FISHERIES RESEARCH BOARD OF CANADA

BIOLOGICAL STATION
ST. ANDREWS, N.B.

ANNUAL REPORT

and

INVESTIGATORS' SUMMARIES

1962-63

J. L. HART, DIRECTOR

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BIOLOGICAL STATION, ST. ANDREWS, N.B.

The Fisheries Research Board investigates practical and economic problems connected with marine and freshwater fisheries. Its Biological Station at St. Andrews conducts the biological research for the Maritime Provinces. Animals and plants are studied in relation to regulations, fish culture, other aspects of conservation and management, and to fishing and handling practices. This involves, among other things, critical studies of growth, survival, distribution, recruitment, habitat, diseases, predators, and special statistics. Conclusions can be applied in a variety of ways. In the past, results have frequently been used in proposing and assessing regulations. While this remains important, more and more emphasis is being given to increasing the efficiency of offshore fishing operations and to practices which will increase the resource in inshore and inland waters.

The administrative headquarters for biological research in the Maritimes is at St. Andrews. Resident scientists are established at two other localities. The Atlantic Oceanographic Group (AOG) is at Dartmouth, N.S., in the Bedford Institute of Oceanography, and oyster research is centred at a Biological Sub-Station at Ellerslie, P.E.I. There is a statistical office in Halifax, N.S. Port contact technicians and year-round bases for field operations are maintained at seven other points in the Maritimes. Temporary field headquarters are set up throughout the area as occasion demands.

LIAISON. Problems associated with fish often impinge on the interests of several agencies. Accordingly, substantial effort goes into liaison with other governments and departments in addition to frequent informal consultations.

The Interdepartmental Shellfish Committee is advisory to the Department of Fisheries, the Department of National Health and Welfare, and includes representatives from these two departments and the Board. Its main function is to reconcile the objective of making full use of molluscan shellfish resources and protecting the health of consumers. The United States as importers of fresh Canadian molluscs also participate usefully. Information supplied by the St. Andrews Station is used in framing recommendations.

Salmon are anadromous and the federal authority is responsible for their conservation. Provincial governments control the shores of the streams the fish live in and derive benefit from the resource. The situation calls for liaison at all levels. Within the fisheries ministry, Departmental officers are responsible for management while Board staff carry out research. Co-ordination between federal groups is now assured by personal contact and group meetings. Co-ordination between federal and provincial activities is achieved by annual meetings of personnel active in research and management of salmon and trout. Proposals arising from these meetings are presented to a Salmon Section of administrators for consideration in framing its report to the Federal Provincial Atlantic Fisheries Committee.

Salmon are involved in another more specialized liaison. The spruce budworm in epidemic proportions destroys mature stands of spruce and balsam through defoliation. Suspensions of DDT sprayed from aircraft are the most economical ways of controlling budworm. However, indiscriminate distribution of poison kills young salmon and their food. To reconcile conflicting interests, a federal Interdepartmental Committee on Forest Spraying Operations was set up in 1958. Data collected by the St. Andrews Station are used by the Committee in designing budworm control operations that are less destructive to aquatic life.

Canadian offshore fishermen exploit the same grounds as fishermen from the United States and eleven European countries. Recognizing the need for concerted conservation, these countries subscribe to the International Convention for the Northwest Atlantic Fisheries and have representatives in its Commission (ICNAF). Scientists from the participating countries meet among themselves when necessary to pool data and consider recommendations and they meet annually with the Commissioners. St. Andrews scientists present information on Maritimes fisheries and research.

An important part of Canadian participation in ICNAF work is supplying fishery statistics and data on sampling catches. This is arranged through co-operative action with officers of the Department of Fisheries and the Bureau of Statistics. Data are presented in a form to provide total statistics as required by the Statistics Subcommittee of the ICNAF Standing Committee on Research and Statistics.

Statistics are used by ICNAF scientists to find trends in fisheries and forecast the effects of proposed regulations. A special assessment committee concluded that the effects on yield of further changes in mesh size of trawl nets were likely to be small and turned attention to the effects of changing fishing efforts and to the consistency and pertinence of the data available for making forecasts.

Oceanography in its many aspects interests several agencies of government. The interdepartmental Canadian Committee on Oceanography (CCO) co-ordinates research and application among the various agencies. On the Atlantic coast, the East Coast Working Group (ECWG) of CCO considers for each agency its needs for research and facilities, and arranges to provide them. A Fisheries Panel of the ECWG, including representation from the St. Andrews Station assesses and presents requirements of fisheries investigators for oceanographic studies.

FISHING EFFICIENCY. The St. Andrews Station has a long established interest in increasing the efficiency of fishing operations. With a few important exceptions, this has been done by introducing fishing methods whose effectiveness had been proved in other regions. Many promising introductions have now been made and successful ones adopted. Additional developments will depend upon application of new information of several kinds. Some of this information is beyond the scope of the

Biological Station. A committee of senior Fisheries Research Board and Department of Fisheries officers was set up in 1962 to examine needs and co-ordinate efforts. The Committee has stimulated new investigations and redirected others. New products from scallops are being sought and tested. Fishing methods for taking large pelagic fishes are under study and fishing grounds for them are being sought. Studies of movements of groundfish at different times of day were undertaken and considered in relation to fishing success. A survey of fishing practices showed great need for detailed bottom charts of Canadian Atlantic offshore fishing grounds. Recognizing the need, the Department of Mines and Technical Surveys undertook to produce a series of special charts for fishermen. An engineering study of fishing gear has been undertaken. Equipment is being assembled for objective tests of established and experimental trawl gear on such points as: warp tensions at vessels, warp angles, hydrodynamic pressure, mouth openings, bridle tensions at nets, etc. Scallop gear performance is being critically assessed to decide whether to work on improving present gear or to invoke new principles.

LOBSTER

The fishery for lobsters is almost entirely conducted inshore by small boat fishermen. It provides employment to more individuals than any other commercial fishery in the Atlantic region, and lobsters are moreover the most valuable single-species fisheries product in all Canada. The landings in 1961 were 47.8 million lb, valued at $17,925,000. Because of its sociological importance and high value the species merits careful study. Small percentage improvements in yield from the fishery can be important in dollar values. Improved handling methods can extend markets geographically and thus sustain or increase prices. Furthermore the lobster fishery has undergone natural cyclic fluctuations in yield. Production is good at present and recent increases have coincided with imposition of size limits. A cause and effect relation is not clear or proved and it is possible that we are reaping the benefit of a favourable natural fluctuation. It is important that future changes in the fishery and the stock be followed to indicate their causes.

Studies on lobsters have been pursued along four main lines. The commercial fishery has been followed at three ports exploiting different stocks of lobsters. Studies of distribution and survival of larval and young lobsters have been continued and adapted to accumulating knowledge. Growth and survival of lobsters on the fishing grounds were explored further. Research related to shipping and holding lobsters was continued. In addition some attention was given to problems related to the effect of cover on survival in nature, the care of lobsters in fishing boats, improving condition by feeding lobsters held in captivity, the effects of crowding on survival in storage, the brown marks on shells caused by injuries in holding, and the relationship between the internal chemistry and the moulting cycle in lobsters.

STUDIES OF THE COMMERCIAL FISHERY. At Port Maitland, N.S., total landings declined from 1951 to 1961 to about 40% of the 1951 production. However, the decline has been accompanied by reduction in fleet size (by half) and increasing prices with the result that earnings per boat have risen slightly. The trend applies generally in southern Nova Scotia where catches have declined from 12.2 million lb in 1951 to 8.6 million lb in 1960.

At Fourchu, N.S., the effective start of the 1962 spring season was delayed beyond the legal opening date by heavy drift ice, and a week's extension was granted to the 2-month season. Landings during the extension amounted to 10% of the season's catch by weight and 12% by value. The quality of the lobsters remained good and the rate of exploitation remained below the average for recent years.

Research fishing off Miminegash, P.E.I., prior to the opening of fishing on August 10, showed lobsters plentiful. However, strong winds lowered water temperatures by about 9°F before the opening of fishing, and early catches were unprecedentedly low. The drop in yield is greater than can be explained by what is known about temperature effects on activity.

STUDIES OF LARVAL AND EARLY BOTTOM STAGES. After fertilization, lobster eggs adhere to the under part of the female's tail for nearly a year before hatching. When eggs do hatch, the young float free in the water for several weeks before settling to the bottom. There they continue to live and grow like small adults. During their free-swimming life as larvae, the young lobsters grow by moulting just as adults do. Typically there are four free-swimming stages. For 14 years the numbers of larvae at different stages and young lobsters have been followed in Northumberland Strait by special fishing methods. The object has been to find out mortalities during the critical stages and to see what relationships exist among larval abundance, mature spawners, and later recruitment.

In 1962 there was a marked scarcity of stage IV larvae in comparison with other years and with earlier stages. Surveys showed only 300 IV-stage larvae per square mile. This is only a small part of the number necessary to sustain the fishery at its present level. Although methods of assessment are still under review, the possibility of poor recruitment to the fishery must be taken seriously.

GROWTH AND SURVIVAL. Lobsters grow only when they moult. Accordingly growth of a lobster stock depends upon the amount of growth per moult and the proportion of lobsters moulting. From this must be subtracted losses from natural mortality. The relation between growth and survival at different sizes is basic to considerations of size regulations.

The results of large scale marking experiments to determine growth and survival at Port Maitland and Miminegash are now available. Off Port Maitland, 46% of the lobsters that were of legal size when marked failed to moult. Lobsters that did moult grew an average of 0.41 inches in length regardless of sex or size. Because of the large proportion that failed to grow by moulting, average growth per year was only 0.24 inches. Only 7.3% of the marked lobsters were recovered during the next two seasons. This indicates very heavy mortality. Fishing trials using lobsters as bait and food studies suggest that the catfish, *Anarhichas lupus*, may be an important predator.

At Miminegash average growth per moult was 0.35 inches and average growth per year 0.17 inches. Survival for 10 months was 24%.

SURVIVAL OF LOBSTERS IN CAPTIVITY. Many lobsters are marketed alive and it is important to know the conditions influencing their survival in holding units and in shipping. Work during 1962 concerned survival of lobsters out of water and oxygen consumption of lobsters in sea water under different conditions.

The importance of light-weight shipping of lobsters has led to further exploration of survival in air. Lobsters acclimated to 68° F survived much longer in air at 32 to 41° F than at 50 to 59° F. Fine mists and sprays did not extend survival time significantly. Increases in oxygen concentrations of air surrounding lobsters did not lengthen survival time usefully but did increase oxygen consumption.

Experiments were continued to determine the amount of oxygen used by lobsters under various conditions. As oxygen concentrations in sea water increase, oxygen consumption by lobsters rises at first (to 2-3 cc/l) and then becomes constant at a level depending upon conditions. Feeding, crowding or increased temperature lead to higher consumption.

OYSTER

Of all marine animals in the temperate zone, the oyster lends itself best to farming. As in the case of cultivating domestic animals on land, farming leads to special problems in reproduction, nutrition, and disease. With oysters, these may be accentuated because marine animals are more subject to the vagaries of their environment than warm blooded species. The oyster work carried out at Ellerslie is designed to supply the information necessary to provide a large assured supply of high quality oysters and a confident market.

An important facility for applying research on oysters is an oyster hatchery. This is being constructed by the Department of Fisheries and will be operated jointly with the Fisheries Research Board. It is hoped that it will meet the problem of regularly supplying young oysters for growing areas and can give oyster farmers encouragement to expand efforts with the assurance that seed stocks will be available.

The culture of the oyster is intimately bound up with its life history. The female Atlantic oyster produces very high numbers of eggs which develop for several weeks while drifting free in the water. Eventually these larvae settle permanently in one place as spat. They settle on any suitable surface but growers prefer to catch them on special clean friable cultch put out for the purpose.

Main projects at the Ellerslie Sub-Station have been directed to monitoring larval development and forecasting times of spatfall, to determining oceanography in relation to oyster activities, to studies of so-called Malpeque disease and other diseases, and to the possibilities of oysters harbouring and concentrating poisonous substances. New work is being undertaken in studying the relationship of oysters to conditions on the beds.

LARVAL DEVELOPMENT AND SPATFALL. On the whole, reproduction of oysters in the Malpeque Bay area was unsuccessful in 1962. Some spat were produced but their growth was slow. At Gillis Cove and Crowdis Bridge, N.S., spatfall was poor. At Malagash, N.S., and Shippegan, N.B., there was none.

In spite of the poor season in 1962, tests of strings of scallop shells as spat collectors gave useful results. The strings caught spat when hung from floats or fencing, when laid on plastic sheeting, and when used in other recognized ways. When hung from floats the scallop shell strings also served well for rearing 1960 and 1961 spat. These grew quickly and when they reached bedding size were readily separated for maturing as single oysters.

OCEANOGRAPHY IN RELATION TO OYSTERS. When water temperatures drop to 3° C oysters hibernate. While hibernating the oysters get in poor condition and become subject to excessive mortalities. Interest in water temperatures on oyster beds was renewed in 1961. It was found that in the winter of

1961-62 oysters were subjected to 3° C or lower temperatures for 132 days as compared to 170 days in 1960-61.

MALPEQUE DISEASE FIELD STUDIES. Epidemic "Malpeque disease" devastated most mainland oyster areas in the early nineteen fifties. Further spread of the disease is being followed and the success of rehabilitation efforts by introducing immune breeding stock is being monitored.

Oysters held on trays in areas yet unaffected by Malpeque disease showed no unusual mortalities. Evidently there was no spread of the disease in 1962.

The effectiveness of rehabilitation was investigated by holding trays of resistant, susceptible, and local oysters at Malagash, N.S., Shippegan, N.B., and Mill Creek, P.E.I. The general conclusion is that resistance is developing satisfactorily in the south, but that spat produced in northern areas is still susceptible to disease.

ZINC IN OYSTERS. The zinc content of oysters is becoming a matter of public health concern. The Station is co-operating with public health officials and in turn is receiving help from the Department of Mines and Technical Surveys in making zinc analyses of oysters. Oysters at the head of the Miramichi estuary contained over 1000 ppm zinc and in areas where they are exposed to normal sea water they contained 400-500 ppm. There is evidence of a direct ionic zinc concentration by oysters. Quahaugs from the same areas have a lower zinc content.

CLAMS AND QUAHAUGS

In the 1940's clam digging provided a useful supplement to low incomes around the Maritimes. However, the practice has become less productive. There are three causes for the decline: the accumulated stock has been harvested; disease; and wasteful harvesting methods.

During 1961 a hand-operated hydraulic clam rake was developed which increased a fisherman's capacity to produce and at the same time avoided breaking or burying unused clams and thus wasting the resource. Commercial scale trials in 1962 showed that the rake was effective on intertidal flats that are seldom exposed.

A disease among quahaugs at Neguac was shown to be spreading.

Paralytic shellfish poisoning has produced severe illness and even death in the Maritimes. It is accordingly an important public health problem as well as a fisheries problem. The source of poison in the clams has long been suspected to be a minute organism called Gonyaulax tamarensis which the clam eats with impunity. This belief is now confirmed. High toxicities in clams coincide with or closely follow peaks of abundance of Gonyaulax in the water. Non-toxic clams become toxic when fed on Gonyaulax. Slightly toxic clams become more so in similar tests. Extracts from pure Gonyaulax cultures are highly toxic, and the poison is shown by filtering to be present in the cells rather than to be an excreted product in the surrounding water.

Paralytic shellfish poisoning also occurs in Quebec around the St. Lawrence estuary. Plankton samples taken at several locations between Bic and Grande Riviere through the co-operation of the Quebec Minister of Fisheries showed Gonyaulax to be most abundant between Metis Beach and Baie de Capucins. This is also the area where clams are the most toxic.

SCALLOP

After many years as a minor fishery by inshore vessels the scallop fishery has within 5 years increased to major proportions. It is now pursued by large vessels mainly working on Georges Bank. To meet the national and international needs for managing the fishery, there is immediate need for more knowledge of the fishery itself; of how thoroughly the resource is being used; of the basic biology of the animal (all stages of its life history are not yet known); and of the population dynamics and how the stock may be expected to react to exploitation. How best to use the animals that are taken by the fishery, and how best to modify gear are regarded as part of a fishing efficiency program.

In 1962 scallop landings increased again, and reached a record 14 million lb of shucked meats worth 4.7 million dollars. This represents a 30% increase in weight and a 46% increase in value over 1961. As in recent years, most of the volume was produced by the rapidly increasing offshore fleet working on Georges Bank. The increase in production there was the result of increased effort. Boats fished harder in 1962 and covered more of the Bank. Deck loading became uncommon as catches fell off. The catch of market-sized scallops in bushels per drag has declined markedly during the last three years from 1.93 in 1960, to 0.58 in 1961, and to 0.4 in 1962. The inshore fishery at Digby also increased, reaching 0.8 million lb, partly because of an abundance of scallops. Successful fishing was also carried out in Charlotte County, N.B., and in the Gulf of St. Lawrence.

Studies of basic biology of scallop centred on early free-swimming larval stages. Artificially spawned larvae were reared in sterile sea water where they were fed small plankton plants cultured under sterile conditions. Some larvae survived for 58 days, and seemed ready to settle but none did. It is hoped that development of this work will provide information useful in recruitment studies.

GROUNDFISH

Collectively, the groundfishes are the most valuable fisheries resource on the Atlantic coast. Because production is so high, quite minor improvements in management or in the efficiency of operation can result in substantial increases in earnings. The groundfish resource in offshore waters is shared by many nations most of whom co-ordinate their research efforts through the International Commission for the Northwest Atlantic Fisheries. The Station carries out Canadian research obligations for the Maritimes.

Much groundfish is landed by otter trawling in offshore waters, but other fishing grounds and other fishing methods are also important. Primary attention has been given to the whole commercial operation to establish a baseline and examine the problem. The otter trawl fishery takes a wide variety of species of various values. Their biological characteristics, their reactions to exploitation and fishing gear, and their behaviour are being studied as opportunity allows. The possibility of using additional species to widen the resource base is under consideration.

COMMERCIAL FISHERY. Catches by the commercial fishery are carefully recorded and analysed as an index of importance of the various components of the resource and of trends in their exploitation.

Half of the Canadian groundfish by value (16 million dollars) are now landed in the three Maritime Provinces. The species are cod, haddock, pollock, halibut, American plaice, witch (or gray sole), redfish, hake, cusk and catfish (or wolffish) in decreasing order of importance.

Half of the groundfish by weight are caught by the mobile fleet. The otter trawl is now by far the most important gear. Danish seines and longlines are of much smaller importance. The shift from line fishing, largely inshore, to mobile dragging offshore has developed since 1945.

With the development of a mobile fleet the greatest expansion has been on the open-water coast where fishing is year round. Nova Scotia groundfish landings have increased to a value comparable with those of Newfoundland (13.0 as against 13.8 million dollars), although still substantially behind in volume. The value of Nova Scotia landings are nearly half of the Canadian Atlantic landings for all species (30.8 as against 65.5 million dollars).

The species composition of offshore landings has become more diversified. Recently, more attention has been directed to pollock and witch, and in 1962 monkfish was landed for the first time. The mobile fleet now takes important catches of scallop, swordfish, and herring, and flexibility has become important in the design of offshore vessels.

In addition to compiling weight and values of different kinds of fish taken, landings are sampled to find out about sizes and ages of fish landed. Altogether 204 samples comprising over 53 thousand individuals were measured for length. From 9660 of these, otoliths were taken. Otoliths are the ear stones of the fish and are made up of alternate annual bands of opaque and transparent bone which are counted for age determinations. Sampling data are used in studies of growth, mortality, and of success of different broods of fish.

SELECTION BY FISHERY. The otter trawl is designed to catch everything of suitable size in its path. As a result, many individuals of commercial species are brought on deck at a size too small to market. By the time small fish have been sorted and returned to the water, they are stressed too much to survive. They are thus lost to the resource. Examination at sea of this wastage showed that rejection practices varied among species, with locality, and with the objectives of the fishing trip. The percentage of fish retained for landing depends upon the size distribution of fish caught.

Surveys with small-mesh otter trawls provide information on all sizes and species on the grounds rather than just those captured by the 4½ inch trawl nets in common use. Examining records of research dragging using small meshed trawls in 1960 gives an indication of the whole resource available if means can be developed to use it. Except for the skates and sharks, larger fish commonly caught are used. Substantial quantities of small individuals of commercial species are thrown away. Some kinds of fish are never big enough to be retained in commercial nets. Large quantities of herring, silver hake, argentines, capelin, and sand launce could be taken if satisfactory markets can be developed. There are other small fish taken by experimental nets for which no commercial use can be contemplated in the near future.

COD. The cod is the most valuable of the Atlantic marine fish resources, providing almost 45% of the weight and 30% of the value of Canadian landings. It is also the species most actively sought by the European fleets traditionally working off the Canadian coast. Studies during 1962 dealt with the migrations, availability, growth rates, and distribution of commercial sizes and young. Studies of the early free-drifting stages of young cod and haddock have been made to learn the positions of mature spawning schools and as a background for studying early mortalities and the success of year broods.

Recoveries in 1962 of tags used on cod in the Sept-Iles area in 1961 showed the relationships of these fish to others in the Gulf of St. Lawrence. Cod present in the Sept-Iles area in autumn migrate south outside the Gulf in winter. There is substantial mixing of these fish with cod stocks in the southwestern Gulf during the subsequent summer. Some fish have a migration pattern which takes them from the southwestern Gulf to the northern side of the Laurentian Channel in autumn.

Research vessel surveys in the southwestern Gulf of St. Lawrence allow prediction of the sizes of cod in the catch based on the sizes present in the third quarter of the preceding year. The 1962 survey supports the expectation of significant landings of 6-, 7-, and 8-year-old cod in 1963. Accordingly, average lengths and weights should rise. Catch per unit fishing effort should be somewhat increased.

The availability of food to cod and the efficiency of its utilization are important in theoretical studies of the productivity of the sea. During 1962 laboratory studies of the feeding and growth of cod were resumed. It was shown that more food was required for maintenance at high temperatures than low and that additional food was used more effectively for growth at high temperatures.

Comparisons of cod and haddock winter distributions have been based on survey cruises of the A. T. Cameron. Cod are regularly found in shallower water than haddock. Both species were taken in deeper water along the Laurentian Channel than on the Nova Scotia Banks. In general cod were found in colder water.

HADDOCK. April 1962 research vessel surveys provided bases for forecasts of haddock abundance in the Sable-Island-Emerald-Bank region. Both 1958 and 1960 year-classes are weak and the 1959 year-class is below average. A reduced abundance of haddock in the important winter fishery in the area may be expected with the shortage showing first among small scrod.

HALIBUT. Halibut research is on life histories in relation to the effects of the fishery on the stock. Studies include tagging, examinations of food, and examinations of reproductive organs for size at maturity and spawning period.

AMERICAN PLAICE. A study of American plaice in the Gulf of St. Lawrence was brought to a conclusion in 1962. Most emphasis was on analysing returns from tags put out from 1958 to 1961. Recoveries are in accord with the results of fishing surveys in showing sedentary summer concentrations on the Magdalen Shallows, some movement offshore in autumn, and all three winter recoveries in deep water along the edge of the Laurentian Channel. Tag recoveries gave no indication of movements between major fishing areas and confirm conclusions drawn from growth studies that there is little or no interchange of fish. Tag return data showed total mortality rate on two fishing grounds to be 67 and 60%.

POLLOCK. Pollock are taken in a new and growing fishery in the Maritimes. In 1962 the fishery produced 1.6 million dollars. A study of life history in relation to the fishery is completed and ready for publication. It deals with distribution of different sizes and schooling, temperature preferences, movements and migrations, spawning, growth, and food.

DIURNAL MIGRATION. Day and night catches of several species of groundfish have been analysed and the results compared with records of location obtained by echo sounders. Cod, haddock and redfish were found to be more abundant in day hauls than at night. Echo sounder records showed them to be off the bottom at night.

PELAGIC FISHES

Pelagic fishes are the most important of the incompletely used resources within range of the Canadian fishing fleet. Herring in some places where they are available close to shore produce substantial and valuable catches but much of the resource is exploited inadequately, or not at all. Some herring are taken well off the North American coast in international fisheries and the species now comes under consideration by the International Commission for the Northwest Atlantic Fisheries. Research during 1962 dealt with sizes and ages of herring in important stocks, developing marking methods to establish ranges of stocks, surveying spawning grounds as an indirect method of assessing populations, distribution of young, and effects of disease on stocks. Of the large pelagic fishes the swordfish is exploited aggressively but the others, such as tunas and porbeagle sharks, are not used by Canadian fishermen. The swordfish fishery is being followed and the catch examined. Exploratory fishing for unusual species is being carried out to survey the resource and its availability. Work on mackerel was limited to sampling commercial landings in southwest Nova Scotia for size, age, growth, and year-class composition.

CATCH STATISTICS. Landings of pelagic fish on the Canadian Atlantic coast in 1962 amounted to 262 million lb, valued at 5.8 million dollars. The total catch included 242 million lb herring, 16.1 million lb mackerel, 3.5 million lb swordfish, and 0.24 million lb tuna.

In the southern Maritimes, the herring fishery shows trends and yearly variations. Mobile gear is taking an increasing share of the catch. In 1958 and 1961, most of the catch was taken on the Nova Scotia side of the Bay of Fundy and this was associated with the set of surface currents in the bay which differed from that of most years when fishing was better on the New Brunswick side.

HERRING. In 1962 important herring populations were sampled for length and weight, and otoliths were taken for age determination. This work was done at Caraquet and Magdalen Islands in the southwestern Gulf of St. Lawrence, on both sides of the Bay of Fundy, and in the Georges-Browns Bank region of the Gulf of Maine. In the Gulf of St. Lawrence, 10 year-classes were represented in the samples and fish were of moderate size

(29.2 cm average at Caraquet and 31.4 cm at the Magdalens). Herring in the Bay of Fundy were small on the New Brunswick side (12 to 15 cm) and about the same size as Gulf fish on the Nova Scotia side (25 to 32 cm). On Georges Bank, herring were more numerous and larger (28.5 to 30.6 cm) than on Browns Bank (21.4 cm).

A herring spawning survey was carried out in Chaleur Bay in 1962. Observations by divers were supplemented by sampling with a Peterson dredge. The spawning area surveyed was about 450,000 square yards in extent. The estimated total number of eggs on this ground was 35.5×10^{11}. From this and the known fecundity of herring, the total number of spawning fish was calculated as 185×10^{6}. This is about 25 times the fishing mortality of the area. It seems that this stock is being under-utilized.

From 1954 to 1956 herring in the Gulf of St. Lawrence were ravaged by an epidemic fungus disease. This disease is believed to have killed at least half the mature fish in the area. It also changed the quality of the population by decreasing mean age and the number of year-classes in the population. Growth rate and the relative abundance of autumn-hatched fish both increased. Other changes involved spawning habits and distribution patterns. There is evidence that since 1960 herring stocks in the Gulf of St. Lawrence are recovering from the results of the epidemic.

SWORDFISH. In 1962 landings of swordfish amounted to 3.5 million lb valued at 1.6 million dollars. Successful fishing was distributed along the edge of the continental shelf from Georges Bank to Grand Bank. This was in contrast to 1961 when most catches were made on Georges and Browns Banks.

In 1962 longlining was introduced into the swordfish fishery with marked success. The average catch per day was 8.1 fish with longlines as against 2.9 with harpoons. Longlining also improved efficiency by lengthening the fishing season. In 1962 fishing continued into November whereas it was usually over at mid September when fishing was limited to harpooning.

Sampling for length and weight showed that swordfish caught in 1962 averaged 190 lb and showed no differences with fishing ground or months whereas in 1961 the average weight of fish sampled was 196 lb but there were average weight differences up to 30 lb between adjoining fishing areas.

EXPLORATORY FISHING. Between July and September 1962 four exploratory fishing cruises were carried out, mainly on Georges and Browns Banks. Experimental fishing with longlines, bottom trawls, handlines, and gill nets was used to discover commercial concentrations of pelagic fish.

Forty-four sets of longline gear produced 197 blue sharks, 16 porbeagles, 4 swordfish, 3 mako sharks, and 1 brown shark. Bottom trawls were used in 52 sets and caught mainly haddock and herring. Herring were abundant on Georges Bank in September. Handlining catches consisted of 4 dusky sharks and 1 porbeagle.

Marking methods for large fish are being explored. Dart type tags have been used and trials with branding begun. One branded fish was caught again 250 miles away from the site of marking.

SALMON

Canada has in the Miramichi and other rivers some of the world's most famous salmon waters. The opportunity to fish these rivers attracts many anglers from outside the area. The fishery also provides valuable recreation for Canadians. The contribution to the national and local economies of angling with its established fishing camps and employment of guides is undoubtedly high, but it is difficult to estimate with confidence. In addition to the sports fishery there are commercial fisheries with drift and trap nets which support inshore fishermen. Sports and commercial fishermen are in competition for fish and each seeks regulations favourable to its interests. Equitable management can only be based on biological studies of the fish and its reaction to exploitation at different stages.

The conflict between two users of the salmon resource is further complicated by human activities which tend to destroy the resource without using it. Farming and lumbering near salmon streams alter the habitat and reduce its suitability as homes for salmon. More dramatic are the results of forestry and mining. In order to suppress epidemic outbreaks of spruce budworm, affected areas are sprayed with DDT formulations. This is necessary to prevent lethal defoliation of valuable forest stands, but DDT falling on the water kills salmon and their food. Several metallic ions when present in fresh water repel salmon or kill them, and also destroy food organisms. Drainage from mining operations are found to carry lethal concentrations of heavy metal ions. Problems raised by these menaces to the salmon are under study.

Except as modified by threats to the salmon's habitat, the general course of salmon research has followed lines laid down in 1949 by the Federal-Provincial Co-ordinating Committee on Atlantic Salmon. The program and its accomplishments have been under review during 1962 as a prelude to assessment and possible re-direction of research.

Salmon are anadromous. They mature in salt water for 1 or 2 (or more) years before returning to fresh water to spawn. Eggs are deposited in autumn and protected by gravel in redds dug by the fish. Eggs hatch during winter and remain in the gravel as alevins until spring when they emerge as fry which are later called fingerlings or underyearlings. After about a year, fry gain characteristic black bars and become parr. After 1 or 2 years as parr, the bars disappear, the young salmon becomes silvery, and migrates to sea as a smolt. Fish that remain at sea for 1 year before maturing return as grilse. Fish that grow at sea for 2 years or longer return as large salmon.

CATCH STATISTICS AND EXPERIMENTAL FISHING. An important part of this work is analysis of salmon catches to provide an objective measure of the status of the salmon populations. Since 1949 the Department of Fisheries has assembled annual records of commercial and angling catches in the Maritime region in three areas, Gulf, Atlantic, and Fundy. Commercial landings in 1962 in the Maritime region (including a pro-rated estimate for the Quebec section) totalled 1.42 million lb, a 19% increase over the 1961 total. The Gulf and Atlantic areas increased by 33% and 10% respectively, and the Fundy area decreased by 40%. Angling catches increased by 21% over 1961 but catch per rod-day fell off from 2.1 fish in 1960 to 1.9 fish in 1962. There was an increase of nearly 30% in fishing effort without a corresponding increase in catch.

Through the 1949-60 period total commercial and angling catches follow similar patterns. Both seem to be governed by the strengths of successive year-classes or by water conditions. Commercial landings since 1870 have fluctuated widely around an average of 2.5 million lb with indications of a relationship between sea water temperatures and catches. The present upward trend from 1.4 million lb may continue if the current decline in sea water temperatures continues and if deterioration of the freshwater habitat can be controlled.

For Newfoundland, statistics provided by the Department of Fisheries show commercial landings totalling 2.2 million lb or 4% higher than in 1961. By increasing effort 38%, Newfoundland anglers caught 53% more fish. In Quebec commercial catches were 0.5 million lb, 7% lower than in 1961.

A commercial-type trap for sampling salmon runs is maintained in the Miramichi estuary throughout the open-water season. Counting weirs or fences are established in the Northwest Miramichi at Curventon, and higher up at Camp Adams. In the estuary counts of both grilse and large salmon during the fishing season were among the lowest recorded since 1954. Grilse were quite plentiful after September 1 and the annual total was average. This suggests satisfactory survival from the good 1961 smolt run. The total season count of large salmon was the lowest on record. The very low catch during the commercial season parallelled the poor catches in commercial gear in the estuary. At Curventon there was a good run of grilse but large salmon were few. The grilse reached Camp Adams in fair numbers. The relationship between the poor runs and mine effluent is dealt with elsewhere.

TAGGING. Since 1958 tagging has been used to supplement marking salmon smolts by fin clipping in studies of homing and of the contribution of Miramichi smolts to various Atlantic fisheries. One of the smallest taggings, 750, at Camp Adams in 1960, has already produced interesting results. Of the 25 recoveries to date one was recovered at Greenland as a post grilse. All the rest were early returns to the Miramichi system, or its approaches. There were 12 grilse at Curventon between June 23 and July 25, 5 grilse in the Miramichi estuarial fishery between June 26 and August 7, 1 grilse angled on July 19, all in 1961. Six large salmon were taken in 1962 between May 29 and June 12. Of these, 5 were taken in set nets in the Miramichi estuary and 1 by drift net in Northumberland Strait.

RELATION OF FOREST SPRAYING TO SALMON. Mature stands of spruce and balsam are subject to killing defoliation by spruce budworms when they appear in epidemic numbers. Budworms can be controlled relatively cheaply by spraying various formulations of DDT from aircraft. After spraying this poison makes its way into salmon waters in one way or another, killing both salmon and their food. Much effort has been diverted to assessing damage and seeking ways of minimizing it. Some observations were made co-operatively by Board and Department staffs.

In 1962 effects of spraying the Cains River watershed with DDT were monitored by holding caged fish near its outlet and comparing mortalities among them with those of controls in an unsprayed area. All affected fish were dead within 12 days of the start of spraying. Mortalities among controls were salmon parr 3%, salmon fry 17%, and trout fry 4%.

DDT is regarded as a specific poison for insects and as such may be expected to be destructive of the aquatic insect larvae that fry and parr live on. The destruction and restoration of the insect population in sprayed New Brunswick streams have been followed since 1955. Observations show significant recovery of insect populations within 5 or 6 years following spraying at ½ lb DDT per acre.

A new systemic insecticide, Phosphamidon, may control budworm effectively. Exploratory tests conducted co-operatively by forestry and fisheries interests during 1962 on the Taxis

River did not show damage to young fish or to aquatic insects.

Since 1951 an annual census of young salmon in various Miramichi tributaries was started. It has been continued and expanded so that it now provides a basis for assessing effects of different spraying procedures on young salmon at various stages. An analysis in 1962 of all data to date indicates clearly that numbers of young salmon at all stages are greatly reduced by spraying and that the extent of reduction is related to the amount of DDT used.

EFFECTS OF CONTROLLING MERGANSERS ON RUNS OF ADULT SALMON. Research on the Pollett River and elsewhere has demonstrated that thorough control of mergansers increases production of salmon smolts from a stream. It remains to be shown that the number of usable returning adults is correspondingly increased. An experiment to establish this point has now been begun on the Margaree River where returning adults can be kept track of effectively and where base lines are now established. The project involves several agencies working in a co-ordinated effort. In addition to the Fisheries Research Board, the Canadian Wildlife Service, the Nova Scotia Department of Lands and Mines, and the Fish Culture Development and Protection Branches of the Department of Fisheries are all involved in various aspects of a co-operative venture.

BEHAVIOUR. It seems likely that remedial action will be necessary to help salmon stocks surmount hazards placed before them by human activities. Effective action must help salmon to help themselves and will depend on knowledge of normal behaviour of salmon. Studies of buoyancy in young salmon and movements within a stream were begun during 1962.

It was found that the initial filling of the swim bladder in alevins was delayed by holding them in fast currents. In general young salmon in swift currents were less buoyant than those in still water. Smolts were more buoyant than parr. These observations are related to fish holding their places in streams and have applications in stocking.

Parr were found in both pools and riffles and individuals tended to remain in small "home areas". They showed a tendency to return to these when moved elsewhere.

TROUT

Trout provide a much valued resource for recreation and the use of tourists. It is difficult to fix a monetary value on a recreational fishery. It is certain, however, that with increased population in New Brunswick and beyond, the value of the trout resource will increase and with it the need for knowledge on management. Natural waters ordinarily produce trout to their capacity. The need is to modify the fish habitat so as to have it produce more trout or to make fish already there more available. This was done at Crecy Lake, N.B., where a combination of stocking, fertilization, and predator control greatly increased the yield of a small lake in an infertile area. Habitat control approaches completeness in utilization of farm ponds for fish or in put-and-take stocking. Interest in farm ponds is increasing now and both expedients should be considered when appropriate.

A pond made by damming Ellerslie Brook in Prince Edward Island stopped movement of fish out of the stream. It made trout more available to anglers so that the potential of the brook was fully utilized. However production of sea run trout was lost. Hatchery trout were planted in the brook estuary below the dam in 1961 to remedy this loss. Results to date show good growth and good survival of these fish. Further tests are proposed in 1962 to test this new technique of management.

In Ellerslie Brook during 1959 and subsequently, minor modifications (dams, deflections, cover) were made to improve the habitat for trout. A marked improvement in carrying capacity for older trout resulted in some of the study areas. In addition trout became more available to anglers. The net effect on the whole system will be studied over the next two years.

As increased control of both populations and habitat are contemplated, the adaptability of two species of trout to management was compared. When brook trout and rainbow trout are both planted as yearling fish of catchable size, so that the lake is essentially an over-winter holding area, survival of the two species is comparable. When brook and rainbow trout are stocked as fish of the year, so as to use the lake as a growth area, survival was on the whole somewhat better for brook trout.

POLLUTION

Pollution of natural waters is a national and international problem of great concern. It is being studied actively by scientists interested in public health and industrial implications, and valuable information is being accumulated. However, all information collected for other interests is not necessarily applicable to fishery management. In some cases, for example, tolerances of fish to lethal substances are much lower than public health requirements. The study of pollution from the fisheries point of view requires application of known information gained by other agencies and the execution of special research necessary to meet fisheries needs.

Relative to other areas, the situation about polluted waters in the Maritimes is not bad. There are, however, serious instances of pollution and some of these are on important fishing rivers. Pollution is easier to prevent than to remedy, and now is the time to profit from experience in other areas which have been fouled by the advance of industrialization. In general opportunities for constructive application of research on fisheries pollution are good as provincial governments in the Maritimes have set up or are setting up water boards whose co-operation in meeting fisheries needs may be anticipated.

There are many current and potential problems in the Maritimes calling for research and some selection is necessary. The effects of zinc and copper ions on aquatic life have been selected as most important because of the new upsurge in activity in base metal mines in northern New Brunswick. Parallel investigations in laboratory and field studied lethal and sublethal effects, especially avoidance reactions, of anadromous fishes.

AVOIDANCE BY SALMON OF MINE EFFLUENTS. In the summers of 1960, 1961, and 1962 migrating salmon in the Northwest Miramichi River moved downstream in unusual numbers. Between 1954 and 1959 only 1.8% of salmon going upstream came down again. In the three following years percentages were 22.4, 13.7, and 10.0. Downstream movement was attributed to effluents from a re-opened base metal mine on the tributary Tomogonops River. Of fish which moved downstream about half were never heard of again. Of those that were again noted over three quarters proceeded upstream and the rest were taken in various commercial or sports fisheries.

The concentration of zinc and copper which causes avoidance among adult migrating salmon is important to know. It was suggested in last year's report that 15% of the incipient lethal level was a safe level of metal pollution. Results in 1962 suggest that the value may be about 40%. The subject is still under review.

Studies of the effects of heavy metal pollution in the Northwest Miramichi have called for a detailed examination of the chemistry of the water. These analyses in addition to meeting their main purpose gave a revealing year-round picture of the chemistry of a river. They are being distributed to interested groups.

Observations in the Northwest Miramichi River were followed up by laboratory experiments on young salmon to study avoidance of heavy metals. The experiments allowed the fish to choose between natural water and water to which metallic ions were added. Although analysis of results is not complete, preliminary examination provides convincing evidence of avoidance of copper at 7.5% of the incipient lethal level. Zinc also gave positive results at low concentrations.

LETHAL CONCENTRATIONS OF ZINC AND COPPER. Knowledge of lethal levels of pollutants is necessary to show cause of death of fish in natural waters and provides a useful criterion for other studies on pollution. For example the incipient lethal level (ILL) is the highest concentration which just fails to kill 50% of fish. The ILL was found to depend upon water hardness for both zinc and copper. When the pH was raised above 8.5, zinc for most practical purposes was not lethal to salmon. At low temperatures the ILL is raised. When zinc and copper are used in combination the effect is greater than the sum of their individual lethal actions.

EXTREME FLOWS IN THE SAINT JOHN RIVER. Proper river management depends upon knowledge of extreme flows. For fisheries and pollution investigations the severity of low flows during summer is most important. A chart has been prepared for the Saint John River from which may be read how often any given low (or high) flow may be expected to occur in a representative period.

MATHEMATICAL STATISTICS

Work in mathematical statistics at the St. Andrews Station is involved in three kinds of objectives. Supervision is provided for putting catch and fishing effort statistics and data from census surveys on IBM cards for routine processing prior to critical analysis. Consulting service is provided to biological investigations to assist in planning sampling and experimental routines, and with the analysis of data. Much emphasis is given to original theoretical work.

In connection with groundfish studies, analysis of IBM records show that there is a bias in the collection of catch-effort data in favour of larger vessels and successful trips. Study of fishing power or performance of vessels shows that within a gross tonnage class size of net is an important factor. Analysis of records demonstrates definite selection of the major species landed per trip but the extent to which this is a result of selective fishing remains to be determined.

Theoretical studies were primarily exploratory in nature. Simulation of searching for contagious distributions by hypothetical fishing vessels emphasized both the importance of schooling and clustering behaviour of fish to fishing success, and the need to develop more efficient sampling techniques. Other theoretical studies were concerned with fish production models. The covariance and multiple regression analysis of growth efficiency show the relative importance of rations, temperature, and relative size.

OCEANOGRAPHY

Oceanography studies the environment of fish. Its inclusion as part of fisheries research has long been accepted by the Board which for many years recognized and carried out all Canadian research on the subject. More recently other agencies have assumed responsibility for Canadian national needs in oceanography.

The Board's oceanographers on the Atlantic Coast work out of two headquarters. The Atlantic Oceanographic Group is accommodated in the Bedford Institute of Oceanography in Dartmouth, N.S., but functions independently under the Board's direction. The Institute is operated by the Marine Sciences Branch of the Department of Mines and Technical Surveys and joint projects with it are pursued in closest co-operation. During 1962 the Atlantic Oceanographic Group moved to its present accommodation from Halifax, N.S.

The Atlantic Oceanographic Group is actively engaged in projects on the continental shelf, particularly in the Gulf of St. Lawrence. The investigations stem from the general needs of east coast fisheries for basic research in oceanography and from various national and international requirements of the Fisheries Research Board and the Canadian Committee on Oceanography. Some of the projects are carried out with other Board Stations or member agencies of the Canadian Committee on Oceanography.

Oceanography more closely related to fisheries is centred at St. Andrews. Much of the work of defining the environment for fish is done in active on-the-spot co-operation with biological investigations.

Work at sea is carried out on C.N.A.V. Sackville supplied by the Royal Canadian Navy. Board vessels, such as the M. V. A. T. Cameron and M. V. Harengus are also used as well as ships controlled by other government agencies.

GEOLOGY AND GEOCHEMISTRY. Work in geology and geochemistry is based at the Atlantic Oceanographic Group and is carried out mainly in the Gulf of St. Lawrence, the Scotian Shelf and Grand Banks areas.

Studies of the calcium carbonate system are considered to be of prime importance because of its close association with nutrient conditions, sedimentary deposition, shell composition, and environment. The calcium carbonate content of the bottom material increases seawards and centrally from the Saguenay River towards the mouth of the St. Lawrence River, indicating that no important detrital calcitic material enters the river above the Saguenay River. The carbonate content is high along the south coast of Anticosti Island, reflecting its geological composition.

Samples of rock, sediment and a molluscan shell were analyzed from the sediments around Anticosti Island to establish the source of marine carbonate. All samples with the exception of the molluscan shell were calcitic in nature and are similar to the limestone of Anticosti Island. Some molluscs secrete pure calcite or aragonite whereas others secrete a mixture of both, depending on the temperature and salinity environment. An examination of shells is being carried out to key populations and the bottom temperature environment by X-ray diffraction techniques. In the water the calcium ion concentration holds to about 9-11 millimolar but drops to about half this value near the Saguenay River. Surface concentrations vary considerably, reflecting the influence of biological activity. It has not been possible as yet to establish whether the solubility product is exceeded in Gulf waters.

Some 20 bottom samples have been examined for P_2O_5, Fe_2O_3, MnO and Na/K ratios. High P_2O_5 concentrations are found near shore and along the slopes of the Laurentian Channel, possibly associated with areas of high organic productivity. Fe_2O_3 concentrations are high in the centre of the St. Lawrence River, the largest percentage of which is being deposited as $Fe(OH)_3$ or being oxidized to Fe_2O_3 at the sediment-water interface. It is across this fundamental sedimentary boundary that nutrients and trace elements diffuse between the sediment and the overlying waters; consequently, the extent and degree of oxidation and composition of this material is fundamental to other chemical studies.

Preliminary studies have also been made on the levels of concentration of exchangeable heavy metals in the sediments of the Gulf. The values vary between 1-4 ppm in the near shore areas to 7-13 ppm in the offshore areas. In some locales concentrations ranged from 14-35 ppm. Exchangeable heavy metal concentrations reflect the sorption capacity of the sediments--

clays and silts being the highest; sand, clastic fragments and detrital carbonate being very low.

CHEMICAL OCEANOGRAPHY. Two conductance salinometers, and one inductive sea-going bridge have been overhauled and recalibrated by the Atlantic Oceanographic Group. High precision and low precision titration assemblies have been set up and are in use for specialized analyses in the salinity processing laboratory.

Two research programs are under way. They concern the calcium carbonate system in the Gulf of St. Lawrence and the solubility of ferric hydroxide. The latter investigation stemmed from an attempt to identify some of the suspended matter responsible for turbidities in Gulf waters. It was found that concentrations were an order of magnitude too low to be of any consequence in the overall turbidity, but the method employed provided an alternate means of measuring solubility products to those now generally employed. The value found was $10^{-37.5 \pm 0.5}$ which is in reasonable agreement with values found using other methods.

BENTHIC BIOLOGY. The benthic biological surveys in connection with the work of the Atlantic Oceanographic Group were modified in 1962 from 1961 to study the biological communities in five distinct sedimentary areas. The sampling techniques proved adequate for small species but not for large individuals.

The greatest variation in the numbers of species and total biomass occurred in sediments of unsorted gravel rather than on level bottom composed of sand or mud. For instance, at three level bottom stations 95% of the total biomass could be accounted for by seven species or less, while in other regions 17 species accounted for 95% of the standing crop.

PHYSICAL OCEANOGRAPHY BY THE ATLANTIC OCEANOGRAPHIC GROUP. Over the past 15 years there have been many observations of temperature and salinity in the Gulf. These have served to indicate the broad seasonal patterns and distribution of temperature and salinity, but only limited calculations of geostrophic flow have been undertaken.

Dynamic computations are available for many of the Sackville cruises in the Gulf and a program is well under way in a study of geostrophic flow. Sections have been checked for salt and volume transports. A clear cut pattern of flow is evident in Gaspé Passage and along the Laurentian Channel to Cabot Strait. The results to date in Cabot Strait are not encouraging.

In conjunction with this work studies are in progress on the variation of property related to the phase of tide. Simultaneous current, temperature and salinity observations were taken in Gaspé Passage. A detailed study has not been completed but initial evidence suggests no systematic variation in properties related to the phase of tide. The results indicate that over a 2-day period, there is a change in property distribution apparently related to non-tidal parameters.

CIRCULATION. At St. Andrews emphasis is given to surface and bottom circulation as indicated by drift bottle and sea-bed drifter releases and recoveries along the Canadian Atlantic Coast from the Bay of Fundy to the Gulf of St. Lawrence. In the Bay of Fundy the open circulation region was featured in 1962. This regime started earlier and was less intense than in 1961. In Northumberland Strait the change from a general easterly transport during summer to a westerly movement in autumn was more pronounced than in recent years. In the eastern sector of the Strait there was a weak easterly flow. Cabot Strait releases of drift bottles showed a weakening inflow along the Newfoundland west coast toward autumn accompanied by diversion toward the Magdalen Shallows. Releases in Central Cabot Strait showed a northeasterly drift in summer changing to southward later in the season. Along the Cape Breton shore the southerly drift persisted at all times.

A local eddy-like counter-clockwise bottom drift between Gaspé Peninsula and Orphan Bank has been inferred from recoveries of sea-bed drifters but the main feature of the bottom circulation in the southwestern Gulf of St. Lawrence is a southeasterly drift along the edge of the Magdalen Shallows. On the Scotian Shelf in Emerald Bank area, bottom drift was westward at an average speed of 0.7 mile per day.

In Cabot Strait other means of measuring currents involved use of radar drift poles for the surface drift and Pisa tubes on the bottom. Forty-eight hour tracking of drift poles showed a drift of 16 miles a day toward the south on the Cape Breton side and 8 miles a day toward the north on the Newfoundland side. At 180 metres depth Pisa tubes over a 66-hour period gave an average current velocity along the bottom of 0.11 knots at 130°.

TEMPERATURE AND SALINITY. St. Andrews oceanographers monitor coastwise surface temperatures at six stations between the Bay of Fundy and the Gulf of St. Lawrence. Surface temperatures were below the long-term averages by 0.2 to 1.0° C. During the first 6 months of 1962 surface temperatures were generally higher than those of 1961 which had been much below normal. Bottom temperatures observed at three stations were below average during 1962 with a greater departure from average in the Halifax region than in the Bay of Fundy area.

Temperature and salinity observations at St. Mary Bay show marine climates of two types. The lower third of the Bay is dominated by conditions at the entrance to the Bay of Fundy. The head of the Bay has a purely local regime.

Surface temperatures in Northumberland Strait were generally below average. The salinity stratification was less pronounced than usual and the autumn overturn early.

The cooling trend experienced since the beginning of the fifties continues with minor year-to-year variations for both surface and bottom temperatures.

ACKNOWLEDGEMENT. An important part of the studies of surface currents has been made possible by the co-operation of the masters and officers of the following vessels: CPR <u>Princess Helene</u>; CNR <u>Bluenose</u>, <u>Abegweit</u>, <u>William Carson</u>, <u>Lord Selkirk</u>;

Sambro and Lurcher Lightships. Their interest and help is gratefully acknowledged.

OTHER INVESTIGATIONS

SMELT. The Miramichi smelt fishery has been followed through Fisheries Officers' reports, fisheries statistics, and log records from ten co-operating fishermen. The catch per licensed net was 200 lb above average and the catch per net-day 29% above average. However, because of poor prices, reduced effort, and low total catch the season was rated as poor.

The 1962 spawning run of fairly large fish was quite good. Precipitation was 60% average during the run. These circumstances should make for good larval production.

INSHORE COD. Work on oxygen requirements of cod in confinement has been completed and reported. Earlier results showing less oxygen consumption on a per pound basis by large cod than small ones, by starved cod than feeding ones, and by crowded cod than uncrowded ones have been confirmed. Increasing temperature raises oxygen consumption in both starved and fed cod. Handling cod also increases oxygen consumption by as much as 70%. Moderate reduction in the availability of oxygen does not change the amount used significantly. This may place the fish under stress as it must pump more water over its gills to maintain the oxygen supply to its blood.

BULLETIN ON ATLANTIC COAST FISHES. Preparation of text and illustrations for this needed work is proceeding satisfactorily and should be completed during 1963.

STAFF LIST BY INVESTIGATIONS

(April 1, 1962 to March 31, 1963)

Staff other than seasonals and term are classified as of March 31, 1963.

Director	J. L. Hart, Ph.D.
Director's Secretary, Clerk 4	Winifred E. Young
Assistant Director, Principal Scientist	L. R. Day, M.A. (to March 13/63)
Assistant Director, Principal Scientist	C. J. Kerswill, Ph.D. (from March 1/63)

Groundfish Investigations

Principal Scientist in charge	W. R. Martin, Ph.D. (to Dec. 31/62)
Senior Scientist in charge	F. D. McCracken, Ph.D. (from Jan. 1/63)
Senior Scientist	F. D. McCracken, Ph.D.
Senior Scientist	L. M. Dickie, Ph.D.
Senior Scientist	Y. M. L. Jean, Ph.D.
Associate Scientist	F. W. H. Beamish, Ph.D. (from July 3/62)
Associate Scientist	A. C. Kohler, Ph.D.
Associate Scientist	P. M. Powles, M.Sc. (educational leave to April 30/62)
Technician 4	D. N. Fitzgerald
Technician 4	G. J. W. Sullivan
Technician 2	M. F. Fraser
Technician 2	R. M. MacPherson
Technician 2	N. J. McFarlane
Technician 1	G. J. DeLouchry, B.A.
Technician 1	L. L. MacLeod, B.Sc. (from April 30/62)
Technician 1	R. J. Thurber
Assistant Technician 2	R. K. Robicheau
Assistant Technician 2	Irma I. Thompson
Stenographer 3 (Secretary)	C. Ruth Garnett
Clerk 3	Shirley W. DeLong
Associate Scientist - Term	D. H. Steele, Ph.D. (June 4 - Aug. 22/62)
Technician 3 - Term	T. T. Miyata, B.Sc. (to Sept. 11/62)
Clerk 1 - Term	Miriam R. Carson (Jan. 14 - Feb. 13/63) (March 1 - 31/63)
Student Assistant	Janice I. Bartlett, B.Ed. (May 22 - Aug. 22/62)
Student Assistant	V. S. S. Kennedy, B.Sc. (May 14 - Sept. 6/62)
Student Assistant	J. S. Wasson (May 7 - Sept. 12/62)
Student Assistant	I. R. Woolfrey, B.Sc. (May 30 - Aug. 29/62)
Port Observer - Part-time	Fred Berrigan
Port Observer - Part-time	R. C. MacMillan

Anadromous Fishes

(a) Salmon Investigations

Principal Scientist in charge	C. J. Kerswill, Ph.D. (to Feb. 28/63)
Senior Scientist in charge	M. W. Smith, Ph.D. (from March 1/63)
Senior Scientist	P. F. Elson, Ph.D.
Associate Scientist	R. L. Saunders, Ph.D.
Assistant Scientist	J. H. Gee, M.Sc. (to Jan. 10/63)
Technician 3	E. J. Schofield
Technician 2	R. J. Gibson, B.A. (educational leave without pay from Sept. 12/62)
Technician 1	P. R. Graves
Technician 1	I. M. Jones
Assistant Technician 3	H. P. Barchard
Assistant Technician 3	W. G. Irving
Assistant Technician 2	L. R. MacFarlane
Stenographer 2	R. Marion Haley
Assistant Technician 3 - Term	G. W. Cooper (April 2 - Nov. 30/62)
Assistant Technician 1 - Term	W. R. Currie (April 2 - Nov. 30/62)
Assistant Technician 1 - Term	E. K. Geldart (to Nov. 30/62)
Assistant Technician 1 - Term	J. H. King (April 2 - Nov. 30/62)
Assistant Technician 1 - Term	E. C. Tucker (April 2 - Nov. 30/62)
Student Assistant	E. A. J. Chambers (May 9 - Sept. 17/62)
Student Assistant	R. H. Currie (May 7 - Sept. 7/62)
Student Assistant	C. D. Grant, B.Sc. (May 10 - Sept. 12/62)
Student Assistant	Beniah Hicks, B.A. (June 1 - Aug. 15/62)
Student Assistant	J. G. Marshall (May 10 - Sept. 7/62)
Student Assistant	Nancy M. Peters (May 14 - Sept. 14/62)
Casual employees	

(b) Trout Investigations

Senior Scientist in charge	M. W. Smith, Ph.D.
Associate Scientist	J. W. Saunders, M.Sc.
Technician 1	C. R. Hayes
Technician 1	Cyril Williams
* Assistant Technician 2	Mary Holmes
Student Assistant	D. K. Rushton, B.Sc. (May 29 - Aug. 31/62)
Pond Guardian	W. A. Simpson
Pond Guardian	J. O. Doucette
Casual employees	

* Also general laboratory assistance

Crustacea

Lobster Investigations

Principal Scientist in charge	D. G. Wilder, Ph.D.
Associate Scientist	D. W. McLeese, Ph.D.
Associate Scientist	D. J. Scarratt, Ph.D.
Technician 2	R. C. Murray
Technician 1	D. E. Graham
Technician 1	U. J. Walsh
Clerk 1	F. Willa Williamson
Student Assistant	Susan Carey (May 10 - Sept. 12/62)
Student Assistant	Elizabeth J. Quance (May 14 - Sept. 11/62)

Pathology

Associate Scientist in charge	Jaap Demelker, Phil. Doctorandus (to May 2/62)

Pelagic

Senior Scientist in charge	S. N. Tibbo, M.A.
Senior Scientist	R. A. McKenzie, M.A.
Assistant Scientist	T. R. Graham, M.Sc. (to Aug. 2/62)
Technician 2	E. G. Sollows
Technician 1	A. W. Holt
Technician 1	C. F. Monaghan
Assistant Technician 3	A. W. Brown
Assistant Technician 3	C. A. Dickson
Assistant Technician 2	Cariene D. Burnett
Assistant Technician 1	W. H. Dougherty
Stenographer 2	Janet L. Mahoney
Student Assistant	Nareshwar Das, M.Sc. (May 18 - Sept. 18/62)
Student Assistant	C. R. Wyman (May 7 - Sept. 7/62)

Mollusca

Senior Scientist in charge	J. C. Medcof, Ph.D.

(a) Clam and Scallop Investigations

Associate Scientist in charge	N. F. Bourne, Ph.D.
Associate Scientist	Anand Prakash, Ph.D.
Technician 3	J. S. MacPhail
Assistant Technician 3	R. A. Chandler, B.A. (from April 16/62)
Assistant Technician 3	Esther I Lord
Student Assistant	Jonet C. Glennie (May 7 - Aug. 24/62)

(b) Oyster and Quahaug Investigations

Associate Scientist in charge	R. E. Drinnan, B.Sc.
Assistant Scientist	M. L. H. Thomas, M.S.A. (from Oct. 1/62)
Technician 3	S. E. Vass, B.Sc.
Technician 1	E. B. Henderson
Maintenance Supervisor 1	K. R. Oatway
Associate Scientist - Term	W. B. Stallworthy, Ph.D. (June 19 - Sept. 7/62)
Technician 1 - Term	B. T. Khouw (to Sept. 10/62)
Assistant Technician 1 - Term	R. R. Payne (June 27 - Sept. 7/62)
Maintenance Helper - Term	J. L. Ellis (May 1 - Sept. 28/62)
Student Assistant	Austina V. Kennedy, B.Sc. (May 14 - Aug. 31/62)
Student Assistant	Annabelle M. M. Thorne (June 25 - Aug. 24/62)
Casual employees	

Biological Oceanography

Senior Scientist in charge	L. M. Lauzier, D.Sc.
Technician 4	J. G. Clark
Technician 2	J. H. Hull
Assistant Technician 1	Therese M. Parker (L.W.O.P. Sept. 17 - Oct. 31/62)
Student Assistant	J. L. Gosbee (May 22 - Sept. 7/62)
Student Assistant	E. R. Joubert, B.Sc. (May 17 - Aug. 16/62)

Pollution Studies

Associate Scientist in charge	J. B. Sprague, Ph.D.
Technician 3	W. V. Carson, B.Sc.
Student Assistant	Barbara A. Ramsay (May 28 - Aug. 31/62)

Mathematical Statistics

Senior Scientist in charge	J. E. Paloheimo, M.A.
Associate Scientist	E. L. Cadima, Lic. Math. (from Oct.11/62)
Technician 2	G. S. Mann, B.Sc.
Assistant Technician 1	G. E. Fawkes (from July 3/62)
Associate Scientist - Term	W. R. Knight, Ph.D. (June 11 - Aug.10/62)

Fishing Efficiency

Senior Scientist in charge	P. J. G. Carrothers, S.M.I. (from Sept. 1/62)

Short-term Investigations and Technical Services
(Museum, Library, Photography and Drafting, Observer)

Principal Scientist in charge	L. R. Day, M.A. (to March 13/63)
Principal Scientist in charge	C. J. Kerswill, Ph.D. (from March 1/63)
Technician 1	P. W. G. McMullon
Technician 1	F. E. Purton
Assistant Technician 2	F. B. Cunningham
Clerk 2	M. Beryl Stinson
Senior Scientist - Term	W. B. Scott, Ph.D. (June 4 - Aug. 3/62)
Student Assistant	Marion E. Cook, B.A. (May 22 - Sept. 7/62)
Student Assistant	Janet D. Given (June 4 - Aug. 31/62)

Administration and Maintenance

Administrative Officer 3 in charge	D. S. Mann, M.B.A.
Administrative Assistant	W. D. Burton

Accounts, Purchases, Stores and Personnel

Clerk 3	Frances L. Stinson
Stenographer 3	Charlotte A. Gibson
Storeman 2	B. H. Foster

Director's Secretary, Mail, Files and Switchboard

Clerk 4 in charge	Winifred E. Young
Stenographer 3	M. Barbara Stickney
Stenographer 2	Frances J. Armstrong
Clerk 2	Dorothy M. McLaughlin
Clerk 1	Dorothy M. Fawkes
Clerk 1 - Term	Nancy R. McCullough (June 1 - Aug. 31/62)
Casual employees	

Maintenance, Services and Boats (St. Andrews)

Technician 5 (Research) in charge	H. Y. Brownrigg
Maintenance Supervisor 1	F. M. Langley
Maintenance Craftsman 1	P. M. Green
Maintenance Craftsman 1	J. F. Johnson
Maintenance Craftsman 1	F. G. Lord
Maintenance Craftsman 1	C. S. Tucker
Caretaker 4	K. W. Johnston
Caretaker 3 (Groundsman)	D. A. Stinson
Watchman	H. E. Lee
Truckman	G. F. Wentworth
Cleaning Service Man	C. E. Teakles
Laboratory Helper	H. M. Sampson

M/V "Harengus"

Captain	H. H. Butler
Chief Engineer	Harvey Yarn
2nd Engineer	Stanley Evans
Mate	E. A. Mason
Boatswain	W. J. Horne
Cook-Steward	Edgar Kendall (to Aug. 3/62)
Cook-Steward	Phillip Comeau (from Aug. 2/62)
Twinehand	E. B. Fevens
Twinehand	L. V. Richard (on leave N.S.W.C.B. to April 26/62)
Twinehand	T. V. Richard (to April 26/62)
Deckhand	Vessie Richard (to April 26/62)
Deckhand	T. V. Richard (from April 27/62)

M/B "Mallotus"

* Technician 1 (Capt.)	W. G. Carson
Seaman	F. R. Johnson

* Responsible to Assistant Director for technical aspects of work

M/B "Pandalus II"

Captain	P. T. Ossinger
Engineer - Term	A. D. Roberts (April 10 - Nov. 13/62)
Cook-Deckhand - Term	Alexander MacDonald (April 10 - Nov. 9/62)

SCIENTIFIC STAFF

Biological Station, St. Andrews, N. B.

J. L. Hart, Ph.D. (Toronto), F.R.S.C., Director.
L. R. Day, M.A. (Western Ontario), Assistant Director. To March 13.
C. J. Kerswill, Ph.D. (Toronto), Assistant Director. From March 1.

Biological Oceanography

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

Fishing Efficiency

P. J. G. Carrothers, S.M. (Mass. Inst. Tech.). From September 1.

Groundfish

W. R. Martin, Ph.D. (Michigan). To December 31.
F. D. McCracken, Ph.D. (Toronto).
L. M. Dickie, Ph.D. (Toronto).
Y. M. L. Jean, Ph.D. (Toronto).
F. W. H. Beamish, Ph.D. (Toronto). From July 3.
A. C. Kohler, Ph.D. (McGill).
P. M. Powles, M.Sc. (Western Ontario).
D. H. Steele, Ph.D. (McGill). Term, June 4 to August 22.

Lobster

D. G. Wilder, Ph.D. (Toronto).
D. W. McLeese, Ph.D. (Toronto).
D. J. Scarratt, Ph.D. (Wales).

Mathematical Statistics

J. E. Paloheimo, M.A. (Toronto).
E. L. Cadima, Lic. Math. (Lisbon). From October 11.
W. R. Knight, Ph.D. (British Columbia). Term, June 11 - August 10.

Mollusca

J. C. Medcof, Ph.D. (Illinois).
N. F. Bourne, Ph.D. (Toronto).
R. E. Drinnan, B.Sc. (London).
Anand Prakash, Ph.D. (British Columbia).
M. L. H. Thomas, M.S.A. (Ontario Agricultural). From October 1.
W. B. Stallworthy, Ph.D. (Toronto). Term, June 19 to September 7.

Pathology

Jaap Demelker, Phil.Doctorandus (Leiden). To May 2.

Pelagic

S. N. Tibbo, M.A. (Toronto).
R. A. McKenzie, M.A. (Toronto).
T. R. Graham, M.Sc. (Liverpool). To August 2.

Pollution

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

Salmon and Trout

C. J. Kerswill, Ph.D. (Toronto).
M. W. Smith, Ph.D. (Toronto).
P. F. Elson, Ph.D. (Toronto).
J. W. Saunders, M.Sc. (Laval).
R. L. Saunders, Ph.D. (Toronto).
J. H. Gee, M.Sc. (British Columbia). To January 10.

Taxonomy

W. B. Scott, Ph.D. (Toronto). June 4 - August 3.

Non-Staff

C. M. Boyd, Ph.D. (Scripps). Volunteer Investigator.
Winifred Frost, D.Sc. Consultant.
F. P. Ide, Ph.D. (Toronto). Consultant.
Irené Scarratt, M.A. (Mount Holyoke). Volunteer Investigator.
Vladislava J. Steele, M.Sc. (McGill). Volunteer Investigator.

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(January 1, 1962, to December 31, 1962)

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Gee, J. H., and T. G. Northcote. Comparative ecology of two sympatric species of dace (*Rhinichthys*) in the Fraser River System, British Columbia. J. Fish. Res. Bd.

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Tibbo, S. N., and T. R. Graham. Biological changes in herring stocks following an epizootic. J. Fish. Res. Bd.

Tibbo, S. N., D. J. Scarratt and P. W. McMullon. An investigation of herring (<u>Clupea harengus</u> L.) spawning using free-diving techniques. J. Fish. Res. Bd.

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Movements, growth and survival of marked and tagged lobsters liberated in Egmont Bay, Prince Edward Island. J. Fish. Res. Bd.

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(Previously reported)

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Dickie, L. M., and J. C. Medcof. Causes of mass mortalities of scallops (<u>Placopecten magellanicus</u>) in the southwestern Gulf of St. Lawrence. J. Fish. Res. Bd.

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McCracken, F. D. Comparison of tags and techniques from recoveries of Subarea 4 cod tags. North Atlantic Fish Marking Symposium, Woods Hole, Mass., May 1961. International Commission for the Northwest Atlantic Fisheries.

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Effect of mesh size variation on selection span. Proceedings of the Lisbon Conference sponsored by ICNAF/ICES/FAO.

Hook selection for cod and haddock. Proceedings of the Lisbon Conference sponsored by ICNAF/ICES/FAO.

Selection factors for cod and haddock with codends of different materials. Proceedings of the Lisbon Conference sponsored by ICNAF/ICES/FAO.

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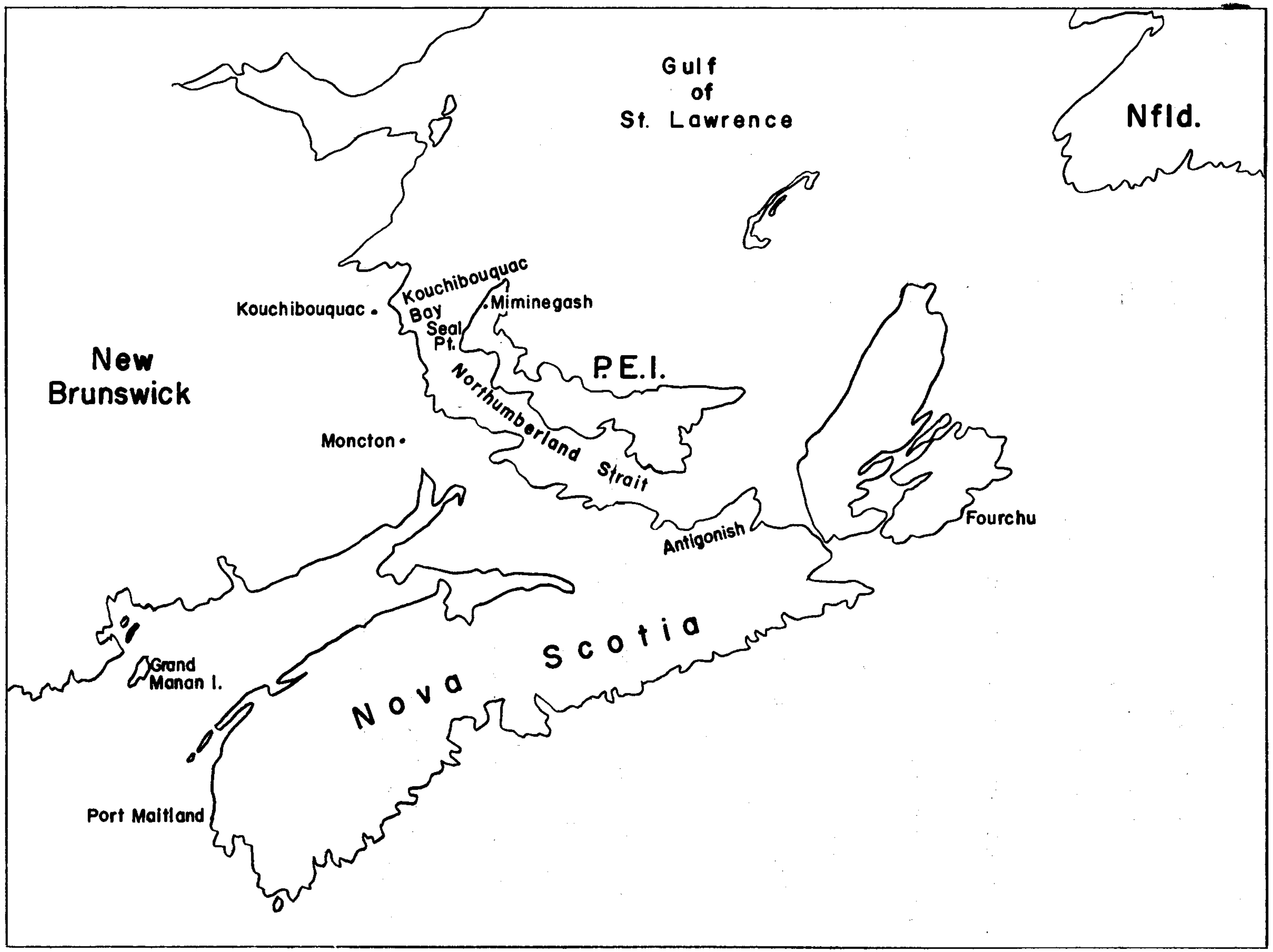
FILMS AND FILMSTRIPS

1962

No new films or filmstrips were obtained in 1962.

INDEX TO SUMMARY REPORTS

LOBSTER SUMMARIES


Gulf
of
St. Lawrence
Nfld.
Kouchibouquac
Bay
Kouchibouquac
Seal
Pt.
Miminegash
P.E.I.
New
Brunswick
Northumberland Strait
Moncton
Antigonish
Fourchu
Grand
Manan I.
Nova Scotia
Port Maitland

No. A-1

LOBSTER INVESTIGATIONS

The lobster, our most important fisheries species in terms of landed value, contributes significantly to the livelihood of many thousands of small-boat fishermen. The limited supply, together with a growing demand, lead to landed prices and rates of exploitation seldom approached for most marine species. Research directed toward wise use of this resource follows two main lines--field studies of larvae, young and adults to provide the biological basis for managing the fishery and laboratory studies of the factors affecting the survival and behaviour of lobsters during commercial storage and shipment and in nature.

The commercial fishery

Studies were continued at Port Maitland and Fourchu, N.S., and at Miminegash, P.E.I. (Summary No. A-2). At Port Maitland declining catches over the past 11 years have been accompanied by rising prices and a decreasing fleet. The gross value of the catch per boat has increased slightly. At Fourchu where the opening of the spring season was delayed by drift ice, a week's extension was granted. Landings during the extension amounted to 10% of the season's catch by weight and 12% by value. The quality of the lobsters was not affected adversely and the rate of exploitation was below average. At Miminegash, strong winds accompanied by a 9°F drop in bottom water temperature resulted in a brief but dramatic drop in catch per unit effort.

In a review of the lobster fishery regulations presented at the 1962 meeting of the International Council for the Exploration of the Sea, it was shown that the quality and the sizes of lobsters marketed had been affected by regulation. It was not possible, however, from the available data to present convincing evidence that management had altered the sustained yield significantly. With the thought that factors such as suitable bottom, cover, food, predation and disease play a more important role in determining the abundance of lobsters, some effort is being diverted from studies of the commercial fishery to direct observations of the lobster in relation to its environment (Summary No. A-4 and A-5).

Larvae

The annual survey for larvae in Northumberland Strait has shown a scarcity of fourth-stage larvae for the fourth year in a row (Summary No. A-3). Although a clear relationship between catches of fourth-stage larvae and the commercial fishery has not been established, the possibility that a succession of poor years for larvae will be reflected in the commercial landings should be kept in mind. Evidence was obtained that the vertical distribution of larvae during daytime is affected by light intensity and that with winds above 4 knots the flow through the net was reduced by about 15%.

Young bottom stages

The catchability of lobsters above 1½ inches carapace length with the double 4-foot drag is about twice as great in the fall as in the spring (Summary No. A-4). Observations by divers of the drag in action have shown it to be quite inefficient at least on rocky bottom. Effort will be made to develop a more accurate sampling program using divers.

Cover

The behaviour and distribution of lobsters in nature suggest that cover may play an important part in determining the abundance of all bottom stages. Of one group of 24 four-inch diameter drainage tiles set on June 22 in 4 fathoms off Kouchibouguac, N.B., 4 had lobsters in or underneath them on July 25 (Summary No. A-5). Two similar groups of tiles could not be found again.

Growth and survival

The two most recent large-scale marking experiments to determine growth and survival were completed at Port Maitland, N.S., and Miminegash, P.E.I. (Summary No. A-6). At both ports the growth was so poor and the mortalities so high that the existing minimum size limits in these areas can be seriously questioned. Growth at Miminegash may have been slower than usual because of below average temperatures. There is some suggestion that at least part of the mortality at Port Maitland was from predation, possibly by catfish (*Anarhichas lupus*).

Care of live lobsters in fishing boats

Lobsters exposed to a moderate breeze at 75°F and a relative humidity of 33% for 6 hours suffered 35% mortality. If protected by covering, splashing with sea water every half hour, dipping in sea water every half hour or by immersing in sea water for one half hour the mortality was 2 to 18% (Summary No. A-7). With such simple treatments lobsters could be landed in much better condition.

Survival and condition of stored lobsters

The mortality of lobsters stored in wooden tanks for 18 months at the rate of one pound per square foot was 21% among those provided with hollow tiles for cover and 43% for those with no cover (Summary No. A-8). Newly moulted lobsters were fed at the rate of 0.5 lb of herring per 100 lb of lobsters per day. After 4 months their condition (meat yield) approximated that of freshly caught lobsters.

Survival of lobsters out of water

Lobsters acclimated in water to 20°C (68°F) survived much longer in air at 0 to 5°C (32 to 41°F) than at 10 to 15°C (50 to 59°F). Fine mists and sprays of sea water did not extend the survival time significantly. At oxygen concentrations of 40 to 80%, oxygen consumption was greater than in air but survival times, if anything, were shorter. After 10 days in air lobsters had lost 6% of their weight (Summary No. A-9).

Oxygen consumption

Oxygen consumption varied from 22 to 41 cc/kg/hr depending partly on the degree of crowding. Contrary to reports in the literature, consumption was constant over a fairly wide range of O_2 concentrations (1.5-3 to 6 cc/l). When lobsters were fed, consumption nearly doubled and remained high for 3 days (Summary No. A-10).

Effect of crowding on survival of stored lobsters

Lobsters stored commercially are usually crowded at rates of 1 to 25 pounds per square foot depending on the type of unit and storage time.

The major factor limiting the degree of crowding appears to be the supply of dissolved oxygen. If this could be overcome, lobsters might be stored at greater densities providing of course that crowding itself does not, through more frequent contacts, increase mortalities. When groups of 20 lobsters were stored with ample oxygen for 6 months at rates of 1, 4, 9, and 12 per square foot, the mortalities of those stored at 1 per square foot were 10%, appreciably lower than the 35 to 40% mortalities among those more crowded (Summary No. A-11).

Brown marks

Lobsters with one to three irregular brown marks on the underside of the abdomen were brought to the station by a Grand Manan pound operator. He reported a high and rapidly increasing incidence. Seven of these lobsters have lived well in our tanks for 40 days (1 death at 25 days) with some enlargement of some of the marks. Seven normal lobsters held in the same tank have not developed marks. Seven other lobsters punctured in two places with a rostrum, a common injury, developed brown areas around each injury. Apparently these brown marks develop at the site of a wound and do not spread to intact lobsters. No appreciable mortality appeared to be associated with the marks, although bleeding at the site was easily started by gentle probing (Summary No. A-12).

Histochemistry of the hepatopancreas

A study of changes in the hepatopancreas and other tissues in relation to moulting was started a few months ago. Some alkaline phosphatase activity in the hepatopancreas of the intermoult lobsters was demonstrated but there was little evidence of calcium or glycogen storage. Hepatopancreas cell types and structure in *Homarus* differ markedly from those described for *Panulirus*, the spiny lobster (Summary No. A-13).

Information

Requests for information regarding the storage and shipment of live lobsters continue to be time-consuming. A series of five 9-minute TV interviews for CBC Fisherman's Log, Halifax, were recorded in June and have now been shown twice. Nine brief radio interviews were also recorded for the CBC Fishermen's Broadcast. Illustrated talks were given to lobster fishermen at Antigonish and Moncton and to St. Francis Xavier extension workers at Antigonish.

Staff

Dr. D. W. McLeese, assisted by summer workers, Susan Corey and Elizabeth Quance, has conducted the laboratory studies of survival and behaviour. Dr. D. J. Scarratt, with seasonal assistance in diving from D. E. Graham, has been responsible primarily for the studies of larvae and young bottom stages in Northumberland Strait. Thurston Ossinger has ably skippered the 50-foot M.B. *Pandalus II*, used almost entirely in connection with Dr. Scarratt's work. R. C. Murray, U. J. Walsh and D. E. Graham have carried out the field studies at Fourchu, Miminegash and Port Maitland respectively and have assisted in the tabulation of data and with laboratory experiments. Willa Williamson has been mainly responsible for the care of our experimental stock, has checked all suspect specimens for blood disease and has assisted generally with laboratory experiments. Irené Scarratt who joined the staff in November as a volunteer worker has started a study of the histology and histochemistry of the integument and hepatopancreas.

D. G. Wilder

No. A-2

THE COMMERCIAL FISHERY

Field studies have been conducted annually since 1945 at Port Maitland and Fourchu in Nova Scotia and at Miminegash, P.E.I. The main purpose of these studies has been to follow trends in the landings, population densities, size composition in relation to water temperature, rates of exploitation, recruitment, etc. Recent marking experiments at these ports (Summary No. A-6) have provided valuable information on growth and survival.

Port Maitland, N.S.

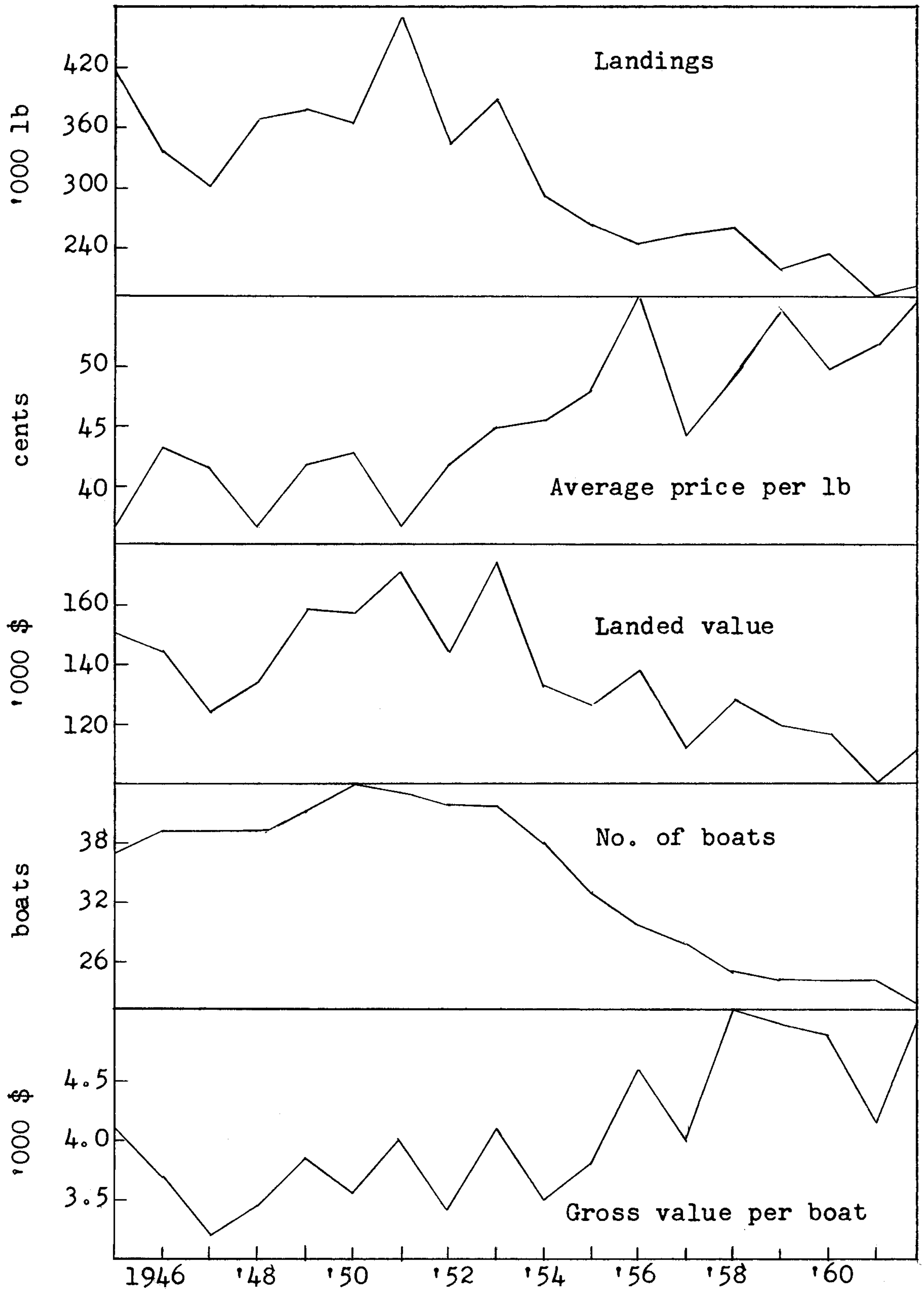
Total landings at Port Maitland have declined from a peak of 469,000 pounds in 1951 to 192,000 pounds in 1961, as shown in the accompanying figure. This has been partially compensated for by a rise in wharf prices but the total value of the catch has declined from $174,000 in 1953 to $99,000 in 1961. During this period the less efficient fishermen have dropped out, the fleet declining from 44 boats in 1950 to 22 in 1962. With rising prices and fewer boats, the gross value of the catch per boat has actually risen. These trends apply generally to southern Nova Scotia where the catch has declined from 12.2 million pounds in 1951 to 8.6 million in 1960.

No explanation for the decline in landings is as yet possible. Southern Nova Scotia is an area of late maturity where berried females and larvae are relatively scarce. In this connection it is of interest to note that the average percentage of large lobsters in the catches at five ports in southern Nova Scotia has declined from about 15% in the early 30's to about 5% in the early 50's.

Fourchu, N.S.

The lobster season in this area is normally open from May 16 to July 15. This year, as in 1961, the opening was delayed by heavy drift ice and no gear was set until May 21. Unlike 1961 however, the 1962 season was officially extended to July 21.

During the 6-day extension the 24-boat fleet landed 11,800 pounds or approximately 10% of their entire catch. With the record price of 65 cents a pound during the last 5 days, this catch was worth $7,600 or 12% of the total value. As in 1961, bottom water temperatures were below average and the lobsters did not trap readily. Although with the extension, the 1962 catch was 17% higher than 1961, it was still 20% below the 1954-62 average. Similarly the rate of exploitation in 1962 (54%) was considerably below the 1956-60 normal of 69%.



Port Maitland, N.S., lobster fishery statistics 1945-62.

Moulting was almost certainly later than usual in 1962 so the lobsters would be in as good condition on July 21 as they normally are on July 15.

Miminegash, P.E.I.

Many fishermen still believe that sudden changes in their catches are the result of migration. This year during pre-season fishing at Miminegash to obtain lobsters for tagging the catches were the best on record. From August 4 to 7, at an average temperature of 62.4°F, lobsters were caught at the rate of 393 per 100 trap hauls. Following a strong NE wind on August 8 and 9, the water temperature dropped to 53.6°F. When the official season opened on August 10 the catch per 100 trap hauls was only 51--the poorest in the fishermen's memory. As the water warmed to 59.2°F on August 13 the catch per 100 trap hauls increased to 200. The sudden drop in catch per unit effort is greater than can be explained by the effect of temperature on activity as measured by the walking rate. It is certain, however, that other aspects of the lobster's behaviour (e.g. feeding) are markedly affected by temperature. Tag returns which were the highest on record (90%) gave no indication of unusual movements that would account for the brief period of poor catches.

D. G. Wilder

No. A-3

LOBSTER LARVAL SURVEY, 1962

The larval survey program started in 1948 (see previous annual reports) was continued this season on a slightly modified basis. The original 23 stations were reduced to 12 by eliminating alternate stations and an additional 3 stations were fished at 5-mile intervals across the middle of the area. These changes permitted more time for detailed sorting of the fresh material, for experimental tows and to give a better appreciation of larval distribution across the area.

Two hundred and one tows were made in the series and the catch of larvae was:

Stage I	Stage II	Stage III	Stage IV
4,093	343	121	22

These figures corrected for the length of time each stage was present in the plankton and length of life per stage give a productivity per unit area (12 feet x ½ mile approx.) of:

Stage I	Stage II	Stage III	Stage IV	Survival I-IV
322.41	23.54	4.97	0.34	0.10%

The hatch was therefore almost identical with that of 1959 when survival was 0.54% and Stage IV productivity was approximately half that of the two previously lowest years, 1954 and 1960, when the figure was 0.7/unit area.

At Miminegash this year, roughly 13,000 lobsters were taken per square mile. Recruitment in the whole area at Stage IV level was approximately 300/sq. mile. This means that if fourth stage abundance reflects in some way the seasonal recruitment, then recruitment this year was about 2% of what is required to maintain the lobster fishery at its present level. There are three possible conclusions: (1) Distribution and catchability of Stage IV larvae may be such that they are inadequately sampled; i.e. there is an unknown correction factor. This may well apply to all four stages. (2) Settlement may effectively occur at the termination of Stage III (Templeman, 1936, J. Biol. Bd. Canada, 2(5)). (3) The grounds might be stocked by migration of very young lobsters off unfavourable areas where they originally settled.

In order to check the efficiency of the sampling methods a series of experimental tows was made. Two series of tows at 2-hour intervals over a 24-hour period at the same station were made and revealed no pattern of diurnal variation of lobster larvae in the upper 2-ft layer. The second of these series (Aug. 2-3) was made with an additional net fishing the 2-ft to 4-ft layer. During the daylight hours in bright sunshine eight tows were made yielding 300 Stage I larvae in the upper net and 64 in the lower. On other occasions on cloudy and sometimes rainy days, the figures for 17 tows were 396:8. Whether these larvae in the 2- to 4-ft depth have come up from below or down from the 2-ft layer has yet to be resolved. A tentative conclusion from this is that the surface net may be underfishing by about 20% on sunny days. A series of 18 tows between the 2½- and 8-fath. depth yielded a total of 14 larvae which may have been contaminants from the surface layer.

One further source of error in the standard tows was briefly investigated by fitting a flow meter to the net. Up to wind speeds of 4 knots meter readings were reasonably constant at about 3,200 revs per ½-hour tow. Above 4 knots wind speed the readings fall and at 8 knots the mean is about 2,700 revs per ½-hour tow. In such conditions the larval abundance may be underestimated by 15% or more. As yet, no corrections of this nature have been applied to the raw data since it is proposed to investigate further the distribution and catchability of the larvae in the coming season.

D. J. Scarratt

No. A-4

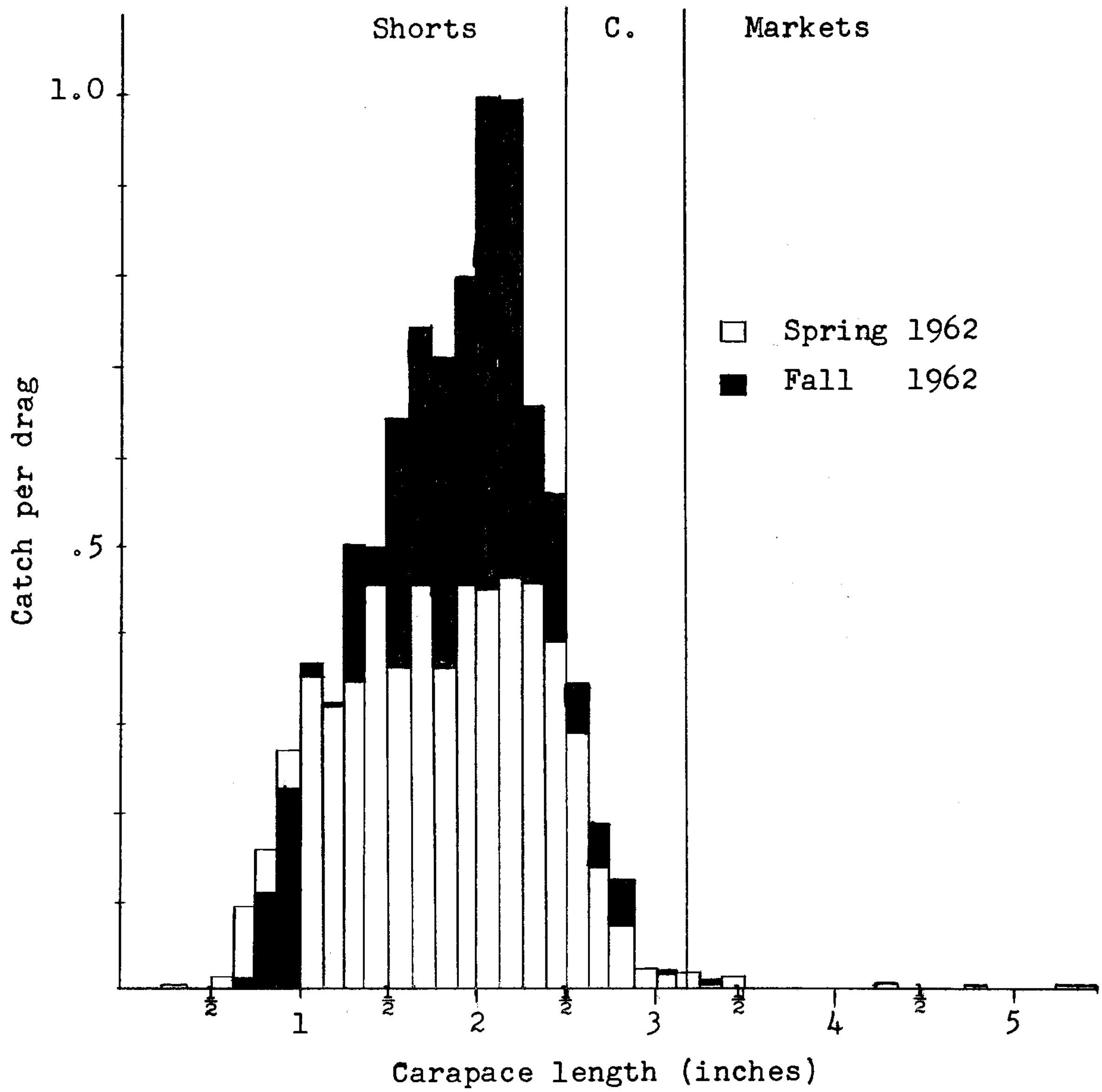
DRAGGING PROGRAM FOR YOUNG LOBSTERS, 1962

The program was continued this year as before, using the double 4-ft lobster drags. The spring series of 143 drags taken between May 11 and June 14 yielded 886 lobsters, of which 869 were measured. The fall series of 123 drags from October 1 to November 1 yielded 1,109 lobsters of which 1,094 were measured. The catch per drag is plotted by 1/8-inch increments of carapace length in the accompanying figure.

It is apparent from the figure that the catchability of lobsters by the drag is different in spring and fall. It is also apparent that this difference is not identical for all size groups. Below 1 inch carapace length lobsters are more catchable in the spring. Above 1½ inches carapace length the fall catch per drag is about 2 times that in the spring. Above 2½ inches carapace length the lobsters are available to the fishery and comparisons of spring and fall abundance are difficult. It cannot be explained by growth of yearling lobsters out of this size group during the summer since lobsters do not exceed 1 inch carapace length before they are about 2½ years old. The implications are that the smallest lobsters respond sooner to the warming up of the water and begin to move about earlier in the year than do the larger ones. The trends are visible in all years except 1960 when the spring collection suffered from the then new skipper and crew being unfamiliar with dragging stations. By the fall of that year the location of suitable stations had been resolved but it is apparent from the data and from <u>in situ</u> observations that the magnitude and composition of the catch is somehow dependent upon the nature of the sea bed at the sample points. Quite small deviations off the station or established lines of tow usually result in lowered catches due to increased roughness or muddiness of the bottom or the absence of lobsters. Thus the towing stations are the outcome of explorations to find where lobsters may be caught with the drags and all attempts so far to infer the population structure from catch data have failed.

Observations by divers made on the drag while it was being worked showed that almost as many lobsters were seen to escape as were caught and additional dives in the area showed that on rocky bottom at least, a diver could catch as many lobsters as the drag in comparable time without moving more than a few yards. It has been decided therefore to shelve the

Catch per drag of lobsters by 1/8" groups



dragging program for the forthcoming season and replace it with what is hoped will be a more accurate qualitative and quantitative sampling program by divers.

D. J. Scarratt

No. A-5

ARTIFICIAL COVER FOR LOBSTERS IN NATURE

Following a small experiment conducted off the station wharf in November 1961, three more experiments were made in Northumberland Strait during the summer of 1962. A group of 25 4-inch diameter terra cotta drainage tile was laid on sand in 2½ fathoms of water north of Seal Point, Prince Edward Island, on June 19, and a further two groups in 4 fathoms of water on rocky bottom in Kouchibouguac Bay on June 22 (Bottom stations 21A and 22A). The history of each group was somewhat different.

6" lobster on July 25 occupying 4-inch diameter drainage tile set in 4 fathoms in Kouchibouguac Bay on June 22

The tiles at Seal Point were not found on the fourth examination about 5 weeks after they had been laid. It was felt that the heavy gales in the middle of July had washed them away. The group at Station 22A were marked with a buoy tied to a very heavy rock on the bottom. On their first examination, one lobster was hiding under a tile. On the second examination, about one month after being laid, the buoy was obviously not on station and no tiles were found, either then or during a systematic search made a few days later.

The 25 tiles at Station 21A were set 6 feet apart in 4 rows in 4 fathoms of water on June 22. They were marked with a buoy made fast to a large rock. On July 25, 24 tiles were found on the station, quite scattered, lying singly and in groups. Three had lobsters in residence and one had a lobster underneath. On being disturbed, one of the three lobsters moved from one tile into another. The tiles were displaying some algal growth and accumulation of silt, also numbers painted on the tiles were wearing off (see Figure). The site was again examined on August 28 when 20 tiles were found. There were no lobsters in residence. This, however, was after the start of the lobster fishery in that area, and many would have been caught. The size of the tiles would make them more favourable to the larger lobsters.

Further experiments should perhaps be made with a range of tile sizes, and greater density on the bottom.

D. J. Scarratt

No. A-6

GROWTH AND SURVIVAL

Large-scale marking experiments to measure growth and survival under natural conditions were continued this year at Port Maitland, N.S., and Miminegash, P.E.I. Lobsters sorted into ten carapace length groups were distinctively marked by drilling two small holes through the tail fan and were then distributed over the fishing grounds. Recoveries were made up to two years after release by trained technicians who carefully searched for marked lobsters among commercial catches.

Port Maitland, N.S.

During April and May 1960, a total of 9,041 marked lobsters (6,925 sub-legal and 2,116 legal size) were released. These ranged from 2½ to 3¾ inches carapace length. The next fishing season (Dec. 1, 1960 - May 31, 1961) 97% of the Port Maitland catch was examined and 560 marked lobsters recovered. In the 1961-62 season, 87% of the catch was examined and a further 100 marked lobsters recovered.

From the sizes of lobsters recovered and the appearance of the marks it was apparent that 46% of the lobsters that were legal-sized when marked had failed to moult during the summer following their release. Failure of sub-legal sizes to moult would pass largely undetected since these would not be included among the commercial landings. The lack of a relation between size and proportion moulting among the legal size groups suggests, however, that a significant fraction of the sub-legal lobsters did not moult.

Growth per moult did not differ appreciably between sexes and was remarkably constant over the size range marked, averaging 0.41 inches carapace length. Growth per year was considerably less, averaging 0.24 inches for the legal-sized lobsters.

Of the 9,041 lobsters marked, 660 (7.3%) were recovered during the next two seasons. Undoubtedly some that were landed at neighbouring ports escaped detection but the data suggest only small numbers were involved. A very few are still alive, one having been reported during the 1962-63 season. The thoroughness of the search and the low returns, particularly of the smaller sizes marked, indicate heavy mortalities between release and recapture.

With the thought that catfish (Anarhichas lupus) which appear in large numbers on the Port Maitland grounds in the spring might have taken significant numbers of the marked lobsters, further observations were made. In early May, a trawl of 76 treble hooks baited with live lobsters in one set caught 8 catfish, a relatively large catch considering the conditions of the test. During the latter half of May the stomach contents of 21 otter trawl catfish ranging from 10 to 26 pounds were examined. Four of these contained 5 lobsters.

The combination of slow growth and high mortalities cast serious doubt on the value of releasing sub-legal lobsters in this area, particularly during the spring. Further studies are needed.

Miminegash, P.E.I.

From September 15 to October 11, 1961, a total of 8,202 marked lobsters (5,164 sub-legal and 3,038 legal size) were released. These ranged from 2 1/5 to 3 1/3 inches carapace length. The next fishing season (August 10 to October 10, 1962) 89% of the Miminegash catch was examined and 1,243 (15.2%) marked lobsters were recovered. Of these, 1,222 were suitable for growth studies.

Of the lobsters recovered that were legal size when marked, 57% had failed to moult. The trend in percentage moulting in relation to size suggests that possibly 20% of the sub-legal lobsters also failed to moult.

The growth per moult was similar for males and females and was relatively constant over the size range marked, averaging 0.35 inches carapace length. Growth per year was considerably less, averaging 0.17 inches over the legal size range (2.5 to 3.3 inches).

Of the 3,038 legal-sized lobsters marked, an estimated 583 were recaptured during the marking period. This left 2,455 on the grounds at the close of the 1961 season. Of these, 480 were recovered in 1962. Since 89% of the catch was examined and since the fishery removed 90% of the available legal-sized stock, it appears that only about 600 (24%) of the legal-sized lobsters survived from October 1961 to August 1962.

Here again, with poor growth and poor survival, the minimum size limit is open to question. Somewhat lower than normal water temperatures during the 1961 and part of the 1962 growing season may have reduced the growth rate.

D. G. Wilder

No. A-7

CARE OF LIVE LOBSTERS IN FISHING BOATS

The usual practice in lobster fishing is to put the legal-sized lobsters in standard 100-pound capacity, wooden crates as they are caught. The day's catch which may fill several crates is normally stored aboard in air for periods up to 10 hours or so. During the cooler part of the year lobsters so treated are usually landed in good condition. In summer, however, heavy mortalities may occur particularly if the lobsters are exposed to a drying breeze. With these conditions it is best to put the lobsters in tanks of sea water but such tanks have not yet been installed in Canadian lobster boats. Simpler treatments are practised by the more conscientious fishermen but there has been some doubt as to the value of these procedures.

To evaluate various possible treatments, lots of 40 one-pound lobsters were acclimated to 60°F, placed in standard lobster crates and exposed for 6 hours to a moderate breeze at a room temperature of 75°F and a relative humidity of 33%. After exposure the lobsters were returned to 60°F water and checked for mortalities after 24 hours.

Treatment during 6-hour exposure to moderate breeze at 75°F	Mortality %
Crate open - control	35
Crate open - pail of sea water poured over lobsters every ½ hour	17.5
Crate closed	15
Crate closed - pail of sea water poured over lobsters every ½ hour	2.5
Crate closed - dipped in sea water every ½ hour	5
Crate closed - after 3 hours placed in sea water for ½ hour	7.5

Pouring a pailful of sea water every ½ hour over the lobsters in the open crate or simply closing the crate reduced the mortality by about half. Marked, further reductions in mortality were realized when these treatments were combined or when the closed crate was dipped in sea water every ½ hour or left in sea water for ½ hour at the mid point.

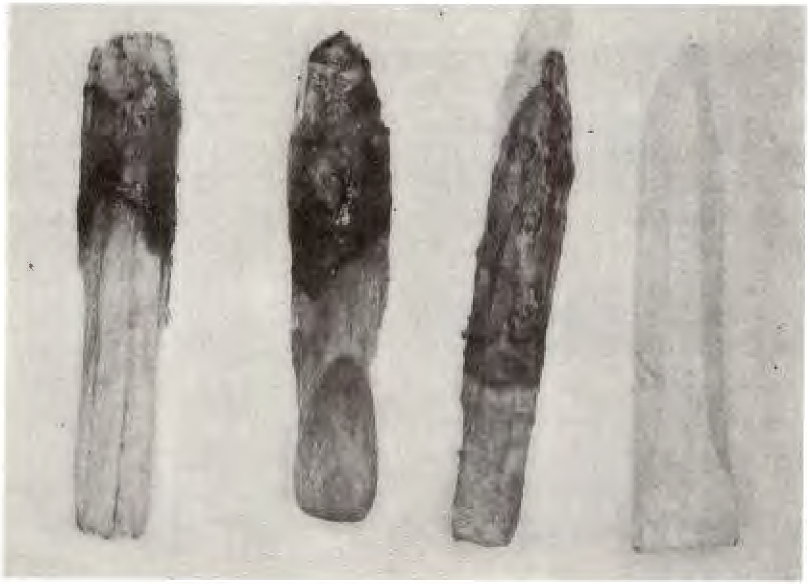
It is clear that lobsters protected from exposure by simple practicable treatments such as those tested, can be landed in much better condition.

D. G. Wilder

No. A-8

SURVIVAL AND CONDITION OF STORED LOBSTERS

On July 10, 1961, an experiment was started to follow the survival of lobsters in captivity. Three lots of 50 one-pound lobsters with both claws plugged were stored in wooden tanks at a concentration of one pound per square foot. Hollow tiles were provided for each lobster in one lot and for half the lobsters in the second lot. Within a few minutes the lobsters occupied the tiles and continued to use them throughout the experiment, usually emerging only briefly to feed or moult. Every few days the lobsters were fed frozen herring, the amount depending on the consumption. The experiment was continued for nearly 1½ years to December 10, 1962.



Used wooden plugs with discoloured tissue adhering. New plug shown for comparison.

Shell erosion around plugging site.

Shell removed to expose discoloured claw meat.

During the first year, 34% of the lobsters moulted during the last half of August and in September. In the second year, 62% moulted from mid July to late October.

Seventy-nine per cent of the lobsters provided with tiles and 57% of those without survived to the end of the experiment.

Sixteen of the lobsters known to have moulted between August 22 and September 10, 1962, were boiled on January 4, 1963, and the claw and tail meat weighed. During the 4-month period since moulting these had been fed frozen herring at about the rate of 0.5 lb per 100 lb of lobsters per day. Their meat yield averaged 21.3%, as compared to 23.2% from freshly caught lobsters. At this rate of feeding, lobsters in captivity recovered condition at about the same rate as those in nature.

The wooden plugs in general use in Canada to inactivate lobster claws usually lead to infection. With prolonged storage this is often accompanied by marked erosion of the shell and darkening of the claw meat. Typical examples are shown in the accompanying photographs.

D. G. Wilder

No. A-9

SURVIVAL OF LOBSTERS OUT OF WATER

Millions of pounds of live lobsters are shipped to market in air each year. During 1962 a study of the lobster's resistance to a non-aquatic environment to establish survival times at various storage temperatures and to determine if survival time could be extended by simple treatments was continued.

Resistance time in moist air

The resistance of 20°C acclimated lobsters in moist air at 0°, 5°, 10° and 15°C was determined to complete a series of tests at acclimation temperatures of 0°, 10° and 20°C. The results are summarized in Table I:

Table I. Time to 10% and 50% mortality of groups of 50 lobsters from 20°C water in moist air.

Air temperature	Days to 10% mortality	Days to 50% mortality
0°C	7	13
5°C	6	10
10°C	2	6
15°C	1	2.5

The 20°C acclimated lobsters survived longest at the lowest air temperature (0°C). Survival time decreased as the temperature increased. A similar relationship had been found previously for those acclimated at 0° and 10°C.

Effect of spraying with sea water

In previous tests, lobsters held under continuous sprays of sea water did not live appreciably longer than those held in moist air. This conclusion was supported by additional observations this year. The times to 50% mortality among lobsters held at 5°C when exposed to a fine mist and to sprays of 1.5, 3.0 and 33 cc/min ranged from 7 to 9.5 days. Others held at 12° to 14°C in sprays of 120, 500 and 1,600 cc/min had a resistance time of 1.5 days, about 1 day less than those held at 15°C in moist air.

Survival at various levels of oxygen

Since lobsters do not take up oxygen efficiently when they are in air, a popular notion prevails that survival can be extended by exposing the animals to oxygen. In previous tests, 50%, 70% and 80% oxygen did not extend the survival times. Some of this work was repeated this year. The results are summarized in Table II:

Table II. Times to 50% mortality of lobsters at 5°C and at three levels of oxygen.

Oxygen content	Time to 50% mortality
20% (air)	10 days
40%	11.5
75%	7

The treatments with oxygen did not extend survival time.

In further observations, five lobsters were sealed in each of six small airtight chambers containing from 20-80% oxygen. Regardless of the original oxygen content, the lobsters used approximately one half of the available oxygen over a 2-day period; that is, the group starting with 80% oxygen took up four times as much oxygen as the group starting with 20% oxygen. However, survival was no better among the groups using the greater quantities of oxygen.

It is concluded from these two sets of observations that oxygen lack is not a major cause of death of lobsters in moist air.

Weight loss in air

The literature states that lobsters lose considerable water from the blood. This conclusion is supported by our observation that swelling may occur when they are returned to sea water. The average weight loss for 19 lobsters reached 6% of the body weight by 10 days at an air temperature of 5°C. The weight lost is equivalent to 35% of the blood volume. Although it is unlikely that water loss from the blood accounts for the entire weight loss, the blood must be undergoing major changes while the animal is in air.

Since simple treatments such as spraying or increasing the oxygen fail to extend survival times, it now appears that a detailed study of the physiology and biochemistry of the blood is required to determine the cause of death.

D. W. McLeese

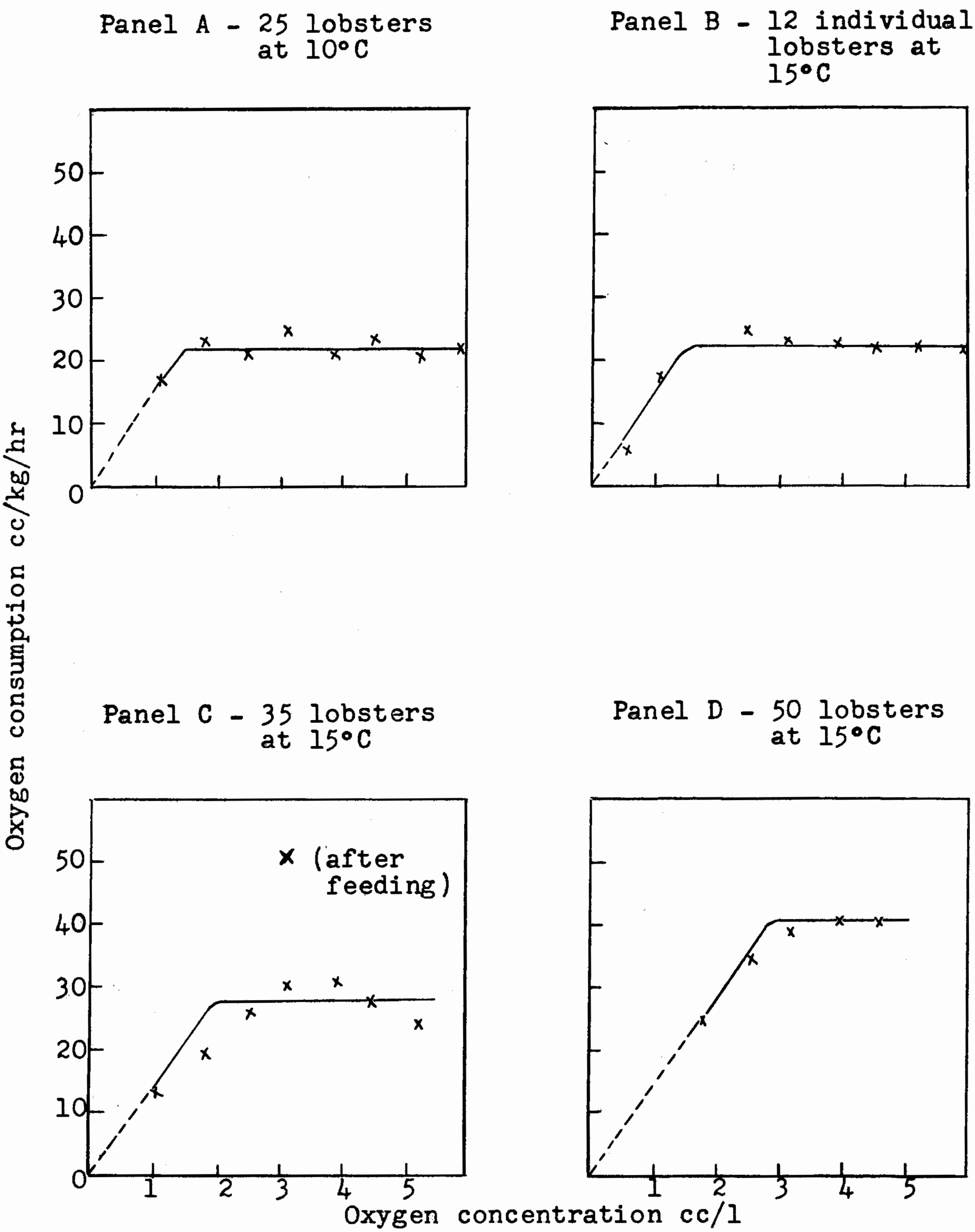
No. A-10

OXYGEN CONSUMPTION OF LOBSTERS

During 1962, tests were conducted to determine the relationship between the amount of oxygen consumed and oxygen concentration of the environment. With techniques used previously, both here and elsewhere, consumption was determined while the animal was exposed to a rapidly falling oxygen content. In this study, consumption was measured at various oxygen concentrations maintained over long periods with constant flow respirometers. The results are summarized in the Figure. Each point on the graphs represents the average of a series of determinations within a concentration interval of 0.7 cc/l.

Oxygen consumption of a group of 25 lobsters at 10°C was constant (22 cc/kg/hr) over a concentration range from 6 cc/l down to about 1½ cc/l (Panel A). Below 1½ cc/l, the rate of oxygen consumption decreased. Similarly, the average consumption by 12 individual lobsters at 15°C was constant (22 cc/kg/hr) at concentrations from 6 cc/l down to about 1½ cc/l (Panel B). The group of 35 lobsters at 15°C maintained a constant but higher rate of consumption (28 cc/kg/hr) down to a concentration of about 2.5 cc/l (Panel C), while the group of 50 lobsters at 15°C maintained a yet higher rate (41 cc/kg/hr) down to a concentration of about 3 cc/l (Panel D).

Oxygen consumption increases when lobsters are crowded, presumably because they are more active. When the animals were fed, thus further increasing activity (Panel C),



Oxygen consumption of lobsters in relation to oxygen content of the water the rate of consumption increased to 51 cc/kg/hr at a concentration of 3.1 cc/l. This rate was maintained for more than 3 days.

These results demonstrate that lobsters can maintain a constant rate of oxygen consumption over a considerable range of environmental oxygen concentrations.

D. W. McLeese

No. A-11

EFFECT OF CROWDING ON SURVIVAL IN CAPTIVITY

The density of lobsters in commercial storage units varies from as high as 25 pounds per square foot in shore-based tanks to about 1 pound per square foot in tidal pounds.

To determine whether better use could be made of storage units by increasing the load, the following observations were made. The mortalities within groups of 20 lobsters at densities from 1 to 12 pounds per square foot over the 6-month period, June 11 to December 11, 1962, were as follows:

Density of crowding lb/sq ft	No. dead	% dead
1	2	10
4	7	35
9	8	40
12	8	40

These results suggest that there is a significant increase in mortality when the density increases from 1 to 4 pounds per square foot. Further increases in density did not result in greater mortalities. Further observations are required.

D. W. McLeese

No. A-12

BROWNISH DISCOLOURATION IN LOBSTERS

On January 11, lobsters with brown marks on the underside of the tail were brought in from a Grand Manan lobster pound. The owner first noticed a similar condition a year ago. He reported that the size and number of the marks seemed to increase on individual lobsters and spread rapidly from one lobster to another. Observations were made to determine if the marks would in fact enlarge, become more numerous and spread to undamaged lobsters, or if they resulted from relatively minor injuries and would appear on lobsters afflicted with punctures.

The 7 Grand Manan lobsters had a total of 14 marks, 3 small (1/8" diam.), 6 medium (1/8" to 1/4" diam.) and 5 large (1/4" and larger). The transparent membrane over 4 of the large marks was torn or ruptured. These lobsters were stored alive for 40 days in a small tank (2.6 sq. ft. bottom area) in close contact with 7 uninjured lobsters and with 7 others that we punctured in two places with the rostrum of a lobster. No new marks developed on the Grand Manan stock, 9 marks remained unchanged, 2 of the medium and 3 of the large marks more than doubled in area. All of the 14 scars of the punctured group became brown. Seven marks remained small, 4 became medium sized and 3 became large. The uninjured lobsters did not develop brown marks.

The tear in the transparent membrane on 3 of the Grand Manan and on 3 of the punctured lobsters became enlarged. Gentle prodding caused heavy bleeding.

Of the 21 lobsters, 20 were still alive and in vigorous condition after 40 days' storage. One Grand Manan lobster died on the 25th day.

These observations suggest that the brown marks occur at the site of a wound. Although it is likely that the wounds themselves are infected, other lobsters are not infected unless they in turn become wounded. There is no evidence to suggest that marked lobsters die at a faster rate than unmarked lobsters.

In addition, examination of the tails of 100 freshly caught lobsters and of 120 that had been stored in the laboratory for 18 months showed the following:

Condition	100 Freshly caught lobsters		120 Lobsters stored 18 months	
Clear	69%		63%	
Small marks (1/8" diam.)	26%)		26%)	
Medium marks (1/8" to 1/4" diam.)	3%)	31%	8%)	37%
Large marks (1/4" and larger)	2%)		3%)	

This observation suggests that about one third of freshly caught lobsters are marked and the size of the spots and the number of lobsters affected do not increase appreciably during 18 months of storage.

D. W. McLeese

No. A-13

HISTOLOGY AND HISTOCHEMISTRY OF THE INTEGUMENT AND HEPATOPANCREAS OF THE LOBSTER

Recent studies of the moulting cycle in Crustacea have turned to a histochemical consideration of the changes encountered in the skeletal and hepatopancreatic tissues, in addition to analyses of blood and urine of normal animals.

Travis (Biol. Bull. 1955, 1957) demonstrated by histochemical and biochemical methods that in the spiny lobster, *Panulirus argus*, cyclic changes occur in the exoskeletal tissues which are accompanied and in some ways conditioned by other cyclic changes in the tissues of the epidermis and hepatopancreas. Various organic and mineral reserves, e.g. lipid, calcium and glycogen, are stored by the hepatopancreas during the pre-moult period and it is from this organ that such reserves are drawn when required by other tissues.

Little is known of the pattern of such changes in the American lobster and work has commenced to investigate this from a histochemical viewpoint.

As yet, only the intermoult stages of the adult lobster have been investigated since pre-moult and post-moult lobsters and also the larvae are only available in abundance in the summer months.

The hepatopancreas of the intermoult lobster stores great quantities of lipid material in the absorption and secretion cells of the glandular tissue. Some alkaline phosphatase activity was demonstrated but there was little evidence of calcium or glycogen storage at this stage. These results are essentially in agreement with the findings of Travis for the intermoult stage of *Panulirus*. There are, however, marked differences in the types and structure of cells found in the hepatopancreas of *Homarus* and the cellular distribution of substances is different in the two animals.

Since the hepatopancreas also functions as a secretory and absorptive organ in digestion, knowledge gained of the changes associated with the moulting process should help towards an eventual appreciation of the total role played by the hepatopancreas in the metabolism of the lobster, both as a larva and as an adult.

Irené S. Scarratt

MOLLUSCAN SHELLFISH SUMMARIES

(Continued)

MOLLUSCAN SHELLFISH SUMMARIES

No. B-1

MOLLUSCAN SHELLFISH INVESTIGATIONS

Molluscan shellfish investigations involve one offshore species, the sea scallop, and several estuarial species, oysters, clams and quahaugs. But all are luxury foods that command high market prices.

For several years now the value of scallop landings has exceeded the value of all the estuarial species combined. The scallop fishery depends on fishing wild stocks growing on the continental shelf. Shelf areas are intermediate in terms of fertility being ten times as productive per acre as the open sea but only one tenth as rich as estuarial grounds. Other features of the scallop fishery are that it requires expensive fishing boats, that relatively small numbers of fishermen participate in it, that there is strong international rivalry for the enormously variable natural production and that there are limits to what can be done to improve catches.

In contrast, oysters can be cultured, quahaugs can be semi-farmed and we hope some day to discover ways of farming clams. For these reasons and because these animals live in the very richest parts of the sea, we believe that fisheries based on them might eventually rival our scallop fishery in economic importance. There are vast areas that may be exploited, large capital investments are not required to begin with so there is opportunity for many people to engage in estuarial shellfish culture on grounds over which they have complete control under the Department of Fisheries' scheme of leasing. Development depends on our finding ways of controlling interspecific competition, natural mortality, recruitment and genetic constitution of the animals we are working with. In other words, it depends on advancements in animal husbandry and we are making advances.

In 1962 we made advances at two levels:

1. We broadened our knowledge of the biology of our species. Broadening our knowledge discovers or permits fuller appreciation of opportunities and problems that are facing us now or will face us in the future.

As examples of advances at this level I might point to--(1) Extension of our knowledge of how food and feeding conditions affect the development and lifetime of oyster larvae (Summary No. B-2) and scallop larvae (Summary No. B-13). (2) Proof that paralytic shellfish poison is endogenous (contained within the <u>Gonyaulax</u> cell, not excreted freely into the sea water) and therefore available only to animals which feed on and digest the dinoflagellate

(Summary No. B-12). (3) Demonstration that flotation is the physical principle involved in hydraulic raking for soft-shell clams (Summary No. B-10).

2. We also made advances by finding new ways of applying current or past findings at the operational level--i.e. we have put the knowledge to practical use. Because we are primarily researchers we have not done this by ourselves. We have affiliated with some half dozen agencies who are especially well equipped to implement research findings but need the presence of researchers during the early stages of implementation. We are gratified that we have been able to aid them substantially in their programs.

To illustrate the roles we have played at this level in 1962 I might point out that--(1) We have been advisors to the Department of Fisheries in its planning for construction of an oyster hatchery (Summary No. B-2). (2) We have alerted the Department of Fisheries and of National Health and Welfare to the high zinc content of shellfish in some areas (Summary No. B-9). (3) We have shown that paralytic shellfish poison derives from the same organism in the estuary of the St. Lawrence as in the Bay of Fundy which means that their problems are closely similar (Summary No. B-12) and (4) We have demonstrated that the hydraulic clam rake is an effective harvesting tool in commercial-type operations in several parts of the Maritimes (Summary No. B-10).

With an eye on the future we have planned projects for 1963 that we hope will be equally fruitful of new knowledge and new applications. We know very well that much accumulated knowledge needs to be put to work but we also know that this supply is limited and that we must augment it by further research if we are to maintain our usefulness.

J. C. Medcof

No. B-2

OYSTER HATCHERY DEVELOPMENT

Final drawings of the hatchery building and its equipment lay-out have been prepared by J. P. Parkinson of the Department of Fisheries Fish Culture Branch of the Conservation and Development Service. Construction and operation of this experimental hatchery is to be financed by the Department. But it is to be jointly staffed by the Department and Board and its operation will be supervised by the Board. It is hoped that building will be complete by the fall of 1963 and that the first commercial-scale rearing attempts will be made in the spring of 1964.

For the first few years the hatchery will serve to develop commercially applicable methods of oyster spat production. Later it will serve for the continuous improvement of these methods and for investigation of oyster genetics. The aim will be to select strains of oysters with commercially desirable characteristics, disease resistance, rapid growth, etc.

The hatchery facilities will include a supply of filtered, sterilized sea water, maintained at constant temperatures; a constant temperature room for food culture; holding facilities for conditioning oysters for spawning; spawning benches; larval rearing benches; a tank area for experimental spat settlement and rearing and office and laboratory space.

The oyster farmers' shortages of bedding oysters demonstrate the inadequacy of natural production. And our laboratory-scale efforts have shown the commercial possibility of hatchery production of oyster spat in Canada. Construction of this commercial-scale, experimental hatchery seems to be the logical next step in trying to overcome the industrial difficulty that stands in the way of vigorous expansion. But it will require some years to prove the system and assess the economics of operation.

In earlier work (Annual Report 1960-61, Summary No. 17; 1961-62, Summary No. 10) we found that frequent changes of filtered river water provided all the food that growing larvae needed. But in 1962 this apparently failed to meet the food requirements. The summer was cool and the naturally produced larvae and spat in Bideford River showed poor growth and survival (Summary No. B-3). We had similar problems with our laboratory cultures. Larval growth appeared normal for the first week but it slowed down so that at 21 days larvae were only half the expected size. The normal free-swimming period is 21 days but in the cultures spat settlement did not begin until 44 days and even then the mean setting size was considerably below normal. Mortality in newly settled spat was high.

After spatfall ceased there were still many live larvae in the cultures and they continued to grow slowly. No more spat were observed and accelerating mortality eventually killed all larvae but some lived for more than three times the normal larval period. This year's failure of natural spat production provides a demonstration of the industrial need for hatcheries.

Experiments would have to be continued for many years to show what could be considered normal conditions but the 1962 results demonstrate the importance of food in larval welfare.

They also illustrate that hatchery results will be valuable in explaining the dynamics of larval production in the field.

R. E. Drinnan
S. E. Vass

No. B-3

FIELD OBSERVATIONS ON LARVAL DEVELOPMENT AND SPATFALL, 1962

Ellerslie Culture Station, P.E.I.

The first spawning occurred in late June but July was cold and the concentration of larvae was low and development was slow. August was warmer and the numbers of larvae rose and development was only a little slower than normal.

August 21 was predicted as the date of the first major spatfall. In Smelt Creek spatfall was continuous but light from August 17 to September 4. In Paugh's Creek a much heavier set occurred in the third week of August.

Spat survival and growth were poor. Late-autumn examinations of commercial collectors (concrete-coated egg-crate fillers) showed a mean of 140 spat/filler, for spat ¼ to ½ inch in diameter and large numbers of spat of much smaller sizes.

In spite of poor conditions in 1962, the tests with Japanese-style shell strings gave useful results. Gulf of St. Lawrence scallop shells made the best strings for all purposes. They served well as spat collectors in Paugh's Creek when hung from floats and fencing; when laid on plastic sheeting spread over the bottom; when laid on low racks and when spread in the "umbrella" patterns. When hung from floats they also worked well for rearing spat. Two year-classes of spat (1960 and 1961) were used; these grew quickly and when they reached bedding size they were easy to separate for maturing as single oysters. The simplest way of separating was to cut the "mother shell" (scallop shell) with pruning shears.

Orangedale Culture Station, N.S.

Gillis Cove experimental collectors showed a continuous spatfall from August 10 to September 21 with a peak in late August and mid September.

Commercial collectors showed a mean autumn count of 50/filler.

Crowdis Bridge experimental collectors showed a very light spatfall from August 20 to September 17. Commercial collectors had a mean count of 14/filler.

Other Areas

Experimental collectors at the Malagash, N.S., and Shippegan, N.B., Culture Stations showed no spatfall.

Commercial collectors at Malagash and Shippegan and wood veneer rings at Mill Creek and Neguac, N.B., showed virtually no spat.

R. E. Drinnan
S. E. Vass
W. B. Stallworthy

No. B-4

HYDROGRAPHIC AND METEOROLOGICAL CONDITIONS AT ELLERSLIE, 1961-62

Analysis of long-term climatic and hydrographic trends and the study of winter hydrography in Bideford River (Annual Report 1961-62, Summary No. 19) are continuing this year.

Winter hydrography 1961-62

Water temperatures fell to 3°C (threshold for oyster hibernation) on December 8, 1961, and permanent ice formed December 17. The rate of ice production to March 1 was similar to that in 1960-61. But from March 1-15 the thickening rate was less and maximum thickness was only 30 inches. (It was 40 inches in 1961.)

In the two weeks preceding break-up on April 10, some 5 feet of fresh water accumulated beneath the ice.

When water temperatures rose to 3°C on April 19, local oysters had experienced 132 days below 3°C, compared with 170 days in the winter 1960-61.

Open water season

Mean air and water temperatures for May and June 1962 were somewhat higher than in 1961. Bideford River bottom temperatures reached 10°C on May 14 compared to May 27 in 1961, and 15°C on June 10 compared to June 16 in 1961.

Compared with the spring, the summer weather was constantly cloudy, cool and wet, and water temperatures were below average and below those for 1961 as shown in the table:

Bideford River bottom temperatures (°C)

Year	May	June	July	August	September
1961	5.5	15.5	20.4	20.5	18.8
1962	9.8	16.6	15.8	18.9	15.5

The subnormal water temperature continued through September, October and November, falling to 15°C on September 15 (Oct. 11 in 1961); to 10°C on October 9 (Oct. 21 in 1961) and to 3°C on December 1. Permanent ice formed on December 12 (Dec. 9 in 1961).

S. E. Vass

No. B-5

FIELD STUDIES ON MALPEQUE DISEASE

Spread of disease

Oysters held on trays in areas as yet unaffected by Malpeque disease have shown no unusual mortalities. Evidently there has been no spread of the disease in 1962.

Rehabilitation studies on mainland collector spat

Our monitoring (Annual Report 1960-61, Summary No. 11; 1961-62, Summary No. 11) of attempts to rehabilitate mainland areas by the transfer of resistant breeding stock from Prince Edward Island has continued.

Mortalities in year-classes of collector spat for some mainland areas are shown below.

Cumulative mortalities (%) up to November 1962

Site	Bideford (resistant)	Native	Cape Breton (susceptible)
1959 year-class			
Malagash, N.S.	14	20	90
Shippegan, N.B.	17	69	94
Mill Creek, N.B.	17	5	16
1960 year-class			
Malagash, N.S.	18	19	32
Shippegan, N.B.	16	84	-
Mill Creek, N.B.	12	11	

The Bideford (resistant) and Cape Breton (susceptible) oysters provide standards against which the resistance of native oysters can be measured.

Malagash oysters of the 1959 and 1960 year-classes behave like resistant oysters and are assumed to be resistant but (Summary No. B-6) this requires confirmation by further monitoring.

In 1961, mortalities in the 1959 year-class of Shippegan natives were low and suggested that resistance was developing. In 1962, however, mortalities of both the 1959 and 1960 year-classes approached those of susceptible oysters. We can only conclude that the natives have developed no resistance.

At Mill Creek the native oysters are still showing low mortalities like those of resistant oysters. However, the susceptible Cape Breton oysters there are also showing low mortalities. Presumably the local virulence of the disease is insufficient to cause epidemics in susceptible oysters. Therefore no conclusions can be drawn as to resistance of the natives.

<u>Rehabilitation studies on wild mainland spat</u>

Resistance tests of mainland native oysters were also carried out with small wild spat picked along the shores and held on trays.

Malagash wild spat have shown the low mortalities expected from our experience with tray-held year-classes of collector spat.

Shippegan and Caraquet Bay wild spat have shown high mortalities signifying their susceptibility.

At Neguac, N.B., wild spat have shown low mortalities, suggesting resistance but susceptible Cape Breton oysters have also shown low mortalities. This suggests a low local level of disease virulence as at Mill Creek. In 1962 native oysters from both Neguac and Mill Creek were moved to areas where epidemics are still occurring. This should permit a critical test of resistance.

The general picture seems to be that spat being produced in the northern "rehabilitated" areas are still susceptible but that resistance is developing satisfactorily in the south. The only reasonable explanation for susceptibility of northern spat is that they are the progeny of native, susceptible parents. Possibly the disease-resistant, adult

Prince Edward Island oysters have found it difficult to acclimatize so far to the north and have failed to spawn resistant young. We may assume that transferring to more southerly locations like Malagash had no such effects. In 1962 we tried to test this acclimation theory by gonad examinations but the summer was unusually cold and spawning was erratic so that no clear conclusions were possible. The attempt will be repeated in 1963.

R. E. Drinnan
E. B. Henderson

No. B-6

EFFECTS OF MALPEQUE DISEASE ON OYSTER GROWTH

So far our only method of detecting and measuring disease resistance of oyster stocks has been the checking of survival rates during 2- to 3-year periods of exposure to disease. We need other and better methods and there is evidence that growth characteristics may be useful (Annual Report 1960-61, Summary No. 11; 1961-62, Summary No. 12). Compared with resistant oysters, diseased oysters grow less per year and show late-summer and early-fall abnormalities in growth.

The 1962 observations were designed to explore these features and:

(1) Provide comparative data on oyster growth throughout the Maritimes.

(2) Measure effects of Malpeque disease on growth.

The observations were made on seventeen lots of resistant and susceptible oysters held at Department of Fisheries Oyster Culture Stations throughout the Maritimes. There were 50 or 100 oysters in each lot; the ages varied from 1 to 3 years; and they were measured once a month during the open-water season.

Resistant oysters

In 1961 the growth of resistant oysters increased to a peak in mid summer and declined in late fall. In 1962 at Ellerslie, however, their peak growth occurred earlier, their growth stopped a month earlier and their total growth was less as shown in the first table. This was due to the poor growth in July, probably caused by the unusually low temperatures (Summary No. B-4) and the early autumn decline in water temperature.

Length growth (mm per year)
of resistant and susceptible oysters at Ellerslie

	1 yr old	2 yr old	3 yr old
Resistant			
1961	34.0	23.7	
1962	21.4	15.1	14.1
Susceptibles			
1962	19.1	6.8	10.0

Susceptible oysters

During the first year after susceptible oysters are transplanted to a disease area their growth is similar to that of resistant oysters. But there is a great reduction in their growth in the second and third years when the disease takes hold (first table). Our 1962 records (second table) show that this is brought about by a late-summer decrease in growth of the susceptible oysters. It may be significant that this is also the time of year when mortalities from Malpeque disease are at a peak.

Growth in length (mm per day)
of resistant and susceptible oysters at Ellerslie, 1962

	Resistant 1-yr-olds	Susceptible 1-yr-olds	Resistant 2-yr-olds	Susceptible 2-yr-olds
May/June	0.17	0.23	0.23	0.14
June/July	0.19	0.10	0.11	0.05
July/August	0.29	0.26	0.08	0.00
August/Sept.	0.12	0.07	0.14	0.01
Sept./Oct.	0.03	0.03	0.00	0.02
Oct./Dec.	0.00	0.00	0.00	0.02
Total increment	21.4	19.1	15.1	6.8

Growth of native spat
at Malagash

Until 1962, our monitoring of rehabilitated, disease-depleted mainland oyster fisheries (Summary No. B-5) has involved little more than survival tests of successive year-classes of spat. And the results assembled so far suggest that spat setting at Malagash, N.S., since 1959 are resistant. However, our 1962 seasonal growth data (third table) suggest that the situation is not simple.

Growth in length (mm per day)
of oysters at Malagash, 1962

	Native 2-yr-olds	Resistant 3-yr-olds	Native 3-yr-olds
May-June	0.05	0.14	0.13
June-July	0.21	0.13	0.12
July-Aug.	0.12	0.10	0.06
Aug.-Sept.	0.17	0.15	0.08
Sept.-Oct.	0.00	0.00	0.01
Total growth	16.8	15.8	12.5

In their first two years the native spat show a seasonal growth pattern very similar to that of resistant oysters (compare native 2-yr-olds and resistant 3-yr-olds). In their third year, however, the natives show a marked drop in late-summer growth like that of susceptible spat in their second year (second table). What this means in terms of disease resistance of native Malagash spat should appear from growth and mortality studies that are planned for 1963.

R. E. Drinnan
E. B. Henderson

No. B-7

GILL WORMS AND OYSTER CONDITION IN MALPEQUE BAY

For four years we have been investigating oysters in two Malpeque Bay areas where there had been substantial mortalities not attributed to Malpeque disease. The oysters were typically thin in the autumn and died overwinter. Following these mortalities, both native oysters and oysters introduced from other parts of Malpeque Bay were held in the two areas and periodically sampled. No unusual mortalities have occurred on these grounds since observations began and histological examinations have shown no unusual internal parasites. However, initially there were large numbers of small flatworms on the native oysters' gills; later these spread to introduced stock. The worm-infested native oysters were initially thinner than the worm-free introduced stock. Subsequent events differed in the two localities.

Bideford Narrows

Native and introduced oysters have been monitored for worm count and index of condition since 1959. At first worm counts were higher and condition lower in native oysters than in those introduced. However, this condition slowly reversed, the two stocks being similar in both respects in

1961 and by autumn 1962 the introduced oysters had more worms and were thinner than natives.

This correlation between worm infestation and index of condition suggests a hypothesis that worms rob oysters of food directly from the gills, their food collecting organs.

Little Rock

During 1959 the condition of native and introduced oysters was similar to that at Bideford Narrows. However, while the worm count increased in introduced stock in the same manner as at Bideford Narrows the index of condition remained consistently higher than in natives. The facts observed at Little Rock do not support our hypothesis but basic ecological differences between the two areas may account for the observed difference.

Gill worms and the general decline in index of condition

Low index of condition is an increasingly common feature of oysters in the Malpeque Bay area (Summary No. B-9) and may be caused by poor feeding conditions. It is possible that the flatworm is harmless when oyster feeding conditions are good but damaging when they are poor. We cannot say whether this is true because we lack means of measuring food availability. This is a serious deficiency and we are investigating the possibility of obtaining such measurements and plan long-term monitoring of index of condition and worm count.

Biology of the flatworm

The flatworms, which were first noticed in Malpeque Bay oysters early this century, are less than one millimetre in length, white with yellow patches and have conspicuous eyes. They are absent from oysters in winter but appear on the gills in May disappearing again in the autumn. Worms may overwinter as eggs; an object looking like an egg cocoon has been found in an oyster collected late in the autumn.

Preliminary anatomical studies suggest that the worm may be a rhabdocoel of an undescribed genus.

R. E. Drinnan
E. B. Henderson

No. B-8

PRELIMINARY SURVEY OF BENTHIC DEPOSITS AND FAUNAL COMMUNITIES IN BIDEFORD RIVER, P.E.I.

Fifteen stations chosen to represent the broad range of conditions found near the Sub-Station were sampled in November 1962. Depths ranged from 4 to 14 feet. At each station roughly half a square metre of bottom deposit was examined using repeated samples from a Petersen grab. Fauna was collected from sediment after passing through a graded series of screens. The method used left much to be desired in volumetric constancy of samples and it should be improved if the survey is continued.

Bottom deposits

In general the particle size of bottom sediments was smaller at deeper stations but at all stations silt (particle diameter $< 62\ \mu$) was the major constituent. At most stations silt comprised more than half of the bottom sample. Almost all other alluvial constituents were below medium-sand size (particle diameter $< 500\ \mu$). The larger particles were mainly fragments of molluscan shells. Sediments in the deep hole off Shipyard Point were notably coarser, probably because of current scouring.

The percentage of water in the sediments was directly proportional to the silt content. Water content can be simply and quickly determined and may prove to be a useful index for describing sediments.

Benthos

Several distinctive communities were recognized but some important ones, including that of the oyster bed, were not adequately sampled.

Yoldia limatula made up the majority of the benthic biomass in the most extensive community which occupied stations at depths over 9 feet. This community was typified by its comparative paucity of fauna both in biomass and variety. Other typical members were Tellina agilis, Bittium alternatum and nephthyd worms.

Mytilus edulis was the main member of the second largest community, found at depths from 4 to 10 feet and generally close to shore. This community had a high biomass and a large number of species. Other typical members were Crepidula fornicata, Nassarius obsoletus and nereid and aphroditid worms.

Macoma balthica was the main member of a community found only in the centre of the rivers where depths were less than 7 feet. The biomass of this community was higher than in the Yoldia communities but lower than in Mytilus communities. The number of species present was also intermediate. Typical were Hydrobia minuta and Venus mercenaria.

At two stations large quantities of Nassarius obsoletus were found. Although these made up a considerable proportion of the biomass, they were probably not typical members of the fauna but seasonal aggregations.

Little is known of bottom communities and deposits in our oyster producing areas. Prior to this survey no quantitative measurements have been made and therefore no comparisons with past conditions can be drawn. The present observations permit only broad generalizations but it appears that the standing crop in the river is quite high. This aspect of oyster and general estuarine ecology is important and a thorough investigation is planned for the future.

M. L. H. Thomas
E. B. Henderson

No. B-9

OYSTER BRIEFS

Index of condition in oysters in Malpeque Bay

The index of condition of Malpeque Bay oysters has been 20 to 50 units lower in recent years than it was 20 to 25 years ago. Our data cover several years and several areas in each period, so there is little doubt that this downward trend is real. There are many areas like Malpeque Bay and it seems safe to assume that the trend is general.

The decrease in fatness may be due to a decline in productivity of Malpeque Bay attributable to the removal of nutrients from circulation by increased silting in the past decade or two. Dr. Uyeno, a post-doctoral Fellow at Dalhousie University Institute of Oceanography, studied estuarine productivity at Ellerslie in 1962 and obtained data which support this hypothesis.

Whatever the cause, the phenomenon is of great importance to the future of the oyster industry because productivity affects both total yield and quality. A study of nutrient salts in bottom cores seems desirable to discover recent changes in silting and how this may have affected estuarine productivity.

R. E. Drinnan

Zinc in oysters

In 1960, United States workers found that oysters from some areas contain so much zinc that they are toxic to laboratory animals. Concentrations of up to 4,000 ppm (mg/kg wet weight) have been recorded and last year assays of oysters from the Miramichi estuary showed that they also carried large amounts of zinc and copper. Oysters from the head of the Miramichi estuary showed zinc concentrations over 1,000 ppm (wet weight) and the score declined to 300 to 400 ppm at the mouth. Recently, assays of oysters from other Maritime areas have shown variable but universally high zinc concentrations. Scores of 1,000 ppm seem not unusual in our oysters and 400 to 500 ppm seem normal for oysters in areas where they are exposed to normal sea water. Surveys of zinc content of oysters should be continued because of possible public health hazard. Assays of quahaug meats showed low zinc content even in areas where oysters had a high content. Workers in the United States found a similar situation.

It has been suggested that oysters feed on organisms that carry out the first phase of concentrating zinc from the sea water. But we found that the zinc content of oysters held in a tray with a galvanized screen bottom was six times as high as that of oysters living on the bottom nearby. This suggests that the concentration process is a direct one by the oyster itself.

We are grateful to Dr. Boyle of the Geological Survey of Canada, Ottawa, who has carried out all analyses on meats and shells prepared by us and by the shellfish group at St. Andrews.

R. E. Drinnan
E. B. Henderson

Studies on the trophozoites of *Hexamita* in axenic culture

Hexamita is a minute protozoan which some believe to be damaging to oysters. Studies of trophozoites (free-swimming stages) in culture were begun at Ellerslie two years ago and are being continued under a contract arrangement with Mr. B. T. Khouw at Assumption University, Windsor, Ontario.

Observations on axenic (pure) cultures prepared with artificial sea water of varying salinities (0-28‰) have shown no growth below 20‰. The complete absence of trophozoites from cultures at salinities below 20‰ shows that this is not due to a failure to multiply but an inability of the organism to survive at these salinities. Growth was normal and appeared independent of salinity through the range 20‰ to 28‰. Identical results were obtained at the two temperatures tested, 4°C and 17°C.

Studies are continuing on the anaerobiosis of Hexamita. The aim is to define its growth requirements, physical and chemical. Initially observations will be made on a strain isolated at Ellerslie. It is hoped that eventually comparisons can be made with trophozoites from other areas on the North American continent.

R. E. Drinnan
(from a report by B. T. Khouw)

Histology of diseased British Columbia oysters

In 1960 there were serious oyster mortalities at Denman Island in British Columbia (FRB, MS Rept. (Biol.) No. 713). These were thought to have been caused by a disease and there was fear of recurrence in 1962. On request of the Nanaimo station we examined:

1. Oysters collected and preserved by D. B. Quayle (Zenker) in May 1960.

2. Live oysters sent by air in June 1962.

The 1960 sample showed extensive necrotic areas of tissue breakdown and heavy local concentrations of Hexamita trophozoites. The 1962 sample showed normal gonad development and plump meats with no pustules. However, there were internal abnormalities like those in the 1960 samples but less extreme. Trophozoites of Hexamita and bacteria were abundant in the tissues, a long slender rod predominating. Besides this, there were dense concentrations of a cell like that associated with early stages of Malpeque disease. However, we saw none of the symptoms of later stages of that disease.

R. E. Drinnan

No. B-10

THE HYDRAULIC CLAM RAKE - ITS FUNCTIONAL PRINCIPLE AND PRACTICAL OPERATION

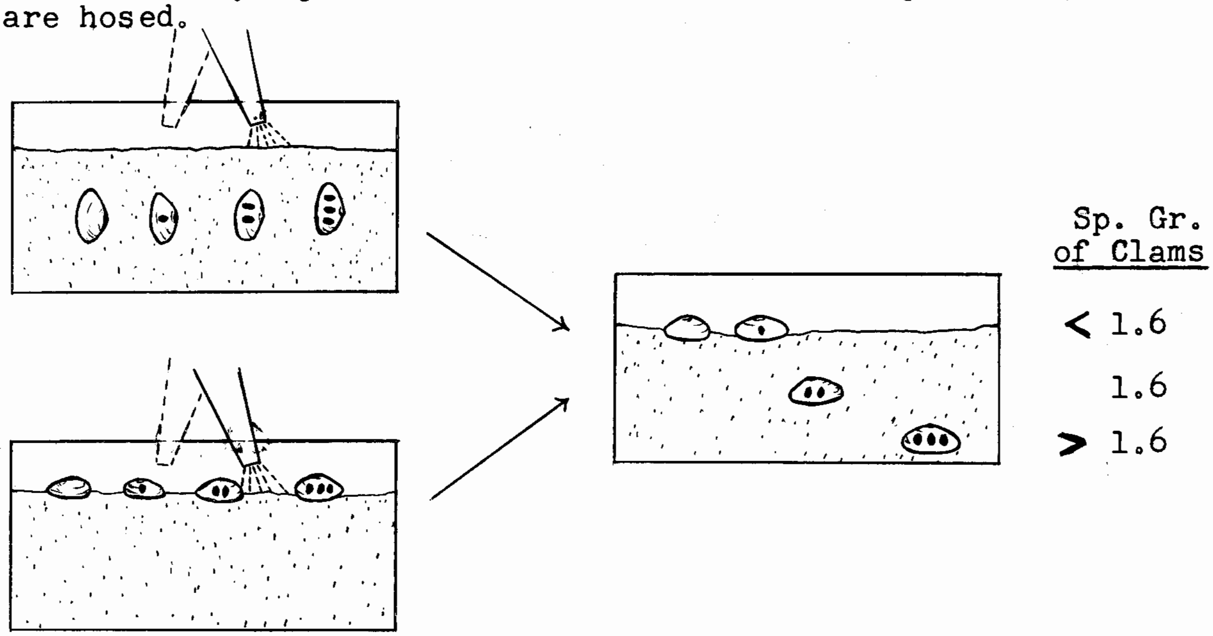
Last year (Annual Report 1961-62, Summary No. 21) we completed development work on the hydraulic rake for harvesting soft-shell clams. This year we:

(1) Demonstrated the functional principle of its operation. This helps explain the way the rake performs in different types of soil and allows us to predict how useful it may be in harvesting other kinds of shellfish such as quahaugs and bar clams.

(2) Carried out commercial-scale trial fishing for soft-shell clams in areas where intertidal flats are seldom exposed, i.e. in places where the rake could be most useful.

Functional principle

It is often said that hydraulic diggers wash clams out of the soil. This may be true for the hydraulic escalator harvester. But experiments with normal and artificially weighted clams (lead pellets in mantle cavities) show that in hydraulic raking clams are not washed out--they float up. The significant results are summarized in the figure of what happens in laboratory aquaria when clams of different specific gravities are hosed.



Behaviour of normal and weighted clams when hosed in an aquarium containing soil and water.

The result was the same regardless of whether the test clams were buried in the soil or lying on the surface of the soil when hosing started. Normal clams and lightly weighted clams came to or remained at the soil surface; weighted clams with specific gravities of about 1.6 were usually found at mid depths in the soil and weighted clams with specific gravities appreciably greater than 1.6 were usually found on the very bottom of the aquarium beneath all the soil.

These experiments and field observations reveal what the hydraulic rake's water jets actually do. They convert the upper stratum of the clam flat from a solid to a fluid state. The fluid soil-water mixture produced by the rake has a high specific gravity and in it clams pop up like corks.

The specific gravity of one lot of quahaugs from Charlotte County, N.B., was found to vary about 1.5. From this we suspect that fishing for quahaugs with the hydraulic rake might be difficult. They are likely to sink in the soil-water fluid rather than float up. We hope to make raking field trials next spring with quahaugs and bar clams.

Commercial-scale fishing

Trials were made in Chezzetcook Harbour (Halifax Co.) and St. Mary's River (Guysborough Co.), Nova Scotia, and in Kouchibouguac Gully (Kent Co.), New Brunswick.

On heavy clayey clam flats the hydraulic rake's water jets (25 lb per sq.in.) apparently failed to bring about the solid-to-fluid conversion of the upper stratum. They merely cut grooves in the surface and harvested a small proportion of the clams.

On sand-mud and sandy flat, however, the rake performed well. And, where density of marketable clams on the flats was 3 per square foot or greater, the catch averaged from 1 to 1½ bushels per man per hour.

J. S. MacPhail
J. C. Medcof

No. B-11

1962 MORTALITIES AND A POSSIBLE DISEASE ORGANISM IN NEGUAC QUAHAUGS

Our observations on quahaug mortalities in the Neguac area (Annual Report 1960-61, Summary No. 13; 1961-62, Summary No. 22) were continued in 1962 and a supposed disease organism was carefully studied.

Hay Island

Our trays here were damaged overwinter and the quahaugs lost. The only mortality data we have in 1962 are therefore from marked quahaugs on the bottom. Native and transplant quahaugs have shown mortalities of 30% and 24% respectively in the last year. This is similar to the mortalities shown by such stocks in earlier years.

The Malpec

Marked quahaugs on the bottom showed a mortality of 24% in the past year.

Air storage

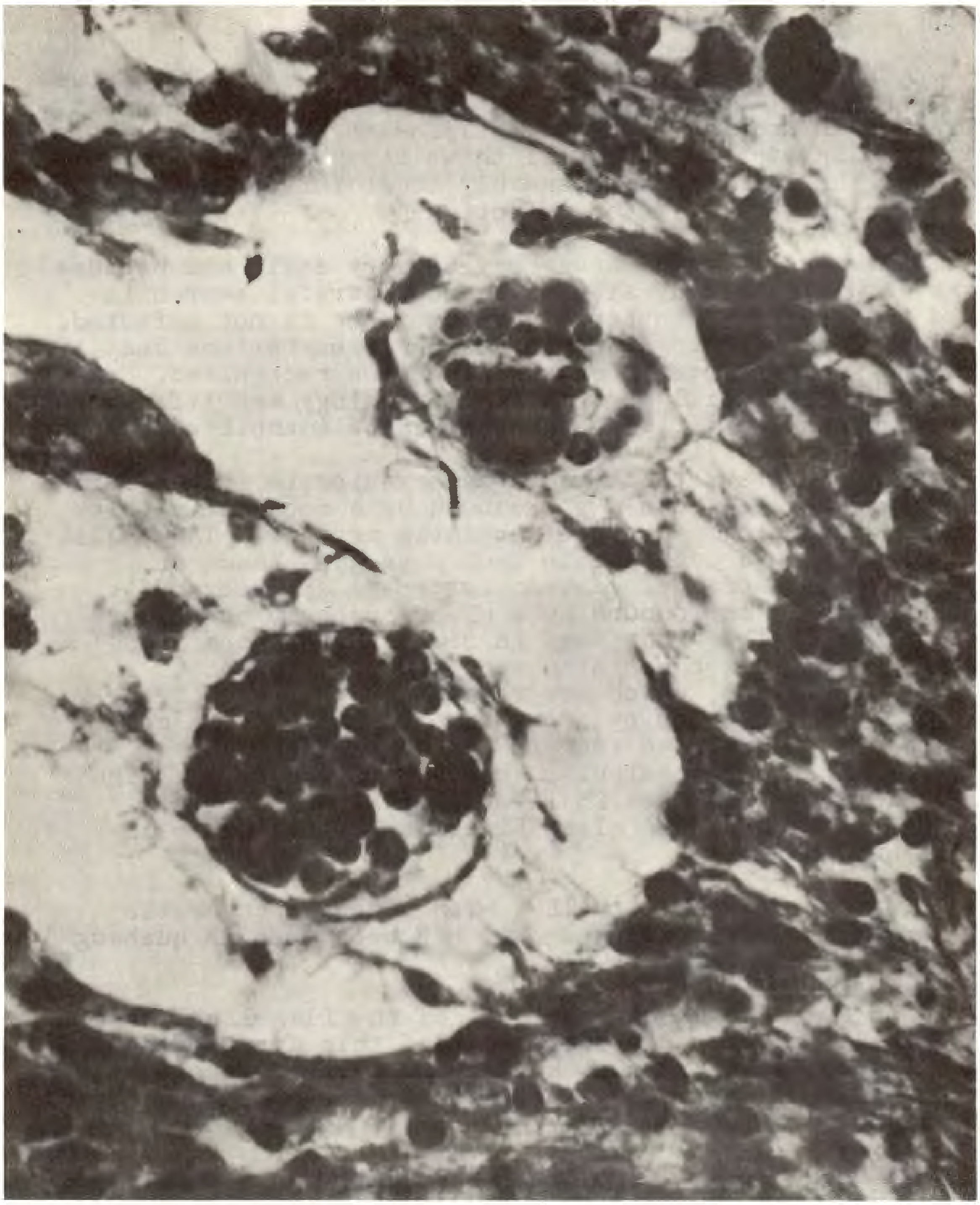
Samples of quahaugs collected during the summer of 1962 were held in cold air with mortalities as shown below:

Stock	Mortality after 19 days in cold air July-August 1962
Hay Island	
1959 transplants	82%
1960 transplants	55%
Mixed 1959 and 1960 transplants	76%
Malpec	
1960 transplants	65%
Mixed 1959 and 1960 transplants	59%

All stocks show high mortalities, confirming the earlier evidence that both areas are now affected.

Histological observations

Histological observations in 1959 showed a number of parasites in Hay Island quahaugs which were not observed in animals from other beds. In 1961 and 1962 the same parasites were seen in living and dead quahaugs at Malpec. The most



Photomicrograph of a thin, stained section of a sick Neguac quahaug. Two sporangia (diameter, 50 μ) containing numerous planonts of a fungus are seen in tissues it has damaged.

prevalent of these in both living and gaping quahaugs is a large fungal cell (Figure) causing severe local damage. Dr. John Karling of Purdue University, who saw material two years ago, confirmed our tentative assignation of this organism to the Phycomycete order Chytridiales and went further in assigning it to the genus Olpidium.

The thalli of this fungus occur in almost all tissues of the quahaug but most often in the dorsal part of the gills, the renal organ and the connective tissue of the visceral mass, especially close to the gut. All these sites are close to the exterior of the animal and presumably local infections develop close to the original site of infection.

Because infected areas may be very small and because they may occur in so many sites, the most careful search is required to determine whether a quahaug is or is not infected. The organism can be recognized in stained preparations and living material and several stages have been recognized. However, there are still gaps in its morphology and life history that must be filled before it can be identified.

The vegetative stage of the organism is in the form of a simple sphere (4-20 μ), surrounded by a moderately thick sheath and containing a diffuse chromatin network. The thalli occur typically in a conspicuous lesion in the tissue or embedded in a mass of dissociated tissue and amoebocytes, characteristically surrounded by a clear space in the tissue. The vegetative thallus increases in size and develops into a sporangium (Figure) containing many (20-40) planonts, presumably flagellate, which are released by rupture of the cell wall. These develop by growth and formation of a cell wall. This stage has been seen in amoebocytes, which may indicate either an intracellular stage or phagocytosis. The planonts have not been seen in live material and so their flagellation, on which the classification of this group is based, is not known.

A thicker walled thallus with a denser chromatin network, presumably a resting spore, has been seen in quahaug gapers.

In the absence of knowledge of the flagellation of the planont the precise classification of this fungus cannot be determined. On our present knowledge of its morphology it could belong to any one of three genera from two orders of the Phycomycetes.

Attempts to culture the fungus have shown promise and are continuing. But its relation to quahaug mortalities will remain obscure until we are able to induce infections.

R. E. Drinnan
E. B. Henderson

No. B-12

PARALYTIC SHELLFISH POISON STUDIES

Investigation of paralytic shellfish poison problems in the Bay of Fundy and the estuary of the St. Lawrence was re-opened in 1961. It was hoped that better understanding might enable us to make long-range predictions of danger periods, do better monitoring and achieve more efficient control. During this 2-year period most attention has been devoted (1) to tracing the poison to its source and (2) to examining the importance of environmental factors that regulate the annual cycle of shellfish toxicity trends. Preliminary results of this study have already been communicated (Annual Report 1961-62, Summary No. 23).

Shellfish toxicity trends in 1962

Bay of Fundy toxicity scores for clams and mussels were low in 1962 compared with 1961. The rise started in the second week of July and peaked in late August and early September. Head Harbour mussels (*Mytilus*) showed the lowest scores since 1955 with an annual mean of 49 µg, a summer (June-October) mean of 61 µg and a peak score of 176 µg recorded on August 14. Toxicities at Lepreau Basin were also low. Mussels (*Mytilus*) peaked at 1,088 µg and clams (*Mya*) at 432 µg on August 27.

On the Nova Scotia side of the Bay of Fundy most sampling stations remained toxin-free or showed extremely low scores. The highest reached 77 µg for red mussels (*Volsella*) at Centreville on September 4.

Plankton studies

Year-round water samples and plankton net hauls were taken at Head Harbour and Lepreau Basin for plankton study and records of water temperature and salinity were kept. A plankton calendar describing the seasonal succession of planktonic organisms and the abundance of the poison-bearing dinoflagellate, *Gonyaulax tamarensis*, was prepared.

In 1962, *G. tamarensis* was less abundant than in 1961. It appeared first at Head Harbour in the first week of July and by the third week densities as high as 6,000 cells/litre were recorded. Peak density of 19,000 cells/litre was observed in the last week of August. At Lepreau Basin the peak density of 18,000 cells/litre was recorded on August 23. These peaks seemed to coincide with or precede the shellfish toxicity peaks. As in 1961, plankton extracts showed detectable poison only during these peaks.

Situation in St. Lawrence estuary

In August when shellfish toxicities were rising in the estuary of the St. Lawrence, plankton and water samples were examined at several south shore locations between Bic and Grande Rivière. We found G. tamarensis in these samples and isolated it in unialgal culture. It was most abundant at Metis Beach and Baie des Capucins. These are also the areas where shellfish are most toxic. We believe that, as in the Bay of Fundy, G. tamarensis is the primary source of poison in the St. Lawrence estuary. The St. Lawrence toxicity trends are highly variable compared with those in the Fundy and further study is recommended to explain this.

Uptake of poison by natural and experimental shellfish populations

Non-toxic clams and mussels were placed in experimental floating cages at Head Harbour and Lepreau Basin. Weekly samples of these and of stocks on natural beds were assayed for toxicity.

Figure 1 shows that changes in toxicity of the natural and experimental populations were closely similar. In both cases mussels accumulated more poison than clams which is probably due to more efficient feeding. The gains in the experimental mussel population were greater at Head Harbour where the shellfish were constantly submerged in water than at Lepreau Basin where feeding was interrupted by the exposure of cages on the flats at low tide. The cage method should be useful for detecting poison in areas where the indigenous shellfish are scarce or difficult to sample.

Feeding shellfish on Gonyaulax

Non-toxic clams were placed in an aquarium filled with a unialgal culture of G. tamarensis (population density 1.9×10^4/ml) and assayed at regular intervals. The clams showed detectable poison on the second day and by the sixth day scored 112 µg. In this period there was a progressive decline in the cell density of the surrounding culture indicating that the clams were feeding on it. Similar experiments were conducted on mildly toxic clams from Lepreau Basin and a rise in toxicity was noticed following feeding on Gonyaulax (Table I). The clams that were given the most culture became most toxic. Thus we have direct evidence that our shellfish derive their poison from G. tamarensis.

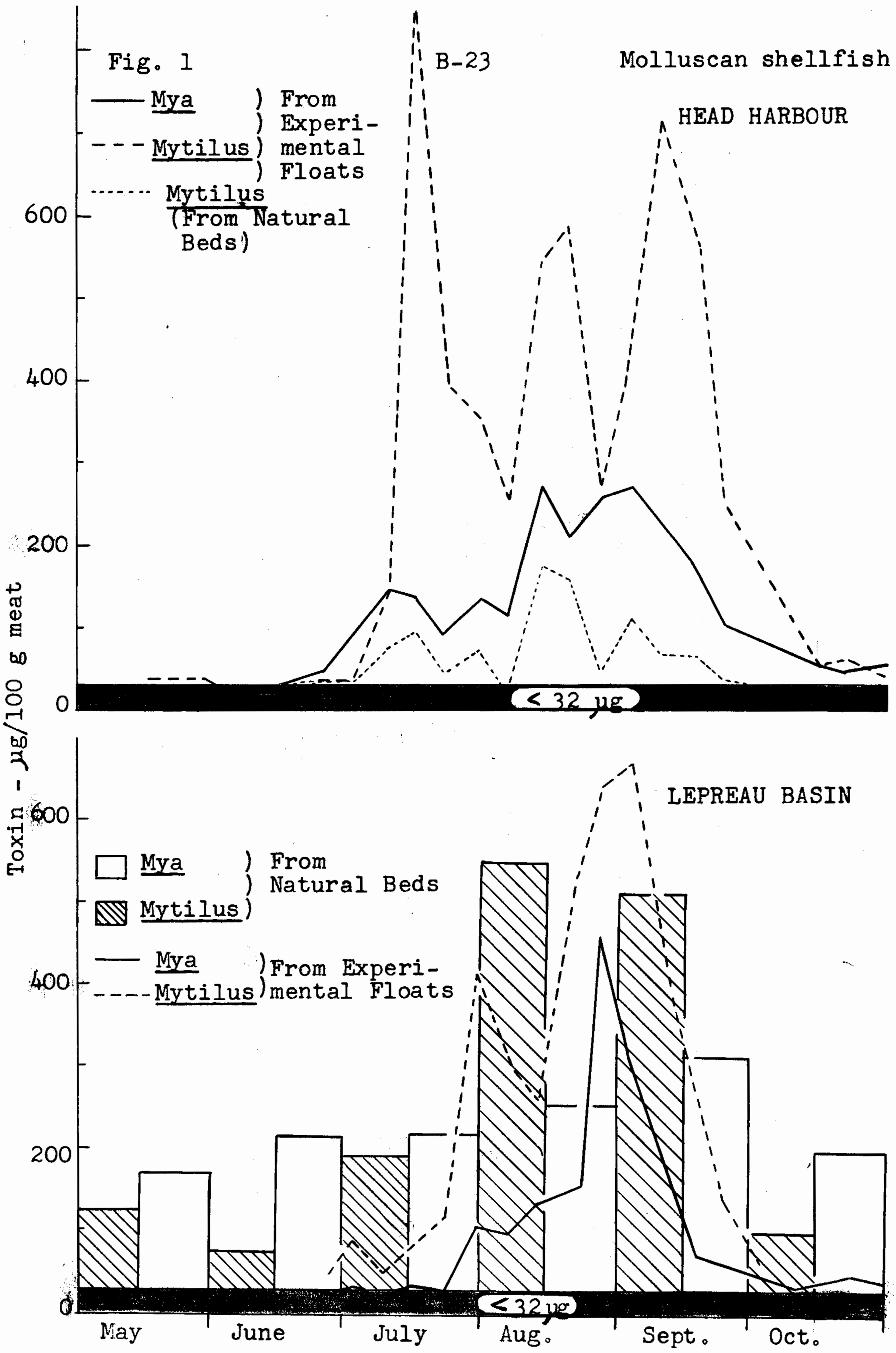


Fig. 1
B-23
Molluscan shellfish
Mya) From
) Experi-
Mytilus) mental
) Floats
Mytilus
(From Natural
Beds)
HEAD HARBOUR
600
400
200
0
< 32 µg
Toxin - µg/100 g meat
LEPREAU BASIN
600
Mya) From
) Natural Beds
Mytilus)
Mya)From Experi-
Mytilus)mental Floats
400
200
0
< 32 µg
May
June
July
Aug.
Sept.
Oct.

Table I. Accumulation of further toxin by mildly toxic Lepreau Basin soft-shell clams when fed different amounts of Gonyaulax tamarensis. The toxicity level is a function of the number of cells consumed.

Group (25 clams)	Vol. of culture fed	Estimated no. of cells eaten	Toxin level
	ml		µg
A (control)	0	0	176
B	1,200	2.28×10^7	200
C	1,400	2.66×10^7	192
D	2,000	3.80×10^7	240

Production of toxin and growth characteristics in G. tamarensis cultures

Experimental cultures were grown in 20 mm x 125 mm culture tubes each containing 10 ml of a selected medium (Erd-Schreiber or ASP 7) and inoculated with 0.5 ml of unialgal stock culture. These cultures were maintained at 10 ± 1°C under constant illumination (400-500 ft. candles). Growth was measured by direct cell counts using Utermohl's method.

When the cultures became fairly dense, acid extracts of "in situ" cultures, filtered cells, and the filtrates were assayed for toxin at frequent intervals to see if there was any relationship between the production of toxin and the density of G. tamarensis. Table II shows that there is no detectable toxicity (32 µg) until the cell density reaches 4,000 cells/ml. Beyond this point toxicity score is a direct function of cell density.

The toxin from G. tamarensis is essentially an endotoxin remaining within the dinoflagellate and not leaching into the culture medium while the cell wall is intact. The toxicity of filtrates of old cultures indicates leaching of poison from dead cells.

Comparisons of toxicity scores for cultures of equal density show that G. tamarensis carries a heavier poison load per cell than G. catenella.

Conclusions and recommendations

Information gathered during the last two years enables us to examine the paralytic shellfish poison problem with a clearer perspective. Laboratory and field studies have

Table II. Production of toxin in unialgal cultures of *G. tamarensis* from the Bay of Fundy.

Tube no.	Cell density/ml Initial	Cell density/ml Final	Days after inoculation	Toxin - µg/100 ml culture "In situ"	Toxin - µg/100 ml culture Filtered cells	Toxin - µg/100 ml culture Recovery in filtrate
1	10	2.5×10^3	46	< 32	< 32	nil
2	10	4.0×10^3	56	32	32	nil
3	10	9.0×10^3	61	53	54	nil
4	10	8.4×10^3	68	50	51	nil
5	10	1.3×10^4	73	53	72	nil
6	10	1.2×10^4	82	66	72	nil
7	10	1.6×10^4	89	70	78	nil
8	10	1.8×10^4	96	70	78	37
9	10	1.9×10^4	103	66	120	53
10	10	2.0×10^4	110	106	94	53
11	10	2.0×10^4	117	80	66	40

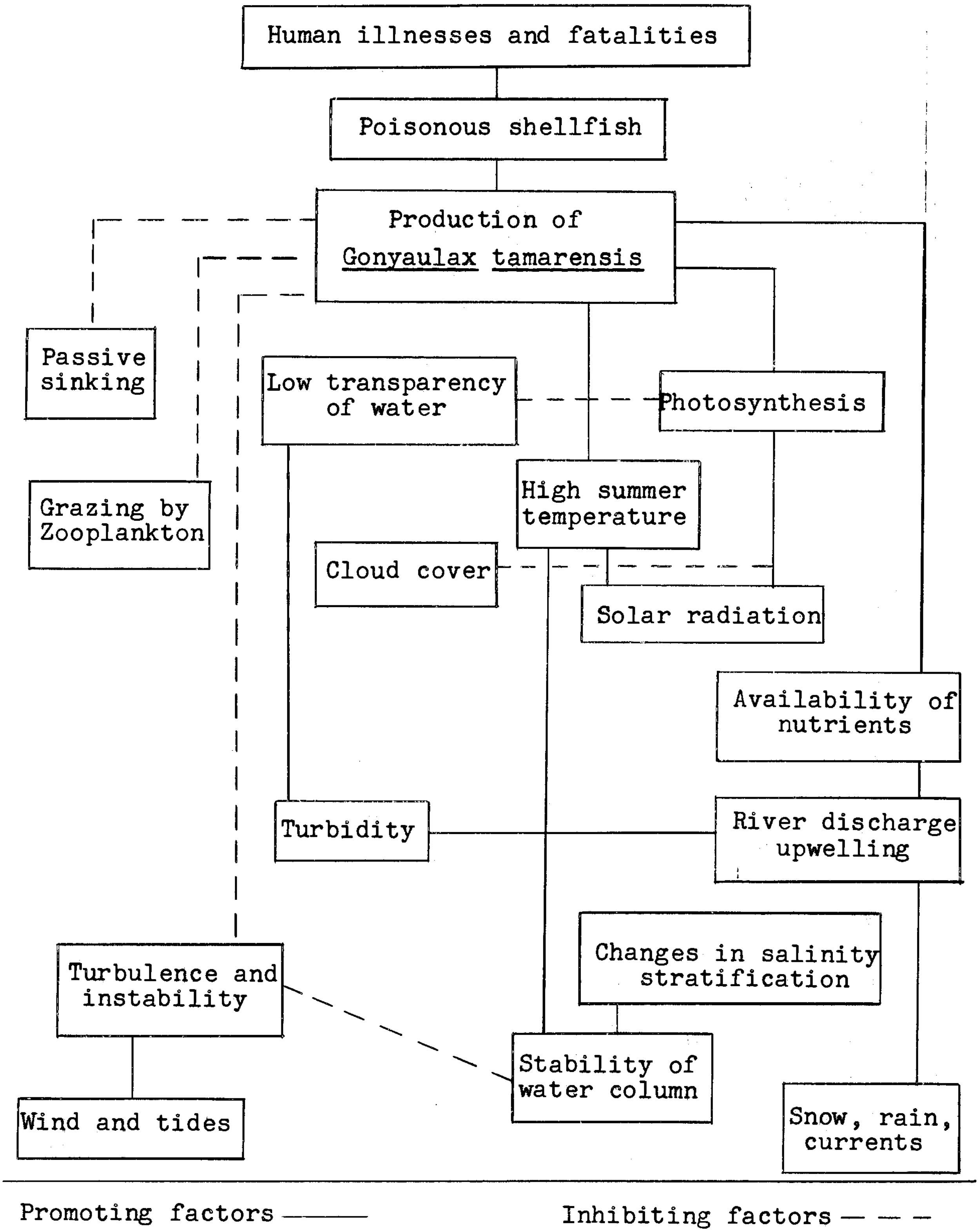


Fig. 2. Some important factors affecting production of *Gonyaulax* in nature.

shown that fluctuations in shellfish toxicity result from fluctuations in abundance of the causative organism. The striking seasonal abundance changes of G. tamarensis in the Bay of Fundy and the estuary of the St. Lawrence show how efficient this organism is in taking advantage of favourable environmental conditions when they occur. But they also suggest that its tolerance ranges are limited. The production of G. tamarensis in nature is an outcome of an unbalanced state which often exists between growth-promoting factors on one hand and growth-inhibiting factors on the other. Some of these factors are summarized in Figure 2.

Toxicity records assembled since 1944 reveal a well defined seasonal (within-year) cycle in the Bay of Fundy. The exact timing varies somewhat but one can be fairly certain that the shellfish will be unfit for human consumption for at least a brief period between June and October. However, there seems to be no trend or cycle of the between-year differences in toxicity level. Many of the factors regulating toxicity (Fig. 2) do not lend themselves to quantitative measurements or reliable prediction. Thus, although we can say within limits when conditions are likely to be bad in a particular year, we cannot forecast the exact time when danger will be greatest or just how great it will be.

Our earlier belief that there is a constant order in the time of appearance of the poison in different areas and that shellfish in areas exposed to the open Bay show poison about 10 days before it appears in inlets is now subject to question. The existing monitoring system is reasonably successful but, for the reason just mentioned and possibly for other reasons (e.g. high cost), it may require modification. A "blanket closure" from June to October each year imposed on the entire Bay of Fundy might be the simplest and best solution. This would not only cut down the unnecessary routine sampling from certain areas but may also help in the rehabilitation of the existing shellfish stocks. Sampling could be reduced or eliminated in areas (1) where there is a trend towards very low toxicity over a period of a few years, (2) which are in close proximity to other sampling areas, and (3) which are not economically attractive or easily accessible to the general public.

A. Prakash

No. B-13

LARVAL DEVELOPMENT OF SEA SCALLOPS

Investigations of the basic biology of sea scallops were continued in 1962. Emphasis again centred on a study of the larval stages and some progress over last year's results was realized.

Conditioning and spawning adults

Adult scallops were collected locally in Passamaquoddy Bay and held and preconditioned for spawning in aquaria in the lab. Aquaria temperatures were held at 11°C and the natural food supply was augmented with three species of cultured phytoplankton: _Phaeodactylum tricornutum_, _Isochrysis galbana_ and _Dicrateria_ sp. The scallops remained in good condition and the gonads were ripe and full.

Before spawning, the scallops were first scrubbed clean. They were placed in shallow dishes and covered with filtered sea water which had passed over an ultra-violet light (referred to here as sterile sea water). In an effort to induce spawning, scallops were subjected to a variety of sudden changes of water temperatures ranging from 2°C to 20°C. The most successful treatment was to take the animals out of the aquaria, hold them in air for up to 3 hours, and then return them to sterile sea water, maintained at 10° to 15°C.

After spawning, the adults were removed from the dishes and the eggs and sperm allowed to remain in separate dishes for 1 to 3 hours. They were mixed and stirred gently. These fertilized eggs were washed and then placed in 15 litres of sea water in plastic culture buckets.

Larvae were obtained from six separate spawnings, two in July, two in August and two in September.

Rearing larvae

Larvae were reared under three different feeding conditions: (1) They were held in sterile sea water to which two species of cultured phytoplankton, _Isochrysis galbana_ and _Dicrateria_ sp. were added. (2) They were held in sea water collected off the Biological Station wharf and filtered through a No. 18 or 25 plankton net. (3) They were held in a mixture of the above two: 5 litres of filtered sea water and 10 litres of sterile sea water with the added two species of phytoplankters.

In all cases the water was changed every second day. Most of the cultures were maintained at the temperature of

Passamaquoddy Bay in late summer, 10° to 13°C. A few cultures were kept at 20°C and some at 10°C.

Results

The best results were obtained when larvae were held in sterile sea water and fed the two species of phytoplankters. Larvae from the first four spawnings grew well for the first 2 or 3 weeks and then suffered unexplained heavy mortalities. After 3½ weeks all were dead. Copepods and nematodes appeared in most cultures and undoubtedly ate some larvae but were probably not responsible for the massive mortalities.

Larvae from the last two spawnings (Sept. 6 and 17) fared better. They were kept in sterile sea water plus the cultured phytoplankters. Some survived for 58 days and grew to 275 by 288 microns. Some developed a foot and appeared ready to settle but apparently none settled.

We have plotted a growth curve for sea scallop larvae but we still do not know the duration of the larval period or the size at which they settle, either in cultures or in nature. It appears that the sea scallop larval period is longer than the oyster, soft-shell clam or quahaug.

In 1962 we again attempted to collect natural larvae by plankton tows and natural spat by setting out spat collectors in Passamaquoddy Bay. Both attempts failed.

We plan to continue these studies in 1963 since an understanding of the larvae and their post-settlement behaviour, as well as definite knowledge of the position of the first growth ring, are essential for age determinations and therefore basic to recruitment studies.

N. Bourne

No. B-14

STATUS OF THE MARITIMES SCALLOP FISHERY - 1962

Sea scallop landings increased again in 1962 to a record 14 million lb of shucked meats, valued at 4.7 million dollars, a 30% increase in weight and a 46% increase in value over 1961. As in 1961, all phases of the fishery--offshore, Bay of Fundy and Gulf of St. Lawrence--shared in this increase.

Offshore fishery

The offshore fleet accounted for the bulk of the landings, 13.1 million lb (93.6% of the catch) valued at 4.4

million dollars, an increase of 30% in weight and 49% in value. Almost the entire effort of this fleet was concentrated on Georges Bank. Three of the smaller boats (65-footers) made one or two trips to Port au Port, Newfoundland, and two other 65-footers made a couple of trips to the scallop bed near the Lurcher Shoals at the mouth of the Bay of Fundy.

The 1962 landings increased because of a further build-up of the offshore fleet (39 boats as compared to 28 in 1961). Crew sizes remained the same as 1961 or even decreased. As was predicted last year, the catch per boat was down in 1962. However, the increase in wharf price compensated for this decrease and the earning power of the boats remained about the same as in 1961.

The abnormally abundant year-class which provided the large catches in 1960 and part of 1961, contributed little to 1962 catches. Boats fished much harder in 1962 and covered a great deal more of the Bank. In 1962 they fished in 30 different sub-divisions as compared to 19 in 1961. Deck loading, which was the accepted practice in 1960 and '61, was uncommon in 1962 because the catch per unit effort decreased. This was measured by observers on commercial boats and expressed as catch of market-size scallops in bushels per drag per tow per minute. Mean values for the past 3 years were 1.93 in 1960, 0.58 in 1961 and 0.4 in 1962.

Two trips were made on commercial draggers to sample catches, study mortalities, record cull points and make biological observations. Catches were smaller and crews on the double watches were idle at times. The cull point dropped slightly and the 50% cull point is now between 90-95 mm in shell height. Clappers (paired empty shells) which indicate natural mortality comprised less than 10% of the catch in almost all areas.

Two samples of live scallops were brought back for shell-height, meat-weight analysis. Scallops of the same shell height from two areas separated by about 20 miles showed differences as great as 20% in meat weight.

<u>Inshore fishery</u>

Bay of Fundy landings increased 15% to 833,000 lb (Digby 803,000 lb and Charlotte County, N.B., 30,000 lb). In both areas scallops were more abundant and the increased wharf price made scalloping much more attractive to fishermen.

Gulf of St. Lawrence scallop landings increased $2\frac{1}{2}$ times to 51,000 lb but this is still below the landings of the good years of 1956 and '57. Results of our survey in 1961 (Annual Report 1961-62, Summary No. 27) and the increased wharf price provided a stimulus to the fishermen of this area.

Outlook for 1963

The future of the offshore fishery is encouraging but perhaps not as bright as in some former years. Building of scallop boats continues and by the end of 1963 the fleet will expand to about 60 boats. Our limited sampling indicates that the incoming year-class is not exceptionally strong and we expect that the catch per boat will decrease further in 1963, although total landings may increase slightly because of increased effort. This prediction of a decrease in catch per boat is shared by United States scientists. Wharf price increased in 1962 and if it continues to increase in 1963, the boats should earn about the same in 1963 as they did in 1962.

Scallop stocks at Digby are in one of their cyclic periods of abundance. This period of abundance started in 1961, continued in 1962 and if it has the same history as previous cycles should provide reasonably good fishing at Digby in 1963. Interest in scallop fishing at Digby often depends more on wharf price than on abundance.

The future of the scallop fishery in the Gulf of St. Lawrence is always difficult to predict. If other fisheries in this area are further depressed, some boats may attempt to drag for scallops. Wharf price will be an important factor. If roes could be utilized (Summary No. B-16) this might provide a much needed stimulus for this fishery.

N. Bourne

No. B-15

SCALLOP GEAR RESEARCH

Since the Canadian offshore scallop fishery began in 1945, there has been only one significant change in the gear. In 1948 the present sweep-chain drag replaced the old bar-type drag. To date our gear research has been confined to studying size selection of scallops when rings of different diameter are used in this drag.

The standard ring has an inside diameter of 3 inches. In 1959 and '61 we compared catches by drags with 3- and 4-inch rings (Annual Report 1959-60, Summary No. 27; 1961-62, Summary No. 26). The results showed the difference in scallop size selection between the two size rings to be small. Poor selection resulted from two factors: (1) Scallops do not struggle to escape from drags and (2) in the initial stages of the tow the drags plug up with trash and little sorting is possible.

In 1962 the Georges Bank catch per boat declined and boats began dragging in rocky areas which were previously ignored because they are so hard on gear. Exploitation of these rough areas is likely to continue. There is a need for information on the efficiency and towing characteristics of the offshore drag on different types of bottom. As part of the fishing efficiency program, we initiated studies in 1962 to examine these characteristics of the offshore drag. In September we used the M.V. Harengus in the southern Gulf of St. Lawrence to tow an 8-foot offshore-style drag. Two members of our staff, Dr. D. J. Scarratt and P. W. G. McMullon, who are trained Scuba divers, attempted to observe the drag's action on the bottom and determine its efficiency. We thank these gentlemen for their assistance.

Unfortunately towing speeds during commercial dragging are so fast (about 4 knots) that the divers were unable to ride the drag and observe its towing action. However, an attempt was made to measure its efficiency by two methods: (1) When the tow was completed, the two divers followed the track of the drag and picked up scallops left by the drag. (2) Transects were made to assess the scallop population. Then the drag was towed over measured distances and the efficiency of the drag ascertained.

Preliminary results indicate that the drag is very efficient at catching market-size scallops when they are sparsely distributed on smooth bottom.

We plan to continue these studies in 1963 using an underwater camera to study the towing action of the drag and the reaction of scallops to approaching drags.

N. Bourne

No. B-16

FULLER UTILIZATION OF SCALLOPS

In the Canadian scallop industry the large adductor muscle (approximately 12% of the total or "round" weight) is the only part of the scallop that is utilized. The remainder of the animal is discarded. In some countries, other soft parts are also used, e.g. gonads (roes or tongues) and mantles (rims). Some potential markets are closed to our industry simply because the roe is not marketed along with the adductor muscle.

To date this has not encouraged any change in the fishing practice of industry. Scallops have been so plentiful that industry has not been obliged to seriously consider using the other soft parts. Furthermore the adductor muscle is so large that it is relatively cheap and easy to obtain a pound of meats. If the catch per boat decreases further as predicted (Summary No. B-14), industry may become interested in marketing additional parts.

In 1962 we made a cursory study of the possibilities of utilizing roes along with muscles. Samples were taken from two areas, Georges Bank and Passamaquoddy Bay.

By a slight variation in technique, fishermen are able to shuck out the roe along with the meat. This does not propose any major problem.

Seasonal variation

Female roes are bright coral red in colour and the male is creamy white. Roes could only be marketed from early May until late September, when they are large and full. During this time they are about the same size and about half the weight of the adductor muscle. In other words using the roes would increase landings by about 50% during these five months (see Table).

Mean weight of gonads, expressed as a percentage of the weight of the meat

	Passamaquoddy Bay		Georges Bank	
	Male	Female	Male	Female
June 12	$\bar{x}$ = 59.6%	$\bar{x}$ = 94.8%		
June 24			$\bar{x}$ = 54.3%	$\bar{x}$ = 47.9%
July 3	$\bar{x}$ = 69.6%	$\bar{x}$ = 65.8%		
Aug. 6			$\bar{x}$ = 62.1%	$\bar{x}$ = 59.8%

Handling problems

The major problem in marketing roes is the handling problem. This is particularly true for the offshore fishery. The digestive tract loops through the gonad and a piece of intestine is always removed when roes are shucked. This probably accelerates the rate of decomposition and it is impossible to take it out or even wash it out. However, scallop fisheries in other countries face the same problem and yet are able to market roes.

Samples of Georges Bank scallop roes were collected in June and August and iced aboard ship in rigid containers to prevent squashing. Mr. F. C. Read of National Sea Products, Lunenburg, N.S., examined the roes when they were landed, using the standard organleptic tests he uses to determine the quality of adductor muscles. Fresh roes were enjoyed by all who ate them. The red roes remained fresh for 6 days and the white roes for 5 days after shucking. Mr. Read felt that the roes could be kept longer and in better condition if they were first dipped in an antibiotic such as "Acronize".

Toxicity tests

Tests for paralytic shellfish poison have now been carried out in June, July, August and September on Georges Bank. Material sampled included horse mussels (Volsella modiolus) and scallop "livers", which would show toxicity if it were present. To date no toxicity has been found.

Roes taken from scallops in Passamaquoddy Bay showed little toxicity, certainly below acceptance levels, although the "livers" were very toxic. We have not tested those from Gulf of St. Lawrence scallops but expect those from the southwestern Gulf will be consistently poison-free because clams and mussels from this region are always negative.

Future utilization

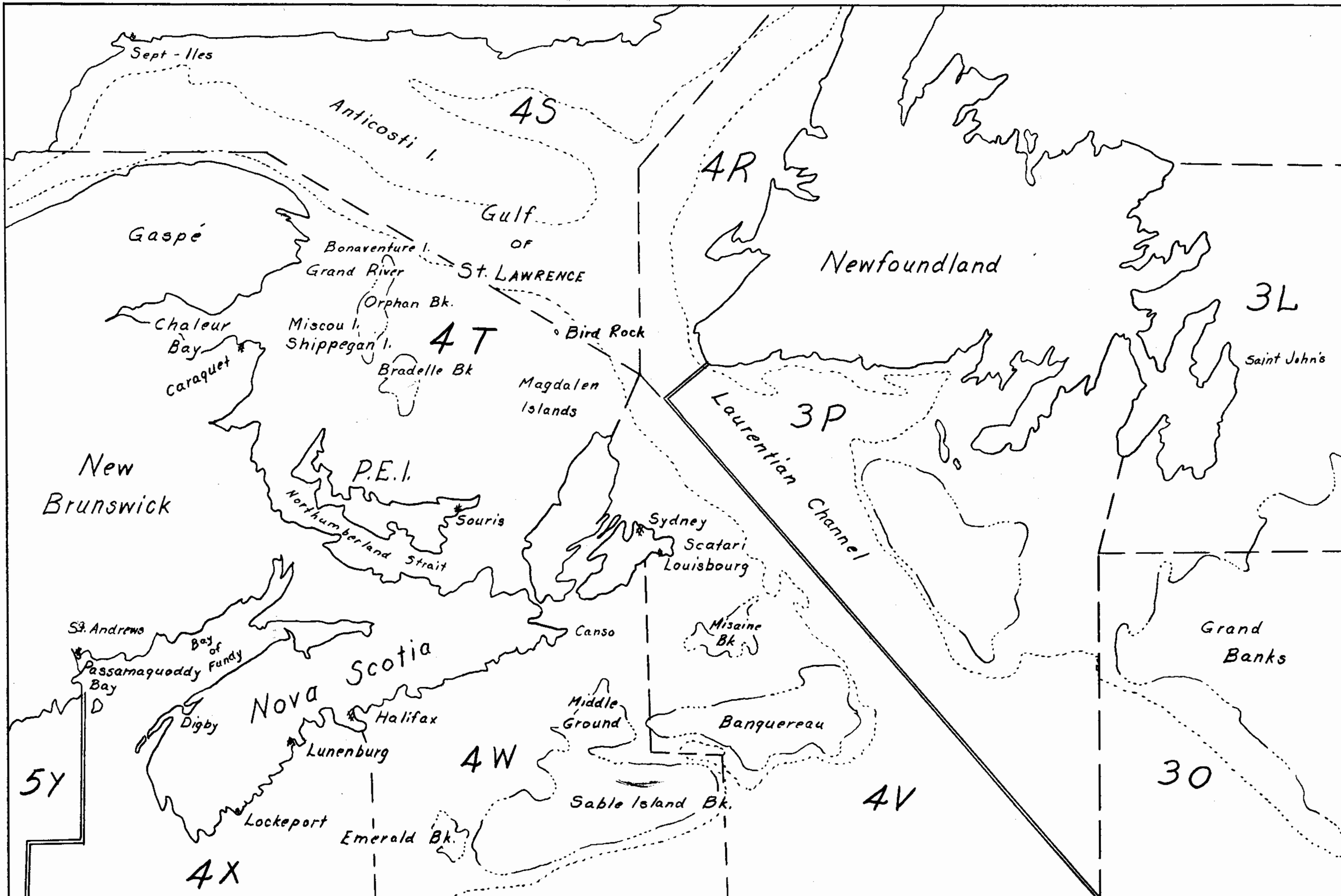
There seems to be a real possibility of increasing landings and potential markets by using roes. The product would have to gain market acceptance by the public but this is probably a minor problem.

Utilization of roes could be tested easier in the Gulf of St. Lawrence scallop fishery than most other places because it is a summer fishery and shucking is carried out in plants on shore. In most years this fishery is a borderline operation should welcome a yield increase of 50% above the catch they obtain now.

Use of roes certainly warrants further investigation but possible uses for the other parts of the scallop should be kept in mind. Once the "livers" are cut out, any and all soft parts are said to be better than clams for chowders.

N. Bourne

GROUNDFISH SUMMARIES



Sept - Iles
Anticosti I.
4S
4R
Gulf
of
St. LAWRENCE
Gaspé
Bonaventure I.
Grand River
Orphan Bk.
Newfoundland
3L
Chaleur
Bay
Caraquet
Miscou I.
Shippegan I.
4T
Bird Rock
Bradelle Bk
Magdalen
Islands
Saint John's
3P
Laurentian Channel
New
Brunswick
P.E.I.
Northumberland Strait
Souris
Sydney
Scatari
Louisbourg
St. Andrews
Bay
of
Fundy
Canso
Misaine
Bk
Passamaquoddy
Bay
Nova
Scotia
Grand
Banks
Halifax
Middle
Ground
Banquereau
Digby
Lunenburg
4W
5Y
30
Sable Island Bk.
4V
Lockeport
Emerald Bk.
4X

No. C-1

INTRODUCTORY SUMMARY--GROUNDFISH

During 1962 groundfish investigations were closely associated with other offshore investigations of pelagic species, scallops and oceanography. Co-ordination was achieved through the newly-established Co-ordinating Committee on Fishing Efficiency and the expanding work of the International Commission for the Northwest Atlantic Fisheries (ICNAF).

Research for the fishing efficiency program was arranged by diverting existing staff to new projects, by transferring a research engineer from Nanaimo to St. Andrews, and by appointing a scientist to study fish behaviour.

A survey of the fishing industry supported the great need for bottom charts of Canadian Atlantic offshore fishing grounds. This study led to a commitment by the Department of Mines and Technical Surveys to produce a series of special charts for fishermen. A manuscript report prepared from the survey will be used as the basis for action.

Research-vessel surveys continue to provide forecasts of trends in fishing success. In the southwestern Gulf of St. Lawrence it is apparent that the abundance of large cod has been greatly reduced by intensive dragging, and that there is no significant change in recruitment of young fish. On Nova Scotia Banks haddock are also of small average (scrod) size because of intensive otter trawling.

Studies of groundfish distribution (eggs to adults) and behaviour were carried out from research vessels and in the laboratory. Echo-sounder records added to the information obtained from research dragging. Fish behaviour studies were initiated to explain diurnal and species differences in otter-trawl catches. Instrumentation is being developed and procured for a study of the towing relationships between vessels and otter trawls of various sizes. This project has immediate practical value, and will provide the basis for subsequent studies of otter-trawl performance and improved design.

Statistics and sampling of commercial fishing operations are demanding and growing responsibilities. A study of flounder species in commercial landings was carried out and advice was accepted by the Department on provision of improved statistics by species for an expanding flounder fishery. Efficient processing of Maritimes area statistics is arranged at annual meetings with officers of the Department of Fisheries and the Bureau of Statistics. Discrepancies in cod age reading among ICNAF countries were dealt with at an otolith workshop in Bergen, Norway.

A comprehensive report on fishery assessment in relation to regulation problems was published by ICNAF, and a second report by the Assessment Group was submitted to the Commission. Emphasis is now shifting from a study of effects of various mesh sizes to the relation of landings to fishing effort. Development of models which will provide better descriptions of fish production, inter-species relationships, and effects of fishing is an important research project. As a step in this direction, models for description of growth have been improved, and effects of temperature and food on this parameter are emerging from laboratory feeding experiments on cod.

The effects of mesh regulations were assessed by examining changes in commercial nets and by observing changes in the quantities and sizes of cod and haddock caught and discarded at sea. Although wastage has been greatly reduced, by using large-mesh nets and by a reduction in the sizes of fish acceptable for markets, significant quantities of small fish are still discarded.

A study of plaice flounders in the western Gulf of St. Lawrence was completed. High discards at sea and intensive fishing are reducing the availability of large plaice to the commercial fishery. Halibut research was directed toward a study of the commercial fishery, and an assessment of the value of returning to the water small halibut which are caught in large numbers incidentally to fishing for other groundfish. A study of the pollock at the mouth of the Bay of Fundy has shown that the expanding otter-trawl fishery is having little effect on sizes and availability in commercial catches.

A large part of the reporting of groundfish investigations may be found in the various meeting documents and publications of ICNAF.

W. R. Martin

No. C-2

GROUNDFISH STATISTICS

Canadian Atlantic fish landings for the year 1962 are summarized by weight and value in the accompanying table. Statistics are presented for groundfish species and groups of other species by Provinces.

Half the groundfish, by value, are now landed in the three Maritime Provinces. The species are cod, haddock, pollock, halibut, American plaice, witch (greysole), redfish, hake, cusk and catfish (wolffish), in decreasing order of importance. Groundfish landings represent over half the

1962 Canadian Atlantic landings (thousands metric tons) and landed value (millions dollars), by Provinces.

	N.S.		N.B.		P.E.I.		P.Q.		(est.) Nfld.		Total	
	L	V	L	V	L	V	L	V	L	V	L	V
Cod	52	4.0	22	1.5	5	0.3	36	2.1	204	10.6	319	18.6
Haddock	39	3.5	2	0.2	1	0.1			20	1.0	62	4.8
Pollock	27	1.3	6	0.3							32	1.6
Hake	5	0.2	1		4	0.2					10	0.4
Cusk	3	0.2									3	0.2
Redfish	7	0.5	1				4	0.2	15	0.8	27	1.5
Catfish	1	0.1									1	0.1
Halibut	3	1.5						0.1	1	0.2	4	1.8
Flounders	20	1.6	5	0.3	2	0.1	3	0.2	18	1.1	47	3.3
Other groundfish	1								2	0.1	3	0.1
Total Groundfish	157	13.0	37	2.4	11	0.7	43	2.6	261	13.8	509	32.5
Total Pelagic	39	3.1	49	1.8	2	0.1	19	0.4	7	0.3	117	5.6
Total Estuarial	2	0.4	5	0.7			1	0.5	6	0.8	14	2.4
Total Lobster	9	9.7	4	3.9	4	3.2	2	1.3	2	1.6	21	19.7
Total Mollusc	52	4.8	1	0.1	1	0.3	1		1		56	5.2
Grand Totals	260	30.8	96	8.9	19	4.4	65	4.9	276	16.5	716	65.5

weight and over one third of the value of all species landed in the Maritimes area.

Half the groundfish, by weight, are caught by the mobile fleet. The otter trawl is now, by far, the most important gear. Danish seines and longlines are of much smaller importance. The shift from line fishing largely inshore to mobile dragging has developed since World War II.

With the development of a mobile fleet, greatest expansion has taken place on the open-water coasts where fishing is year round. Nova Scotia groundfish landings have increased to a value comparable with that for Newfoundland. Nova Scotia accounts for almost half the value of Canadian Atlantic landings of all species.

The species composition of offshore landings has become more diversified. More attention has been directed recently to pollock and witch, and in 1962 monkfish (angler) were landed for the first time. The mobile fleet now takes important catches of scallops, swordfish and herring, and flexibility has become important in the design of offshore vessels.

Mobile-fleet statistics are collected by a field staff and compiled at a statistics office in Halifax. Landings by species, fish size categories, gear, vessel size, fishing effort, and area fished, are recorded by trips on pegbar Kwiksort transfer cards. The Department of Fisheries and the Bureau of Statistics are producing IBM cards and tabulations from these data for use in research studies, and for statistics reporting to the International Commission for the Northwest Atlantic Fisheries (ICNAF). Detailed statistics are published annually in the ICNAF Statistical Bulletin.

Canadian statistics reporting is co-ordinated with statistics for other countries fishing the ICNAF area, to provide total statistics in the various forms required, through the Statistics Subcommittee of the ICNAF Standing Committee on Research and Statistics. St. Andrews scientists continued their participation in the work of this group, with the writer terminating a series of years as chairman. In 1962 the tables in the Statistical Bulletin were extended and rearranged, prescribed reporting forms for landings were modified for greater efficiency, and a new form was designed for information on discards and industrial fish.

A paper on standardization and simplification of North Atlantic fisheries statistics reporting to international agencies was prepared for the ESTANA Continuing Working Party meeting on the subject, scheduled for March 18, 1963, in Rome.

W. R. Martin

No. C-3

AGE AND LENGTH SAMPLING--COMMERCIAL LANDINGS

Sampling

Routine sampling of landings of commercial groundfish continued during 1962. The main effort was expended at or near Sydney, Louisbourg, Halifax, Lunenburg, Lockeport, Digby Neck, Caraquet, Souris and Beaver Harbour. Assignment of responsibilities for this program to seven technicians working part time on it resulted in an increased and better balanced sampling program. Numbers of samples, measurements and otoliths taken for 1962 are shown in the table below. Requirements for sampling were programmed so that a general picture of sizes and ages of groundfish landed in the Maritimes was obtained. Particular emphasis was placed on sampling cod landings from ICNAF Division 4T and haddock landings from Division 4W, for detailed study of the age and length structure of these populations.

Groundfish sampling summary for 1962

Species	No. of samples	No. measured	No. otoliths
Cod	60	20,344	3,080
Haddock	70	18,818	3,311
Halibut	18	3,347	2,205
Redfish	10	2,451	-
Plaice	17	3,176	345
Witch	6	1,139	107
Yellowtail	4	883	45
Winter Flounder	3	520	82
Hake	4	687	-
Cusk	3	805	-
Pollock	9	1,020	484
Total	204	53,190	9,660

Exchange programs

Two data exchange programs were continued during 1962. The redfish-halibut exchange program initiated with the St. John's Station and reported on last year (Annual Report 1961-62, Summary No. 29) has operated in a routine manner. The haddock data exchange program for ICNAF Division 4X carried on with the Woods Hole group of the U.S. Fish and Wildlife Service biologists has made good progress. A backlog of otolith reading was completed by Woods Hole with the help of a St. Andrews technician. Woods Hole biologists produced a preliminary report on the analysis of commercial fishing by both U.S.A. and Canada for the years 1957-61. The report was presented at a December meeting in St. Andrews. This report will form the basis for adjustments in sampling effort in Division 4X as well as for a more detailed analysis for publication.

Ageing techniques

Research into methods of ageing groundfish was intensified during the year. Efforts were stimulated by an Age Determination Workshop conducted under the auspices of ICNAF at Bergen, Norway, in November. Here, one of the main problems dealt with was discrepancies between countries in cod age and growth data for ICNAF Subareas 3 and 4 appearing in ICNAF publications. In addition, standard notation and terminology for otolith readers in ICNAF countries was discussed and accepted. Preliminary work for the meeting included examination of validity studies and techniques used at this Station for cod age determination. At the meeting, discrepancies in techniques causing variation in the data were identified. A detailed summary of the results has been made and will appear as a document for the 1963 ICNAF Annual Meeting.

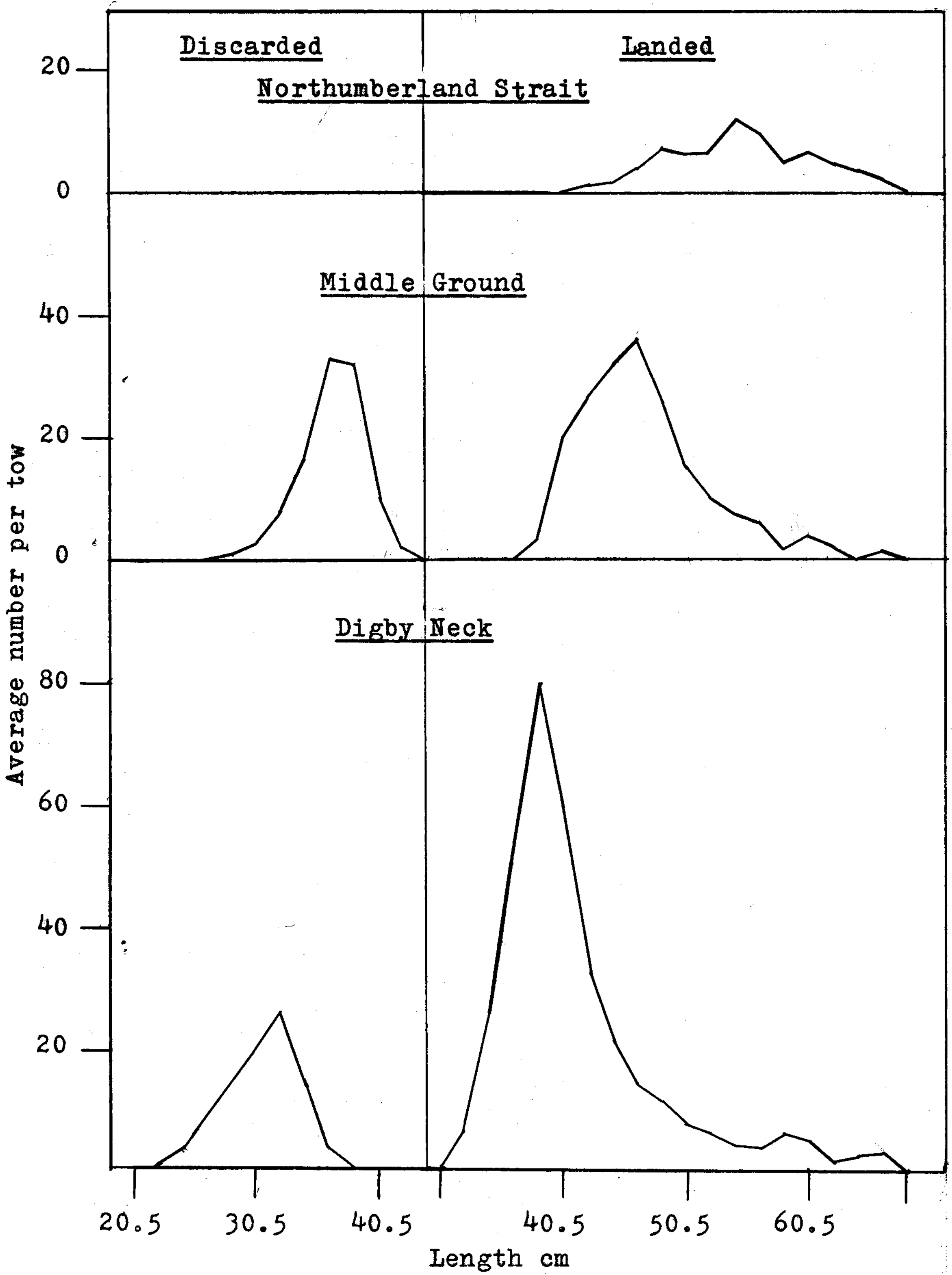
A. C. Kohler

No. C-4

GROUNDFISH DISCARDS

From June to August 1962 an observer was sent on draggers operating in the Bay of Fundy, off southwestern and central Nova Scotia and in Northumberland Strait, to measure and record discards of groundfish species. In addition, one trip was made from central Nova Scotia in December. The main species fished, the size of vessel and the area of operation varied widely.

Off southwestern Nova Scotia trips were made on small otter trawlers (about 40 ft long) fishing a mixture of haddock, cod and flounders. In the Bay of Fundy a trip was made on a medium trawler (about 65 ft long) fishing pollock almost exclusively. From P.E.I. the medium otter trawler chosen fished in the eastern Northumberland Strait, catching mainly haddock, cod, hake and flatfish. From central Nova Scotia the large trawlers (over 100 ft) fished the Grand Banks region, along the Laurentian Channel and on offshore grounds from Banquereau to Sable Island Bank. Main species caught differed for each trip, but included American plaice, cod and pollock. Haddock were taken in quantity only on a portion of one trip. With these wide variations in grounds fished, species caught, and sizes of vessel and gear used, there are marked differences in quantities and sizes of fish discarded. Only superficial quantitative estimates of fish discarded can be made, since the number of trips for which samples could be obtained by one observer was limited.



Size composition of haddock landings and discards, summer 1962.

Cod discards

Quantities of cod discarded ranged between 15% by number on Nova Scotia Banks, about 20% by number in the eastern Northumberland Strait, and about 30% by number on the Grand Banks. Catches of cod off Digby Neck and in the Bay of Fundy were small and virtually all were landed. Sizes discarded ranged from about 34 to 43 cm for all areas.

Haddock discards

Quantities of haddock discarded varied from nil in the Northumberland Strait region to about 13% by number in the Digby Neck region and 35% by number for the small catches taken on Nova Scotia Banks. These variations were caused mainly by differences in size of haddock available and size acceptable for landing. The accompanying figure shows that in the Northumberland Strait region only larger haddock (about 45-65 cm) were taken and none were discarded. On Nova Scotia Banks haddock between 35 and 60 cm were taken and those between 35 to 40 cm were discarded. In the Digby Neck region most haddock caught were between 35 and 42 cm, but, in contrast to offshore banks, most of these were landed. Discards in the Digby Neck region were mainly below 35 cm in length.

Other species

The following tabulation lists the observations on discards for other species along with explanatory remarks:

Species	Discards % by weight	Remarks
Pollock	0	Where pollock main species fished -- Bay of Fundy and fall fishery N.S. Banks.
	100	Incidental catches in summer on N.S. Banks.
Redfish	1	Taken in quantity part of 1 trip; all discards small fish.
Hake	10	Northumberland Strait region only area where caught during these trips.
Winter flounder	5	Digby Neck and Northumberland Strait region--small fish.
American plaice	18	Grand Banks region--in other regions incidental catches were either discarded or kept.

Witch) Halibut) Catfish)	0	Incidental catches in all areas.
Skates) Yellowtail) Sea raven) Sculpins) Silver hake) Monkfish)	100	Incidental catches taken in small quantities on all trips.

Discarding practices for species such as pollock, hake, redfish and flounders depended on their availability, size caught and marketability in specific areas. In addition, there was a group of species (skates, ravens, sculpins, etc.) which were taken in small numbers in most tows and all discarded regardless of size of fish.

F. D. McCracken

No. C-5

SPECIES COMPOSITION OF SURVEY CATCHES

The summaries on groundfish statistics and groundfish discards at sea describe trends toward greater utilization of the varied species and sizes of fish available to the commercial fleet. Increasing diversity is apparent in landings, and quantities of fish discarded at sea, although still substantial, are being reduced. As the demand for fish increases these changes will continue, and we can look forward to more species and smaller sizes of fish in future landings.

Survey cruises with small-mesh otter trawls provide information on species and sizes of fish available on the fishing grounds. Such information on availability of fishes, together with development of new products and markets, contributes to rational exploitation of our fisheries resources.

The accompanying table shows the numbers of fish by species per thousand fish caught in research-vessel cruises by the A.T. Cameron and the Harengus during 1960. Cruises have been separated by ICNAF Division, western Gulf of St. Lawrence (4T), eastern Nova Scotia Banks (4V) and central Nova Scotia Banks (4W). Because of seasonal differences in distribution, summer and winter catches are listed separately.

The species which grow to a large size are almost all used commercially. Little use is made of the abundant skate and dogfish species. Other round fish (cod, haddock, redfish, hake, pollock, wolffish and cusk) and flatfish (halibut, turbot, and four flounder species) are used at marketable sizes. Substantial quantities of most of these species are still discarded at sea because they are too small.

Numbers by species per 1,000 fish caught; survey cruises, A.T. Cameron and Harengus 1960.

	4T		4V		4W	
	Summer	Winter	S	W	S	W
Cod	497	448	362	350	48	40
Haddock	23	20	155	110	513	475
Redfish	76	182	308	367	77	41
Halibut					1	1
Plaice	272	64	108	50	59	67
Witch	5	8	9	43	1	8
Yellowtail	15	2	22	1	92	9
Winter Flounder	5					
Turbot		1				
Skates	5	35	12	22	5	7
Dogfishes		54		16		
Hake	9	57	2	25	8	27
Pollock	1	1	4	1	3	11
Wolffish				2	1	1
Cusk						1
Monkfish			1		2	2
Mackerel						1
Herring (and Alewife)	77	46	2	2	82	85
Silver Hake		9	4		76	115
Argentine					3	102
Capelin		2			7	
Smelt		3			1	
Sculpin	7	4	5	1	20	7
Eelpout	4	2	3	4		1
Grenadiers	2	53				
Rockling		2				
Stickleback		3				
Other	2	4	3	6	1	1

Another group of species is abundant on trawling grounds but the maximum size is such that most escape through the 4½-inch mesh size in general use in towed nets. Large catches of herring, silver hake and argentine could be taken by otter trawl if a satisfactory market could be developed for these species. Small-mesh otter trawls will be required to exploit these species. On other occasions, large catches of capelin and sand launce have been taken in survey cruises. These additional two small fishes should be included among those offering a potential opportunity for exploitation.

A final group of small fishes (sculpins, eelpouts, grenadiers, rockling, stickleback, and others) is available in large numbers on fishing grounds. Most of these species are released by 4½-inch mesh otter trawls. Early utilization of these fishes is not anticipated.

These survey data, which are recorded on IBM cards, are useful for provision of advice to government and ICNAF on such questions as effects of changes in mesh size. They are also valuable for advice to industry on availability and distribution of species by sizes. An inquiry about monkfish, a newly-exploited species, was a case in point during 1962.

W. R. Martin

No. C-6

PRELIMINARY STUDIES ON DIURNAL MIGRATION

Analysis of the catch data from groundfish cruises on which the otter trawl is used almost exclusively shows a marked diurnal variation in the number of fish of a given species. Records from cruises on the vessels A.T. Cameron and Harengus indicate that cod, haddock and redfish are caught in greater numbers during the hours of daylight, whereas most species of flounders, sea ravens, long-horn sculpins, eelpout, and skates are taken in greater numbers at night.

A comparison of night and day catches was made in the area of Miscou Island (Gulf of St. Lawrence) during October 1962 on the Harengus. The results are shown in Fig. 1. Approximately twice as many cod were caught during the hours of daylight as at night. American plaice were captured in greater abundance during the daylight hours on this cruise. However, this is the one species caught abundantly which does not show a consistent diurnal pattern. A second cruise on which night and day catches were compared was made again on the Harengus in the Clam Cove Head area of Passamaquoddy Bay (Bay of Fundy) during November 1962. The results of this cruise are summarized in Fig. 2. Winter flounder, sea raven, long-horn sculpin, eelpout and skate were caught in greater numbers during the hours of darkness than during daylight hours. Although relatively few cod, haddock and redfish were taken, they were more abundant in the day catches.

Echo-sounder records suggest a vertical migration of fish between the hours of sunset and sunrise. This could, of course, explain why cod, haddock and redfish are captured less abundantly at night. An example of the nocturnal vertical ascent of fish, recorded on an echo sounder, is given in Fig. 3. It can be seen in the figure that the fish remained on or near bottom during the daylight hours and rose to mid water at night. While positive identification of echoes cannot be made, it is assumed that the fish in the figure are cod and/or redfish, since only these species were caught in abundance in this area.

The predominance of some species in night sets presents a somewhat different problem. Long-horn sculpin, sea raven and eelpout appear to be awkward swimmers, incapable of a sustained vertical ascent. Flounders and

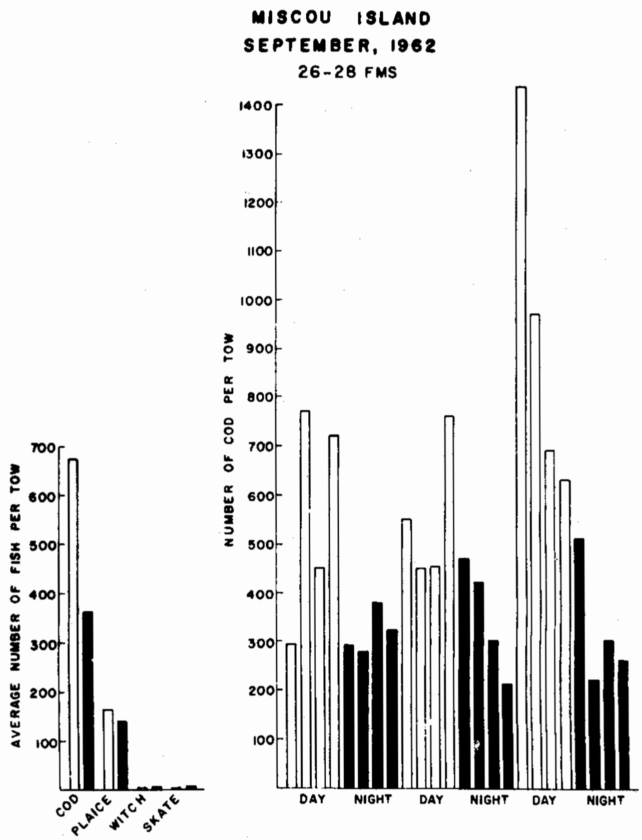


Fig. 1.. Comparison of the average number of fish per tow during the hours of darkness (closed bars) with that caught during daylight hours (open bars). The comparison is extended for cod to include the results of individual tows.

skate are adequate swimmers, but they appear to remain on or near the bottom. This apparent lack of vertical migration is substantiated to some extent by echo-sounder records which seldom show fish off bottom during daylight hours. While vertical migration does not seem to be important, it does not seem unreasonable to assume that the variation in numbers results from a change in direction and degree of activity.

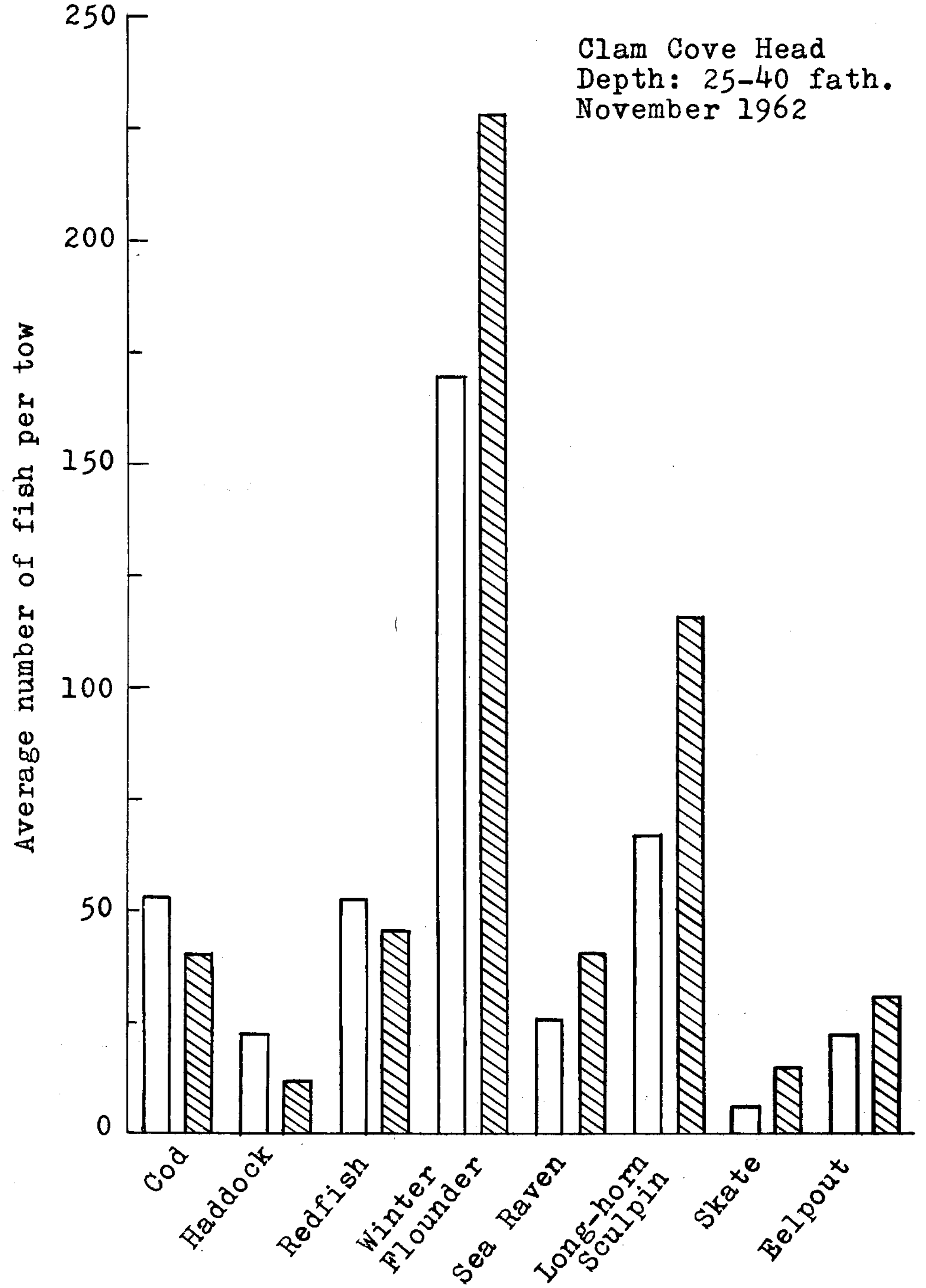


Fig. 2. Comparison of night and day catches. Open bars refer to daylight catches while closed bars signify night catches. Seven night and eight day tows were made.

Fig. 3. Echo-sounder records taken from cruise A.T. Cameron 19 to show the vertical migration of fish at night. Fish can be seen descending at 0815 A.S.T., and are on bottom at 0923. The vertical ascent is beginning at 1700, and fish are well distributed in mid water by 2300.

It is tempting to speculate that the diurnal migration, observed for some species, is triggered by photoperiod. However, additional information is required from both field and laboratory studies. It is expected that at least some of this information will be obtained through underwater photography. Further, photography will be used to determine activity rhythms of flounder, long-horn sculpin, sea raven, eelpout and skate.

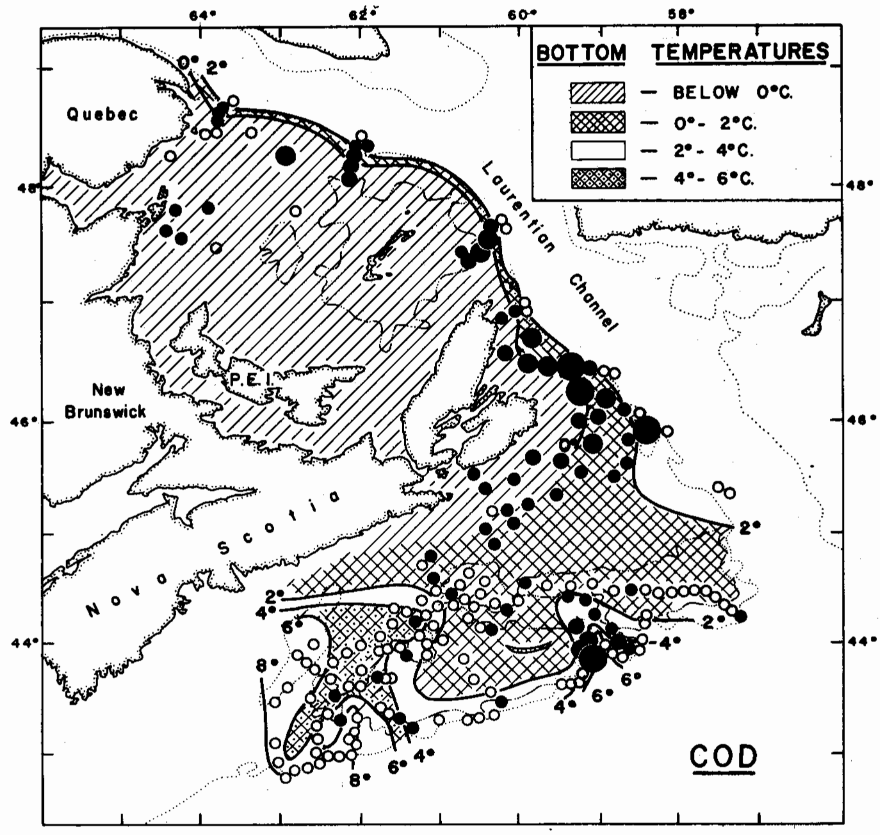
F. W. H. Beamish

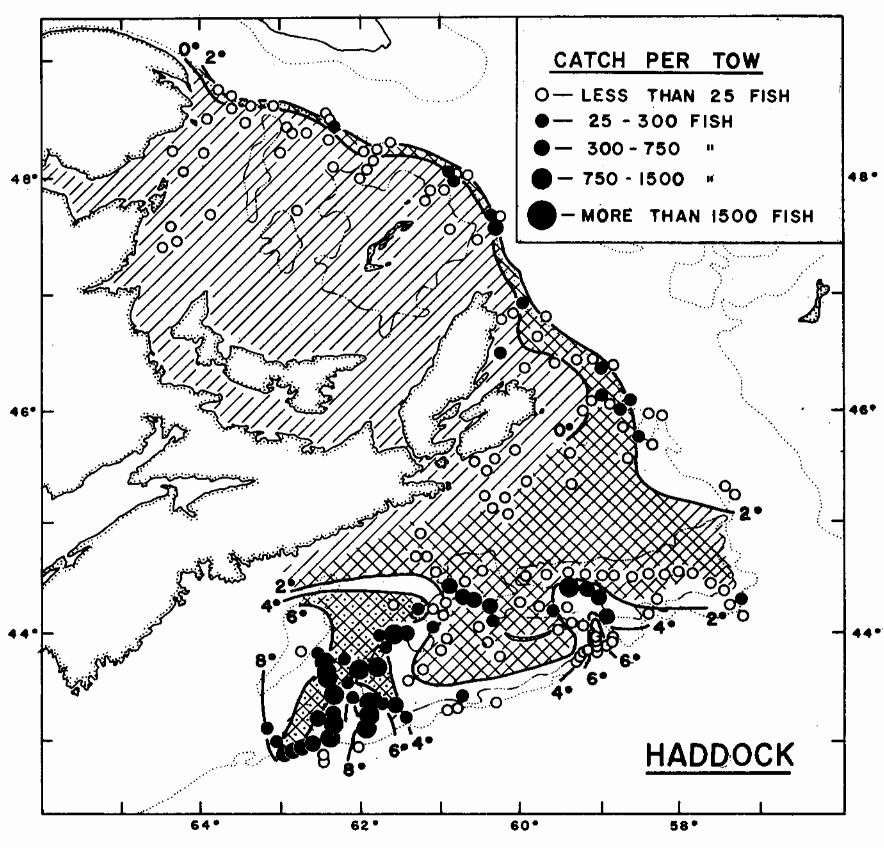
No. C-7

COMPARISON OF COD AND HADDOCK WINTER DISTRIBUTION IN GULF OF ST. LAWRENCE AND NOVA SCOTIA BANKS AREAS

During winter survey cruises by the A.T. Cameron a large amount of information was collected on the distribution of cod and haddock in relation to area, depth and bottom temperature. From 1959 to 1962, 12 survey cruises were made. Three cruises made in 1961 (No. 32, 33 and 37) are not included in this summary since they are not comparable in time. Cruises 32 and 33 took place in January and Cruise 37 at the end of April.

A total of about 400 hauls with fine-mesh codend were made. Each haul lasted 30 minutes. Surface and bottom


BOTTOM TEMPERATURES
— BELOW 0°C.
— 0°- 2°C.
— 2°- 4°C.
— 4°- 6°C.
Quebec
New Brunswick
P.E.I.
Nova Scotia
Laurentian Channel
COD
64°
62°
60°
58°
48°
46°
44°


CATCH PER TOW
— LESS THAN 25 FISH
— 25 - 300 FISH
— 300 - 750 "
— 750 - 1500 "
— MORE THAN 1500 FISH
HADDOCK
64°
62°
60°
58°
48°
46°
44°

temperatures were taken and a BT cast was made at each station. Average catches of cod and haddock per haul were calculated. The results are shown in the accompanying chart. Bottom isotherms, based mainly on 1962 observations, are also shown.

Cod

The winter distribution of cod in the SW Gulf of St. Lawrence (ICNAF Divisions 4T and 4V north) is mainly in deep water (80-125 fath) along the western edge of the Laurentian Channel. Cod were found in increasing numbers from Gaspé southeast to the Scatari Bank area, and in decreasing numbers from Scatari southwest to Misaine and Canso Banks. Further south, on the Scotian Shelf (4V south and 4W), cod were absent from the top of the banks. They were caught in large numbers in some hauls on the western edge of the Banquereau gully, but in small numbers from Middle Ground to Emerald Bank.

A gradual increase in cod sizes was observed in the Gulf, from Gaspé to Scatari and farther south. A few cod caught in the shallow water of the western Gulf were smaller than 15 cm. Those caught in deep waters off Gaspé were from 20 to 40 cm in length. Most cod of commercial sizes (40-70 cm) were found in the Sydney Bight area. From Misaine Bank southward the proportion of large cod (above 70 cm) in the catch was generally greater than farther north.

The bottom temperatures at which the largest catches of cod were made varied from about 1° to 3°C along the Laurentian Channel and from 2° to 4°C in the Nova Scotia Banks area.

Haddock

The winter distribution of haddock in ICNAF Divisions 4T, V and W is mainly in depths of about 45 to 70 fathoms along the western end of Sable Island Bank and in the vicinity of Emerald Bank off central Nova Scotia. Fair catches of small haddock, mainly under 40 cm, were taken in the deep-water gully between Sable Island, Middle Ground and Banquereau at depths of 55 to 80 fathoms. Small catches of haddock were taken in deeper water, around 125 fathoms, along the edge of the Laurentian Channel off Cape Breton and the southwestern Gulf of St. Lawrence.

To the eastward smaller haddock were taken in water temperatures of about 2° to 4°C. Largest catches were made in the western region at bottom temperatures of about 4° to 6°C.

Conclusions

Winter surveys have shown the relationship between cod and haddock in their distribution by area, depth and water temperature. Areas of greatest cod concentrations, mainly off the Cape Breton coast and the western edge of the Banquereau gully, have yielded small or nil catches of haddock; vice versa, areas of haddock concentrations on the eastern side of the gully and from Middle Ground westward to Emerald Bank show generally very low catches of cod.

In each region cod were found in shallower water than haddock. Both species were taken in deeper water along the Laurentian Channel than on the Nova Scotia Banks. In the Laurentian Channel cod were most numerous around 100 fathoms and haddock around 125 fathoms. On Nova Scotia Banks cod were most numerous at about 50 fathoms and haddock around 55 fathoms. In both regions cod were found in colder water than haddock but there appeared to be regional differences in the temperatures at which both species were found in greatest numbers. To the eastward, particularly along the Laurentian Channel, both cod and haddock were taken in colder water than to the westward on Nova Scotia Banks. Respective temperatures at which cod and haddock were found to the eastward were 1° to 3°C and 2° to 4°C; to the westward, 2° to 4°C and 4° to 6°C.

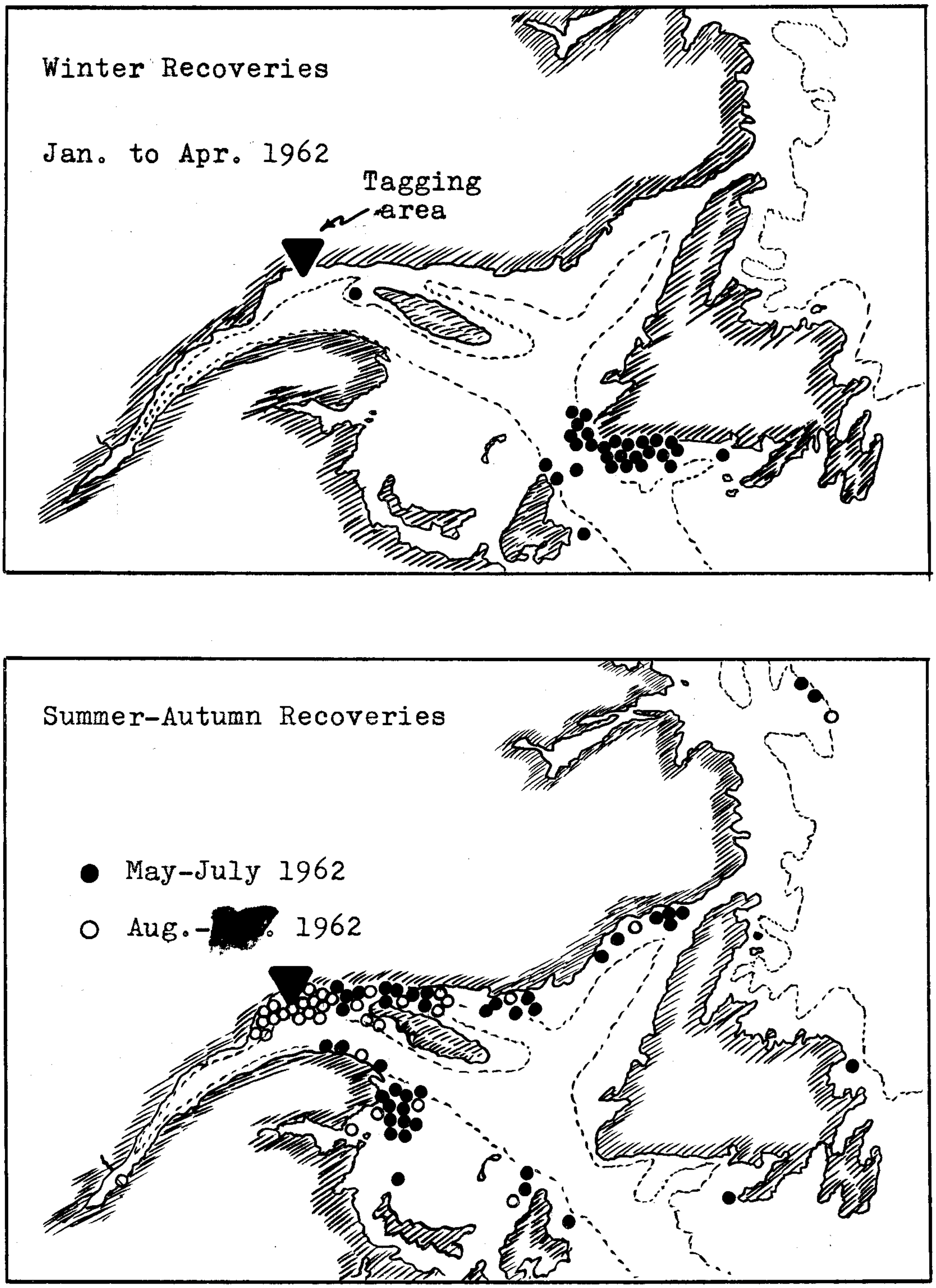
Yves Jean
F. D. McCracken

No. C-8

FIRST-YEAR RETURNS OF COD TAGGED OFF SEPT-ILES IN OCTOBER 1961

During a survey cruise with M.V. Harengus in the Sept-Iles area on the north shore of the Gulf of St. Lawrence in October 1961, 1,496 cod were tagged with yellow Petersen disks (Annual Report 1961-62, Summary No. 30). The purpose of this tagging was to study the migrations of north shore cod and the relation of this stock to other stocks in the Gulf of St. Lawrence. All fish for tagging were taken by otter trawl at depths of 50 to 60 fathoms. The lengths of tagged cod varied from about 46 to 82 cm, the modal length being 58 cm.

Returns during the 14 months following tagging, i.e., to December 1962, totalled 148 or 10% of the number tagged. The locations of recaptures by season are shown in the accompanying figure. Thirty-six tagged cod were caught in the area of tagging in the autumn of 1961. These are not shown in the figure. Other returns, 4 in all, for which area or month of capture were not known, have also been omitted from the figure.



Recoveries from January to December 1962 of cod tagged off Sept-Iles in October 1961.

The 29 winter (January-April 1962) recoveries, with one exception, were made at distant points, from 300 to 400 miles from the area of tagging (see figure). Of these, 24 were recaptured near the southwestern tip of Newfoundland, 3 off the east coast of Cape Breton, 1 in Cabot Strait (260 fath) and 1 off West Point, Anticosti (by a line fisherman in late April 1962).

Of the 45 summer (May-July 1962) recoveries, 21 came from the north shore of the Gulf of St. Lawrence between Sept-Iles and Belle-Isle, 20 from the southwestern Gulf (16 in the Gaspé area and 4 off Cape Breton), 2 from the Labrador coast, and 1 each from the east and south coasts of Newfoundland.

In autumn (August-December 1962) 34 tags were recovered. Of these, 27 were taken along the north shore, mainly in the area of tagging, 6 in the southwestern Gulf (including 1 in the St. Lawrence estuary at Kamouraska, P.Q.) and 1 off the Labrador coast.

Otter trawls accounted for 77%, lines for 17%, traps for 5% and gill nets for 1% of the recaptures. The returns by Europeans totalled 9, or 6% of the total recoveries.

The following conclusions can be drawn from the first-year recoveries of this tagging: (1) Cod that are present in the Sept-Iles area in autumn migrate south outside the Gulf in winter. More winter recoveries came from the Newfoundland side of Cabot Strait than from the Cape Breton side. This would indicate that the Sept-Iles cod are related mainly to the west coast of Newfoundland stock. Ice in the winter of 1962 considerably reduced fishing off the coast of Cape Breton. It is therefore possible that as many tagged cod were present on the Cape Breton side as on the Newfoundland side of the Laurentian Channel but that they were not recaptured in as large numbers because of less fishing on the Cape Breton side. (2) The relatively high percentage of recoveries in the southwestern Gulf (20% of all recoveries) in the summer following tagging indicates a much larger degree of mixing between the west coast of Newfoundland and the southwestern Gulf stocks than fall and winter taggings south of the Laurentian Channel had led us to believe. Of 1,497 cod tagged by Dr. Dickie off Miscou and Bonaventure Islands in September 1961, 228 were recaptured in 1962. Of these, only 7, or 3%, were recaptured across the Laurentian Channel on the Newfoundland side. (3) A comparison of summer and autumn returns (see figure) suggests a migration northward from the southwestern Gulf across the Laurentian Channel to the north shore. Of the 40 recaptures from inside the Gulf in summer, 19, or 50%, were made in the southwestern Gulf. Of the 32 recaptures from inside [redacted] Gulf in autumn, only 5, or 15%, came from the southwestern Gulf. The others were caught mainly on the north shore, in the area of tagging. An analysis of the fishermen's log records for 1962, not available at the time of writing, will be necessary for final interpretation of the results.

Yves Jean

C-9

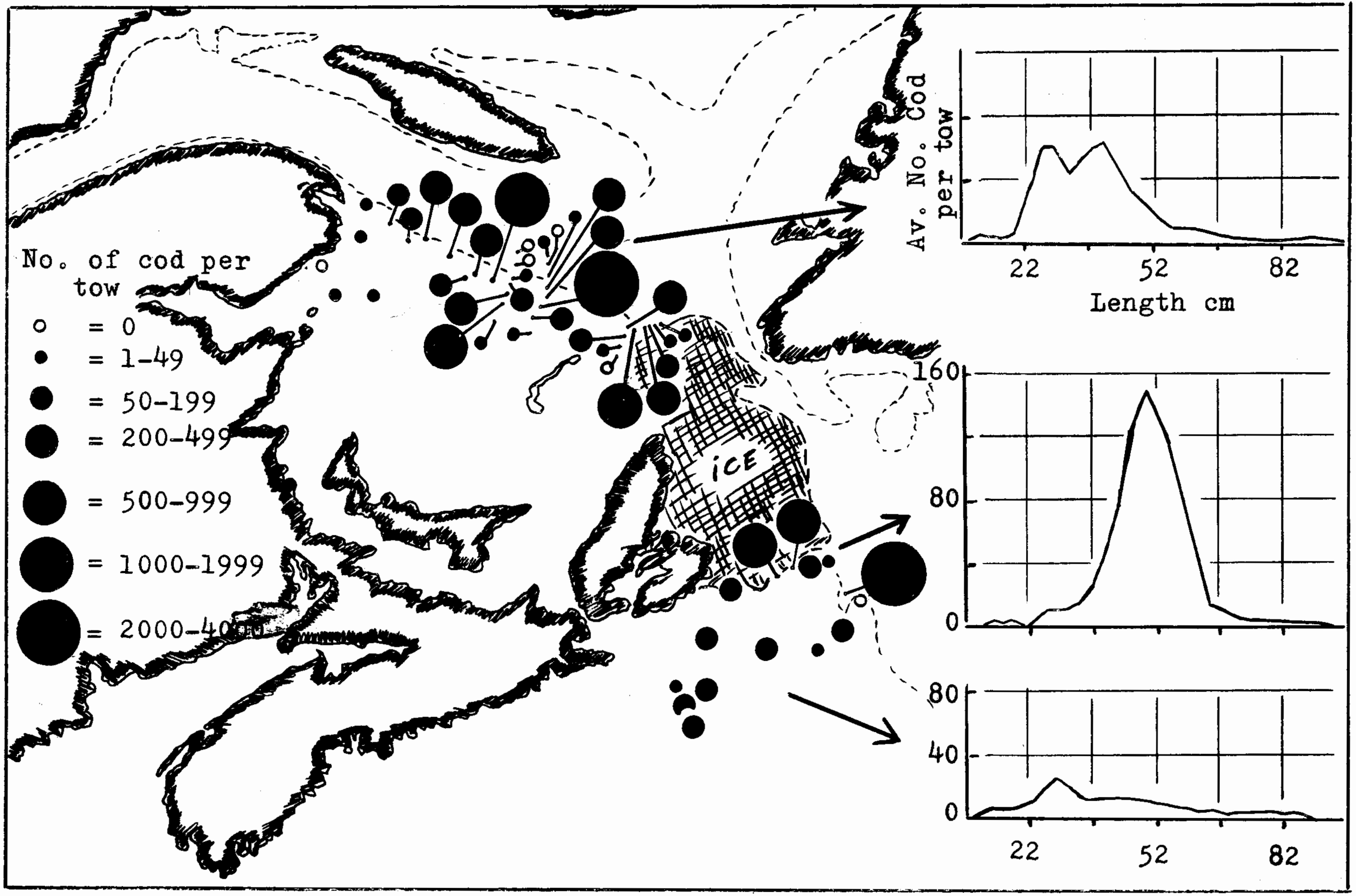
DISTRIBUTION OF COD ALONG THE WESTERN SLOPE OF THE LAURENTIAN CHANNEL IN APRIL 1962

The purpose of A.T. Cameron cruise 54 (April 17-27, 1962) was to study the distribution and abundance of cod along the western edge of the Laurentian Channel in areas fished by the European otter-trawl fleet in the spring. Winter ice covered the eastern coast of Cape Breton from Scatari Bank north to Bird Rocks and prevented fishing in that area. It was possible, however, to make survey hauls from Canso Bank northeast to Scatari Bank, and from Bird Rock northwest to Grand River at the mouth of Chaleur Bay.

The survey stations are shown in the figure. Catches of cod are indicated by circles of varying sizes. The size compositions of cod caught at the seven southernmost stations (Canso-Misaine Banks), at seven stations east of Scatari Bank and at 36 stations north of Bird Rock in the Gulf are also shown in inserts in the figure.

Catches in the Canso-Misaine Banks area were light. The size composition, with its absence of a mode around 46 cm which has characterized Gulf cod in recent years, and the spent stage of gonads, suggest that these cod are of a different stock than the western Gulf stock. Catches were markedly larger in the Scatari Bank area (see figure). Up to 3,000 cod per half-hour haul were taken. These cod had a unimodal size distribution with a mode at 49 cm. They were in a ripening or ripe stage of maturity. On that basis, they are considered as Gulf cod. This is confirmed by the returns from 501 cod tagged in that area. Of the 41 recaptures to the end of 1962, only one was made south of the tagging area. The other returns came from the Gulf of St. Lawrence. The Scatari Bank area appeared to be the southern limit of winter distribution of Gulf cod in April 1962. A large number of cod of commercial size were present there at depths of 45 to 75 fathoms and at bottom temperatures of 0.5° to about 1.5°C.

A series of hauls at various depths along the Channel from Bird Rock northwestward (see figure) yielded light or nil catches in both deep (over 100 fath) and shallow (less than 50 fath) water. Catches up to 3,300 cod per haul were made at depths of 75 to 100 fathoms, and at temperatures of 0.5° to about 3.0°C. These cod (see inset) were much smaller in size than the ones caught off Scatari Bank. Modal lengths were 25 and 40 cm in the Gulf compared with 49 cm off Scatari. As seen in the figure, the number


No. of cod per tow
○ = 0
● = 1-49
● = 50-199
● = 200-499
● = 500-999
● = 1000-1999
● = 2000-4000
ICE
Av. No. Cod per tow
22
52
82
Length cm
160
80
0
80
40
0
22
52
82

of cod caught decreased gradually from more than 3,000 off Magdalen Islands to less than 50 per tow off Cape Gaspé. Four tows in 60 fathoms or less at the mouth of Chaleur Bay caught less than 25 cod per tow.

The results of this survey indicate that in the latter half of April southwestern Gulf cod are distributed from Scatari Bank north to about 60 miles northwest of Bird Rock. Commercial-size cod are still present in the Scatari Bank area whereas mostly below commercial size cod are caught in the Gulf north of Bird Rock. Winter surveys in other years have shown that small cod do not migrate out as far as the larger ones (No. C-7). The April 1962 survey shows that small cod are the first ones to return to the Gulf in spring. It also shows that at the end of April cod are still in waters deeper than 50 fathoms and have not yet migrated into shoal water where they are caught later in spring.

Yves Jean

No. C-10

ABUNDANCE OF COD EGGS AND LARVAE IN THE GULF OF ST. LAWRENCE, 1958-1962

During groundfish surveys in the southwestern Gulf of St. Lawrence, varying numbers of surface plankton tows were made from 1958 to 1962. The net used was a No. 0 silk net with a circular opening, 1 m in diameter. All tows were 30 minutes in duration. The area covered extended from Cape Breton to the Gaspé. Most tows, however, were made in the areas between Miscou and Bonaventure Islands and between Miscou and Prince Edward Island. All plankton collected was preserved in 5% formalin. Cod eggs and larvae were picked out and counted in the laboratory. The number of tows, total and average numbers of cod eggs and larvae, are given by months and by year in the accompanying table.

The 1958 and 1961 collections showed a peak in abundance of cod eggs in May. Otter-trawl surveys in the same area from May 14 to July 3, 1958, caught the largest numbers of running females during the second half of June. On this basis, it was concluded that the peak in spawning took place in late June in the Gulf. Seasonal abundance of cod eggs, however, suggests a peak in spawning in May rather than June.

In 1958 and 1959 cod eggs were collected as late as November. This confirms the results of otter-trawl surveys which caught spawning cod in late October of those years.

Except for 1959, the average number of eggs collected did not show large annual variations (between 35

Number of cod eggs and larvae collected in the southwestern Gulf of St. Lawrence from 1958 to 1962.

Month	1958 No. tows	1958 Total No. Eggs	1958 Total No. Larvae	1958 Av./tow Eggs	1958 Av./tow Larvae	1959 No. tows	1959 Total No. Eggs	1959 Total No. Larvae	1959 Av./tow Eggs	1959 Av./tow Larvae	1960 No. tows	1960 Total No. Eggs	1960 Total No. Larvae	1960 Av./tow Eggs	1960 Av./tow Larvae
May	23	3092	0	134	0	-	-	-	-	-	-	-	-	-	-
June	12	219	1	18	-	13	10742	3	826	0.3	6	271	0	45	0
July	5	26	0	5	0	-	-	-	-	-	-	-	-	-	-
Aug.	7	4	1	0.6	-	14	401	0	29	0	-	-	-	-	-
Sept.	7	0	0	0	0	-	-	-	-	-	5	110	0	22	0
Oct.	10	61	0	6	0	-	-	-	-	-	-	-	-	-	-
Nov.	10	125	0	13	0	9	504	0	56	0	-	-	-	-	-
Total	74	3527	2	48	<1	36	11647	3	324	<1	11	381	-	35	0

Month	1961 No. tows	1961 Total No. Eggs	1961 Total No. Larvae	1961 Av./tow Eggs	1961 Av./tow Larvae	1962 No. tows	1962 Total No. Eggs	1962 Total No. Larvae	1962 Av./tow Eggs	1962 Av./tow Larvae
May	4	459	0	115	0	5	288	0	58	0
June	5	98	0	20	0					
July	-	-	-	-	-					
Aug.	-	-	-	-	-					
Sept.	-	-	-	-	-					
Oct.	5	10	0	2	0					
Nov.	-	-	-	-	-					
Total	14	567	0	41	0	5	288	0	58	0

and 58 eggs per haul). In 1959, however, about seven times as many eggs as in other years, viz., 324 eggs per haul, were collected. The larger abundance of eggs in 1959 did not seem to result in a strong year-class. The number of 3-year-old fish (1959 brood) caught in the 1962 (October) survey with otter trawl was, in fact, slightly below average, 36 fish per haul compared with a 1957-62 average of 40.

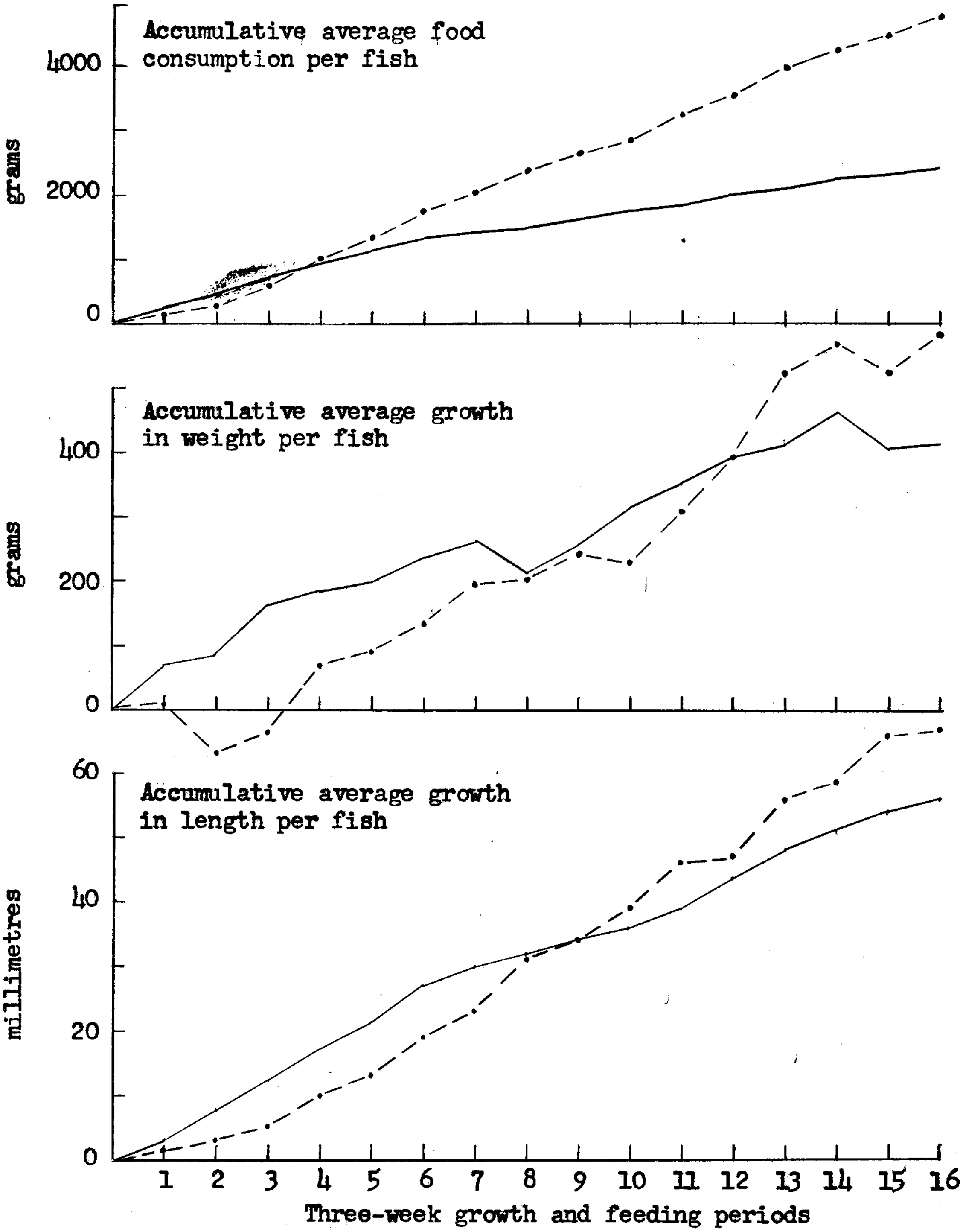
Cod larvae collected during those years were very few in number; only 2 larvae were caught in 74 hauls in 1958 and 3 in 36 hauls in 1959. One or more of three factors are responsible for the almost total absence of cod larvae in plankton hauls in the southwestern Gulf of St. Lawrence: inefficiency of the gear in catching cod larvae, drift of eggs and larvae outside the area sampled, and high egg and larvae mortalities. The net caught large numbers of larvae of other species, such as plaice, mackerel, redfish, four-bearded rockling, and appeared efficient enough. Drift-bottle releases in the southwestern Gulf (Annual Report 1960-61, Summary No. 90) indicate a counter-clockwise circulation of surface water in summer, with extensive easterly drift toward the west coast of Newfoundland and the north shore of the Gulf of St. Lawrence. This surface drift, carrying eggs and larvae away from the area of sampling, would alone account for the absence of cod larvae in the southwestern Gulf. Our limited observations do not provide estimates of egg and larvae mortalities.

Yves Jean

No. C-11

COD GROWTH AND FEEDING

Earlier controlled laboratory experiments on the growth of cod showed that increased feeding was correlated with increasing water temperature and also that increases in growth were correlated with increased feeding (Annual Report 1959-60, Summary No. 37). These experiments were carried out at uncontrolled water temperatures with a summer high near 13.5°C and a winter low near 2°C. The work indicated that maintenance requirements for food were higher near the top of the temperature range than at the lower end. It also seemed that faster growth rates could be achieved if the cod were living at the higher temperatures. Accordingly, an experiment was planned to examine both maintenance and maximum growth and feeding rates at constant high and low temperatures. Limitations of space, equipment and time made it possible to run only four tanks of fish, two at low and two at high temperatures plus one control tank under the conditions of the earlier experiment. The temperatures chosen were 4° and 12°C since these were the extremes at which cod seemed to feed normally in the earlier experiment.



Feeding and growth of cod on maximum rations and at constant water temperatures of 4°C (·———·) and 12°C (·- - - - -·) for 48 weeks.

Three fish were placed in each tank. The average sizes in each tank are shown in the table.

The cod were fed frozen whole herring on a schedule determined by results from earlier work (Annual Report 1957-58, Summary No. 37), starting on January 10, 1962. Every three weeks each individual was weighed and measured after first being anaesthetized. The experiment was carried on for 48 weeks, a total of 16 three-week periods.

Average lengths and weights of cod on Jan. 10, 1962

Tank No.	Water temperature °C	Feeding rate	Average length cm	Average weight g
1	12	Maintenance	51.5	1264
2	12	Maximum	49.2	1146
3	1.9-13.5	Maximum	49.9	1179
4	4	Maintenance	50.3	1200
5	4	Maximum	49.6	1121

To determine maintenance requirements at the two temperatures, trial-and-error methods were used to adjust the amount fed to keep the fish at a constant weight. During the course of the experiment it was possible to keep the fish in the colder water for 33 weeks at the beginning and end of which their weight was the same. For the fish in the 12°C water a 45-week period under these conditions gave equivalent average weights. Average food consumption for these periods was taken as the maintenance requirement in the high and low temperature water for these periods. These data, extrapolated to values for 48 weeks, gave average maintenance values per fish of 2735 g for those in 12° water and 1502 g for individuals at 4°C.

Differences in feeding and growth for fish on maximum rations are shown in the figure. Accumulative food consumption for fish in 12°C water was almost twice that of fish in 4°C water for the 48-week period. Differences in growth in length and weight are not so clear-cut. In fact, at the end of 27 weeks there was practically no difference in the average size. At the end of 48 weeks, growth in weight of fish at the low temperature was 70% of those at the high temperature. It may be that these variations in relations between feeding and growth were not all due to differences in the maintenance requirement at the two temperatures since, when these were subtracted from total food consumed, the resulting "food for growth" figures were 911 g for the low temperature tank and 270 g for those in the high temperature water. The lower "food for growth" figure is 34% of the higher but it produced 70% of the higher growth in weight.

The experiment is continuing to check these results and to see if the optimum temperature for growth lies between 4° and 12°C.

A. C. Kohler

No. C-12

GULF COD FISHERY--OUTLOOK FOR 1963

Research-vessel surveys carried out in the south-western Gulf of St. Lawrence in autumn have led to short-term forecasts of the otter-trawl cod fishery (Annual Reports 1958-59 to 1961-62).

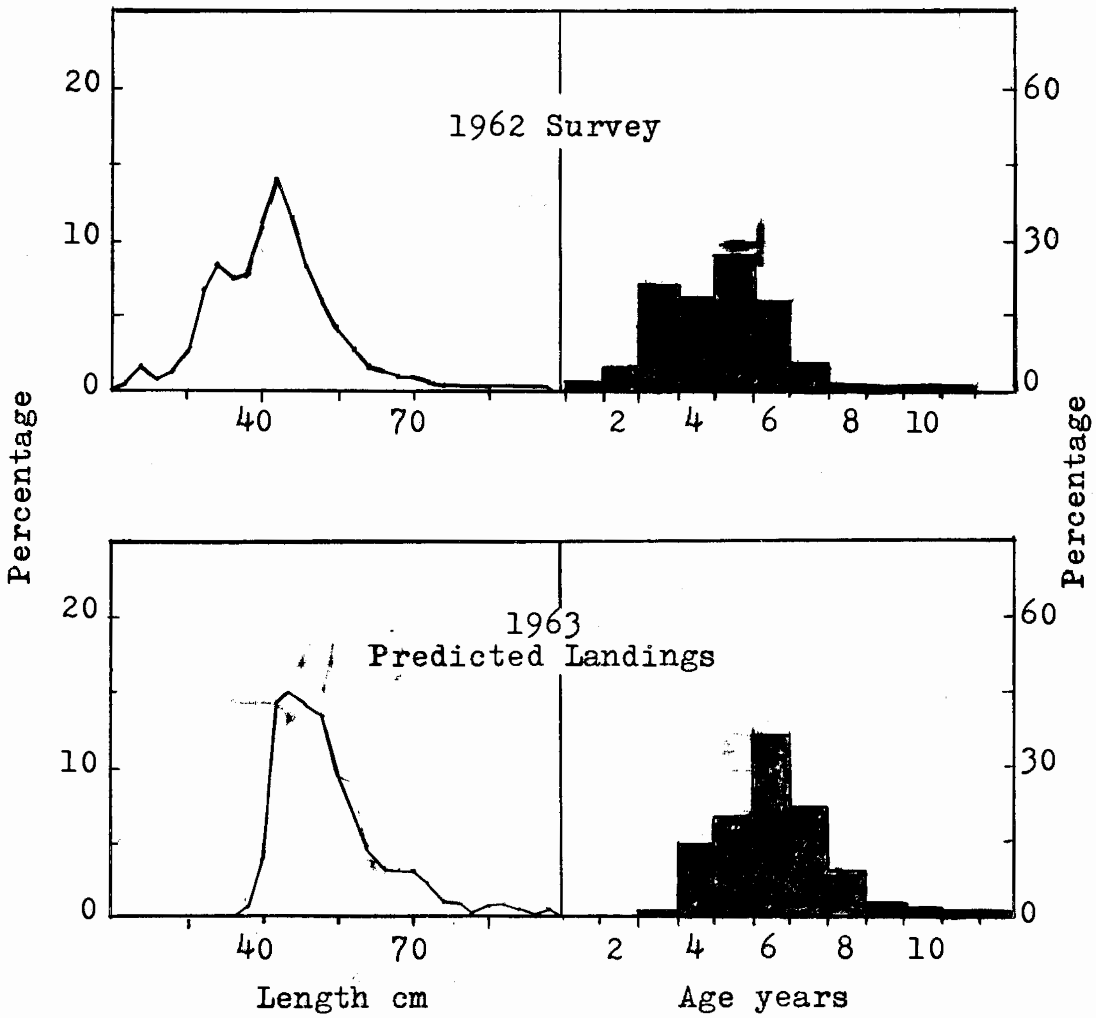
On the basis of the October 1961 survey it was predicted that the average size of cod landed in the third quarter of 1962 would further decline from 53 to 51 cm in length and from $2\frac{3}{4}$ to $2\frac{1}{2}$ lb in weight. The modal length predicted was 46 cm. The mean length per fish in the landings sampled in 1962 was in fact 51 cm, the mean weight 2.4 lb, and the modal length 46 cm.

The dominant age-group in the 1962 landings, however, was the 6-year group instead of the predicted 5-year group. This resulted from the continued trend towards smaller sizes at age noted by Kohler (Annual Report 1961-62, Summary No. 32). Some fish which, on the basis of the 1961 age-length key, were assigned to the 5-year group, should have been assigned instead to the slow-growing 6-year group. There is no way to predict growth accurately at present. It is expected, however, that mean size at age, which reached a peak in 1956-57 and has decreased since, will level off at the pre-1956 sizes in 1963.

The size and age compositions of cod caught in the October 1962 survey are shown in the figure. From these data a forecast of the 1963 otter-trawl fishery is made. The 1957 year-class which was dominant in the 1961 survey (Annual Report 1961-62, Summary No. 35) was still dominant in the 1962 survey as 5-year-old fish. This year-class appears to be slightly above average in strength (Annual Report 1960-61, Summary No. 37). It is expected therefore that the 1957 year-class will be the dominant one in the third quarter 1963 landings as 6-year-old fish.

The 1962 survey also caught somewhat higher-than-average numbers of 6- and 7-year-old fish. These should appear in 1963 otter-trawl landings as 7- and 8-year-old fish.

For these reasons it is predicted that the sizes of cod landed in 1963 will be slightly larger than in 1962. The mean length should increase from 51 to 53 cm. The mean weight per fish landed will increase by $\frac{1}{4}$ lb to about $2\frac{3}{4}$ lb. Discards will be negligible again in 1963.



Size and age compositions of cod caught during 1962 survey (October) and predicted otter-trawl landings for the third quarter of 1963 in the southwestern Gulf of St. Lawrence.

The 1962 landings per hour fished by Gloucester-type draggers were about 450 lb, i.e., about 100 lb per hour more than in 1961. The predicted increase of 6- to 8-year-old fish in the 1963 catch should result in larger poundage landed per unit effort, possibly to the 1959 level of 550 lb per hour fished.

An increase in sizes of fish available should also benefit the line fishery in the southwestern Gulf, mainly around the Gaspé.

Yves Jean

No. C-13

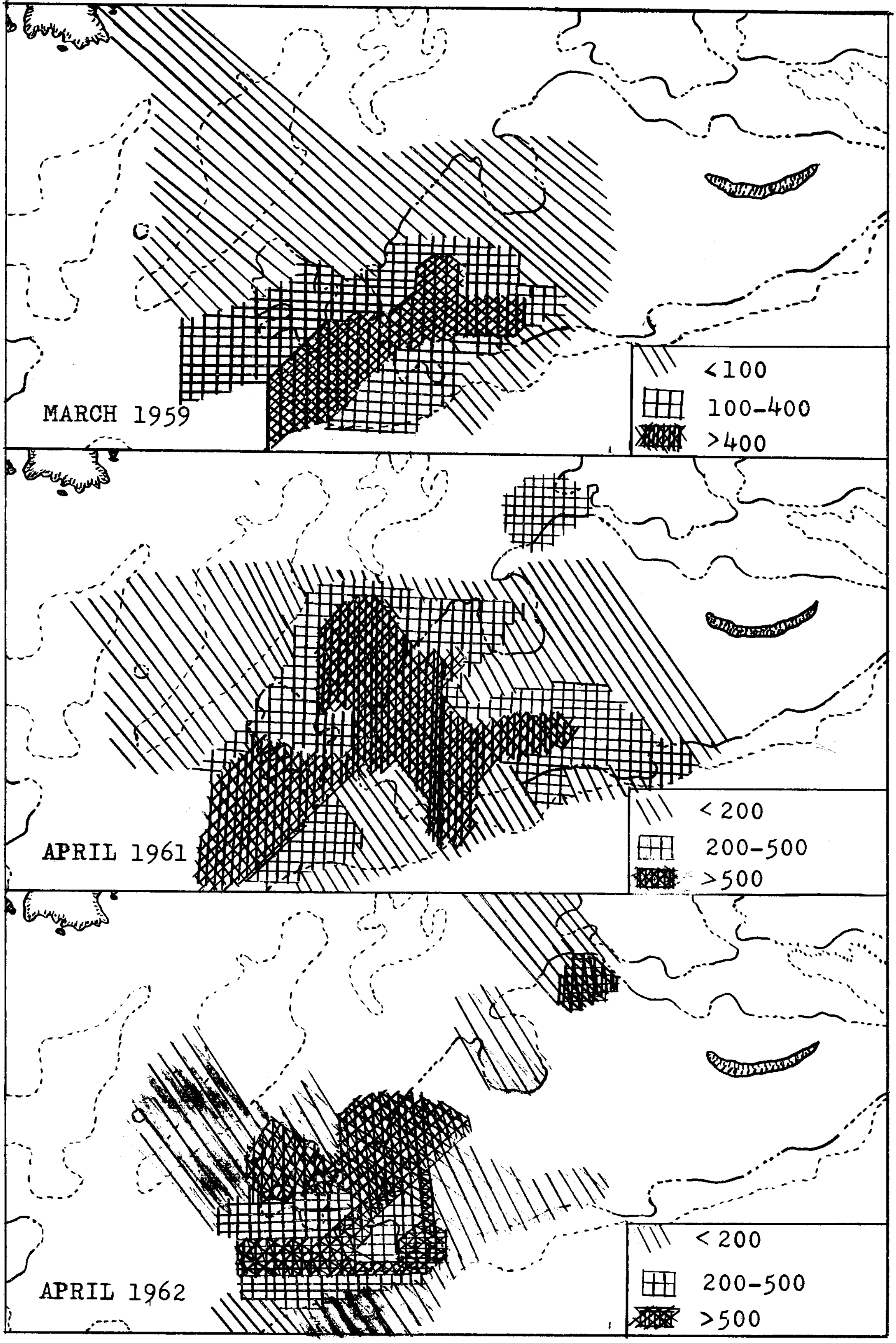
DISTRIBUTION OF GADOID EGGS IN THE SABLE ISLAND-EMERALD BANK REGION

During survey cruises with the A.T. Cameron in the winter and early spring of 1959, 1961 and 1962, horizontal surface plankton hauls were made at all fishing and hydrographic stations with a 1-metre plankton net. Sorting of eggs and larvae from these collections was carried out during the summer of 1962. For each station the gadoid eggs were counted and tabulated and the fish larvae sorted. The fish larvae readily identified were recorded; others were retained for later identification.

No haddock or cod larvae were taken in the tows. Presumably little hatching would have taken place at the time of these cruises. In 1961 and 1962 sand launce larvae predominated in the hauls, ranging up to 500 specimens in some tows at the western end of Sable Island Bank. In 1959 sand launce larvae were not taken in any numbers. Occasional specimens of other fish larvae included pollock, redfish, sculpins and mackerel.

The distribution of gadoid eggs for each of the years has been plotted in the accompanying figure. In all three years the greatest abundance of eggs was found in the vicinity of Emerald Bank and the western end of Sable Island Bank. The distribution of eggs corresponds closely to the distribution of haddock as shown in Summary No. C-7. While the artificially-hatched larvae from the egg collections on the cruises have not yet been sorted and identified, it seems reasonable to assume that the eggs result mainly from the concentration of ripe and ripening haddock found in about the same region.

A comparison of distribution of eggs for different years is of interest. In 1959 the survey cruise was made in March and the centre of greatest egg abundance (300-500 per plankton haul) was south of Emerald Bank and on the southwest portion of Sable Island Bank toward the edge of the Scotian Shelf. Numbers of eggs taken to the north and east were



Distribution of gadoid eggs taken during winter cruises in the Sable Island-Emerald Bank region.

negligible. In 1961 the cruise was made in late April and early May, and the centre of egg abundance (over 500 per plankton haul) tended to be across Emerald Bank and on the northwest section of Sable Island Bank, extending toward Middle Ground. In 1962 the survey cruise was made in early April and distribution of gadoid eggs tended to be in a relatively compact area, with the centre of abundance (over 500 per haul) over Emerald Bank and western Sable Island Bank. Numbers of eggs both to the eastward and toward the edge of the Scotian Shelf tended to be small.

The distribution of gadoid eggs fits the pattern of distribution of haddock on the bottom and effectively outlines the distribution of spawning fish. Variations between years indicate both differences in distribution of fish and presumably also differences in drift of eggs in the surface layers. The proximity of centres of egg abundance to the edge of the Scotian Shelf suggests a possible mechanism for differences in success of year-classes.

F. D. McCracken

No. C-14

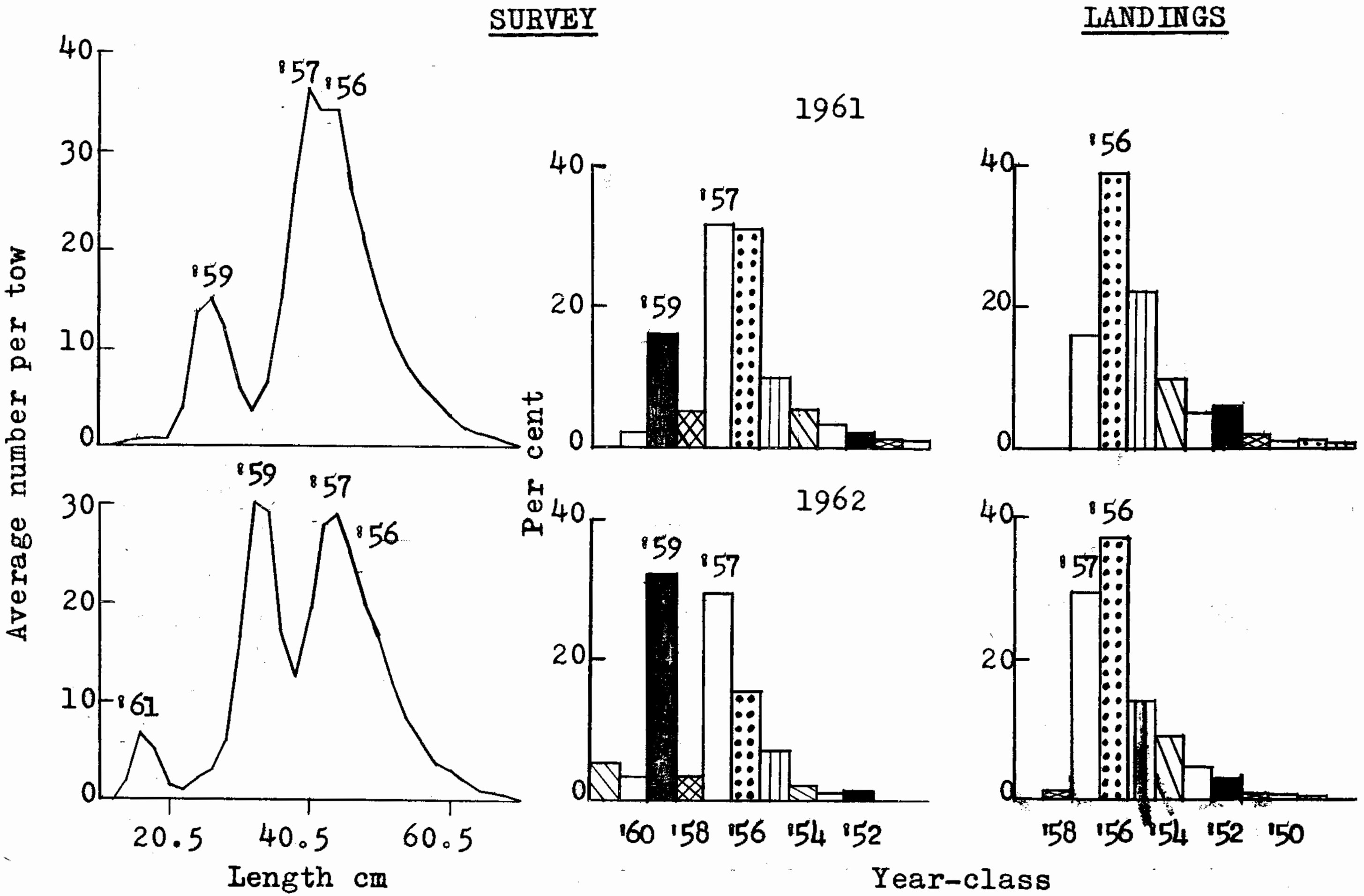
HADDOCK ABUNDANCE FORECAST FOR NOVA SCOTIA BANKS

Groundfish surveys in the Sable Island-Emerald Banks region (ICNAF Division 4W) were continued in April 1962 with the A.T. Cameron, using a 41 trawl with a small-mesh codend liner.

Analyses of size and age compositions of haddock from survey catches in 1961 and 1962 (accompanying figure) show that the 1956, 1957 and 1959 year-classes predominated. Analyses of the age compositions of commercial haddock landings from Division 4W in February and April 1961 and 1962 show that the 1956 and 1957 year-classes predominated.

In the survey catches the 1957 year-class was numerically somewhat stronger than the 1956 year-class. In the commercial fishery the 1956 year-class appeared numerically stronger than the 1957 year-class. This reversal of relative numerical strength suggests that some haddock of the 1957 year-class (modal length about 43 cm, 1½ lb) were being discarded. Catches of the 1956 year-class, with modal length about 50 cm (2½ lb), appeared to be fully utilized.

Survey catches in 1962, as in 1961, continued to show that both the 1958 and 1960 year-classes of haddock are weak. Fish of the 1958 year-class will be entering the fishery in 1963 and reduced numbers of small scrod are expected. The 1959 year-class, currently with modal size about 33 cm (¾ lb), appears to be of about average or somewhat less than average numerical strength. Haddock of the 1961 year-class, around 16 to 18 cm in length, were



Comparison of sizes and ages of haddock in survey catches and landings from Division 4W, first quarter, 1961 and 1962.

taken in fair numbers in several tows southeast of Emerald Bank. However, it is still too early to make predictions about the relative strength of this year-class.

The sequence of relatively poor year-classes of haddock among the fish of pre-commercial size is expected to result in reduced abundance of haddock in the important winter fishery around Sable Island and Emerald Banks. Abundance of small scrod (about 1½ lb) will be reduced in 1963 and abundance of larger fish should be reduced in subsequent years.

F. D. McCracken

No. C-15

POLLOCK IN THE BAY OF FUNDY

Analysis of data gathered in a pollock investigation was completed and submitted for publication. The following summary is taken from the completed manuscript.

The pollock is an amphiboreal Atlantic species whose largest landings in the western Atlantic are made at the mouth of the Bay of Fundy (ICNAF Division 4X).

The best catches of fish of commercial size are made at temperatures above 1.1°C, at depths of 20 to 100 fathoms, on the edges of shoals and banks where an abundant food supply is available. In Division 4X, where tidal turbulence keeps the summer surface temperature low and displaces the food, they may be caught at times in large numbers at the surface and in the shallow, sublittoral zone.

Spawning takes place in the southern Gulf of Maine and probably also on the Scotian Shelf, but not in the northern Gulf of Maine. The Bay of Fundy pollock are recruited from spawning in the southern Gulf of Maine and possible spawning on the Scotian Shelf.

The summer concentration of pollock in the Bay of Fundy appears to be a distinct group of fish from those found in the southern Gulf of Maine and south of western Nova Scotia. However, in the winter the Bay of Fundy pollock migrate south and spawn in the southern Gulf of Maine and possibly on the Scotian Shelf, presumably mixing with the fish in those areas at that time.

The juvenile pollock move inshore in the early summer. The first winter is apparently spent offshore, but the 1-year-old fish return to the shallow, sublittoral zone in the following summer. They disappear from the shallow, sublittoral zone in early August when 20 to 25 cm in length, and presumably move away from shore. The 2-year-old pollock may be found in deeper water near shore or on offshore banks, but their typical habitat is not known.

The offshore pollock show a marked gradient in their size compositions across the Bay of Fundy, with large fish (65-85 cm) found on the New Brunswick side, medium-size fish (60-75 cm) around Grand Manan and the smallest fish (45-60 cm) off western Nova Scotia.

Size segregation also occurs in catches from local areas and shows that schooling is an important feature of pollock behaviour.

The growth rate of the inshore "harbour" pollock is similar to that found in pollock caught off western Norway, but more rapid than that of Faroese and Barents Sea fish.

The growth rate of the larger offshore pollock is rapid until the fish are approximately 6 years old, but is much slower thereafter. The growth rate of the Bay of Fundy pollock is similar to that recorded for other areas, except at the older ages. It is suggested that this discrepancy may be caused by a failure to collect adequate samples of old fish in the Bay of Fundy, due to the segregation by size.

Both the round and the gutted-gilled weights of equal-sized pollock increased from April-May to August.

Male pollock were found to mature at ages of 4 to 7 and a size range of 50 to 60 cm. Females reach maturity when 5 to 7 years old and sizes of 55 to 70 cm.

Spawning occurs in the winter. In May and June all of the Bay of Fundy pollock examined were in the recovering phase of their reproductive cycle. In July a few ripening males were found. In August most males were ripening and a few ripening females were also observed.

The 0-class pollock were found to contain mainly algae-inhabiting organisms (amphipods, insects, harpacticoid copepods) in the summer. Planktonic organisms were of less importance. The 1-year-old fish had a similar but more restricted diet and consumed more plankton (euphausiids and calanoid copepods).

The offshore pollock in the Bay of Fundy are mainly plankton eaters and the euphausiid Meganyctiphanes norvegica is by far the most important organism. The smaller, offshore pollock also eat quantities of planktonic copepods and the largest sizes consume relatively more fish. On the Scotian Shelf and in the Laurentian Channel pollock were found to contain large quantities of fish, even at the smaller sizes.

D. H. Steele

No. C-16

HALIBUT INVESTIGATION

The main aim of the present Atlantic halibut investigation is to study the relative effects of the otter-trawl catch of smaller, younger halibut and the longline catch of larger, older fish on the yield of the fishery. In order to further this aim, data on a number of facets of the basic biology of the fish are being collected. Efforts in 1962 have been directed mainly towards tagging and stomach and gonad collection in the field and analysis of food and maturity data from research-vessel catches in the laboratory. Detailed biological examination of all halibut caught by our research vessels has been carried on as a routine.

Tagging

A program has been designed to supplement tagging carried out by F. D. McCracken in 1946 and 1947 in the Anticosti and southwestern Nova Scotia regions. This has taken the form of taggings in the more easterly parts of the Nova Scotia Banks, mainly the "gully" region between Sable Island Bank and Banquereau, and on the southwestern edge of the Grand Banks. These efforts will give information on movements of halibut in the other two important halibut fishing areas of the Canadian fleet.

The "gully" tagging was carried out during March 16-28, 1962, from the A.T. Cameron. A total of 707 halibut were tagged, 648 from otter-trawl sets and 59 from longline sets. Red and yellow Petersen disk tags were used, with the yellow disk being placed on the upper dark side of the fish. A wide range of sizes was obtained with most of the smaller fish (30-100 cm fork length) being obtained from shoaler water around 75 fathoms, and the majority of large fish (80-196 cm fork length) being obtained by longline, mainly in depths of over 100 fathoms. Returns so far have indicated movement up the gully onto Middle Ground. A clearer picture is expected this winter when the Canadian otter-trawl and longline fleets usually concentrate on the central and western parts of the Nova Scotia Banks.

A cruise is being carried out in February 1963 to tag halibut on the southwestern edge of the Grand Banks.

Stomach and gonad collections from commercial boats

Collections of halibut stomachs and gonads are made at sea by fishermen on commercial longliners. A payment is made for each 5-gallon container of viscera preserved in formalin solution, accompanied by data on area of capture, date and depth fished. One difficulty is that the exact sizes of the fish are not recorded. However, this is being overcome by developing a relation between empty stomach volume and weight versus fork length.

From October 1961 to November 1962 eighteen containers of halibut viscera were collected and examined. These were from a number of Canadian fishing areas and spread out over the time interval. Although the data were not specific to any small area, it was obvious from the changing state of the gonads collected throughout the period that the main spawning in these areas must take place between December and February. Winter sampling is being intensified in order to specify spawning times in more limited areas.

Food found in stomachs of commercial-size fish included in these collections was usually fish remains with occasional crustaceans or molluscs.

Food studies from A.T. Cameron catches

All halibut taken incidental to other catches on the A.T. Cameron are subject to detailed biological examination. Stomach-content data from research-vessel catches proved to be very similar to data from commercial collections. Young halibut, up to a size of about 75 cm fork length, feed mainly on crustaceans but also on molluscs, echinoderms and annelids. Halibut have been found to feed on fish at sizes as small as 35 cm, and fish becomes practically their sole diet over 75 cm. This change in diet and the known rapid growth rate and large ultimate size are inter-related. As the fish grows large, it both needs and is able to capture food items of larger average sizes.

A. C. Kohler

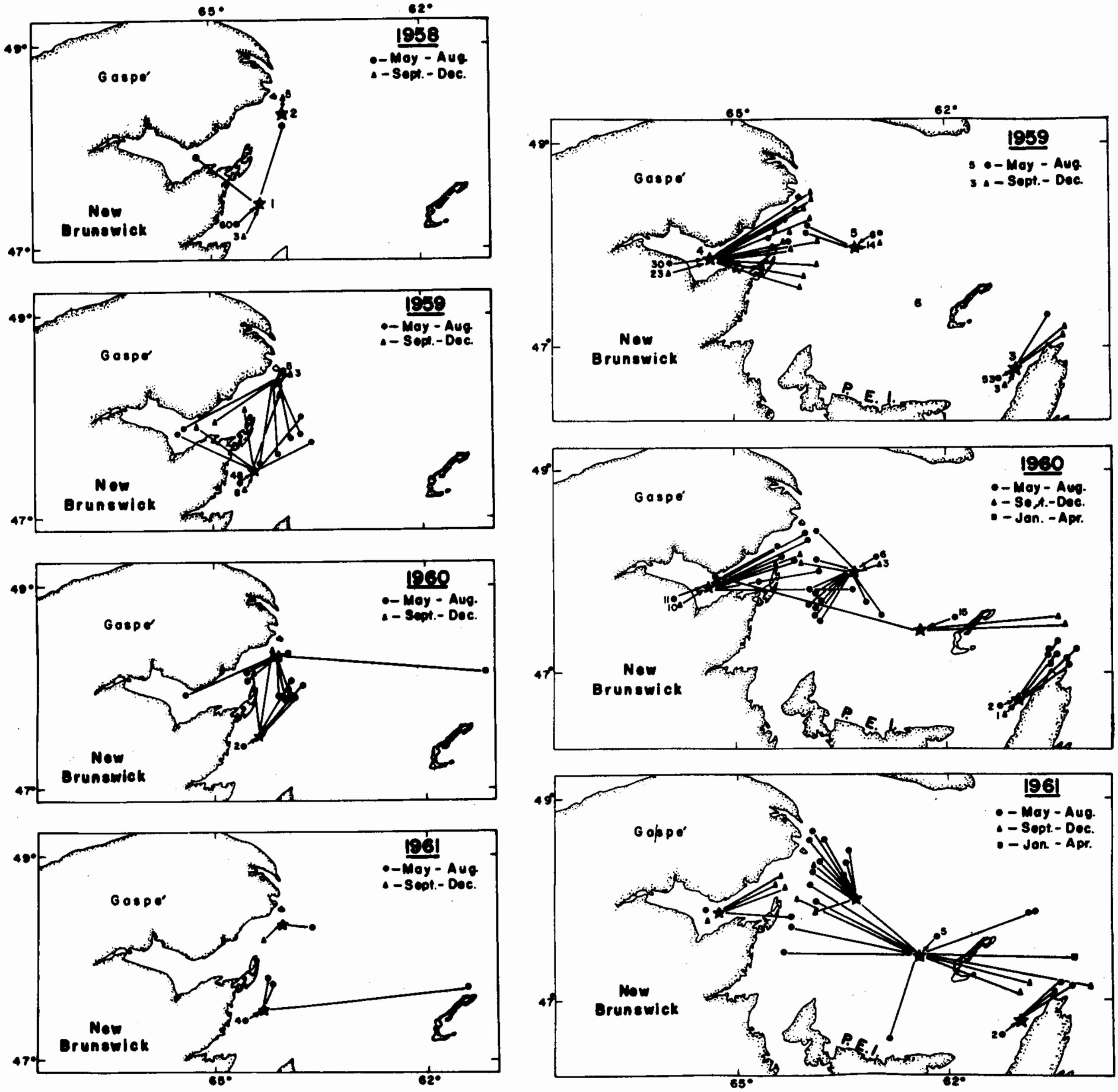
No. C-17

PLAICE TAGGING EXPERIMENTS 1958-1961 MAGDALEN SHALLOWS

Tagging experiments initiated in 1958 were continued in conjunction with plaice surveys in the Magdalen Shallows. The resulting analyses of these data have brought to light certain consistent features associated with the movements and nature of this stock of American plaice.

Seasonal movements

The localities and numbers of recaptures of plaice tags are presented in Fig. 1. During the summer months little movement was apparent, with most of the recaptures occurring in the release areas. In the fall months, however, some indications of offshore movement were apparent. Nearly all fall recaptures of fish tagged in Chaleur Bay came from outside the Bay the first autumn after tagging (Fig. 1B, lot 4). Similarly for plaice tagged west of the Magdalen Islands, the majority of fall recaptures were offshore towards the Laurentian Channel (Fig. 1B, 1960 and 1961, lot 3). Only three returns were made in the winter and all of these were



A B

Fig. 1. Recaptures of American plaice tagged in the Magdalen Shallows. Circles, triangles and squares indicate localities of individual fish retaken outside the release area which is denoted by a star and number. The numbers of recaptures on the release area are indicated by arrows.

from deep water along the edge of the Laurentian Channel (Fig. 1B, 1960 and 1961, lots 6 and 3).

The majority of summer recaptures from all areas in successive years were from the release areas. Short, apparently undirected movements occurred during the first summer after release, and these were atrributed to food seeking.

These tagging results are in accord with surveys carried out at various times during the year. During the summer months the main concentrations of plaice occurred in the Chaleur-Shippegan-Orphan Bank region and in the North Bay-Sydney Bight region. In January and February the distribution was confined to deep water (180-240 fath) along the Laurentian Channel (Annual Report 1961-62, Summary No. 40). During early spring and late fall the main concentrations were located in intermediate depths (60-100 fath) in areas half way between the inshore-summer and offshore-winter grounds.

Nature and division within the stock

Recaptures of plaice tagged north of the Magdalen Islands for all years were restricted to this northern sector. Furthermore, no adult fish tagged in the Cape Breton region moved to the north. There was therefore little or no mingling between the two main groups, except possibly during the winter (Fig. 1B, 1961, lot 6). Surveys made in the Magdalen Shallows during summer months disclosed that two main concentrations of American plaice occurred, but the amount of mixture taking place between them was not known. The two groups have been termed the Miscou-Magdalen (northern sector) and Cape Breton (southern sector) groups.

No plaice tagged within the Magdalen Shallows has been retaken outside the area, which is therefore considered to support a discrete stock. Significant differences in growth rate have been noted between samples of plaice from the Magdalen Shallows, Seven Islands and Nova Scotia Banks regions, supporting the conclusion obtained by tagging experiments.

Total annual mortality

While only those tags returned together with the known locality of recapture were used in the determination of the nature and movements of the stock, total returns (see table) were used to estimate rates of annual total mortality. Estimates of total mortality may be obtained from ratios of tag returns in successive years (Ricker method), providing fishing pressures are relatively even from year to year. These conditions were satisfied during the period 1959 to 1961 for the Cape Breton area (4Tg). For this area, survivals, s, were therefore:

$$103/300 = 0.33 \text{ for } 1959\text{-}60$$

$$34/103 = 0.33 \text{ for } 1960\text{-}61$$

$$12/34 = 0.35 \text{ for } 1961\text{-}62$$

from whence total mortality rates, 1-s, were 0.67, 0.67, 0.65, respectively.

Average annual total mortality rates for the northern sector obtained in a similar manner were 0.60 and 0.56 for 1960 and 1961, respectively, although inshore areas when treated separately were characterized by a somewhat greater total mortality rate.

Numbers of American plaice tags returned in successive years by ICNAF unit area, Magdalen Shallows

	Chaleur Bay (4Tm)	Orphan Bk. (4Tn)	Grand R. (4Tn)	Shippegan Gully (4Tl)	Magdalen Is. Bradelle Bk. (4Tf-k)	North Bay (4Tg)
No. tagged	319	215	151	320	427	300
Recaptures:						
1958		8		90		
1959	93	19	17	92		103
1960	46	8	28	16	36	34
1961	15	5	13	10	24	12

P. M. Powles

No. C-18

PARTICIPATION IN THE ICNAF FISHERY ASSESSMENT PROGRAM

Initial assessments of ICNAF fisheries in relation to regulation problems were completed in 1961 by a small working group of scientists from six countries plus an FAO participant. The report used the fishery and sampling data available to the end of 1958, and presented results of calculations designed mainly to estimate effects of various changes in otter-trawl mesh sizes on yield. It concluded that effects of further changes were likely to be very small (certainly within the limits of error of measurement). However, even this conclusion must be accepted with reservations based on the knowledge that (1) the population parameters can be measured only very inaccurately; (2) the fisheries observed were in transitory states as a result of recent fishing effort increases, whereas the analytic models did not always deal satisfactorily with non-equilibrium states. In addition, the working group was able to offer only general advice about the effects of effort changes.

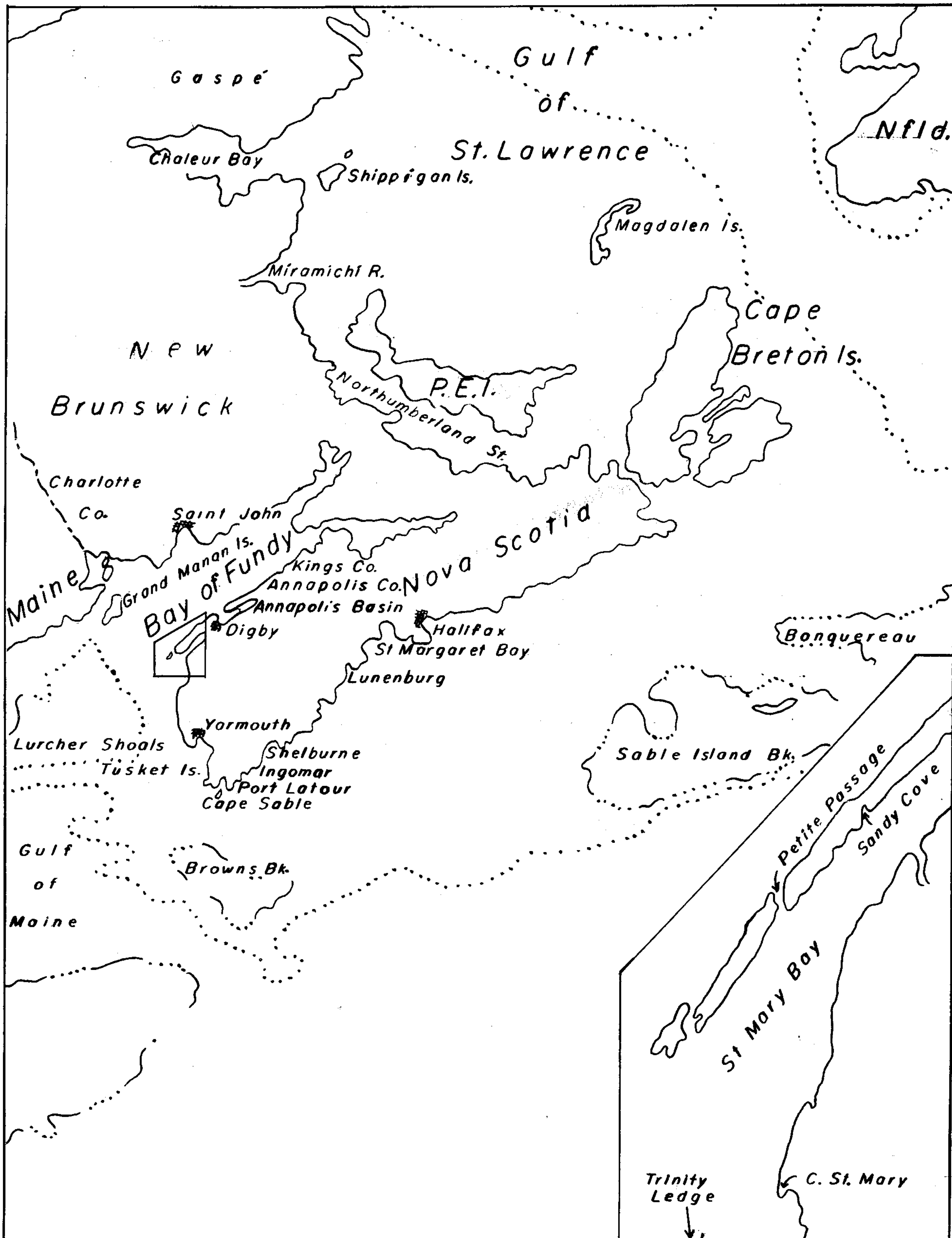
During the year 1961-62 the working group began the job of checking the first results and broadening their applicability. In addition to clarifying certain obscurities in the description of theoretical effects of mesh change and inadequacies in analyses of redfish fisheries, this has consisted primarily of a study of the reliability of the measurement of effort and abundance changes, and the means of detecting and measuring functional relations between them.

The problems encountered in this development of the assessment program may be considered in three major categories. The first is a study of the homogeneity of the sampling data submitted by member countries to ICNAF as representing the characteristics of the parts of the various stocks they fish. The second consists of special studies of the variations in catch per unit effort data to show the limits of its capacity for describing stock changes. Finally, there is the work of detecting the factors which contribute most to the variation so that they may be taken into account in further data collections and analyses. At its 1962 meeting in Moscow, the group reviewed evidence of heterogeneity in the catch and effort statistics and its relation to characteristics of fleet operation and departures of fleet and fish distribution from the random type assumed in present analyses. New theoretical developments which should permit analysis of such data were discussed and plans made to carry out co-operative pilot studies which would be examined at later meetings.

The main responsibility for study of the homogeneity of the sampling data is being assumed by the Lowestoft Group. The St. Andrews groundfish and mathematical-statistics investigations are providing much of the guidance for development of the program of studies of effort. The latter investigation is responsible for a major part of the analyses to be reported to the 1963 meeting of the group at Halifax, with the writer as convener.

L. M. Dickie

PELAGIC SUMMARIES



Gulf of St. Lawrence
Gaspé
Chaleur Bay
Shippigan Is.
Magdalen Is.
Nfld.
Miramichi R.
Cape Breton Is.
New Brunswick
P.E.I.
Northumberland St.
Charlotte Co.
Saint John
Grand Manan Is.
Maine
Bay of Fundy
Nova Scotia
Kings Co.
Annapolis Co.
Annapolis Basin
Digby
Halifax
St Margaret Bay
Lunenburg
Bonquereau
Yarmouth
Lurcher Shoals
Tusket Is.
Shelburne
Ingomar
Port Latour
Cape Sable
Sable Island Bk.
Gulf of Maine
Browns Bk.
Petite Passage
Sandy Cove
St Mary Bay
Trinity Ledge
C. St. Mary

No. D-1

PELAGIC FISH LANDINGS

The value of pelagic fish landings on the Canadian Atlantic coast in 1962 amounted to $5,772,400, an increase of 13% over the 1961 values and 22% over the long-term (1939-60) values. Figures for 1961 and 1962 are preliminary.

Landings totalled 262 million lb--34 million lb more than in 1961. There was an increase of almost 33 million lb of herring and small increases in mackerel, swordfish and tuna landings (Fig. 1). However, even with these increases, the pelagic landings were still 35 million lb below the long-term average. In fact, Figure 1 shows that from about 1952 to date the herring, mackerel and tuna landings have remained below the 1939-60 average. Swordfish was the one exception to this downward trend. These landings which are all made on the outer Nova Scotia coast have remained above the long-term average for about the same period of years.

Figure 1 shows that the total herring landings on the Atlantic coast of Canada increased from 228 million lb in 1939 to 414 million lb in 1946, but declined irregularly thereafter to an all-time low (189 million lb) in 1961. This downward trend in herring landings was followed by a 33 million lb recovery to 242 million lb in 1962.

Figure 2 shows a breakdown of Figure 1A into 6 area subdivisions. It is seen that the herring landings in all subdivisions except one increased from 1939 to produce the overall peak landings in 1946. In one subdivision, the northern Gulf of St. Lawrence, landings declined irregularly from about 30 million lb in 1939 to about 5 million lb in 1962. In contrast to this the landings on the Nova Scotia side of the Bay of Fundy increased over the whole period, slowly from 1939 to 1954 and more rapidly from then to the present. This increase may be attributed mainly to purse-seining which began with New Brunswick seiners, and then was augmented in the late 1950's by a growing fleet of Nova Scotia seiners. The overall increase of 33 million lb in 1962 was caused by very definite increases in the southern Gulf of St. Lawrence (particularly at the Magdalen Islands and in New Brunswick) and on the New Brunswick side of the Bay of Fundy. All the other subdivisions showed a decrease.

Figure 1 shows that from 1939 to 1959 mackerel landings throughout the Maritimes, Quebec and Newfoundland declined irregularly but steadily from a high of 52 million lb in 1939 to a low of 9 million lb in 1959. From 1959 to date, however, the trend has been slowly upward to a catch of

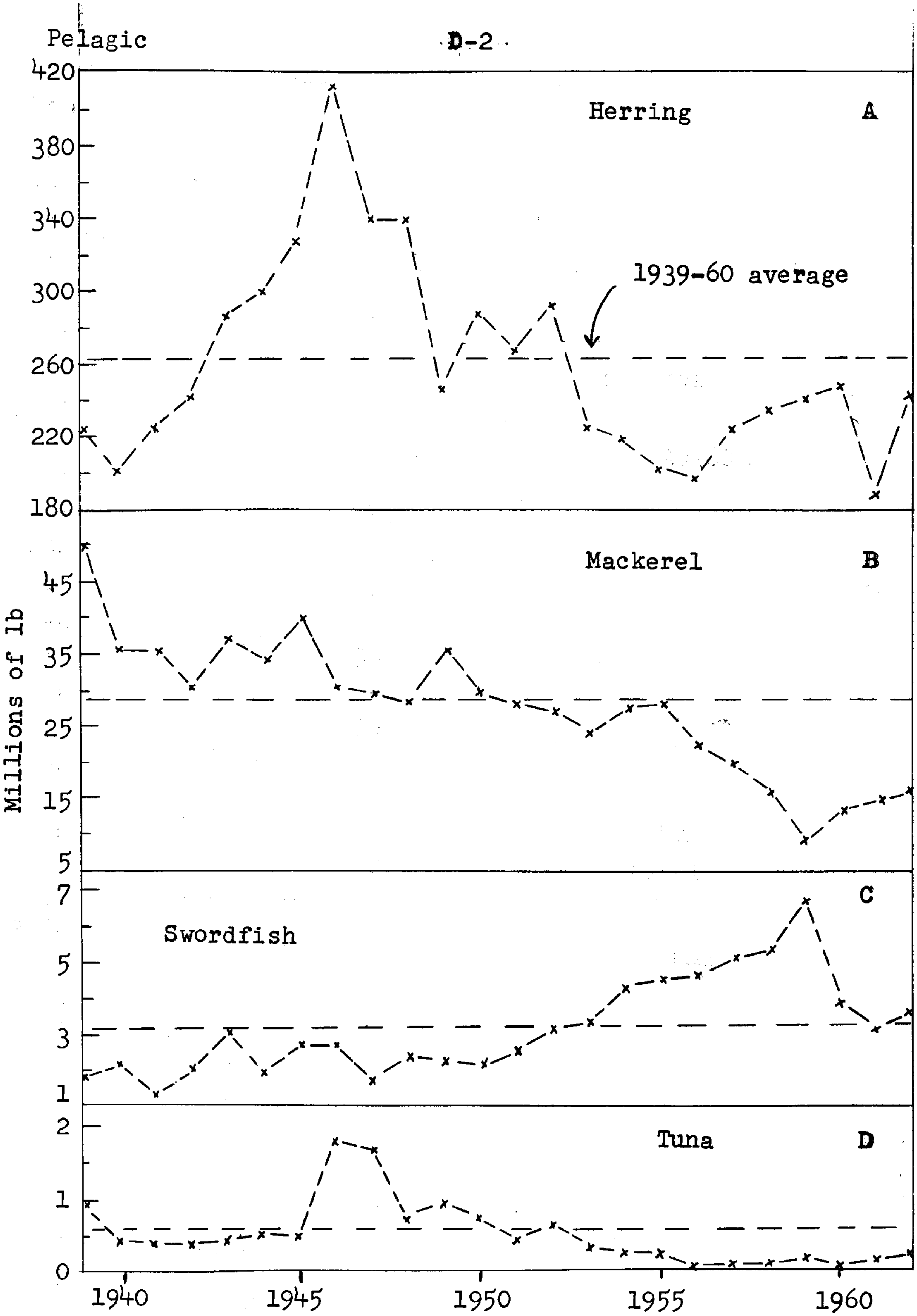


Figure 1. Pelagic fish landings, Canadian Atlantic, 1939-62.

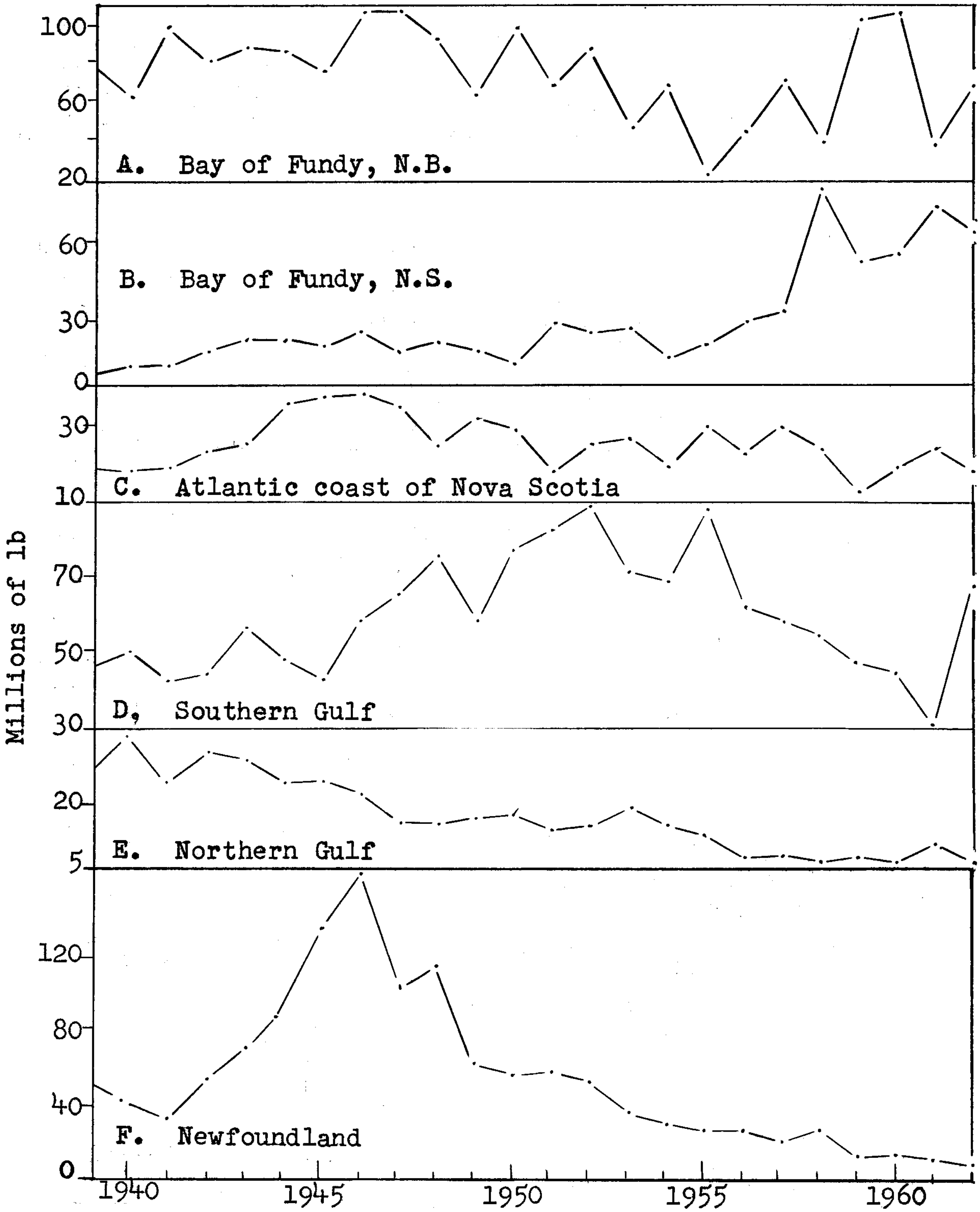


Figure 2. Herring landings according to six Canadian Atlantic subdivisions, 1939-1962.

16.1 million lb in 1962. This increase has been the result of improved catches on the Atlantic coast of Nova Scotia (3.6 to 9.1 million lb) during this period, in the southern Gulf of St. Lawrence (1.6 to 6.4 million lb) and in Newfoundland (0 to 1.3 million lb). In the northern Gulf of St. Lawrence there has been a slight increase (1.6 to 2.5 million lb) while in the Bay of Fundy the downward trend continued (2.6 to 0.8 million lb).

During the last 3 years the swordfish catch has varied from about 3.2 to 3.9 million lb (3.5 million lb in 1962), there being little difference between these years. However, the 1960-62 landings were only about half those (6.7 million lb) in 1959--the peak year. This peak was reached through a gradual, but steady increase year by year beginning about 1950. While this increase was undoubtedly influenced by a growing market demand, it was principally attributable to the development of an offshore fleet designed primarily for groundfish operations.

Though still below the long-term average (see Fig. 1) the 1962 tuna catch of 0.24 million lb was 0.10 million lb greater than 1961. Most of this increase occurred in Lunenburg County during September.

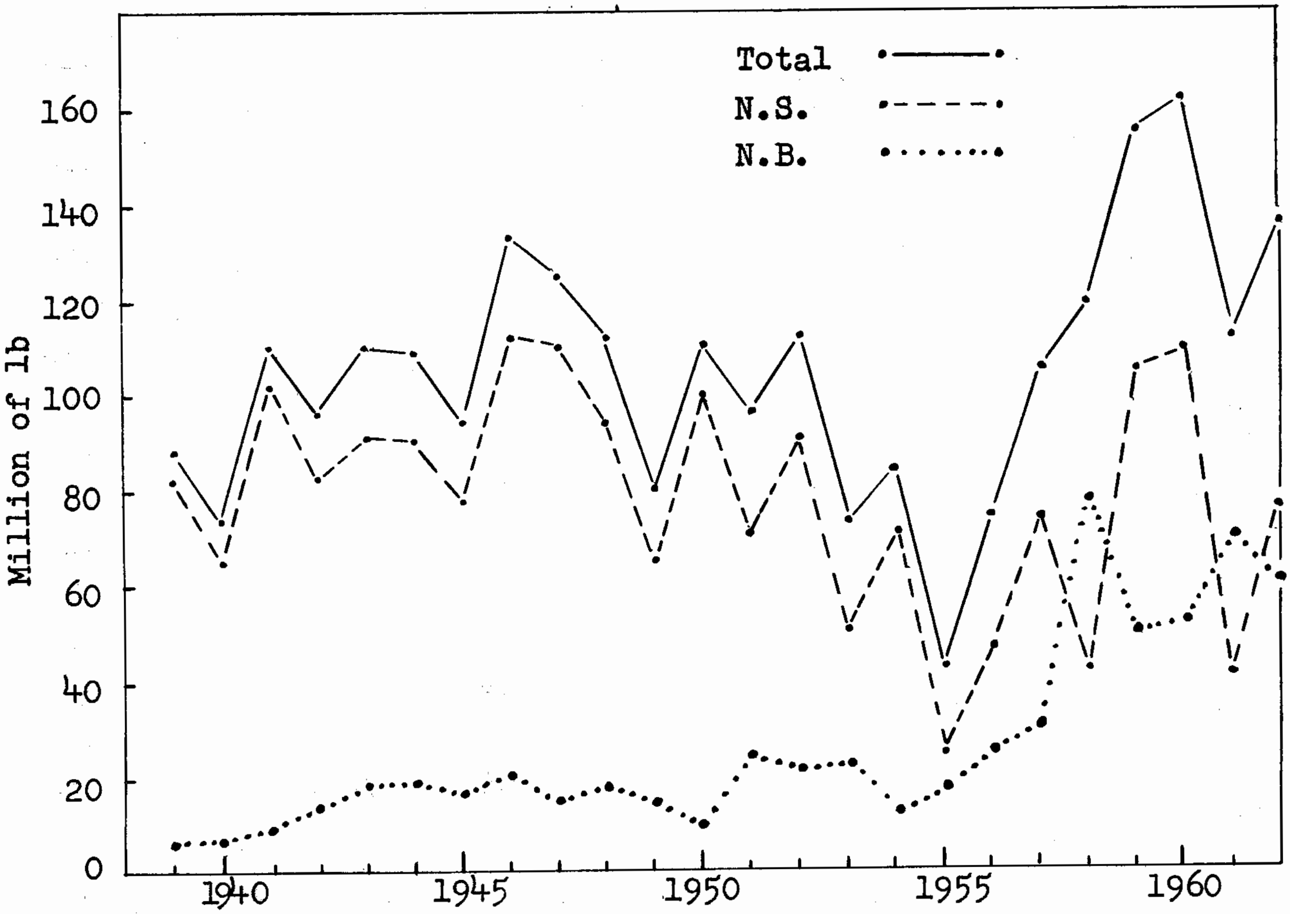
R. A. McKenzie

No. D-2

THE "SARDINE" FISHERY OF THE BAY OF FUNDY

Although about 24 million lb lower than the all-time high of 161 million lb in 1960, the 1962 catch of 137 million lb was 34 million lb higher than the 1939-60 average herring landings in the Bay of Fundy. The accompanying figure shows that for the period 1939 to 1962 the catch on the Nova Scotia side of the Bay of Fundy was lower than on the New Brunswick side except in 1958 and 1961. This change in recent years from one side of the Bay to the other has been due mainly to fluctuations in Digby and Charlotte County landings particularly in the West Isles and Grand Manan parts of Charlotte County.

While Yarmouth landings in 1962 were at about the same level as other years those in Digby were less than those in 1961--53 million lb compared to 62 million lb. On the New Brunswick side, the Charlotte County landings were 2½ times those of 1961--72 million lb compared to 28 million lb in 1961. St. John catches, however, were only 1/3 those of 1961--4 million lb compared to 13 million lb. Within Charlotte County the landings in West Isles and Grand Manan seem to determine whether or not those for the whole New Brunswick side of the Bay of Fundy will be high or low.



Herring landings in the Bay of Fundy including Yarmouth County.

Drift-bottle experiments show that the circulation in the Bay of Fundy may be of an open or closed type and it has been found that the open type corresponds with years of good catches on the Nova Scotia side and the closed type corresponds with good catches on the New Brunswick side. In 1962 tendency towards being open was not as pronounced as in 1961 which agrees with above correlation.

From 1957 to date, detailed records of the gear used and the catches made on the New Brunswick side (and to some extent on the Nova Scotia side) of the Bay of Fundy have been obtained annually from the Federal Department of Fisheries (St. Andrews) and through the cooperation of Connors Bros. Ltd., Black's Harbour, N. B., H. W. Welch Ltd., Fairhaven, N. B., and the United States Bureau of Commercial Fisheries at Boothbay Harbor, Maine. Some determination of the relative success of the different branches of the fishery has thus been possible. The totals in Table I do not necessarily agree with those reported by the Dominion Bureau of Statistics.

Table I shows (a) the number of units of gear licensed and the number of weirs built and operated, (b) the total catch by types of gear, and (c) the average catch by type of gear.

Table I. Details of herring gear and catches in Charlotte and Saint John Counties 1957-62.

(a) Gear (No. of units)

Year	Weirs			Licensed drag seines	Licensed purse seines
	Licensed	Built	Not built		
1957	371	290	81	22	17
1958	376	269	107	31	13
1959	386	271	115	25	19
1960	403	270	133	21	15
1961	345	261	84	14	17
1962	372	286	86	20	21

(b) Total catch (millions of lb)

Year	Weirs	Drag seines	Purse seines	Total
1957	73.4	4.2	8.2	85.8
1958	25.5	2.5	7.9	35.9
1959	74.7	6.6	19.1	100.4
1960	76.3	5.9	37.0	119.2
1961	17.8	1.6	27.2	46.6
1962	48.2	4.9	19.5	72.6

(c) Average catch/unit of gear (lb)

Year	Weirs[1]	Drag seines[2]	Purse seines[2]
1957	253,237	193,133	481,804
1958	94,728	81,364	606,413
1959	275,637	264,184	1,003,507
1960	282,688	279,037	2,467,545
1961	68,329	114,231	1,602,600
1962	168,690	244,020	930,388

1 Operated
2 Licensed

In 1962 the number of weirs licensed (372) was only 4 less than the previous 5-year average whereas the number built and operated was 5% greater than the 5-year average of 272. The 20 drag seines licensed in 1962 was 3 or 13% less than the 5-year average and the 21 purse seines licensed was 5 or 31% above the 5-year average.

In the landings by gear a small percentage each year has been of unknown gear origin. However, in 1962 this percentage increased to about 5%. In each case the landings in Table I (b) were about average in 1962.

However, the average catch per unit of gear (Table I (c)) during the 1957-61 period was 196,178, 184,071, and 1,227,160 lb respectively. In 1962 the weir catch was thus 13% below average, the drag-seine catch 31% above average and the purse-seine catch was about 25% below average.

Most of the herring catch made on the Nova Scotia side of the Bay of Fundy (Yarmouth included) is landed on the north side of this bay, either in New Brunswick or the State of Maine. Dominion Bureau of Statistics records a catch in 1962 of 7.9 million lb for Yarmouth, 52.9 for Digby, 0.1 for Annapolis, 0.09 for Kings and 0.01 for Colchester, or a total of 61.1 for the Nova Scotia side of the Bay of Fundy. However, landings of herring on the north side from catches on the south or Nova Scotia side total 49.6 million lb (Table II) not including the catches made in Yarmouth Bar trap or any of the gill-net catches of autumn-spawning herring in the Trinity-Lurcher area which are landed in Nova Scotia.

Table II. Herring caught on the south side of the Bay of Fundy but landed on the north (millions of lb).

Landed in	Weirs	Purse seine	Gear unknown	Total
New Brunswick				
Mainland	4.4	10.7	0	15.1
Grand Manan	1.1	3.6	0	4.7
Maine	2.9	24.0	2.9	29.8
Total	8.4	38.3	2.9	49.6

On the basis of log records and personal surveys the 1962 herring catch on the Nova Scotia side of the Bay of Fundy was estimated at 83 million lb, 70 caught by purse seines, 11 by weirs and 2 by gill nets.

Table III gives an estimate of the herring landings and disposition of the catch made on the Nova Scotia side of the Bay of Fundy. It is estimated that about 13% of the catch was in weirs, 84% by purse seines and 3% in gill nets.

Table III. Estimated landings of herring catch by types of gear on Nova Scotia side of Bay of Fundy (millions of lb).

Landed in	Weirs	Purse seines	Gill net	Gear unknown	Total
New Brunswick					
Mainland	4.4	10.7	0	0	15.1
Grand Manan	1.1	3.6	0	0	4.7
Maine	2.9	24.0	0	2.9	29.8
Nova Scotia	2.6	17.0	2.0	0	21.6
Unknown	0	11.8	0	0	11.8
Total	11.0	67.1	2.0	2.9	83.0

R. A. McKenzie
C. D. Burnett

No. D-3

SOUTHWEST NOVA SCOTIA PELAGIC FISHERIES

Eighty-three percent of the total landings of herring in southwest Nova Scotia in 1962 were caught in the Digby-Yarmouth-Shelburne area. The rapidly expanding purse-seiner fleet accounted for 80% of this catch. The availability of herring close inshore to fixed methods of fishing such as anchored gill nets and weirs was generally poor in 1962.

Log book coverage of the seiner fleet showed that most of the effort was concentrated on the Trinity to Cape St. Mary spawning grounds from May to October. For the first time, good catches were made about 25 miles offshore from Shelburne County during the last week in May. These herring were very fat with immature gonads. The average length was 29.3 cm. It is anticipated that an increased effort for these fish will develop in 1963.

New additions to the purse-seiner fleet in southwest Nova Scotia are proposed. In anticipation of an expanding herring market fishermen are planning to build a large type of vessel which will combine facilities for seining, pumping, and carrying. Two 91-foot steel vessels of stern-trawler design are presently under construction and one 116-foot vessel is being considered. It is expected that these vessels will prosecute not only the herring fisheries but mackerel and tuna fisheries as well.

There is a growing interest in mackerel and tuna fisheries in southwest Nova Scotia. During the latter part of May, large catches of mackerel (up to 40,000 lb per set) were made off Seal Island in Yarmouth County. Tuna were caught on many occasions along with catches of herring. As many as 5 tuna weighing from 400 to 700 lb each were taken in purse seine sets during September. Altogether more than 100 tuna were taken by seiners and another 32 were caught by sports fishermen in 1962.

Routine sampling of commercial herring landings for length and age studies showed no significant change in size composition during the 1962 fishing season. An increased number of seiner landings involved in the sampling program resulted in a slightly higher percentage of relatively small herring. The average size of purse-seined fish was approximately 30 cm whereas catches from 2½ inches to 2 5/8 inch mesh gill-nets had average lengths of 31 to 32 cm.

With the growing commercial interest in other pelagic species detailed sampling of mackerel and swordfish was carried on during the year. These samplings consisted of lengths, body proportions, weights, etc., the results of which are recorded elsewhere. A preliminary effort was made to gather information on tuna and consisted mainly of recording occurrence and obtaining water temperatures in areas where tuna were either caught or sighted.

The first evidence of herring spawning in 1962 was obtained on May 12 when a fisherman operating in the Trinity Rock area found herring spawn attached to his lobster traps. However, no ripe and running herring appeared in commercial catches until June 1. Continuous spawning on a small scale was reported by fishermen throughout July and August and spawning reached a peak in September. The area where heaviest spawnings took place was in the vicinity of Cape St. Mary. Fishermen agreed that heavier and more prolonged spawnings took place in 1962 than for many years. In many cases reports by fishermen were substantiated by examination of stomachs of haddock and flounders which contained herring eggs and frequently masses of herring eggs were taken in otter trawls.

Plankton tows for collections of herring larvae were made throughout the year. In St. Mary Bay 30 mm (average length) larvae were abundant in April and 50 mm (average length) larvae in May. It is interesting to note that the stomachs of 66% of a herring sample taken at Belliveau Cove on May 24 contained herring larvae from 40 to 60 mm long. In two other samples from the same location 11% and 21% of the herring stomachs contained herring larvae. The abundance of herring larvae throughout southwest Nova Scotia was apparently much greater than it has been for several years.

Oceanographic work during 1962 consisted of making monthly releases of drift bottles from the M.V. Bluenose and maintaining supplies of bottles for daily releases from the M.V. Bluenose and the Lurcher Lightship.

E. G. Sollows

No. D-4

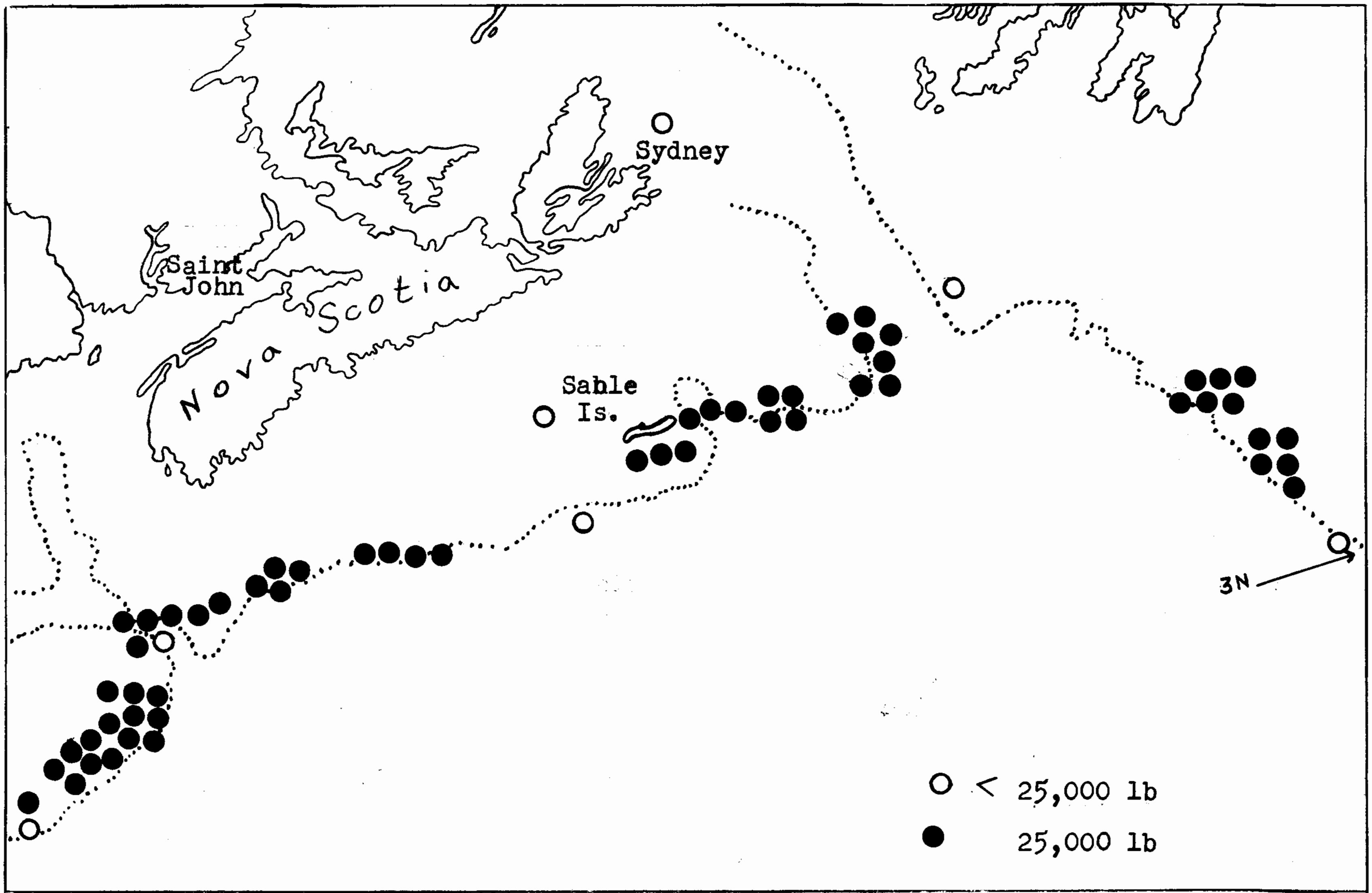
THE 1962 SWORDFISH FISHERY

A study of the swordfish fishery which was initiated in 1958 to follow variations in the distribution of catches and in the success of fishing, was continued in 1962. Department of Fisheries' catch statistics were examined and log records from a sample of the fleet were analysed.

Landings of swordfish in 1962 amounted to 3.5 million lb with a landed value of 1.6 million dollars. This represents an 8% increase in weight and a 27% increase in value over 1961. The landed value in 1962 established an all-time record high for swordfish on the Atlantic coast. Landed values per lb have been increasing steadily over the past four years. In 1959 the average price per lb to fishermen was 20.7 cents; in 1960 it was 34.6 cents; in 1961 it was 38.8 cents and in 1962 it was 45.4 cents.

The number of vessels engaged in the swordfish fishery in 1962 is not available but it is certain that there was no major increase in the fleet. In fact, there may have been a decrease as some vessels that normally fish for swordfish were diverted to an offshore scallop fishery.

In 1962, log records were received from 49 vessels and these accounted for 42% of the total landings. The fishery began in early June somewhat later than usual and throughout the month was centered chiefly in the southeast part of Georges Bank. In July most of the swordfish landed were caught on Browns Bank, Emerald Bank and Sable Island Bank and were fairly evenly distributed between these three areas. The fishery in August was located almost exclusively in the Banquereau area. Some landings were made from Sable



Distribution of swordfish catch, 1962.

D-11

Pelagic

Island Bank and Georges Bank in September but most of the effort from late August to early November was along the southwest edge of the Grand Banks. The season was exceptionally long even though it was late starting and strikingly unusual in that successful fishing on the Grand Banks continued into the late autumn about 6 weeks later than usual. The distribution of swordfish catches in 1962 as shown by log records is given in the accompanying figure. By comparison with 1961 when most of the swordfish landings were made from Georges and Browns Banks the catch in 1962 was much more evenly distributed along the edge of the continental shelf from Georges Bank to the Grand Banks.

The accompanying table summarizes the information obtained from log records and compares results with similar data for 1960 and 1961. For this table, only the log records from vessels fully occupied with swordfish fishing were used. Many vessels are engaged in mixed fishing and some vessels make only one or two short trips each season. The records from such vessels are included in the catch distribution figure but not in the table.

Summary of swordfish log records 1960-62.

	1960	1961	1962
No. of trip records	219	175	158
No. of days at sea	3,119	2,323	2,226
No. of fishing days	2,346	1,847	1,725
No. of fish caught	8,105	6,117	6,261
Weight of fish caught	1,747,494	1,237,899	1,234,573
No. of days at sea/trip	14	13	14
No. of fishing days/trip	11	11	11
No. of fish caught/day at sea	2.6	2.6	2.8
No. of fish caught/day fished	3.5	3.3	3.6
No. of fish caught/trip	37	35	40
Total landings/trip (lb)	7,979	7,074	7,814
Gross stock/trip ($)	2,761	2,745	3,544
Annual landings/vessel (lb)	39,716	35,369	39,825
Annual gross stock/vessel ($)	13,742	13,723	18,061

There were only minor differences in the catch of swordfish per unit of effort in the three years. However, the fishing success as measured in dollar earnings was considerably greater in 1962 than in 1960 and 1961. This, of course, is due to higher market values for swordfish in 1962.

In 1962 a new method of fishing was introduced into the swordfish fishery. In late August and early September some vessels combined longlining with the traditional harpoon method of fishing and met with spectacular success. Before the season ended there were at least 34 vessels engaged in longlining. The few records that are available suggest that longlining is a far more effective method of catching swordfish than harpooning. The average number of fish caught per day fished with harpoons was 2.9 as compared with 8.1 for longlines. In addition average size of longline-caught swordfish (227.3 lb) was greater than the average size of harpooned fish (198.5 lb). This resulted in an average landing per trip of 19,493 pounds valued at 8,800 dollars for longlining as compared with 5,882 pounds valued at 2,700 dollars for harpooning.

One of the great advantages of longlining for swordfish is that the gear can be used at night and when the weather is unsuitable for harpooning, thus greatly increasing the fishing time per trip. In addition there is evidence that both male and female swordfish can be taken with longlines whereas only females are taken with harpoons. It seems certain too that longlining will extend the fishing season by 6 to 8 weeks or more thus providing more opportunity for increased landings.

S. N. Tibbo

No. D-5

SIZE COMPOSITION OF CANADIAN ATLANTIC HERRING

In 1962, herring were sampled for length and weight, and otoliths were taken for age determinations in three general areas off the Canadian Atlantic coast. In the Gulf of St. Lawrence samples were obtained at Caraquet and the Magdalen Islands in May during tagging operations in these areas. In the Bay of Fundy the sampling program covered both the New Brunswick and Nova Scotia coasts throughout the year and were obtained from various kinds of gear. Sampling in the Gulf of Maine was conducted only in September with fish caught in bottom trawls.

During the spring herring fishery at Caraquet the fish sampled from traps averaged 28.1 cm (676 fish) and from gill nets 30.6 cm (608 fish) in length. Ten year-classes were found with the average age being 4.6 years and length 29.2 cm. In Tables I and II ages 9, 10, 11 and 12 are combined under 8+.

Table I. Herring sampled at Caraquet, May 1962.

Year-class	Age	% age in catch	Average length
1959	3	.7	28.0 (3 fish)
1958	4	59.5	27.9 (237 fish)
1957	5	28.7	30.3 (115 fish)
1956	6	5.2	32.3 (21 fish)
1955	7	3.5	32.1 (14 fish)
1954	8	1.2	33.5 (5 fish)
	8+	1.2	33.9 (5 fish)

At Magdalen Islands the herring sampled were from purse seines (av. length 32.1 cm, 1,900 fish) and traps (av. length 30.4 cm, 1,325 fish), no gill nets being used there.

Ten year-classes were also found in the herring catch at Magdalen Islands. The average age was 5.7 years and length 31.4 cm. The herring at the Magdalens were thus on the average 1 year older and 2.2 cm longer.

Table II. Herring sampled at Magdalen Islands, May 1962.

Year-class	Age	% age in catch	Average length
1959	3	1.8	25.2 (7 fish)
1958	4	23.2	28.8 (93 fish)
1957	5	27.5	31.0 (110 fish)
1956	6	23.7	32.6 (95 fish)
1955	7	12.5	33.2 (50 fish)
1954	8	2.7	33.8 (11 fish)
	8+	8.6	34.6 (34 fish)

The data compiled in Tables I and II for the Caraquet and Magdalen Islands fish were obtained from studies carried on by T. R. Graham.

On the New Brunswick side of the Bay of Fundy, a total of 4,906 fish were weighed, measured for length and otoliths taken for age determinations. Most of the samples were from the West Isles region (1,400) and eastern Charlotte County (2,400) with 806 from Grand Manan and 300 from the head of Passamaquoddy Bay. The average lengths for all regions for the year was 13.4 cm, about 400 "sardine" herring being sampled monthly.

Practically all the samples from May to October inclusive were weir-caught fish with an average length of 14.3 cm while most of those caught earlier and later in the year were purse-seined fish of average length 12.3 cm.

From January to April, whether weir-caught or purse-seined (almost all the latter), the herring were from 9.4 cm to 10.1 cm long in West Isles and Charlotte east. During June to October inclusive when almost all the samples were weir-caught, the length increased from about 12.0 cm to 15.1 cm in September then declined to 14.5 cm in West Isles by October while in east Charlotte it declined from 19.2 cm (peak for the year) in June to 14.3 cm by October. In November and December samples from both types of gear varied from 12.5 cm to 15.5 cm. However, 1 sample from each of the following areas, Wolves (July), Bliss Island (August) and Grand Manan Bank (November) had fish that averaged 24.3 cm to 27.8 cm in length, possibly because they were relatively close to deep water.

On the Nova Scotia side of the Bay of Fundy, 9,108 herring were sampled as on the New Brunswick side of this Bay but during a shorter period (May to October). The average length of all the fish was 27.7 cm, of weir-caught fish 25.0 cm, of purse-seine caught fish 29.6 cm and of gill-net (2 5/8 inch-2 3/4 inch stretched measure) caught fish 31.5 cm. Samples from weir-caught herring were obtained from May to October, purse-seined samples from June to October, and gill-net fish from June to August (all months inclusive).

In the Cape Sable area (754 fish examined) the average length of samples from weir catches declined from 30.0 cm in June to 19.8 in July. Purse-seined fish were about the same size in July but gill-net caught herring in July were about the same size as the weir-caught fish in June--29.3 cm. Gill-net caught herring at Ingomar (193 fish) a short distance east of Cape Sable were about 32.7 cm in length in June and July while those at Port Mouton (100 fish) still farther east were 30.7 cm long in August.

Herring samples (2,545 fish) from the Yarmouth Bar region indicated that schools of various sizes were in the region. May samples from the trap on the average were 25.7 cm long, June samples 29.7 cm, July samples 21.3 cm, August samples 28.0 cm and September samples 19.7 cm. However, gill-net and purse-seine fish were a little larger than trap-caught fish in August--30.8 cm and 30.1 cm respectively.

Purse-seined herring in the Cape St. Mary-Trinity Ledge area were about the same from July to September (29.6 cm -30.5 cm) as at Yarmouth, but were much smaller in October--14.7 cm. Gill-net herring in this region in August were slightly longer--31.4 cm.

In St. Mary Bay, weir-caught herring declined in length from 24.9 cm in May to 12.6 in October, but in one gill-net sample in July the fish were 31.6 cm in length.

Annapolis Basin weir-caught herring in June averaged 23.8 cm in length but in August were only 14.5 cm.

A comparison of the herring on the two sides of the Bay of Fundy (Table III) shows that on the average those on the Nova Scotia side were twice as big as those on the New Brunswick side, i.e., 27.7 cm compared to 13.4 cm. According to gear the weir-caught herring were 25.0 cm in Nova Scotia and 14.3 cm in New Brunswick while the purse-seined herring were 29.6 cm in Nova Scotia and only 12.3 cm in New Brunswick. Gill-net herring were the largest (31.5 cm) but this gear was used only on the Nova Scotia side of the Bay of Fundy.

Table III. Average length of herring sampled in the general Bay of Fundy area according to gear. (Number of fish in brackets.)

Gear	New Brunswick		Nova Scotia	
	cm		cm	
Weirs	14.3	(2,700)	25.0	(3,947)
Purse seines	12.3	(2,206)	29.6	(4,568)
Gill nets	0.0		31.5	(593)
	13.4	(4,906)	27.7	(9,108)

Sampling in the Gulf of Maine was carried out on two cruises in September. Herring were scarce on Browns Bank and found only on the northwest part, average length of 144 fish in 2 samples was 21.4 cm.

Fishing with bottom trawl along the northern edge of Georges Bank yielded small numbers of herring east of 67°30'W. Longitude of average length 30.6 cm while just west of 68°W. Longitude herring were more abundant, gonads full but hard, average length 29.3 cm. During the second cruise in the same region with the same gear, small numbers of herring were found west of 67°30'W. Longitude, where they had been numerous on the first cruise. The average length was 28.8 cm. Just eastward of this line the Russian fleet was operating in 30 fathoms, taking "running" herring, average length 28.5 cm.

R. A. McKenzie

No. D-6

THE LENGTHS AND WEIGHTS OF SWORDFISH

Biological studies of swordfish were concerned chiefly with length and weight measurements from commercial catches landed in southwest Nova Scotia during the summer months. In addition, five whole specimens were available for detailed body measurements. Swordfish caught commercially are dressed at sea and in most cases measurements can only be made in the dressed condition.

The dressed weight of 532 swordfish examined at Yarmouth during 1962 varied from 83 to 491 pounds. The mean weight was 190 pounds. The weight distribution is shown in Figure 1. Compared with similar data obtained in ~~1962~~ 1961, the swordfish caught in 1962 tended to be somewhat smaller. The

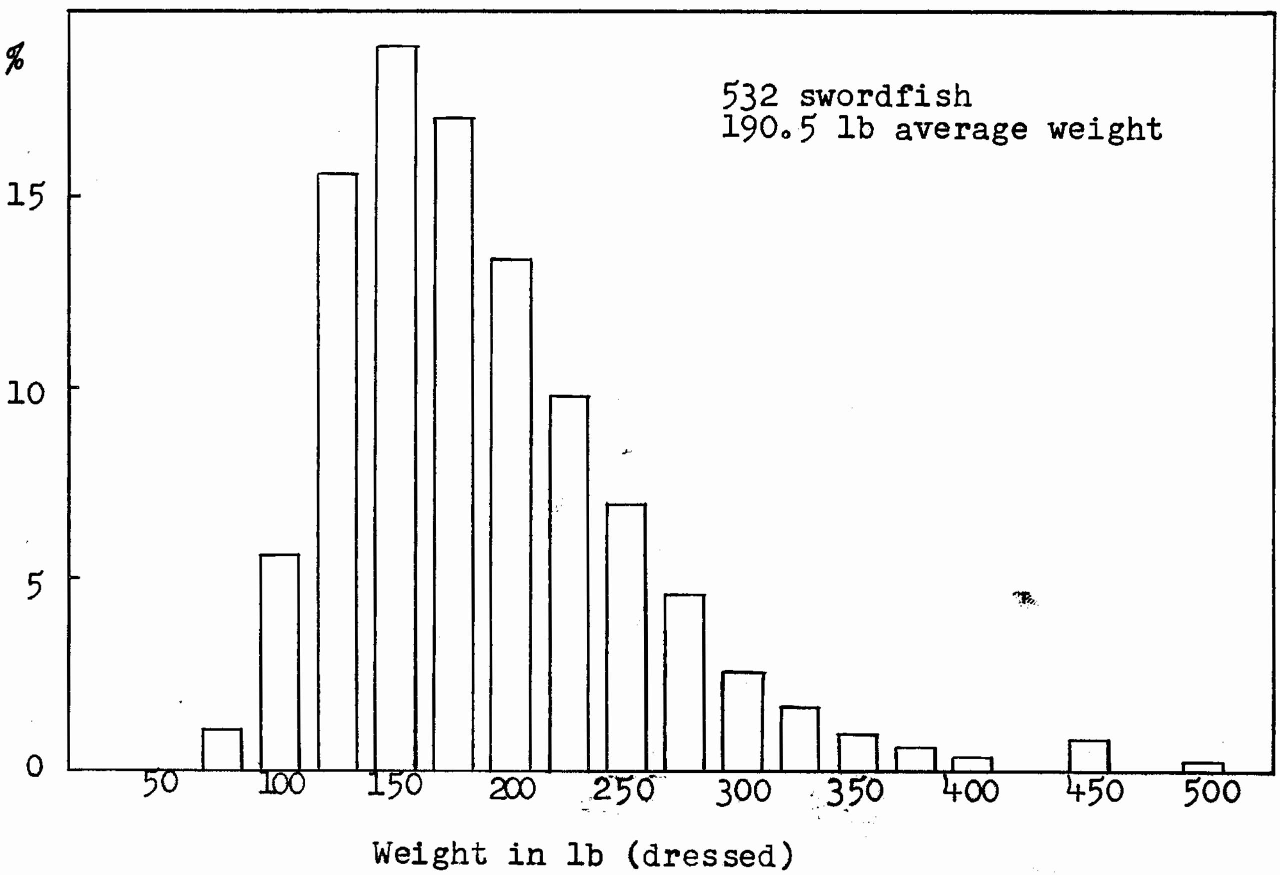


Figure 1. Weight distribution of swordfish, 1962.

modal weight class was 200 (188-212) lb in 1961 and 150 (138-162) lb in 1962. However, the mean weight differed by only about 6 lb. Examination of results by areas showed little variation. For example, in August the average weight of swordfish caught on Banquereau was 198 lb, on Sable Island Bank it was 212 lb, on Browns Bank it was 197 lb and on Georges Bank 192 lb. In 1961 there was a weight difference of 30 lb between swordfish caught on Georges Bank and those caught on Sable Island Bank through the whole fishing season. The 1962 results are in agreement with results obtained in 1960 when there was also no indication of any size difference for the various fishing areas.

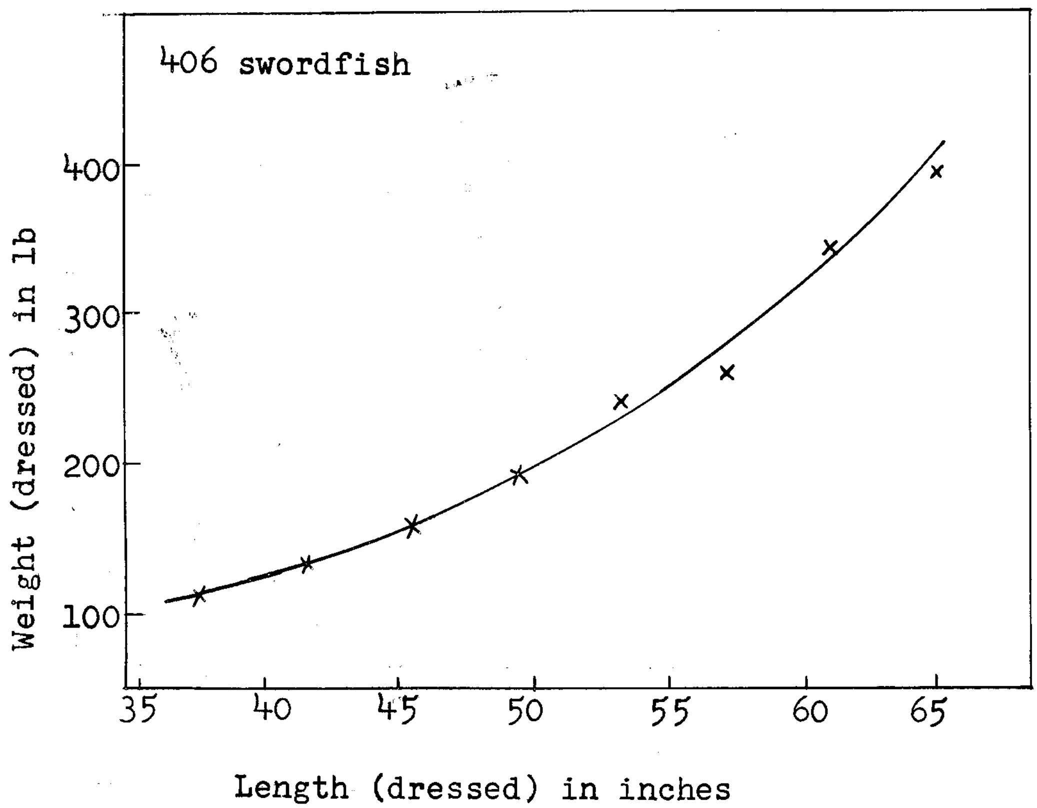


Figure 2. Length-weight relationship of swordfish.

There were 406 swordfish for which both length and weight data were obtained. These data were plotted to show a length-weight relationship and are given in Figure 2.

The five whole specimens were 75, 196, 112, 74 and 114 inches total length and varied in weight from 36 to 262 lb. Proportional dimensions in percent of total length are listed below. All measurements except fin margins were made as straight lines between points.

Body length:		62.1, 64.5, 67.6, 65.8, 66.2
First dorsal fin:	Vertical height:	14.7, 16.2, 16.1, 18.1, 15.1
	Base length:	19.0, 13.6, 12.3, 11.4, 13.2
First anal fin:	Vertical height:	8.2, 10.9, 7.1, 8.4, 6.8
	Base length:	7.3, 6.2, 6.3, 7.7, 6.1
Caudal fin:	Upper margin:	17.5, 20.0, 17.0, 19.3, 18.1
	Caudal spread:	21.0, 26.8, 25.7, 27.5, 26.9
	Peduncle width:	7.5, 9.3, 11.5, 8.9, 7.7
	Peduncle depth:	2.0, 2.7, 3.1, 2.5, 2.0
Pectoral fin:	Length:	12.4, 13.9, 13.2, 15.1, 13.4
Eye:	Horizontal diameter:	3.7, 2.9, 3.0, 3.2, 3.5
Sword:	Length:	30.6, 29.5, 30.7, 28.7, 28.0
	Base width:	3.5, 3.9, 4.0, 3.7, 3.9

Three of the above specimens were weighed in both the whole and dressed condition. The whole weight was 28% greater than the dressed weight.

S. N. Tibbo

No. D-7

MACKEREL INVESTIGATIONS 1962

Landings of mackerel on the Canadian Atlantic coast dropped from about 52 million lb in the 1930's to about 16 million lb now. The causes of this decline are unknown although many theories have been advanced including scarcity of fish, changes in distribution of fish, competition from other fisheries and lack of markets.

In 1962, a preliminary attempt was made to discover whether there is a biological explanation for the decrease in catch. Samples of mackerel were obtained from commercial fisheries in southwest Nova Scotia and examined for size, age, growth and year-class composition. These data have not been fully examined as yet but the results available at present are of interest. The accompanying table gives the size range and mean sizes of samples from May 5 to October 16 and show definite variations related to time.

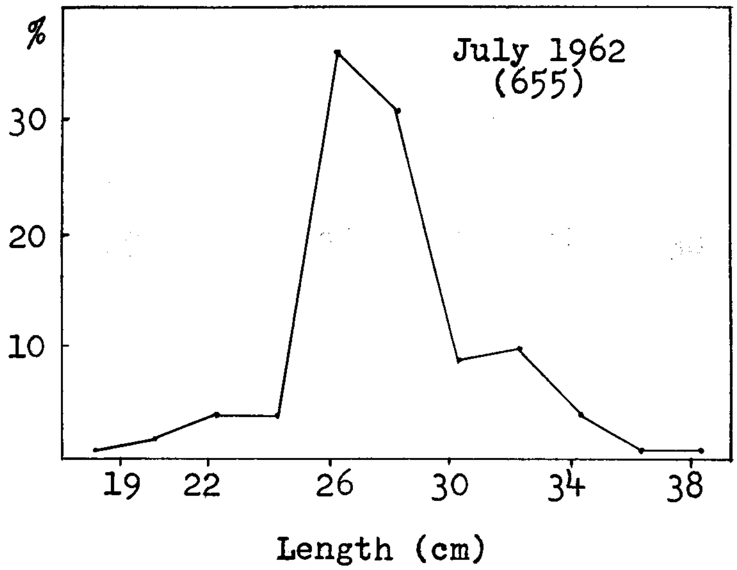
In general, the size range and the mean size, tends to decrease as the season advances. This almost certainly means that the schools of mackerel which appear early in the season do not remain in the area for long and are gradually replaced by other schools of smaller fish. Although there are no data from other years and other areas, this change in size composition as the season advances supports the belief that mackerel from the Gulf of Maine migrate northwards during the summer months with the largest and oldest fish "leading the way".

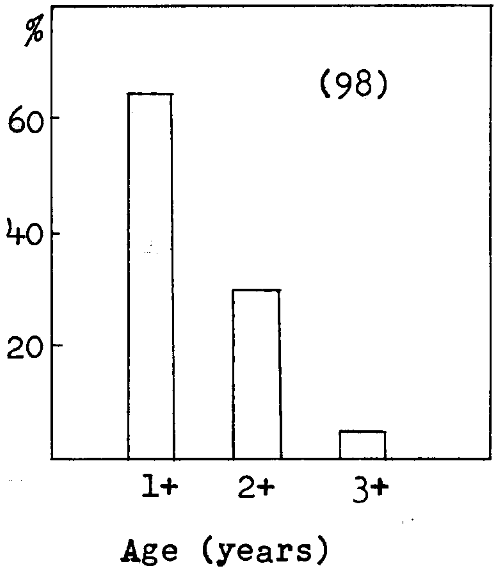
Mackerel

Date	Locality	Gear	No. of fish	Length (cm) Range	Mean
May 5	Abbots Hbr.	Weir	130	10-47	39.03
May 28	Abbots Hbr.	Weir	43	34-46	40.60
June 1	Yarmouth	Trap	102	32-46	38.91
June 1	Yarmouth	Trap	100	33-46	38.48
June 1	Yarmouth	Trap	19	33-43	39.51
June 4	Yarmouth	Trap	200	26-49	36.52
June 4	Port Labout	Purse seine	24	32-36	33.90
June 12	Yarmouth	Trap	178	30-43	34.27
June 21	Yarmouth	Trap	50	25-40	33.02
June 22	Yarmouth	Trap	50	24-38	33.17
June 28	Abbots Hbr.	Weir	65	24-39	31.97
July 4	Yarmouth	Trap	99	24-39	29.55
July 6	Tusket River	Weir	58	26-36	30.39
July 6	Abbots Hbr.	Weir	40	26-34	28.69
July 10	Yarmouth	Trap	100	29-36	32.78
July 11	Yarmouth	Trap	200	29-35	32.62
July 13	Yarmouth	Trap	100	26-35	29.53
July 17	Yarmouth	Trap	100	28-35	31.49
July 18	Yarmouth	Trap	60	18-31	22.92
July 19	Yarmouth	Trap	100	25-35	27.74
July 20	Yarmouth	Trap	100	26-34	27.89
July 25	John's Is.	....	98	25-34	27.47
July 30	Yarmouth	Trap	215	26-39	28.62
Oct. 16	Little River	Weir	100	11-13	11.34

Age analyses were made for only a few samples and showed that during July three year-classes were represented with 1+ year-old fish presumably of the 1961 year-class making up most of the catch (see accompanying figure).

The age readings also show that the rate of growth is rapid, at least, for the first 3 years of life. The sizes at the various ages are in agreement with rates of growth reported by Bigelow and Schroeder (1953).





S. N. Tibbo
(from T. R. Graham's notes)

No. D-8

HERRING TAGGING 1962

In 1962, 3 types of tags were used on herring in four localities in the Canadian Maritimes to tag a total of 25,466 herring. Two styles of tags were attached through the back just ahead of the dorsal fin and the third was attached to the operculum or cheek. Except for the nylon-covered elastic threads used to attach one style, the tag material was scarlet plastic.

<u>Passamaquoddy area</u>: During the period July 9-18, 1962, tagging was carried out at 3 locations at the entrance to Passamaquoddy Bay--off Head Harbour, at Paul's Cove and at Deadman's Ledge. There were 4,399, 2,609 and 1,200 "sardine" herring tagged at these locations. The fish were all caught in weirs. Of the 8,208 total, 4,508 were cheek tags and 3,700 were nylon-covered elastic thread-type tags, some of each being used at the first two places but only thread-type at the last.

Of the thread-type tags 1% were returned in the first 6 months following tagging while 1.1% of the cheek tags were returned. Most of the 81 recoveries were made within Passamaquoddy Bay or off Charlotte County east. One came from the coast of Maine and 2 from the St. Mary Bay area of Nova Scotia.

Digby County, N. S.: On June 19th, 20th and 21st, 1962, a total of 3,491 "sardine" herring were tagged off Digby County, 1,700 at Sandy Cove, St. Mary Bay (200 thread and 1,500 cheek-type tags), and 1,791 off Point Prim (1,100 thread and 691 cheek-type tags). Thus, a total of 1,300 thread and 2,191 cheek tags were put on. These fish were all caught in weirs.

In the 7 months following tagging 0.7% of the string tags and 0.7% of the cheek tags were recovered. Fish tagged at these two Nova Scotia points moved but little on the Nova Scotia side of the Bay of Fundy although one was found at Baxter's Harbour 75 miles farther into the Bay of Fundy. However, 8 of the 25 recaptures were reported to have been caught on the New Brunswick side of the Bay of Fundy and at least 4 of these were authentic. There was no chance of their being brought across in a carrier and the point of origin lost among New Brunswick caught fish in the plants.

Magdalen Islands: From May 3rd to 11th, 1962, a total of 5,101 pre-spawning herring were tagged off Grindstone. All but about 300 that were taken (with an otter trawl) were caught in trap nets. Of the total, 2,012 were thread-type tags, 200 spaghetti type and 2,889 cheek tags.

In the first 8 months following tagging 0.7% of the thread, 2% of the spaghetti and 0.6% of the cheek tags were recovered. All of the recaptures were made at the Magdalens, mostly from the Pleasant Bay side of Amherst Island, although a few were recaught at Grand Entry and 1 at Etang du Nord.

Caraquet: At this location in the Chaleur Bay region of the Gulf of St. Lawrence, 8,666 spawning herring were tagged (see accompanying figure) from May 11-21, 1962; 2,966 with thread-type tags, 3,900 with cheek tags and 1,800 with spaghetti tags. These were all trap-caught fish.

During the 8 months following tagging, 31 tags were recovered, from 0.3% to 0.4% of each type. All but 3 of the recaptures were made in the tagging area. These 3 were taken southward along the shore of the western Gulf of St. Lawrence from Point Escuminac to Shediac.

Summary: Of the herring tagged, 172 or 0.7% were recovered during the summer and autumn of tagging. The 3 types of tags all yielded from 0.6% to 0.7% returns. Little movement away from the tagging areas occurred in the Passamaquoddy, Caraquet and Magdalen taggings. There were indications

of some movement to the New Brunswick side of the Bay of Fundy from Digby County, Nova Scotia.

R. A. McKenzie

No. D-9

EXPERIMENTS IN MARKING LARGE PELAGIC FISH

Both Japan and Norway have been prosecuting long-line fisheries for large pelagic fish in the Northwest Atlantic for a number of years. The Japanese catch of tuna-like fishes in this area totalled 160 million lb in 1960 together with a smaller amount of swordfish. The Norwegian porbeagle fishery totalled 3.3 million lb in 1960, much of this being taken in the Northwest Atlantic. Canadian Atlantic fishermen, located much closer to these fisheries than either of the foregoing countries, should thus give consideration to entering this field, for catches are sold on International markets which are expanding--the world catch of 4 of these species (Yellowfin, Bluefin, Albacore and Bigeye) having risen from about 260 thousand metric tons in 1953 to 560 thousand in 1960.

In the development of such fisheries information on abundance, seasonal and depth distribution, and temperature preferences could play important roles. To this end offshore fishing, including some longlining, has been carried on to the extent of 3-4 cruises each year during the last 2 years. Marking of some of the large fish caught has been experimental so far in order to develop the best technique for use on the commercially important fishes as swordfish, tuna and mackerel sharks. Most of the fish marked have been blue sharks as they were most numerous in the catches--a total of 72 blues, 2 porbeagles and 1 shovelnose having been marked. Aside from developing marking techniques, information on the migrations of blue sharks will be useful since the skins, livers and fins of many sharks are marketable.

Many of the tags used on large fishes are of the dart or fish-hook type, that is, they are held in place by a barb in the flesh while the message is carried in a tube or on a plastic dangler suspended from it. On large fish these are relatively small and may be missed or lost when the fish is handled. Loose tags have been found on Norwegian wharves recently when tuna catches were being landed. There is, in addition, the fact that many sharks are cut clear of the fishing gear without being boated. It is important therefore that they be marked conspicuously to attract attention readily either while the fish is in the water alongside the vessel or after the fish is boated.

Scars on the back or sides of fish are usually easily seen, so branding was tried out in 1962 along with tagging. In this way there was a double chance of recovering the marked fish and obtaining information about the success of the 2 types of marking. A total of 23 sharks in 1962 were tagged and branded with letters and figures 1½ inches high. So far, one recapture of a fish doubly marked at Corsair Canyon, Georges Bank, has been made, a distance of 150 miles farther southwest. While the lettering on the recaptured fish was visible it was blurred because the surrounding flesh had been scorched and appeared also as a white scar. With proper branding irons excessive scorching should not occur and the white scar lettering should stand out conspicuously on the dark back of any of these large pelagic fish.

It is anticipated, that this branding technique carried out at sea on large fish for the first time during the summer of 1962, will prove to be a valuable addition to the marking of such fish.

R. A. McKenzie

No. D-10

EXPLORATIONS FOR PELAGIC FISH IN 1962

During July, August and September four exploratory fishing cruises were carried out in offshore waters of the Canadian Atlantic in an attempt to discover concentrations of pelagic fish (herring, mackerel, tuna, swordfish and sharks) that might be available for commercial exploitation. The relationship between the distribution of these fish and the conditions of the biological and physical environment were important aspects of the program. The areas of operation were chiefly Browns and Georges Banks although some observations were made near the entrance to the Bay of Fundy.

Cruise HS-39: Cruise HS-39 was carried out from the *Harengus* during the period July 23-31. The program included fishing with gill-nets and longlines, observing temperature and salinity conditions at fishing and other stations, and releasing drift bottles and seabed drifters. Longline gear was used on six occasions with three sets during the day and three overnight. The day sets totalled 290 hooks and the catch was six blue sharks or about two sharks per 100 hooks set. The overnight sets totalled 145 hooks and the catch was eight porbeagles and 9 blue sharks or about 12 sharks per 100 hooks set. The average weights of porbeagles were 121 lb for females and 171 lb for males. Male and female blue sharks had average weights of 153 lb and 33 lb respectively. Four blue sharks were tagged and released during this cruise. Gill-nets were set only once during the cruise and nothing was caught.

Cruise HS-40: Cruise HS-40 was carried out from the *Harengus* during the period August 2-10. The program was essentially the same as for cruise HS-39. Japanese longlines were set on 9 occasions and bottom trawls 5 times. Two longline sets were made in the Lurcher-Seal Island area, 5 sets on Browns Bank and 2 sets on Georges Bank. Altogether 498 hooks were set and catches consisted of 11 blue sharks, 2 porbeagles, 2 mako sharks, 1 swordfish, 1 brown shark, 2 dogfish and 1 monkfish. Five blue sharks and 1 brown shark were tagged and released and the remainder of the catch was taken on board for detailed study and measurement.

Bottom trawls were used four times on the southwest part of Browns Bank. All of the tows contained some herring but the total catch was less than 100 pounds. Haddock predominated the catches and small quantities of silver hake, cod, pollock, argentine, halibut and scallops were also taken.

Cruise ATC-59: Cruise ATC-59 was made from the A. T. Cameron during the period September 8-16. Exploratory fishing operations were carried out with modified No. 41 bottom trawls and Japanese type tuna gear. Modifications of the No. 41 trawl consisted of substituting a small-mesh lengthening piece and codend for the regular codend thus lengthening the trawl as well as providing small mesh (1¾ inch) for retaining herring. Tuna longlines were set near the surface and baited with mackerel, herring and squid. Three lines of drift-bottle and seabed-drifter stations were run, nonstop, off western Nova Scotia and four plankton tows were made. Altogether, 75 stations were occupied during the cruise.

Bottom trawls were used 19 times on Georges Bank, 4 times on Browns Bank and 7 times in the Trinity Ledge region of southwest Nova Scotia. Catches were dominated by herring and haddock. On Georges Bank herring were most abundant (up to 9,000 lb/tow) in the northwestern part of the bank whereas haddock were most abundant (up to 1,500 lb/tow) in the northeastern part of the bank. Cod, common hake, silver hake, plaice, and skates were caught frequently but not in large quantities. Herring were scarce on Browns Bank with haddock and cod making up the bulk of the catch. In the Trinity Ledge region haddock again dominated the catches with cod, pollock and flounder ranking next. Very few herring were taken.

Five sets of the longline gear were made along the northern edge of Georges Bank with a total catch of 62 blue sharks and 3 porbeagles. In one set on Browns Bank, 18 blue sharks were caught. In addition, five sets were made in the Trinity Ledge region and 1 porbeagle and 6 blue sharks were caught. All of the sharks were killed and detailed weights and measurements were made. Average weights of blue sharks varied from 54 lb in the Trinity region to 125 lb on Georges Bank. The 1 porbeagle taken in the Trinity region weighed 122 lb and the average weight of the three taken on Georges was 79 lb.

Cruise ATC-60: Cruise ATC-60 was made from the A. T. Cameron during the period September 18-28. The cruise program was essentially the same as for cruise ATC-59 although a considerable effort was expended on improving and testing tagging techniques as well as testing branding for the first time. Temperature and salinity observations were made at all fishing stations and in other areas and drift bottles were released regularly.

Bottom trawls were used on 18 occasions. There were 13 sets on Georges Bank and 5 on Browns Bank. Haddock predominated in the Browns Bank catches (max. 1,900 lb/tow). No herring were taken on Browns Bank. On Georges Bank haddock made up about 25% of all fish caught with a maximum catch of 2,300 lb/tow. Herring made up about 20% of the total catch with a maximum catch of 600 lb/tow. Other species caught included common hake, silver hake, cod, halibut and flounders.

Longline gear was set six times on Browns Bank and ten times on Georges Bank. The sets varied in length from 2 to 6 hours, 3 night and 3 day sets on Browns Bank and 8 night and 2 day sets on Georges Bank. Nine blue sharks, 2 porbeagles and 1 swordfish were caught on Browns Bank and 76 blue sharks, 1 porbeagle and 2 swordfish were taken on Georges Bank. Comparable sets near the surface and at 25 fathoms yielded 8 blue sharks and 1 swordfish near the surface and 3 blue sharks and 2 porbeagles at 25 fathoms. No other species of fish were taken with this gear. Hand-lines were used on 5 occasions while the vessel drifted with longlines. Handline catches consisted of 4 dusky sharks, 10 blue sharks and 1 porbeagle.

S. N. Tibbo
R. A. McKenzie

No. D-11

STUDIES OF THE PRODUCTION, DISTRIBUTION AND GROWTH OF HERRING LARVAE

Studies of the production, distribution and growth of herring larvae in the Gulf of St. Lawrence and in the Bay of Fundy-Gulf of Maine areas were continued in 1962. Plankton tows taken primarily for lobster larval studies in the west entrance to Northumberland Strait were examined for numbers of herring larvae. Two offshore cruises in the Gulf of Maine--one from the *Harengus* in August and the other from the *A. T. Cameron* in September included plankton tows as part of the overall program. Prince stations 5 and 6, at the entrance to and inside Passamaquoddy Bay respectively were occupied once each month throughout the year to monitor hydrographic conditions and plankton abundance. In St. Mary Bay and across the entrance to the Bay of Fundy eight cruises designed especially for studies of herring larvae were carried out on a monthly basis from February to May and from September to December.

Gulf of St. Lawrence: The accompanying table gives the average catch of herring larvae per tow and the

Average catch of herring larvae in Northumberland Strait 1951-62. (Number of tows in brackets.)

Year	Average catch per tow June 16-July 15	July 16-September 30
1951	74.6 (125)	0.0 (213)
1952	1,897.8 (42)	0.2 (64)
1953	855.9 (35)	0.0 (68)
1954	127.4 (36)	0.2 (82)
1955	407.8 (46)	0.0 (50)
1956	31.6 (54)	0.0 (87)
1957	32.5 (73)	1.1 (77)
1958	9.1 (186)	0.0 (294)
1959	1.5 (154)	0.1 (311)
1960	11.6 (182)	0.4 (298)
1961	0.2 (175)	19.3 (293)
1962	2,166.9 (67)	214.4 (189)

number of tows examined during the last 12 years. The separation of tows before and after July 15 was made on the assumption that larvae caught before July 15 were the result of spring spawnings whereas those caught after July 15 were the result of summer spawnings. Most of the larvae taken were small (<20 mm) indicating a fairly recent hatch.

The numbers of larvae taken in 1962 were far greater than any previously recorded for this area. During the period June 16-July 15, 145,180 larvae were taken in 67 tows. Not since 1952 when 79,709 larvae were taken in 42 tows has the relative abundance of larvae approached this level. For the period July 16 to September 30, the 1962 catches (40,524 larvae in 189 tows) were more than 11 times greater than at any time during the period of observation.

Populations of herring in the Gulf of St. Lawrence have probably been at a low level of abundance since 1954 when mass mortalities occurred as the result of a disease epidemic. It is conceivable that this disease not only reduced the numbers of spawning herring but also affected the vitality of eggs and larvae so that relatively few larvae were produced or survived much beyond the hatching stage. The increased number of larvae taken in 1962 may indicate a return to the pre-disease condition of the herring stocks in the Gulf of St. Lawrence and it will be interesting to see whether this results in a strong 1962 year-class which should enter the commercial fishery as 4-year olds in 1966.

Gulf of Maine: No larvae were taken in the Harengus and Cameron cruises in August and September in offshore areas of the Gulf of Maine. This is perhaps not surprising in view of the fact that spawning on Georges Bank was later than usual in 1962. Examination of maturity stages of adults showed that none were in the ripe and running stage before mid September.

Passamaquoddy Bay: The two Prince stations (Prince 5 and 6) which were occupied once each month throughout the year produced only 10 herring larvae in 24 tows. These larvae were all taken at Prince 6 inside Passamaquoddy Bay in May. The size of the larvae was from 5-7 mm indicating a very recent hatch. In more than 25 years of plankton observations this is the first time there has been any evidence of spring-spawning herring in the Passamaquoddy region. A few (total 7) spring-spawned larvae have been taken previously but the size (9-17 mm) was such that they could have drifted to the area from spawning grounds outside.

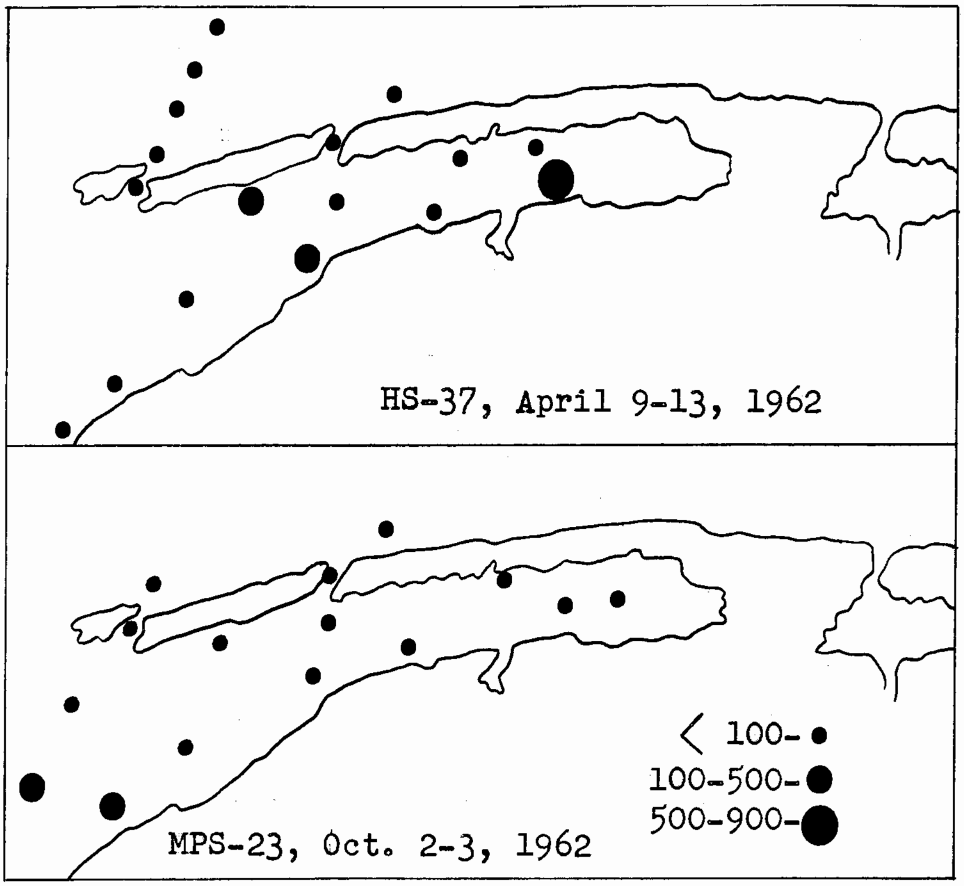
Bay of Fundy-St. Mary Bay: In the Bay of Fundy-St. Mary Bay cruises, 2,239 larvae were taken in the spring and 1,053 in the autumn. The accompanying figure shows the distribution of the catches of larvae for two representative months (April and October).

In April and December herring larvae were abundant at the entrance to the Bay of Fundy but in other months they were found chiefly in St. Mary Bay. A cruise in November covered the whole Bay of Fundy area and showed small numbers of larvae at most stations but no heavy concentrations anywhere. During April and May maximum abundance occurred in and near St. Mary Bay.

During the spring cruises most of the larvae were in the 25-40 mm size range indicating hatching during the autumn of 1961. Newly-hatched larvae (5-7 mm long) appeared in the September and early October cruises. By November the size range had increased to 15-25 mm.

The abundance of larvae as determined by the average catch per tow was considerably smaller in 1962 than in the previous year. The average catch of larvae per tow with an Isaacs-Kidd trawl was 16.1 in 1961 and 9.9 in 1962. With a 1-metre net the average catch was 38.1 in 1961 and 11.9 in 1962.

The production and growth of herring larvae in the Bay of Fundy is the subject of a special study being carried out by Mr. Nareshwar Das at McGill University for Doctor of Philosophy credits. This will include an analysis



of data collected over several seasons including 1962 and a final report is anticipated early in 1964.

Mr. C. A. Dickson carried out the examination of plankton tows and the sorting, counting and measuring of herring larvae.

S. N. Tibbo

No. D-12

THE EFFECTS OF DISEASE ON HERRING STOCKS

Heavy and widespread mortalities of herring occurred in the Gulf of St. Lawrence starting in the late spring and early summer of 1954. Dead herring were seen floating at the surface and washed up on the beaches throughout most of the inshore areas of the southwestern Gulf from Gaspé to Cape Breton and along the west coast of Newfoundland.

The mortalities started about mid May near the end of the fishery for spring-spawning herring. They reached a peak in June, continued at about the same level throughout July and apparently ceased in August before the fishery for autumn-spawning herring started. Similar mortalities occurred in 1955 throughout the same areas but continued into August and September involving both spring- and autumn-spawning stocks. In 1956 fewer herring died than in either of the two previous years and only the Chaleur Bay and Magdalen Islands areas were involved. The disease was still present in 1957 but no mass mortalities were reported that year or in subsequent years.

Investigations of these mortalities showed that the dead and dying fish were infected with fungus Ichthyosporidium hoferi, a pathogen which causes a systemic infection focused in the heart and lateral line musculature of herring and which, in an acute phase, results in the death of the fish.

The effects of the disease were undoubtedly severe. Conservative estimates place the destruction of herring in the Gulf of St. Lawrence at not less than 50% of the total number of mature fish in the area at that time. Landing statistics give some support to this conclusion as commercial catches of herring dropped from 112 million lb in 1954 to 77 million lb in 1957 with no change in fishing effort.

Biological studies of herring were carried on in the years following the disease epidemic and results compared with similar data collected earlier. These studies showed that major changes had occurred in the intervening years and were probably caused by the disease or resulted from the effects of it. These changes included a decrease in mean age, an increase in growth rate, a decrease in the number of year-classes represented in commercial landings and an increase in the relative abundance of autumn-hatched fish. In addition there were changes in spawning habits and seasons and in distribution and migratory patterns. A paper, coauthored by the writer and T. R. Graham describing the changes that occurred in the herring stocks of the Chaleur Bay area of the Gulf of St. Lawrence has been accepted for publication in the Journal of the Fisheries Research Board of Canada.

Recently there has been some evidence that the herring stocks in the Gulf of St. Lawrence are recovering from the effects of the disease. Average catches in Chaleur Bay for 1960 and 1961 were about 20% higher than during the 1955-59 period. At Magdalen Islands, where the catch declined from 49.6 million lb in the mid 1950's to 11.1 million lb in 1960, it increased to 13.8 million lb in 1961 and to 34.0 million lb in 1962.

Additional evidence of recovery is contained in the results of a study of the proportions of spring- and autumn-hatched herring in the commercial catches. Before the epidemic, spring-hatched herring outnumbered autumn-hatched herring by about 5:1. In 1960 the proportions were roughly equal but in 1961 spring-hatched herring were more than twice as numerous as autumn-hatched herring.

S. N. Tibbo

No. D-13

HERRING SPAWNING SURVEY

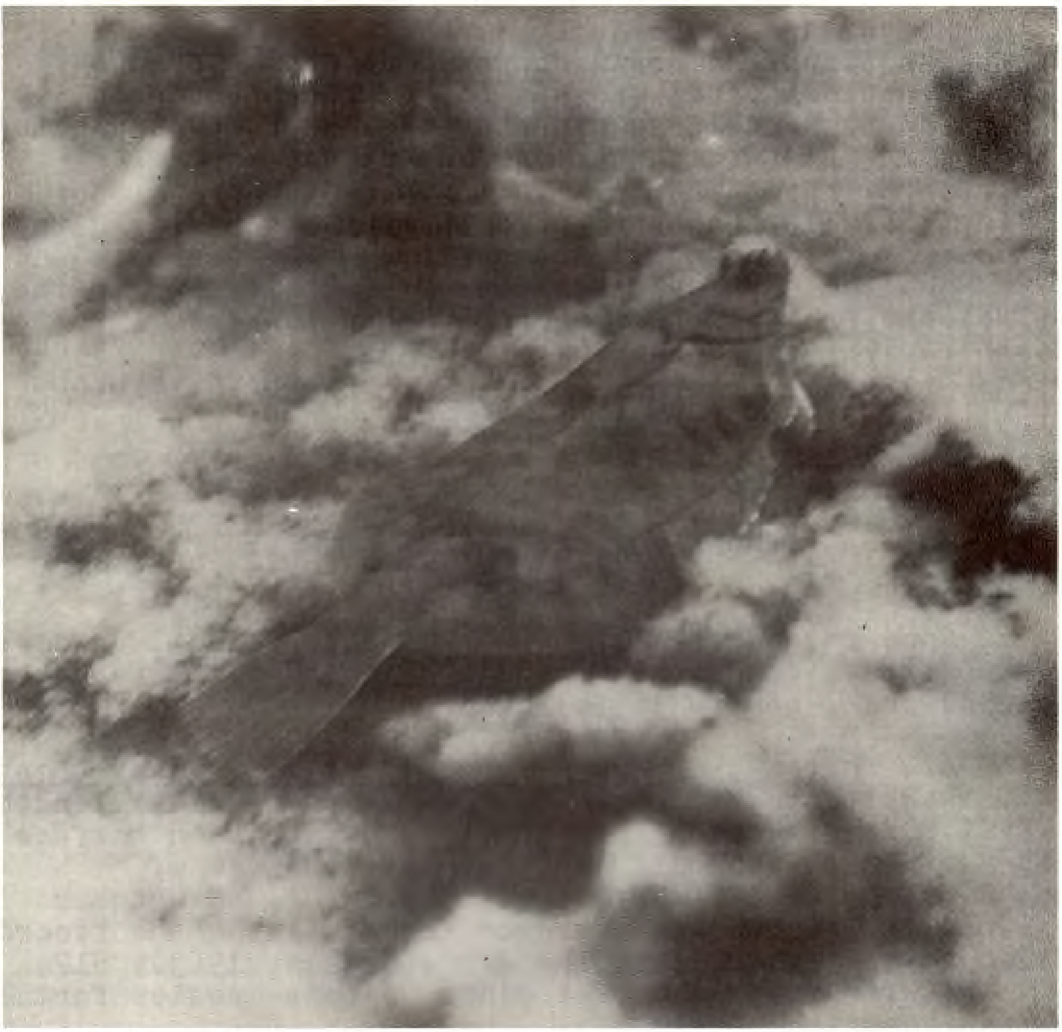
The locations of herring spawning areas in the northwest Atlantic are poorly defined and few attempts have been made to determine the density of eggs on spawning beds or the production of larvae from the various spawnings. As a contribution towards a better understanding of this aspect of the life history of herring a survey of a herring spawning bed was carried out in May 1962, near Blanchard Point, Chaleur Bay, N. B. The principal technique used was free diving (Scuba) although a Petersen grab was used both at the beginning and near the end of the survey.

The outside (seaward) edge of the spawning bed at Blanchard Point was mapped by divers who swam along this edge and either released market buoys or surfaced and indicated where they should be released. The shape and dimensions of the bed were plotted later by taking compass bearings between each marker buoy and establishing their distance apart with a range finder.

Sampling was accomplished by establishing a series of transects across the long axis of the spawning bed and using a form of "cookie cutter" made from 6-inch (15 cm) stovepipe, to standardize samples. Thus each sample was from approximately 28.5 square inches (183.9 sq cm) of sea bed.

The spawning area surveyed by divers measured approximately 880 yards X 260 yards (805 m X 238 m) and that sampled by the Petersen grab 1,100 yards X 200 yards (1,000 m X 180 m) for a total area of 448,800 square yards (375,200 sq m).

Herring eggs were attached to seaweeds and varied in density from 1.18 million to 17.54 million per square yard (1.5 million to 21.9 million per sq m). The density of eggs was directly related to the density of vegetation or the presence of fishing gear. It was quite noticeable



that there were fewer eggs where the alga cover was sparse and there were no eggs at all on bare gravel, sand or rocks. In the deeper areas of the spawning bed the vegetation consisted mainly of species of Phyllophora and Laminaria with occasional patches of Furcellaria. In the shallower areas it was mainly Chondrus, Fucus and Ascophyllum with small areas of Zostera.

Very few dead or unfertilized eggs were observed but there were large numbers of predators (chiefly winter flounders, see accompanying figure). Stomachs of the flounders contained from 4,980 to 16,582 herring eggs each.

The total number of eggs on the spawning bed was estimated to be 35.46 X 10^{11} and the number of spawners 185 X 10^6 fish. Using this estimate of total spawning stock size and the commercial catch in the immediate vicinity the fishing mortality rate was calculated to be 4%.

Hatching of herring eggs started about May 24 about 3 weeks after the beginning of spawning. Concentrations of newly-hatched larvae (5-7 mm long) could be observed visually and large numbers were taken with plankton nets.

A detailed description of techniques and results of this survey coauthored by the writer, D. J. Scarratt and P. W. G. McMullon has been submitted for publication in the Journal of the Fisheries Research Board of Canada.

S. N. Tibbo

No. D-14

UNUSUAL SPECIES OF LARGE PELAGIC FISH IN THE CANADIAN ATLANTIC

Some records of large specimens of unusual species of pelagic fishes caught in Canadian Atlantic offshore waters during 1961 and 1962 are as follows:

A. White-tip shark, Pterolamiops longimanus (Poey) 1861: This specimen, a male about 87 inches in total length, weighing 140 lb was taken from the A. T. Cameron on surface longline with mackerel bait near the eastern edge of Georges Bank, Lat. 41°01'N., Long. 65°54.5'W., on October 10th, 1961. This fish was measured in detail and the record published as a note (J. Fish. Res. Bd. Canada, 19(3): 517, 1962). This record extends the range of this species farther north than reported previously.

B. Dolphins, Coryphaena hippurus, Linnaeus 1758: Eight specimens of this species, 20 to 33 inches total length, were caught on handlines at the same time and place as the foregoing white-tip shark and recorded in the same manner. Both these species (frequently found together) are tropical and subtropical in distribution and their capture probably indicated an incursion of Gulf Stream water on to the eastern slope of Georges Bank.

C. Opah, Lampris regius (Bonnaterre) 1788: On September 10th, 1962, an Opah was captured by the longliner Sen Sen, Captain Wesley Ross, approximately 110 miles south (true) of Halifax, Nova Scotia, (Lat. 42°46'N., Long. 63°15' W.). The fork length of this specimen was 44 inches and the weight 108 lb.

This brings to 9 the recorded recaptures of this species in the Northwest Atlantic but does not increase our knowledge of its horizontal or vertical distribution nor extend its range in any way. A report has been submitted for publication.

D. Mako sharks, *Isurus oxyrinchus*, Rafinesque 1810: During the summer of 1962, 2 mako sharks were caught on the Peak of Browns Bank (approximately Lat. 42°10'N., Long. 65° 40'W.) from the M.V. *Harengus*. These are apparently the first authentic records of occurrence of mako sharks in Canadian Atlantic waters.

The 2 specimens were caught on August 5th and 8th using a surface longline with No. 9 Mustad tuna hooks baited with mackerel. One was a male 74 inches total length weighing 176 lb, and the other a female 84 inches total length weighing 165 lb.

The lower jaws of both specimens were preserved and sent to the Royal Ontario Museum and a manuscript including detailed measurements of these specimens has been submitted for publication.

E. Dusky sharks, *Carcharhinus obscurus*, Lesueur 1818: On September 23, 1962, 4 specimens of this species were caught at the surface with handlines and squid bait from the *A.T. Cameron* in the Corsair Canyon region of southeast Georges Bank, approximately Lat. 41°22'N., Long. 66°10'W. These fish were all males, 122, 130, 124 and 125 inches long (total length) and 390, 440, 460 and 420 lb weight respectively.

The report on these captures, which extends the known northern limit of their range in the Northwest Atlantic, has been submitted for publication.

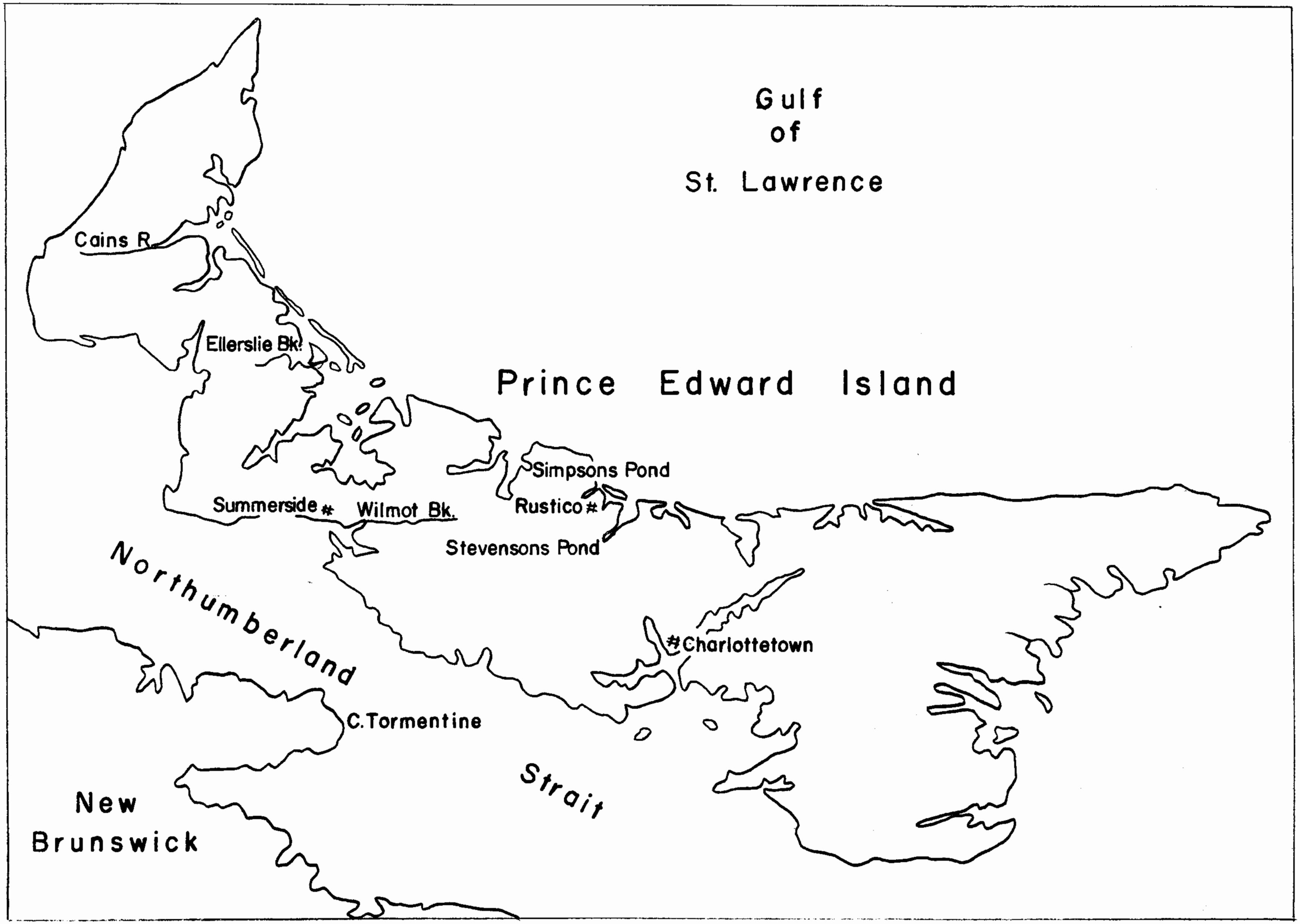
F. Brown shark, *Carcharhinus milberti* (Müller and Heule) 1841: This shark was caught August 9, 1962, by the *Harengus* at the surface on longline gear in the Corsair Canyon region of Georges Bank, Lat. 41°23'N., Long. 66° 16'W. The estimated length of this male specimen was 9½ feet. It was marked with FTlA tag No. 122 and released.

This record of its occurrence on southeast Georges appears to extend the limit of its range somewhat to the northeast for Cape Cod is the usual limit of its northerly dispersal though it is common off Rhode Island and abundant off New Jersey.

G. Blue marlin, *Makaira ampla* (Poey) 1860: One specimen about 87 inches in total length and weighing 126 lb (gutted weight) was caught on Browns Bank on August 25, 1962, by the longliner *I Wonder*, Captain Arthur Bernard. This apparently is the third record of blue marlin occurence as far north as Browns Bank.

R. A. McKenzie
S. N. Tibbo

TROUT SUMMARIES


Gulf
of
St. Lawrence
Cains R.
Ellerslie Bk.
Prince Edward Island
Simpsons Pond
Summerside #
Wilmot Bk.
Rustico #
Stevensons Pond
Northumberland
#Charlottetown
C.Tormentine
Strait
New
Brunswick

No. E-1

LIMNOLOGICAL (TROUT) INVESTIGATIONS
GENERAL STATEMENT

The brook trout fishery of the Atlantic provinces, prosecuted for sport, remains largely a hunter operation. Most of the trout taken by anglers are produced under natural conditions without man's assistance, and in some situations, in spite of man's adverse actions. Dams, agricultural practices lumbering operations, pest control, and so on, have encroached upon trout habitats with varying permanency. As a function of increasing human population and economic advancement, this encroachment will continue in greater degree. Fortunately as yet, much unaffected, or not permanently affected, trout habitat remains in the Atlantic provinces. To meet demands for more trout to angle, a positive approach is to manipulate environments and fish to overcome natural and man-made deficiencies restrictive of production. Trout investigations have given sufficiently positive results with respect to stocking, predator control, fertilization and pond formation to indicate feasible and effective application in many Maritime freshwaters.

Current investigations deal with pond formation for improved production and yield of brook and rainbow trout, physical stream improvement for better trout production, planting of brook trout in estuarial waters, and relative value of brook and rainbow trout in Maritime freshwaters.

Of long-standing need has been an economic assessment of the worth of Maritime trout and salmon as sport species to serve as a guide in direction and extent of research and management warranted in future development. The Economics Service, Department of Fisheries, Ottawa, is now proceeding with a sport fishery evaluation for the Maritime provinces, with particular reference to brook trout and the Atlantic salmon.

M. W. Smith

No. E-2

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

Brook trout move between fresh and salt water in the Prince Edward Island area. Ponds formed on Prince Edward Island streams provide good trout angling, but curtail the movements of trout between fresh and salt water. A pond was formed on Ellerslie Brook, P.E.I., to evaluate the effects of pond formation on movements, growth and yield to anglers in a stream system. Movements of brook trout within and between salt water and yields of trout to anglers have been assessed in this brook since 1947 by maintenance of creel censuses annually and by operation of two 2-way fish traps. A 5-acre pond was formed on the lower reaches of Ellerslie Brook in the early autumn of 1952.

Following pond formation, the number of trout that moved from fresh water into the estuary declined sharply. The average annual number for five years before pond formation was 1,775, and for eight years (to 1962) after pond formation, 311. In 1962 only five trout were recorded moving downstream through the trap from fresh water into the estuary.

With pond formation in 1952, brook trout moving upstream from the estuary and captured in the trap below the pond were transferred to the pond until December, 1955. With relatively few trout leaving the pond, either upstream or downstream, there was appreciable accumulation of the trout stock in the Ellerslie System in the pond, and this is reflected in higher than average effort and catch (Table I). With time catches have fallen to pre-pond levels and below, and probably indicate effective cropping of the annual recruitment from the stream of trout of catchable size. The low catch in 1961 (734) is associated with severe drought conditions in 1960. Of the 1962 catch from pond and pool, i.e., 1,373 trout, 548 were trout planted in the estuary, thus not produced in the Ellerslie System (Summary No. E-4). The high catch of 712 trout from the stream above the pond would appear to reflect improved holding conditions in the stream that resulted from habitat alteration (Summary No. E-3).

Management of Ellerslie System to date has involved pond formation, improvement of stream habitat (Summary No. E-3) and stocking of the estuary (Summary No. E-4). The total catch of 2,085 trout in 1962, above the average annual catch (1,478) prior to pond formation, suggests that these operations, particularly stream improvement and estuarial stocking, were having a favourable effect upon yield to anglers. The pond has served as a holding area for better availability of trout to anglers, but its potential productive capacity for trout does not appear to have been fully utilized. An additional planned operation is the direct stocking of the pond with brook trout of the year.

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

	Total catch	Total rod-hours	Catch per rod-hour	Catch from pond and pool	Catch from stream
1953	1,981	1,325	1.5	1,843	138
1954	2,949	2,452	1.2	2,343	606
1955	1,718	1,676	1.0	1,126	592
1956	2,047	1,605	1.2	1,554	493
1957	1,677	1,259	1.3	1,348	329
1958	1,229	1,011	1.2	553	676
1959	1,222	925	1.3	958	264
1960	1,448	987	1.5	863	585
1961	734	535	1.4	495	239
1962	2,085	1,020	2.0	1,373 (548)*	712

* From planting in estuary

M. W. Smith

No. E-3

STREAM IMPROVEMENT, ELLERSLIE BROOK

Background

It has been found at Ellerslie, P.E.I., that the productive capacity of a pond for trout was only partially utilized in the face of angling pressure. Recruits to the pond population came from Ellerslie Brook and its tributary, Hayes Brook. Methods were sought to increase the production of trout in the feeder streams and ultimately to increase the number of recruits entering the pond.

Availability of suitable hiding places was found to be a dominant factor in limiting the carrying capacity of a 450-yard study section of Hayes Brook for older trout (age I and older). In the summer of 1959, 13 dams, 12 deflectors and several covers were constructed in the study section to create suitable hiding places for trout. After one year the numbers of older trout were about double the average of the numbers over the previous 13 years.

On the basis of our findings in the tributary Hayes Brook, a more extensive stream improvement programme was begun, in 1961, on Ellerslie Brook proper.

It has been established that the population of older trout in Ellerslie Brook is maintained by the downstream movements of trout from the smaller nursery areas. Consequently stream improvement was applied to the lower 2,000 yards of the brook and the small upper reaches were left undisturbed. Ten of the twelve 50-yard sample sections in the lower part of the stream, in which the standing crops are determined annually, were altered by stream improvement.

Methods

The devices used to alter the environment of Ellerslie Brook consisted for the most part of dams, deflectors and covers (alders tied down over the stream and spruce trees anchored at the edge of the stream). In all about 30 devices were constructed in Ellerslie Brook, 20 of these were dams.

A few of the dams were damaged by freshets during the winter months. These were repaired in the spring of 1962.

Results

The standing crops of older trout in 1962 in 3 of the 10 altered sample sections were the highest on record. In 3 other altered sample sections the standing crops were above the averages for the previous 9 years. Although the trout-carrying capacities of some of the sample sections were improved, there was an overall decline from the previous year (831 to 718) in the total standing crops of older trout in all of the sample sections. This decline resulted largely from a greater catch by anglers in 1962 and from a lack of fingerlings in the previous year.

The effect of stream improvement on angling

Population studies are begun on Ellerslie Brook in early August; the angling season opens April 15. The catch from the stream (excluding those caught in the pond and estuary) during the period April 15-August 1, 1962, exceeded by about 2 1/2 times the average for the previous 9 years. Apparently, stream improvement acted to make trout more available to anglers.

Recruitment to the stream population

It was apparent during the past summer that there were insufficient yearlings to utilize fully the new habitats created by stream improvement. This was not unexpected since, because of severe drought conditions, fingerling stocks were low in the previous year (1961). The lack of yearlings was most noticeable in the larger pools in the lower part of the improved area. Apparently the new habitats in the upper part of the improved area retained downward-moving fish and few reached the lower part of the stream.

Stocks of fingerlings in Ellerslie Brook, in summer, as in other streams in the region, were low in 1962. Consequently, a high population of older trout in Ellerslie Brook in 1963 can only be possible if there is a high survival of fry to age I or if good numbers of the present age I trout are retained in the stream, or both.

Discussion

Stream improvement on Ellerslie Brook has resulted in a marked improvement in the carrying capacities of some of the study areas for older trout. Trout became more available to anglers and there was a significant increase in catches over other years. Further observations (at least 2 years) are necessary before it can be established that the number of recruits entering the pond can be increased by improving the environments of the feeder streams.

J. W. Saunders

No. E-4

PLANTING BROOK TROUT IN ESTUARIAL WATERS

A pond formed on the lower part of Ellerslie Brook, Prince Edward Island, retained seaward-moving brook trout (Summary No. E-2). To explore a method to compensate for the loss of native Ellerslie trout to the estuary and to increase the trout stocks for angling in the Ellerslie system (stream, pond and estuary) as a whole, hatchery-reared brook trout of the year were planted, in early December, directly into the estuary.

Similar numbers of trout were planted on December 1, 1961, at two locations, (a) immediately below the dam at the head of the estuary, and (b) 300 yards below the dam.

Results are summarized in Table I. Returns to anglers in 1962 were similar from both plantings. The planted trout made up 27 per cent by number and 20 per cent by weight of the overall catch from the Ellerslie system. Growth in the estuary was good. During winter the estuary is ice-covered and salinities range from 0 to 30‰. From 6 plantings in other years in the freshwater part of the Ellerslie system percentage returns to the anglers varied from 1.4 (planted fingerlings) to 19.1 (yearlings).

Plantings in 1962

In December of 1962, 2,000 yearling trout were planted in the Ellerslie Estuary.

The dam on Ellerslie Brook blocks the movements of trout from the estuary. In order to evaluate estuarial stocking in an estuary from which trout are free to move into fresh water, a planting of 2,500 fingerlings was made in the estuary of Cains Brook, Bloomfield, where a counting fence is maintained. Another 2,500 fingerlings were planted in the freshwater part of the Cains system. Evaluation of the 1962 plantings will have to await the 1963 angling season (April 15-September 30).

Table I. Number and size of planted brook trout taken by anglers from Ellerslie Estuary during season following planting.

	Number and average fork length in centimeters			
	Group A[1]	Length	Group B[2]	Length
Planted, Dec. 1, 1961	973	11.9	1,005	11.9
Angled, 1962				
April 15-30	59	12.7	53	12.6
May	98	13.6	97	13.6
June	101	15.0	114	15.3
July	15	15.2	7	16.4
Aug.	5	18.5	3	19.7
Sept.	0	--	1	23.0
Season total	278		275	
% survival to anglers' catches	28.6		27.4	

[1]Planted at head of estuary in pool below dam
[2]Planted in estuary 300 yd below dam

J. W. Saunders

No. E-5

RELATIVE SURVIVAL AND YIELD TO ANGLERS OF PLANTED BROOK AND RAINBOW TROUT IN MARITIME FRESH WATERS

The introduced rainbow trout has become established in a number of Maritime fresh waters. In the Prince Edward Island area at least the species is sea-running, and captures of "steel heads" annually increase. Does the fact that the rainbow trout has established itself in certain Maritime fresh waters, and is spreading, indicate that it is equally, if not more, adaptable than the native brook trout to environmental conditions in our streams and lakes? Can the rainbow trout more effectively utilize the productive capacity of our fresh waters? Both brook and rainbow trout are excellent sport species. Attempted courses of management of these species will in large measure depend upon their relative status with respect to growth and movement, and yields to the anglers.

Simpson's Pond, P.E.I.

Marked hatchery-reared rainbow and brook trout in approximately the same number were planted in 2.3-acre Simpson's Pond in September, 1960 and 1961. Survival and growth were assessed a year later by draining the pond. All fish were removed from the pond before the plantings were made. Fish of the year were planted. Results of the two years' operations are given in Table I. In both years the survival of brook trout was the same, but that of rainbow trout differed about threefold. Growth of rainbow trout was greater in both years. The rainbow trout competed well with equal numbers of planted brook trout. In addition the numbers of brook trout were augmented by recruits from the tributary stream. Reasons for the lower standing crop of trout in the pond in 1962 cannot be documented, but escapement downstream from the pond and unrecorded angling may have been factors, which in turn may or may not have had a differential effect.

Crecy Lake, New Brunswick

Contemporaneous stocking with brook trout, fertilization, and control of fish-eating birds and mammals resulted in much improved angling in 50-acre Crecy Lake. The procedure was replicated, but stocking with rainbow rather than brook trout. Few brook trout were in the lake when rainbow trout were planted. Thus, unlike the situation in Simpson's Pond, P.E.I., there was little competition between the two species. Comparative results with respect to survival and yields to anglers are given in Table II.

Table I. Yield and growth of stocked brook and rainbow trout in Simpson's Pond, P.E.I.

	Year planted	Number planted	Number recovered a year later	% survival	lb/acre	Length (in.) when planted	Length (in.) when recovered
Rainbow	1960	4,000	422	10.5	49.7	3.1	8.4
Brook	1960	4,000	168	4.2	14.1	3.5	7.9
Native brook	--	--	449	--	24.3	--	--
					88.1		
Rainbow	1961	4,200	131	3.1	12.4	3.0	7.9
Brook	1961	4,000	167	4.2	11.9	3.4	7.3
Native brook	--	--	235	--	15.5	--	--
					39.8		

Table II. Yield of planted rainbow and brook trout to anglers' catches from Crecy Lake, New Brunswick.

Rainbow trout

Year of planting	1958	1959		1960		1961
	F	F	Y	F	Y	F
Size (mm)	64	75	197	106	176	92
No. of recaptures						
1959	156	--	--	--	--	--
1960	177	32	1,244	--	--	--
1961	42	51	173	2,852	942	--
1962	1	30	19	538	55	144
Total recaptured	376	113	1,436	3,390	997	144
Number planted	13,350	13,440	1,561	13,420	1,350	13,460
% recovery	2.8	0.8	92.0	26.0	73.9	1.1

Brook trout

Year of planting	1951			1952			1953			1954
	F	Y	Y	F	Y	Y	F	Y	Y	F
Size (mm)	79	173	248	67	208	260	75	197	248	101
No. of recaptures										
1952	1,317	240	550	--	--	--	--	--	--	--
1953	333	4	2	1,746	597	574	--	--	--	--
1954	6	--	--	417	--	5	2,707	377	536	--
1955	--	--	--	--	--	--	127	--	--	5,484
Total recaptured	1,656	244	552	2,163	597	579	2,834	377	536	5,484
Number planted	14,160	675	674	13,440	675	675	13,390	675	675	13,230
% recovery	11.7	36.2	81.9	16.1	88.4	85.8	21.2	55.9	79.4	41.5

F - fish of the year (age 0)

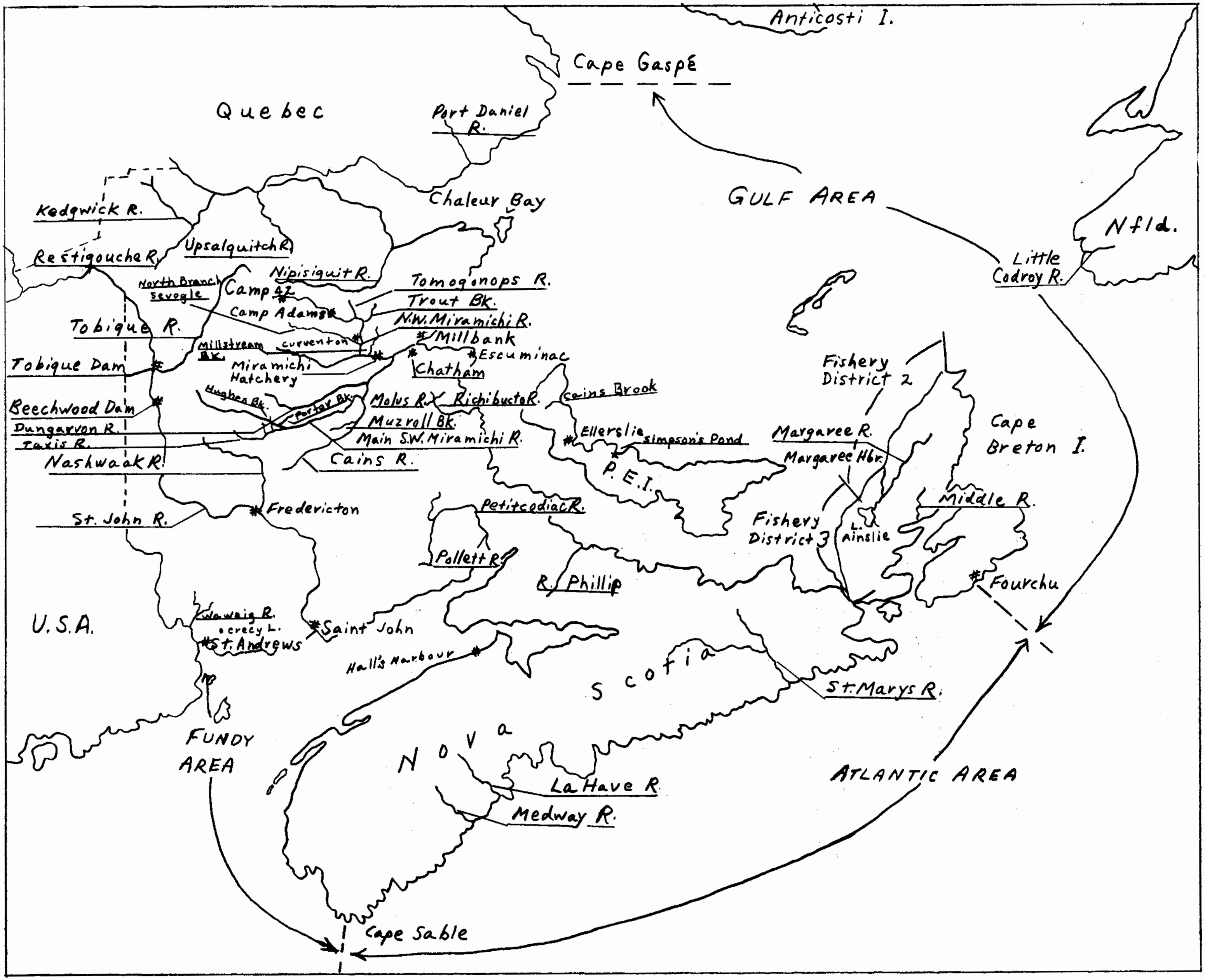
Y - yearlings (age I)

When planted as yearlings of catchable size (that is using the lake largely as an over-winter holding area), survival to anglers' catches of both rainbow and brook trout was quite comparable. When planted as fish of the year (that is using the lake more as a growing area), the survival was more consistently good for brook than rainbow trout. Advantage of one species over the other, however, was not clear-cut.

These investigations will be terminated in 1963.

M. W. Smith

SALMON SUMMARIES



Anticosti I.
Cape Gaspé
Quebec
Port Daniel R.
Chaleur Bay
GULF AREA
Nfld.
Little Codroy R.
Kedgwick R.
Restigouche R.
Upsalquitch R.
Nipisiquit R.
Tomogonops R.
Trout Bk.
North Branch Sevogle
Camp 42
Camp Adams
N.W. Miramichi R.
Millbank
Escuminac
Tobique R.
Tobique Dam
Millstream Bk.
Miramichi Hatchery
Chatham
Beechwood Dam
Hughes Bk.
Porter Bk.
Molus R.
Richibucto R.
Cains Brook
Fishery District 2
Dungarvon R.
Taxis R.
Muzroll Bk.
Main S.W. Miramichi R.
Ellerslie
Simpson's Pond
Margaree R.
Cape Breton I.
Nashwaak R.
Cains R.
P.E.I.
Margaree Hbr.
Middle R.
St. John R.
Fredericton
Petitcodiac R.
Fishery District 3
L. Ainslie
Pollett R.
R. Phillip
Fourchu
U.S.A.
Waweig R.
St. Andrews
Saint John
Hall's Harbour
Nova Scotia
St. Marys R.
FUNDY AREA
ATLANTIC AREA
La Have R.
Medway R.
Cape Sable

No. F-1

GENERAL SUMMARY, ATLANTIC SALMON INVESTIGATIONS

In 1963 the Board's Atlantic salmon program is under review and future investigations are to be planned. To facilitate assessment of the present status of responsibilities of the St. Andrews Station, recent salmon studies involving the Pollett, Miramichi and other rivers are outlined. Accomplishments in various projects are related to the plans for investigation and management of Atlantic salmon developed at a July, 1952 meeting of the Federal-Provincial Co-ordinating Committee on Atlantic Salmon held in Ottawa (Summary No. F-2).

As previously, commercial and angling catch statistics for the 1962 season are compared with earlier records. Commercial landings in the Maritime Region in 1962 totalled 1.7 million lb, 19% higher than in 1961, yet were only 70% of the average of the past 90 years. The total angling catch improved also. There is hope of further increases in salmon abundance and catches over the next few years (Summary No. F-7). Miramichi sampling trap and counting fence operations through the open-water season again provided useful information on time and size of adult runs, and the extent to which they were affected by DDT spraying, mine pollution and other factors (Summary No. F-3).

Returns of salmon tagged as smolts and released in lots ranging from 25 to 5,000 in various parts of the Miramichi since 1958, have been compiled to date. A release of only 750 tagged native smolts at Camp Adams, upper Northwest Miramichi, in 1960 has given best returns so far, totalling 25 adults (3.3%). These fish have returned towards fresh water consistently early in the season, perhaps related to their upriver origin.

Again much effort was given to the effects of aerial insecticide sprayings on salmonids and aquatic insects, the main food of young fish. In 1962 more time was spent by St. Andrews staff on preparation of previous data for publication than on new work. Dr. F.P. Ide, University of Toronto, again assisted in directing two student assistants with (1) completing the follow-up of effects of earlier DDT sprayings on aquatic insects on the Northwest Miramichi, (2) determining effects on aquatic insects of a new insecticide, Phosphamidon, which was sprayed experimentally, in co-operation with the Department of Forestry, on the watershed of a small brook. Phosphamidon had no observable effects on either caged young salmonids or aquatic insects but further tests on a larger scale are desirable. It controls spruce budworm but forest biologists do not yet consider it to be a satisfactory substitute for DDT. Many data on recent angling and commercial salmon catches have been compared with prior young salmon population assessments, and

DDT spray history. A recent decline in Tobique adult salmon stocks is closely associated with DDT spraying of that watershed. It is estimated that if DDT spraying had not reduced Miramichi and Restigouche adult salmon, commercial catches of these stocks in the Gulf Area during the past 4 years would have been from 1 1/2 to 2 times greater than they actually were (Summary No. F-7). All data on young salmon production in Miramichi streams since 1951 have been examined in relation to DDT sprayings starting in 1954. It is concluded that DDT applied at 1/2 lb per acre over watersheds of salmon streams has been followed by over 90 per cent reduction of underyearling salmon, and a smaller yet important reduction in older parr. Usually single application of DDT at 1/4 lb per acre has been followed by reductions of only 50 to 70 per cent; effects of double application of 1/4 lb DDT per acre are about as harmful as single application of 1/2 lb DDT per acre. Effects of spraying may extend in streams for 15 miles below the spray boundary. Young salmon population data for the sprayed Tobique, Nashwaak and Richibucto watersheds conform with the Miramichi data (Summary No. F-6).

Variations in population density of underyearlings, small and large parr in the Northwest Miramichi, 1951-62, have been related to blockage by pulpwood, DDT spraying and mining pollution. Underyearlings have been affected drastically by each factor in the year of occurrence, larger fish less seriously. Recovery tends to be rapid if the catastrophes do not recur at critical intervals (Summary No. F-8).

On August 1, 1962 a new experiment in predator control was started on the Margaree River, aimed at showing whether or not the beneficial effects on young salmon survival of systematic year-round removal of mergansers carries through to adult catches. It is a co-operative project involving the Board, Department of Fisheries, Canadian Wildlife Service, and the Nova Scotia Department of Lands and Mines (Summary No. F-9).

Studies of physiology and behaviour of young salmon included (1) continued experiments on buoyancy regulation, showing that initial filling of the swimbladder of alevins can be delayed by holding the fish in fast currents and that smolts are usually more buoyant than parr; (2) observations from August to December on movements of young salmon within a small coastal stream, showing (a) that parr stay within restricted areas and can return to home territories after being displaced up- or downstream for distances as great as 600 feet; (b) that fry occur mainly in shallow riffles until August-September but later join parr in pools or rough bottomed riffles; (3) comparison of growth rates of salmon parr and smolts under similar conditions in laboratory tanks where salinity was gradually increased to that of seawater, showing faster growth rate for smolts than parr.

Unusual downward movements of adult salmon at the Curventon counting fence were again related to mining pollution entering the Northwest Miramichi 15 miles upstream via the Tomogonops River (See "Pollution Studies" Summary Nos. H-2 - H-6).

C. J. Kerswill

No. F-2

OUTLINE OF ATLANTIC SALMON INVESTIGATIONS TO 1962

The course of recent research and management was shaped by the Federal-Provincial Co-ordinating Committee on Atlantic Salmon, organized in 1949. At that time the Atlantic Salmon Association, founded in 1948 and including many influential anglers, was spearheading an attack on salmon management through a series of published documents. The decline in Canadian catches since 1930, the last peak in commercial production, was emphasized. The 17th document in 1951, by Mr. W.J.M. Menzies of Scotland, included 28 recommendations, mainly urging more restriction on commercial fisheries. The Co-ordinating Committee first reviewed accomplishments of salmon research since the first significant work around 1930, then assessed existing needs and drew up a program of investigations aimed at providing a sound basis for effective management. It was agreed that experiments started in 1941 on the Pollett River, N. B., aimed at learning how to produce maximum smolt runs, should continue. New studies were to start on a large salmon river that supported various kinds of fishing, to give information on topics like the extent of utilization of smolts of known river origin, migrations and homing. The Miramichi River was chosen as the site of the new work and counting fence, smolt marking, merganser control and other operations started in 1950. In July 1952 at a special meeting of the Co-ordinating Committee, progress was reviewed and a comprehensive list of research and management projects was prepared as a guide for the next few years. The projects have been re-assembled in the following list under general topic headings. Those intended mainly for Board attention are designated by "RB", those for the Department's Conservation and Development Service by "CD". Priorities established in 1952 are indicated by Roman numerals. By 1952 most of the other projects to which priorities were not assigned, were either under investigation by RB or under consideration by CD and RB jointly. Also it was agreed that Quebec and Newfoundland now should be included in the new program as soon as possible.

Statistics:

1. Review commercial and angling statistics. (RB)

Natural History:

2. Continue existing studies (life history, feeding habits, growth rates, parasites, etc.), often incidentally to other projects. (RB)

Physiology and Behaviour:

3. Physical and chemical factors for survival and growth at all stages of life cycle. (RB)

4. Specifically the effects of pollutants, including trace elements, on movement, survival, etc. (RB)

5. Reactions of different ages to various stimuli, e.g., at barriers, by laboratory studies. (RB)

Population Studies:

6. Relation of number of spawners to fry-parr-smolt production, for full use of available area. (RB,IV)

7. Population estimates of all freshwater stages (fry, parr, smolts), basic to other projects. (RB)

8. Adequacy of existing spawning escapements, various rivers. (CD,II)

Manipulation (to improve natural conditions; to remedy man-made changes; biological, e.g., predator control):

9. Survey accessibility of all salmon waters; plan obstruction removal. (CD,I)

10. Assess effects of water level fluctuations. (RB,V)

11. Improve spawning beds where desirable.

12. Plant hatchery stock when and where required, at optimum density.

13. Predator control (birds, eels, other) where considered desirable. (RB,II) only re parr assessment, St. Marys R. experiment.

14. Use early-run planting stock to improve early season fishing, if advantage demonstrable (RB,III) in co-operation with CD.

15. Remedial action where investigation shows effects of pollutants on movement, survival, etc. (CD,III)

16. Remedial action if redds found damaged by ice.

Fishery Regulations:

17. Assure adequate spawning escapement by regulating fisheries, as may be found desirable by smolt marking studies, parr assessments, etc.(RB,I) (Extend smolt-adult studies to a Quebec river (by Prov. Govt.) and to a Newfoundland river (by RB).)

18. Protection of kelts and grilse, in light of biological, economic and sociological factors.

19. Protection of early-run adults, if genetic influence found important.

20. Prevent various undesirable environmental changes, e.g., obstructions, water level fluctuations, pollution, etc.

The following outline of progress to date on investigations at (a) the Pollett River, and (b) the Miramichi and other New Brunswick Rivers, indicates the present status of projects assigned to the Board in 1952. The research-management program has been reviewed annually by a scientific advisory group of the Co-ordinating Committee (since 1958, the Salmon and Trout Section, Atlantic Fisheries Committee) resulting in some changes in emphasis or in details of projects after consideration by the Board.

(a) Pollett River, 1942-1962 (P.F.E.)

The Pollett River was originally selected for studies on the production of Atlantic salmon smolts because, with knowledge then available, it appeared to offer a variety of suitable salmon habitats which were barred from use by salmon through dams and falls. Lack of native salmon implied that comparative lack of unfavourable public concern over procedures incidental to investigation could be expected. The stream was accessible compared to comparable reaches for most Maritime salmon streams. The phases through which the investigation has passed are outlined below, with short statements on results.

1. Planting procedure to get best production of smolts under natural conditions (1942-1949) (See FRB Bulletin 133, Part 1) Very light and very heavy plantings of salmon underyearlings were made in 3 years in the main river, in 2 years in the tributaries. Production from the main river was at the rate of 0.2 to 1.1 smolts per 100 sq yd stream bottom, with bird predation seen as the limiting factor. Production in the tributaries was 3.3 smolts/100 yd^2, with bird predation seen as unimportant. Because of much greater area the main river offered as great or greater production than all tributaries

together. Suitable rates of planting August hatchery fingerlings for such a condition with normal natural predation were 10 to 20 underyearlings/100 yd^2.

2. Bird control (See Bulletin 133). Using the same heavy main river planting as above, smolt production was measured when kingfishers and mergansers were controlled (1947-53). Smolt production increased by at least 5 times. Mergansers, not kingfishers, were the limiting factor. Examination of predator-prey relationships showed the importance of systematic effort through the entire open-water period to assure useful benefits to production.

3. Important techniques for assessing small fish in salmon streams, developed during the above phase, were electroseining and improved smolt traps.

4. The capacity of the area to produce smolts from hatchery stock was determined by planting numbers (1950-56) 1/4 and 4 times those used in the study of bird control (1950-56) (See Canadian Fish Culturist No. 21). Maximum rate of production was about 5 smolts/100 yd^2, requiring a rate of initial planting of about 35 August underyearlings per 100 yd^2.

5. Amount of dispersal of (a) underyearlings (1948-53) and (b) yearlings (1957-61) at planting to give best survival. There was no difference in survival rate associated with wide dispersal versus no dispersal at planting when fish were planted only in sufficient numbers to seed about 1 mile of stream in both directions from the planting site ((a) in Canadian Fish Culturist, No. 21). Other observations (Bulletin 133, Part 1) indicate that underyearling stock will not effectively utilize stream areas more than about 1 mile from the point of liberation. In the above plantings similar survival rates were observed for underyearlings remaining 1 1/2 years in the stream after planting as for yearlings remaining 1/2 year.

6. Number of adult salmon for optimum smolt production (1950-60). In 1950 a Denil-type fishway, then the only one in Canada, was built at the lower end of the 10-mile experimental part of the Pollett. Through this, known numbers of adults (potential spawners) could be introduced to the river. Additional adults were seined and transported to the experimental area from other Petitcodiac streams as required. The number of spawners used varied from under 100 to almost 1,400. The progeny were followed as fry and parr by electroseining and as smolts by trapping. Similar data to that developed for light, medium and heavy hatchery plantings were obtained. The observed maximum capacity for smolts was the same (about 5/100 yd^2) as that using hatchery underyearlings. For this, about 45 lb of female salmon per mile of stream 10 yd wide are required (and up to 70 lb for streams with 3-year

smolts). These figures allow for normal removal (about 25%) of adults before spawning, as by angling, poaching, etc. (Partially reported in Canadian Fish Culturist No. 21).

7. Survival rates of young. Throughout all the studies on smolt production, whether from hatchery or natural seeding, survival rates and corresponding population densities of the various stages of young were observed. These results permit identification of local deficiencies at any given stage and thus open the door for reasonable remedial action as through addition of hatchery stock. Pollett data were combined with pertinent Miramichi and Margaree data to provide a general summary of such survival rates in FRB Ann. Rept. 1961-62 and in Atlantic Salmon Journal for June, 1962.

8. Habitat requirements of young salmon (1955-60). The entire experimental area was measured for bottom type, gradient and depth and additional seining stations added to permit a mathematical analysis of habitat types in which salmon under-yearlings and parr, as well as other fish, were most abundant. The results (Annual Report 1960-61, Summary No. 74) indicate that shallow gravel and cobble areas, especially riffle areas of these types, provide the most suitable habitat, with coarser bottom favouring the larger parr. This has led into further studies of comparative productive capacity on the upper Pollett, where there is a greater proportion of the most favourable habitat. Winter conditions, especially the occurrence of frazil and anchor ice, are suspected as a contributing factor to habitat values; these have been noted for several years on the middle reach, and beginning in 1961-62 on the upper Pollett.

9. Migratory behaviour of hatchery-reared smolts (1957-60). The seaward-migrating tendency of hatchery-reared smolts was studied on the Pollett and replicated on the Miramichi (Annual Report 1959-60, Summary No. 74). A size prerequisite for early migration was defined. For migration of maximum numbers, liberation no later than mid-June, i.e., within the normal period of smolt descent, is indicated.

10. Planting to supplement deficient native populations (1956-64). Experiments in supplementing inadequate native populations of underyearlings, yearlings (= pre-smolts in the Pollett) and smolts have been undertaken. For younger fish, plantings calculated to fill identified inadequacies through previously determined survival rates have worked well (Annual Report 1960-61, Summary No. 73). A planting of 1,800 tagged or fin-clipped hatchery smolts added to an adequate natural smolt run, gave 65% return of the hatchery smolts at a fence 10 miles downstream despite serious trap malfunction, suggesting the possibility of greatly increasing smolt runs above normal through hatchery practice. The value in returning adults of such introduced fish is still unknown. Experiments to elucidate

this were begun on the Margaree and Miramichi in 1962. The value of smolts from foreign stocks introduced at younger stages also needs further elaboration. A special tag is under development for the latter purpose. At present it has given limited useful information over periods of a few months, but no adult returns.

11. Introduction of adult salmon to new areas (1961-62). To study production in the upper Pollett, barred by an impassable falls, adult salmon have been trucked up and liberated. Liberation at a holding pool has been followed by extensive upward movement of 3/4 of the fish as indicated by identified spawning redds. On the same basis, liberation in shallow swift water has been followed by extensive downstream movement of about 2/3 of the fish.

12. Returns from and use of introduced and native stock (1950-64). The Pollett was not selected as an area for studying adult returns. But records have been kept of fin-clipped smolts returning through the fishway and are available for fish taken in fisheries. Returns to the river have been several times greater for native stocks than for earlier planted stock. The planted stock was, however, used even in distant commercial fisheries (ICES Rapp. et Proc.-Verb. Vol. 148). In recent years there has been increasing use of Petitcodiac, including Pollett, stocks for angling. In 1962, despite poor conditions for river entry, 30 of the 110 salmon entering the Denil fishway had been marked as Pollett smolts. Only about 6,000 smolts had been marked in 1961 and most Pollett fish return as grilse. Petitcodiac fisheries in 1962 took 23 marked salmon which, judging by size, may have been 1961 smolts.

Because of other exigencies, Pollett investigations are expected to terminate in 1964. Were this not necessary, the field would appear to offer good opportunity for studying methods of improving the utilization of a resource developed to quite an extent through the Board's past work here. A "market" appears to be available through the rapidly growing interest of anglers in the Moncton area.

13. Other work (a) Pool improvement. In 1948 some observations were made on the association of fish populations with the physical characteristics of a pool. The subject was seen as leading towards effective utilization of fish in a stream. Subsequently the work was shelved in favour of studies on production of stocks, then appearing more urgent. (b) Smolt behaviour at dams. In 1958 and 1959 experimental work towards facilitating smolt passage over a dam was undertaken at the Pollett. The experimental area contained 2 dams, over one of which smolts passed readily and another at which they were delayed in seasons of low water. Studies included use of an electrical field combined with water jets for guiding, modifications to the vertical face of the dam, and modifications

of overspill characteristics to conform more nearly to appropriate fish behaviour in respect to patterns of water flow. Results were suggestive but plans to extend the work had to yield to needed research in other areas. Provision was made for some water control to assist this guidance work. The facility, not used, is also adaptable to work on improving utilization of adults through limited water control. (c) Study of post-smolts at sea. Since 1952 systematic records have been kept of Pollett and other marked post-smolts taken across the Bay of Fundy from the Petitcodiac. Records and specimens should provide further information on movements of salmon in the sea, food and growth rates. Preliminary examination of catch records suggests a mixing of stocks from the Fundy-Gulf of Maine region in this Hall's Harbour area, with yearly variation dependent on sea water movements and on relation of freshwater discharge into the sea. (d) Censusing operations in the Pollett river have led to information on some inter-specific relations between different kinds of fish in salmon streams. The recently-begun headwater studies may or may not, because of short duration, yield further information on relations between young salmon and speckled trout.

(b) Miramichi and other river areas (C.J.K.)

1. Catch statistics; adult sampling traps. Compilation of landings in the Maritime Region, comprising Gulf, Atlantic and Fundy areas (as defined by Huntsman, 1930) was completed for 1870-1949, then supplemented by commercial and angling statistics obtained by the Department under a revised system starting in 1949. Over the past 93 years, total Maritime commercial landings fluctuate around an average of about 2 1/2 million lb. Peaks over 5 million lb occurred in 1874 and 1930, extreme lows in 1881, 1945 and 1953. Comparison of Maritime Region landings, 1906-50, with those of British Isles and Wye River fisheries alone, showed similar periodicity, with similar decline since last peaks in production around 1930. This has interest because A.S.A. claimed remarkable benefits to Wye from extreme restrictions on local commercial fisheries since 1906. Landings in Newfoundland plus Quebec beyond southern Gaspé, are 2 to 3 times the annual Maritime totals, and total Atlantic landings for 1910-62 average 7 million lb. Angling statistics since 1949 show total annual catches ranging from 25,000 to 65,000 fish in Maritime Provinces, 17,000 to 26,000 fish in Newfoundland, and in Quebec around 12,000. (Salmon statistics reviewed annually since 1954 in 'Trade News';commercial landings by provinces, 1910-59, reviewed in Atlantic Salmon Journal, Sept. 1960)

Information on time and size of adult runs into the large Miramichi system, in relation to environmental conditions and fishery regulations, has been obtained by operating yearly through the open water season, a sampling trap in the estuary and counting fences on typical freshwater tributaries. These operations have enabled population assessments of young salmon to be related to adults, provided returns on marked and tagged adults, demonstrated the high proportion of total adult run entering in the fall, etc. In the Miramichi area evidence is accumulating that commercial fishing does not have noticeably harmful effects on angling, but that all kinds of fishing tend to fluctuate together with changing environmental conditions. Catches are usually best in years well provided with freshets.

2. Smolt-adult studies. Annually since 1950 smolts were fin-clipped on Northwest Miramichi at Curventon (maximum 30,000 in any one year); 1957-62 at Camp Adams (maximum 12,500); 1950-56 on Southwest Miramichi at Dungarvon (maximum 21,000); 1958-62 on lower Cains (maximum 8,100). Total returns in commercial and angling fisheries, 1950-59, of 172,400 Northwest Miramichi (LV + A) marks, 1.5%; total returns all other 101,232 (RV + A) marks, 1.3%. Adult sampling estuarial trap and counting fences above tidehead gave additional recaptures totalling about 1%. About 2.5% of total smolts marked can be accounted for. Correcting for inadequate search in some areas suggests approximately 5% smolt survival to adults. Commercial fishery recaptures are spread over a wide area of coast as far away as Greenland with many around Newfoundland-Labrador; but freshwater recaptures are limited to the Miramichi, with a high degree of return to the home branch. The fraction of total catch of Miramichi stock taken by Newfoundland nets has been estimated at one-third, from data on largest smolt markings in 1953 and 1954; later data being processed. Total Miramichi smolt production was estimated at around 2 million in mid '50's, lower later.

3. Fry-parr assessments. In 1951-62 autumn electroseining was carried on at 10 stations on the Northwest Miramichi and in 1952-56 at 6 Dungarvon stations as regular programs. In some years stations were sampled elsewhere in the Southwest Miramichi and upper St. John to assess new conditions re dams, DDT spraying, etc. now totalling 207 Miramichi operations. Population levels of fry and parr in the Miramichi have indicated that spawning escapements and fry production have usually been adequate; exceptions are occasional physical or chemical barriers, e.g., mine pollution. These assessments have suggested beneficial effects of the early merganser control experiment and recently have given invaluable data on extent of harm through DDT and mine pollution.

4. Predator control (a) Mergansers. A new experiment was started in 1950, with removal of mergansers on Northwest Miramichi (11% of Miramichi watershed), no removal on Dungarvon, as an extension of Pollett experiment. Parr assessments, 1950-53, indicated an increase by two to four times in Northwest Miramichi pre-smolts. In February, 1954, it was agreed to recommend extension of experimental control to the whole Miramichi system to improve production of smolts and adults in the Gulf area. The Department undertook removal starting in 1954. Severe effects of DDT spraying in 1954 and later,

obscured the effects and in 1961 control was stopped on Miramichi and a new experiment was planned for the Margaree watershed, to show relation of merganser control to adult catches. (b) Eels. Early observations by H.C. White showed that eels could be serious predators of salmon fry. In 1952 H. Godfrey was engaged seasonally to investigate the eel-salmon relationship and developed a useful electroseining technique for the work on small streams. In 1954 D.A. Hurley, student assistant, tried to develop the investigation. It became obvious that the problem needed full-time attention of experienced staff for several years, and it was dropped because of other urgent commitments.

5. Effects of pollutants. With the start of aerial forest spraying of DDT in the Miramichi watershed in 1954, it became necessary to divert much effort to checking effects of operational sprayings on young salmon and aquatic insects, and to estimate the effects on later adult runs. The Board and Department co-operated in the studies of immediate effects of spraying using caged fish, in operational sprayings mainly in 1954, 1960 and 1961. The Board has undertaken annual assessment of effects on aquatic insects since 1955, and has obtained valuable information on native young salmon by annual electroseining, 1951-62. Besides, small-scale experimental sprayings were studied co-operatively with the Department of Forestry in 1958, 1959, 1961 and 1962. An outcome of the latter experiments was reduction of strength of DDT in operational Miramichi spraying from 1/2 to 1/4 lb per acre starting in 1960. In 1961 the systemic insecticide Phosphamidon showed promise in having no noticeable effects on fish. In 1958 effects of previous DDT sprayings on future adult stocks were forecast, and public catches and sampling trap counts have been low, as expected. In 1960 mine pollution became a serious problem on the Northwest Miramichi, and counting fence and seining data have been useful to the St. Andrews Pollution Investigation for correlations with Cu and Zn, water hardness, etc.

6. Physiology and behaviour. From 1930, some useful field and laboratory observations were made by Huntsman and associates. Since the late '40's, except for homing observations involved in Miramichi smolt marking experiments, little was done along this line until 1958 when M.H.A Keenleyside, with experience in ethology, started behaviour studies on young salmonids. After several years of promising field and laboratory observations on territorial behaviour and related topics, he left the Board. R.L. Saunders joined the staff in 1960 with training in experimental biology and has made good progress in studies of buoyancy regulation in young salmon, cause of increased growth rate at smoltification, fry and parr movements in streams, and analysis of homing data. He plans to start soon studies of performance of salmonids in relation to various environmental factors. In 1961, J.H. Gee joined the staff, started behaviour studies, but left in 1962 for post-graduate studies in Australia.

7. <u>Natural history</u>. In connection with smolt marking and recapture studies and seining operations, thousands of scale samples of young and adult salmon from many Atlantic areas have been collected. Readings have been made of all fin-clipped adults to show the year of marking. A large number of unmarked representative samples from various fisheries have been analyzed. All give useful background information on life history, mainly supporting previously published work but sometimes providing useful new information, e.g., effects of DDT on growth rates. Information on incidence of sea-lice and lampreys on adults and on occurrence of other fish species in rivers, etc., has been obtained and documented.

<u>Synopsis of present situation</u> (C.J.K.)

Probably a list of requirements for salmon investigation prepared in 1963 will be rather similar to that of 1952. Many of the projects have yielded useful results, however, and some could be dropped, to permit work in other directions. Unforeseen environmental changes, including DDT spraying and mining pollution, have already forced some changes in emphasis since 1952. It is likely that such problems will occur during any long-term program involving major salmon rivers. To prevent disrupting basic work, provision of staff for 'ad hoc' projects should be considered in future planning. Staff changes and occasional failure of essential field equipment have hindered progress in some lines, but experience gained in the Miramichi area should be invaluable in planning programs for large rivers.

Some program changes have already been initiated. In 1962 a new merganser control experiment was started on the Margaree River, and one Pollett River technician was transferred there. The Pollett investigations are to end in 1964. The Little Codroy River project, under the St. John's, Newfoundland Station but closely associated with the St. Andrews investigations, ends shortly.

To assure a fresh outlook it seems desirable that those who will be immediately responsible for future investigations on salmon and other anadromous fishes should develop the plan of attack along with present management staff of the Department. The following suggestions, however, may be useful.

A continuing basic program of population studies involving both young and adult fish should be considered for the Miramichi system. It is a large contributor to total Maritime salmon catch, both commercial and angling; trout are plentiful and desired for angling. Our extensive background on effects of insecticide and mining pollution will be useful there and investigation of effects of deforestation is worth consideration. A new counting fence on a permanent sill is scheduled for construction, under contract, in 1963 at Curventon on the Northwest Miramichi. It replaces the temporary-type fence now used there and elsewhere, which suffers washouts during freshets and may thus give incomplete fish counts. Pulp driving, which usually prevented trapping during the early part of smolt descent, ends in 1963 on the Northwest Miramichi. It should be possible in future to handle completely both up- and downstream migrants, and obtain new information on important topics like the time of adult return from smolts produced in upriver and downriver rearing areas.

New oceanographic investigations now being considered for the Gulf of St. Lawrence might be associated with experimental netting for all stages of salmon in the Miramichi outflow, and if combined with tagging, fill some of the gaps in knowledge of the sea phase of the life cycle.

Continuation of studies on physiology and behaviour should be given high priority, including definition of requirements for artificial smolt production, which will likely have to replace much of former natural production from areas above dams. The factors influencing time of adult return (early and late runs), maturation as grilse, etc., need attention. Progress with most of those topics seems to depend on availability of the proposed joint FRB-Department experimental fish culture establishment, now in the planning stage.

Availability of staff will be an important factor in deciding the future programs, and recently the St. Andrews staff has been short-handed. The necessity for informing various associations of anglers and commercial fishermen and the public generally, on the progress of investigations has involved much effort annually in travel, attending meetings and preparing popular accounts for publication. Annual meetings of the Federal-Provincial Co-ordinating Committee and its successor, plus separate associated meetings of scientific advisory groups, regulations sub-committee, and annual meetings since 1958 of the Interdepartmental Committee on Forest Spraying Operations, have all required preparation of special progress reports. This has been considered to be an essential part of the work of the St. Andrews scientist-in-charge, and other staff members have contributed much effort as well. Recent experience has shown that in future planning it is important to take into account the time requirements for liaison work, to permit continuity in the working up of data for scientific publications. Employment of one or more additional assistant scientists with full-time technicians well qualified for laboratory work, is recommended if activities continue at the present level.

C. J. Kerswill
P. F. Elson

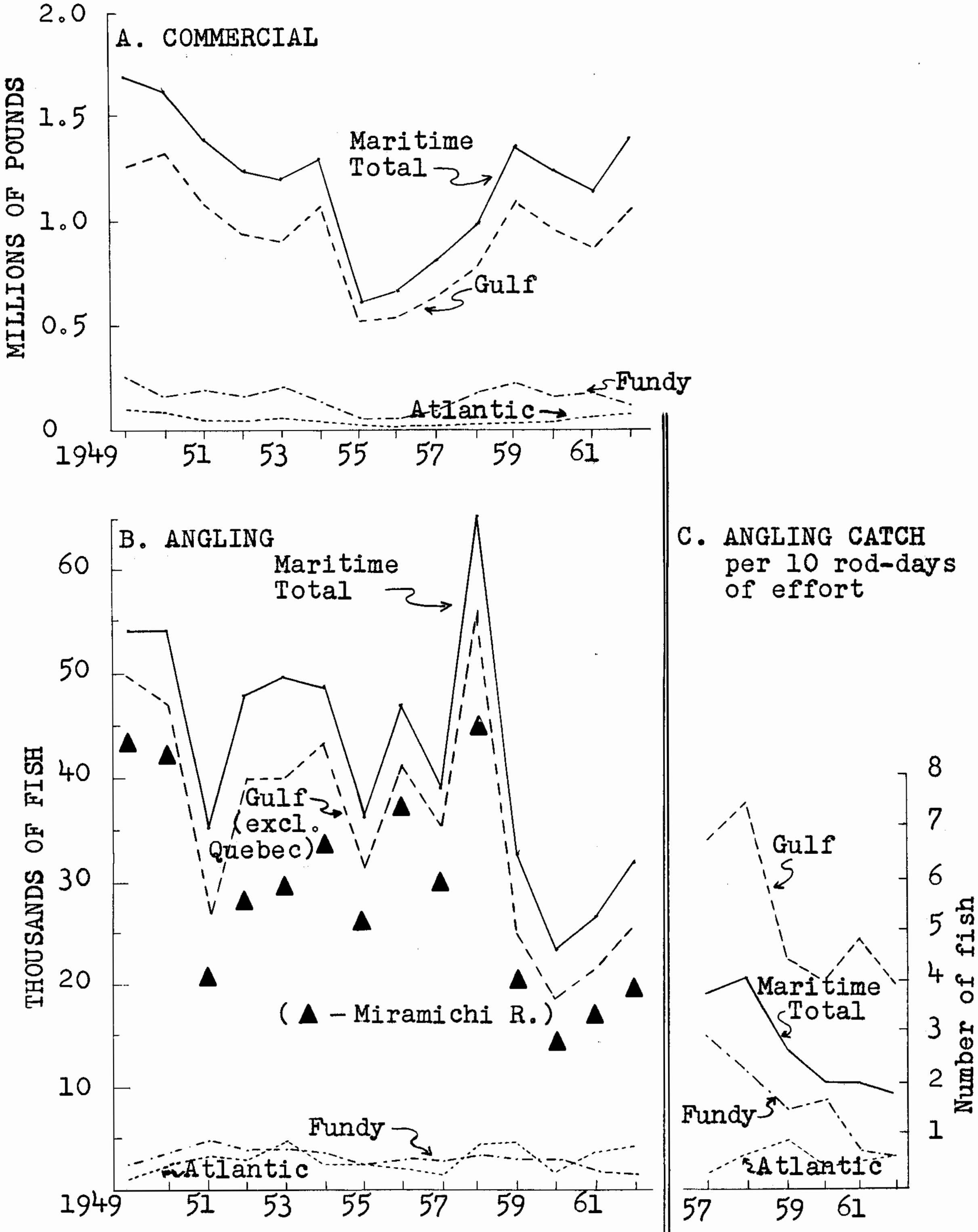


Figure 1. Atlantic salmon catches, Maritime Region, 1949-62

No. F-3

CATCH STATISTICS AND MIRAMICHI SAMPLING TRAPS

(a) Salmon catch statistics 1949-62

Since 1949 the Department of Fisheries has assembled annual records of commercial and angling catches in the "Maritime Region", which comprises three areas, Gulf, Atlantic and Fundy, chosen to separate stocks of salmon having somewhat different life histories. The Gulf Area includes the Quebec shore as far north as Cape Gaspé, and commercial catch statistics for that portion of the area have been obtained from Provincial published reports. For 1962 a breakdown of Quebec total landings is not yet available but the southern Gaspé catch has been estimated at 220,000 lb from the percentage of the total Quebec catch made there in the three previous years (44%).

Commercial landings in 1962 in the Maritime Region, including the Quebec estimate, totalled 1,419,700 lb, a 19% increase over the 1961 total. It was the net result of increases over 1961 catches by 33% in the Gulf Area and 10% in the Atlantic Area, and a decrease by 40% in the Fundy Area (Figure 1A).

Angling catches in 1962 in the Maritime Region (excluding Quebec rivers for which data are not yet available) totalled 31,925 fish, an increase of 21% over the 1961 total (Figure 1B). Average Maritime total catch per 10 rod-days fell slightly from 2.1 fish in 1960 and 1961 to 1.9 fish in 1962 (Figure 2C). Angling effort increased in Gulf rivers from 44,000 rod-days in 1961 to 63,000 rod-days in 1962 and in Atlantic rivers from 61,000 rod-days in 1961 to 72,000 rod-days in 1962 without corresponding increases in catch.

Total commercial and angling catches follow a similar pattern through the 1949-62 period. Probably the difference in timing by one year for some of the outstanding peaks and lows is associated with a predominance of grilse (1-sea-year fish) in angling catches, while commercial catches are mainly 2-sea-year fish. This gives some support to the view that public catches reflect the abundance of salmon, and that a strong year-class may carry through from smolts to both grilse and older fish. In years like 1955, when both commercial and angling catches are low, catchability may have been unusually poor from unfavourable environmental conditions like lack of freshets.

Total commercial catches in the Maritime Region since 1870 are shown in Figure 2, for comparison with recent catches in Figure 1A. There have been wide fluctuations around an average catch of about 2.5 million lb and the 1962 total, at 1.4 million lb, is still distressingly low. It is encouraging, however, to see some improvement recently. The upward trend may

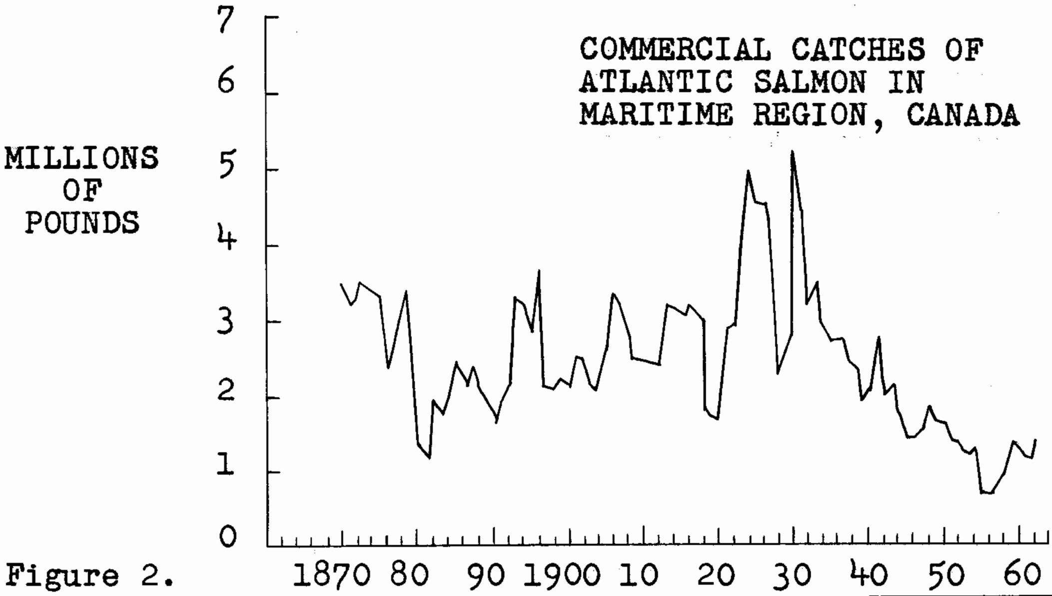


Figure 2.

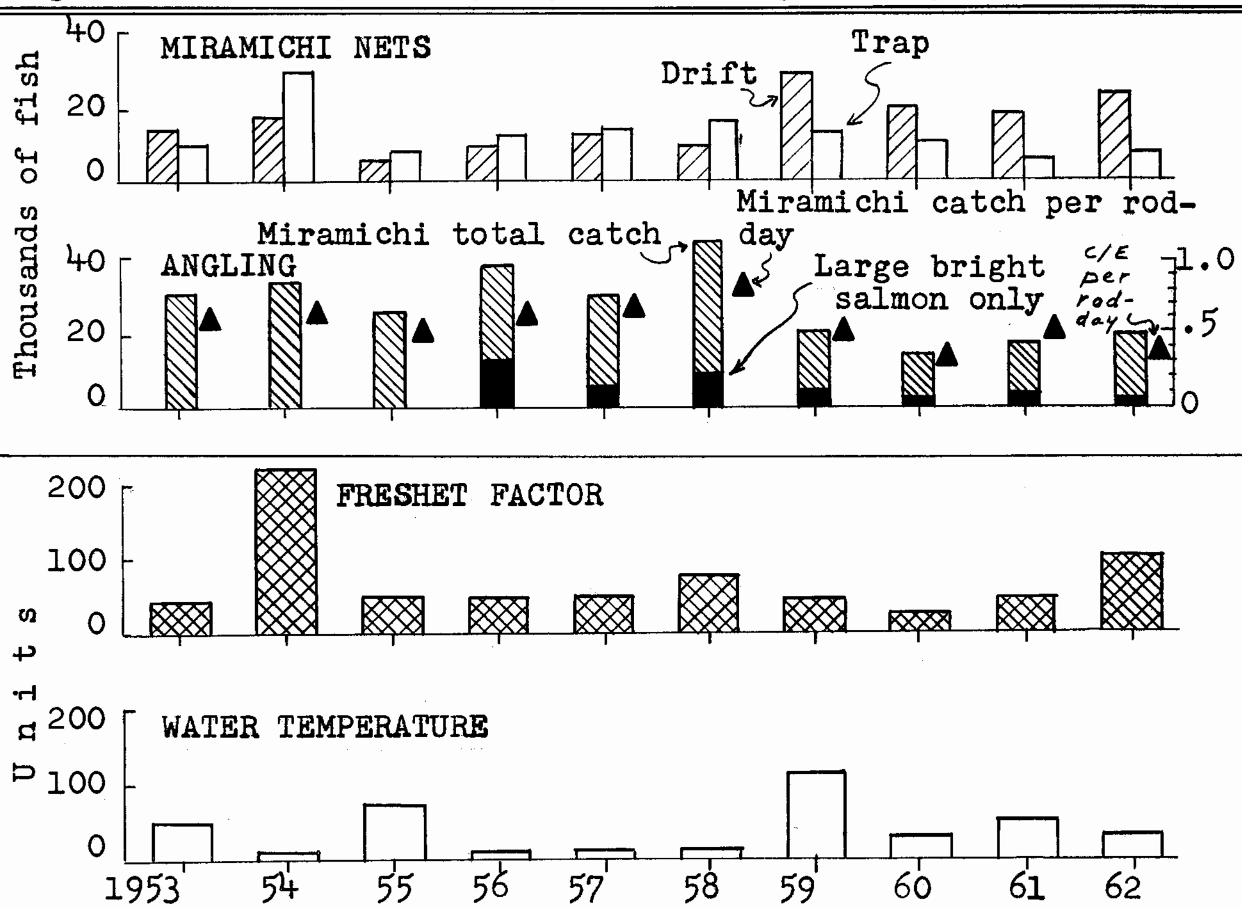


Figure 3. Miramichi salmon catches and water conditions, 1953-62.

continue, if the relationship between catch and sea temperature (Summary No. F-7) is valid, and if effects of DDT spraying and other environmental changes become less serious.

For Newfoundland, statistics provided by the Department of Fisheries show commercial landings totalling 2,160,000 lb, or 4% higher than in 1961. Newfoundland anglers caught 26,152 fish for 51,324 rod-days of effort, as compared to only 17,048 fish in 37,074 rod-days in 1961. In Quebec, 1962 commercial catches totalled 499,800 lb, 7% lower than in 1961.

Total commercial salmon production for the Atlantic coast was about 3,800,000 lb with landed value of $1.6 million in 1962 compared to 3,500,000 lb with landed value of $1.4 million in 1961. The 1962 catch comprised about 500,000 lb from Quebec, 1,200,000 lb from the Maritime Provinces and 2,100,000 lb from Newfoundland. The total 1962 angling catch for the Maritime Provinces and Newfoundland was about 58,000 fish, to which the Quebec figure, usually totalling at least 12,000 fish must be added when available.

(b) Miramichi sampling data

Figure 4 summarizes annual counts of adult salmon at an estuarial FRB sampling trap in the Miramichi estuary at Millbank and two counting fences in the freshwater part of the Northwest Miramichi tributary at Curventon and Camp Adams. The black lower sections of bars represent the portions of the total counts made before the end of the public fishing season in the area, i.e., August 31 for commercial netting, Millbank; September 30 for angling at Curventon and September 30, 1957-1959, now September 15, at Camp Adams.

In the estuary, counts of both grilse and large salmon during the commercial fishing season were among the lowest recorded since 1954. Grilse were quite plentiful after September 1 and the annual total was average, suggesting satisfactory survival of the 1961 smolt run, which was judged to be quite good. The total season count of large salmon was the lowest on record, and the very low catch during the commercial season paralleled catches in public gear in this section of the estuary.

At Curventon a good run of ascending grilse was counted but the large salmon run was very low. The grilse reached Camp Adams in fair numbers. The relationship of these records to mine effluents is discussed under Pollution Studies.

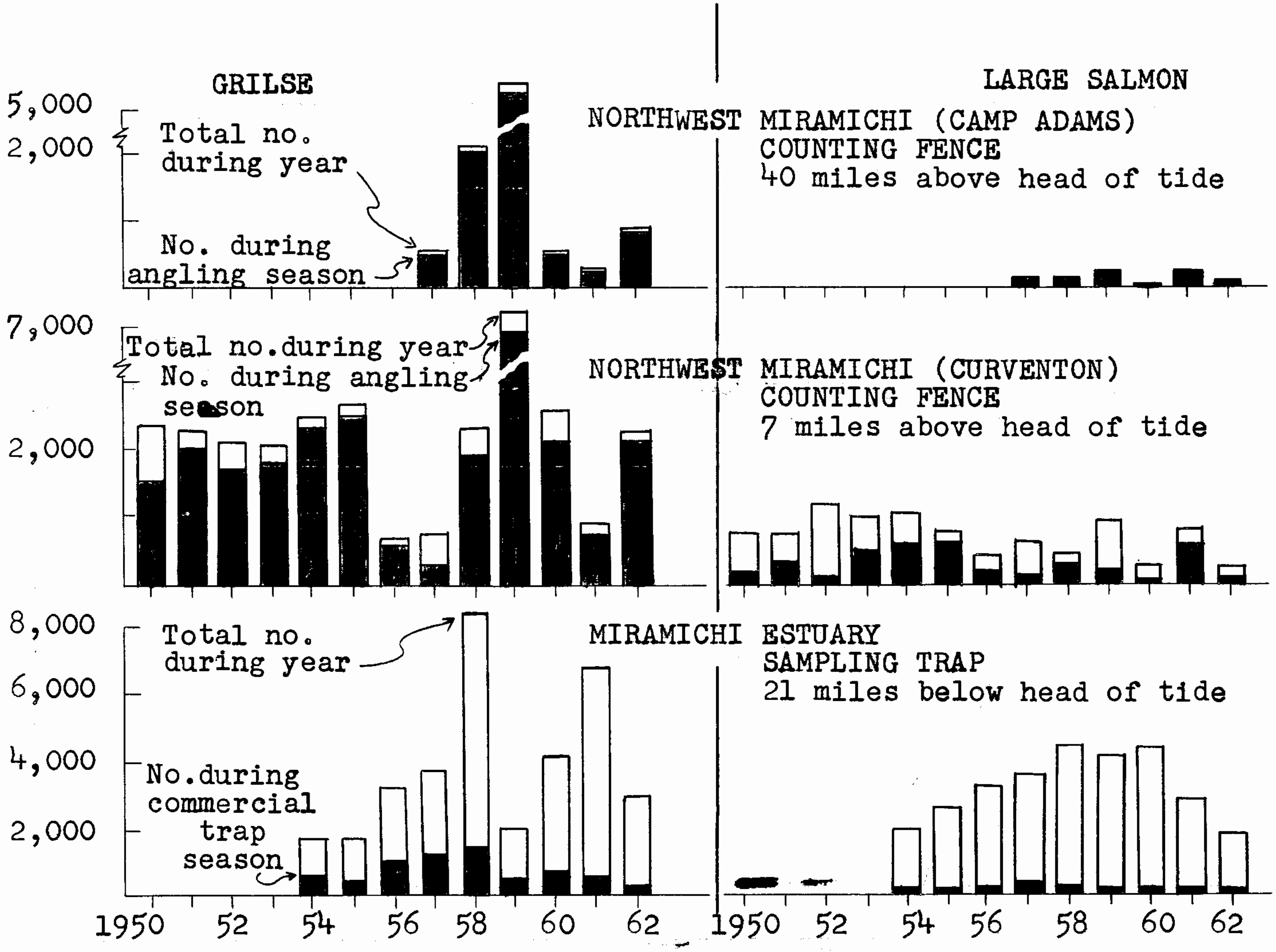


Figure 4. Summary of counts of adult salmon at Miramichi estuarial sampling trap and up-traps at two counting fences on Northwest Miramichi tributary, New Brunswick.

Miramichi commercial netting, angling, and water conditions

In Figure 3 are shown total annual catches by "offshore" drift-nets, estuarial trap nets and angling for the period 1953-62, with freshet and water temperature indices for each year, as calculated by J.H. Gee. The 'freshet factor', indicating number of changes in water level and their duration was calculated from $\frac{\text{"inch-day increases"}}{3}$ using Curventon fence data, assuming that a 3-inch rise is required to affect salmon movements. The temperature index is mean degree-days above 20°C from water records at Curventon.

The data indicate that in the Miramichi area the two kinds of commercial fishing and angling are associated with the frequency of river freshets. Catches by all types of fishing tend to rise or fall together from year to year. In the years before 1960 when DDT effects were expected to show in commercial catches, in years with higher commercial catches there were not noticeably lower angling catches. In later years the estuarial trap catches were depressed, likely from Miramichi pollution to a considerable extent, but drift-net catches have held at a relatively high level. The latter is likely related to the fact (shown by tagging experiments) that salmon in the drift-netting area are only partly, perhaps about 50%, of Miramichi origin, and also that the new drift-net boats which replaced the 29 lost in the 1959 Escuminac disaster have higher efficiency.

C. J. Kerswill

No. F-4

RETURNS OF SALMON TAGGED AS SMOLTS AND RELEASED IN THE MIRAMICHI RIVER SINCE 1958

This report brings up to date the returns as adults of salmon tagged as smolts starting in 1958. The objectives and details of the work are given in the Annual Report of the Biological Station, St. Andrews, for 1961-62 (Summary No. 65).

The results to date are summarized in Table I. Returns of those fish tagged in 1958 have ceased and we can expect no more. Although there were four additional returns from the 1959 tagging, three of these were from black salmon which presumably returned in 1961 and stayed in the river till the spring of 1962. One tag was returned from a bright salmon caught commercially in 1962. Few, if any, additional returns of fish tagged in 1959 can be expected. The low rates of return from tagging in the estuary in 1958 and 1959 are possibly owing to the damage smolts suffer by being handled at a time when they are very delicate. Subsequent experiments have

Table I. Tag returns as adults from smolts tagged between 1958 and 1962 in the Miramichi River System.

	Year tagged	Place released	Number tagged	Method of capture	1959	1960	1961	1962	Total returns	% return
A.	1958	Millbank	1,023	Angled	1	2	1	...		
				Commercial	...	4	...	...	8	0.8
	1958	Camp Adams	25	Curventon down trap	...	...	...	...	...	...
B.	1959	Millbank	3,442	Angled		10	4	3		
				Commercial		11	29	1	63	1.8
				Curventon up trap		5	...	...		
C.	1960	Camp Adams	750	Angled			1	...		
				Commercial			6	6	25	3.3
				Curventon up trap			12	...		
	1960	Cain's River	132	...			...	...	...	...
D.	1961	Camp Adams	310	Commercial				1		
				Curventon up trap				2	3	1.0
E.	1961	Curventon	394	Commercial				1	1	0.3
F.	1961	Wayerton Bridge	5,088	Commercial						
		From Saint John Hatchery -		Miramichi Estuary				2		
		Miramichi stock, (2,543)		Elsewhere				6		
		Fast-growing stock, (2,545)		Curventon up trap				1	9	0.2

demonstrated the value of tagging smolts in the Northwest Miramichi in which we have counting fences where returning adults, which might otherwise go unnoticed, can be observed.

The experiment started at Camp Adams in 1960 has been the most successful so far. Twenty-five or 3.3% of the tagged fish have been captured by angling, commercial netting and Northwest Miramichi counting fence. The most striking fact associated with these returns is that most of them were taken early in the season. The 12 grilse observed at the Curventon counting fence appeared between June 23 and July 25, 1961. Five grilse taken in the Miramichi estuarial fishery were taken between June 26 and August 7. One post-grilse was taken in October at Napassog Fjord, Greenland. A single grilse was angled on July 19. Of the six large salmon taken commercially in 1962, five were taken by set-nets in the Miramichi estuary and one by drift-net in Northumberland Strait. These were all taken early in the season, between May 29 and June 12, 1962.

Returns of the small numbers of smolts tagged at Camp Adams and Curventon in 1961 have been few. The three returns from the Camp Adams experiment were early in the season, between June 15 and July 27. The single recovery from the Curventon group was made early in July.

Only nine of the planting of 5,088 smolts reared in Saint John Hatchery were recovered as grilse in 1962. These recoveries are summarized in Table II. These salmon of late-run Miramichi parentage may provide interesting biological information pertaining to the season of their return to fresh water and whether or not they do return to the river in which they spent only a short time before going to sea.

Smolt tagging was continued in 1962. Approximately 10,100 smolts were tagged and released in the Northwest Miramichi. Of these, 6,100 were native Northwest Miramichi fish and the remainder were of various stocks reared to the smolt stage in hatcheries. An additional 4,000 hatchery-reared and 500 native smolts were tagged and released in Margaree River, N. S. About 1,200 native smolts were tagged at Cains Brook, a small stream flowing into Cascumpeque Bay, Prince Edward Island.

Four tags from smolts released in the Miramichi were recovered from the gannet nesting area on Bonaventure Island. This raises the interesting possibility that gannets and other large sea birds may be partly responsible for the low rates of return of tagged smolts. The finding of four needles in the proverbial haystack suggests that there may be many more tags to be found among the debris about the gannet nesting area. We hope to tag many smolts this year in order to learn more about this and other aspects of salmon biology.

Table II. Recoveries as grilse of 5,088 smolts reared in Saint John Hatchery and released in Northwest Miramichi River in spring, 1961.

Date recovered	Place	Method of capture
10/7/62	Birchy Cove, Bonavista Bay, Newfoundland	Commercial net
26/7/62	Englishtown, Nova Scotia	Commercial net
17/7/62	Cassilis, Northwest Miramichi, New Brunswick	Commercial net
11/8/62	Off Potato Creek, Ruisseau Patate, Gaspé Nord, Quebec	Commercial net
23/7/62	Indian Harbour, Nova Scotia	Commercial net
16/7/62	Bill of Ragged Pt., Twillingate, Newfoundland	Commercial net
27/7/62	Fox Island Cove, Robin Hood Bay, Newfoundland	Commercial net
15/8/62	Loggieville, Miramichi River Estuary, New Brunswick	Commercial net
22/9/62	Northwest Miramichi River, New Brunswick	Salmon counting fence

R. L. Saunders

No. F-5

INSECTICIDE SPRAYING EFFECTS ON CAGED YOUNG SALMONIDS AND ON AQUATIC INSECTS

In 1962 observations were made by fisheries staff on (1) effects of operational DDT spraying of woodland to control budworms in central New Brunswick, and (2) effects of experimental spraying of the watershed of a small Miramichi tributary, Hughes Brook, with the systemic insecticide Phosphamidon. The following FRB and Departmental personnel participated in the fisheries studies in consultation with C.J. Kerswill and R.R. Logie: J.R. Macdonald and H.E. Edwards, Dept. Fisheries - observations on caged young salmonids; E.J. Schofield and other FRB technicians under supervision of P.F. Elson - electroseining assessment of young salmon populations, August-October; C.D. Grant, FRB student assistant, guided by F.P. Ide, University of Toronto - field studies of aquatic invertebrates before and after Phosphamidon spraying, Hughes Brook and unsprayed control; J. Marshall, FRB student assistant, guided by F.P. Ide - determining effects of earlier DDT sprayings, 1954-58, on aquatic insects of Northwest Miramichi. The results were reported to the fifth annual meeting of the Interdepartmental Committee on Forest Spraying Operations, held in Ottawa on November 2, 1962.

In winter, 1962-63, data on effects of earlier sprayings, 1952-61, have been assembled for publication.

A. Operational DDT spraying

Caged young salmon and trout, 1962. Short-term mortality test cages were held at the lower end of the Cains River. Its whole watershed was to be sprayed with single application DDT at 1/4 lb per acre, and part of it a second time. Unsprayed control cages were held at the FRB Camp Adams counting fence, upper Northwest Miramichi. The specimens comprised 50 salmon parr, 50 salmon fry, and 50 trout caged at the Cains site; 100 salmon parr, 100 salmon fry and 50 trout fry caged at Camp Adams. Spraying started June 4. By June 16 the watershed had been sprayed on 11 days as different blocks were treated and all Cains specimens were dead, as compared to the following mortalities at Camp Adams: salmon parr, 3%; salmon fry, 17%; trout fry, 4%. The 1962 effects of single application DDT at 1/4 lb per acre were more severe than the 1960 observed effects at the same scheduled dosage on Muzroll Brook, tributary to the Cains. Then, total mortalities by 10 days after the final spray date (June 9) were: salmon parr, 38%; salmon fry, 20%; trout fry, 82%. A new system of spraying using larger planes, square spray blocks and uniform coverage of both land and streams within blocks, appears to nullify the beneficial effects of using 1/4 lb DDT per acre instead of 1/2 lb DDT per acre as used from 1953 to 1960 for most operational spraying in New Brunswick (From report by J. Marshall and H.E. Edwards).

Effects of earlier sprayings on aquatic insects. Starting in 1955, the year after DDT spraying first occurred in the Miramichi watershed, emerging insects have been collected annually 5 days per week, from late May through August, in yard-square cage traps at several sites with different spray histories in the Northwest Miramichi watershed. Included were similar observations from 1955-58 on Millstream Brook, a nearby unsprayed stream. Operations have comprised the following cage-trapping on affected streams: 1955-62 on Trout Brook (sprayed 1956); 1955-58 and resumed 1962 on North Branch Sevogle (sprayed 1954, 1957, 1958); 1957-61 on Northwest Miramichi at Camp 42 (sprayed 1954); 1959-62 on Northwest Miramichi at Camp Adams (sprayed 1954, slightly affected 1956). In 1962 it was desired particularly to learn whether or not in streams heavily sprayed only once, a general recovery suggested by 1960 data had continued. Extreme spring flooding in spring 1961 had affected insect production and the acquisition of significant data that year. At both Camp Adams and Trout Brook the 1962 emergence was much greater in both number and volume of insects than in 1961, and average size of individuals was similar to that in 1959 and 1960. It appears, therefore, that significant recovery of aquatic insect population has occurred within 5 or 6 years following heavy spraying of DDT at 1/2 lb per acre. At North Branch Sevogle, heavily sprayed in three years before 1959, some improvement had occurred by 1962 in numbers of emerging insects but they were small-sized forms and the population was deficient in species of moderate to large size, which are most suitable food for parr (From reports by F.P. Ide, C.D. Grant and J. Marshall).

B. Experimental Phosphamidon Spraying, 1962

Small field tests in 1961 by the Department of Forestry showed that Phosphamidon, a systemic insecticide developed in Europe, could control budworms. Laboratory tests in 1961 at the Nanaimo Station showed that young coho salmon are many times more tolerant of Phosphamidon than DDT. In 1962 a co-operative forestry-fisheries project was carried out on Hughes Brook, tributary to the Taxis River. The whole upper watershed of the brook was covered by a 640-acre spray block to be sprayed with Phosphamidon in aqueous solution, at 1 lb per acre. An upper stream station 200 yd above the lower boundary of the spray block, and a lower stream station 2 1/2 miles downstream near the mouth of the brook, were used for several kinds of systematic assessments before and after spraying on June 9.

Three series of square-foot Surber bottom samples at the two Hughes Brook stations and on unsprayed Porter Brook, all taken just before spraying and 10 and 20 days after spraying, failed to show effects of Phosphamidon on either number of insect species or individuals. No effects of spraying were shown by daily collections of emerging insects from yard-square cage-traps operated at both stations from June 5 to 30. Three foot-square 25-mesh drift screens at each station were cleared daily from June 5-30, and hourly from midnight to 10 a.m. on the spray morning. The hourly sampling showed no immediate increase in drifting insects as occurs with DDT. All the drift collections made at daily intervals had not been analyzed by February, 1963, but there was no definite increase in numbers of aquatic insects descending through being affected, among samples picked for analysis at intervals of several days from June 4 to June 20.

Electroseinings on May 30 and August 21 did not indicate any damage to native populations of brook trout, sculpins, dace or crayfish. Caged young salmon fry and trout fry survived even better in Hughes Brook than at the unsprayed control, from June 8 to 23.

Available information indicates, therefore, that from the standpoint of effects on fisheries, Phosphamidon is a promising substitute for DDT as a forest pesticide. Unfortunately the price is high at present, but likely would decrease with greater industrial demand (From reports by F.P. Ide and C.D. Grant).

C. J. Kerswill

No. F-6

PRODUCTION OF YOUNG SALMON IN MIRAMICHI STREAMS IN RELATION TO FOREST SPRAYING OPERATIONS

Systematic annual censusing of young salmon in various Miramichi tributaries was started in 1951 with 8 sampling stations on the Northwest Miramichi River from headwaters nearly to its confluence with the Sevogle. In 1952 sampling included 2 additional stations there and 6 stations on the Dungarvon River. All these stations were either directly within the area of first spraying in 1954 (1/2 lb of DDT per acre) or downstream from sprayed areas. In 1955 three stations were added on the Renous River and 5 on the Cains. In 1960, 2 stations were added on the upper reaches of the Main Southwest Miramichi, and one on a small brook entering the lower half of the Main Southwest. All of these stations have now received DDT spray at one time or another. Taken over the years, 207 such censusing operations have been made on the Miramichi system.

In Table I data are presented showing the estimated number of young salmon per 100 square yards of stream bottom for areas sprayed in the year of sampling. The data is restricted to cases in which the fish had not been subjected to spraying earlier in their life history, although some stations contributing data under the various columns may have received spray previous to the advent of year-classes involved.

In 1955 underyearlings were about twice as abundant in unsprayed areas as in all other years without spray. That the strength of this 1955 year-class is not attributable as an after-effect of 1954 spraying, is indicated by the fact that this 1955 year-class was as abundant in areas not sprayed in 1954 as in areas sprayed in 1954.

The "no spraying" value of 28 given for underyearlings in Table I includes this 1955 year-class. If

Table I. Relative abundance of young salmon found in sample areas of Miramichi streams as associated with DDT spraying in year of sampling only. Figures are given as mean number per 100 sq yd of stream.

	No spraying	Nominal single spraying at 1/2 lb/acre	Nominal single spraying at 1/4 lb/acre	Nominal twice spraying at 1/4 lb/acre
Underyearlings	28	2	11	4
small parr	23	6	17	--
large parr	12	6	4	--

it is excluded the value becomes 24. This is identical with a "before spraying" value of 24 derived from 59 samplings made before the sample areas received any spraying. Thus there is no indication that spraying in one year has any effect on the number of underyearlings in the following year.

Operational spraying of DDT over the surrounding area at 1/2 lb per acre has been followed by a 90 per cent reduction in populations of underyearling salmon. Lesser but still important reduction in older parr is evident also. DDT applied at half this operational dosage has been followed by lesser reductions (50 to over 70 per cent).

The effect of repeating the lighter dosage twice, on an operational basis, is less clear, but appears to approximate the harmful effects of operational single application of 1/2 lb DDT per acre. Much of the lower Cains River received nominal repeat application in 1962. The upper censusing stations showed moderate numbers of underyearling salmon, but 1 lower station showed none and another a number compatible with a hatchery planting made after spraying if there had been no survivors of the spraying. Spray had been deposited over various parts of the stream above on 9 different days.

That the effects of spraying may extend some distance downstream from the actual area sprayed is indicated by the numbers of young found varying distances below areas sprayed at 1/2 lb/acre. With little tributary water entering below the lower spray boundary, less than 1/4 of the usual normal numbers of underyearlings were found as far as 15 miles below. But with unsprayed tributary inflow contributing about 1/4 to 1/2 of stream flow numbers of underyearlings were from about 1/2 normal to normal at 10 to 15 miles below.

Young salmon populations were also examined in other areas affected by spraying at some time during the studies, including the Tobique (1957-61) the Nashwaak (1960-61) and the

Molus, 1961. The West St. Nicholas and Coal Branch, Richibucto area, were used as unsprayed streams for comparison with the Molus in 1961. In these places young salmon conformed essentially to the order outlined above for the Miramichi.

P. F. Elson

No. F-7

NUMBERS AND CATCHES OF ADULT SALMON FOLLOWING FOREST SPRAYING OPERATIONS

1. River populations

(a) Decline in stock associated with DDT in the Tobique River.

Most adult salmon entering the Tobique River do so through the fishway at the Tobique Narrows dam. Beginning in 1959 some salmon have been carried each year by truck from the Beechwood fish-elevator below to the Tobique above the Narrows dam. Recent tagging studies by the Fish Culture Development Branch indicate that about ~~10~~ 60 per cent of salmon entering the Beechwood elevator subsequently pass through the Narrows fishway. Assuming homing, the magnitude of Tobique stocks in each year can be calculated by taking the number passing through the Tobique Narrows fishway and adding to it 60 per cent of the number carried up by truck. In Figure 1 the sum of these 2 numbers is taken as the "observed" population (solid line) of Tobique salmon. In the same figure the dotted line shows the estimated effect of DDT spraying on Tobique stocks measured as per cent of what these stocks would have been with no spraying. This "expected line is based on spraying done from 1953 to 1957, and was calculated after the 1957 spraying (Annual Report 1957-58, Summary No. 78). The two series of values show a high degree of correlation. There was, however, a notable drop of actual runs below the general trend in 1957. In this year construction operations of the Beechwood dam seriously impaired salmon runs to upper areas including the Tobique River. Also 1957 was the year of return for surviving underyearlings of the first and extensive 1953 spraying, as 3-year-smolt grilse and 2-year-smolt 2-sea-year salmon, the groups which together constitute the greatest return from a given year-class, and would probably be most seriously affected by spray programs on several northern New Brunswick salmon streams. Many of the progeny from this small 1957 run of spawners were sprayed as underyearlings in 1958. It might thus be expected that 1962 would see an even smaller run of adults of the two age groups noted above. The run, estimated as noted above, was 288 fish.

It appears that the recent decline in Tobique salmon is closely associated with DDT spraying, but that the construction phase of Beechwood dam, in 1957, gravely reduced

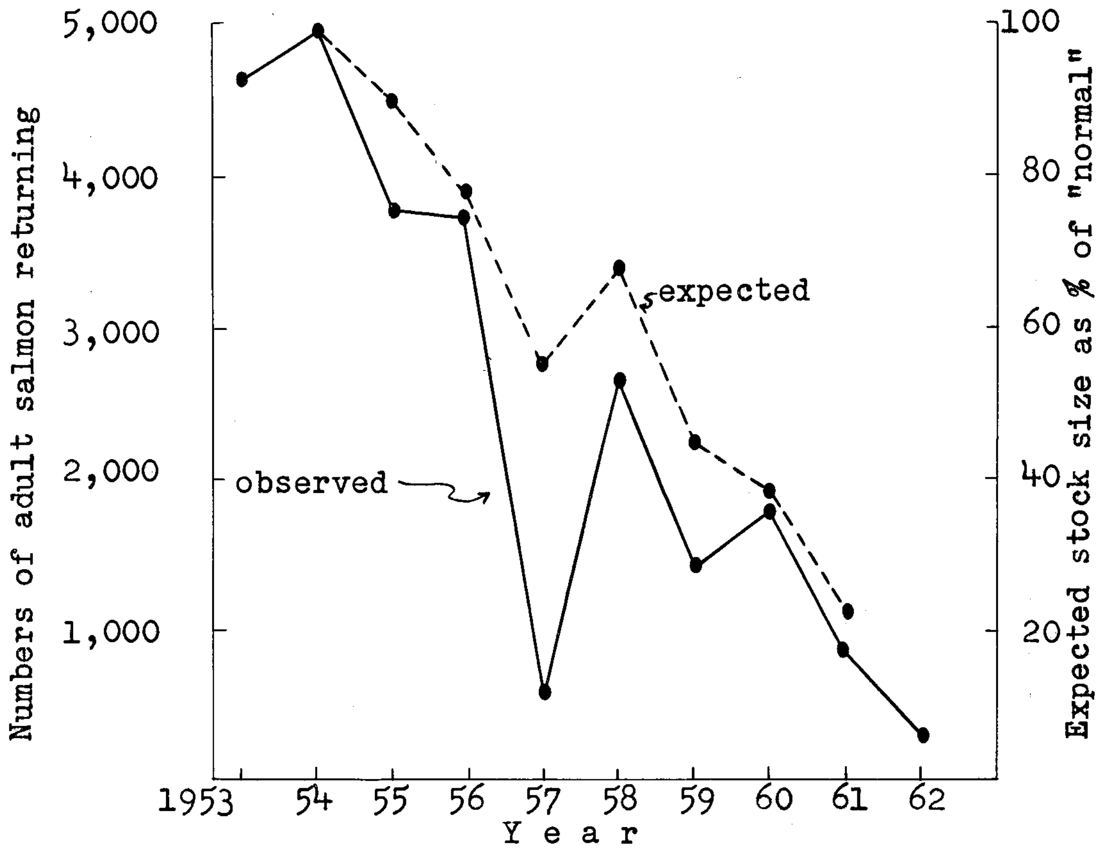


Figure 1. Solid line - observed stock size (= number through fishway + 60% of number trucked up from Beechwood) of Tobique adult salmon. Broken line - expected stock size calculated as percentage of what it would have been without spraying in the years 1953-57. "Expected" was calculated from proportion of drainage basin sprayed, observed effects of DDT spray in killing various sizes of young salmon, assumption of largely 2- and 3-year smolts, and assumption of adults returning in ratio of 2 grilse to 1 large salmon as indicated from Tobique fishway and Saint John angling catches up to 1957. 1957 adults are believed largely from first spraying of underyearlings in 1953. They were delayed by Beechwood dam construction in 1957. Their progeny were sprayed as underyearlings in 1958 and should have returned largely in 1962.

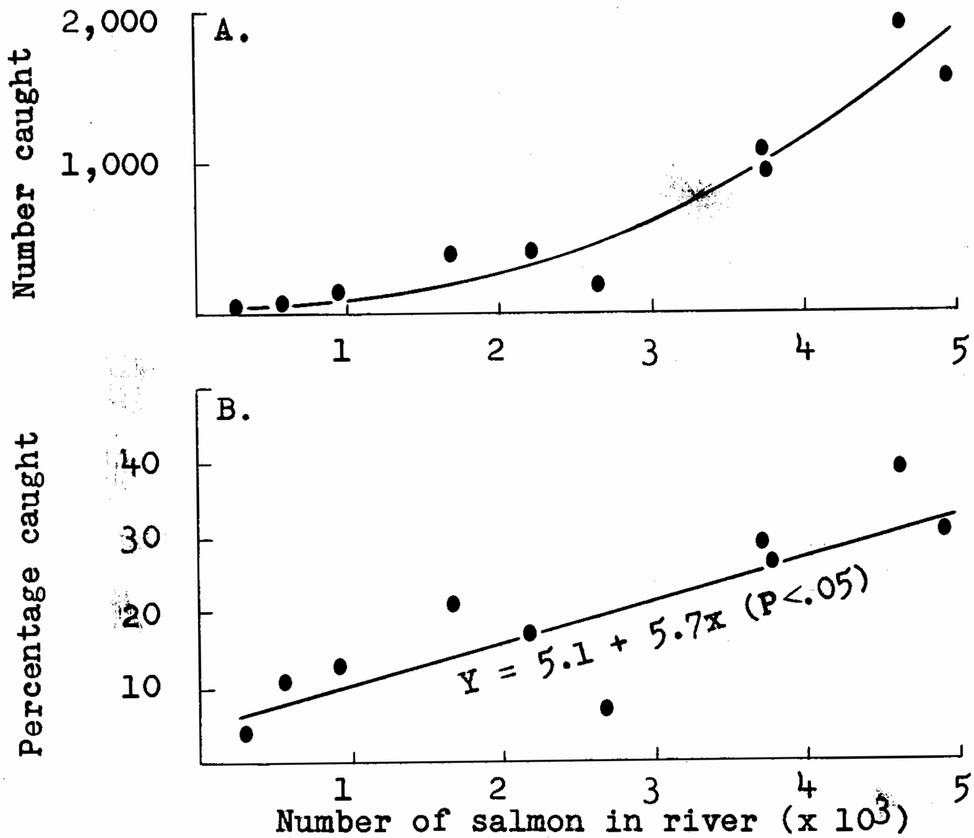


Figure 2. Salmon caught by angling in relation to total number entering river.
A - Numbers caught.
B - Percentage caught; the straight line fitting these points has the equation $Y = 5.1 + 5.7x$, i.e., angling catch with under 1/5 of "normal" abundance is about 5%, but increases by about 6% with each increase of about 1/5 up to "normal".

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spawning in one year.

There has been no spraying recorded on this watershed since 1958. Hence it may be expected that, aside from effects of the 2 hydro-electric dams, Tobique salmon populations should increase noticeably by 1963 with the advent of the two age-classes noted above from a fairly good spawning run, little taxed by angling, in 1958.

(b) Stock and angling success in the Tobique River.

The effect of forest spraying on salmon angling success was discussed last year (Annual Report 1961-62, Summary No.69(g)).

The graphs accompanying that report illustrated an expected decline in salmon abundance resulting from DDT spraying. They also showed actual angling success in terms of catch per rod-day relative to the 1949-54 average being taken as 100 per cent. For several of the streams studied including the Tobique, angling success closely paralleled the expected decline in stocks.

It is well known that salmon angling success depends in part on such environmental factors as river discharge and water temperature. Some measure of its dependence on abundance of fish is evident from recent records for the Tobique River. Here, since 1953, all salmon have entered the river either through the Tobique Narrows fishway where they are counted before release above, or by being trucked up from the Beechwood dam to above the Tobique fishway. The relationship between numbers in the river and numbers taken by angling is shown in Figure 2A. Figure 2B shows the catch in terms of per cent of numbers present. With more fish present, not only a greater number, but also a greater percentage of available fish were taken. To quite an extent these results doubtless reflect the fact that good fishing attracts more fishing, and that with many fish present the chances of an angler encountering fish along a river are enhanced.

The above observations also imply that when fish are very scarce, restrictive regulation will have relatively minor value for saving spawning stock.

2. Sea populations and commercial netting success

As discussed above, angling success appears to give a gross indication of the size of stocks of Atlantic salmon in a river. The fact that commercial recaptures of salmon tagged at sea show some order of constancy, indicates that there is also a broad relationship between commercial catches and magnitude of sea stocks. It is apparent from records of commercial catches for the Gulf Area (roughly, Cape Gaspé in Quebec to Cape North in Cape Breton) that the Miramichi area contributed about 3/5 of the total catch for this area until the mid 1950's. It seems reasonable to assume that the Restigouche system, with a drainage area about 3/4 as large as the Miramichi, and the Miramichi together contributed about 4/5 of the total Gulf catch. These two systems received extensive spraying in the years between 1953 and 1958, and damage to stocks appears to have been well demonstrated by examination of the effects on young and confirmed by association of low angling catches in the years following spraying. It does, then, seem likely that this spraying must also have had effect on commercial fishing dependent on the stocks of these streams.

In Figure 3 commercial catches for the Gulf area from 1920 to 1962 are indicated by the heavy solid line. The

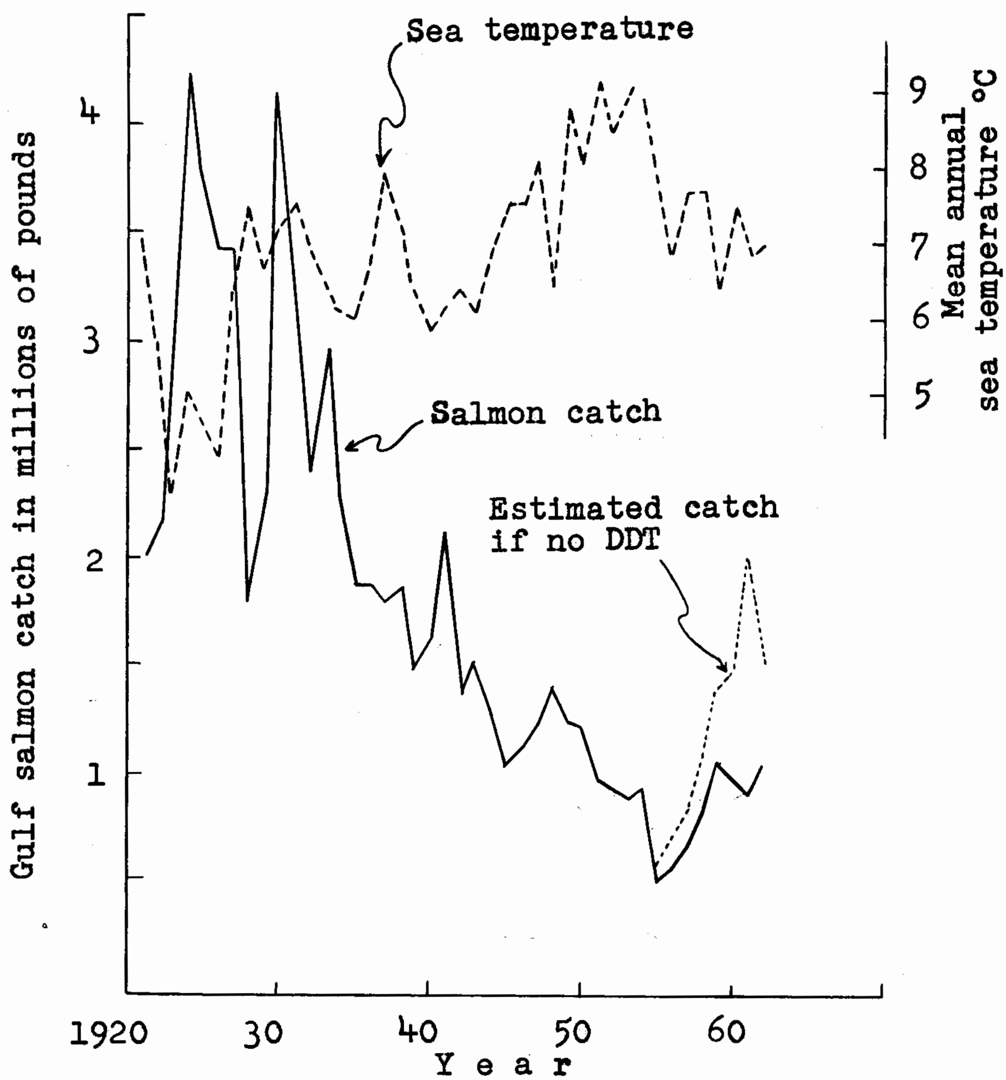

Figure 3. Heavy line - commercial salmon catches in the Gulf of St. Lawrence area, i.e., Cape Gaspé in Quebec to about Cape North in Cape Breton; dotted line - estimate of what these catches would have been in recent years had Miramichi and Restigouche stocks not been subjected to DDT spraying; broken line - mean annual surface sea temperature at St. Andrews, New Brunswick.

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broken line indicates the course of mean annual sea temperatures for the same period. These were recorded at St. Andrews but have been shown to reflect also conditions in the Gulf of St. Lawrence and elsewhere. As pointed out in the Annual Report 1955-56, Summary No. 62, size of commercial catch appears to be correlated with sea temperature ($P<.01$). For recent years catch and temperature appear to continue this inverse relationship, except that in the last 5 years or so catch has risen only by a small amount whereas, if the temperature relationship is real, it should have climbed to about the level of the mid 1940's. The dotted line joined to the solid catch line in Figure 3 was derived by assuming that associated commercial catches would be decreased as a result of DDT spray in proportion as the river populations of adults contributing to the fisheries, were affected (Annual Report 1957-58, Summary No. 73). This correction is based on the area of streams sprayed and the expected time of returning adults. At this writing no attempt has been made to separate adults returning as 2-sea-year salmon from those returning as grilse which are not taken commercially. To compensate for this, the dotted line allows for only half of the lost stocks being a loss to commercial fisheries. Nevertheless, there is a suggestion that in the last 4 years, catches would have risen to the levels of the 1940's except for damage done by forest spraying, which appears to amount to a loss of between 1/2 million and 1 million lb of commercially-caught salmon per year.

P. F. Elson

No. F-8

ENCROACHMENT OF INDUSTRY ON PRODUCTION IN A SALMON STREAM

The Northwest Miramichi River has long been noted as a salmon angling stream. Up to 1953 it remained in a comparatively unchanged state as far as impact of modern forest-harvesting techniques or other aspects of natural resource development were concerned. Previous to this time the upper 2/3 of the stream was accessible only on foot or by horse-and-wagon transport. The forest was cut off in small blocks from time to time but with about 30 or 40 years intervening between cuts on any one part. Logs were floated down the river in spring high water, there being no large driving dams. In the intervening years about its only visitors were salmon anglers, travelling in by portage wagon, and occasional hunters and trappers.

In 1951 the Board entered a program of systematic annual censusing of young salmon in the river. This was based on electroseining at 10 sampling stations scattered along the river, the same stations being used year after year.

In 1954 modern large-scale lumbering operations began with the opening of truck roads to the headwaters and the establishment of large lumbering camps. The whole basin was sprayed with DDT (1/2 lb per acre) to stave off damage to the forest by spruce budworm. In the next few years the valley was

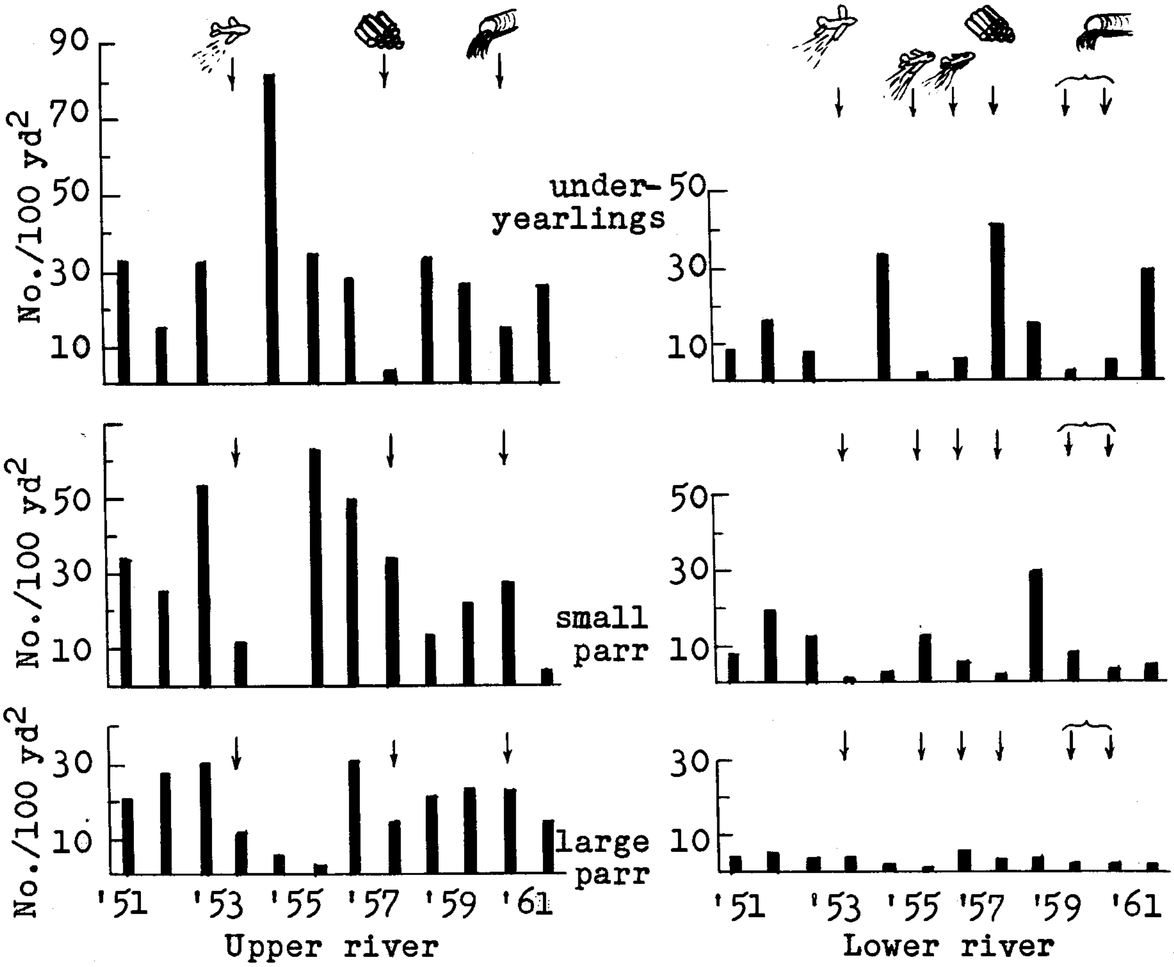

Figure 1. Populations of young salmon in the upper and lower parts of the Northwest Miramichi River as estimated from electroseining. Underyearlings are fish hatched in the year indicated; small parr are mostly yearlings, but can be older, and 10 cm or less in total length; large parr are mostly 2-year-olds, but can be older or 1-year-olds, and are over 10 cm long. Figures for upper river are averages of 3 stations, except in 1951, 2 stations; figures for lower river are averages for 4 stations except in 1951, 3 stations; 1954, 1 station; 1958 and '62, 2 stations. Values given are average numbers per 100 sq yd of stream bottom. Symbols: plane = DDT spraying; pile of pulpwood = stream blockage below upper stations in autumn, 1958; drain-pipe = base metal mine effluent in 1960 and '61.

extensively cut off for timber and pulpwood, to the extent that many patches were bared of (dominant forest type) coniferous trees more than a few feet in height. In 1956 and 1957 the lower part of the river was again subjected to spray. In the fall of 1957 pulp-harvesting operations in a time of low water resulted in a partial barrier to upward-moving adult salmon just below the lowest of the 3 upper sampling stations. In the summer of 1960 and in 1961 heavy metal-carrying mine-sump water was discharged into the river via a tributary entering just above the uppermost of the 4 lower stations.

Year-to-year changes in the densities of young salmon populations in 7 of these stations are illustrated in Figure 1. In years of spraying fish-of-the-year are absent or very scarce in and below sprayed areas; a scarcity of these year-classes continues evident in the first and second years after spraying. Note however that there may be some small and large parr in the following years because of slower- or faster-growing fish. The mechanical blockage of the upper river to 1957 spawners is evident in the small number of underyearlings in the upper part in 1958 with particularly good numbers in the lower part, indicating that some of the fish which failed to reach the upper part did spawn below. Similar relative densities of small parr in 1959 continue to show the effect of this blockage. Such a forced shift in populations is not advantageous if it prevents the upper part from being fully utilized and places an excess number of fish in the lower part. In the present instance the greater numbers of small parr in the lower part in 1959 did not appear as corresponding numbers of large parr in 1960. This is associated with poisonous mine effluent throughout the summer of 1960, which appears to have seriously reduced fish of all groups in the lower part. The same condition is known to have hindered upward migration of spawners in 1960. This fact shows in reduced numbers of underyearlings in the upper part in 1961. But in contrast to the 1957 pulp blockage situation, there were not greater numbers of underyearlings in the lower part in 1961, because fewer fish spawned here in 1960. Throughout 1961 the condition was somewhat ameliorated and there were moderately good numbers of underyearlings throughout the river in 1962.

It is to be noted that the adverse effects of each of these 3 factors for underyearlings has been drastic in the year of occurrence, but that there is some tendency for the effects to be partly ameliorated for the larger fish, and thus presumably for smolt production in any one year, by variable growth rates. It should also be noted that recovery of population strengths has been comparatively rapid once the harmful factor was removed. Such rapid recovery could scarcely occur, however, if similar catastrophes were to re-occur immediately to the progeny of a previously affected generation of salmon.

P. F. Elson

No. F-9

MARGAREE MERGANSER CONTROL STUDY

The second phase of an experiment to evaluate the effect of controlling merganser predations on young salmon in a stream upon associated salmon fisheries has been entered. Following 5 years of base-line study there, control of mergansers on the Margaree River system, Nova Scotia, was started on August 1, 1962. Because of high water conditions it was not possible to complete the usual censusing of young salmon at several stations in this stream and the adjacent Middle River before August 1. After this date a combination of high water and pressure to maintain control operations militated against completing the program. The one station completed on a Margaree tributary did not show materially different fish populations from the preceding 5 years.

The study involves the co-ordinated participation of several agencies.

The Canadian Wildlife Service will continue to monitor merganser populations by periodic surveys, at least until a valid comparison is established between earlier Wildlife records and the control operation records being maintained by the Board. This Service will also continue its studies of mergansers in adjacent areas, including some banding to further elucidate the relations between merganser populations on various streams.

The Fisheries Research Board is assuming primary responsibility for mounting and maintaining the control operation, recording, analysing and reporting results.

The Department of Fisheries, Protection Branch, is providing the year-round services of 2 men, together with essential items of their equipment such as guns, rubber boots, camping equipment, a canoe, and an outboard motor-boat as needed on the estuary and Lake Ainslie. There is also arrangement for occasional assistance by the local Fishery Officer and one additional Warden if occasion arises. This Service is also providing, through arrangement with Nova Scotia, an overnight camp midway up the head-water section. It is hoped that another overnight shelter can be provided near the head of the area to be patrolled in summer.

The Fish Culture Development Branch has provided storage and working space at the hatchery, as well as steel screens, for a smolt-counting trap on Ingram Brook. This Branch is also providing hatchery-reared smolts for tagging to contribute additional information on smolt-adult returns.

The Nova Scotia Department of Lands and Mines, through its Director of Wildlife Conservation, defrayed half the cost of the smolt trap framework. It has provided the assistance of one man and a car throughout the control operation. It undertook the opening of foot-trails along the upper river with a crew of unemployed miners. The Province also facilitated maintenance of previous salmon fishing seasons to assist in evaluation of the bird control study and agreed to forego closure of the Northeast headwaters to angling for the duration of the study.

On the Southwest branch, and on the Northeast as far as the head of settlement, the control operation is proceeding as planned with some minor exceptions. Patrol on the Southwest has been largely restricted to travel by car and foot pending more canoeing experience by field personnel. On this narrow, rapid stream it will also be necessary in future to assure that all gaspereau weir stakes, etc., are removed as soon as this fishery is over to permit safe canoeing. It is also likely that early reduction of broods on Lake Ainslie and its feeder streams will give better protection to Southwest salmon.

On the Northeast above the head of settlement, winter patrol is not safe because of heavy snowfall and steep-sided gorges. The desired regularity of open-season patrol will depend on whether reasonable facilities for frequent crossing of the river, perhaps by rope slings, can be arranged. Observations in 1962 strengthened opinion on the desirability of providing protection from mergansers up here. Below the head of settlement systematic patrols have been maintained with success, except as winter road conditions have been a hindrance. The desirability of a 4-wheel drive vehicle, not yet obtained, to facilitate winter patrol on the lower reaches and spring-to-autumn control on headwaters is becoming more evident.

The August 1 commencement of control was late enough to allow some of the young birds to attain flying ability. During the first month 75 mergansers were shot out of 111 seen on the river. As expected there was a considerable influx of autumn migrants, but the constant patrols seem to have kept these birds to much lower levels of resident abundance than formerly. Recent activity of the control crew indicates a population of 20-30 mergansers on river and estuary through January, with a decrease to 15-20 towards the end of February. These birds spend much time on the estuary but their numbers appear to be decreasing as birds are shot on open-water reaches upriver. It is estimated, roughly, that the system could support a year-round population of 15-20 mergansers with little or no detriment to its salmon-rearing capacity, but that a year-round population of 45-60 birds on the freshwater reaches would preclude benefits from any concomitant bird control. Present operations seem to be holding merganser populations well towards the lower limit. The expected almost total elimination of mergansers from June to September should give some leeway in respect to permissible predation from heavy spring and autumn influxes.

P. F. Elson

No. F-10

REGULATION OF BUOYANCY IN YOUNG SALMON

This work is a continuation of that reported earlier (Annual Report 1961-62, Summary No. 71). Preliminary field experiments established that salmon parr from slowly flowing water are more buoyant (have a lower specific gravity) than those from rapidly flowing water. This results from different degree of swimbladder filling.

It was found in the laboratory that initial filling of swimbladders of alevins could be delayed by holding the fish in fast currents. Filling of swimbladder was delayed as much as a week in alevins in fast water as compared with controls in still water. Most of the alevins in the fast water experiment filled swimbladders during a night when the current was accidently reduced. It is likely that initial filling could have been delayed much longer in a steady, fast current. It is possible that delayed initial filling of swimbladders may protect young salmon from being swept downstream during spring freshets occurring when alevins are emerging from redds.

Comparison between the buoyancies of smolts and parr in a number of individual tests with different current velocities revealed that smolts are usually more buoyant than parr. Difference in size between smolts and parr was ruled out as the reason for greater buoyancy of smolts. A number of tests using widely different sized parr showed no difference in buoyancy between small and large parr. The greater buoyancy of smolts may influence their downstream movement to sea.

R. L. Saunders

No. F-11

THE MOVEMENTS OF YOUNG SALMON WITHIN A SMALL COASTAL STREAM

This study was an attempt to determine the extent of movement of salmon fry and parr in a small coastal stream. Fish were captured and released within a 1,000-ft study area and their locations at various times were observed during the period August to December, 1962. Serially numbered tags were attached to parr. Fry from three widely separated sections within the study area were differentially marked by fin-clipping. For simplicity in describing movements, the places of original capture of individual parr are called their homes.

About two thirds of the parr tagged were subsequently recaptured. Most recaptures of parr were in or near their respective home areas. In most instances, parr tagged in pools were recaptured there and those tagged in riffles were recaptured in their respective riffles, even when these different habitats were closely adjacent. It appeared that the movements which did occur between pools and riffles were induced by changing water level; low water reduced the riffle habitat and some parr moved to nearby pools.

Of 25 parr tagged and transported various distances from original places of capture, 9 were recaptured subsequently. Seven of the 9 were found in their respective homes. One parr was recaptured in the area in which it was released and the other was found about 100 ft from the point of release. These observations show that salmon parr do home both up- and down-stream over distances as great as 700 ft.

Young of the year (fry) were found mainly within shallow riffle areas during August and September. During this period their movements appeared to be as restricted as those observed for parr. In the autumn or early winter fry left the shallow riffle areas and were found with parr in pools and rough-bottomed riffles where both apparently sought protection among rocks.

There was a marked reduction in fishing success starting in late September. Three suggestions are offered for this real or apparent decrease in numbers of young salmon: (1) they went into hiding among rocks and gravel of the stream bottom and were difficult to catch there; (2) predation reduced their numbers, or (3) they moved from unsuitable to more suitable areas for wintering or in response to the presence of spawning adults in the river.

R. L. Saunders
J. H. Gee

No. F-12

GROWTH OF SALMON PARR AND SMOLTS IN SEA WATER

Large brownish parr and silvery smolts from fresh water were tagged and placed in a large cylindrical tank where the salinity of the water was gradually increased to <u>ca</u>. 30‰ during a week. All survived the gradual increase in salinity and all fed well a few days after being tagged. It was soon

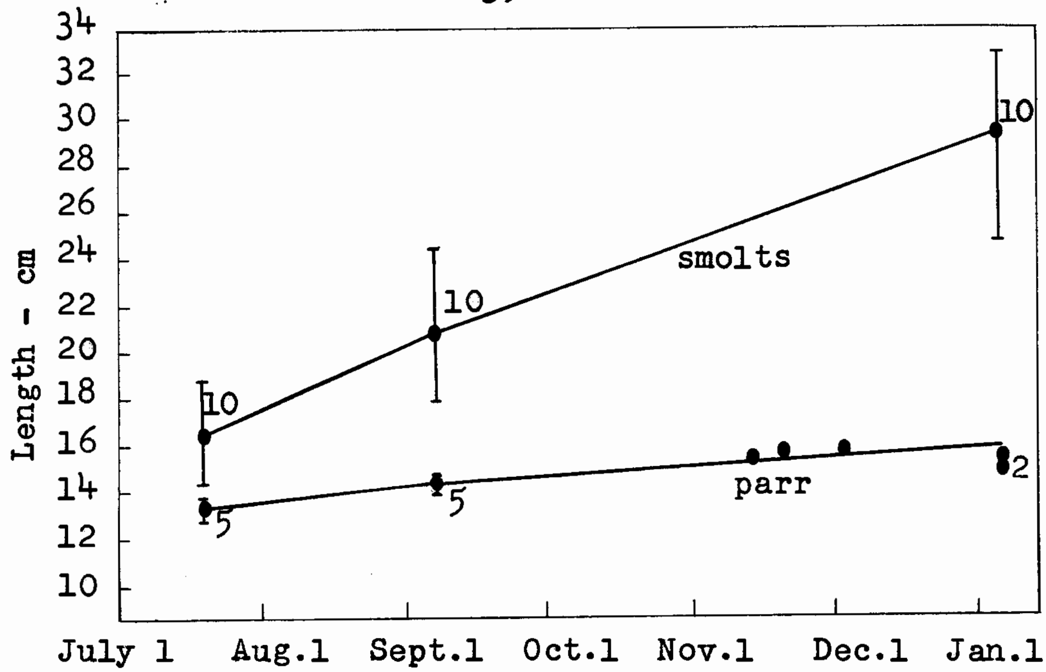

Figure 1. Average fork lengths of 5 parr and 10 smolts after various periods in sea water. The ranges in length and numbers of fish surviving are indicated. Lengths are indicated of 3 parr which died in November-December.

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obvious that the smolts were growing at a much greater rate than the parr (Figure 1). This suggests that the great increase in growth rate of smolts after they migrate to sea is not entirely owing to the greater food supply there, in comparison with the rivers in which they lived as parr, but their physiology is much changed from that of parr. It is possible that the metabolic cost of osmoregulation in smolts in salt water is lower than that for parr and that this allows more energy to be available for growth in smolts than in parr. Suitable experiments are being designed to test this idea.

R. L. Saunders

INSHORE COD PROJECT SUMMARY

	Number	Page
Oxygen consumption of cod	G-1	G-1 - G-2

No. G-1

OXYGEN CONSUMPTION OF COD

This work was completed during 1962. The results are given in a scientific paper which is to be published in the Journal of the Fisheries Research Board of Canada in 1963. The summary of that paper follows.

Rates of oxygen consumption of various sized cod were measured under different conditions of temperature and crowding and with starved and recently fed individuals. Some of the measurements of oxygen consumption (routine rates) were made with groups of from one to twelve fish in a mass respirometer while others (standard rates) were made with one fish at a time in a single fish respirometer. The effects of crowding and handling on routine rates of oxygen consumption were studied. A limited number of experiments were done to study the effect of low ambient levels of oxygen on the standard rate of oxygen consumption of starved fish.

1. Small cod consume oxygen at a greater rate per unit weight than do large ones. The slope of the regression line which relates the logarithm of fish weight to the logarithm of routine rate of oxygen consumption in mg/hr is between 0.79 and 0.89 in starved and between 0.76 and 0.83 in recently fed fish.

2. Rates of oxygen consumption measured in the single fish respirometer are slightly lower than those measured in the mass respirometer.

3. An increase in temperature brings about rises in the rates of oxygen consumption of starved and fed cod. There is a greater rise in the rate of oxygen consumption as temperature increases from 3 to 10 than from 10 to 15°C.

4. The rate of oxygen consumption of starved cod may be increased by from 40 to 90% by feeding them. The duration of this increased rate is from 4 to 7 days. Oxygen consumption of cod at 15° returns to the rate for starved fish more quickly than for those at 10°C.

5. Handling of cod may result in increasing the rate of oxygen consumption by as much as 70%. These increased rates for starved individuals subside to previously established routine levels in less than one day.

6. An effect of crowding is to reduce the rate of oxygen consumption per unit weight of fish. It is suggested that crowding reduces the space for movement with the

result that fish swim less and demand less oxygen than under conditions wherein they can be more active.

7. Although the rate of oxygen consumption is reduced slightly or not at all by lowering the ambient oxygen level from 10 to 3 mg/ℓ, the volume of water pumped over the gills (the respiratory volume) is markedly increased. It is suggested that such increased respiratory volumes place stress on the fish because the rate of oxygen consumption does not keep pace with the increased metabolic cost of irrigating the gills.

R. L. Saunders

POLLUTION STUDIES SUMMARIES

No. H-1

POLLUTION STUDIES

The first obligation of fisheries biologists working on water pollution is perhaps to answer the invariable question "What is the safe concentration of this material for fish?" During the past year almost all our effort has been concentrated on investigating the "safe" levels of zinc and copper for aquatic life. The problem is a practical one, with a new upsurge of activity in base-metal mines in northern New Brunswick.

Parallel investigations in the laboratory and in the field studied lethal effects and sub-lethal effects, especially avoidance reactions of salmonid fish. The field investigation was interwoven with that of the Anadromous Group in the Northwest Miramichi River, and the biological part of the data came in fact from their regular program. Effects of mining pollution on resident populations of young salmon are discussed in Summary No. F-8 of the anadromous fish investigation.

Another demand almost invariably made in cases of pollution is that someone should monitor conditions in the affected body of water. This may be done by chemical analyses or by caged fish, but if properly done, both methods are time-consuming and therefore expensive. It is hoped that a suitably simple system of invertebrate indicators can be developed to show the degree of heavy-metal pollution. Such a system might partially or completely replace chemistry and caged fish, since it could be used with small expenditure of time, and the invertebrates would serve as 24-hour-a-day, year-around monitors.

Invertebrate indicators are not mentioned in the summaries since it has not been possible to work up the samples of bottom fauna already collected. These samples are from the Miramichi system and are therefore associated with known chemical conditions. Pursuit of this subject remains a major aim of pollution studies.

J.B. Sprague

No. H-2

EFFECTS OF MINING POLLUTION ON THE MOVEMENTS OF ADULT SALMON IN THE N.W. MIRAMICHI R. IN 1962

In the summer of 1962, as in 1960 and 1961, unusually large numbers of adult salmon moved downstream through the Curventon counting fence. This unusual movement has been attributed to pollution, first noticed in 1960, from a base-metal mine near a tributary stream. Prior to 1960 movement of salmon in relation to the counting fence was predominantly upstream during this period. The relations between numbers of salmon moving up and downstream past the counting fence for the past nine years are summarized in Table I.

Table I. Movement of adult salmon past the Curventon counting fence.

Year	Number up	Number down **	Number down / Number up x 100
*1954	3,681	42	1.1
1955	3,534	69	2.0
*1956	1,362	27	2.0
*1957	1,581	45	2.8
1958	3,000	73	2.4
*1959	8,357	51	0.6
*1960	3,151	704	22.4
1961	1,764	242	13.7
*1962	2,466	246	10.0

* Fence washed out for various periods by floods
** Does not include kelts from the previous or present year's spawning.

In 1962 the counting fence was washed out on three occasions. It was inoperative for 17 days during the period 24 May through 27 October. It is likely that salmon moved past the fence during the periods of high water. The observed numbers of salmon moving past the fence in either direction are, then, lower than actual numbers. Although the available data suggest that downstream movement past the fence was much reduced in 1962 as compared with the movements in 1960 and 1961, it may have been greater than in these years.

An effort was made to learn where the salmon went after moving down past the counting fence. Of the salmon observed moving downstream during the last three years of study, 156, 54 and 133 were tagged in 1960, 1961 and 1962 respectively. The data pertaining to tagging and recovery are given in Table II.

Table II. Fates of tagged adult salmon after they moved down river through Curventon counting fence.

	Number of fish			Percentage of total		
	1960	1961	1962	1960	1961	1962
Subsequently ascended river past counting fence	70	22	27	45.0	40.7	20.3
Not heard of again in year tagged	64*	27**	96	41.0	50.0	72.2
Caught by angling or commercial net in N.W. Miramichi, at some point below Curventon fence	13	4	8	8.3	7.4	6.0
Angled in other rivers	9	1	2	5.7	1.9	1.5
	8 Sevogle R. 1 S.W. Miramichi R.	1 Sevogle River	1 Sevogle River 1 Little S.W. Miramichi R.			
TOTALS.	156	54	133	100.0	100.0	100.0

* Two caught in Northwest Miramichi commercial nets in 1961
** One large salmon caught in drift-net fishery in 1962

In 1962 a large percentage of the descending fish were not heard of after passing Curventon fence. It is likely that some of these fish did ascend the river again and were not observed because the counting fence was inoperative during severe freshets. On the other hand, it is also likely that fish were descending the river as they have been observed to do during high water periods which have been shown to be periods of heavy pollution level. Since large numbers of adult fish were observed to be descending the river during a time of year when little such descent was observed in 1959 and earlier, a safe conclusion is that in 1962, as in 1960 and 1961, considerable numbers of main-stem Northwest Miramichi salmon were lost from the spawning stock of that river.

R.L. Saunders

No. H-3

PHYSICO-CHEMICAL CONDITIONS IN THE NORTHWEST MIRAMICHI RIVER 1960 - 1962

To assess sub-lethal effects of heavy metal pollution in the Northwest Miramichi River, biological changes must be tied to chemical determinations. Chemical results for the years 1960-1962 have now been brought into a final form, and are shown in Figure 1. Besides serving as a record of degree of pollution, these results are also interesting since they show the seasonal changes in basic water chemistry, which are not well documented for rivers in the Maritime Provinces.

Temperatures shown in Figure 1 were taken at the Curventon counting fence during the warm season and are mostly for 8 a.m. and 5 p.m. each day. In 1962 the effect of the cold summer is noticeable in July and August temperatures. Hydrogen-ion concentration did not vary greatly, and was always within the limits of 6.0 to 8.0. The higher values were in the summer time, and pH dropped quickly during freshets, and stayed near 7 during the winter time. Specific conductance and total hardness are both measures of the mineral content of the water and show almost identical seasonal patterns. Soft water from rain storms or melting of snow causes hardness to drop off during freshets. The Northwest Miramichi River is certainly classified as "soft" water at all times of the year. Upstream of the Tomogonops it qualifies as "very soft water" (less than 30 mg/l) at all times of the year. The Tomogonops River contributes a considerable amount of calcium to the Miramichi; much of it probably results from lime added at the mine site. Volumes of flow after October 1, 1961, have been provided by the Department of Northern Affairs and National Resources but are as yet provisional. Flows before that have been estimated from water levels at Curventon counting fence. The flood in

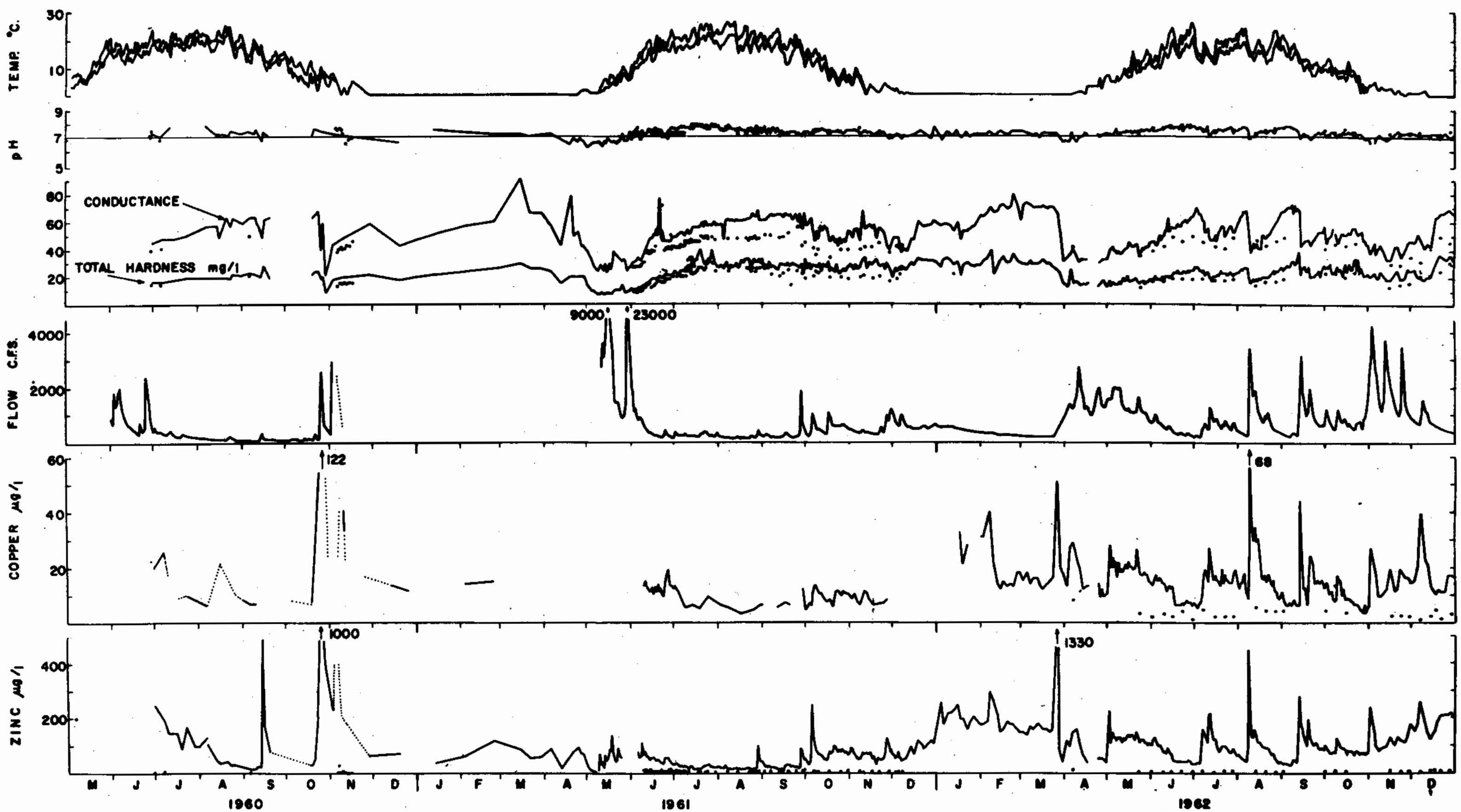


Figure 1. Physical and chemical conditions in the Northwest Miramichi River. Results for the section of river near Curventon are represented by lines. Results for the unpolluted section of river upstream of the Tomogonops River mouth are represented by circular points.

late May 1961 was exceptional and dislodged part of the bridge at Wayerton upstream from the counting fence. The freshet in early August 1962 was higher than ordinary at this season and was remarkably sudden, so that part of the counting fence was lost.

Copper and zinc show very similar fluctuations in 1962 when sampling frequency was good. They also fluctuate according to the flow, at least for the latter part of 1962. Apparently rain and freshets flushed out more material from the mine area. Degree of pollution seemed to be relatively well controlled in 1961. However zinc concentrations increased considerably in January 1962, when the mill was scheduled to start operations again. In the unpolluted section of the Miramichi, concentrations of copper were usually 5 µg/l or less while zinc was usually 10 µg/l or less. Both averaged 3 µg/l during 1962.

Besides serving as a base for showing effects of sub-lethal pollution on fish and other aquatic life, these chemical results are being distributed to interested groups as a monitor of the degree of pollution. In addition, this year-around picture of basic chemical conditions is surprising in its variability and teaches us to use caution in attempting to typify a river on the basis of one sample or a few samples.

J.B. Sprague
W.V. Carson

No. H-4

LETHAL CONCENTRATIONS OF ZINC AND COPPER FOR YOUNG SALMON IN THE LABORATORY

Determining lethal concentrations is a reasonable starting-point to show effects of a pollutant on fish. Results can be used, if necessary, to prove the cause of death of fish in natural waters. In addition, the "incipient lethal level" (the concentration above which the fish can no longer live for an indefinite period of time) is a useful reference-point for expressing the degree of pollution from the fish's point of view. For example, sub-lethal effects on growth might be found at 25% of the incipient lethal level (25% ILL).

Toxicity tests with zinc and copper have now been carried out at St. Andrews using young Atlantic salmon. Tests were done in water having a total hardness of 20 mg/l, and incipient lethal levels agreed very well with results for rainbow trout obtained at the British Water Pollution Research Laboratory. Therefore it seems likely that changes in toxicity for waters of differing hardness will parallel changes found in the British work. Estimated incipient lethal levels for young salmon are:

Water hardness, mg/l	Approximate ILL, ug/l	
	Zinc	copper
10	400	24
20	600	42
30	750	60
40	900	75
80	1,400	130

Incipient lethal levels were very sharply defined, and fish which survived the test concentration of metal for 50 hours apparently would live indefinitely.

When pH was raised above 8.5, zinc was for most practical purposes not lethal to salmon.

When tests were run at 5°C, survival-time in a given concentration of zinc was increased by about 4 times, which was more than expected. Furthermore at the lower temperature fish could survive in stronger concentrations of zinc. The ILL was raised from about 600 µg/l at 15° to at least 900 µg/l at 5°C. The British work on rainbow trout had indicated no change in the ILL for different temperatures.

When zinc and copper were tested together, there was potentiation of lethal action, that is, effects were more than additive. Fish died twice as fast as would have been predicted by adding the separate lethal actions. This was true even for concentrations of zinc and copper which were non-lethal when applied separately. It had been assumed last year that these metals were merely additive when expressed as fractions or multiples of the ILL, as had been found for rainbow trout.

It is unfortunate that these toxicity tests on salmon raised as many questions as they answered. It is clear that the simple British system used last year for "adding" lethal effects of copper and zinc, must be modified for Atlantic salmon because of potentiation. The effect of temperature in changing the ILL must also be taken into account.

J.B. Sprague

No. H-5

LEVELS OF ZINC AND COPPER AVOIDED BY YOUNG SALMON IN THE LABORATORY

Results from the Northwest Miramichi River indicated that salmon avoided sub-lethal heavy metal pollution. This

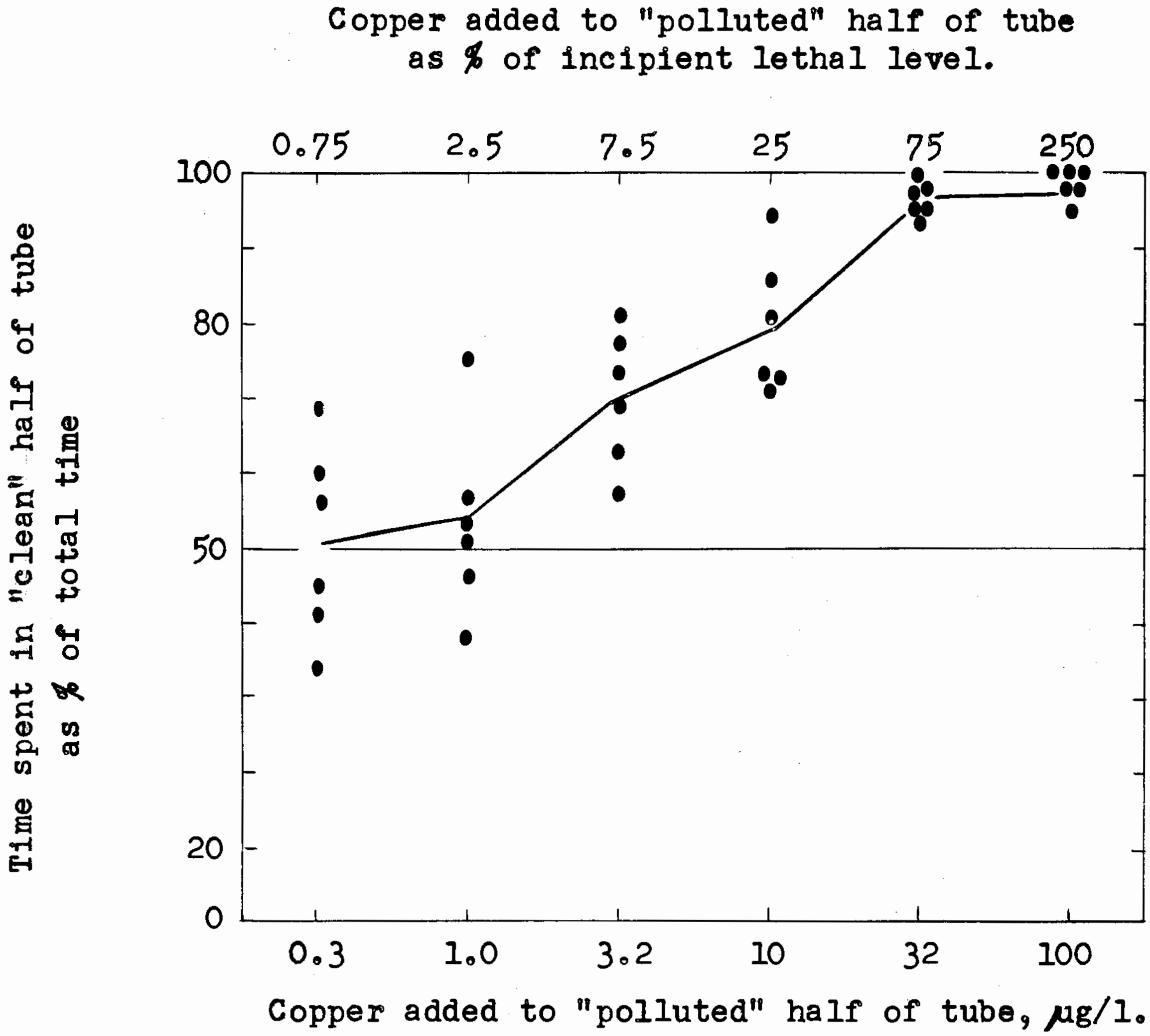


Figure 1. Avoidance of copper by Atlantic salmon parr. Six fish were tested individually in a large diameter tube which gave them a choice between clean water and water with copper added. There was about 2 µg/l of copper naturally present in the water besides that added to one end of the tube.

unique and interesting field experiment needed parallel experiments in the laboratory to be convincing. Indeed, a recently published monograph on water pollution makes it clear that some fish do not avoid copper.

Accordingly, avoidance reactions were tested in the laboratory by means of a long plastic tube about six inches in diameter. Equal flows of water entered at the ends of the tube, and passed towards the centre where they drained out. There was little mixing of the two waters in the tube, so the fish had a distinct choice when a known amount of metal was introduced into one flow of water. The fish's movement was recorded on kymograph paper during 10 minutes of active swimming. Use of random numbers decided which end of the tube should contain metal in each test.

Some results for avoidance of copper are shown in Figure 1. Observations were convincing - fish which entered the higher concentrations of copper swam frantically until they got out. Often they "backed up" quickly instead of continuing across the mid-line into the "polluted" end of the tube. Tests of statistical significance will allow an objective decision on the lowest level of copper which causes avoidance. Tentatively, there seems to be some avoidance at only 7.5% ILL, since each of the six fish spent more time in the "clean" end of the tube. This is only 3 μg/l of added copper, which is remarkably low. It is in fact the average concentration which is present naturally in the Northwest Miramichi River.

Zinc was tested and also seems to be avoided at concentrations in the vicinity of 10 or 20% ILL. Mixtures of zinc and copper were also tested. Detailed analysis will be necessary to show whether they potentiated each other, as in the lethal tests, or were merely additive.

These experiments show that young salmon can detect very low concentrations of metal, and certainly will avoid them. It should be remembered that there was no particular motivation for the fish to stay in either end of the tube. The results may not show, for example, the concentration of metal which would be required to move a fish from a territory which he was holding. Nor is there any proof that salmon parr and adults react in the same way. However, since the laboratory results correspond in general with conclusions from the field, they tend to confirm that downstream movements of adult salmon in the Miramichi are largely the result of avoidance reactions to metal pollution.

J.B. Sprague

No. H-6

LEVELS OF ZINC AND COPPER AVOIDED BY ADULT SALMON IN THE NORTHWEST MIRAMICHI RIVER

Last year it was estimated on the basis of salmon movements at the Curventon counting fence, that the "safe" level of metal pollution for migration was 15% of the incipient lethal level. This was assuming that the effects of zinc and copper were merely additive, and did not potentiate each other. Whether this assumption is valid should be clearer after analysis of laboratory experiments on avoidance. Since last year's report the chemical data for 1961 have been corrected (Summary No. H-3) and this may lead to revision of the "safe" zinc-copper level estimated from that year's information.

The results on salmon movements during 1962 are not entirely satisfactory as a field experiment on avoidance of metal pollution. As mentioned in Summary No. H-2, the counting fence was inoperative because of freshets for a total of 17 days, mostly during critical periods when pollution was high. What information there is for 1962 suggests that the "safe" concentration of metals is higher than estimated last year. It seems to be about 40% ILL, again merely adding together contributions by zinc and copper. It is possible that the unusual river flows in 1962 may also have influenced salmon movements.

It is intended to continue chemical analyses of metals at Curventon for one more year, to correlate these with salmon movements, and thereby attempt a firmer estimate of the "safe" level of pollution for migration.

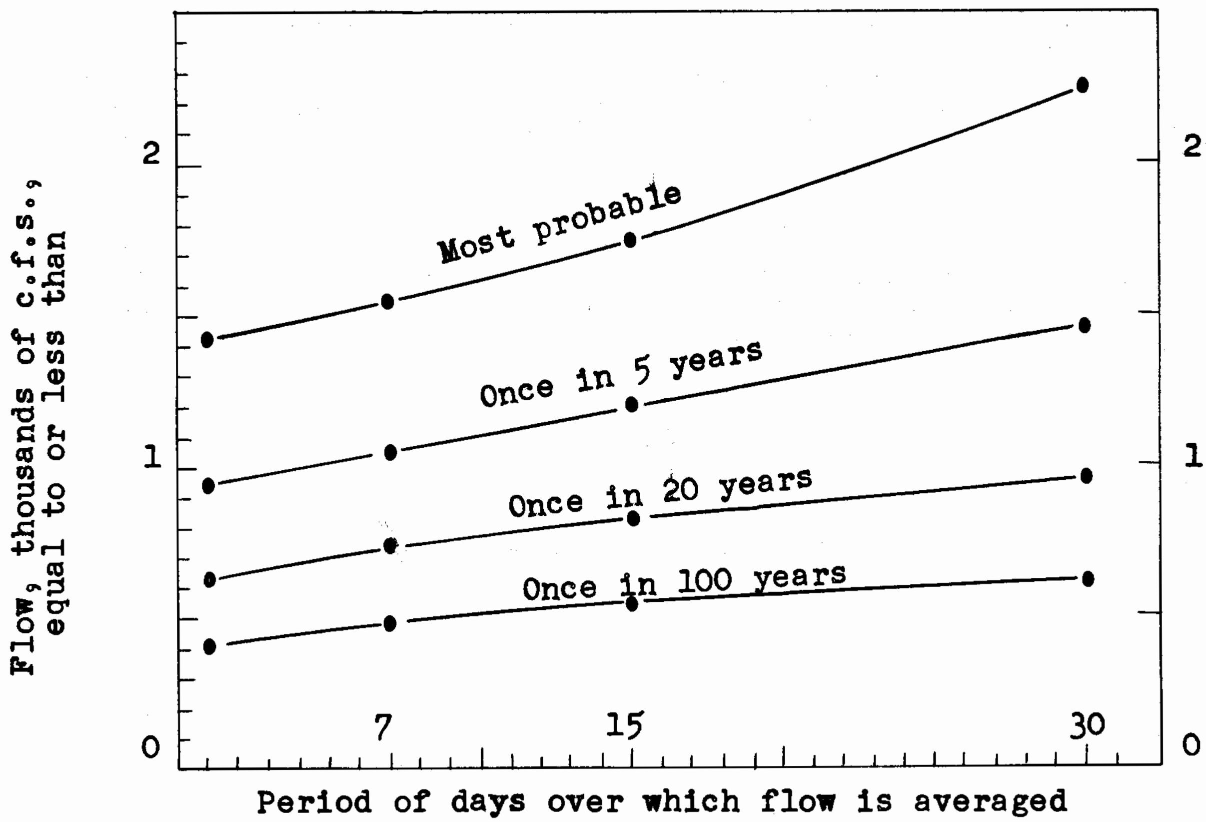
J.B. Sprague

No. H-7

EXTREME FLOWS IN THE SAINT JOHN RIVER

In order to reach logical solutions of problems of multi-purpose development of a river, one must have some idea of its flow characteristics. Two things which should be known are the size of the spring flood, and more interesting for fisheries management, the severity of low flow during the summer. Such knowledge, for example, gives some idea of reasonable flows of water through fishways at dams. It also allows a realistic appraisal of the amount of dilution available for waste-disposal.

An analysis technique using extremal probability paper has been applied to flows in the Saint John River. This method is straightforward and useful, but seems to be little used as yet among fisheries investigators. Spring freshets



Probable summer drought flows in the upper Saint John River at Fort Kent, Maine.

and summer drought flows have been tabulated for an upstream location at Fort Kent, and a downstream station at Pokiok. One set of results is shown in the above figure.

The values indicated for the "100-year drought flow" are extrapolated and perhaps are not estimated accurately by this technique. However, the picture is reasonably accurate and comprehensive for the shorter time-periods. As an example of interpreting the above figure, once in five years we would expect flows at Fort Kent to be so low for 15 days in succession that the average flow during this period would be 1,200 cubic feet per second or less.

To take a very practical example, National Health and Welfare made a pollution survey of the upper Saint John River in 1960, and found extremely bad conditions. The question was whether they normally occurred during most summers. By using the above figure and its supporting data, the answer can be supplied. The single-day low flow during the survey was

871 c.f.s., and this flow or an even lower one would be expected every 6.5 years on the average. The lowest 7-day average flow was 1,030 c.f.s. and this or a lower flow could be expected about every 5 years. The lowest average flow for 30 consecutive days during the survey was 2,020 c.f.s. and would be expected to occur every 2 years. Thus the flow conditions could not be considered very unusual.

Of course this system of analysing extreme flows does not predict what will happen next year - it might for instance be a 500-year flood. However, it shows what to expect on the average, and can thus be of some aid in management plans.

J.B. Sprague

FISHERIES OCEANOGRAPHY SUMMARIES

No. I-1

FISHERIES OCEANOGRAPHY

The aim of this investigation is to provide environmental information needed to study the natural fluctuations of the fisheries. The two main factors of the ocean environment, as related to fisheries, we have considered so far are the circulation and the water properties, temperature and salinity. These factors are being studied mainly in co-operation with other investigations at the Station: groundfish, pelagic, and lobster.

There are two systems of observations for each of the factors. A monitor system is established to follow the seasonal and year-to-year variations and in some cases the long-term trends. A survey system is worked out where biological and other oceanographic observations are taken at the same time.

Circulation

Emphasis is given to the surface and bottom circulation as indicated by drift bottle and sea-bed drifter releases and recoveries along the Canadian Atlantic coast from the Bay of Fundy to the Gulf of St. Lawrence. In the Bay of Fundy, the "open" circulation regime was featured in 1962. This regime seemed to start earlier than usual, however, the circulation was not as intense as in 1961. In St. Mary Bay, after a winter "standstill", the circulation of the surface waters out of this embayment seemed to occur earlier in 1962 than in 1961. These waters persisted in flowing along the Nova Scotia side of the Bay of Fundy, while a small portion only curved slowly towards the New Brunswick coast. The circulation off the outer coast of Nova Scotia seemed to be in small "cells" as inferred from local recoveries and the relative lack of long "travel".

In Northumberland Strait, the inferred eddies, observed during previous summers in the northern sector, seemed to persist in 1962. The change from a general easterly movement of the waters during the summer to a westward component during the autumn was more pronounced in 1962 than in previous years. The drift bottle work done in the eastern sector of the Strait revealed a fairly weak easterly flow. Except in the northern sector of the Strait where the average drift was computed as 3.7 miles a day, the drift in the rest of Northumberland Strait did not exceed 2 miles per day.

From Cabot Strait releases, the inflow along the Newfoundland coast towards Belle Isle Strait, seemed to weaken in the autumn and divert towards the Magdalen Shallows. The releases in the central portion of Cabot Strait indicate a predominant northeasterly drift for part of the summer and a southerly drift later in the seasons. Along the Cape Breton side of the Strait, the southerly drift seemed to persist at all times.

Bottom drift inferred from sea-bed drifter recoveries in the southwestern Gulf of St. Lawrence indicate a local circulation in the area between the Gaspé Peninsula and Orphan Bank superimposed to a southeasterly drift along the edge of the Magdalen Shallows. On the Scotian Shelf in Emerald Bank area, the bottom drift was observed to be predominantly to the west at an average speed of 0.7 miles per day. The sea-bed drifters released off Cape Sable and in the Bay of Fundy are subjected to fairly turbulent waters and very strong tidal current. The large number of recoveries on the beaches infer a certain amount of upwelling along the southwest coast of Nova Scotia and an "upstream" bottom current in St. Mary Bay and in the Bay of Fundy.

Other current measurements were made in Cabot Strait using radar drift poles for the surface and Pisa tubes on the bottom. The G.E.K. was also used. Forty-eight-hour tracking of drift poles showed a drift of 16 miles a day towards the south on Cape Breton side and 8 miles a day towards the north on Newfoundland side. At 180 metres, on the bottom, Pisa tube measurements over a period of 66 hours gave an average velocity of 0.11 knots at 130°.

Temperature and salinity

The coastal surface temperatures were monitored at six stations along the coast from the Bay of Fundy to the Gulf of St. Lawrence. The surface temperatures were below the long-term averages by 0.2 to 1.0°C. During the first six months of 1962, the surface temperatures were generally higher than those of 1961, which had been much below normal. The bottom temperatures observed at three coastal stations were below average during 1962 with a greater departure from average in the Halifax region than in the Bay of Fundy area.

Summer and winter temperature conditions on the offshore banks of the Scotian Shelf and in the Cape Breton area were studied for the period 1958-1962. The features of the central Scotian Shelf are the only ones reported upon. The bottom temperatures on the offshore banks are controlled by the thickness and depth of the intermediate temperature layer mostly during the summer season, they also vary widely with the seasons and from year-to-year. An estimate of temperature coverage shows, for instance, that more than 55% of the area had a bottom temperature lower than 4.0°C during summer and winter of a cold year (1959) and that less than 17% of the area had a bottom temperature lower than 4.0°C in an average year (1960). This type of analysis shows the necessity of a "base-line" such as the Halifax section in this area.

The continued study of temperature conditions along the western slopes of the Laurentian Channel shows a local systematic variation in the thickness of the layers from north to south during the winter season.

Temperature and salinity conditions have been studied in St. Mary Bay area, to relate the environment in the Bay with that of the surrounding waters. The marine climate of St. Mary Bay is of two types: one, which has been observed in the lower third of the Bay, is a slight modification of the conditions at the entrance of the Bay of Fundy, the other for the rest of St. Mary Bay, towards the head, is purely local with wide range of temperatures and salinities.

The conditions in the northern sector of Northumberland Strait during the open season of 1962 were such that the surface temperatures were generally below average and the bottom temperatures oscillating above and below average. The autumn overturn giving homogeneous conditions from surface to bottom occurred earlier than usual. The salinity stratification was less pronounced than usual, and the annual salinity minimum was somewhat below average.

Surface temperature data from Grande Rivière, Gaspé coast, for the last 22 years, are being analysed along with those of other points in the Gulf of St. Lawrence in order to define the marine climate and its local variations in the western Gulf of St. Lawrence. Daily temperature variations of the water column at the Station wharf are studied in function of the amplitude and time of the tide. These two items are not reported here.

Long-term variations

The cooling trend experienced since the beginning of the fifties is still continuing, with some minor year-to-year variations for both the surface and bottom temperatures.

Acknowledgements

Co-operation with Atlantic Oceanographic Group is gratefully acknowledged. Technical assistance, sea water analysis and BT processing is provided by the Group to the Station. The coverage of monitoring sections was made on a co-operative basis. Releases of drift bottles and sea-bed drifters were carried out by the various investigations at the Station and by A.O.G. The masters and officers of CPR Princess Helene, CNR Bluenose, Abegweit, and William Carson, of Sambro and Lurcher Lightships and Lord Selkirk have co-operated wonderfully in the task of daily releases of drift bottles. Oceanographic data have been collected by the various investigations at the Biological Station. Co-operation with Woods Hole Oceanographic Institution in the drift bottle and sea-bed drifter work is also acknowledged.

L.M. Lauzier

No. I-2

DRIFT BOTTLE RELEASES - 1962

During the year drift bottles were released from fixed stations and during various cruises along the Atlantic coast in certain determined areas. Releases at fixed stations were as follows:

a) 2 bottles once a day at Sambro Lightship and at Lurcher Lightship.

b) 2 bottles once a day at two stations from the ferry boat CPR Princess Helene between Saint John, N.B. and Digby, N.S. and from the ferry boat CNR Bluenose between Yarmouth, N.S. and Bar Harbor, Maine. In the summer time when the Bluenose schedule is accelerated, 2 bottles at two stations are dropped twice a day.

c) 2 bottles once a day from May to December at one station from the ferry boat CNR Abegweit between Borden, P.E.I. and Cape Tormentine, N.B.; at two stations from the ferry boat Lord Selkirk between Woods Island, P.E.I. and Caribou, N.S.; and at three stations from the ferry boat CNR William Carson between North Sydney, N.S. and Port aux Basques, Newfoundland.

d) 8 bottles at each of six stations, once a month between Saint John, N.B. and Digby, N.S. on CPR Princess Helene and also between Yarmouth, N.S. and Bar Harbor, Maine on CNR Bluenose.

e) 24 bottles once a month on stations Prince 5 and 6.

f) 2 bottles each time the Pandalus occupied stations 3, 5 and 18 in the Prince Edward Island area.

The releases during the cruises varied from 5-48 per station depending on the area. The cruises during 1962 covered areas in the Bay of Fundy, St. Mary Bay, Western Nova Scotia, and the Scotian Shelf.

Table I. Drift bottle releases and recoveries, fixed stations, 1962

Station	Period	Releases	Recoveries	Percentage
Sambro Lightship	Jan.-Dec.	636	43	6.8
Lurcher Lightship	Jan.-Dec.	622	69	11.1
Princess Helene Station #1	Jan.-Dec.	578	55	9.5
Princess Helene Station #2	Jan.-Dec.	578	44	7.6
Princess Helene Special	Jan.-Nov.	528	50	9.2
Bluenose Station #1	Jan.-Dec.	657	33	5.0
Bluenose Station #2	Jan.-Dec.	648	19	2.9
Bluenose Special	Jan.-Dec.	440	32	7.3
Pandalus Stations 3, 5 and 18	May -Nov.	162	96	59.0
Prince Station #5	Jan.-Dec.	284	44	15.5
Prince Station #6	Jan.-Dec.	282	97	34.4
Abegweit	Jan., June-Dec.	368	150	40.8
Carson Station #1	Jan. Feb. June-Dec.	422	47	10.0
Carson Station #2		422	26	6.1
Carson Station #3		422	23	5.5
Selkirk Station #1	May -Dec.	390	94	24.0
Selkirk Station #2	May -Dec.	390	118	30.3
TOTAL		7,829	1,040	13.2

Table II. Drift bottle releases and recoveries, Cruises 1962

Station	Month	Area	Releases	Recoveries	Percentage
HS-37	April	St. Mary Bay Bay of Fundy	252	50	19.8
HS-38	July	St. Mary Bay Bay of Fundy	229	67	29.2
HS-39	July	Western Nova Scotia	144	9	6.3
HS-41	November	St. Mary Bay Bay of Fundy	372	18	4.3
HS-42	December	St. Mary Bay Bay of Fundy	264	47	17.8
MPS-18	Feb.-March	St. Mary Bay Bay of Fundy	240	20	8.3
MPS-19	May	St. Mary Bay Bay of Fundy	228	70	30.7
MPS-20	May	St. Mary Bay Bay of Fundy	240	74	30.8
MPS-21	June	St. Mary Bay Bay of Fundy	180	32	17.8
MPS-22	September	St. Mary Bay Bay of Fundy	240	48	20.0
MPS-23	October	St. Mary Bay Bay of Fundy	252	29	11.1
ATC-53	April	Scotian Shelf	432	13	3.1
ATC-59	September	Western Nova Scotia	330	21	6.4
ATC-60	September	Western Nova Scotia	174	0	0.0
	TOTAL		3,577	498	13.9

As in the previous year, on the average, the largest percentage of recoveries were made from bottles released in the second quarter of the year i.e. April-June. Over the whole year the rate of recovery was maximum within the first three months after release. A breakdown of releases and recoveries are given in Tables I and II.

Co-operation of the masters and officers of the following ships is acknowledged: CPR _Princess Helene_, CNR _Bluenose_, CNR _Abegweit_, CNR _William Carson_, _Lord Selkirk_ and _Sambro_ and _Lurcher_ Lightships. The success of non-tidal drift monitoring network depends on their efforts and their interest in the drift-bottle program.

J.G. Clark
A.W. Brown

No. I-3

PRELIMINARY ANALYSIS OF DRIFT BOTTLE RECOVERIES

The 1,537 recoveries from 11,406 releases in 1962 show a general decrease in the rate of recovery from the 1960 and 1961 levels. However, there is an increase in certain areas, the most noticeable one is in the rate of recoveries from the releases made in Cabot Strait.

The purpose of the drift bottle program is to monitor the seasonal and the year-to-year variations of the surface non-tidal drift along our coast with emphasis in the Bay of Fundy area and in Northumberland Strait where plankton studies are being conducted. The analysis of recoveries from 1962 releases is made on the area basis.

a) _Gulf of Maine_, _Bay of Fundy_ and _Western Scotian Shelf_.

The maximum rate of recovery from the bottles released at fixed stations in the Gulf of Maine was recorded for those of the second quarter of the year, as in 1960. From _Lurcher_ Lightship releases and recoveries, the inferred northeast circulation towards St. Mary Bay and the Bay of Fundy seemed to indicate a more rapid through type of circulation in the last 2 years than in 1960. The proportion of bottles that reached the New Brunswick coast was high in 1962 as in 1961 compared to 1960. From _Bluenose_ releases at the two stations, the relatively low rate of recovery does not add much to the inference made from the _Lurcher_ Lightship releases and recoveries. It seems, however, that the strong circulation experienced along the coast of Maine during the last quarter of 1961 was still effective during part of the first quarter of 1962. Such a winter circulation had been observed in 1958, it was then stronger than in 1962.

The rate of recovery from the releases made in the Bay of Fundy during the second quarter was low in 1962 as compared to the previous two years. The proportion of recoveries made outside of the Bay of Fundy to the total recoveries was higher than in 1961 in the first three months of the year indicating that the "open" circulation regime started earlier than usual in 1962. The circulation from the Nova Scotia side of the Bay of Fundy to the New Brunswick side, as inferred from the drift bottle recoveries in 1962, seems to be stronger than usual.

In general the surface circulation regime in the Bay of Fundy during 1962 seems to be "open" starting earlier than usual, but not as strong as in 1961. The period of "closed" circulation during the winter season 1961-1962 seemed to be short as compared to previous winters.

The rate of recoveries from Sambro Lightship in 1962 was much below the 1960 and 1961 level. In 1962, the easterly movement of the coastal waters during the summer season, as inferred from recoveries east of Halifax, was much weaker than in the two previous years. In the westerly circulation during the other seasons in 1962 also differed from what has been observed previously. Most of the recoveries in 1962 were made within 50 miles of the point of release and only one bottle was recovered as far as St. Mary Bay and none was recovered in the Bay of Fundy or Passamaquoddy area.

b) St. Mary Bay

The contributions from surrounding waters to St. Mary Bay as indicated by recoveries from Lurcher and Bluenose # 1 releases, show a maximum in March-April 1962, this was a maximum of the actual rate of recovery and in the relative number of recoveries inside St. Mary Bay as compared to outside.

During 1962, 10 series of drift bottle releases were carried out in St. Mary Bay and the surrounding waters to study the surface non-tidal drift in the area, its seasonal and year-to-year variations, as one of the environmental parameters that might influence the distribution of herring larvae in the area. This study was started in September 1960 and will continue until spring or early summer 1963.

From the 1961 recoveries, a seasonal pattern of outflow from St. Mary Bay to outside waters has been shown. A similar seasonal regime is inferred from the 1962 recoveries, but it is somewhat out of phase with the 1961 pattern. In order to define this seasonal variation, the 1961 and 1962 data have been compiled by two-month instead of three-month periods as shown in previous analysis. In 1961, the maximum outside recoveries were attributed to May-June releases, while in 1962, they were to March-April releases. From November 1961 to February 1962, there was a significant outflow from

St. Mary Bay to outside areas. Another difference between the two years was observed in the area of recovery outside St. Mary Bay. In 1961 the recoveries on the Nova Scotia and New Brunswick sides of the Bay of Fundy were almost equal in number, but in 1962, they were almost twice as many recoveries on the Nova Scotia side as compared to those on the New Brunswick side of the Bay. This is in contrast with our previous conclusion that the circulation from the Nova Scotia side of the Bay of Fundy to the New Brunswick side seems to be stronger than usual in 1962. No explanation is offered, at this time, for such a difference.

c) Quoddy Region

During 1962, most of the recoveries in the Quoddy region from outside fixed stations have been recorded in August and September as compared to a longer period such as July to October in 1961 and June to October in 1960. The rate of recovery from all stations except Lurcher Lightship was also lower in 1962 than in 1961. The circulation into and out of Passamaquoddy Bay, as measured by the recoveries from Prince 5 and Prince 6 releases seemed to reach a maximum in late spring and early summer. However, from Prince 5 releases, the maximum rate of recovery was 31% in July-September. It was higher than in 1960 and 1961.

In 1962, the recoveries in Passamaquoddy Bay from St. Mary Bay releases were less numerous than in 1961 and the travel-time between the two areas was also longer in 1962 than in 1961, 45 days as compared to 25 days. We have calculated, from 1961 data, that only one-fifth to one-quarter of the bottles that are known to "leave" St. Mary Bay are recovered in Passamaquoddy Bay. Using 1962 data, this proportion is reduced down to one-tenth. This is in accordance with the general outside drift of St. Mary Bay releases in 1962, as a greater proportion of recoveries have been recorded on the Nova Scotia side than on the New Brunswick side of the Bay of Fundy.

d) Cabot Strait

For the second consecutive year, the non-tidal drift in the main opening of the Gulf of St. Lawrence to the ocean has been monitored by daily releases of drift bottles at three stations in Cabot Strait.

The rate of recovery very low in 1961 increased five-fold in 1962 with a maximum for releases made in June-July. The non-tidal drift, as inferred from the drift bottle recoveries, indicate an inflow into the Gulf of St. Lawrence along the west coast of Newfoundland up to the Strait of Belle

Isle at a speed that reach 8 miles per day, the speed of 5 miles per day is frequent. This flow predominant in the summer seemed to divert, to a certain extent, towards Magdalen Shallows in the autumn. From the center portion of the Strait, the waters seem to flow predominantly in a northeasterly direction for part of the summer and change to a southerly direction as the seasons progress. The bottles released on the Cape Breton side of Cabot Strait show a relatively low rate of recovery with a southerly flow at all times. The computed current speed of this last group of releases in Cabot Strait varies between 1 and 4 miles per day, which is much below the expected value. It should be remembered that the number of recoveries is relatively small and that the distance travelled is also short. Only one recovery was recorded west of Canso, N.S.

e) Northumberland Strait

Drift bottle releases in the northern sector of Northumberland Strait have been made from May to November during the last three years. A study of the surface circulation in this area was required as one of the environmental factors influencing the drift and consequently the distribution of lobster larvae. Additional drift bottle releases were made during the summer and autumn of the last two years in the central sector of Northumberland Strait in order to show if the northern sector is subjected to northerly flow of water from the central sector. The eastern sector of Northumberland Strait was studied at the same time as the central and northern sector in 1962 only.

A summary of recoveries from the releases in the northern sector during the period 1960-1962 is given in Figure 1. The total percentage recoveries from the *Pandalus* series vary between 52 and 59% depending on the year. The main features of the surface non-tidal drift as inferred from the drift bottle recoveries are:

1) There is a general movement of the surface waters from west to east and northeast within the northern sector of the Strait may be as part of eddy in a counter-clockwise direction;

2) a certain proportion of the water from the northern sector moves out of the area towards northern Prince Edward Island, the Magdalen Islands and Newfoundland;

3) in Northumberland Strait most of the recoveries are made on the Prince Edward Island side showing a predominant west-east circulation. However, in 1962 the recoveries along the New Brunswick coast were more numerous than in previous years, 27% of the recoveries in 1962 as compared to 6% in 1960 and 1961. The relative number of recoveries on the New Brunswick side has a tendency to increase in the autumn;

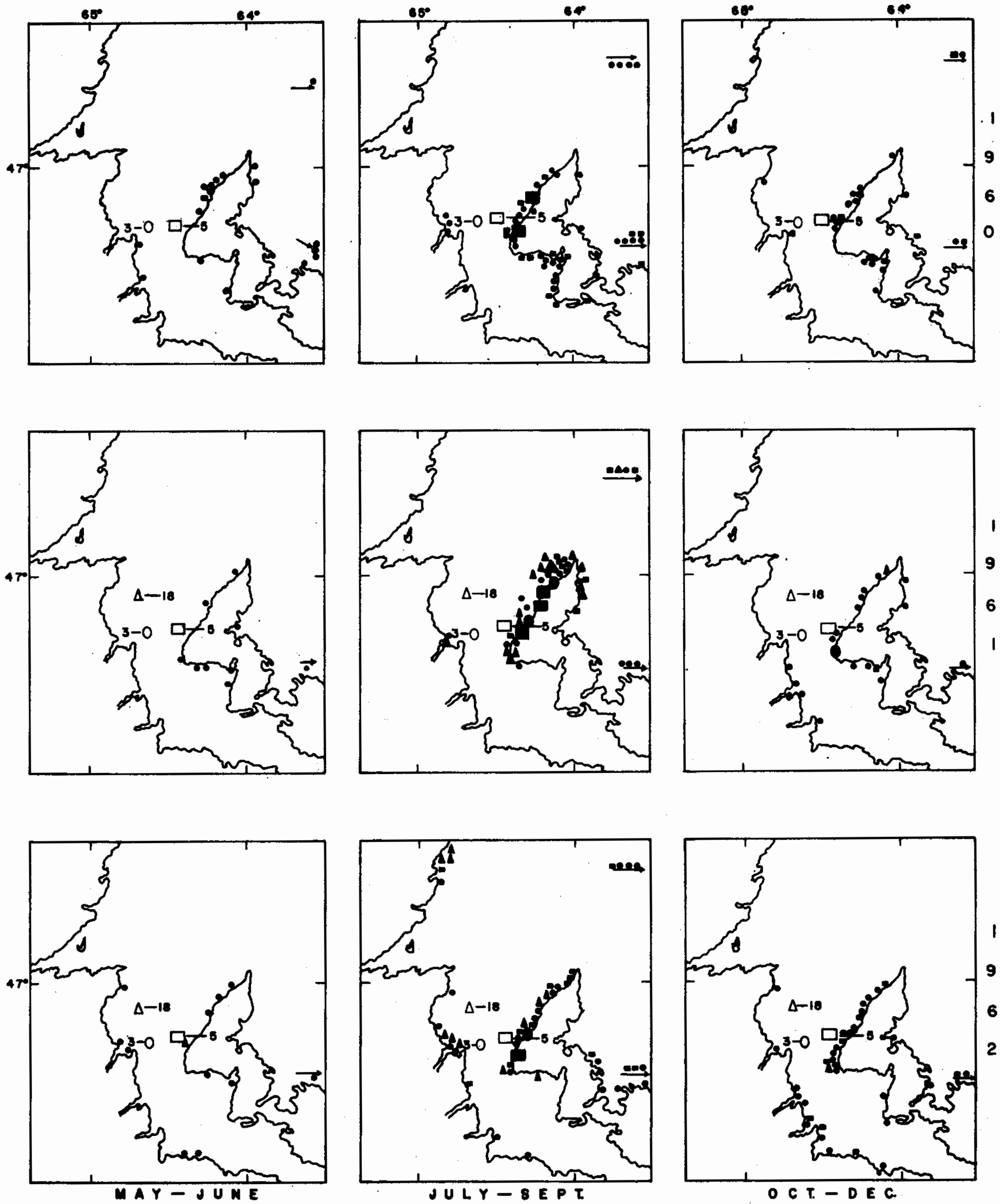


Figure 1. Drift bottle recoveries from the Pandalus series, stations 3, 5 and 18, in Northumberland Strait from May to December in 1960-1962.

4) the southerly movement past West Point, P.E.I., is inferred for a certain number of recoveries from 12% (in 1961) to 27% (in 1960) of all the recovered bottles. There is an indication of a second eddy (presumably clockwise) in the embayment between New Brunswick coast and Egmont Bay;

5) the southeasterly movement past Cape Egmont, P.E.I., and Cape Bald, N.B., is almost negligible, less than 2% of the recovered bottles or 1% of the bottles released.

The releases made in the central sector of the Strait, the Abegweit series, also exhibit a very high rate of recovery up to 52%. The main features of the circulation as inferred by the drift bottle recoveries are:-

1) The predominant circulation from the mainland to P.E.I. seems to weaken during the autumn as compared to the summer for both years. It was also less pronounced in 1962 than in 1961. Relatively more recoveries along the New Brunswick-Nova Scotia coast have been recorded in 1962 than in 1961.

2) A northwesterly flow into the Egmont Bay sector was not detected for either year since less than 1% (0.7%) of all the recoveries was recorded west of Cape Egmont. The rate of recovery of Abegweit bottles outside Northumberland Strait is equally low, 1% of all recoveries.

The releases in the eastern sector of the Strait, the Lord Selkirk series, show a reduced rate of recovery, 27%, as compared to the previous two series.

The predominant circulation from the mainland to Prince Edward Island is also one of the features of the waters in the Pictou area. The seasonal variation shown for both the central and the northern sector is even more pronounced in the eastern sector. The westward flow from the eastern sector into the central sector of Northumberland Strait was not detected since only 1.4% of all the recoveries was recorded west of Hillsborough Bay. However, the circulation from Pictou area eastward, out of Northumberland Strait, is significant since 11% of all the recoveries were recorded east of Port Hood, Cape Breton. In the area of releases, within 20 miles, there is no evidence of differential flow on the south side of the Strait as compared to the north side.

The three series of drift bottle releases and recoveries seem to indicate that we were dealing with three "stocks" that do not "intermingle". However, these bottles released in a relatively small body of water have a short average lifetime and are subjected to a very high rate of recovery. It is suspected that those released in the central section of the Strait do not have a chance to travel up or down the Strait. The average speed, as computed from 15-20 mile "trips" seems to vary from 3.7 miles a day in the northern sector, to 1.6 miles a day in the central sector. The corresponding speed in the eastern sector was 1.8 miles a day. In the same three areas, the Canadian Hydrographic Service recorded residual currents of somewhat lower strength between 1.1 and 1.3 miles per day. The present results suggest a change of plans in the study of surface non-tidal drift in Northumberland Strait by concentrating the effort in an enlarged northern sector including Egmont Bay and the area off Miramichi Bay using both drift bottles and radar drift poles.

L.M. Lauzier

No. I-4

SEA-BED DRIFTER RELEASES - 1962

A sharp increase of sea-bed drifter releases in 1962 as compared to 1961 resulted from extension of studies of bottom non-tidal drift from the Gulf of St. Lawrence to the Scotian Shelf and the Bay of Fundy.

Two different types of releases have been made during the year: repeated or monitor releases at fixed stations and releases during cruises. The releases at fixed stations were made as follows:

a) 3 sea-bed drifters once a day at 4 stations from the ferry boat CNR William Carson between North Sydney, N.S. and Port aux Basques, Nfld.

b) 6 drifters once a month at 5 stations across the lower Bay of Fundy between Grand Manan Island, N.B., and Brier Island, N.S.

During cruises, the sea-bed drifters were usually released en route at the rate of 6 every 5 miles. From January to December 1962, a total of 474 sea-bed drifters were released at fixed stations and 1,418 during cruises. A grand total of 204 drifters have been recovered as of December 31, 1962. A breakdown of releases and recoveries are given in Table I. The area of releases are shown in Figure 1.

Table I. Sea-bed drifter releases and recoveries 1962

Area			Period	Releases	Recoveries	% Recoveries
Fixed stations:						
Across Bay of Fundy			May-Dec.	366	55	15
Across Cabot Strait			Dec. 12-31	108	0	0
Cruises:						
RCN ships	Central Scotian Shelf	(D)	Jan.-Feb.	295	18	6
MPS-19	St. Mary Bay	(A)	May 5	64	42	65
MPS-20	St. Mary Bay	(A)	May 29	66	38	58
ATC-54	South of Cape Breton	(F)	April	108	1	1
	Gulf of St. Lawrence	(G)	April	54	0	0
	Gulf of St. Lawrence	(H)	April	108	17	16
S-63	Emerald Bank	(C)	June	120	0	0
	Banquereau	(E)	June	144	0	0
	Gulf of St. Lawrence	(I)	June	195	5	3
HS-39	off S.W. Nova Scotia	(B)	July	138	18	13
ATC-59	off S.W. Nova Scotia	(B)	Sept.	126	12	10

The letter in brackets refers to areas shown in Figure 1.

J.G. Clark
A.W. Brown

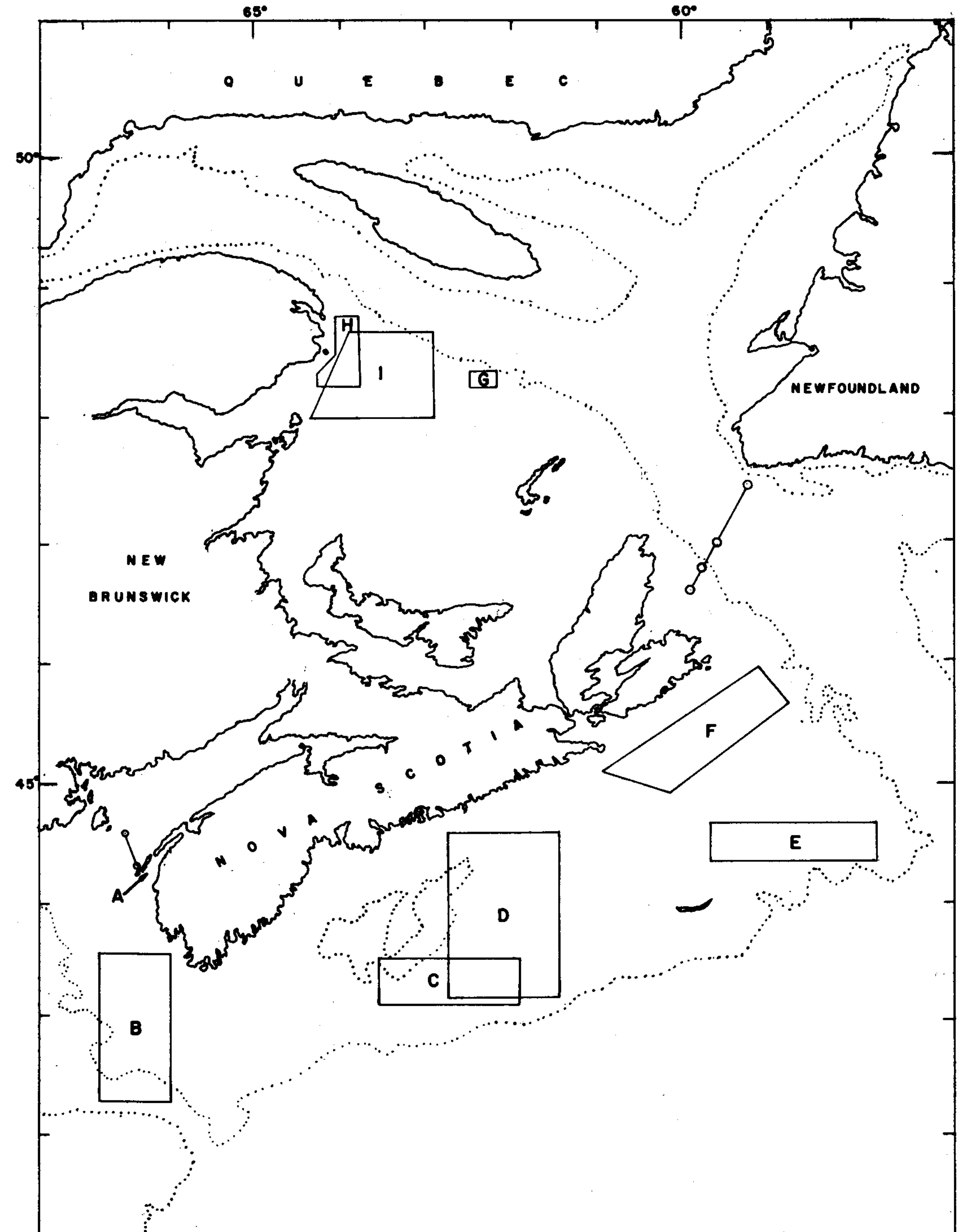


Figure 1. Areas of sea-bed drifter releases in 1962.

No. I-5

PRELIMINARY ANALYSIS OF SEA-BED DRIFTER RECOVERIES

The 1962 sea-bed drifter recoveries in the Gulf of St. Lawrence came from 1961 and 1962 releases. In 1961, 556 drifters had been released with 46 recoveries up to the end of December 1961, and 35 more recoveries in 1962, including 6 recoveries along the eastern edge of the Magdalen Shallows. These 6 recoveries made during May, June and July (Figure 1) infer an average drift of 0.35 miles per day for some of the bottom waters in a southeasterly direction. There was also one recovery showing a definite northwest movement at the rate of 0.21 knots. However, most of the recoveries in the Gulf from 1961 and 1962 releases have been made in the area between the Gaspé coast and Orphan Bank. In this smaller area, the 1962 recoveries show a pattern of bottom drift similar to that observed in 1961.

On the Scotian Shelf, the recoveries made from January-February releases in Emerald Bank region were the only ones to bring significant results, with 6% recoveries. The computed drift for these recoveries varied between 0.2 and 2.1 miles per day with an average of 0.7 miles per day predominantly to the west. Releases were made in the same area in June and also on Banquereau with no recoveries as yet.

From the two series of releases made off the southwest coast of Nova Scotia all the recoveries were found along the coast on the beaches inferring a minimum speed varying between 0.1 and 0.5 miles a day. The recoveries from several series of releases across the mouth of the Bay of Fundy (May to December) and in St. Mary Bay indicate an inward movement along the bottom, for a certain time at least, since most of the recoveries were made on the beaches, east of the point of release. These recoveries on the beaches between Cape Sable, N.S., and the Bay of Fundy inclusive came from releases made in turbulent waters, in areas of strong tidal currents, where the sea-bed drifters may not have the expected behaviour of drifting along the bottom, but bouncing on and off bottom and, at times, subjected to surface layer currents. However, the recoveries infer a certain amount of upwelling along the southwest coast of Nova Scotia and an "upstream" bottom current in St. Mary Bay and in the Bay of Fundy. This is not surprising if we consider St. Mary Bay and Bay of Fundy as estuaries.

L.M. Lauzier
J.G. Clark

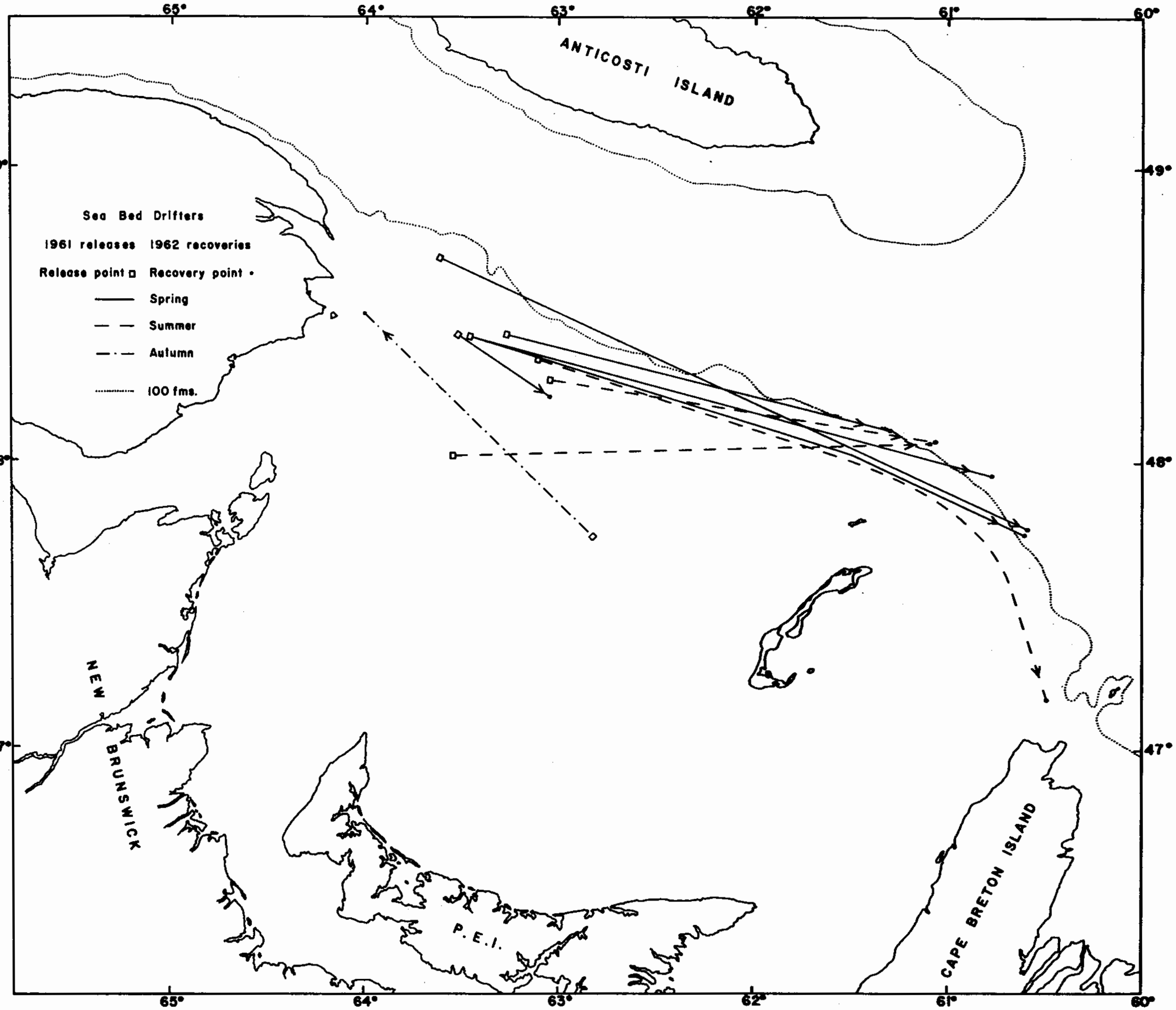


Figure 1. Long distance "travel" by sea-bed drifters released in 1961 and recovered in 1962.

No. I-6

COMBINED OPERATION SACKVILLE - HARENGUS IN CABOT STRAIT - JUNE 1962

The purpose of this operation was 1) to study the variability of water properties in the Laurentian Channel and the applicability of dynamic methods of calculation of currents in the area; 2) to study the bottom circulation on offshore banks of the eastern Scotian Shelf and on the Magdalen Shallows; 3) to study the oceanographic conditions along the Halifax Section and along the western slopes of the Laurentian Channel.

Five repeated crossings of Cabot Strait were made at various stages of the tide within 5 days. During each of these crossings, G.E.K. and drift pole measurements were taken, and oceanographic observations were taken at five stations each time. While Sackville was criss-crossing Cabot Strait, Harengus was anchored on the western slope of the Laurentian Channel engaged in bottom current measurements with Pisa tubes at 100 fathoms for three periods of 12 hours and one period of 30 hours. BT casts were also made from Harengus while engaged in Pisa tube measurements. Sackville and Harengus worked 48 hours tracking drift poles on both sides of Cabot Strait at the same time in order to evaluate the surface drift under the same conditions.

Sackville also completed one longitudinal section in the Laurentian Channel and four crossings of the Channel, north and south of the regular Cabot Strait section, one of these sections covering the northern portion of St. Pierre Bank. Harengus and Sackville made closely spaced BT casts down the western slopes of the Laurentian Channel, off Scatari Island, the Magdalen Islands and north of the Magdalen Islands.

Sea-bed drifters were released by Sackville on Emerald Bank, Banquereau and Magdalen Shallows.

Sackville made repeated crossings of the Gaspé Passage in co-operation with "North Star VI" (chartered by Canadian Hydrographic Service) and covered the north western Gulf of St. Lawrence. G.E.K. measurements were made in the Gaspé Passage and along the Gaspé Peninsula.

This Sackville cruise (S-63) covered a period of 30 days while Harengus contribution covered a period of 11 days. Personnel from St. Andrews, A.O.G., and D.M.&T.S. took part in the combined cruise. It is felt that this type of operation allows us to collect synoptic data otherwise impossible to obtain.

L.M. Lauzier
J.G. Clark
J.H. Hull

No. I-7

CURRENT MEASUREMENTS IN CABOT STRAIT JUNE 1962

During the combined *Sackville-Harengus* cruise, June 1962 current measurements have been made during repeated crossings of Cabot Strait in order to relate the transport through Cabot Strait as calculated from density distribution with velocities at the surface and at one depth along the bottom.

The dynamic calculations of volume transport through Cabot Strait have not been performed pending the salinity data yet to come. It seems worth-while to report on some of the results of current measurements. Three different techniques were used, one indirect, the electromagnetic method with the G.E.K. geomagnetic electrokinetograph and two direct methods, the radar drift pole and the Pisa tubes. The radar drift poles were used during each of the five crossings at various stages of the tide, left adrift for a period of approximately 5-6 hours, on the Cape Breton side of Cabot Strait. They were also used for a 48-hour period simultaneously on both sides of Cabot Strait. The Pisa tubes were used at the depth of 100 fathoms for three 12-hour periods and one 30-hour period. The G.E.K. was used on five crossings at various stages of the tide with a minimum of 5 readings on each crossing.

The results could be summarized as follows: The G.E.K. readings indicated a maximum current in the region of 60° 00'W with a fairly consistent direction, 133° as an average. In the center Strait, the currents were variable in intensity and in direction, but predominantly in towards the south. Near the Newfoundland coast, the currents had a tendency to pick up strength, flowing towards the northeast. The drift pole measurements made on the Cape Breton side during the five crossings show a decrease in the intensity of the average southeasterly flow from 0.8 knots (111°) at 12 miles from Cape North to 0.2 knots (117°) at 23 miles from Cape North. The variability of the speed and direction was greater at the station further away from the coast. From the 48-hour tracking of drift poles on both sides of the Strait, the computed resultant drifts were of the order of 16 miles a day towards the south on Cape Breton side and 8 miles a day towards the north on Newfoundland side. The Pisa tube measurements at 100 fathoms off Aspy Bay seem to show a certain regularity in the change of direction from approximately 180° to 90° which might be related to the stage of tide, the overall average velocity for the 66 hours of observations on the bottom was 0.11 knots at 130°.

L.M. Lauzier
J.G. Clark

No. I-8

COASTAL SURFACE AND BOTTOM TEMPERATURES-1962

The surface water temperatures along the Canadian Atlantic coast were monitored from twice daily observations at six coastal stations. These are the continuation of a long series of observations. The longest continuous series was started in 1921 at St. Andrews, N.B. They are used as an index to follow the trend of temperature variations and to establish the basis for the study of the marine climate of the area.

Table I. shows the monthly mean surface temperatures at the six coastal stations and their deviation from the 1961 temperature, as well as the average deviation from 1950-59 mean.

In general, the surface temperatures in 1962 have changed very little from those of 1961 if we consider the year as a whole. However, they had a tendency in the first six months of 1962 to be warmer than in 1961 and in the last six months colder in 1962 than in 1961, resulting in very little change for the whole year. This was due to the fact that the 1961 temperatures were much below average during the first six months. In the Bay of Fundy area, the temperatures at St. Andrews were below the long-term average (1921-1959) by 0.2°C and below the 1950-1959 average by 0.9°C. The observed temperatures at Lurcher were above the 1961 level, but below the long-term average. In the Halifax region, which is representative of most of the outer coast of Nova Scotia, the temperatures were below the 1950-1959 average as well as below the long-term average. In the Gulf of St. Lawrence, the temperatures at Entry Island and Port Borden were definitely higher than those of 1961 during the first six months, but rapid cooling in the autumn brought the temperature down below the long-term average at the end of the year.

It could be said that the surface temperatures in 1962 were in general below average and that the cooling trend, as shown by the variations of the 10-year averages at St. Andrews, still continues.

The forecast of St. Andrews annual temperature for 1962 was to be between 6.8° and 7.0°C, the observed temperature for 1962 was 6.8°C. The forecast for 1963: The St. Andrews temperature will be near average, with an annual temperature between 6.9 and 7.1°C.

The coastal bottom water temperatures were monitored at three points along the Canadian Atlantic coast: at Station Prince 5, on the northern side of the Bay of Fundy, monthly observations; at <u>Lurcher</u> Lightship, once daily observations; at <u>Sambro</u> Lightship, twice daily BT casts. Observations at

Table I. Monthly surface water temperatures along the Canadian Atlantic coast - 1962

	St.Andrews N.B.	Lurcher Lightship	Halifax Harbour	Sambro Lightship	Entry Is. Que.	Port Borden P.E.I.
Jan.	2.6	4.9	3.7	2.4*	- -	-1.1
Feb.	0.4	2.3	-0.1	-0.1	- -	-1.0
March	1.4	1.5	0.7	0.9	- -	-0.6
April	3.9	2.9	2.9	1.2	- -	0.4
May	6.1	4.9	6.3	3.6	5.0	5.9
June	9.3	7.3	10.0	7.8	9.0	12.4
July	10.8	8.6	12.4	12.2	13.3	15.7
Aug.	12.4	10.0	15.3	15.6	15.5	18.2
Sept.	12.2	- -	14.0	- -	13.7	16.2
Oct.	10.4	- -	11.1	11.2♣	10.0	11.5
Nov.	7.4	8.0	7.2	7.9	5.4	6.4
Dec.	4.7	7.2	5.1	5.3	- -	1.9
Average monthly temperature variation from 1961 to 1962						
Jan. to June	+0.5	+0.8 (4 mo.)	+0.6 (5 mo.)	+1.1 (5 mo.)	+2.1 (2 mo.)	+1.4
July to December	-0.4	+0.2 (3 mo.)	-2.0	+0.1 (2 mo.)	-1.7 (5 mo.)	-0.8 (5 mo.)
January to Dec.	+0.1	+0.5 (7 mo.)	-0.8 (11 mo.)	+0.8 (7 mo.)	-0.6 (7 mo.)	+0.4 (11 mo.)
Average monthly temperature deviation from 1950-59 mean						
January to Dec.	-0.9	-0.9 (10 mo.)	-0.5	-2.0 (9 mo.)	-0.7 (7 mo.)	-0.4

* 21 day period only

♣ 20 day period only

Sambro are made by Naval Research Establishment who supplied the data for use with other monitoring observations. In 1962, the bottom temperatures at Station Prince 5 were higher than in 1961 by 0.4°C and lower than in 1960 by 0.3°C. They were lower than the long-term average by 0.1°C. At Lurcher Lightship, the bottom temperatures in 1962 were higher than in 1961 by 0.5°C and lower than in 1960 by less than 0.1°C. They were lower than 1950-1959 average by 1.1°C. At Sambro, the bottom temperatures from January to August had decreased by 0.7°C from 1960 to 1961 and increased by 0.3°C from 1961 to 1962. The 1962 temperatures were below average (1949-1959) by 1.6°C.

These bottom temperatures, in spite of a slight increase in 1962 over the 1961 level, indicate the continuation of the long-term cooling "trend" similar to that of the surface waters.

L.M. Lauzier
J.H. Hull

No. I-9

TEMPERATURE CONDITIONS ALONG THE WESTERN SLOPES OF THE LAURENTIAN CHANNEL

Emphasis has been placed on the water conditions along the western slopes of the Laurentian Channel as environment of groundfish during their seasonal north-south migrations.

Closely spaced observations along the slopes have been taken by A.T. Cameron in 1960, 1961 and 1962, during groundfish survey cruises, also by C.G.S. Baffin in winter 1962 and by C.N.A.V. Sackville and M.V. Harengus in June 1962. The results from these observations in three main areas, off Scatari Island, off Bird Rocks, and north of Magdalen Islands are tentatively related to the conditions observed in Cabot Strait which is one of the monitor sections along the Canadian east coast.

The results are given in Table I. as thickness of layers 0.0°-2.0°C and 2.0°-4.0°C and could be summarized as follows: North of Cabot Strait, the two layers could be considered as two wedges inversely oriented with the thick side of 0.0°-2.0°C off Bird Rock and thick side of 2.0°-4.0°C north of Magdalen Islands. These two layers off Scatari Island at times seem to be the prolongation of the wedges south of Cabot Strait. There is a tendency for the 4.0°C water to be deeper in the upper regions of the Laurentian Channel than in Cabot Strait or off Scatari Island. This is a verification of previous observations. The depth of 2.0°C water is very variable, more than that of the 4.0°C water. However, the variations in the thickness of these layers are greater south of Cabot Strait than in the Gulf of St. Lawrence.

The thickness of these two layers as observed in Cabot Strait are a poor intermediate between the conditions observed north and south of the Strait. May be they are more representative of the conditions in the Gulf than south of the Strait.

Table I. Thickness of temperature layers along the western slopes of the Laurentian Channel.

Year	Month	Layer	North of Magdalen Is.	East of Bird Rock	Cabot Strait Section	East of Scatari Island
1960	Jan.	0.0-2.0°C	50 metres	80 metres	100 metres	140 m.
		2.0-4.0	75	40	45	30
1961	Jan.	0.0-2.0	45	55	--	40
		2.0-4.0	70	35	--	55
1962	Feb.	0.0-2.0	45	45	40	60
		2.0-4.0	55	50	40	35
	April	0.0-2.0	50	90	--	55
		2.0-4.0	90	45	--	20
	June	0.0-2.0	55	45	--	(30)
		2.0-4.0	50	50	45	85

L.M. Lauzier

No. I-10

SUMMER AND WINTER TEMPERATURES ON OFFSHORE BANKS

From 1958 to 1962 groundfish survey cruises have been conducted by either M.V. Harengus or A.T. Cameron on the offshore banks during summer or winter or both.

Oceanographic observations made at each fishing station consisted of BT cast, surface and bottom temperatures and salinities. They were, sometimes, supplemented by a complete hydro station. The Halifax section was frequently covered by another ship, usually C.N.A.V. Sackville.

Data from the central Scotian Shelf and Cape Breton areas have been analysed but only some of the features of the Scotian Shelf area are given here. The bottom temperature distribution for the winter from 1959 to 1962 are shown in Figure 1. It should be noticed that during the years 1961 and 1962, the surveys were conducted in April and May. Therefore, the conditions were those of late winter or early spring.

With the exception of 1960, 2° water was present during the winter in the form of a tongue coming from the northeast over the shoals of Sable Island Bank. Bottom waters of 8°C were present during the winter in 1960 and 1962, only south of Emerald Bank. Fairly steep temperature gradients on the bottom were present every winter except in 1960. The area of steep gradient was usually located in the west or northwest portion of Sable Island Bank. During the winter, the minimum temperature on Emerald Bank was always lower than 4.0°C, except in 1962.

During the summer, the area occupied by 2.0°C water is very small, there were small patches in 1959 and 1960 north of Sable Island Bank and in 1959 south of Sable Island Bank. Bottom waters of temperature below 4.0°C occupied only two small areas in summer 1958, one on southwest Sable Island Bank and the other north of Sable Island where cold patches of 2.0°C water were found in 1959 and 1960. The extent of 4.0°C water was somewhat restricted in summer 1960 as compared to summer 1959 when it occupied a very large portion of the offshore banks. During the summer, the area occupied by water above 6.0°C was maximum in 1960 and minimum in 1959.

The fundamental difference between summer and winter temperature is due to the fact that an intermediate cold water layer is generally present during the summer over the offshore banks bringing cold waters in varying quantities on some portions of the shallow banks. If the intermediate cold water layer is well developed and thicker than usual, the extent of water temperature below 4.0°C is greater than usual extending

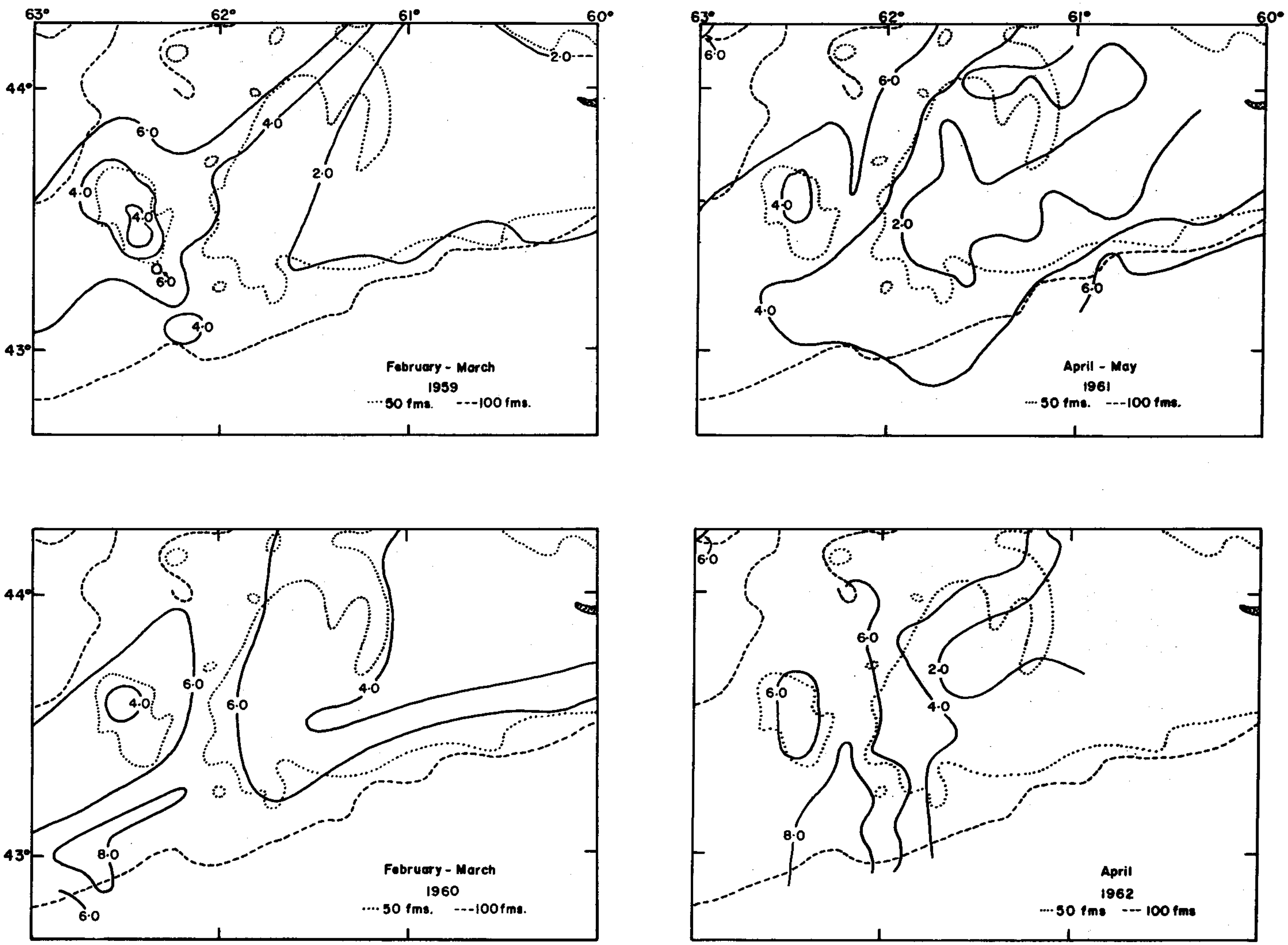


Figure 1. Bottom temperature distribution on the offshore banks of the central Scotian Shelf during the winters of 1959 and 1960, and the late winters of 1961 and 1962.

over the depths that correspond to those of the intermediate cold water layer. This has been observed before by other workers in the area. During the winter, the intermediate cold water layer is not developed as such, the temperatures have a tendency to be uniform, or at least uniformly increasing from surface to bottom. The Halifax section data shows this seasonal change in the stratification.

In an attempt to classify the conditions found on some of the offshore banks in different years during winter and summer seasons, the coverage of various temperature layers on the bottom has been calculated and is shown in Table I. as percentage of the total area. This area is roughly bounded by longitudes 60° 30' and 62° 50', by latitude 44° 00' and the edge of the continental Shelf. The offshore banks included in this area are: Emerald Bank, south of Emerald, western Sable Island Bank including the Horse Shoe.

Table I. Percentage of area of bottom covered by various temperature layers on some offshore Banks

Season	Year	<2.0°C	2.0-4.0°C	4.0-6.0°C	6.0-8.0°C	>8.0°C
Summer	1958	0	<1	42	42	15
	1959	1	57	29	11	2
	1960	0	7	29	25	38
Winter	1959	31	27	23	20	0
	1960	0	17	38	44	1
	1961	19	31	41	8	0
	1962	6	32	15	38	9

This Table shows wide variations of conditions from year-to-year and from summer to winter. For both summer and winter, the year 1959 and 1960 are considered to be cold and warm, respectively the late winters of 1961 and 1962 seem to be increasingly warm or less cold. Comparing these data with a longer period of observations on the Halifax section, it seems that the year 1960 was more an average year than a warm year, 1958 was definitely on the warm side.

L.M. Lauzier
J. Gosbee

No. I-11

TEMPERATURE AND SALINITY CONDITIONS IN THE NORTHERN NORTHUMBERLAND STRAIT

Hydrographic observations in northern Northumberland Strait from May to October were continued in 1962 for the 15th consecutive year as a monitor series in relation to lobster larvae study in the area. The weekly observations, at a station off Richibucto, were made at three different depths: surface, 10 and 20 metres.

The surface temperatures were lower than average by as much as 2.0° in May, 1.2° in June, 2.6° in July and 1.3°C in August. In September the surface waters were slightly below average (1948-1961). The bottom waters stayed cold, at temperatures below 3.0°C, until the first days of June after which they warmed up rapidly above the average temperature for the rest of the month of June and most of July. For a short period in July-August, the bottom waters were below average. By mid-September, the thermal stratification had disappeared. In general, 1962 temperatures were lower than in 1961 at the surface and higher than in 1961 on the bottom. Surface temperatures at Borden, in the central portion of Northumberland Strait, were also reported as being below average.

The surface salinities in 1962 were higher than average (1948-1961) during most of the open season, except for part of July and in October. The feature of the salinity variation in 1962 is the rapid decrease during June and July to reach the annual minimum late in July. This minimum was somewhat below average, 27.1‰ as compared to 27.3‰. The salinity stratification disappeared by mid-September at the same time the thermal stratification did. The autumn overturning occurred one month earlier in 1962 than in 1961.

Observations made on July 10 show that the column of water was homogeneous with respect to both temperature and salinity. In considering temperature salinity relationship before July 10, on that day, and afterwards we believe that the conditions brought about to produce such homogeneity were those of transport and subsidence of surface layer waters into the area due to wind action more than vigorous mixing of the layers "in situ", presumably by wind action.

L.M. Lauzier
J.H. Hull

No. I-12

TEMPERATURE AND SALINITY CONDITIONS IN ST. MARY BAY AREA - 1961

Oceanographic observations have been collected during the herring larvae cruises starting in September 1960 and continued since. 1960 and 1961 data have been analysed to describe the seasonal variations of the environment in St. Mary Bay in relation to that of surrounding waters. The analysis of 1962 data yet to come will complete the seasonal pattern and will show, if any, year-to-year variations in relation to the circulation as inferred from drift bottle recoveries. The purpose of this study is to relate these three parameters; temperature, salinity and non-tidal drift to the distribution of herring larvae and possibly the growth of young herring in the Bay of Fundy.

The marine climate of St. Mary Bay is of two types. One, which is a slight modification of conditions observed at the entrance of the Bay of Fundy, is found in the lower St. Mary Bay, from the mouth of the Bay to Petite Passage. The other, which is purely local, is found in the upper St. Mary Bay, from Petite Passage to the head of the Bay.

The observed maximum and minimum temperatures in the lower Bay were 12.0° and -0.5°C respectively as compared to 10.5° and 1.3°C at Lurcher Lightship. In the upper Bay, the maximum and minimum temperatures were 16.0° and -1.5°C. The maximum temperature occurs first in the upper Bay in August, which is earlier than in the lower Bay and at Lurcher (October). The minimum generally occurs in February, which is earlier than at Lurcher or outside the Bay. Between the lower and upper Bay, there is a transition area which has a temperature regime somewhat related to the other two.

The salinity variations between areas are not as marked as the temperature variations. However, the lowest salinity at the surface is found in the upper Bay between April and June. The observed surface salinity in the lower Bay was always above 31.0‰. Waters of a salinity lower than 31‰ are found only in the upper Bay and in the Passage area. Most stations show a maximum salinity in late summer or early autumn. However, the maximum salinity observed in St. Mary Bay (32.75‰) was recorded in the upper Bay during February under ice cover. The range of salinities is smaller in the lower Bay than in the upper Bay.

The horizontal gradient of temperature is minimum in November and maximum in August. The horizontal gradient of salinity is minimum in August and maximum in May. In February, because of ice formation in the upper Bay, the salinity increases from the mouth to the head of the Bay.

During the summer of 1961 there were two surveys covering the eastern Gulf of Maine and the entrance of Bay of Fundy. In July, a large area of the coast was apparently subjected to upwelling or vigorous vertical mixing, considering the relatively low temperatures and high salinities. Two intrusions of warm lower salinity waters were noticeable, one, east of Cape Sable area and the other, in the northeastern Gulf of Maine. In August, upwelling was also noticeable but to a lesser extent than in July. Intrusion of warm water was observed east of Cape Sable, but not in the northeastern Gulf of Maine. During these two months, the surface temperatures at Lurcher were below average. Recoveries from drift bottles released in this area, at the time, seem to indicate movement of surface waters either away from or along the shore rather than towards the shore. This was observed for the area between Cape St. Mary and Cape Sable, N.S.

L.M. Lauzier
E. Joubert

SMELT SUMMARY

No. J-1

SMELT STUDIES, MIRAMICHI, 1961-62

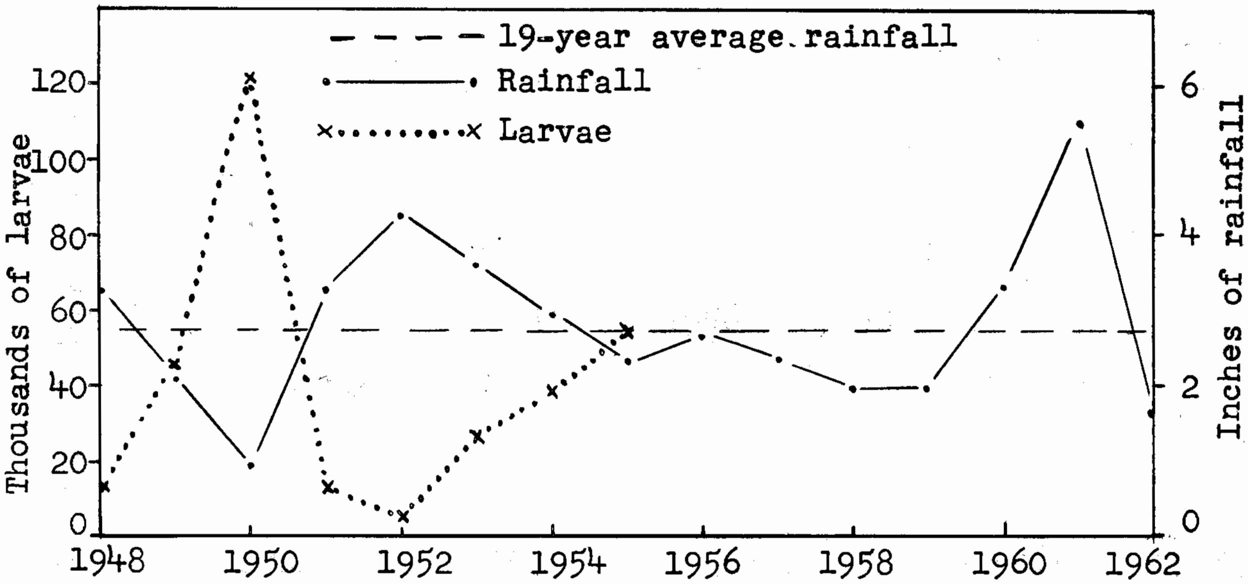
In the early part of the fishing season (Oct. 16/61-Feb. 28/62), Neguac Bay only experienced good quantities of smelt. Later on, fair catches were made at the mouth of Miramichi Bay (Hardwicke, lower Baie Ste Anne, Portage Is., Tabusintac) but on the whole the season was rated as poor.

The accompanying table shows that the 1961-62 total catch, price, and number of nets licensed, was the lowest in the last 16 years. Competition with low-priced, attractively packaged smelt from the Great Lakes appears to have had its effect on the Miramichi fishery. Though the fishery was generally rated as poor quite a number of fishermen experienced good seasons. The average catch per licensed net was 200 lb above the 16-year average and the average catch per-net-day fished, by 10 fishermen keeping log books, was 29% above an 11-year average. However, the average price of 8 cents per lb was the lowest in 16 years.

Statistics of the Miramichi smelt fishery, 1946-62.

Season	Total catch	Value per cwt	No. nets licensed	Catch pet net per season	Av. catch per-net-day fished
	cwt	$	No	lb	lb
1946-47	11,417	19.0	2,432	469	-
1947-48	23,437	20.3	3,066	764	-
1948-49	20,133	11.0	3,266	616	-
1949-50	11,775	15.1	3,085	382	-
1950-51	21,780	13.7	2,811	775	-
1951-52	8,535	21.6	2,218	385	5.3
1952-53	16,235	19.6	2,482	654	13.3
1953-54	11,831	12.8	2,139	553	9.4
1954-55	20,579	12.0	2,027	1,015	17.5
1955-56	11,815	13.0	1,513	781	9.9
1956-57	5,024	13.5	1,533	328	4.9
1957-58	8,722	11.7	1,360	641	14.0
1958-59	6,709	15.9	1,288	521	6.4
1959-60	4,677	12.0	1,073	436	7.8
1960-61	4,569	9.0	518	882	9.4
1961-62	3,936	8.0	481	818	12.0
Average	11,948	14.9	1,956	611	9.3

From Fisheries Officers reports and personal observations, the 1962 smelt spawning run was rated as fairly good. Though poor in some streams it was good in others, for example, Fishery Officer Gilks reported for the Renous River "...large numbers, more than I have seen for a number of years". A number of other reports mentioned the large size of the fish which probably means the proportion of smaller, younger fish was lower than usual. This is in line with above average rainfall (see accompanying figure) in 1960 and 1961 and forecasted poor larval production in these years. The fairly good spawning run in 1962, along with below average rainfall during the spawning period (2nd lowest in last 15 years, about 50% of the normal on the Miramichi watershed) should have combined to give above average larval production in 1962.



Smelt larval production compared to rainfall at spawning time.

To improve conditions on the Miramichi for production of smelt larvae, some time was spent in the area in May-June 1962 examining culverts that were impassable to spawning smelt and other obstructions on smelt spawning streams. It is gratifying to report that some improvements were carried out on at least 4 culverts by the Department of Highways in 1962. It was also possible to assist Protection Officers in the area in their efforts to make the spawning streams passable for spawning smelt. In this connection maps locating all the Miramichi smelt spawning streams together with a set of notes indicating the lengths of each stream that should be cleared, were provided for the Fisheries Officers in the Miramichi area.

R. A. McKenzie

MATHEMATICAL STATISTICS

No. K-1

CATCH AND DISTRIBUTION OF FISH

In a study of fisheries, we try to infer the character of the underlying fish population from the commercial catch records. In doing so, we need to know the nature of the dependence of catch on the abundance and distribution of fish. If fish are uniformly distributed, we know that catch per hour fished is linearly related (proportional) to the abundance of fish. When the distribution is not uniform but exhibits heterogeneity or a schooling pattern, the relationship becomes less obvious.

From analysis of sampling records and from general observations we know that many of the groundfish species, herring, scallops, and perhaps also lobsters, have a tendency to school or aggregate. However, quantitative information on the schools or aggregates of these species is lacking, partly because of sampling difficulties. Some of our efforts to remedy the situation are reported in Summary No. K-2. To assess the effect of distribution on fishing success in an attempt to evaluate in the first place how serious the problem is and in the second place to learn what types of information are necessary before we can make use of the catch records, hypothetical fish distributions and fishing practices have been simulated and the dependence of fishing success on abundance and distribution calculated for these examples.

Calculations for one such example are shown in the accompanying Figure 1. In this case, the fish were assumed to be distributed in the area in randomly placed schools. Two levels of abundance were considered by letting the number of schools per unit area take two values. The fishing vessels were assumed to search in the general area in a random manner at a fixed cruising speed. Two different cruising speeds have been considered. When a vessel traverses the area occupied by a school, it is assumed to be able to detect the presence of the school and to proceed to fish it. The time required to fish a school has been taken to be proportional to the size of the area it occupies.

In the second example, Figure 2, the basic fishing model is the same as in the previous example except that the radius of detection of fish schools by fishing vessels is now taken as a variable. In effect, the change in the radius of detection has more or less the same effect as the change in the radius of schools as far as the calculations are concerned, with one exception, and that is that while the change in the school size increases the probability of detection, it also increases the fishing time.

Figure 2

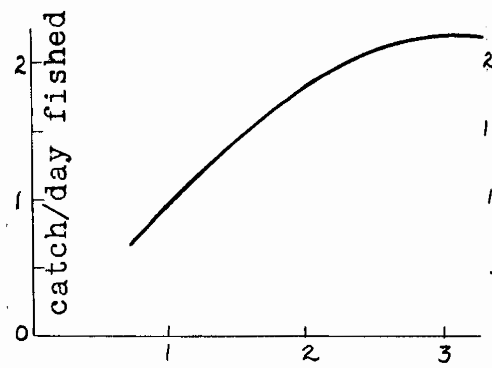
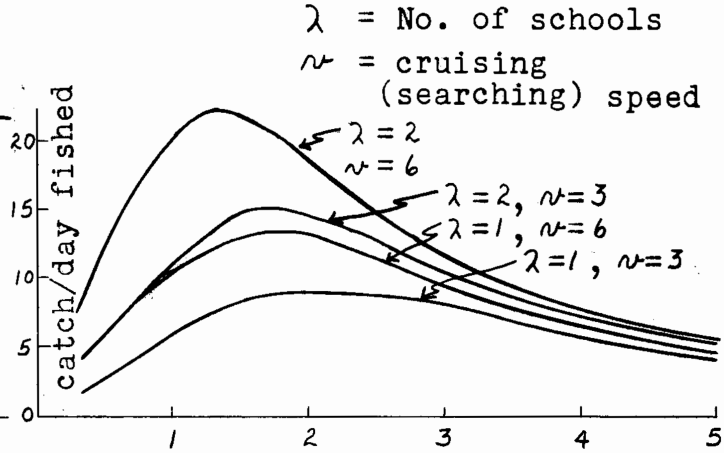


Figure 1



Calculations shown in Figure 1 demonstrate the extent to which the distribution of fish may affect the catch and show that this distribution must be considered in relation to the operational characteristics of the fishing vessels such as cruising or towing speed. The figure shows that under these conditions density can, for instance, double or halve without any noticeable change in catch if this change in density is accompanied by appropriate changes in the distribution. Similarly, we note from Figures 1 and 2 that the density of fish may be reduced to half without any noticeable change in catch if the searching efficiency of vessels (cruising speed in Figure 1 and the radius of detection in Figure 2) is increased at the same time.

Our calculations demonstrate that considerable changes in population abundance may take place without any effect on catches if these changes are accompanied by changes in the distribution of fish or in the operational characteristics of vessels. Catch and effort data of commercial vessels therefore offer very limited means for detecting the changes in the distribution of fish. It appears that these must be followed independently by research vessel surveys.

J.E. Paloheimo
L.M. Dickie

No. K-2

POPULATION SAMPLING WITH ECHO SOUNDERS

It is a truism that the amount of sampling and the design of a sampling program must take into account the size and nature of the distribution of the population being sampled. In the course of a year, commercial groundfish vessels landing in the Maritimes drag over about 7,000 square miles of bottom, a fraction of the total fishable. In the course of a year's operation, research surveys drag over a little more than 10 square miles of this. Furthermore, records from commercial and research surveys show that most species encountered are non-uniformly distributed (Summary No.K-1). There is marked clustering into schools or other aggregations, and these schools themselves appear to be stratified by species, sizes, maturities, etc. It is obvious that at present we are dependent on commercial statistics for information on distribution and abundance.

In analyses of commercial statistics, there are, however, a number of features which make interpretations for natural distribution and abundance questionable, and make checking by research vessels highly desirable. Yet it is an easy conclusion that the present research vessel results could give meaningful information on stock abundance only if the distributions were completely uniform. Not only would it be prohibitively expensive to attempt adequate coverage by research otter trawling, but doubtful if such information could be completely satisfactory. This is because it is difficult if not impossible to relate the size of area sampled by trawl gear to the fundamental unit of population structure -- the school or aggregation. Thus the observed variations among sample catches cannot be related to differences in school sizes or other characteristics. It can only be concluded that present research vessel sampling methods are not likely to add substantially to information on distributions and abundance to relate to the effects of the physical environment and fishing.

A review of existing information on echo survey techniques indicates that they provide a practical method for overcoming the serious limitations of sampling by trawl alone. European trials with specially built equipment have demonstrated that sufficiently sensitive recording of echo signals of fish on bottom can be correlated with catches. It is also known that it is possible to distinguish echos from various fish shapes and sizes. Given sensitive transmitting equipment, together with sufficiently discriminating pulse analysis and recording, there seems to be every prospect that echo sounder surveys, judiciously supported by trawl sampling, could provide all the necessary detailed information on abundance and local distribution of sizes and species. Operations of this sort would immeasurably strengthen the value of the research vessel as a fisheries research tool.

Results of echo sounder work of the type suggested are likely to find application to commercial as well as research operations. For example, Summary No.K-1 shows that, with non-uniform distributions, changes in the ability of fishermen to detect fish would cause major differences in catch. Many fishermen now claim that echo sounders are primarily useful for fine navigation along depth contours, and of very little use in searching. Echo-sounder research might reasonably be directed toward better commercial equipment purchasing or design as well as to instruction in more effective and skilled utilization of existing equipment. Even more important is the recognition that with given kinds of non-uniform fish distributions, catching success can be significantly affected by the degree of selectivity that fishermen exercise respecting the sizes of schools fished. Our calculations show that the importance of the selective operation to overall success becomes greater as schools become smaller, or more dense. Application of this knowledge for maximizing the catch for a given distribution and abundance level assumes prior knowledge of the sort which could be developed by use of echo sounders.

Our full recognition of the need for information of the sort which can be supplied by echo sounders has emerged from attempts to use research vessel data to illustrate the theoretical effects of abundance and distribution changes on catching success. Continued development of these theories of fishing is proceeding with an eye to more complete specifications of the ways in which such equipment could be used to reveal important fishery information for research, and to increase the efficiency of fishing operations.

J.E. Paloheimo
L.M. Dickie

No. K-3

THE PHYSIOLOGICAL AND BEHAVIOURAL BASES FOR NATURAL PRODUCTION

Fish population studies are concerned with the production from a sea area in terms of the species, sizes and total poundage of the yield. However, ecological studies reveal that there is a tendency for homeostasis in the community energy flow. As a result a change in any part of the system will be expected to affect the remainder leading to complex interaction of the components of yield. This implies that, for an understanding of factors affecting present fisheries production and an appreciation of the possibilities of regulating or changing it, it is necessary to understand how energy turnover depends on the physiological and behavioural characteristics of the sizes and species and how these interact in the exploited communities.

Physiological investigations have long since shown that animals of widely different species have a remarkable similarity and stability of standard metabolism (measured as rate of oxygen consumption in a resting state) relative to the body weight. Recent reviews by Winberg in U.S.S.R. and Fry in Canada have amply affirmed this for fishes, indicating a high predictability of certain basic facets of their energy expenditure. With these studies for background, we have made reviews of published data on feeding, metabolism and growth in order to explore how this basic expenditure of energy is related to the supply. The results show that the relationships discussed by Winberg and Fry can be detected when (as suggested by Winberg) the energy expenditure is measured as a difference between energy of the rations and the growth. A statistical analysis of the relation between energy expenditure, T, and body weight, W, in the equation $T = aW^b$, where a and b are parameters, further shows that at any given temperature a change in the rate at which food was made available to the fish changes "a" but apparently leaves "b" unaltered. That is, the rate of expenditure of energy (total metabolism) is linked with the availability of the food supply in a surprisingly simple fashion.

Total metabolism is divided between active and maintenance metabolism, whereas only the former can be related to food getting. This relationship suggests therefore that there is a subtle and complex compensatory system within the animal which, under given environmental conditions, causes it to feed in order to satisfy an established level of nutrition. This suggestion is confirmed by other recent work in behaviour and nutrition. Similar evidence for apparent simplicity and predictability of the results of compensatory physiological mechanisms in fishes within conditions likely to lead to one type of behaviour pattern are described in Summary No. K-4.

The results of the various facets of this investigation have important implications for studies of natural production. That is, they demonstrate that results of appropriate physiological and behavioural experiments in the laboratory can be used to reveal the compensations that animals make to the conditions they encounter in nature, and are not simply limited to an exploration of the animals' capacities for response to various conditions. They further suggest that, unless there is a recognition of the complex compensatory responses that fish make to changes in conditions of feeding and nutrition, results of many experiments to study responses to the physical environment may appear meaningless or be misleading. However, with proper control, these implications give strong support to the practicality of constructing biologically realistic population models. Because of the importance of such results and interpretations to the study of fisheries production it is a matter of some importance to describe the phenomena and test the hypotheses in experiments designed expressly for this purpose.

J.E. Paloheimo
L.M. Dickie

No. K-4

FOOD CONSUMPTION AND GROWTH

Our review of the biological phenomena important in fish production models has begun with a study of the food-growth relations. It is well known that changes in food availability affect the growth. Initially, therefore, we have attempted to specify the adaptation that fish make in food consumption and growth efficiency at any given level of availability of food, and their response to any changes in it. Published data from laboratory experiments on growth and feeding rates of fishes are being studied from this point of view. We report here the results of our re-analysis of a typical set of data relating to growth efficiency.

These experiments were done by Kinne (1960 and in press) at the University of Toronto on _Cyprinodon macularius_. A total of 41 groups of 10 fish each were observed and the rations and resulting growth recorded for bi-weekly periods. Experiments were done at 5 constant temperature levels: 15°, 20°, 25°, 30°, 35°C, the temperatures of 15° and 35° being at the extremities of the biokinetic range of the species. The data for these two extreme levels were excluded from the following analysis, leaving 33 observations altogether. The statistical analysis is summarized in the accompanying table.

We note first of all the strong correlation between the logarithms of the food use efficiency and rations ($r_{ef} = -0.937$) and between the rations and weight ($r_{fw} = 0.889$). However, despite the strong correlation between the rations and weight, the partial correlation between the log efficiency and rations eliminating the effect of the weight is reduced only very little from $r_{ef} = -0.937$ to $r_{ef.w} = -0.842$, whereas when the effect of rations is eliminated the partial correlation between the log efficiency and weight becomes non-significant ($r_{ew.f} = 0.297$).

Correlation coefficients between the logarithms of the efficiency of food utilization (e), rations (f), and body weight (w). No. of observations = 33 groups of 10 fish each; data: Kinne 1960.

Simple correlation coefficient	Total and partial correlation coefficient	Total and partial correlation coefficient within constant temperature groups	Simple correlation coefficient within constant temperature
$r_{ef} = -0.937$*	$R = 0.943$*	$R = 0.779$*	$r_{ef} = -0.779$*
$r_{ew} = -0.785$*	$r_{ef.w} = -0.842$*	$r_{ef.w} = -0.522$*	$r_{ew} = -0.679$*
$r_{fw} = +0.889$*	$r_{ew.f} = 0.297$	$r_{ew.f} = 0.043$	$r_{fw} = 0.889$*

*indicates significance at 5% level

The effect of temperature was tested by means of covariance analysis. The result showed small but significant temperature effect on the log efficiency. The third column of the table shows the partial correlation coefficients when this temperature effect was removed. General weakening of the correlations is due to complete confounding in the experimental set-up of the temperature with the mean body weight, resulting in a very much reduced range of body size or rations within each temperature group.

Despite this, the partial correlation between the log efficiency and rations is still significant while the partial correlation between the log efficiency and the body weight remains non-significant. Deleting the apparently superfluous body weight variable, the partial correlation between the log efficiency and rations within the temperature groups increases from $r_{ef.w} = -0.522$ to $r_{ef} = -0.779$, as shown in the third and fourth columns of the table. The remaining correlation coefficients in the fourth column are included for comparison.

Since the feeding regime and general food abundance level remained the same during the experiment, either the rations or the body size should suffice for predicting the growth efficiency. However, the analysis shows first of all that the knowledge of rations specifies the growth more accurately than a knowledge of the body size and, indeed, that the knowledge of body size does not add anything substantial if the ration is known. Secondly, it shows that the different sized fish vary their food intake in a different manner at different temperatures but yet make such compensations as to allow the prediction of their growth from the rations alone by a simple linear relationship.

Preliminary analysis of experiments of several other species in cases where the rate of feeding was determined by the demands of fish appears to confirm the foregoing results and to show the general applicability of the linear relationship at maximum and intermediate rations down to near the maintenance level and throughout most of the biokinetic temperature range of the species.

The relationship between efficiency and rations may be used to describe the dependence of the apparent respiratory metabolism on rations. This may in turn be used in various ways. It predicts the relation between the metabolism and rations observed in fish culture work, where the level of food abundance is progressively changed in proportion to body weight. Application of Krogh's temperature correction for the respiratory metabolism also enables us to predict the observed change in rations for a given change in temperature within the biokinetic range. Thus while the physiological and behavioural interpretation of the results may be problematical, it is apparent that this experimentally derived index of growth efficiency has great ability in the investigation of production processes.

J.E. Paloheimo
L.M. Dickie

No. K-5

FISHING POWER STUDIES

Statistics on catches and efforts of commercial offshore vessels may be studied from two points of view. In the first place, we may consider how accurately the performance of a vessel may be predicted from its characteristics. In the second place we may consider the relationship of the calculated catch-per-hour of a "standard" class vessel to the abundance of fish.

In this Summary we consider the former problem of specifying the fishing power of a vessel by its characteristics, such as the gross tonnage and net size. Exploratory studies of the relationship of the observed fishing power to actual fish abundance was considered in Summary No. K-1.

Following International practice, Canadian offshore vessels have been customarily classified by type of fishing, and by gross tonnage. This gives a primary division of groundfish vessels into classes below 25, 26-50, 51-150, and over 150 gross ton and to otter trawlers, longliners, Danish seiners, and dory schooners. All the gross tonnage classes are well represented in our commercial fleet (Summary No. K-6), but only otter trawlers form a significant type-of-fishing class. Most of our studies, and all commented on here, refer therefore to otter trawlers.

Barring the escape of fish from the front of the net or from the net itself, we may relate the fishing power of a vessel to the size of the net it carries and to the speed at which the net is dragged. Following this reasoning we have therefore divided the vessels in each gross tonnage class by size of net carried on board. Numbers of otter trawl trips in 1960 by these classes are shown in Table I.

Table I. Number of otter trawl trips in 1960 in ICNAF Subarea 4 with effort information complete by gross tonnage and type of net.

	Gross tonnage no. of trips		
Type of net	Gr.T.2 26 - 50	Gr.T.3 51 - 150	Gr.T.4 151 -
1½ Iceland			529
41		170	192
41A			20
Peter Carey			45
36 Yankee			8
35 Yankee	690	560	
c/4 35 Yankee	11		
Flounder net			
Type C net			44

Possible comparisons of the effect of net size within gross tonnage classes and between gross tonnage classes within net size are shown in Table II. It also shows the results of the type of median tests referred to in Summary No. K-6. In estimating the differences the effect of seasons and fishing areas have been eliminated.

Table II. Comparison of gross tonnage and net size.

Comparison	d.f.	χ^2
35 Yankee; Gr. ton. 2 vs Gr. ton. 3	1	50.20 *
35 Yankee vs 41; Gr. ton. 3	1	19.74 *
41; Gr. ton. 3 vs Gr. ton. 4	1	0.06
1½ Iceland, 41, 41A, Peter Carey and Type C net within Gr. ton. 4	4	11.5 *

*indicates significance at 5% level

By and large the tests show that there exist significant differences between the gross tonnage classes and between net sizes within gross tonnage classes. Further breakdown of gross tonnage classes should therefore be contemplated. In some cases this can be done by considering finer breakdown by gross tonnage, e.g., in the 51-150 class, the vessels using the 41 net tended to be over 75 gross tons and the ones using 35 Yankee less than 75 gross tons.

The above results are currently being checked for other years as well. The proper classification of vessels is important for interpreting published national and international statistics series and for following long-term trends in reported efforts and catches.

J.E. Paloheimo

No. K-6

COMPARISON OF PERFORMANCE OF RESPONSE AND NON-RESPONSE VESSELS

Offshore groundfish vessels landing in the Maritime Provinces report their catches to the Department of Fisheries mostly on trip bases. Our field technicians have been collecting auxiliary information on areas and efforts (hours) fished by these vessels since 1947. The collection of efforts has been met with variable success. Table I summarizes the number of trips made to ICNAF Subarea 4 with respect to whether or not the reporting of effort and area is complete.

Table I. Number of trips with complete and incomplete effort for boats landing their catches in the Maritimes.

Gross ton. class	No. of trips in 1959 Complete	Incomplete	% Complete
Below 25	71	1,302	5
26 - 50	985	2,893	25
51 - 150	778	1,437	35
151 - 500	1,352	162	89
Type of vessel over 25 gross ton.			
Otter trawl	2,704	2,087	56
Dory schooner	55	131	30
Danish seiner	92	216	30
Longliner	264	2,058	11

The effort information may have some economic uses, but the primary impetus for the collection has come from its biological significance in management problems. Whatever its uses are, however, it is important that the collection when not complete be at least representative of the class.

Information available for smaller vessels (Table I) is so scanty as to be of no use. For the classes of vessels better covered by our effort collection, we may compare the total catches (catches per trip) of response with non-response boats, i.e., of those boats which do with those which do not report the hours spent fishing.

In order to make this comparison, all the trips in a given area and class were separated into two groups depending whether the trip total was below or above the median catch (per trip). The numbers of complete and incomplete trips in the low and high pile were then counted and a (contingency table) test was made for the equal distribution of complete and incomplete trips in the low and high pile. The table below lists some of the results.

Table II. Comparison of catches per trip with complete and incomplete effort.

Area	Gross ton.	Years	d.f.	χ^2
4T	26 - 50	1957-61	4	47.61*
	51 - 150	1957-61	4	44.67*
4V	26 - 50	1959-60	2	7.91*
4X	0 - 25	1957,61	2	11.50*
	26 - 50	1957-59	3	46.14*
	51 - 150	1957,61	2	17.30*
4W	26 - 50	1957-60	4	17.07*
	51 - 150	1957-61	4	1.75
	151 -	1958-61	3	3.86

*indicates significant difference at 5% level

Table II indicates non-random sampling of vessels or catches in all areas except in 4W. In an attempt to explain the observed differences in the total catches between the completely reported and incompletely reported trips the gross tonnage of vessels for response and non-response trips were compared and a median test was applied. The resulting χ^2 for comparisons made are shown in Table III A. Inspection of the table shows that in some cases the incompletely reported trips tended to be made by vessels with a different (in effect lower) than average gross tonnage within their gross tonnage class, but this does not explain all the differences found.

Table III A. The χ^2 values of the median tests applied to the gross tonnage for response and non-response trips.

Area	Gross ton. class	Year	d.f.	χ^2
4T	26 - 50	1958	1	39.00*
4T	51 - 150	1958	1	0.30
4X	26 - 50	1957	1	0.13

Table III B. The χ^2 values of median tests applied for the total catches for response and non-response trips. Trips were split at a median catch for each vessel separately and the numbers of response and non-response trips on the low and high side of the median were counted.

Area	Gross ton. class	Year	d.f.	χ^2
4T	26 - 50	1958	1	15.48*
4T	51 - 150	1958	1	12.46*

* indicates significance at 5% level

Since it was noticed that in a number of cases a skipper reported his effort figures for some trips and neglected to report them for others, we also studied whether his reporting was in any way associated with his total catch. Some results are shown in Table III B. In all cases studied, it was noticed that when a skipper brought in a small total load he was more likely to forget to mark down the hauls made or hours fished than when he brought in a good catch.

The study shows that our sampling practices do result in biased estimates of catch-per-effort figures in all areas except 4W. In most cases the data for only one year out of three or four examined have been responsible for the significant χ^2's. In retrospect, these changes are hard to explain and almost impossible to correct. A continuous check of the incoming statistics on a timely basis may serve to detect any such deviations and to correct or explain them.

J.E. Paloheimo

No. K-7

SPECIES ASSOCIATION IN COMMERCIAL CATCHES

For quantitative information on exploited fish stocks, we are forced to rely on our interpreations of commercial statistics (Summary No. K-2).

It is generally recognized, however, that the commercial landings depend to a large extent on fishing practices followed by fishermen, especially on the species and area selection they exercise. To study this effort we have calculated indices of what may be termed the "species association" among major commercial groundfish species as reported in otter trawl landings. Especially we have chosen to calculate the rank correlation coefficient (Kendall's τ) for the groundfish data. Results for the 1957 and 1958 landings in ICNAF division 4W by quarter years and by gross tonnage classes are shown in the following table. Similar results have been obtained for other areas.

Most trips to offshore banks are mixed trips in that they represent results of fishing in several unit areas. This would have a tendency to reduce (negative or positive) correlations between species. Nevertheless the correlations are fairly high, although negative, indicating a strong tendency towards "dissociation" or separation among the main species landed. There is a tendency for the correlations to fluctuate from season to season and occasionally also to show significant differences among gross tonnage classes.

The significance of these findings can perhaps be interpreted by reference to the indices derived from research vessel surveys carried out in the same areas. Initial comparisons indicate that correlations calculated from the research surveys tend to be rather lower than these given here. This would imply that commercial boat operators are capable of real selection of the species landed. Further study may serve to show to what extent this is due to commercial discarding of unwanted fish, or to selective fishing within restricted zones or on particular aggregations and schools.

Rank correlation coefficients between major groundfish species in the commercial otter trawl landings.

1957	Haddock/Cod			Haddock/Flounder		
4W	Gr.T.2	Gr.T.3	Gr.T.4	Gr.T.2	Gr.T.3	Gr.T.4
I	-.4643	-.6416	-.4410	-.7165	-.2369	-.3515
II	-.6929	-.5114	-.7081	-.6530	-.4673	-.2000
III	-.1347	-.4814	-.5822	-.5271	-.7793	-.3912
IV	-.2523	-.4207	-.5021	-.4495	-.6785	-.5010

1958	Haddock/Cod			Haddock/Flounder			Cod/Flounder		
4W	Gr.T.2	Gr.T.3	Gr.T.4	Gr.T.2	Gr.T.3	Gr.T.4	Gr.T.2	Gr.T.3	Gr.T.4
I	-.48848	-.2332	-.3481	-.6125	-.6075	-.4668	-.1752		
II	-.4981	-.58565	-.4956	-.2647	-.3901	-.3424	-.2722	+.2679	
III	-.2034	-.2995	-.6956	-.5835	-.4949	-.2030	-.2305		
IV	-.08627	-.3761	-.3152	-.5653	-.6512	+.0895	-.3501		-.0897

J.E. Paloheimo

ENGINEERING

No. L-1

FISHING GEAR RESEARCH

The fishing gear research portion of the fishing efficiency program started at this Station in September 1962. Thus, there are, as yet, no experimental results to report. The work consists primarily of two projects, a relatively short-term project on scallop gear and a long-term project on the otter trawl, both designed to improve the efficiency of the gear from an engineering point of view.

The scallop gear project could proceed in either of two directions, viz., the improvement of existing gear or the development of new gear. The selection of the most desirable course depends primarily on the effectiveness of existing gear. If it does a fairly good job now, it should be improved; if not, it should not receive further attention by us. The general technical behaviour of existing gear will be observed during efficiency trials being programmed by the scallop investigation for this summer, but detailing of the engineering program must await the outcome of these trials.

The long-range objective of the otter trawl program is to establish principles of trawl design so that, in the future, trawls can be designed rationally rather than by trial and error to meet the requirements established by the behaviour biologists on behalf of the fish and by naval architects and marine engineers on behalf of the vessel.

A similar project has been contracted to Saunders-Roe of England by the British Trawlers Federation and the Whitefish Authority and has required about three years by a team of experts to produce results. We could not hope to parallel this achievement for the Canadian fleet within a reasonable period of time with the resources at our disposal. Therefore, we hope to obtain the results of the British work and to adapt them to our needs, supplementing with original research where necessary.

The normal procedure for such a project would be to develop design hypotheses, to check these by experiment, and to modify or even reject them if necessary. However, there is some pressure for immediate results so we are "putting the cart before the horse" by obtaining basic trawl behaviour data for existing Canadian gear first, then by using these data to check design hypotheses which we do not yet have. The data we plan to collect will be of immediate value to the naval architect and marine engineer in their design and construction of trawling vessels and to the fishing industry in the selection of gear for any given vessel.

We plan to obtain gear behaviour data on 3/4 #35, #35, #36, #41, and possibly 1½ Iceland trawls in cotton, manila, and Courlene, normally rigged and towed at a range of speeds. The measurements we plan to take are as follows:

a) Warp tensions at the vessel: These are an essential part of drag data required to match the trawl to the towing capacity and structural strength of the vessel. Because these tensions fluctuate quite considerably, both within and between the warps, even at constant towing speed, the tensions in both warps must be measured simultaneously and should be recorded for proper subsequent analysis. Recording hydraulic dynamometers are most satisfactory for this purpose.

b) Warp angles: When towing a trawl, the vessel pulls against only the fore-and-aft horizontal component of the warp tensions at the vessel. Also, the athwart-wise horizontal component of the warp tension plays an important part in establishing the spreading force required from the doors. Thus, the warp tensions measured under a) must be resolved into appropriate components and, for this, we must know the attitude of the warps in the water. The most satisfactory instrument for measuring this attitude is a recording, two-component cable inclinometer developed at our Nanaimo Station.

c) Hydrodynamic pressure: One of the major forces acting against a trawl during fishing is the hydrodynamic pressure of the water through which it is being towed. This hydrodynamic pressure is a function of the water density and the velocity of the trawl relative to the water. Because of tidal and other local currents, the hydrodynamic pressure should be measured at the net. The most satisfactory instrument for this is a recording pitotmeter developed at our Nanaimo Station, which measures hydrodynamic pressure directly, thereby eliminating the need to measure water density as would be required if an ordinary current meter were used.

d) Ground speed: The other major force acting against a trawl during fishing is the friction force between the trawl and the sea floor, and this is primarily a function of the nature of the sea floor and the net weight of the trawl against the sea floor. The velocity of the trawl relative to the sea floor has some effect on this friction force but, more important, the ground speed is required for an estimation of potential catch for a given tow. For this measurement, we plan to use anchored buoys and radar with possible confirmation by Decca or Loran.

e) Mouth opening: Probably one of the most important factors governing the effectiveness of a trawl is the size and shape of its mouth. Also, a knowledge of these dimensions is essential for an analysis of the stresses within the trawl. The most satisfactory means for measuring these dimensions is by an ultra-sonic echo-sounder technique. A refinement of a recording instrument developed at the Nanaimo Station is being constructed for this purpose.

f) Bridle tensions at the net: An analysis of stresses within a trawl and of the spreading forces supplied by the doors requires that forces be measured in lines behind the doors, and this requires an underwater dynamometer. A recording instrument of this type is being developed at this Station, and it is hoped it will be ready for use by this summer.

None of the above instruments is available commercially. Arrangements have been made for the manufacture of the inclinometers and the sensing units for the pitot-meters in the National Research Council machine shop in Ottawa. For the rest, it is necessary for us to purchase components, assemble them, then calibrate the finished instruments.

The above trials require special tows because of the extra handling required by the instruments. Also, it is desirable to obtain data over a range of speeds at least as wide as that experienced by the trawl commercially. Such an operation is best conducted from research or charter vessels. Hence, we plan to use M.V. Harengus for the smaller trawls and C.G.S. A.T. Cameron for the larger trawls.

P.J.G. Carrothers