to pre-smolt large parr. This is shown, based on preliminary analysis of the seining data, in Table II.

Table II. Comparative abundance per 100 yd^2 of young salmon in the same sample areas of the Northeast Margaree River before (1957-1961) and after (1963-1965) control of mergansers started.

	Number of samplings	Under-yearlings	Small parr	Large parr
Before	35	50	26	10
After	14	21	20	18

Before, but not after, control started, large parr populations in August were still subject to predation before they would leave the river as smolts the following June. Hence the indicated increase in smolt production is materially greater than the 18:10 ratio shown in Table II for pre-smolt parr. Based on standards developed on the Pollett River, the new large parr numbers should adequately fill the capacity of the stream to overwinter pre-smolts.

Returns from tagged smolts

Each spring since 1961 tagged smolts, mostly of imported hatchery origin but some of local hatchery and wild origin, have been liberated in the Margaree. Liberations were in several lots of about 1000 fish each. The objective was two-fold - (a) to see whether any change in rate of recaptures occurred in relation to bird control and (b) to obtain some advance in knowledge about what sort of hatchery stocks might contribute best to fisheries. Because (1) all such smolts were tagged, (2) numbers were small in relation to total natural production, and (3) liberation was at the smolt stage so that fairly prompt exit from the system could be expected, it is not believed that these plantings could damage the bird control experiment. Recaptures have been recorded from commercial fisheries, some distant, and from the Margaree River, but not from freshwater reaches of any other stream (Table III).

Table III. Recaptures as grilse and older salmon of tagged smolts liberated in the Margaree River, before and after merganser control started in August 1962.

		Returns					
		As grilse		As salmon		Total	
Year	Number liberated	No.	Per cent	No.	Per cent	No.	Per cent
Before control							
1961	2600	0	0	1	0.04	1	0.04
1962	4248	4	0.09	4	0.09	8	0.18
After control							
1963	3752	52	1.39	11	0.27	63	1.66
1964	3219	8	0.25		(in 1966 and 1967)		

Preliminary indications are that pre-control predation during the spring period of smolt descent through river and estuary may have been rather severe.

Catches in fisheries

(a) Commercial. The earliest possible appearance in the local commercial fishery of Margaree salmon given protection from mergansers was in the 1965 fishery. This year, 2-sea-year fish from the 1963 smolt run were due to return. From data gathered in 1935 to 1941, about half of Margaree salmon return as 2-sea-year fish and half as 3-sea-year fish. An analysis of the 1935-41 local commercial catches indicated that the component of Margaree origin was only about half of the total. The control operation cannot therefore exert its full impact on the commercial fishery before 1966 at the earliest. A comparison of recent trends in commercial salmon catches of the Maritime Gulf area and the Margaree component of this (Figure 2) does not by itself firmly indicate benefit from merganser control in this first year.

(b) Angling. The total recorded catch by angling in 1965 was 351 salmon and grilse, with 120 of the fish being taken in the last two weeks of the season (Oct. 1-15). Previous to 1961 the season ended on September 30. The 1965 catch of 222 fish

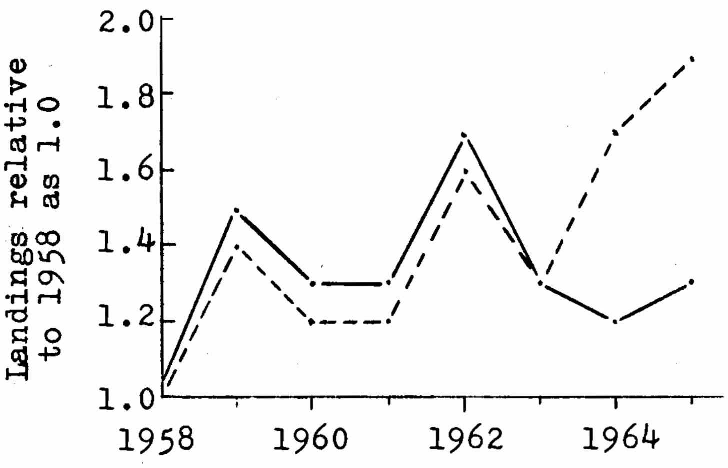


Figure 2. Trends in salmon landings (commercial) in the Gulf Area of the Maritimes (Quebec boundary to northern tip of Cape Breton, broken line) and in the Margaree portion of this area (solid line), plotted relative to landings in 1958.

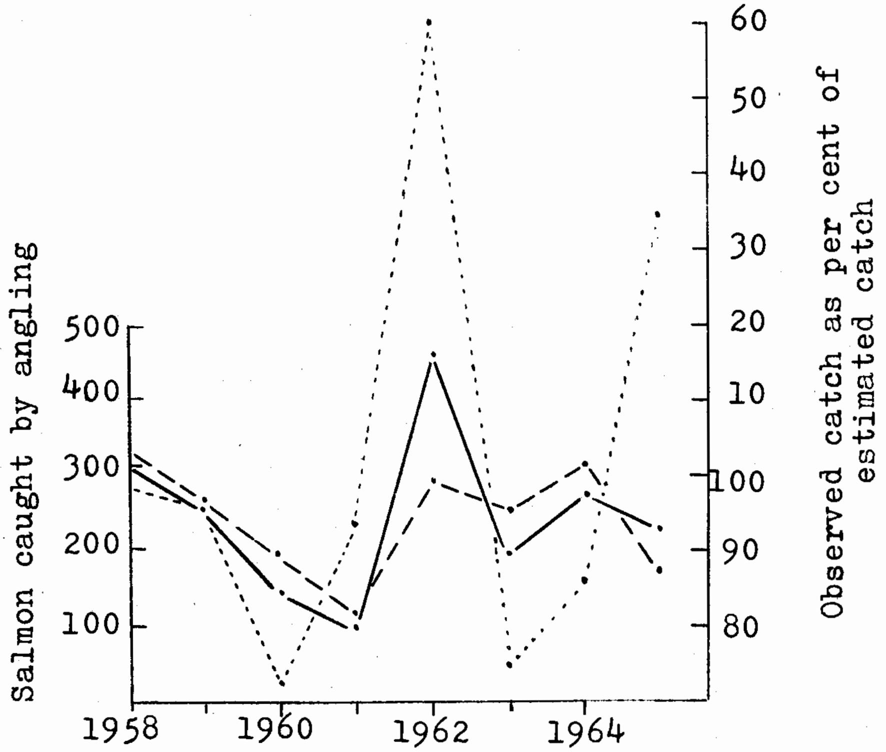


Figure 3. Catch, by angling, of salmon in the Margaree River. Solid line - recorded catch; broken line - estimate of catch by regression equation in text; dotted line - observed catch as per cent of estimated catch.

to September 30 was slightly below the average of 243 for the same period over the eight years from 1958 on. Despite this, there was a surprising amount of angler satisfaction with the 1965 catch. Low water with a lack of reasonably substantial freshets pertained through much of the summer. Because of this, anglers reported they used fine tackle with consequent loss of many fish hooked. Unofficial reports indicated that some anglers lost up to almost half of the fish they hooked. That Margaree salmon angling is greatly dependent on river levels has been documented (FRB Bull. 57). Not only the amount of discharge but also the frequency of freshets affects angling. A preliminary analysis of these relations indicates that frequent freshets adding 50 cfs or more to flow are far more effective than the volume of discharge by itself. Figure 3 presents the results of an analysis of the partial regression of catch (to September 30) on mean discharge of the Northeast Margaree River and frequency of discharge increases amounting to at least 50 cfs within a 3-day period. The equation developed from catch and flow data for these years was:

Catch = 6.4 + 0.02 (mean cfs for July - Sept.) + 17.0 (frequency of flow increases of at least 50 cfs within 3 days)

In two years the actual catch substantially exceeded the expected catch estimated in this way. In 1962 it was nearly 60 per cent greater. In 1965 it was nearly 35 per cent greater. This may (or may not) have reflected increases in availability of stocks.

P.F. Elson

No. E-12

EFFECTS OF POND FORMATION AND STREAM IMPROVEMENT ON MOVEMENTS AND YIELD OF BROOK TROUT IN A SMALL STREAM

A study has been in progress at Ellerslie Brook, Prince Edward Island, to evaluate the effects of a pond on movements and populations of anadromous fish, chiefly brook trout and Atlantic salmon. Published reports have described the effects of the pond on salmon and also the movements of brook trout between and within fresh and salt water before pond formation. A description of trout movements after pond formation and a report relative to the effects of the pond on yield of trout to anglers are in preparation. The present report summarizes some of the more important findings.

Preliminary studies of stream improvement were carried out in Hayes Brook, a small stream tributary to Ellerslie Brook. It was demonstrated that trout production can be substantially increased in a small stream by creating conditions that are favourable to trout. Stream improvement was begun on Ellerslie Brook in 1961. Through the use of low dams, deflectors, and application of new cover, the environment over 1 mile of the stream was altered. The effect, to date, of stream improvement on the yield of trout to anglers is briefly reviewed in this report.

Results

Effect of the pond on movements of trout

Season of movements was the same before and after pond formation. Trout commonly moved up from the estuary in April, June-July, and November, and down from the stream in May and from October to early January. Under pre- and post-pond conditions, most movements occurred during periods when water temperatures and water flows were subject to greatest changes.

The majority of the trout that entered the pond were delayed there for varying periods of time. Accordingly, there was an accumulation of trout in the pond. Because of angling and natural mortalities, few pond fish survived to move farther up- or downstream. The accumulation and resulting loss of fish in the pond resulted in time in the near extinction of seaward runs from Ellerslie Brook.

In pre-pond years (1946-51) there were about 1,800 seaward movements recorded annually. By 1962, seaward movements had fallen to 79. The decline in seaward-moving fish resulted in a decline in the numbers of fish moving up from the estuary. In pre-pond years the annual average number of movements was 825. The inward run now consists of a few individuals.

Effect of the pond on yield of trout to anglers

Angling records are given in Table I. In the first three years following pond formation, there were high catches of trout from the pond, resulting from the accumulation of trout in the pond. This also occurred in the large tidal pool just below the dam. In later years, catches in the Ellerslie system have fallen to and below pre-pond levels and probably indicate effective cropping of the annual recruitment from the stream of trout of catchable size.

Effect of stream improvement on angling

Following stream improvement on Ellerslie Brook more anglers were attracted to the stream part of the system. The increased effort on the stream is reflected in the stream catch from 1962 through 1965 (Table I). The average annual catch from

Table I. Yield of brook trout to anglers from the Ellerslie Brook system, P.E.I.

1. Before pond formation

	Average annual catch	Average annual effort, rod-hours	Average annual catch per rod-hour
1947-52	1,478	812	1.8

2. After pond formation

Year	Total catch	Total rod-hours	Catch per rod-hour	Catch from stream	Catch from pond	Catch from tidal pool	Catch from estuary below estuarial counting fence	Catch area in system not known
1953	1,983	1,325	1.5	42	1,744	-	46	151
1954	2,945	2,452	1.2	160	2,066	-	229	490
1955	1,717	1,676	1.0	375	1,008	25*	153	156
1956	2,034	1,605	1.3	247	770	641	216	160
1957	1,669	1,259	1.3	251	494	697	36	191
1958	1,220	1,011	1.2	476	267	194	164	119
1959	1,213	925	1.3	140	676	266	104	27
1960	1,446	987	1.5	436	384	429	111	86
1961	731	535	1.3	174	332	150	61	14
1962	2,091	1,020	2.0	707	506	804 (548)	54	20
1963	2,033	1,082	1.9	518	629	634 (541)	225	27
1964	1,598	1,035	1.5	595	475	469 (118)	47	Nil
1965	1,727	963	1.8	516	470	649	79	13

*Pool not open to public

( ) From estuarial plantings

the stream in the nine years before stream improvement was initiated was 256. In marked contrast the average catch in the four years (1962-65) with stream improvement was 584.

J.W. Saunders

No. E-13

REPORTING OF ACCUMULATED DATA FROM LIMNOLOGICAL AND TROUT INVESTIGATIONS

In November 1965, the administration of the Anadromous Fish Investigations was taken over by Mr. K.R. Allen from the undersigned, who now has the responsibility of reporting on data accumulated from past limnological and trout investigations. Priority is being given to data (1) from Crecy Lake, New Brunswick, which deal with the stocking, fertilization and effect of predator control on survival and yield of trout to anglers, and (2) from Ellerslie Brook, Prince Edward Island, where the effects of pond formation upon movements, population and yield of trout to anglers has been examined, and involving sea-run brook trout.

Currently, two papers are in preparation, tentatively entitled (1) "Movements of brook trout in relation to pond formation on a small stream," and (2) "Relation of pond formation to catches of brook trout from a Prince Edward Island stream system." These papers will be co-authored with J.W. Saunders.

Pond formation on Ellerslie Brook (a 5-acre pond on the lower reaches of a 6-mile spring-fed stream) has markedly reduced the number of brook trout which ran to salt water from the stream. The pond delayed the seaward movements of trout sufficiently to result in a heavy fishing and natural mortality in the pond. Some trout moved downstream no farther than the pond, and then re-entered the stream above. In many respects the pond appeared to function as the estuary before pond formation, being the first relatively large body of water encountered by seaward-moving trout, beyond which the majority did not appear to move. From both upstream and downstream movements of trout there was an accumulation of fish in the pond when it was first formed. The new pond stimulated an increased fishing effort. There resulted a greater yield of trout from the Ellerslie system for three or four years after the pond was created. Thereafter, effort and yield have fallen to levels comparable to what was realized in pre-pond years. Pond formation, a manipulation of the environment, has not resulted in a sustained higher cropping of trout, nor at any time has it had a demonstrable depressing effect upon the seeding of the freshwater part of the system from spawning in the stream above the pond area. Although annually the angling success declines with the advance of season through spring into mid-summer, the catch per unit of effort is comparatively high in the stream in September, which points to no lasting depletion of stock in the stream system by the angling effort now made.

M.W. Smith

POLLUTION STUDIES SUMMARIES

No. F-1

POLLUTION STUDIES

The pollution group at St. Andrews attempts to provide others with information on danger of pollution to various kinds of fish in waters of the Maritimes area.

Awareness of pollution problems is increasing, we are being asked more questions, and our present resources are over-taxed in trying to provide answers. Although a toxicity lab operated full-time in 1965, and completed several pieces of work, it has not been possible to carry out all research projects required for dependable answers to new problems. Areas of woeful ignorance on Maritimes problems, requiring investigation by specialized scientists, are pesticide pollution, sublethal effects of many kinds of pollutants, and systems of invertebrates as indicators of pollution.

Co-operation was continued with other federal and provincial agencies in the Maritimes. Co-operation with the Anadromous Fish Group measured the background of pollution to support their research in the Mirámichi. Several requests for advice on the physical oceanography of pollution problems were answered by Oceanographic groups at St. Andrews and Dartmouth. General assistance in chemical analyses was provided within the station whenever requested. Similar assistance was given to four outside agencies, chiefly with metal analyses.

It is hoped that it will be possible in the coming year to carry out co-operative or supporting research on the following new topics: toxicity of pesticides of interest in forest-spraying operations; field and laboratory evaluation of pollution by iron ore waste in Labrador; toxicity of bleached kraft pulp mill effluent to lobsters; and a survey of dissolved oxygen levels in the mouth of the Restigouche River where a pulp mill is due for expansion.

J.B. Sprague

No. F-2

SEVERITY OF MINING POLLUTION IN THE NORTHWEST MIRAMICHI RIVER DURING 1964

Pollution from a base metal mine is one of the major environmental conditions in the Northwest Miramichi River where the Anadromous Fish Investigation carries out a research program. Pollution was again monitored during 1965, and water samples were ably collected by field personnel of the anadromous group.

A system of expressing pollution in terms of the lethal level for fish has been developed previously. The lowest level of pollution which kills fish is assigned a value of 1.0 "toxic units", and other degrees of pollution are expressed in reference to this standard.

Copper-zinc pollution in the Northwest Miramichi is summarized in this way in Table I and Figure 1 by monthly averages. It has not been possible to include the effect of low temperature on toxicity, but this would make conditions look less favourable for fish in the winter-time.

From Table I we see that the yearly average for pollution in 1965 was the same as the average for all years. Certainly there was no sweeping improvement. Seven monthly averages in 1965 were above the 6-year average for the same month, and 5 were below.

There were 4 major peaks of pollution during 1965. A peak of 1.8 toxic units on March 19 is not readily explainable on the basis of weather conditions, although it did follow a period of thaw and heavy rain two weeks earlier. A peak of 2.2 toxic units came on April 20 at the time of the spring break-up. A peak of 2.5 toxic units came on August 20 during a freshet which raised water level about two feet at Curventon. Only four other peaks which exceed this value have been recorded, the highest of which was about 3.6 in 1960. Another peak on November 20 came at the time of a moderate autumn freshet.

Compared with the levels of pollution which have caused avoidance reactions by salmon in the past, pollution was generally higher than the avoidance levels during May, near these levels in early June, below them in late June and early July, at or above avoidance levels in late July, below them for the first ten days of August, at or above such levels for most of the remainder of August, mostly below in September, and mostly at these levels or above them during October and early November.

A detailed manuscript report has been written on chemical conditions in this river during 1965.

W. Victor Carson

J.B. Sprague

TABLE I

Monthly average of toxic units for mining pollution of the Northwest Miramichi River at Curventon.

A value of 1.0 toxic units is just lethal for fish at summer temperature.

	1960	1961	1962	1963	1964	1965	All years
Jan.	-	.20	.77	.85	.54	.82	.73
Feb.	-	.39	.53	.70	.48	.69	.59
March	-	.31	.63	.44	.59	.82	.61
April	-	.36	.59	.95	.82	1.0	.78
May	-	.36	.74	1.2	1.0	.57	.85
June	.88	.40	.33	.54	.43	.32	.41
July	.63	.14	.44	.38	.24	.28	.31
August	.22	.11	.56	.61	.29	.42	.39
Sept.	.50	.14	.37	.81	.32	.34	.40
Oct.	1.8	.28	.26	.52	.45	.53	.46
Nov.	1.0	.25	.49	.74	.63	.62	.54
Dec.	.41	.30	.57	.57	1.2	.44	.61
Year	.77	.24	.49	.67	.54	.51	.51

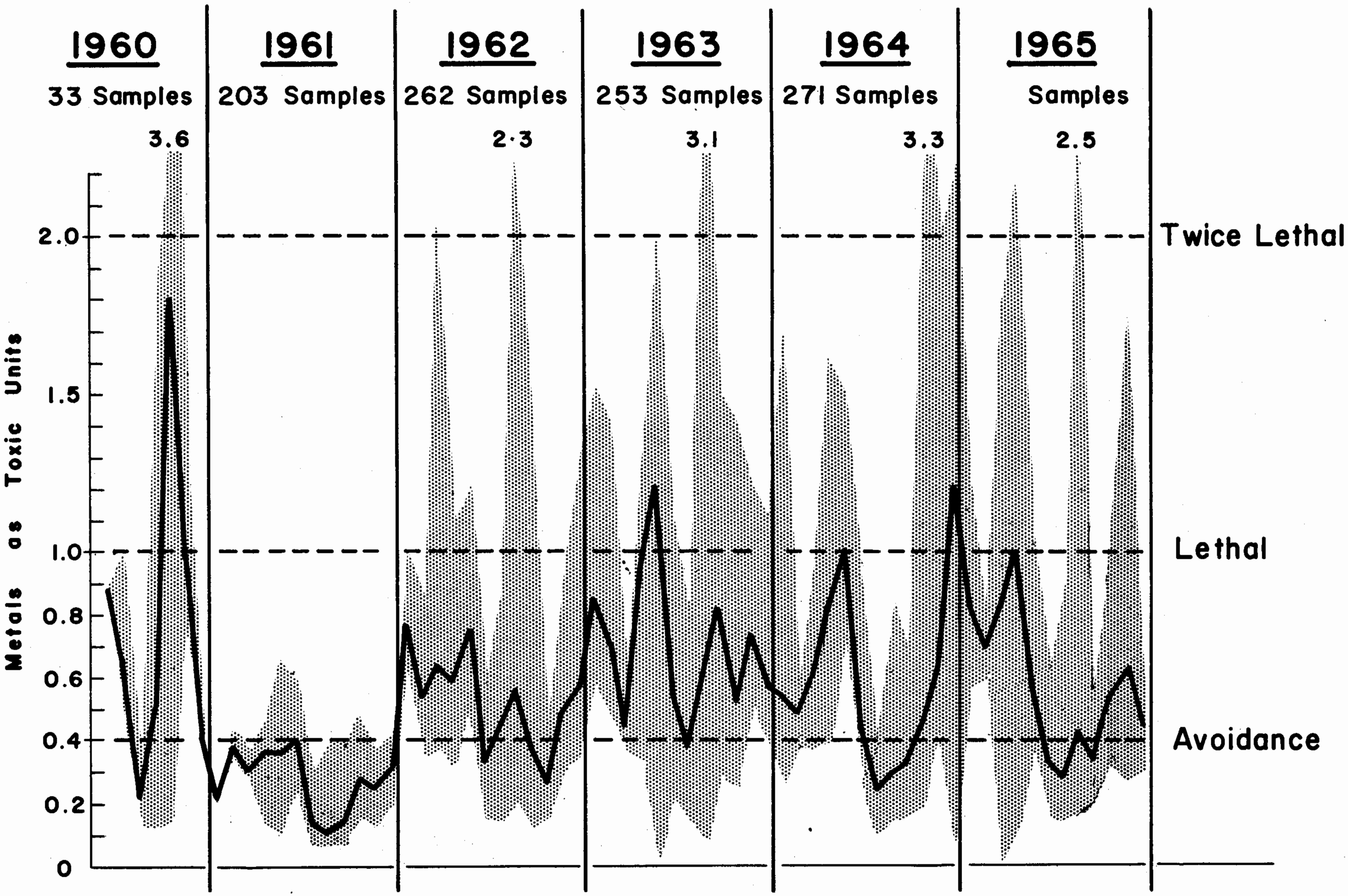


Fig. 1. Monthly averages of toxic units for metal pollution of the N.W. Miramichi R. The black line represents monthly averages, while shading shows extreme high and extreme low values during each month.

No. F-3

GEOCHEMICAL SURVEY OF STREAMS AROUND MT. PLEASANT

The purpose of this survey was to establish a baseline of chemical conditions in the streams draining a potential tin mine at Mt. Pleasant, Charlotte County, New Brunswick. A small biological survey has also been carried out. If the mine develops, this might be an excellent location for field research on pollution, since we would have the picture "before pollution", something which is extremely rare. The survey would also be useful for pollution control by enforcement agencies.

Fifty-five samples were collected from streams and rivers of the area, by ourselves in various seasons of 1964 and 1965, and in 1962 by the New Brunswick Department of Lands and Mines, as previously reported by them.

No serious pollution was found. The small streams draining the mineralized area of Mt. Pleasant showed a somewhat raised metal content, averaging 25 μg/l of zinc and 7 μg/l of copper, far below lethal thresholds. Downstream, the larger streams and rivers averaged 4 μg/l of zinc and 3 μg/l of copper, normal values for unpolluted streams. No lead was detected. An average of 4 μg/l of arsenic was found in streams of the immediate mine area. Waters were slightly acid (pH 6.7) and very soft (14 mg/l as $CaCO_3$). There was no appreciable change in metal content of the streams over the sampling period, except for a slight seasonal change in copper for streams very close to Mt. Pleasant.

A draft for a manuscript report has been completed.

W. Victor Carson.

No. F-4

TOXICITY OF METALS, GYPSUM, AND FLUORINE TO A MARINE FISH

A large smelting, chemical, and fertilizer plant is being constructed at Belledune, N.B. on Baie des Chaleurs. At the design stage, the New Brunswick Water Authority and the firm itself requested information on toxicity of waste products which are slated for disposal in coastal waters. A search of literature revealed that there was a good deal known about toxicity of these wastes in fresh water, but almost nothing for the marine environment. Accordingly, short-term laboratory tests were carried out using small winter flounders collected locally.

Five metals are expected to escape from the smelter into coastal water — copper, silver, lead, cadmium, and zinc. Several concentrations of each were tested for toxicity to flounders 3 to 6 cm long which had been held in the lab for 1.5 to 6 weeks before testing. Holding and test temperatures were 12°C, and experiments were done from September to November 1965. Tests were run for three weeks in continuous-flow test-tanks. Stock solutions of metal were added to the inflowing water by Mariotte bottles, in which solutions were changed every 3 days, and the solution of silver was protected from light. Chemical tests of copper and zinc in the fish-tanks showed satisfactory control of concentrations. Chemical assay of the other metals was difficult because of the sea-water medium. However, tests of concentrations of silver and lead in the stock solutions showed that these were accurate.

The results of the bioassays with copper were very straightforward. There was a straightline relation between the logarithm of copper concentration and the logarithm of lethal time for 50% of individuals (LT50). Thirty-two mg/l of copper as Cu caused mortality in 6 hours, and 1.0 mg/l caused mortality in 160 hours which is only 8 hours short of one week. At lower concentrations, more than half of the fish survived, and the incipient lethal level is estimated as 0.85 mg/l of Cu.

Tests with silver gave peculiar results. The solubility of this metal was known to be very low, about 0.9 mg/l of Ag as a chloride, but experiments at several concentrations were carried out anyway. At all "added" concentrations exceeding the solubility, from 1.0 to 10.0 mg/l, resistance times were similar (60 to 110 hours) and unrelated to concentration. Concentrations of 0.75 and 0.56 mg/l, within the solubility, did not cause 50% mortality. The incipient lethal level is estimated as 0.87 mg/l, very close to the solubility limit.

Lead is also relatively insoluble, and precipitated out in tests at higher concentrations. Fish were held up from the bottom, out of this precipitate, by cages of netting. The incipient lethal level is estimated as 15 mg/l of lead as Pb. For both cadmium and zinc, the incipient lethal levels are in the vicinity of 20 mg/l.

A superphosphate fertilizer plant at Belledune is expected to produce as a wasted by-product, about 4,500 tons per day of gypsum containing 1.3% of fluorine. Tests were carried out with these materials, separately and mixed, using fluosilicic acid as the most likely form of fluorine in the waste.

Concerning details of test-procedure, these were static bioassays which ran for at least one week, sometimes 10 days. No deaths occurred in the control test in 2.5 weeks. All tests involving gypsum were agitated vigorously by propellers on two laboratory stirrers, and fish were held in cages. Test-water was changed every 2 days in tests containing fluosilicates but was unchanged in tests with gypsum alone. Tests were carried out in December 1965 at temperatures which were generally 10 to 11°C. Fish were about 9 to 13 cm. long, and had been held in the laboratory between 5 and 13 weeks before tests, at the same temperatures.

Gypsum did not kill fish except in very heavy suspensions. Half the test fish were killed in 125 hours by 56 gm/l of $CaSO_4$, but mortality increased to only 60% in a week. Some mortality, 20% to 50%, occurred at concentrations down to 2.5 gm/l, which is close to the solubility limit of 2.7 gm/l found for sea-water. At 1 gm/l and below, there were no mortalities in a week of exposure. In the higher concentrations which killed fish, the water was an opaque "cream" of suspended gypsum, which settled out on the quiescent fish so that only their eyes and opercular openings remained clear.

For fluorine, the incipient lethal level was about 44 mg/l of fluosilicic acid, H_2SiF_6. Apparently the toxic effect was not because of fluorine but because of low pH. A non-lethal concentration of 32 mg/l had a pH of 6.2. Lethal concentrations of 56 and 75 mg/l had pH values of 4.0 and 3.7. Almost identical mortality was caused when similar pH values were created by hydrochloric acid instead of fluosilicic acid.

When fluosilicates were mixed with gypsum, 1.3% H_2SiF_6 in $CaSO_4$, low pH again seemed to be the factor responsible for acute toxicity. The presence of gypsum did not seem to greatly modify the acidifying power of the fluosilicates. Mortality was about the same in the mixtures as would be expected from the fluosilicate content.

From this, we would conclude that direct toxicity to fish of the Belledune fertilizer waste could be estimated by measuring pH at the disposal site. In addition, gross settling of undissolved gypsum, if it occurs, can be expected to kill bottom-living creatures including fish such as flounders. Metals escaping from the smelter will be toxic at the levels indicated. In addition, combinations of several metals in the sea at Belledune would probably be toxic at lower concentrations. Unless shown otherwise, it should be assumed that a measured concentration of any metal, expressed as a fraction of its incipient lethal level, may be added to similar fractions of other metals. If the total is greater than unity, it may be assumed that the combination of metals is lethal for flounders, and probably for other marine fish.

J.B. Sprague, William G. Carson, W. Victor Carson

No. F-5

ASSISTANCE TO A PAPER COMPANY TESTING REDUCED TOXICITY OF PULP MILL WASTE

The second and third bleached kraft pulp mills affecting waters in the Maritime provinces will come into production during 1966, one of them on the Miramichi estuary, and a fourth is scheduled for 1967. Bleached kraft mill effluent (BKME) is more toxic to fish than waste from other kinds of mills. Tests of avoidance carried out at St. Andrews and previously reported, showed that young salmon cannot be depended upon to save themselves from BKME.

Biological treatment of waste may be desirable. Fraser Companies Limited has been carrying out bioassays with fish to see if toxicity can be reduced by changing the bleaching process or by chemical treatment of waste. This is an encouraging co-operative project. Frasers have done most of the work, Resources Development Branch of Department of Fisheries has provided lab space in a hatchery and supplied fish and advice, while we have lent some equipment and spent several weeks in interpreting tests, advising on procedure, and attending meetings.

The bioassays were well-done. The company has discovered several ways of reducing toxicity of BKME, not all of them economically feasible. Whether the treatments they prefer are sufficiently beneficial to permit safe disposal of BKME in the Miramichi is still under discussion with the Department of Fisheries. Final results of tests and decisions are likely to set a precedent for other mills.

J.B. Sprague

No. F-6

TESTS WITH PHOSPHAMIDON, A PROMISING INSECTICIDE

The organophosphate insecticide Phosphamidon has been used in forest-spraying operations against the spruce budworm, sometimes with the addition of the penetrating agent Invadine. The toxicity of these chemicals to juvenile Atlantic salmon (Salmo salar L.) was tested in the laboratory. The lethal threshold of Phosphamidon for a one-hour exposure, after which fish were removed to clean water, was about 220 mg/litre (Fig. 2). This is much higher than the concentrations of about 0.1 mg/litre which might be expected in streams following aerial spraying operations.

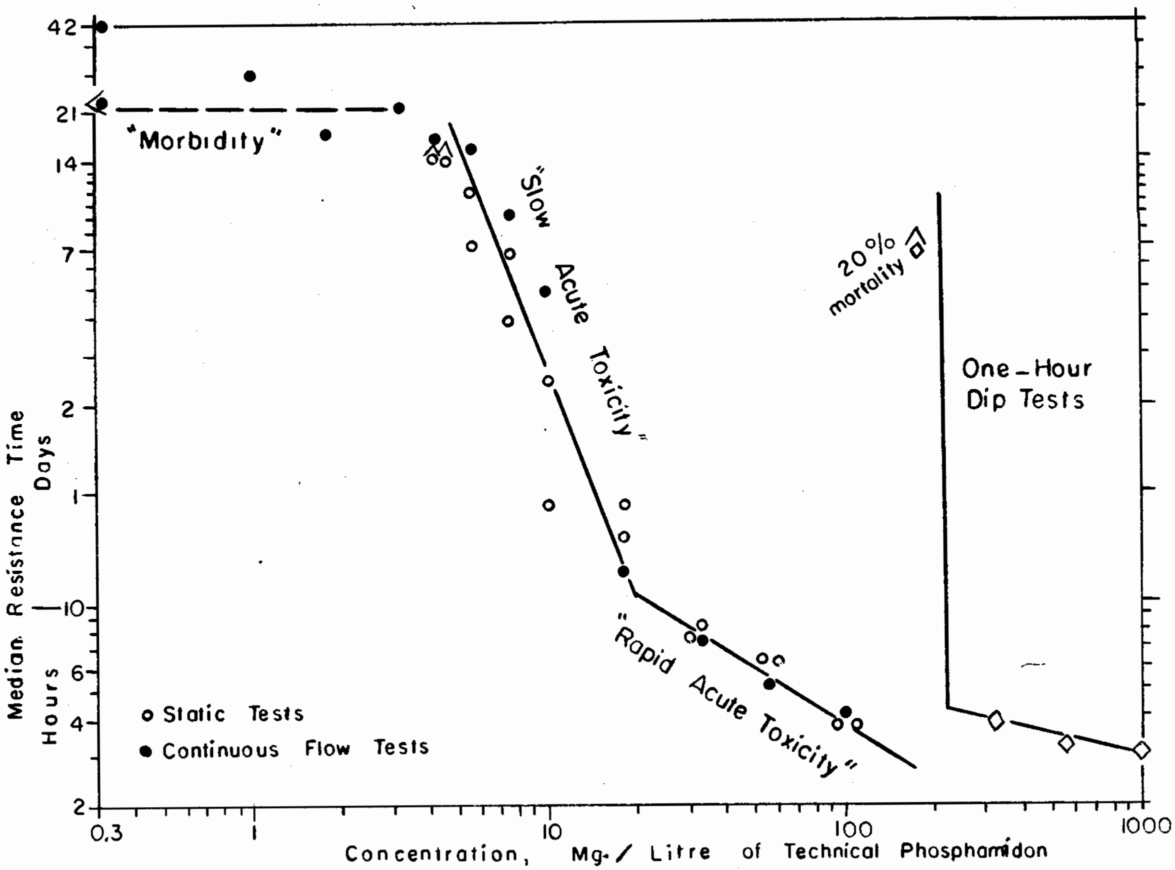


Fig. 2. Results of lethal tests with Phosphamidon against young Atlantic salmon

Static tests in 60 litres of Phosphamidon, without renewal during the 2-week test period, showed essentially the same acute toxicity as continuous-flow experiments lasting as long as six weeks. Concentrations from 100 mg/litre down to about 25 mg/litre killed fish rapidly, in 4 to 10 hours. Lower concentrations, from 20 mg/litre down to about 5 mg/litre had a slower acute toxicity requiring up to two weeks exposure. Survival times were linearly related to concentrations in each of these two ranges of toxicity, as shown in Figure 2.

Morbidity resulting in death occurred during continuous exposure to Phosphamidon. From about 4 mg/litre down to 0.1 mg/litre, the lowest concentration tested, at least half of the fish died in two to six weeks. Survival time did not seem to be related to concentration over this range.

For usual operating conditions, this insecticide is relatively "safe" from the point of view of damage to young salmon.

The penetrating agent "Invadine JFC 100" is often added to Phosphamidon in the field operations. Invadine had a lethal threshold of about 70 mg/litre. This is not particularly toxic, being comparable to household detergent. Invadine added to Phosphamidon in the ratio 0.03 by weight did not noticeably change the toxicity of the insecticide.

J.B. Sprague, William G. Carson,
W. Victor Carson, with J.A. Dalziel