

FISHERIES RESEARCH BOARD OF CANADA
BIOLOGICAL STATION
ST. JOHN'S, NEWFOUNDLAND

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ST. ANDREWS, N.B.

ANNUAL REPORT

and

. INVESTIGATORS' SUMMARIES

1957-58



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Photo courtesy of Taylor, Guardian Pub. Co.,
Charlottetown, P.E.I.

M.B. Cyprina--a mechanized shellfish digger

The photo shows members of the shellfish trade in Prince Edward Island taking a lively interest in one of the bar clam fishing demonstrations in Hillsborough Bay of our mechanized shellfish digger, M.B. Cyprina--gear designed to cut down waste and to improve digging speed and efficiency in soft-shell clam, bar clam, and quahaug fisheries.

The project was supported financially by the Industrial Development Service of the Department of Fisheries.

For further details see text.

REPORT FOR 1957-58 OF THE
BIOLOGICAL STATION, ST. ANDREWS, N. B.

by J. L. Hart, Director

The St. Andrews Station collects and evaluates information on fisheries and aquatic biology in the 3 provinces: Nova Scotia, New Brunswick, and Prince Edward Island. The results are applied to managing the fishery so as to assure the most advantageous use of the resource. This calls for undertaking a wide variety of problems. Some are in basic marine and freshwater biology. Others explore methods in the practical application of our knowledge.

The administrative headquarters for the Maritimes work in biology is at St. Andrews, N.B. The offices of the various program heads, the main library, and the general laboratory are situated there. In order to cover the whole territory, permanent field stations are situated throughout the Maritimes where special needs are found, and field observers are stationed throughout the year at key fishing ports.

The largest field station is at Ellerslie where oyster research is centred. There is a permanent laboratory building there which is used also for the Station's seaweed research. Conveniently next door to the Board's sub-station is the Fisheries Department's base for applied oyster work. Nearby at Ellerslie Brook is the summer headquarters for the important Prince Edward Island trout research. A year-round office and laboratory is maintained in Chatham, N.B., as a base for the general work of the salmon investigations on the Miramichi River and for the guidance of operations at summer counting fences at Curventon and Camp Adams and the experimental estuarial trap at Millbank. A depot and base for salmon research on the Pollett River is established at Elgin, N.B. A statistical office is maintained in Halifax to collect detailed fishery statistics from the groundfish fleet. Through it the statistical operations of field technicians at Halifax, Louisbourg, and Lunenburg, N.S., are co-ordinated. Another field technician, chiefly concerned with herring studies, is stationed at Yarmouth, N.S. Important temporary bases are established for groundfish research at Caraquet, N.B., and at Lockeport, N.S. Lobster sampling and marking are based at Tignish and at Miminegash, P.E.I., and at Port Maitland, Gabarus, and Fourchu, N.S. In addition, the Station has planned and reported work carried out with the co-operation of the Department of Fisheries in managing trout populations at Crecy Lake, N.B., and in experimental oyster culture at Shippegan, N.B., and at Malagash and Orangedale, N.S.

The Station operates 6 vessels. The largest is the 84-foot Harengus which, during 1957, was used principally for herring studies in the Bay of Fundy and the Gulf of Maine. The 70-foot

Cowie was used chiefly in the groundfish survey work in the southwest Gulf of St. Lawrence and for tagging studies at Magdalen Islands, on LaHave Bank, in Passamaquoddy Bay, and around Grand Manan. The Pandalus II is 50 feet long and was used in Northumberland Strait from spring until late fall in surveys for lobster larvae and young. The Mallotus and Clupea H. are 54 and 30 feet long respectively. They were used as duty craft at St. Andrews and Ellerslie. For 9 weeks the Mallotus was used in a groundfish survey out of Lockeport. The Cyprina is a small (35 foot) shallow draft vessel made especially for accommodating hydraulic clam-digging equipment. On a variety of tests she was operated at Clam Harbour, N.S., Neguac, N.B., and Hillsborough Bay, P.E.I.

In addition to its own boats the Station employed 4 chartered vessels. The Barbara Jo (84 feet) and the Gloucester No. 37 (60 feet) were used in scallop explorations. The Barbara Jo was used in the northern Gulf of St. Lawrence, the St. Pierre Bank region, and on the Nova Scotia Banks. The Gloucester No. 37's activities were confined to the southwest Gulf of St. Lawrence. The Betty Lou IV (40 feet) and the Mercury (45 feet) were used in operations connected with the Passamaquoddy Bay survey. Use of the C.N.A.V. Fort Frances in co-operative work with the Atlantic Oceanographic Group facilitated the collection of offshore data in biological oceanography.

LOBSTER

The lobster fishery is the most important in the Maritimes in providing a livelihood for inshore fishermen. The fishery lends itself to regulation through size limits since undersized lobsters survive well when released. Because of the importance of maintaining this resource while using it fully, a great deal of attention has been given to regulations and their effects.

Various aspects of the lobster's life history have been explored. The extent of onshore and offshore movements near Port Maitland, N.S., has been shown to be very limited and unrelated to fishing success. In an attempt to explain variations in the production of lobsters from year to year, studies have been continued on the abundance of various stages of young and on their enemies. Attention is given to the effects of temperature on lobster activity and its bearing on trapping behaviour.

An important feature of the lobster industry is that the animals are marketed alive. In the past, much research has been put on the conditions favouring their well-being. During 1957 the oxygen up-take of lobsters was studied and various experiments were tried in an attempt to discover light-weight packing methods for air-shipping.

Lobster population studies. The reactions of lobster populations to exploitation have been followed by tagging and sampling catches at 2 localities in Prince Edward Island and 3

in Nova Scotia.

Tagging experiments have shown the grounds off Tignish and Miminegash, P.E.I., to be heavily fished with exploitation rates of 59 and 76% respectively. Fishing was unusually good in both areas during 1957. Some of the improvement may reflect the high abundance of young produced in 1952 which should be starting to supply the fishery. If so, fishing should still be good in 1958, and bottom dragging near Miminegash has shown a good supply of sub-legal lobsters. Beyond 1959 the prospects are less favourable. Late larval stages of lobsters which should be recruiting to the fishery about 1960 were relatively scarce in 1953 and 1954.

Annual exploitation rates in southwest Nova Scotia, near Port Maitland, N.S., have ranged from 35 to 61% with an average of 48%. Landings declined rather steadily from 1950 to 1955 but levelled off in 1956. Because of a corresponding decline in the number of boats, the catch per boat has not fallen off so markedly.

At Fourchu, N.S., the minimum legal size of lobsters was increased in 1947 to 3 1/8 inches carapace length. As expected, this was accompanied by an immediate marked decrease in landings. From 1947 to 1951 landings improved relative to adjoining areas which had no change in size limit. From 1951 to 1955 there was a general improvement in landings in the region. Since 1955 total landings have declined appreciably and the catch per boat even more so.

In 1956 a plan to increase size limits by 1/8 inch annually until the limit reached 3 3/16 inches was adopted at Gabarus, N.S. Two years brought the size limit in 1957 to 2 3/4 inches but the catch fell from 333,000 pounds to 235,000 pounds. Similar declines took place in nearby areas so all the decline cannot be attributed to the initial response to regulation changes. However, with catches at their present low level, it seems unlikely that the fishermen will support further size-limit increases which would be certain to depress catches temporarily.

Movements and growth. The results of a special tagging experiment off Port Maitland, N.S., give no suggestion of concerted offshore or onshore movements. Practically all of the lobsters were re-caught close to the liberation point, the average movement being less than 1 mile. The conclusion that movements are much restricted was confirmed by the performance of the fleet in returning tags. There was a well marked tendency for tags put out in 1 lot to be returned by a few boats. This shows that tagged lobsters dispersed little and that in general tags were recovered by fishermen who put their gear close to the tagging site. The apparent movement of lobsters in and out from shore can be explained by changes in activity resulting from seasonal changes in water temperature.

To check on annual variations and other sources of inconsistency in estimates of growth rate a marking experiment was

done at Tignish, P.E.I. In June 1956, 8,200 6- to 10-inch lobsters were given a distinctive mark according to its length group. In May and June of 1957 catches were examined for marked animals and 1,147 were found. About 95% of these had moulted but few, if any, had moulted twice. Of the larger lobsters, 37% had not moulted. Growth in carapace length is remarkably constant at about one third of an inch among all but the largest lobsters marked. Growth fell off among the 2 larger size groups (c. 3 1/2 in. carapace length). The results agree closely with the earlier results for Tignish and suggest that the inconsistencies noted probably originated from area differences.

A tagging experiment on Passamaquoddy Bay produced data bearing on the possible effects of building dams at the Bay's entrance. Of 250 lobsters tagged off Brandy Cove, 58 have been recovered after periods of 1 to 77 days. The greatest movement was 1.3 miles and the average 0.5 miles. Results so far give no indication of movement of adult lobsters out of Passamaquoddy Bay.

Studies of early life history. The abundance of young lobsters at various stages has been followed since 1948. During the first 4 growth stages, the lobster swims freely close to the surface of the water. Systematic net hauls on the surface in Northumberland Strait have shown the relative abundances of the 4 free-swimming stages. The first-stage larvae show only small variations in abundance. The fourth stage is much more variable. In 1952 it was 38 times as abundant as in 1954. It seems possible that the high abundance of commercial lobsters around Prince Edward Island in 1957 may be related to the good supplies of fourth-stage larvae in 1952.

As an aid to prediction, systematic trawling for sub-legal lobsters is carried out in Northumberland Strait. It showed that lobsters just below legal size were almost as abundant in 1957 as in 1956. This is taken as an indication of good fishing in 1958.

The stomachs of 8 species of fishes caught in Northumberland Strait have been examined to see which of them were eating various stages of young lobsters. One third-stage lobster larva was found in a mackerel and 3 small lobsters were found in the stomachs of 2 shorthorn sculpins. There is not yet enough information to indicate the role of fish in limiting the production of legal-sized lobsters.

Activity and catchability of lobsters. Population studies indicate that the catchability of lobsters is markedly affected by temperature. Knowledge of the exact relationship is desirable to allow the interpretation of catch-per-unit-effort data in terms of population size. The relationship was studied in both laboratory and field experiments.

In the laboratory the activity of lobsters was measured by the rate of walking in response to a bright light. When lobsters are completely acclimated to the temperature they are experiencing, their activity increases over the temperature range of 2°C. to 10°C. It remains about the same from 10°C. to 20°C. but increases sharply again above 20°C. In general, lobsters are more active when they are fully acclimated. However, lobsters accustomed to 10°C. are more active at low temperature and those acclimated to 25°C. are more active at 20°C. than those acclimated to these test temperatures.

Trapping experiments in Passamaquoddy Bay with a fairly constant population of lobsters has shown reasonably constant catchability at water temperatures between 9.8°C. and 12.4°C. There was a rapid drop in catchability when the temperature dropped to 6.5°C. and again to 4.1°C. These results are in essential agreement with the laboratory experiments and are in part explained by them.

Behaviour of lobsters. The reactions of lobsters to various conditions control the effectiveness of different trapping methods. The need for general understanding of trapping behaviour has been made evident by the erratic performance of metal traps. As a start toward defining lobster behaviour a number of observations have been made.

Lobsters enter clear glass tubes almost as readily as they do opaque ones but they lie against the outside of dark ones more readily. They do not avoid metals and show no recognition of sound vibrations over a wide range of frequencies. Lobsters can exert at least a 1-pound force to push themselves through a valve in the entrance to a trap.

One pound lobsters made their way up 7-inch wooden ramps at slopes of 30° to 90° with little or no difficulty although there was some slipping on the 45° and 50° ramps. Lobsters slipped and could not proceed on long 45° ramps of galvanized steel. One-quarter inch mesh wire ramps were easily scaled but twine ramps as in ordinary fishing heads caused tangling when lobsters' legs slipped through the meshes.

Oxygen uptake by lobsters. Information on the oxygen requirements of lobsters is necessary to estimate proper water flows in units where these animals are held for sale. The investigation is still in progress. The results to date show that the oxygen uptake of acclimated resting lobsters increases with temperatures up to 20°C. and levels off with no further increase up to 25°C. At 20°C. oxygen uptake is twice as great--0.04 cc. oxygen per gram of lobster per hour as compared to 0.02 at 10°C.

Light-weight shipping methods. The distribution of live lobsters is an important activity of the industry. Shipments

by air could shorten travel time and improve the vigour of lobsters on arrival at their market. Two approaches to developing suitably light shipping methods have been explored. One of these involves a double walled leakproof cardboard box kept cool by ice sealed in plastic bags. When 10 pounds of ice were used this gave a gross weight of 64 pounds for 50 pounds of lobsters. To test this container, 250 pounds of lobsters were shipped by truck to Saint John and thence to Montreal through the courtesy of Trans Canada Airlines and return in the same ways. On the completion of the trip more than 95% of the lobsters were found to be in excellent condition.

The other method involved packing lobsters in dry wood shavings, and was proposed by European buyers. Our tests showed that this method is very effective when holding temperatures are low but only then. A commercial shipment of 12,600 pounds flown from Saint John to Belgium in early December arrived with 97% of the animals in excellent condition.

OYSTER

Oyster fishing and culture provide a much needed supplement to incomes in Prince Edward Island, around the Gulf shores of New Brunswick and Nova Scotia, and on Bras d'Or Lakes. Because the oyster lends itself to being cultured, there is good reason to believe that knowledge of the conditions controlling its survival and growth can be put to practical use. Research on culture methods has been an objective of the Station's work for many years. Recently, however, a large share of research effort has been directed toward studies of disease problems. In Prince Edward Island all oysters are immune to a disease which is endemic there. About 7 years ago the disease crossed Northumberland Strait and is now ravaging the oyster population along the mainland coast. Research has been directed to determining the course of the disease, finding the causative organism, and following remedial measures.

Disease studies. In order to study the spread of the disease, trays of local oysters were maintained at several places in Caraquet Bay, Miscou Harbour, and in the Bras d'Or Lakes. Routine examinations of the oysters in the trays showed Miscou and Bras d'Or to be still disease free. The situation at Caraquet was less clear cut. Up to this year there were no mortalities but in 1957 mortalities were heavy in trays set out around the western half of the Bay. Elsewhere in the Bay, they were light or absent. In some respects the course of the disease in Caraquet was atypic. Where it occurred, the onset of mortality was sudden and its extent more characteristic of second year than first year effects. Moreover the typical emaciation was absent. It remains to be seen whether the disease will henceforth follow its usual course and virtually wipe out the oyster stocks.

Examinations of records from areas where the epidemic has run its whole course have produced new information. For the first time we have a measure of the period of the epidemic. It takes about 6 years after which time only 1% of the original stock remains alive. This low value is of significance as it shows the vital importance of introducing supplementary immune breeding stock in carrying out rehabilitation.

The Conservation and Development branch of the Department of Fisheries has embarked on a program of rehabilitating oyster stocks along the mainland shore by introducing immune breeding stock from Prince Edward Island. The Station has cooperated in this venture by observing samples of the transferred oysters. A few died but no more than would have been expected to do so under ordinary conditions. In most places, the transplanted oysters spawned in their new surroundings. Even although no sets of young oysters were recorded it can be said with some confidence that the transplantations are successful.

In searching for the cause of the disease, special techniques were employed to demonstrate the presence of a fungus which is known to attack and kill oysters in other regions. The known oyster killer was not found but another fungus was. It is being investigated as a possible source of trouble.

Culture studies. When oysters spawn many thousands of minute larvae float freely in the waters for a period of about 3 weeks. During this time, mortality is very high and some times all the young oysters die. A critical stage in the life history is reached when the young oysters are ready to settle down to a sedentary life. They must find a suitable clean surface or they perish. One phase of oyster culture is providing suitable material (culch) for oysters to settle (spat). If the culch is in the water for too long before spatting, it becomes fouled with plant growth and is unsuitable for settlement. Part of the Board's work at Ellerslie is to predict when spatting will take place from an examination of plankton samples. Another is to survey the success of spatting in a wide variety of places and conditions. The oyster larvae which developed in Bideford River in early summer failed to settle at the time predicted and the mid-summer set died a week after setting. At Freeland, only 7 miles from Bideford River the early summer spat settled in good numbers and survived and grew well. In general the year 1957 was poor for collecting oyster spat and no good sets were observed. Even the usually dependable areas in the Bras d'Or Lakes produced none. There were, however, good collections later in summer than is usually useful.

After collecting the spat it is necessary to nurse it along until it is big enough to put out on the commercial growing beds. This requires protecting it from silting over, freezing, starfish, etc. Protection is possible by growing the young oysters in trays but trays are very expensive. At Conway Narrows,

P.E.I., a natural area has been found where spat planted on the bottom seem to grow successfully to bedding size. If further tests show the area to be as effective as it seems, it will be extremely useful to the industry. There are indications already that very small-sized spat, such as those arising from the 1957 Bideford River late-summer sets can survive there. The usefulness of the area is being closely studied.

Boring sponge. The boring sponge is a nuisance on oyster grounds as it galleries the shells, making them too weak to open without breaking. Considerable research has gone into sponge biology and tests of control methods. Emersion in fresh water overnight was found effective in killing the sponges but is laborious. The effects of control by this method were observed for about 3 years. A method of sponge control involving emersing the oysters in salt-water brine for 3 to 10 minutes has been tested. This method is effective and has several advantages in simplicity, safety and economy. Brine dips are accordingly being recommended to oyster growers for sponge control.

European oysters. In an attempt to diversify the resources available to Maritimers, European oysters were introduced. The oysters were a special pest-free stock known to be resistant to low temperatures. They were provided through the courtesy of the British Ministry of Agriculture and Food from the rearing tanks at Conway, North Wales. The introduction had rather mixed success. Less than 10% of the animals survived the initial transportation and necessary handling. However, those that did survive have thrived and grown well in 2 sheltered inlets in southern New Brunswick. They are Sam Orr Pond and the head of Oak Bay. In both of these areas, water circulation is restricted so that high summer temperatures suitable for the spawning and growth of these oysters are produced. It remains to be seen whether the oysters survive winter conditions. If they do, a supplementary introduction using air freight will be recommended.

CLAMS

Soft-shell clams around the Maritimes provide a source of income to residents who lack costly fishing equipment. In recent years, however, clam stocks have declined in productiveness. There are a variety of causes. Changes in climate and green crabs no doubt play a part. In some areas disease is suspected. However, the major cause is believed to be the effect of digging with the usual hand tools. Some decline in yield is a natural and expected result of exploitation. However, careful analysis has shown that current digging methods are not only inefficient in recovering salable clams but in addition they destroy a very large proportion of the young clams in the soil and consequently drastically cut down the recruitment of new individuals for future years. With this in mind other methods of digging have been explored. A mechanical clam digger has been constructed and considerable effort during 1957 was spent in perfecting this machine and assessing its performance from economic and biological points of view.

Mechanical harvesting for shellfish. With the financial assistance of the Industrial Development Service of the Department of Fisheries, a mechanical clam digger for use from a boat was constructed in 1955. It was designed to use jets of water to wash clams out of the soil onto an escalator which brings them to the surface. This equipment was improved in 1956 and performed reasonably well but seemed slow. In 1957 a larger pump was installed to provide the digging head with 750 gallons of water per minute at 40 pounds pressure. With this improvement, the equipment gave excellent performance in digging not only soft-shell clams but quahaugs and bar clams as well. The escalator digger was originally planned as a conservation measure. Its value for this purpose is still to be completely explored. In the meanwhile, it has established its usefulness in exploiting stocks of bar clams and quahaugs that are close to the low-tide mark and stocks of soft-shell clams that are too sparse to allow profitable digging by hand tools.

Green crab. This pest is a southern invader of our clam beaches that has made substantial inroads into our young clam stocks. Its advance into the Maritime Provinces has been followed by questionnaires and by trapping experiments. During 1957 there were no reports of extension in range and our trapping experiments showed definitely that abundance is on the wane. In 1954 a standard trap set produced more than 300 individuals. By 1957 this number had dropped steadily to 65 crabs per trap per night.

Paralytic shellfish poisoning. During 1957, 32 cases of paralytic shellfish poisoning occurred in southwestern New Brunswick after an absence of 12 years. This serious toxic condition is produced by minute animals eaten by the clams. They do not harm the clams but people eating the clams may suffer fatal consequences. Most of the poisonings originated from clams taken at Lepreau where the danger was advertised by conspicuous Department of Fisheries notices. In co-operation with officers of the Inspection Branch of the Department of Fisheries and the assistance of public health officers, a thorough study of the outbreak was carried out. New information was obtained on the sequence of symptoms and on the amount of poison necessary to produce them and suggestions for improved control have been advanced.

SCALLOP

The Canadian scallop fishery is growing very rapidly. From 1941 to 1951 the fishery averaged around 0.70 million pounds. By 1956 it was 2.42 million pounds and in 1957, 3.41 million pounds. The recent increase has arisen from high production in the Digby area and the phenomenal increase of production by the offshore fleet on Georges Bank. The fisheries in Northumberland Strait and on St. Pierre Bank fell off substantially this year.

In the Digby area there was a genuine increase in abundance. This increase was predicted several years ago on the basis of highly successful sets of young scallops during the warm-water years from 1949 to 1951. Cooler years have succeeded and

it now seems likely that Digby landings are close to a peak from which there will be a decline.

The quite spectacular increase in 1957 Canadian offshore scallop landings resulted entirely from the expended effort on Georges Bank. There, landings increased from 0.70 million pounds in 1956 to 1.69 million pounds in 1957. The Station has made no systematic study of scallops on Georges Bank but it seems likely that abundance of scallops there is controlled by environmental factors similar to those on the Digby beds. If so, we may look for fluctuations in abundance and in production, and a falling off from the present very favourable situation.

Temperature tolerance. Severe mortalities among Gulf of St. Lawrence scallops are reported repeatedly and there is good circumstantial evidence for believing that these are related to temperature changes. The temperature tolerance of scallops is accordingly under investigation. Results obtained in laboratory experiments in 1957 are being analysed. The seasonal increase in tolerance of scallops to high water temperatures observed in earlier years was developed later and less strongly in 1957. The reasons for this difference are still under examination.

Scallop exploration. The fact that scallop populations in the Gulf of St. Lawrence are subject to extensive and uncontrollable mortalities suggests that beds there should be fished hard as soon as the animals on them reach marketable size. The Station on behalf of the Industrial Development Service of the Department of Fisheries has aided the industry by carrying out exploration for new scallop grounds there and elsewhere. During 1957 2 vessels carried out exploratory fishing in the Gulf of St. Lawrence and on the St. Pierre and Nova Scotia Banks.

In the Gulf of St. Lawrence the explorations showed that scallops occur on most of the grounds on which they had been reported but catches that would be commercially attractive were made in only 1 area and even on this one, the concentration disappeared toward the end of summer. There is little prospect of a continually successful scallop fishery in this region.

Offshore operations discovered a small but commercially valuable scallop producing area on the southern part of St. Pierre Bank. However, no concentrations of scallops were discovered on the eastern Nova Scotia Banks which had appeared promising in the 1954 survey. There is accumulating evidence from industry and research observations that St. Pierre Bank is a more regular producer of scallops than previously realized. It may prove to be profitable for Newfoundland based draggers to operate there.

The information about the discovery of new grounds was reported to the Industry by radio and the beds have been actively fished.

GROUND FISH

The groundfish collectively are the most important marine resource on the Canadian Atlantic coast. They supply the fish for the large offshore trawlers as well as for a variety of smaller inshore vessels. They are so extensive that quite small improvements in the management of the resource or in exploitation methods can result in substantial increases in profits.

A basic requirement for planning improvement is accurate information on the existing situation. Accordingly, a great deal of effort is diverted to the collection of catch statistics and their analyses on the basis of kinds of vessels and gear used, time and place of capture, and the amount of effort that went into the fishery. In addition special efforts were made by examining samples of the catch to record the size distribution of the fish in the catches and in the parts saved for landings.

Studies have shown that some parts of the resource may be more productive if they are exploited under certain restrictions. Much of the fishery is carried out in international waters and its regulation is consequently arranged through the International Commission for the Northwest Atlantic Fisheries. This commission suggests significant subjects for research, considers the results of investigations by national research groups, and proposes appropriate regulations for enactment and implementation by the 10 member governments.

Some parts of the fish stocks are inadequately used and for all parts it is important to increase the efficiency of Canadian operations. In the past, the Station has been active in introducing improved fishing methods, but recently the introduction of efficient operations has proceeded so rapidly that the Station's efforts in this work have been curtailed. Provincial Fisheries offices and the Development Service of the Federal Department of Fisheries are adequately stimulating the development of a fishing fleet which is landing increasing quantities of groundfish with decreasing effort on the part of the fishermen. As an example, in 12 years the number of licensed draggers and otter trawlers in the Maritimes has increased from about 10 to over 250. The Station's earlier efforts proved very fruitful. Danish seining introduced to the Maritimes by the Station in 1948 has now been adopted by 5 commercial vessels and the Station is co-operating with the Nova Scotia Fisheries Division in following the development of the fishery. The long-line method of fishing which was introduced to the Maritimes by the Station in 1943 has spread widely throughout Nova Scotia. Sixty-foot long-liners are competing successfully with draggers of comparable size. The recent adoption of long-lining methods by large Lunenburg schooners is being followed with interest. During 1957 information concerning the so-called Norwegian jigger was distributed to Provincial Fisheries offices, and jiggers were directly introduced in northern New Brunswick. It is expected that the use of this efficient lure will spread without further promotion.

Mesh regulation. Studies of mortality rates and growth in cod and haddock in the Maritimes area, and of the way in which the sizes of meshes in the codends of trawls influences the size of the fish retained in them strongly suggest that the use of large meshes would eventually result in increased stocks of commercial fish. Consequently in 1955 the International Commission for the Northwest Atlantic Fisheries (ICNAF) recommended to the participating governments that the minimum mesh size in codends should be $4\frac{1}{2}$ inches inside measurement in subarea 4. (Four inches was the recommended size in subarea 3.) After some delays these proposals were accepted by all the participating governments, and Canada made the new regulations effective in March, 1957. The year, accordingly, was one of transition for the Canadian fishery and afforded good opportunity to compare the effects of different mesh sizes on the same stock of fish.

Two kinds of comparison were made on the cod fishing grounds in the Caraquet region. They involved fishing success and the sizes of fish caught. For 39 draggers in 5 size categories, the 1957 landings were compared with those of the 2 previous years and related to the sizes of mesh used in 1957. The comparisons give no evidence of decreased landings for draggers which increased their mesh size in 1957. While there is no evidence of any loss of commercial production from the use of $4\frac{1}{2}$ -inch meshed nets, there is convincing evidence that many fish are released through larger meshes, presumably to survive and grow to commercial size. This evidence was obtained in 1957 by comparing the length distributions of fish caught and brought on deck, using nets of different meshes, with the sizes of fish brought in and sold after culling. As an example 3 small-mesh (3-inch mesh) trips to the Bonaventure Island grounds may be directly compared with 3 large-mesh ($4\frac{1}{2}$ -inch) trips in 1957. The percentage of fish discarded and wasted with the small mesh was 31% by number and 10% by weight. Using the large mesh, these percentages were 12 and 5. A typical situation is shown in the figure.

It is noted that the proportion of cod caught and discarded is still significant even using the larger meshed nets. This raises the question about the desirability of increasing the minimum mesh size further. Extensive studies by Station workers and others have shown a definite proportional relationship between mesh size and the average size at which fish are released. Examination of the data on cod in the Caraquet area indicates that a minimum mesh size in the neighbourhood of $5\frac{1}{2}$ inches would be desirable to eliminate waste. The situation is to be thoroughly explored. Extensive field tests will be carried out and a careful review of existing knowledge is being made to establish the principles that apply to the findings.

The mesh sizes discussed above refer to nets made of manila, and the fish lengths concern codfish. Other fibres are employed and other fish are taken. Observations show that codends made of nylon fibre made in 2 different ways differ from each other and from manila--both nylons release more fish than

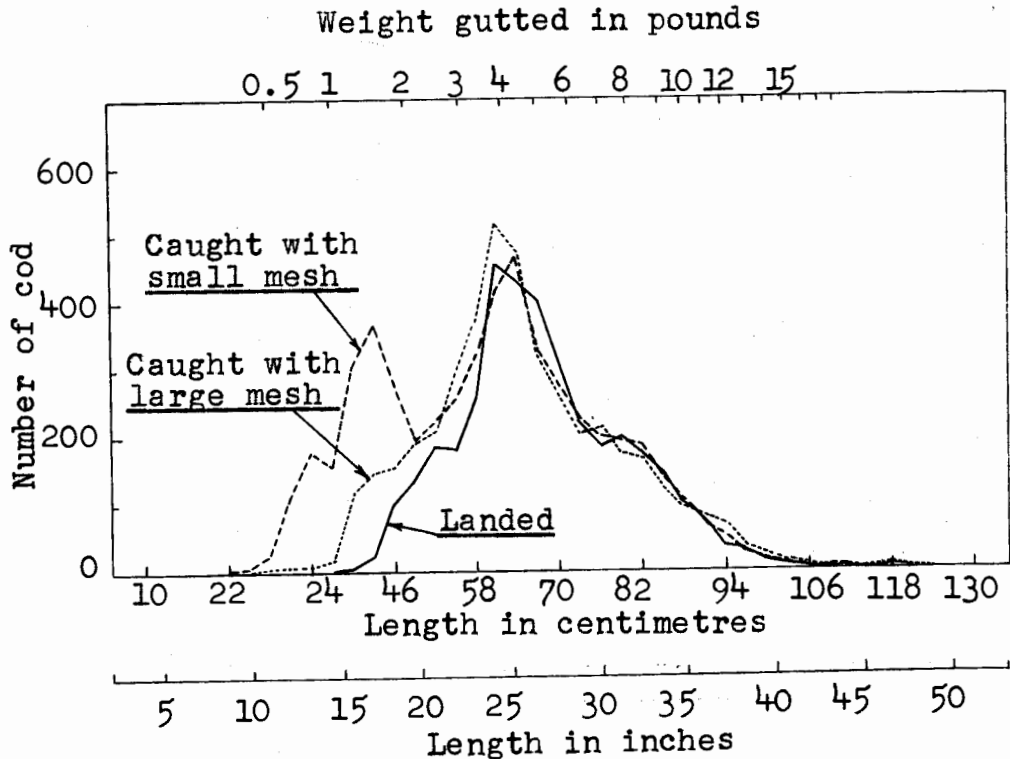


Figure 1. The sizes of cod caught in the Caraquet area by small (3-inch) and large ($4\frac{3}{4}$ -inch) meshed nets compared with the sizes landed commercially. It will be noted that number of fish caught and discarded is much reduced with the large meshed nets. Even with them, however, there is substantial wastage.

manila. This justifies special provisions in the Canadian regulations for other fibres. Plaice of quite small size are retained by any mesh size that has been considered for cod, and it is improbable that any regulation which is likely to be applicable to cod will release marketable individuals.

Tagging studies. Tagging is a useful method of increasing our information about fish stocks. Directly, it provides information on the migrations and dispersion of the various species, and it helps to define the various populations that go to make up the resources. In addition tagging provides data on rate of growth, and on fishing and natural mortality rates. As a research tool, tagging is so useful it seems likely that it should be continued indefinitely where the needs for information seem greatest and as resources permit. Several styles of tag are employed and studies of technique are part of the work. The standard tag used on cod and haddock consists of 2 small celluloid discs held to the sides of the fish's body by a stainless steel pin passing through the centres of the discs and the fish's muscle below the dorsal fins.

One of the discs is numbered for identification. Time and place, and fish size at tagging and recovery provide essential data for biological studies.

During 1957 haddock tagging occupied most of the time devoted to groundfish tagging. About 1,100 haddock were tagged in the LaHave-Browns Banks area off western Nova Scotia in March and April. The work was done in conjunction with similar operations by the United States Fish and Wildlife Service in the same region in order to compare techniques, tag types, and possible differences between conditions of fish caught in large and in small otter trawls. In November and December approximately 1,000 haddock were tagged in Passamaquoddy Bay and Grand Manan Channel, and an additional 70 off Digby. This work also was carried out in co-operation with the United States Fish and Wildlife Service. It is anticipated that the results will bear on the effects on groundfish of the proposed blocking of the entrance to Passamaquoddy Bay by structures to produce tidal power. Cod tagging was limited to some 1,200 fish tagged in the vicinity of the Magdalen Islands to determine whether or not these cod are a separate stock.

It takes several years to get in all the returns from a tagging experiment so that the results can be evaluated. However, recoveries are scrutinized as they come in. For the 1957 offshore haddock tagging recoveries have been lower than anticipated but it is uncertain yet whether this is a result of the techniques of handling fish from deep water or of lack of fishing effort on the appropriate grounds. The Bay of Fundy haddock taggings have produced about 2% returns and the Magdalen cod tagging has produced a few local returns but it is much too early to consider the implications of these results.

The examination of returns from earlier taggings is giving interesting data. Approximately 40% of the haddock tagged at Lockeport in 1953 have been reported to the end of 1957, and in 1957 recoveries were still coming in at the rate of 6% per year of all the unaccounted-for tags. These recoveries continued to give consistent records of inshore recaptures in summer and offshore recaptures in winter. The inshore recaptures have been mainly from the Lockeport region and the offshore ones from the vicinity of LaHave and Browns Banks. In general the distribution of recaptures from the Northumberland Strait haddock tagging fits in well with the results of earlier haddock taggings off the east coast of Cape Breton. It supports the conclusion that haddock migrate out of the Gulf in late fall, spend the winter on offshore banks and return to the Cape Breton region and the Gulf of St. Lawrence in spring.

As in the case of the haddock, recaptures in 1957 of cod tags put on off northern New Brunswick confirmed the pattern of movements shown by earlier work. During winter and late spring these tags were recovered outside the Gulf along the 100-fathom contour of the Laurentian Channel. In the summer most of the

recoveries came from the Gulf of St. Lawrence chiefly from the Bonaventure-Miscou area where the fishery is concentrated.

Growth studies. The growth of individual fish is a most important phenomenon since it is upon it that all production from the resource depends. Estimates of growth rate are basic to schemes for resource management. Variations in growth rate affect the success of fisheries and must be understood if production figures are to be properly interpreted. Available methods of study are accordingly applied to growth. During 1957 these included the analyses of tag recovery data and feeding experiments.

The lengths of cod when tagged in 1955 and 1956 in the Gulf of St. Lawrence were compared with the lengths on recapture. Results from the 1955 tagging show that the average growth increased from 0.6 cm. in July to 3.7 cm. in November of the year of tagging, from 5.3 to 7.7 cm. during the summer of 1956 and from 9.3 to 11.3 cm. in the summer of 1957. The results showed no significant difference in growth rates related to the size of the fish at tagging and that there was considerable growth during winter months. The results from the 1956 tagging showed similar changes but it was evident that there was more growth from 1955 to 1956 than from 1956 to 1957. This difference between years is shown also by growth studies using otoliths from commercial catches.

Captive codfish were kept under conditions which allowed keeping track of the weight of food consumed and the increase in length and weight as well as changes in water temperature. Fish were fed at 3 different levels. The work is continuing but results to date show that growth rate corresponds quite closely to food consumption, that cod convert herring as food into cod flesh at a rate between 2.1 and 8.3 pounds of herring per pound of cod. There was little difference in growth or food consumption with a temperature drop from 12.5°C. to 4.5°C. A rough estimate shows that about 2½ ounces of herring are necessary to maintain a 24-ounce cod for 3 weeks.

Mathematical models. One of the main purposes in collecting data on growth rates, mortality rates, catch statistics, and fishing effort is to allow predictions of effects of changes in fishery management. The known values are used to construct diagrams called mathematical models relating yield to fishing effort under various conditions of growth rate, mesh selection, mortality rate, and catch per unit of fishing effort. Such a model for the cod fishery in the Gulf of St. Lawrence indicates that the sustained yield can be increased by increasing the mesh size beyond the 4½-inch minimum now provided by regulation, or by limiting the total fishing effort. This conclusion is supported by the history of the fishery which showed that catches improved when fishing effort was cut down. Mathematical models were prepared also for the cod fishery in the Lockeport area. The results of these analyses too indicated that increased yields

might be expected from increasing mesh and hook size or from decreasing the amount of fishing.

Gulf census. A systematic census of the cod and plaice populations of the southwestern Gulf of St. Lawrence was started in 1957. The purpose of this census was to determine recruitment. It will also assess the effects of environmental factors on the abundance, distribution and movements of these 2 species. The results should lead to short-term predictions of the relative abundance of the stocks available to the fishery.

With 1 year's work and at an early stage of analysis, it is possible only to report on geographical and seasonal variation in the size composition of the cod stock. Four well-defined and 2 less clearly marked size groups of fish were recognized. These groups changed in length during the summer indicating growth of 3 to 6 cm. during the study period. Small cod were abundant in the spring throughout the study area. They disappeared from the northern parts of the Bay of Chaleur toward the end of June but returned again by mid August. It is anticipated that additional data and further analysis will provide a better knowledge of the cod population in the southwestern Gulf of St. Lawrence.

Included in the census program is a survey of the incidence of 2 copepod parasites of cod Lernaeocera branchialis and Clavella uncinata. Parasites on occasion provide very useful natural tags on fishes and the survey was undertaken in part to see what clues the parasites offer on the life history of the fish. Lernaeocera was found most abundant in inshore waters and abundance, after reaching a peak on fish 41 to 50 cm. long, declined with increasing size of the hosts. There was no evidence of geographical variation in the distribution of Clavella and with it the larger cod were more heavily infected.

Porrocaecum studies. Porrocaecum decipiens is a parasite of codfish and other species which depreciates the acceptability of the fillets and hence lowers their value. Studies of the life history of the parasite have given strong indication that eradication of seals is the only possible way of biologically controlling this parasite. It seems that in some areas at least seal control might be practical. One such area is that in the vicinity of Lockeport where only harbour seals are found. In order to provide a baseline of parasite incidence so that the results of any seal control measures could be assessed, the cod in the area were thoroughly surveyed for parasites.

The survey was carried out in 1957. In general it may be said that the survey defined the incidence of parasites for that year and established practical methods for following the effects of control measures. No further survey is planned at present but another one similar in scope and methods should be undertaken immediately preceding any control program that is undertaken. Some of the observations during 1957 apply to the biology

of the species involved. Of 517 nematodes examined in detail, 95% were Porrocaecum and 5% Anisakis. In August 79% of the parasites observed in fish at Lockeport were found in the parts corresponding to the commercial fillet. The incidence of parasites was generally higher in the older age groups. The amount of increase varies with locality, being least in offshore samples. The degree of infestation generally is higher in inshore samples which supports other evidence that inshore and offshore populations of cod do not mix freely.

Work on the general biology of Porrocaecum has been continued under a contract with the Institute of Parasitology of McGill University. Information on the subject has been collected and reviewed and at the Magdalen Islands numerous experiments were carried out. Under experimental conditions, newly hatched Porrocaecum larvae were introduced into a wide variety of invertebrate and vertebrate hosts from which they were recovered about 24 hours later showing no change in development.

HERRING

During 1957 the emphasis of herring research was placed on studying the statistics and biology of herring in Passamaquoddy Bay and in adjoining parts of the Bay of Fundy and the Gulf of Maine. The research was undertaken to meet the needs recognized by the International Passamaquoddy Fisheries Board. This Board was established by the International Joint Commission to study and report upon the probable fisheries effects of placing dams at the entrance to Passamaquoddy Bay in a scheme to develop hydroelectric power from the tides. Herring provide the most important fishery in the area. The research program for the Board has, accordingly, concentrated on the distribution, source, movements, and habits of the species. Attention is also being given to other marine resources which may be affected.

Herring research is also directed toward meeting other needs. In general, the herring resource is incompletely used and the less used populations are accordingly being studied and possibilities for greater utilization are being explored. The important and growing fishery in southwest Nova Scotia is being followed and the herring population supporting it is being studied. In Northumberland Strait variation in the numbers of herring larvae are being followed. Exploration with herring drift nets has been carried out south of Newfoundland.

Herring statistics in Charlotte and Saint John Counties. For estimating probable effects of dams at the entrance to Passamaquoddy Bay, the commercial distribution of the fish is important. Through the co-operation of the Department of Fisheries Economics Service, a statistical survey of the region is being made. The 1,079 weir sites and their fishing records are being related to the principal engineering plans.

Over the 20-year period from 1938 to 1957, herring catches in Charlotte County have ranged from 22.8 to 109.8 million pounds with an average at 72.7. The part of the catch taken inside Passamaquoddy Bay averaged 15.8%. In 1957 the part of the County catch taken inside the Bay was 27%.

Daily catch records of herring for the area were recorded in 1957 according to gear and locality. Of the total landing of 87.7 million pounds, 69.1 were taken from weirs, 6.4 million pounds were taken in purse seines and beach seines, and data were incomplete for 8.2 million pounds. Weir catches began in February, and reached a peak in September. They stopped in December. Ninety-three per cent of the landings were made between July 2 and October 31. Seine landings were made in 2 periods. January to May produced about 7 million pounds and July to November about 4 million.

Population studies. The herring in the Passamaquoddy region are being studied to find out whether they belong to 1 or several groups and, if there are several groups, how much mixing takes place among them. These studies are being made by comparing different schools in such population characteristics as length distribution, age distribution, average vertebral count, etc. All the data have not yet been analysed but the preliminary examination of the results indicated a succession of more or less distinct groups of herring entering the region. This opinion is supported by studies of the growth patterns of the fish as found by examining the scales.

Herring movements. The movements of herring within the Passamaquoddy region have been studied by using small plastic opercular tags. In a co-operative venture with the United States Fish and Wildlife Service, 37,495 fish were tagged at various weir sites. Of these, 792 or 2.1% were recovered. The tags put out in Charlotte County show movements into and out of Passamaquoddy Bay, including movements into the Bay from Grand Manan. Movements are shown in both directions between Saint John County and Passamaquoddy Bay. However, movements are evidently restricted between the Passamaquoddy area and Nova Scotia and Maine. One tag used in Maine showed up at Point Lepreau but otherwise there was no interchange.

The distribution of recoveries from one of the taggings is shown in the illustration. The variety in the direction of movement and the general move towards Passamaquoddy Bay seem characteristic in 1957.

Herring behaviour. The availability of herring to the fishery depends upon its behaviour--the way the fish react to light, current, temperature, and other features of the environment. Knowledge of the behaviour is needed to forecast the way in which herring will react to new conditions presented by filling and emptying gates in the damming structures proposed by hydro-electric development.

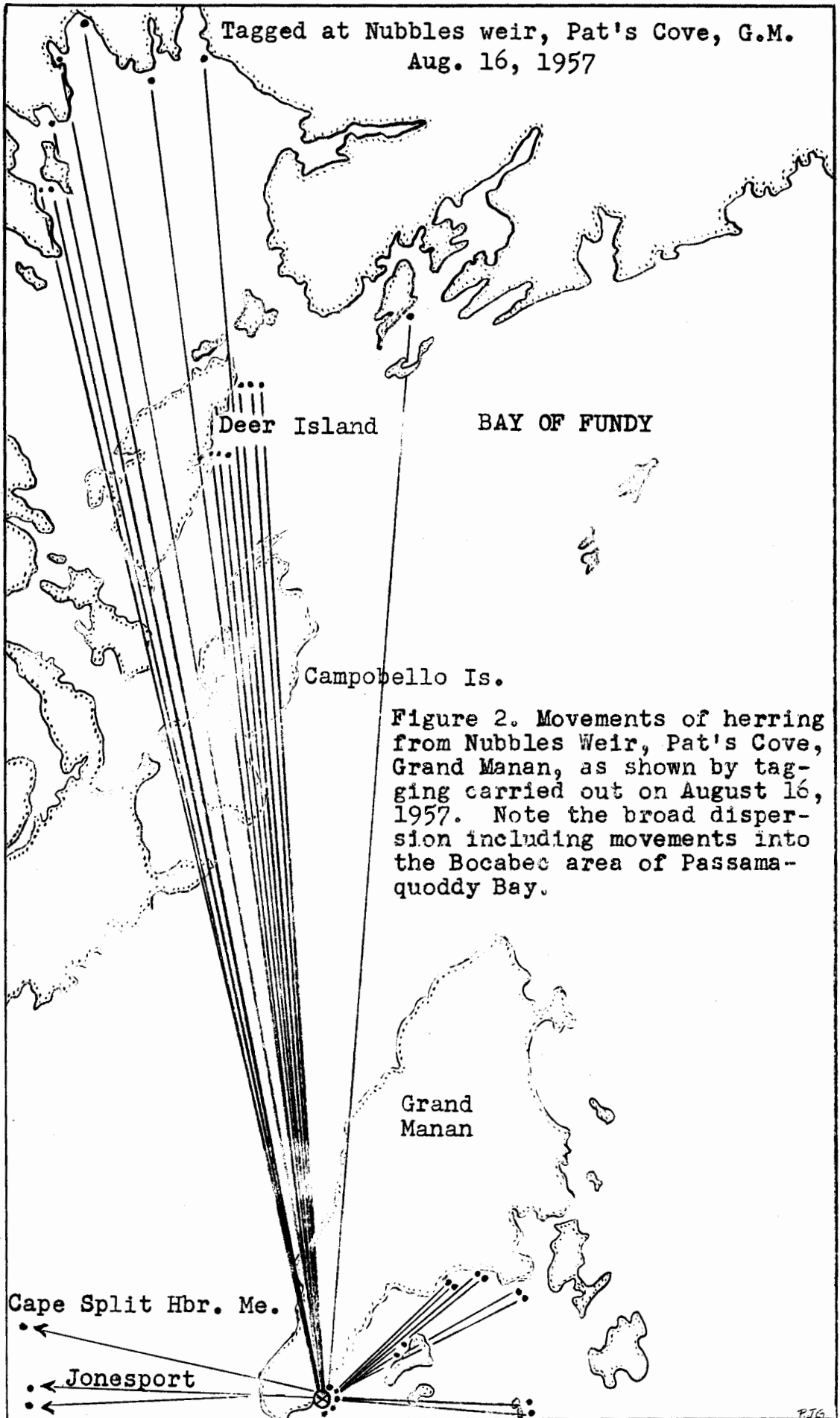


Figure 2. Movements of herring from Nubbles Weir, Pat's Cove, Grand Manan, as shown by tagging carried out on August 16, 1957. Note the broad dispersion including movements into the Bocabec area of Passamaquoddy Bay.

Herring behaviour is being studied by laboratory tests and observations in nature. For the laboratory work, equipment has been designed to give critical tests of the reactions of herring to a wide range of current conditions.

The varying behaviour of herring in nature has been studied by analysing available echo-sounder records at different times of year in relation to the time of day and the depth at which the fish were swimming. Evidently herring in Passamaquoddy Bay remain close to the surface during the summer and fall months but in early spring remain closer to the bottom.

Plankton. Studies of the small drifting life which can be strained from the water of Passamaquoddy Bay gives 2 kinds of information concerning herring. In the first place they tell about the distribution and abundance of young herring. In the same way they tell about the distribution of the herring food.

Two lots of plankton samples have been examined in this work. Some 500 collections taken at regular intervals at stations just outside and in the entrance of Passamaquoddy Bay from 1947 to 1957 inclusive have provided a valuable chronological record. During 1957, these collections were supplemented by others taken in special cruises in the Passamaquoddy region.

In general, herring larvae are scarce in Passamaquoddy Bay and its approaches. Only 28 individuals turned up in the 500 collections and the special cruises produced only 2 more. This situation may be contrasted with those along the Nova Scotia shore of the Bay of Fundy and in its approaches where larva were quite abundant.

A comparison of the abundance of herring food inside and outside Passamaquoddy showed a marked contrast between 1956 and 1957. In the former year, both herring and plankton were consistently very scarce within the Bay. In 1957 herring catches in the Bay were good and plankton collections were relatively rich. The significance of this coincidence must be interpreted in the light of further data from future years.

Surveys to follow changing abundance in herring larvae are made annually in Northumberland Strait. There catch-per-standard-collection tow has ranged from 32 to 1,898. There is little indication of a relationship between the numbers of larvae and the size of the spawning population. It is presumed, accordingly, that the wide variation in abundance of larvae arises from sea conditions affecting their survival. Whether the number of larvae observed is related to the number of adults which will eventually be produced by the brood is another and important question. It will be the subject of later study.

Studies on herring in southwest Nova Scotia. The herring fisheries in Digby, Yarmouth, and Shelburne Counties are undergoing rapid expansion. Landings have increased steadily from 16.8 million pounds in 1948 to 4.20 million pounds in 1957. Increased fishing activity in these areas was undoubtedly influenced by a scarcity of herring on the west side of the Bay of Fundy between 1952 and 1956. However, with the return to normal catches in New Brunswick and Maine in 1957, expansion of the Nova Scotia fishery has continued. Market demand has been expanding but in general the supply of fish still exceeds the demand.

The most important development in 1957 was the use of purse seines for catching adult herring offshore. This took place chiefly in the Digby area but substantial seine catches were made also near Trinity Ledges and Lurcher Shoals.

Samples of commercial catches were examined routinely throughout the year. The average lengths of the fish in these samples show no significant changes from those of recent years and there is, accordingly, no evidence that the population has been affected by exploitation. Age and vertebral count analyses have not yet been completed.

Observations have shown something of the source of the herring stock supplying this fishery. The most important spawnings are usually from mid August to early October. Larvae, 5 to 20 mm. long, were abundant throughout the area in September and October. Growth is slow during the winter but by early May, the young herring were between 35 and 60 mm. in length. When the herring are a year old, they are about 90 mm. ($3\frac{1}{2}$ inches) long.

For the first time direct evidence was obtained of spring spawning in the area. Ripe and running herring were obtained from Port Maitland and Tiverton in gill nets on May 23 and 24. Larvae, 9 to 12 mm. long, taken in St. Mary Bay on May 24, support the idea of spawning as early as April.

Gear experiments. During the late fall of 1957, arrangements were made with the Industrial Development Service and the Newfoundland Department of Fisheries to compare the effectiveness of drift nets with the traditional set nets. The tests were made during the winter and spring fisheries along the south coast of Newfoundland. Forty-three night sets were reported from January to June. The tests showed that the drift nets were definitely more effective in catching herring. In 1 period, they caught 7 times as many fish per net. In another period, they produced good marketable catches while the set nets took nothing. Since drift nets are only 25 or 30% more expensive than anchored nets and are operated at the same cost, general trials of drift nets by commercial fishermen is recommended.

Exploratory fishing. Exploratory fishing has been done in 4 localities.

On behalf of the Industrial Development Service a search was made for summer fishing grounds along the south coast of Newfoundland. Drift nets were set overnight 36 times in 10 likely localities. The average catch was only 44 pounds a set. This is far below the 200 pounds necessary to sustain a successful commercial operation.

In Passamaquoddy Bay trials with a Dutch herring trawl produced catches of only 50 to 70 pounds of herring per tow. Mid-water trawls and curtain gill nets were not successful in making substantial catches.

It seems likely that the damming of the entrance to Passamaquoddy Bay might produce conditions in it similar to those in Kennebecasis Bay. Exploratory fishing with trawls, set lines, and gill nets was accordingly undertaken there to determine the species of fish which appeared to thrive. Small quantities of the following species were taken: herring, gaspereau, sturgeon, tomcod, winter flounder, eel, smelt, hake, cod, whitefish, sculpin, redfish, and stickleback.

A cruise to Georges Bank in 1957 confirmed the presence of a large spawning stock there. This spawning area was discovered in 1955 and was re-examined in 1956.

SALMON

The salmon is valued highly both as a commercial species and as a sport fish. In several areas around the Maritimes and elsewhere it makes an important contribution to the incomes of local commercial fishermen. Throughout its range it is recognized as providing the angler's richest prize. The competition for salmon by different kinds of gear complicates regulation of the fishery. It is particularly desirable as a result for those responsible for management to have unequivocal information about the distribution and abundance of salmon at all life history stages. The life history of the fish itself provides another complication. Salmon are anadromous, spawning in rivers. Typically they spend their first 2 or 3 years in the river as fry and parr before going to salt water as smolts. Salmon which return to the river after 1 year are small and are called grilse. Two- and 3-sea-year fish are larger and are frequently referred to merely as salmon. Some salmon survive to spawn more than once. In the river fry and parr are subject to their normal natural enemies. They are also, however, affected by interferences with their habitat by man. Increasing use of the land interferes with natural run-off, and domestic and industrial wastes pollute the streams. Deterioration in the habitat from these causes is important to the salmon fisheries and demands increasing attention. During the last few years a new danger to the salmon stocks has arisen from human activity. DDT sprayed on New Brunswick forests from aircraft makes its way into rivers in sufficient quantities

to kill a high proportion of the young salmon in them as well as many of the aquatic insects on which they feed. Spraying operations are deemed necessary to protect valuable timber stands from destruction by the spruce budworm. Considerable effort is going into defining the danger and to seeking remedies.

The management of the salmon resource is planned through the Co-ordinating Committee on Atlantic Salmon. This committee involving key representatives of the Fisheries Departments of Canada and the various provincial governments was organized in 1949. The research program to provide basic information is recommended by its Scientific Sub-Committee. During 1957 a second sub-committee on regulations was set up to review and simplify the regulations and to make sure that they are consonant with biological findings.

Statistics. It is necessary to have the facts on the fishery in order to judge its condition. For this reason data on both commercial landings and on angling catches are kept under continuing review.

During 1957 there was a 20% increase of commercial catches in the Maritimes region over the 1956 take although the catch was only about half of the 1950 total. In Newfoundland and Quebec, commercial production was down. In Newfoundland catches were off because heavy ice conditions prevented normal trap net operation. In Quebec poor catches were caused by the fish running late and not appearing in abundance until fishing effort had fallen off.

The 1957 Maritimes angling catch of over 39,000 fish was down from 1956 by 20%. Most of the reduction was in the Miramichi area. However, many of those interested in angling there expressed satisfaction with the season since the number of large salmon taken during July and August was in excess of 1956. Later in the season an abundance of salmon was reported in the Miramichi River but they were difficult to hook and land because of the low water. The spring fishery for spawned-out kelts or black salmon is important locally in Northumberland County and amounted to 20% of all the angling catch in the main Southwest Miramichi. In other smaller tributaries it was even more important.

Records of angling in Newfoundland and Labrador show a marked increase in 1957 to more than 22,000 fish. This increase is believed to be owing to greater angling interest and more complete records rather than to increased abundance of fish.

Routine checks of salmon for lampreys and lamprey scars showed affected individuals to be rather scarce. In the Miramichi estuary near Chatham, 0.66% of the salmon were affected and at Curventon, 28 miles up the river and 6 miles above the head of tide, 0.25% bore scars. There is still no evidence that lampreys are a serious menace to adult salmon in the Miramichi River.

Behaviour studies. Knowledge of the way in which salmon act is important in the management and conservation of the resource. Such knowledge is especially necessary in planning remedial measures to relieve salmon from unfavourable changes in the habitat.

The pattern of spawning migration of salmon in the Miramichi River is observed at 3 points. At Millbank, a commercial type trap net samples the incoming run in the estuary. At Curventon, a few miles above the head of tide, a counting fence provides for actual counts of all upstream and downstream migrants in the Northwest Miramichi. Another similar counting fence, some 40 miles higher up in the same tributary, allows a second check on fish moving in either direction. The run of both grilse and large salmon through the Miramichi estuary has almost doubled during the last 4 years. In the same period the run of grilse passing through the Curventon fence in the Northwest Miramichi has fallen to about a quarter of the 1954 and 1955 level. The decrease is ascribed to DDT spraying on that tributary. The worst effects of spraying on other tributaries will occur in 1960 and 1961. A comparison of the 1957 records at Curventon and Camp Adams shows that a large proportion of both grilse and large salmon passing the lower fence are able to reach the upper one. The 1957 results also confirm the general opinion that "late run" salmon do not reach headwater areas. As river levels were low in 1957, it is believed that this opinion requires further confirmation.

Large salmon were tagged at the Millbank trap in 1957. Of 145 tags used, 15 were recovered by November. Two tags were recovered below Millbank showing some wandering. All tags recovered by anglers were taken in the southwest Miramichi where the upper waters were reached in 4 to 5 weeks. The longest journey was 115 miles to Juniper in 41 days from tagging.

Field observations on salmon behaviour have been made at Ellerslie Brook, P.E.I., at 2 fences installed principally for trout investigations. A pond was formed by damming the brook as part of the trout experiment. It was found that the mature salmon tended to stay in the pond. Some of the females spawned there but there is no evidence that the spawning was successful. Principally in fall salmon parr dropped down from the stream into the pond and from the pond to the estuary. The pond had a definite tendency to retain the seaward migrating smolts.

Information on such subjects as the detailed reactions of migrating smolts to currents, the degree and manner of competition between salmon and brook trout, the difference in behaviour between hatchery reared and wild salmon, and the reactions of salmon to polluted waters is essential to sound management of the salmon resource in a changing environment. During 1957 the normal behaviour of young salmon was studied in aquarium observations as a basic step in behaviour studies. Observations were made on resting and social behaviour, feeding, and activity in weak light.

The migration and dispersion of salmon in the sea is another aspect of behaviour which is important in management. This is being studied by marking large numbers of descending smolts in characteristic ways and examining catches of mature fish for marks. Marking is being done in the Miramichi and Pollett Rivers in New Brunswick, the Port Daniel River in Quebec, and the Little Codroy River in Newfoundland. Adult fish are scrutinized for marks in commercial catches and at the counting weirs. Analyses of recent results has been deferred to provide effort for more urgent studies. Earlier results have shown that many salmon from New Brunswick rivers are caught in trap nets off the east coast of Newfoundland.

Manipulation of the salmon habitat. Under unaltered conditions the salmon stock maintains itself. Moreover, because of the natural resilience of the population, man can use a substantial part of the population each year without reduction in its capacity to produce. An important part of the Station's research has been directed to finding out how many spawning salmon must be spared by the fishery if the effective reproductive potential is to be maintained. Positive measures have been attempted also. Attempts have been made to alter the environment to increase the fraction of the population which man can take without reducing production potential. Very encouraging results have been obtained by controlling fish-eating mergansers in the area and the practical aspects of control are now being tested. Unfortunately most alteration in the habitats induced by man are in conflict with the existence of a prosperous salmon population. Spraying watersheds with DDT to control forest insect pests and damming rivers to develop hydro-electric power constitute 2 menaces to salmon production. They are under study in an attempt to find ways of minimizing their ill effects.

In a series of tests of increasing scope the efficacy of increasing salmon smolt production by controlling mergansers on the rivers has been demonstrated. Currently control is carried out throughout the Miramichi watershed. An important observation in the large scale tests concerns the extent to which control measures carry over from year to year and are cumulative. There has been a decline in birds recorded on the Miramichi system during the last 4 years. No comparable decline was observed when control was started on the Pollett River. It seems likely that the decline may be a secondary effect of DDT spraying rather than the cumulative result of control measures. Where DDT has been used both the larger aquatic insects and salmon parr on which young mergansers feed are very scarce. It is doubtful that the birds can make a living in sprayed sections. The results indicate the necessity of dependable observations. This in turn points up the desirability of retaining trained reliable crews from year to year.

When aerial spraying of New Brunswick forests was undertaken in 1952 there were but few indications that there would be bad effects on the salmon populations. However, some fisheries

scientists had grave doubts on the subject. In 1954 spraying operations were moved to the Miramichi watershed where the Station had for 4 years been studying the salmon populations and had established good baselines on the abundance of young salmon. It, accordingly, became possible for the first time to carry out a critical testing of practical spraying. Observations concerned (1) the fates of young salmon confined in cages in sprayed and unsprayed areas and (2) changes in the abundance of different sizes of young salmon fry, small parr and large parr in sprayed and unsprayed areas. The results gave conclusive evidence that DDT sprays are highly injurious to young salmon and most damaging to the very young stages. The reaction of the salmon population to spraying is shown in the accompanying figure.

Because of the life history of the salmon, the effects of spraying on the adult stocks supplying commercial fisheries and anglers are not observed for some time. As noted above some falling off in runs to the Northwest Miramichi were observed in 1957. However the main effects will not be apparent until 1960 or 1961.

The destruction of aquatic insects by DDT spraying has stimulated attention on the food of young salmon and the way in which spraying affects the supply. Work during 1957 has confirmed earlier conclusions that all groups of aquatic insects are adversely affected immediately by spraying. The smaller fly (Diptera) larvae begin to recover 1 or 2 months after spraying and they reappear in large numbers. Larger insects recover more slowly and some such as the caddisflies had not in 1957 recovered from being sprayed in 1954. The young salmon in the rivers have had to adapt themselves to changed conditions as well as they could. The numerous fry of 1955 thrived. But as parr in 1956, these fish ate fewer stoneflies than ordinarily and none of the larger caddisflies and were in poor condition. There was a striking change in parr diet to snails, water mites and worms.

In an attempt to improve the supply of food for parr, insect larvae were transferred from the unsprayed Millstream to the sprayed Sevogle River. They were moved on stones from the stream bottom and carefully replaced in a corresponding part of the new habitat in the same relation to the current as before. The results are still to be assessed but some of the larvae of desirable forms have survived and become adults. It remains to be seen whether breeding stocks have been established.

A possible relief for the dilemma facing those who want both timber and salmon is to discover an effective forest insecticide which is less toxic to salmon. One insecticide, Malathion, was tested for toxicity to salmon during 1957 but proved to have no advantages to DDT.

Work on the effects on salmon of hydro-electric development in the Saint John River has included assessing the

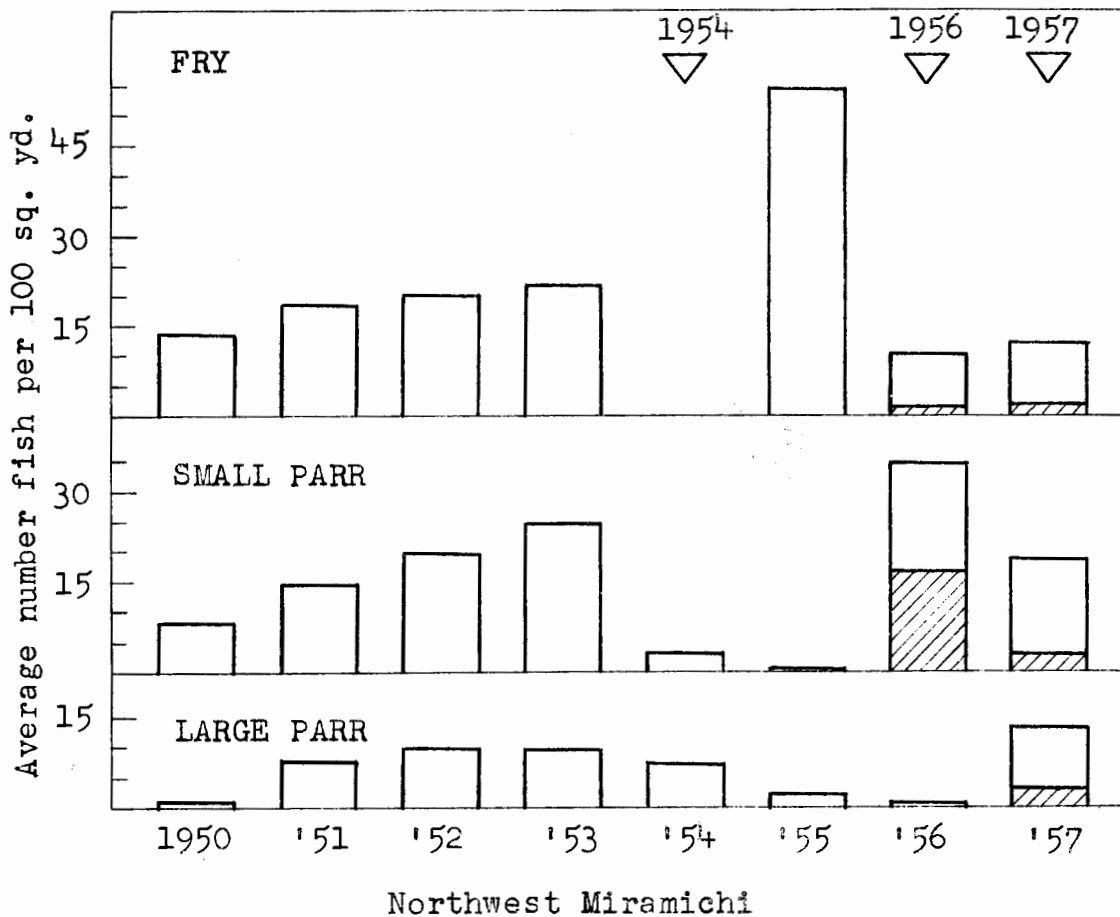


Figure 3. Abundance of young salmon in the Northwest Miramichi River. Solid triangles indicate the years when DDT was sprayed in the area. Cross hatching indicates the fish caught in sprayed parts of the river. The following points may be noted: (1) The fairly stable fry populations from 1950 to 1953. (2) The increased population of small and large parr from 1950 to 1953. This is believed to be a consequence of merganser control. Free from competition fry came back strong in the year after spraying and survived moderately well. In 1957 this group of fish contributed to the good large parr population and also, because of lack of growth, to the small parr group. Growth was inhibited because the larger insect larva preferred as food were poisoned by spraying.

significance of observations on smolts and adults at Beechwood dam, calculating possible losses, and assessing by seining and electro-fishing stocks of young salmon in the principal tributary, the Tobique.

Supplementary natural stocks. The previous section dealt with the effects, good and bad, of manipulating the salmon's

habitat. Another kind of manipulation is possible. The salmon stock itself can be adjusted at various stages. New observations on the Pollett River confirm there the $1\frac{1}{2}$ to 3% survival from eggs to smolts and the desirability of providing from 200 to 350 eggs per 100 square yards of river area. These requirements are approximately met in the Miramichi and under ordinary circumstances supplementary stocking is not indicated. It seems likely, however, that fish populations will be reduced during the next few years as a result of DDT spraying. It may be that they will be reduced to the point where their recovery cannot be complete within a single generation. If stocking is desirable, large parr and smolts may be used. Experiments already under way show the condition under which these stages can be employed successfully.

TROUT

Trout are a valuable asset to the Maritime Provinces since they provide attractive angling for tourists and recreation for residents. The Station's trout work is directed toward developing methods of management which will make the most advantageous use of the resource. Two approaches to management are being explored. One is improving unproductive waters by fertilization. Other steps in this approach included use of hatchery stock and predator control. In productive waters another method of management has been studied. In them, especially on Prince Edward Island, the problem is to keep the plentiful supply of trout available to anglers. Ponds made by damming streams near the outlets have been useful in holding fish and their effects are being studied.

Studies at Crecy Lake. Crecy Lake in Charlotte County, N.B., is typical of many soft-water lakes in the Maritimes. The waters are relatively unproductive. Its area is about 50 acres. A series of manipulations involving stocking, fertilizing, and predator control have demonstrated its potentialities, and have shown the following facts. The combination of management methods provided greatly improved angling--about 40 times improved. Fertilization improved the quantity of food for trout and was thus instrumental in increasing growth rate. Predators were attracted to the increased trout population and had to be driven away or destroyed if anglers were to benefit from the results of fertilization. Large trout can be regarded as predators and increased production of smaller fish follows reducing their numbers.

In 1956 regulation was tried as a tool of management. The opening date for the fishery was moved forward from April 15 to June 1. The objective of the regulation was partly met. The number of fish taken in June and July was greatly increased. However, the total season's catch was much reduced. Management by control of the fishing season is useful only for special objectives.

In Crecy Lake the eel is both a predator on and competitor of trout. Attempts are being made to reduce its numbers by trapping in the lake and by preventing access to the lake by the very young eels as they enter it from the sea. There are indications that control may be successful but, because of insufficient time, the trial has not yet given positive results.

Studies at Ellerslie Brook, P.E.I. The effects of forming a pond on a Prince Edward Island trout stream have been tested by placing a dam near the outlet of Ellerslie Brook and by installing two 2-way counting weirs, one just below the dam and the other 650 yards upstream above the head of the 7-acre pond. This arrangement permits good observations on the general behaviour of trout and on their reaction to pond formation. Trout in Ellerslie Brook move up and down through the traps rather freely at most seasons of the year. This seems to rule out the idea of a sea-run race which is believed in by many anglers. There is a net tendency for trout to drop downstream and remain in the pond where a 40% increase in anglers' catches is shown by creel censuses.

Estimates of the population of trout in various parts of the stream is undertaken annually by electro-fishing. It is found that trout older than yearlings move from the stream to the pond, and that there has been a resulting decrease in the average lengths of the older trout in the brook. This loss of large fish has not, however, had an adverse effect on the annual production of fingerlings.

The dam prevents access from the sea to the pond and the brook. The loss of the sea-run trout to the stream has had no noticeable effect on the stream populations.

All the evidence indicates that pond formation improved the utilization of the trout stocks without jeopardizing the production of young in the tributary streams.

Other ponds on Prince Edward Island. Three other man-made bodies of water have allowed useful observations on trout.

Stevensons Pond has an area of about 3 acres. Its lower end is screened. It was drained in June of 1956 and all the trout removed. It was drained again toward the end of September, 1957. The fish removed from it then were those which had entered from the tributary streams during 15 months. There were 1,344 trout weighing 363 pounds or 121 pounds per acre. The data illustrate that this pond, representative of others formed on Prince Edward Island streams, was quickly and well populated from stocks of young trout in the tributary brook. However, indications from other studies in the area show that trout densities up to 800 per acre do not give any evidence of overstocking. Thus that fact and the observation that the trout taken from Stevensons Pond were in very good condition

suggest that better use of the pond's potentialities could have been made with some supplementary planting of hatchery stock.

Wilmot Pond is formed, like others in Prince Edward Island, by an earth embankment across Wilmot Stream. It differs from some of the others by having the overflow diverted through a "run around" which allows the trout freedom of movement between the pond and the estuary. Counting traps were maintained in the run around during open-water periods and the fish tagged as they passed through. Relatively small proportions (15 to 19%) of the trout angled in the pond were sea-run fish. This suggests that most of them make their way quite rapidly into the tributary stream where they are less accessible.

A fill across the mouth of York River for the trans-Canada highway created a 500-acre lake connected to the salt water at high tide by an opening in the causeway. In summer the water is warm and fresh at the surface and saline and cooler below. The bottom water is stagnant and fish cannot live in it. As the surface water is too warm for trout the fish are confined to a narrow wedge between the warm and stagnant layers. It has been recommended that the salt water be excluded in an attempt to increase the amount of suitable living space for trout and provincial authorities have made the necessary arrangements.

Rainbow trout. Rainbow trout have been introduced on Prince Edward Island. They have become established and are extending their territory. In order to compare their development with brook trout, young fish were planted in Simpsons Pond where the performance of brook trout was known. The survivors of 1,172 underyearling rainbow trout released October 11, 1955, numbered 305 after 10½ months and weighed on the average 6.8 ounces. After another year, 167 out of 300 survived and averaged 13.0 ounces. Yearling brook trout only averaged 4.3 ounces in weight. Evidently the rainbow trout is capable of substantially faster growth. The data show that the most efficient cropping of the rainbow trout is as yearlings.

SEAWEEEDS

The seaweeds constitute a very plentiful marine resource in the Maritime Provinces but only one of them is in general commercial use. It is Irish Moss (Chondrus crispus) a red alga. It is harvested as a source of carrageen, which has a variety of uses in the food industries. Work has been mainly confined to assessing the growth of individuals of this plant and to studying the constitution and productivity of the natural population. The work has been continued in 3 areas: the rocky shelving north shore of Prince Edward Island between Cavendish and North Rustico; Curtain Island Reef in Malpeque Bay, P.E.I.; and the shore of Fundy National Park, near Alma, N.B.

The rate of growth is important in controlling the replacement of the moss after harvesting. Growth rate was studied on the basis of increase in area, length and branching for individual plants over the whole year. Growth rate is highest in late spring and early summer when the water is clear, warming, and enriched by shore run-off, and when there is little competition from annual seaweeds. The growth falls off in the late summer and fall. The proportionate growth rate is variable among individuals but is relatively independent of the size of the plant or the area studied. The growth rate is about 0.01 square centimetres per square centimetre per day in July and falls to about half this during the fall and winter months.

The distribution of the Irish Moss population among different growth stages based on size and amount of branching has been studied near North Rustico, P.E.I. It was found that about 340 grams (oven dried weight) can be removed from a square metre of bottom and that this represents about 3,800 plants. The older plants which are readily harvested by raking represent 85% of the weight of the crop. By numbers, however, the larger plants are less than half of the crop and much less than half of the population on the bottom. Harvesting in 1 year reduced the weight of the crop in the following year but did not reduce the number of individuals growing in the population. There would seem to be no danger of current raking practices reducing potential production but planned harvesting could increase efficiency of operations.

The work on Irish Moss is being supplemented by a general floristic and ecological survey in all areas visited.

HANDBOOK ON CANADIAN ATLANTIC FISHES

A general account of Canadian Atlantic fishes is in preparation to meet a long-felt need. The handbook will cover the coast from the United States boundary to Hudson Bay and from the shoreline to the 500 fathom contour. It will include the anadromous forms.

MATHEMATICAL STATISTICS

For fisheries, interpretation of commercial landing statistics and population studies encounter special difficulties. The most important difficulty arises from incomplete data. Significant facts cannot be collected retroactively and current records are dependent upon the success and whims of commercial fishermen. The availability of fish stocks depends in undefined ways upon environmental conditions and different parts of the stocks are affected differently. These difficulties complicate the analysis of data on most fisheries and lend uncertainty to forecasts based on biological analysis. The application of refined mathematics to the data permits the development of objective estimates of important facts and of the limits of

accuracy affecting them. Each fishery has its own problems which must be solved by a painstaking review of the data on hand. The significance of results obtained from mathematical models for the cod fisheries in the Gulf of St. Lawrence and at Lockeport is reported elsewhere. Other progress during 1957 is outlined below.

It is important in forecasting the effects of changes in fishery management to know the natural and fishing mortalities. Together they control the survival rate. The sources of difficulty in making dependable calculations have been outlined above. Some of these can be circumvented by modification of the "virtual population" method of calculating abundance of a year-class provided we have an estimate of yearly contribution by number to the fishery of a year-class for a number of years, and a measure of the effort expended each year. The calculation in itself is a laborious task but results indicate that it makes more efficient use of the data available than any other method used heretofore.

The usefulness of mesh regulation for increasing the commercial production of haddock is under trial on Georges Bank. The St. Andrews Station is working in close co-operation with the United States Fish and Wildlife Service at Woods Hole in assessing and analysing data collected by the United States group.

The accumulated catch effort data on groundfish in the Gulf of St. Lawrence have been analysed to discover the best methods of using them in developing indices of abundance of fish. Some of the conclusions are (a) that data for all fish species should be considered in any analysis, (b) that net size is more useful than the gross tonnage of the fishing vessels in classifying otter trawlers, (c) consideration of economic factors is useful in assigning catches and efforts to various species of fish, (d) redfish trips should be summarized separately, and (e) quarterly statistics are adequate.

Data from the lobster fishery were analysed to investigate the size of the lobster populations, and the relationship among the catchability of tagged lobsters, activity of lobsters, and water temperature. Population estimates obtained in different ways differed notably. It seems that part of the discrepancy is owing to changing water temperatures. As water temperatures rise, activity increases, and so does catchability.

BOAT FOR USE IN SHALLOW HARBOURS

In several areas around Prince Edward Island navigation is restricted by shallow water. The availability of a versatile inshore fishing vessel of very shallow draft would allow greater mobility and could save heavy channel dredging costs. A boat incorporating a tunnel stern was designed, built, and tested. Although wet in a head sea, it was generally satisfactory afloat.

However, it proved heavy to haul out and its construction costs were substantially higher than those for craft of conventional design. It seems unlikely that the tunnel stern type boat will be adopted by fishermen in the face of these practical disadvantages.

DISTRIBUTING INFORMATION

Much of the Station's efforts were again directed towards making known to the public, to the fishing industry, to branches of Government, and to fellow scientists, the results of scientific investigation. Visits, meetings, letters and memoranda were used to spread information informally. Addresses, radio and television, although more formal, allowed wider dissemination of the results of the Station's work. Circulars, progress reports and the articles published in trade journals, newspapers and magazines again provided a wider range of readers with information on specialized subjects. Scientific writings in technical journals and bulletins kept the work before world scientists and the fishing industry.

The Station has continued to encourage application of research results through demonstration. New fishery resources and gear have been highlighted using funds supplied by the Department's Industrial Development Service.

CO-OPERATION IN APPLICATION

Many of the Station's research programs are the result of efficient co-operation with other nations as in International Commission for the Northwest Atlantic Fisheries, International Passamaquoddy Fisheries Board, and St. Croix Engineering Board. Co-operative planning gave good results in such national bodies as the Interdepartmental Shellfish Committee and the Federal-Provincial Co-ordinating Committee on Atlantic Salmon. Problems are shared with the Maritime Provincial and Federal departments of government as well as Canadian universities. Exchanges of mutual benefit continue to forward the work of investigating species which know no international boundary.

STAFF AND ORGANIZATION

(April 1, 1957 to March 31, 1958)

During this period 242 people have been employed by the St. Andrews Station. Of these 29 were scientific, 50 technical, 12 maintenance, 18 administrative and clerical, 25 boat operation, 52 seasonal and term, 48 casual and 8 part-time employees.

Dr. Yves Jean joined the Groundfish group August 1 on return to Canada from Ceylon. Mr. J. E. Henri Legare arrived on November 4 to join the herring investigation staff. Also during this period, Miss Vivien M. Brawn and Mr. F. D. Forgeron arrived on September 9 and May 27 respectively and are engaged on work associated with Passamaquoddy Studies. Mr. A. E. H. Collin went on educational leave of absence November 8.

Total full-time staff on strength as of March 31, 1958, numbered 115. This includes the Acting Oceanographer-in-Charge, A.O.G., and those employed for Passamaquoddy Studies. Eleven positions were vacant at that season.

(Staff other than seasonals are classified as of March 31, 1958. Those employed for Industrial Development Service are marked IDS; those employed for International Passamaquoddy Fisheries Board project are marked IPFB.)

LIST OF STAFF

Scientific -- Full-time

J. L. Hart, M.A., Ph.D., F.R.S.C.	Director
W. R. Martin, M.A., Ph.D.	Principal Scientist
D. G. Wilder, M.A., Ph.D.	Principal Scientist
L. R. Day, M.A.	Senior Scientist
C. J. Kerswill, M.A., Ph.D.	Senior Scientist
A. H. Leim, B.A., Ph.D.	Senior Scientist
J. C. Medcof, M.A., Ph.D.	Senior Scientist
M. W. Smith, M.A., Ph.D.	Senior Scientist
S. N. Tibbo, M.A.	Senior Scientist
L. M. Dickie, M.Sc., Ph.D.	Associate Scientist
P. F. Elson, M.A., Ph.D.	Associate Scientist
Y. M. L. Jean, M.A., Ph.D.	Associate Scientist (from Aug. 1/57)
M. H. A. Keenleyside, M.A., Ph.D.	Associate Scientist
R. R. Logie, M.A.	Associate Scientist
F. D. McCracken, M.A., Ph.D.	Associate Scientist
R. A. McKenzie, M.A.	Associate Scientist
D. W. McLeese, M.Sc., Ph.D.	Associate Scientist
J. E. Paloheimo, Mag.phil., M.A.	Associate Scientist
Vivien M. Brawn, B.Sc. <u>IPFB</u>	Assistant Scientist (from Sept. 9/57)
A. C. Kohler, M.Sc.	Assistant Scientist
J. E. H. Legare, M.A.	Assistant Scientist (from Nov. 4/57)
J. W. Saunders, M.Sc.	Assistant Scientist

Seasonal and Term

F. P. Ide, M.A., Ph.D.
D. M. Scott, M.Sc., Ph.D.
A. R. A. Taylor, B.A., Ph.D.
Jean Y. R. Baird
D. H. Betts, B.Sc.
D. M. Brown, M.A.
R. E. Burleigh
G. W. Condon
Allison M. Craig
Sheila M. Duff
Patricia W. Fliieger
W. E. Guptill
B. G. Hemmerick
Patricia A. Holt
T. J. Jellinek, B.Sc.
Sylvia M. Lahey
R. D. Lisk, B.A.
G. MacDonald, B.A. IPFB
C. D. MacInnes IDS
M. E. MacLean IPFB
L. L. MacLeod
J. K. Malia
Joan E. Mortimer, B.Sc.
G. M. Somerville, B.Sc. IDS
G. J. Sorger
F. E. Warburton
Norma E. Wiley
F. T. Yamamoto
A. W. Brown IDS
E. C. Durkee IDS
G. W. Cooper
E. F. Thompson
Velma G. Clift
W. H. MacLean
H. D. Clark
H. L. Cunningham IDS
H. L. Cunningham IDS
W. R. Currie
Margaret M. Draper IPFB
H. H. Ferguson IDS
E. A. King IDS
J. H. King
V. A. McCullough
A. W. McGray IDS
H. D. Penney IDS
H. D. Penney IDS
Elda G. McFarlane
Associate Scientist (May 21 - June 24/57)
Associate Scientist (May 1 - Sept. 30/57)
Associate Scientist (May 22 - Sept. 30/57)
Student Assistant (May 21 - Sept. 13/57)
Student Assistant (May 25 - Sept. 5/57)
Student Assistant (May 6 - Sept. 16/57)
Student Assistant (June 3 - Sept. 25/57)
Student Assistant (May 22 - Sept. 16/57)
Student Assistant (May 13 - Sept. 27/57)
Student Assistant (May 21 - July 12/57)
Student Assistant (July 22 - Sept. 13/57)
Student Assistant (May 10 - Aug. 30/57)
Student Assistant (May 22 - Sept. 27/57)
Student Assistant (May 13 - Sept. 6/57)
Student Assistant (May 10 - Oct. 3/57)
Student Assistant (May 21 - Sept. 13/57)
Student Assistant (May 21 - Sept. 9/57)
Student Assistant (May 21 - Aug. 30/57)
Student Assistant (May 27 - Sept. 25/57)
Student Assistant (May 14 - Sept. 13/57)
Student Assistant (May 22 - Sept. 9/57)
Student Assistant (May 13 - Sept. 25/57)
Student Assistant (May 21 - Sept. 20/57)
Student Assistant (May 28 - Sept. 19/57)
Student Assistant (May 15 - Sept. 4/57)
Student Assistant (Sept. 4 - Sept. 30/57)
Student Assistant (May 21 - Sept. 23/57)
Student Assistant (May 15 - Sept. 18/57)
Technician 2 (May 1 - Sept. 30/57)
Technician 1 (May 7 - Nov. 30/57)
Assist. Tech. 3 (Apr. 1 - Nov. 30/57)
Assist. Tech. 3 (June 3 - Aug. 15/57)
Assist. Tech. 2 (to April 30/57)
Assist. Tech. 2 (Apr. 1 - Nov. 30/57)
Assist. Tech. 1 (Apr. 1 - July 15/57)
Assist. Tech. 1 (to May 31/57)
Assist. Tech. 1 (Dec. 2/57 - Mar. 31/58)
Assist. Tech. 1 (Apr. 1 - July 15/57)
Assist. Tech. 1 (June 24 - Aug. 23/57)
Assist. Tech. 1 (July 2 - Oct. 11/57)
Assist. Tech. 1 (Dec. 2/57 - Mar. 31/58)
Assist. Tech. 1 (Apr. 1 - July 15/57)
Assist. Tech. 1 (May 1 - July 31/57)
Assist. Tech. 1 (to May 31/57)
Assist. Tech. 1 (to May 31/57)
Assist. Tech. 1 (Dec. 2/57 - Mar. 31/58)
Clerk 1 (July 22 - Sept. 20/57)

Administrative and Technical -- Full-time

J. A. Rogers, A.C.B.A.	Administrative Officer 2
Winifred E. Young	Clerk 4
W. D. Burton	Clerk 3
Frances L. Stinson	Clerk 3
Evelyn R. MacMillan	Clerk 2
M. Beryl Stinson	Clerk 2
C. Ruth Garnett	Stenographer 3
Joy Sutherland	Stenographer 3
Mary J. Fitzgerald <u>IPFB</u>	Stenographer 1 (from June 17/57)
Charlotte A. Gibson	Stenographer 1
Hazel L. Grant	Stenographer 1 (to July 22/57)
Margaret A. Harriott	Stenographer 1
Magdalena MacKay	Stenographer 1 (May 15 - Sept. 30/57)
Elizabeth D. McAuley	Stenographer 1 (from July 2/57)
Dorothy M. McLaughlin	Stenographer 1
M. Barbara Stickney	Stenographer 1 (to May 14/57)
M. Barbara Stickney	Stenographer 1 (from Sept. 16/57)
B. H. Foster	Storeman 1
H. Y. Brownrigg	Technician 3
D. N. Fitzgerald	Technician 3
J. S. MacPhail	Technician 3
G. J. W. Sullivan	Technician 3
C. J. Bayers	Technician 2 (Capt.) M/V "J. J. Cowie"
H. H. Butler	Technician 2 (Capt.) M/V "Harengus"
L. J. Lewis	Technician 2 (Capt.) M/V "Harengus" (Apr. 1 - Nov. 22/57)
R. C. Murray	Technician 2
E. J. Schofield	Technician 2 (from May 1/57)
S. E. Vass	Technician 2
W. G. Carson	Technician 1 (Capt.) M/B "Mallotus"
L. I. Cross	Technician 1 (Capt.) M/B "Pandalus II"
M. F. Fraser	Technician 1
P. R. Graves	Technician 1
C. R. Hayes	Technician 1
A. W. Holt <u>IPFB</u>	Technician 1 (from Apr. 1/57)
I. M. Jones	Technician 1
R. M. MacPherson	Technician 1
F. W. Matthews	Technician 1 (to Oct. 31/57)
N. J. McFarlane	Technician 1 (from Nov. 18/57)
P. M. Powles, M.Sc.	Technician 1 (from May 10/57)
H. A. Smith <u>IPFB</u>	Technician 1 (from Apr. 1/57)
E. G. Sollows	Technician 1
R. J. Thurber	Technician 1 (from Mar. 3/58)
U. J. Walsh	Technician 1
A. W. Brown <u>IPFB</u>	Assist. Tech. 3 (from Oct. 15/57)
D. E. Graham	Assist. Tech. 3
E. B. Henderson	Assist. Tech. 3 (from Apr. 1/57)
P. W. G. McMullon	Assist. Tech. 3
C. F. Monaghan <u>IPFB</u>	Assist. Tech. 3 (from Sept. 3/57)
Cariene D. Burnett <u>IPFB</u>	Assist. Tech. 2 (from June 3/57)
Phyllis J. Gibson	Assist. Tech. 2
Mary Holmes	Assist. Tech. 2
W. G. Irving	Assist. Tech. 2
Esther I. Lord	Assist. Tech. 2
Delphine C. Maclellan, B.Sc. <u>IPFB</u>	Assist. Tech. 2 (from Apr. 1/57)

L. R. MacFarlane
Irma I. Thompson
C. Williams
H. P. Barchard
C. A. Dickson IPFB
L. D. Gardner IPFB
R. S. Hendricks IPFB
K. H. Murray

Assist. Tech. 2 (from Apr. 1/57)
Assist. Tech. 2 (from Feb. 3/58)
Assist. Tech. 2
Assist. Tech. 1
Assist. Tech. 1 (from Oct. 7/57)
Assist. Tech. 1 (from Oct. 15/57)
Assist. Tech. 1 (from July 2/57)
Laboratory Helper

Maintenance -- Full-time

F. E. Purton
R. A. Greenlaw
K. R. Oatway
K. W. Johnston
H. E. Lee
D. A. Stinson
C. S. Tucker
J. F. Johnson
G. F. Wentworth

Maintenance Supervisor 3
Maintenance Supervisor 1
Maintenance Supervisor 1
Caretaker 4
Caretaker 3
Caretaker 3
Caretaker 3
Maintenance Helper
Truckman

Ships' Officers

H. Yarn
I. M. Corkum
J. O. Allain
B. W. Hart
P. D. LeBlanc
I. D. Demone
W. R. Hooper

Chief Engineer M/V "Harengus" (from
Apr. 1/57)
2nd Engineer M/V "Harengus" (from Apr. 1/57)
Engineer M/B "Pandalus II" (Apr. 16 -
Nov. 27/57)
Engineer M/V "J. J. Cowie"
Engineer M/B "Mallotus" (Apr. 29 -
July 10/57)
Mate M/V "Harengus" (Apr. 1 - June 17/57)
Mate M/V "Harengus" (from July 15/57)

Ships' Crews

I. A. Cottreau
E. B. Fevens
E. A. Mason
A. S. Hawkins
E. T. Hull
R. F. Kohler
F. G. MacIntosh
F. G. MacIntosh
A. L. Surette
V. L. Gowan
W. R. Hooper

Twinehand M/V "J. J. Cowie"
Twinehand M/V "J. J. Cowie" (to Dec. 27/57)
Boatswain M/V "Harengus" (from Apr. 4/57)
Cook-deckhand M/B "Pandalus II"
(Apr. 16 - Nov. 25/57)
Cook-steward M/V "Harengus" (from July 2/57)
Cook-steward M/V "Harengus"
(Apr. 3 - June 28/57)
Cook-deckhand M/B "Mallotus"
(Apr. 29 - July 10/57)
Cook-deckhand M/B "Mallotus"
(Aug. 12 - Sept. 27/57)
Cook-deckhand M/V "J. J. Cowie"
(from Apr. 1/57)
Seaman M/V "Harengus" (July 16 - 22/57)
Seaman M/V "Harengus"
(Apr. 23 - July 14/57)

W. J. Horne
C. A. Jacobs
F. R. Johnson
P. Lake
L. V. Richard

Seaman M/V "Harengus" (from Apr. 1/57)
Seaman M/V "Harengus" (from Apr. 23/57)
Seaman M/V "Harengus" (from July 24/57)
Seaman M/V "Harengus" (Apr. 1 - 15/57)
Seaman M/V "Harengus" (Apr. 1 - 17/57)

Prevailing Rates

H. C. Hillman
W. J. Ross
A. G. Steeves
E. C. Tucker

Carpenter - St. Andrews
Carpenter - St. Andrews
Labourer - Pollett River (Apr. 1 - Dec.10/57)
Netman - Miramichi River (Apr.23 - Nov.30/57)

Part-time -- Port Observers

F. Berrigan
R. C. MacMillan
D. M. Wilson IPFB

Canso, N. S.
Lockeport, N. S.
Point Lepreau, N.B. (from Aug. 1/57)

Part-time -- Pond Guardians

W. A. Simpson
J. Stevenson

Hope River, P. E. I.
Rustico, P. E. I.

OCEANOGRAPHY

Atlantic Oceanographic Group

L. M. Lauzier, M.Sc., D.Sc.
W. B. Bailey, B.Sc.
N. J. Campbell, M.Sc., Ph.D.
R. W. Trites, M.A., Ph.D.
A. E. H. Collin, M.Sc.

F. D. Forgeron, B.Sc. IPFB
J. G. Clark
J. R. Chevrier, B.Sc. IPFB
J. H. Hull
G. B. Taylor
C. C. Cunningham
T. A. Grant
R. K. Robicheau
Madelyn M. Irwin

Senior Scientist
Associate Scientist
Associate Scientist
Associate Scientist
Assistant Scientist (on educational
leave from Nov. 8/57)
Assistant Scientist (from May 27/57)
Technician 2
Technician 1 (from May 14/57)
Technician 1
Technician 1
Assist. Tech. 3
Assist. Tech. 3
Assist. Tech. 1
Stenographer 3

Seasonal and Term

D. G. MacGregor, M.A.
R. D. Graham, B.Sc.
D. W. Kyle
R. B. Perry, B.S.

Associate Scientist (June 14 - Sept.13/57)
Student Assistant (May 16 - Sept. 12/57)
Student Assistant (May 6 - Sept. 16/57)
Student Assistant (June 10 - Oct. 31/57)
(seconded from D.R.B.)

Part-time -- Lighthouse Observers

D. L. Collins
R. A. Doucette
M. R. MacKenzie

Entry Island, M.I.
Lurcher Lightship
Borden, P.E.I.

ORGANIZATION

Director

Assistant Director (Senior Scientist)

J. L. Hart, Ph.D.
L. R. Day, M.A.

A. Scientific and Investigational Staff

1. Groundfish

Principal Scientist in charge
Assoc. Scientist
Assoc. Scientist
Assoc. Scientist
Assist. Scientist
Technician 3
Technician 3
Technician 1
Technician 1
Technician 1
Technician 1
Technician 1
Assist. Tech. 2
Stenographer 3
Stenographer 3
Assoc. Scientist - Term
Assist. Tech. 2 - Term
Student Assistant - Seasonal
Student Assistant - Seasonal
Student Assistant - Seasonal
Port Observer - Part-time
Port Observer - Part-time

W. R. Martin, Ph.D.
L. M. Dickie, Ph.D.
Y.M.L. Jean, Ph.D.
F. D. McCracken, Ph.D.
A. C. Kohler, M.Sc.
D. N. Fitzgerald
G. J. W. Sullivan
M. F. Fraser
R. M. MacPherson
N. J. McFarlane
P. M. Powles, M.Sc.
R. J. Thurber
Irma I. Thompson
C. Ruth Garnett
Joy Sutherland
D. M. Scott, Ph.D.
Velma G. Clift
D. M. Brown, M.A.
G. W. Condon
L. L. MacLeod
F. Berrigan
R. C. MacMillan

2. Anadromous Fishes

(a) Salmon

Senior Scientist in charge
Assoc. Scientist
Assoc. Scientist
Technician 2
Technician 1
Technician 1
Assist. Tech. 2
Assist. Tech. 2
Assist. Tech. 1
Stenographer 1
Assoc. Scientist - Term
Assist. Tech. 3 - Term
Assist. Tech. 3 - Term
Assist. Tech. 2 - Term

C. J. Kerswill, Ph.D.
P. F. Elson, Ph.D.
M. H. A. Keenleyside, Ph.D.
E. J. Schofield
P. R. Graves
I. M. Jones
W. G. Irving
L. R. MacFarlane
H. P. Barchard
Elizabeth D. McAuley
F. P. Ide, Ph.D.
G. W. Cooper
E. F. Thompson
W. H. MacLean

Assist. Tech. 1 - Term	H. D. Clark
Assist. Tech. 1 - Term	W. R. Currie
Assist. Tech. 1 - Term	J. H. King
Student Assistant - Seasonal	D. H. Betts, B.Sc.
Student Assistant - Seasonal	T. J. Jellinek, B.Sc.
Student Assistant - Seasonal	J. K. Malia
Student Assistant - Seasonal	F. T. Yamamoto
Netman (Prevailing Rates)	E. C. Tucker
Labourer (Prevailing Rates)	A. G. Steeves
Casual employees	

(b) Trout

Senior Scientist in charge	M. W. Smith, Ph.D.
Assist. Scientist	J. W. Saunders, M.Sc.
Technician 1	C. R. Hayes
Assist. Tech. 2	*Mary Holmes
Assist. Tech. 2	C. Williams
Student Assistant - Seasonal	Jean Y. R. Baird
Pond Guardian - Part-time	W. A. Simpson
Pond Guardian - Part-time	J. Stevenson
Casual employees	

* Also general laboratory assistance

3. Crustacea

Lobster

Principal Scientist in charge	D. G. Wilder, Ph.D.
Assoc. Scientist	D. W. McLeese, Ph.D.
Technician 2	R. C. Murray
Technician 1	U. J. Walsh
Assist. Tech. 3	D. E. Graham
Clerk 2	Evelyn R. MacMillan
Student Assistant - Seasonal	W. E. Guptill
Student Assistant - Seasonal	R. D. Lisk, B.A.

4. Pelagic Fishes

Herring

Senior Scientist in charge	S. N. Tibbo, M.A.
Assoc. Scientist	R. A. McKenzie, M.A.
Assist. Scientist <u>IPFB</u>	Vivien M. Brawn, B.Sc.
Assist. Scientist	J. E. H. Legare, M.A.
Technician 1 <u>IPFB</u>	A. W. Holt
Technician 1 <u>IPFB</u>	H. A. Smith
Technician 1	E. G. Sollows
Assist. Tech. 3 <u>IPFB</u>	A. W. Brown
Assist. Tech. 3 <u>IPFB</u>	C. F. Monaghan
Assist. Tech. 2 <u>IPFB</u>	Cariene D. Burnett
Assist. Tech. 2	Phyllis J. Gibson
Assist. Tech. 2 <u>IPFB</u>	Delphine C. Maclellan, B.Sc.
Assist. Tech. 1 <u>IPFB</u>	C. A. Dickson
Assist. Tech. 1 <u>IPFB</u>	L. D. Gardner
Assist. Tech. 1 <u>IPFB</u>	R. S. Hendricks
Technician 2 - Term <u>IDS</u>	A. W. Brown
Assist. Tech. 1 - Term <u>IDS</u>	H. L. Cunningham
Assist. Tech. 1 - Term <u>IPFB</u>	Margaret M. Draper
Assist. Tech. 1 - Term <u>IDS</u>	E. A. King

Assist. Tech. 1 - Term	<u>IDS</u>	A. W. McGray
Assist. Tech. 1 - Term	<u>IDS</u>	H. D. Penney
Student Assistant - Seasonal	<u>IPFB</u>	G. MacDonald, B.A.
Student Assistant - Seasonal	<u>IPFB</u>	M. E. MacLean
Student Assistant - Seasonal	<u>IDS</u>	G. M. Somerville, B.Sc.
Port Observer - Part-time	<u>IPFB</u>	D. M. Wilson
Stenographer 1	<u>IPFB</u>	Mary J. Fitzgerald
Casual employees		

5. Mollusca

Senior Scientist in charge		J. C. Medcof, Ph.D.
(a) Clam and Scallop		
Technician 3		J. S. MacPhail
Assist. Tech. 2		Esther I. Lord
Technician 1 - Term	<u>IDS</u>	E. C. Durkee
Assist. Tech. 1 - Term	<u>IDS</u>	H. H. Ferguson
Student Assistant - Seasonal	<u>IDS</u>	C. D. MacInnes
(b) Oyster		
Associate Scientist in charge		R. R. Logie, M.A.
Technician 2		S. E. Vass, B.Sc.
Assist. Tech. 3		E. B. Henderson
Main. Super. 1		K. R. Oatway
Student Assistant - Seasonal		R. E. Burleigh
Student Assistant - Seasonal		Allison M. Craig
Student Assistant - Seasonal		Joan E. Mortimer, B.Sc.
Student Assistant - Seasonal		G. J. Sorger
Student Assistant - Seasonal		F. E. Warburton

6. Seaweeds

Associate Scientist in charge - Term		A. R. A. Taylor, Ph.D.
Student Assistant - Seasonal		B. G. Hemmerich

7. Taxonomy

Senior Scientist in charge		A. H. Leim, Ph.D.
----------------------------	--	-------------------

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

Senior Scientist in charge		L. R. Day, M.A.
Assist. Tech. 3		P. W. G. McMullon
Clerk 2		M. Beryl Stinson
Student Assistant - Seasonal		Sheila M. Duff
Student Assistant - Seasonal		Patricia W. Flieger
Student Assistant - Seasonal		Patricia A. Holt

9. Mathematical Statistician

Associate Scientist		J. E. Paloheimo, M.A.
Clerk 1 - Term		Elda G. McFarlane
Student Assistant - Seasonal		Norma E. Wiley

B. Administration and Maintenance Staff

1. Director's Secretary and Office

Clerk 4	Winifred E. Young
Stenographer 1	Margaret A. Harriott
Stenographer 1	Dorothy M. McLaughlin
Stenographer 1	M. Barbara Stickney
Student Assistant - Seasonal	Sylvia M. Lahey

2. Executive Assistant

Administrative Officer 2	J. A. Rogers, A.C.B.A.
Clerk 3	W. D. Burton
Clerk 3	Frances L. Stinson
Stenographer 1	Charlotte A. Gibson
Storeman 1	B. H. Foster

3. Buildings, Grounds, Boats and Equipment

Technician 3	H. Y. Brownrigg
Main. Super. 3	F. E. Purton
Main. Super. 1	R. A. Greenlaw
Caretaker 4	K. W. Johnston
Caretaker 3 (Watchman)	H. E. Lee
Caretaker 3 (Groundsman)	D. A. Stinson
Caretaker 3 (Net maintenance, etc.)	C. S. Tucker
Maintenance Helper	J. F. Johnson
Truckman	G. F. Wentworth
Laboratory Helper	K. H. Murray
Carpenter - Prevailing Rates	H. C. Hillman
Carpenter - Prevailing Rates	W. J. Ross
Casual employees	

M/V "J. J. Cowie"

Technician 2 (Capt.)	C. J. Bayers
Engineer	B. W. Hart
3 additional crew	

M/V "Harengus"

Technician 2 (Capt.)	H. H. Butler
Chief Engineer	H. Yarn
2nd Engineer	I. M. Corkum
Mate	W. R. Hooper
5 additional crew	

M/B "Pandalus II"

Technician 1 (Capt.)	L. I. Cross
Engineer	J. O. Allain
1 additional crew	

M/B "Mallotus"

Technician 1 (Capt.)
Assist. Tech. 1 - Term

*W. G. Carson
V. A. McCullough

* Responsible to L. R. Day for technical aspects of work.

OCEANOGRAPHY

Atlantic Oceanographic Group

Senior Scientist
Assoc. Scientist
Assoc. Scientist
Assoc. Scientist
Assist. Scientist
Assist. Scientist IPFB
Technician 2
Technician 1 IPFB
Technician 1
Technician 1
Assist. Tech. 3
Assist. Tech. 3
Assist. Tech. 1
Stenographer 3
Assoc. Scientist - Term
Student Assistant - Seasonal
Student Assistant - Seasonal
Student Assistant - Seasonal

L. M. Lauzier, D.Sc.
W. B. Bailey, B.Sc.
N. J. Campbell, Ph.D.
R. W. Trites, Ph.D.
A. E. H. Collin, M.Sc.
F. D. Forgeron, B.Sc.
J. G. Clark
J. R. Chevrier, B.Sc.
J. H. Hull
G. B. Taylor
C. C. Cunningham
T. A. Grant
R. K. Robicheau
Madelyn M. Irwin
D. G. MacGregor, M.A.
R. D. Graham, B.Sc.
D. W. Kyle
R. B. Perry, B.S.
(seconded from D.R.B.)

Part-time -- Lighthouse Observers
D. L. Collins, Entry Island, M.I.
R. A. Doucette, Lurcher Lightship
M. R. MacKenzie, Borden, P.E.I.

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

Fish taxonomy and distribution

A. H. Leim, Ph.D. (Toronto).

Groundfish

W. R. Martin, Ph.D. (Michigan).
L. M. Dickie, Ph.D. (Toronto).
Y. M. L. Jean, Ph.D. (Toronto). From August 1.
F. D. McCracken, Ph.D. (Toronto).
A. C. Kohler, M. Sc. (McGill).
D. M. Scott, Ph.D. (McGill). Term, May 1 to September 30.

Herring

S. N. Tibbo, M.A. (Toronto).
R. A. McKenzie, M.A. (Toronto).
J. E. H. Legare, M.A. (British Columbia). From November 4.
Vivien M. Brawn, B.Sc. (Reading). From September 9.

Lobsters

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

Mathematical Statistics

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

Mollusca

J. C. Medcof, Ph.D. (Illinois).
R. R. Logie, M.A. (Western Ontario).

Salmon

C. J. Kerswill, Ph.D. (Toronto).
P. F. Elson, Ph.D. (Toronto).
M. H. A. Keenleyside, Ph.D. (Groningen).
F. P. Ide, Ph.D. (Toronto). Term, May 21 to June 24.

Seaweeds

A. R. A. Taylor, Ph.D. (Toronto). Term, May 22 to September 30.

Trout

M. W. Smith, Ph.D. (Toronto).
J. W. Saunders, M.Sc. (Laval).

Other

Llewellyn W. Hillis, Ph.D. (Michigan). Volunteer investigator.
R. J. MacIntyre, M.Sc. (Canterbury, N.Z.). Volunteer investigator.
E. A. Martin, Ph.D. (Cornell). Volunteer investigator.

OCEANOGRAPHY

H. B. Hachey, M.B.E., E.D., M.Sc. (McGill), LL.D. (St. Thomas), F.R.S.C.,
Chief Oceanographer (Headquarters at the Biological Station, St. Andrews).

ATLANTIC OCEANOGRAPHIC GROUP (Headquarters at the Biological
Station, St. Andrews).

L. M. Lauzier, D.Sc. (Laval).
W. B. Bailey, B.Sc. (Acadia).
N. J. Campbell, Ph.D. (British Columbia).
R. W. Trites, Ph.D. (British Columbia).
A. E. H. Collin, M.Sc. (Western Ontario). On educational leave from November 8.
F. D. Forgeron, B.Sc. (St. F.X.). From May 27.
D. G. MacGregor, M.A. (Oxon.). Term, June 14 to September 13.

PUBLICATIONS

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- Bailey, W. B. Oceanographic features of the Canadian Archipelago. J. Fish. Res. Bd., Vol. 14, No. 5, pp. 731-769.
- Campbell, N. J., and A. E. Collin. Discolouration of Foxe Basin ice. Association d'Océanographique Physique. Reports of Abstracts and Communications, 1957, p. 91.
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- Godfrey, H. Feeding of eels in four New Brunswick salmon streams. Atlantic Prog. Rept. No. 67, pp. 19-22.
- Hachey, H. B. National Report for Canada. Oceanography in Canada 1954-57. For International Union of Geodesy and Geophysics. International Association of Physical Oceanography. Eleventh General Assembly, Toronto, Canada, 1957, 19 pp.

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- Klawe, W. L., and L. M. Dickie. Biology of the bloodworm, Glycera dibranchiata Ehlers, and its relation to the bloodworm fishery of the Maritime Provinces. Bull. Fish. Res. Bd., No. 115, 37 pp.
- Kerswill, C. J. 1956 Investigation and Management of the Atlantic Salmon. Part 1. The Research Programme. Canadian Department of Fisheries, Trade News, Vol. 9, No. 12, pp. 5-15.
- Lauzier, L. Report of the Atlantic Herring Investigation Committee. Sect. 10. Effect of storms on the water conditions in the Magdalen Shallows. Bull. Fish. Res. Bd., No. 111, pp. 185-192.
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- Mills, D. H. Herring gulls and common terns as possible predators of lobster larvae. J. Fish. Res. Bd., Vol. 14, No. 5, pp. 729-730.
- Pickard, G. L., and R. W. Trites. Fresh water transport determination from the heat budget with applications to British Columbia inlets. J. Fish. Res. Bd., Vol. 14, No. 4, pp. 605-616.
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- Shaw, Barbara, and Helen I. Battle. The gross and microscopic anatomy of the digestive tract of the oyster Crassostrea virginica (Gmelin). Canadian Journal of Zoology, Vol. 35, No. 3, pp. 325-348.
- Somerville, G. M., and L. M. Dickie. Offshore scallop explorations --1957. Fisheries Research Board of Canada, St. Andrews Biological Station, Circular, General Series, No. 30, 4 pp.
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- Smith, M. W. Lea's hydrostatic tag on brook trout and Atlantic salmon smolts. Canadian Fish Culturist, No. 20, pp. 39-44.
- Steele, D. H. The redfish (Sebastes marinus L.) in the western Gulf of St. Lawrence. J. Fish. Res. Bd., Vol. 14, No. 6, pp. 899-924.

- Taylor, A. R. A. A survey of Irish moss on Grand Manan in 1955. Atlantic Prog. Rept., No. 67, pp. 3-5.
- Tibbo, S. N. Report of the Atlantic Herring Investigation Committee. Sect. 3. Herring of the Chaleur Bay area. Bull. Fish. Res. Bd., No. 111, pp. 85-102.
- Tibbo, S. N. Report of the Atlantic Herring Investigation Committee. Sect. 6. Contribution to the biology of herring (Clupea harengus L.) on the Atlantic coast of Nova Scotia. Bull. Fish. Res. Bd., No. 111, pp. 139-151.
- Tibbo, S. N. Report of the Atlantic Herring Investigation Committee. Sect. 7. Herring populations on the south and west coasts of Newfoundland. Bull. Fish. Res. Bd., No. 111, pp. 153-164.
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- Trites, R. W. Ocean floor and water movements. Transactions of the Royal Society of Canada, Vol. 50, Series III, pp. 83-91, 1956.
- Warburton, F. E. Removing intact bivalves from their shells. Pubblicazioni della Stazione Zoologica di Napoli, Vol. 30, 1 p.
- White, H. C. Food and natural history of mergansers on salmon waters in the Maritime Provinces of Canada. Bull. Fish. Res. Bd., No. 116, 63 pp.
- Wilder, D. G., and D. W. McLeese. How temperature and crowding affect the holding of lobsters in artificial sea water. Atlantic Prog. Rept. No. 66, pp. 24-26.
- Wilder, D. G. Lobsters are local. Canadian Department of Fisheries, Trade News, Vol. 9, No. 10, pp. 7-8.
- Wilder, D. G. Canada's Lobster Fishery. Canadian Geographical Journal, Vol. 55, No. 3, pp. 88-107.
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(to March 31, 1958)

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- Bailey, W. B. Some features of the oceanography of the Passamaquoddy region. MS Rept. Series (Oceanographic and Limnological), No. 2, 56 pp.
- Bailey, W. B. Oceanographic conditions in the Strait of Belle Isle region in 1955. MS Rept. Series (Oceanographic and Limnological), No. 7, 37 pp.
- Bailey, W. B. Trinity Bay, Newfoundland survey - September 1956. MS Rept. Series (Oceanographic and Limnological), No. 10, 36 pp.
- Black, W. F. The feeding of nematode-infested Mysids to cod. MS Rept. Biol. Sta., No. 627, 11 pp.
- Campbell, N. J., and A. E. Collin. The discolouration of Foxe Basin ice. MS Rept. Series (Oceanographic and Limnological), No. 6, 32 pp.
- Campbell, N. J. The oceanography of Hudson Strait. MS Rept. Series (Oceanographic and Limnological), No. 12, 82 pp.
- Hachey, H. B. Oceanographic factors relative to the sardine fishery of the Bay of Fundy area. MS Rept. Biol. Sta., No. 625, 25 pp.
- Johannes, R. E. High temperatures as a factor in scallop mass mortalities. MS Rept. Series (Biological), No. 638, 29 pp.
- Keenleyside, Miles H. A. Aquarium observations on the behaviour of young Atlantic salmon, 1957. MS Rept. Series (Biological), No. 643, 23 pp.
- Lauzier, L. Variation of surface water temperatures at St. Andrews, N.B. Numerical forecasting of temperatures. MS Rept. Series (Oceanographic and Limnological), No. 1, 20 pp.
- Lauzier, L. A preliminary report of the winter oceanographic survey in the Gulf of St. Lawrence, 1956. MS Rept. Series (Oceanographic and Limnological), No. 3, 42 pp.
- Lauzier, L. M., and R. W. Trites. The deep waters in the Laurentian Channel. MS Rept. Series (Oceanographic and Limnological), No. 5, 25 pp.

- Lauzier, L. M. Some aspects of oceanographic conditions in the Gulf of St. Lawrence from autumn 1956 to spring 1957. MS Rept. Series (Oceanographic and Limnological), No. 9, 43 pp.
- Lauzier, L. M. and R. D. Graham. Computation of ice potentials and heat budget in the Gulf of St. Lawrence. MS Rept. Series (Oceanographic and Limnological), No. 11, 14 pp.
- McLellan, H. J. A slope water survey - July 1954. MS Rept. Biol. Sta., No. 632, 49 pp.
- Martin, W. R. The status of evidence bearing on optimum size for first capture of ICNAF Subarea 4 cod. MS Rept. Biol. Sta., No. 630, 44 pp.
- Medcof, J. C. Mechanized gear for shellfish harvesting and shellfish culture. MS Rept. Series (Biological), No. 644, 20 pp.
- Paloheimo, J. E. The mathematical formulation of dynamics of fish populations. MS Rept. Biol. Sta., No. 628, 20 pp.
- Paloheimo, J. E. Determination of natural and fishing mortalities: analysis of tag records off western Nova Scotia. MS Rept. Biol. Sta., No. 636, 19 pp.

MANUSCRIPTS SUBMITTED FOR PUBLICATION

(including those published between Dec. 31, 1957, and Mar. 31, 1958)

- Campbell, N. J. Recent oceanographic activities of the Atlantic Oceanographic Group in the Eastern Arctic. Atlantic Prog. Rept.
- Godfrey, Harold. Mortalities among developing trout and salmon ova following shock by direct-current electrical fishing gear. J. Fish. Res. Bd., Vol. 14, No. 2, pp. 153-164.
- Keenleyside, M. H. A. Effects of spruce budworm control on salmon and other fishes in New Brunswick. Canadian Fish Culturist.
- Keenleyside, M. H. A. Comparative effects of the insecticides, DDT and Malathion, on young salmon. Atlantic Prog. Rept.
- Kerswill, C. J. Effects of DDT spraying in New Brunswick on future runs of adult Atlantic salmon. The Atlantic Advocate.

- Logie, R. R. Epidemic oyster disease and rehabilitation transfers in 1957. Fisheries Research Board of Canada, St. Andrews Biological Station, Circular, General Series, No. 31, 2 pp.
- McLeese, D. W. Light weight methods of packing lobsters for air shipment. Trade News.
- Martin, W. R. and Y. Jean. Effects of first year mesh regulations on the northern New Brunswick dragger fishery. Atlantic Prog. Rept.
- Paloheimo, J. E. A method of estimating natural and fishing mortalities. J. Fish. Res. Bd.
- Scott, D. M. and H. D. Fisher. Incidence of the ascarid, Porrocaecum decipiens in the stomachs of three species of seals along the southern Canadian Atlantic mainland. J. Fish. Res. Bd.
- Scott, D. M. and H. D. Fisher. Incidence of a parasitic ascarid, Porrocaecum decipiens, in the common porpoise, Phocoena phocoena, from the lower Bay of Fundy. J. Fish. Res. Bd., Vol. 15, No. 1, pp. 1-4.
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LOBSTER SUMMARIES

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Predators of larvae and young lobsters

The catchability of lobsters in relation to temperature

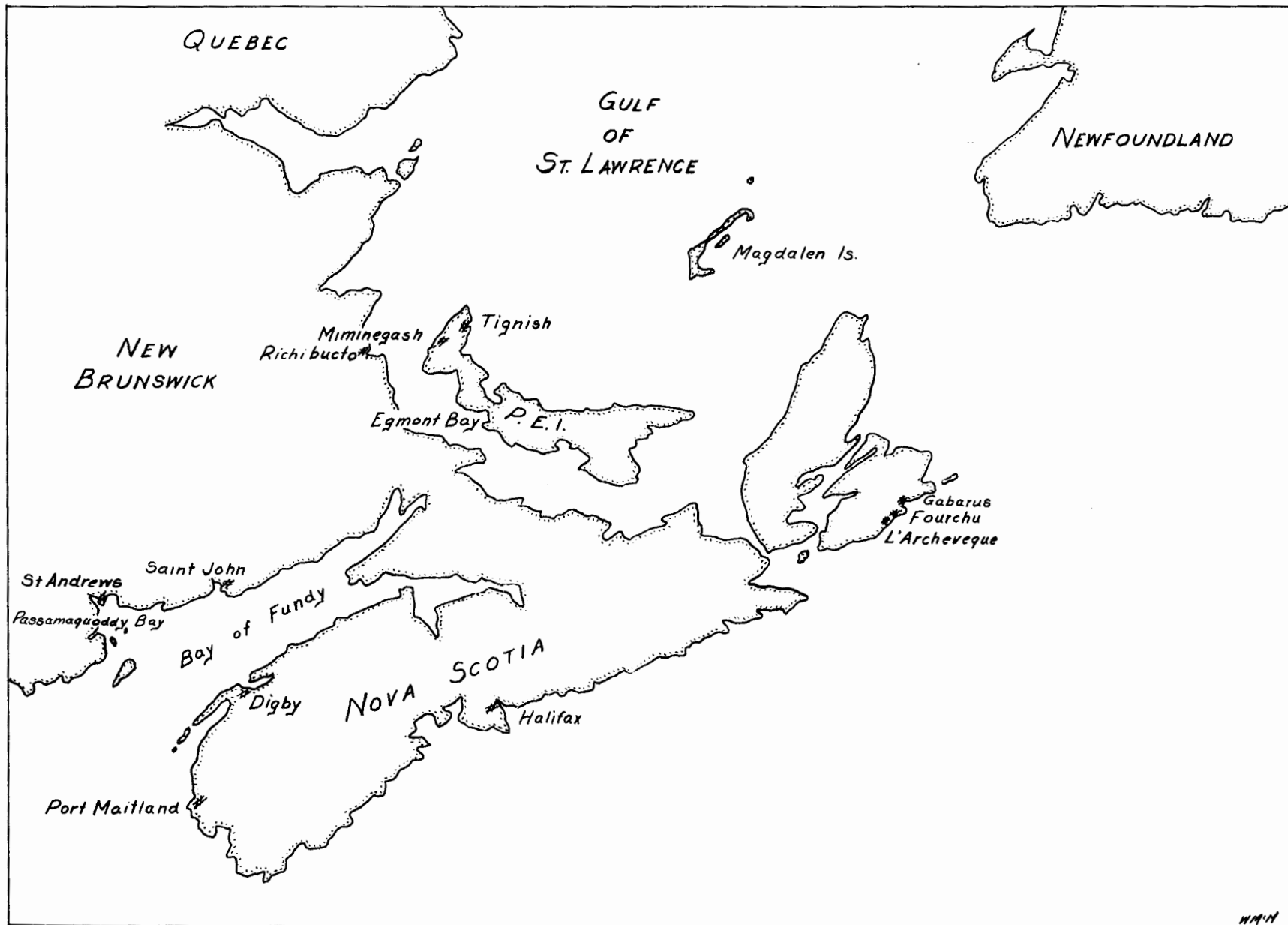
Activity of lobsters in relation to temperature

Oxygen uptake of the lobster

Light-weight methods of packing lobsters for air shipment

Trapping behaviour of lobsters

Toxicity of bunker fuel oil to lobsters

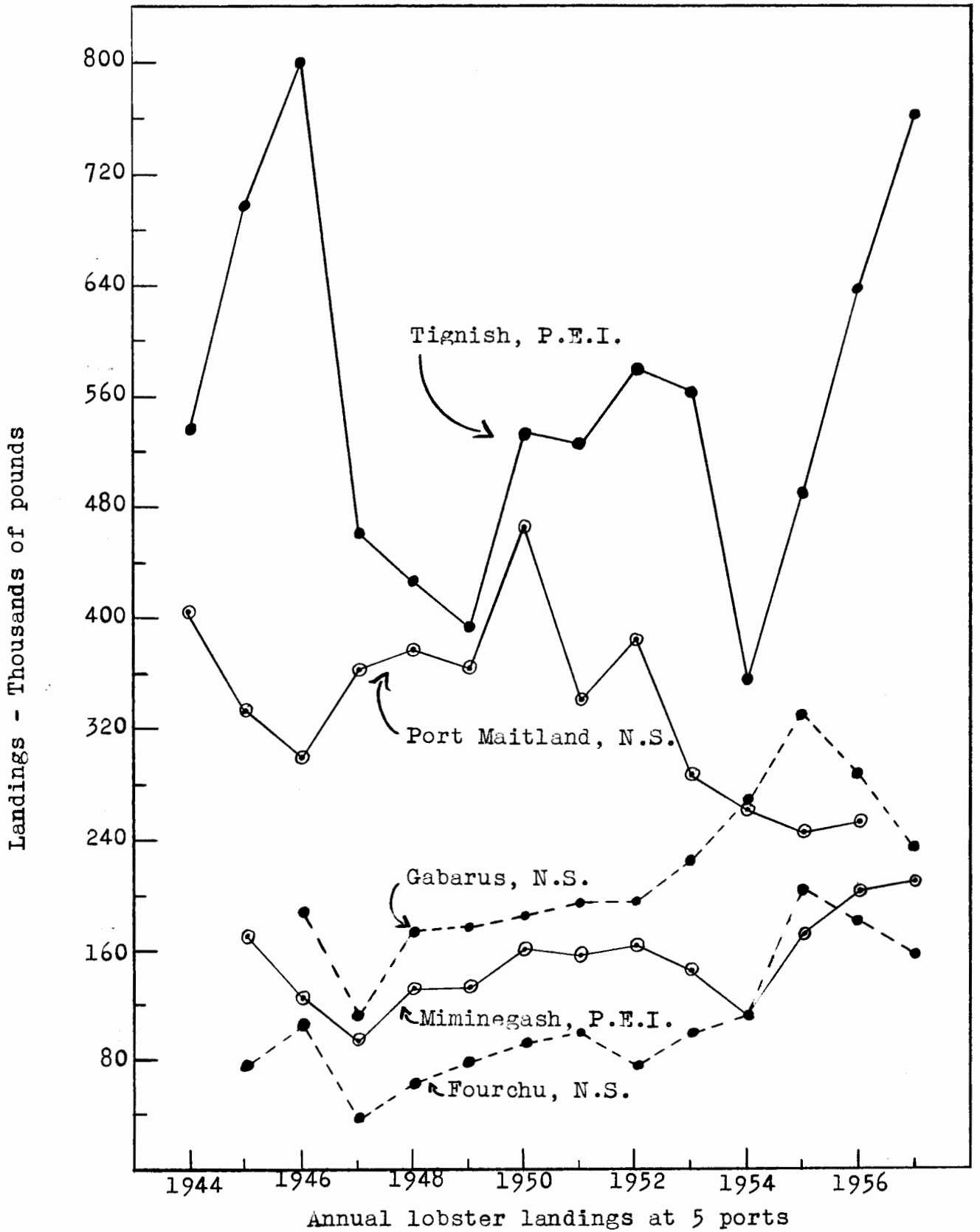


LOBSTER POPULATION STUDIES

Lobster population studies were continued in 1957 at Tignish, P.E.I., Miminegash, P.E.I., Port Maitland, N.S., Fourchu, N.S., and Gabarus, N.S. Comparable data on landings, effort, size distributions and rates of exploitation are now available for the past 12 to 14 years. Annual landings for each port are plotted in the accompanying figure.

Tignish, P.E.I. Annual returns from 1,000 lobsters tagged each year since 1944 have ranged from 42 to 72% with an average of 59%, indicating a fairly high rate of exploitation. The average carapace length of legal-sized lobsters during the 1957 spring season was 2.8 inches. The size limit increase in 1953 from 2 3/8 to 2 1/2 inches was unpopular with the fishermen and was accompanied by heavy traffic in short lobsters during the 1953 spring season and intensive out-of-season fishing that summer. Landings in 1954 were extremely low. Misuse of the stock in 1953 was undoubtedly partially responsible for the poor 1954 catch but improved protection also played a part by restricting the landings of short lobsters. Since 1954 the landings have increased steadily. This increase although encouraging is not necessarily a direct result of improved protection. Part of the apparent improvement results from forcing more of the catch through legal channels where it is more accurately recorded. Natural fluctuations must also be considered. Some of the larvae which settled in unusually large numbers in the summer of 1952 may have reached legal size by the spring of 1957. Consideration of the relative abundance of larvae and young lobsters off Richibucto, N.B., and the course of the fall fishery off Miminegash, suggests that good fishing at Tignish will continue to the spring of 1958 and possibly 1959. There were, however, reports of intensive out-of-season fishing during the summer of 1957. The extent to which such fishing was carried on will be reflected in the 1958 landings. Poor larval survival in 1953 and 1954 suggests that the Tignish stocks will decline as soon as the successful 1952 year class has passed through the fishery.

Miminegash, P.E.I. This fishery is carried on in the fall (August 10 to October 5) but is otherwise similar to the Tignish spring fishery. Annual tag returns since 1945 have ranged from 68 to 84% with an average of 76%, indicating a high rate of exploitation. Legal-sized lobsters in 1957 averaged 2.8 inches in carapace length. The good larval settlement in 1952 probably contributed heavily to the 1957 landings which were the highest in recent history. Bottom dragging in this area indicated a good supply of sub-legal lobsters in the fall of 1957. This suggests good commercial catches in 1958. Subsequent catches may decline seriously because of poor larval settlement in 1953 and 1954.



Port Maitland, N.S. Annual tag returns from this six-month (December 1 to May 31) fishery in southern Nova Scotia have, since 1944, ranged from 35 to 61% with an average of 48%. Legal-sized lobsters during the 1956-57 season averaged 3.5 inches carapace length. Landings declined rather steadily from 1950 to 1955 but levelled off in 1956. Because of a corresponding decline in the number of boats, the catch per boat has not dropped as drastically. Unusually poor weather during December 1957 and January 1958 has seriously affected the fishery.

Fourchu, N.S. In this area the minimum size limit was increased in 1947 from 7 inches total length to 3 1/8 inches carapace length (about 9 inches total length). Annual tag returns since 1945 have varied from 36 to 72% with an average of 51%. Legal-sized lobsters in 1957 averaged 3.5 inches carapace length. The drop in landings accompanying the 1947 size-limit increase was considerably greater than expected. From 1947 to 1951 landings improved steadily in contrast to the similar, nearby L'Archeveque area where the size limit was not changed. Much of this early improvement apparently was a result of the size-limit increase. Subsequent improvements in landings to a peak in 1955 have been general for the outer coast of Cape Breton. Since 1955, landings have declined appreciably. The catch per boat has dropped more drastically because of a marked increase in the size of the fleet.

Gabarus, N.S. This area, immediately east of Fourchu has until recently been studied less intensively. Tag returns in 1950, 1956 and 1957 have ranged from 50 to 53% with an average of 52%. Legal-sized lobsters in 1957 averaged 3.2 inches carapace length. The minimum size limit in this area was relatively uniform from 1942 to 1955. In 1956 a plan was adopted to increase the size limit by 1/8 inch a year until the 3 3/16 inch limit was reached. The size limit was increased from 2 1/2 to 2 5/8 inches carapace length in 1956 and to 2 3/4 inches in 1957. Landings have declined from the 1955 peak of 333 thousand pounds to 288 thousand pounds in 1956 and 235 thousand in 1957. Since similar declines have occurred at Fourchu and elsewhere, only part of the decline at Gabarus can be ascribed to the recent size-limit increases. The catch per boat has declined from 6,400 pounds in 1955 to 3,600 pounds in 1957, partly because of an increase in the fleet size. It now seems unlikely that fishermen in this area will support a further size-limit increase in 1958.

Field observations in connection with these studies were made by U. J. Walsh, R. C. Murray, and D. E. Graham.

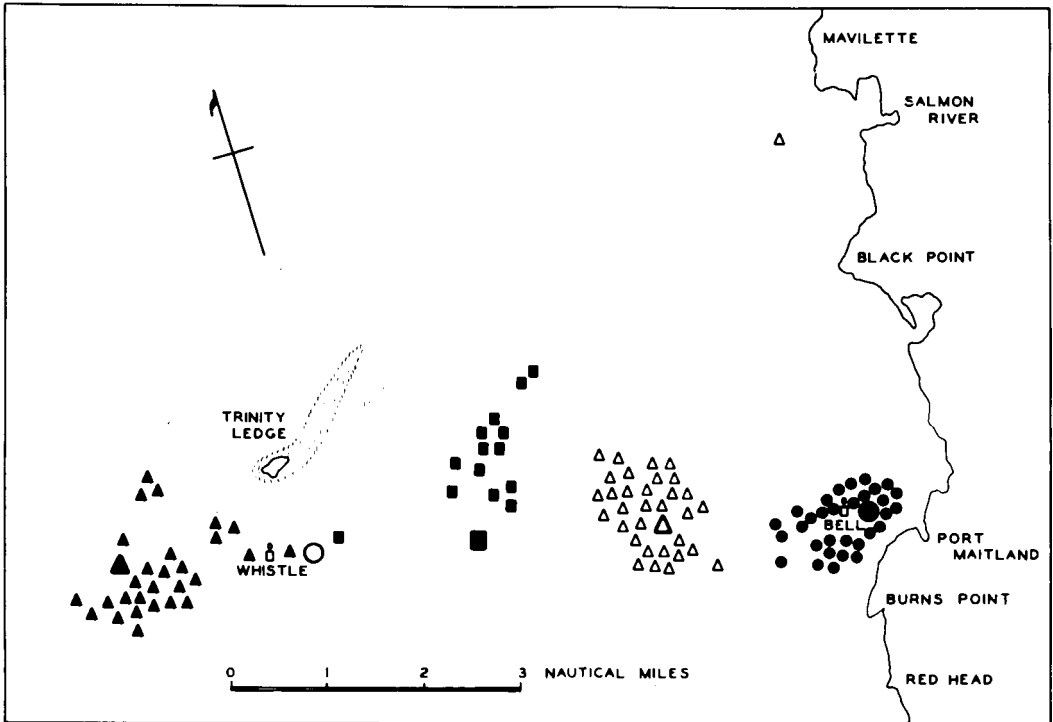
D. G. Wilder

No. 2

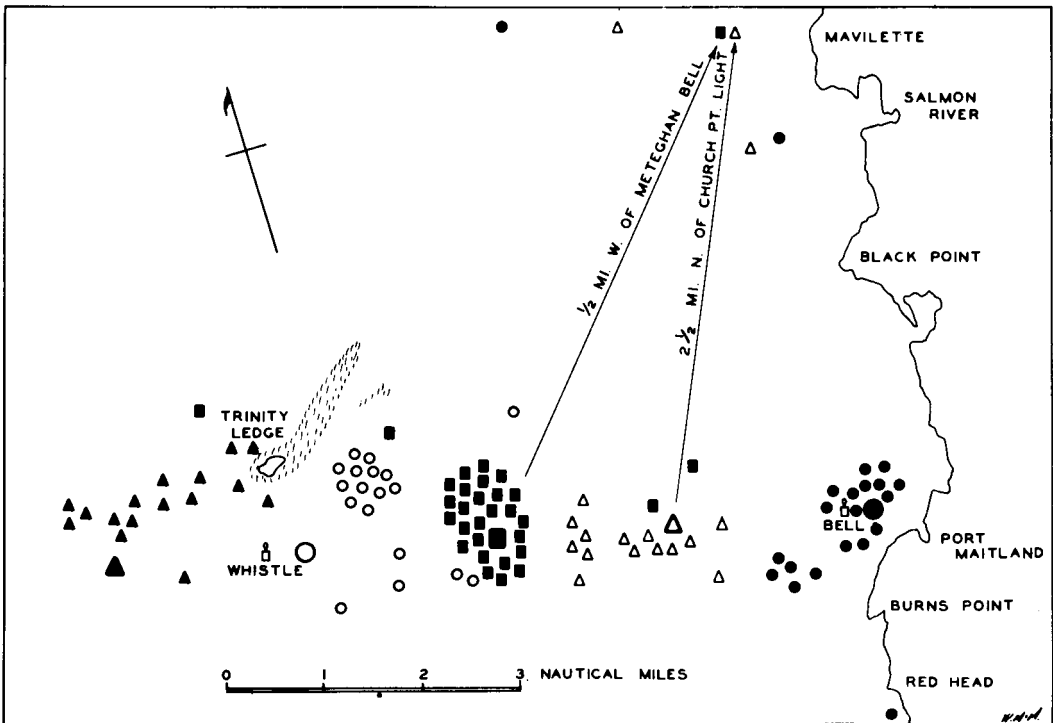
LOBSTER MOVEMENTS OFF PORT MAITLAND, N.S.

Many fishermen believe that lobsters move offshore in the fall and onshore in the spring. Large scale taggings and markings of over 140,000 lobsters over the past 25 years have

WINTER RECAPTURES



SPRING RECAPTURES



Recaptures from 500 lobsters tagged off Port Maitland, N. S., November 6 to 8, 1956. One hundred lobsters were liberated at each of the 5 points shown by large symbols. Winter recaptures (December 1, 1956 to February 28, 1957) and spring recaptures (March 1 to May 31, 1957) are shown by corresponding small symbols.

failed to show evidence of such movements. These markings and taggings were conducted primarily to study the growth of lobsters and to determine the effect of the fishery on the stocks. They were not designed to provide detailed information on small scale movements.

In order to follow the lobsters' movements more closely a special tagging was carried out at Port Maitland, N.S., from November 6 to 8, 1956. Five hundred tagged lobsters were liberated in 5 lots of 100 each at points spaced 2 miles apart along a line running offshore from Port Maitland. Lot 1 was liberated $\frac{1}{4}$ mile from shore and Lot 5 $8\frac{1}{4}$ miles off. Of the 500 lobsters, 211 were recaptured during the 6-month season from December 1 to May 31. One hundred and seven were recaptured in the winter (December, January, February) and 104 in the spring (March, April, May). The recapture points are shown in the accompanying figure.

There was no suggestion of offshore or onshore movements. Seven of the lobsters moved in a northerly direction for $\frac{1}{4}$ to 22 miles. The remainder were caught very close to the liberation points, the average movement of all being slightly less than one mile. On the average these lobsters had been free for $3\frac{1}{2}$ months. The Port Maitland area is fished by 30 boats, most of which have gear pretty well spread over the area. In spite of this most of the tags returned from each lot were caught by a very few boats. One fisherman recaptured 70% of the tagged lobsters recovered from Lot 2 but caught none from the other lots. Three fishermen accounted for 65% of the tags recovered from Lot 5. No gear was set in the immediate vicinity of the Lot 4 liberation during the winter months and none of these tagged lobsters were recaptured until spring. This shows clearly that the tagged lobsters moved about very little. To catch appreciable numbers a fisherman had to set gear at or very close to the spots where the lobsters were liberated.

It seems evident from these taggings that off- and on-shore movements have no appreciable effect on the catch of lobsters. The impression that such movements occur apparently results from actual changes in the abundance and activity of the lobsters. In the fall of the year the lobsters are abundant and active in the warm inshore waters. Intensive inshore fishing produces good initial catches but as the stock decreases and the activity of the lobsters declines in the rapidly cooling water the catches drop off quickly. At this stage the deeper water has not yet cooled appreciably and the less intensively fished offshore stocks provide fair fishing. In the spring the inshore waters warm up quickly and the lobsters that escaped the fall fishery again became active and provide fairly good fishing.

This tagging experiment was conducted by R. C. Murray, U. J. Walsh, and D. E. Graham.

D. G. Wilder

No. 3

LOBSTER GROWTH STUDIES

From 1947 to 1951 a series of 8 marking experiments at 6 rather widely separated points provided information on the natural growth rate of lobsters. Of 27,330 lobsters distinctively marked by means of small holes punched through the tail fan, 2,419 were later recovered. The data indicated that in the southern Gulf of St. Lawrence 6- to 8-inch lobsters usually moulted once a year and grew 13 to 15% in length and 45 to 53% in weight.

In 1954 and 1955 a further marking experiment was conducted at Egmont Bay, P.E.I. Of 6,716 6- to 7-inch lobsters marked, 871 were recovered 10 to 12 months later. Their average growth was 21% in length and 84% in weight. Almost 90% of the lobsters recovered during the last half of the 1955 season had moulted twice. The average growth of these, which represents more closely the growth for the full year, was 36% in length and 165% in weight.

The rapid growth of the Egmont Bay lobsters suggested marked geographic or annual variations or serious sampling errors in the earlier work. To check on these possibilities another marking experiment was conducted at Tignish, P.E.I., where lobsters had been marked in 1947 and 1950. From June 16 to 30, 1956, a total of 8,200 6- to 10-inch lobsters were distinctively marked in 10 carapace length groups and liberated on the fishing grounds.

During the May-June 1957 season, an intensive search was made to recover as many as possible of these marked lobsters from the commercial landings. Approximately 320,000 pounds of lobsters (42% of the landings) were examined individually. A total of 1,147 marked lobsters were recovered. About 95% of these had moulted but few, if any, had completed two moults.

The data are summarized in the accompanying table.

Growth was remarkably constant for size groups I to VIII, averaging about one third of an inch but fell off abruptly for groups IX and X to an average of less than one quarter of an inch. Percentage growth declined gradually from 16% in group I to 11% in group VIII and then dropped to an average of 7% for groups IX and X. The slow growth of groups IX and X was the result of a reduction in the moulting frequency rather than a drop in the growth per moult. Of the lobsters recovered in these two groups 37% had failed to moult. The actual proportion of non-moulters was undoubtedly higher since mature females that failed to moult would be egg-bearing in the spring of 1957. These egg bearing, non-moulters would not normally be landed and hence would escape detection. The data indicate that the minimum size limit for this area which is now $2\frac{1}{2}$ inches should probably never exceed $3\frac{1}{8}$ inches.

These results agree closely with those obtained in the 1947 and 1950 Tignish experiments. It appears therefore that Egmont Bay, P.E.I., is an area of unusually rapid growth.

Growth in carapace length of lobsters marked at Tignish, P.E.I., June 16 to 30, 1956, and recovered in May and June 1957.

Size group	<u>Lobsters marked</u>		<u>Lobsters recovered</u>		<u>Growth</u>		<u>Non-moulters</u>	
	Number	Average carapace length Inches	Number	Average carapace length Inches	Inches	%	Number	%
I	703	2.19	59	2.55	0.36	16.4	0	0
II	1,368	2.31	142	2.64	0.33	14.3	0	0
III	1,369	2.44	227	2.74	0.30	12.3	2	0.9
IV	1,529	2.56	204	2.88	0.32	12.5	9	4.4
V	1,362	2.69	234	3.01	0.32	11.9	14	6.0
VI	932	2.81	162	3.15	0.34	12.1	9	5.6
VII	382	2.94	51	3.26	0.32	10.9	6	11.8
VIII	252	3.06	30	3.39	0.33	10.8	4	13.3
IX	184	3.19	24	3.39	0.20	6.3	10	41.7
X	119	3.31	14	3.58	0.27	8.2	4	28.6
	8,200		1,147				58	

The field work in connection with this experiment was under the immediate supervision of U. J. Walsh. Mr. D. E. Graham assisted with the marking and W. E. Guptill and R. C. Murray assisted with the tedious search for marked lobsters. Additional valuable assistance during the early part of the 1957 season was provided by several Department of Fisheries officers stationed in the area.

D. G. Wilder

No. 4

EXPERIMENTS TO IMPROVE LOBSTER TRAPS

Experiments started in the summer of 1953 have shown beyond doubt that lobster traps built of iron and steel withstand storms much better than wooden traps. In some of the experiments the metal traps fished as well as wooden ones but in others they fished poorly, particularly during cold-water periods. No satisfactory explanation for this variable performance has been found. At times the unballasted metal traps settle on their sides or ends and those that do so undoubtedly fish poorly. Possibly the effect of this is greatest when the water is cold and the lobsters less active.

Efforts to ensure proper settling have involved the use of floats to keep the traps upright on metal vanes to direct their descent. The floats show some promise but both methods are largely restricted to singly set traps that settle freely. In some areas

10 to 15 traps are fastened to a ground line and are fished in such a way that each trap may be temporarily suspended a short distance from bottom. In such cases proper settling might be ensured by bridling the traps from the top rather than from one end as is customary. An experiment using this method was conducted at Tignish, P.E.I., during May and June, 1957.

Thirty steel traps and 30 wooden traps were set alternately in lines of 10 traps. They were fished on 26 occasions from May 9 to June 26. In 707 comparable trap hauls the wooden traps caught 1,144 legal-sized lobsters, the steel traps 623 (54.4%). During this period, water temperatures gradually warmed from 33°F. to 54°F. Contrary to expectation, the efficiency of the metal traps fell from 67% during the first half of May to 36% during the last half of June.

Eleven of the steel traps were coated with a tar base paint and 19 were given a primer and finish coat of "Rustoleum". These treatments appeared to work about equally well, providing reasonably good protection from corrosion.

None of the experimental gear was lost as a result of storm damage.

In general the erratic performance of metal traps and the difficulty in interpreting the results have exposed our ignorance of the biological principles involved in the trapping behaviour of lobsters. A preliminary study of this behaviour is reported in Summary 12.

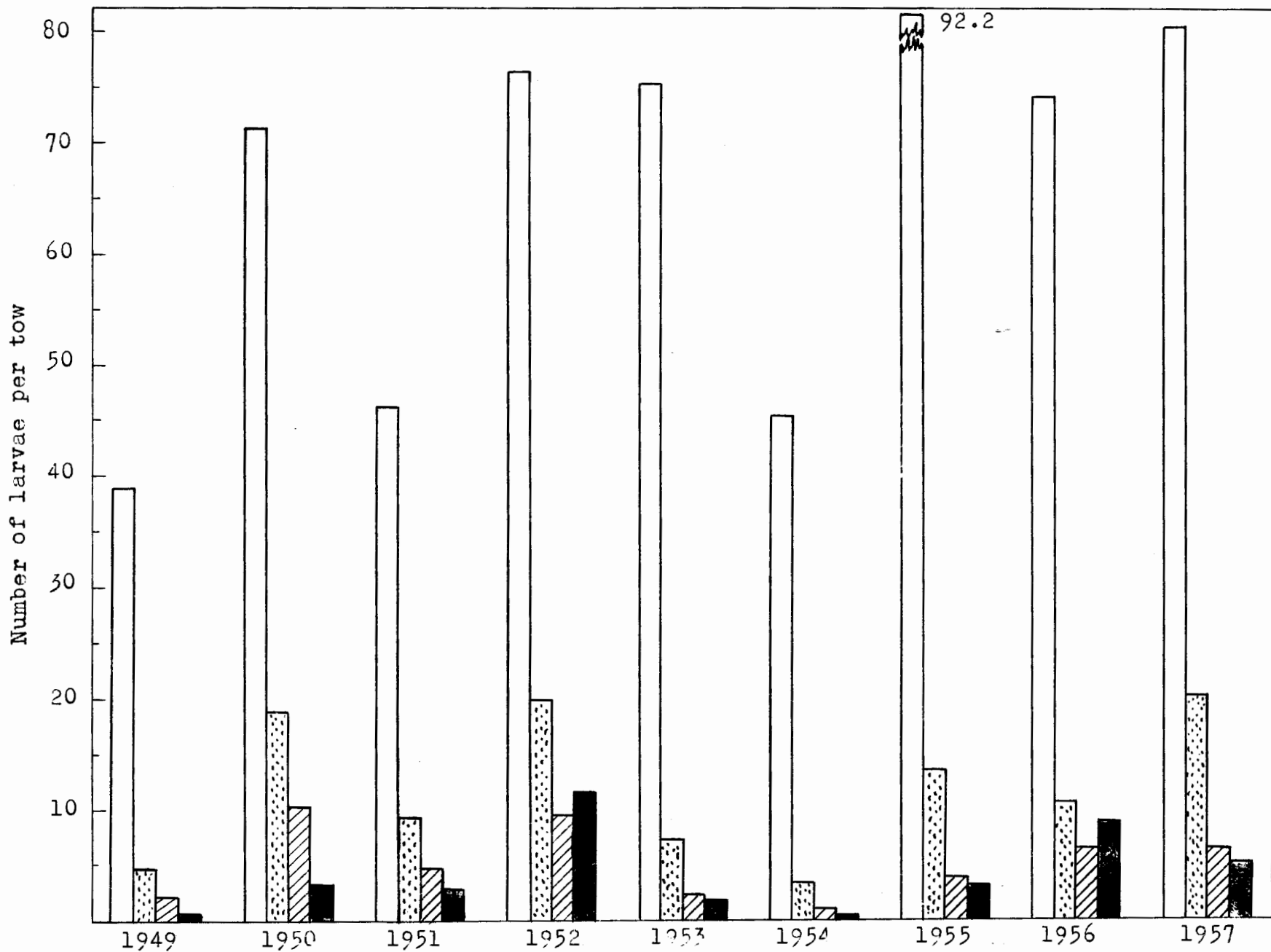
The field work in connection with this experiment was done by U. J. Walsh.

D. G. Wilder

No. 5

RELATIVE ABUNDANCE OF LOBSTER LARVAE IN NORTHUMBERLAND STRAIT

Each summer since 1948 a series of plankton tows for lobster larvae has been made in the Richibucto-Miminegash area of Northumberland Strait. The purpose of the program has been to determine the seasonal occurrence, growth, mortality rates, and relative abundance of the 4 free-swimming stages. The number of half-hour surface tows made with a rectangular, 12 foot by 3 foot, net and the number of larvae caught are as follows:



Relative abundance of lobster larvae 1949 to 1957
 Stage I - white; Stage II - dotted; Stage III - cross hatched; Stage IV - black.

Towing period	No. of tows	Number of larvae				Total
		Stage I	Stage II	Stage III	Stage IV	
1948 June 5-Sept.13	128	931	302	189	148	1,570
1949 June 20-Sept.14	288	7,294	855	330	80	8,559
1950 June 9-Sept.27	256	11,726	3,256	1,563	452	16,997
1951 June 16-Sept.21	338	10,000	1,604	693	441	12,738
1952 June 4-Sept.23	589	22,452	5,042	2,404	2,973	32,871
1953 June 15-Sept.16	630	26,325	3,364	895	725	31,309
1954 June 16-Sept.15	565	15,897	1,636	450	112	18,095
1955 June 15-Sept.14	495	25,174	3,566	1,074	639	30,453
1956 June 15-Sept.13	664	32,886	4,687	2,213	2,792	42,578
1957 June 15-Sept.26	533	28,747	6,462	2,175	1,558	38,942

The relative abundance expressed as the average catch per tow during the 6-week period in each year when each stage was most abundant is plotted in the accompanying figure. The data for 1948 have been omitted because the mesh size of the net differed.

The first stage larvae continue to show relatively minor fluctuations in abundance, being about 2.4 times as abundant in 1955, the best year, as in 1949, the worst year. The fourth or last free-swimming stage is much more variable. This stage was 38 times as abundant in 1952 as it was in 1954. The 1957 hatch was the second best on record but survival to the fourth stage was only fair.

Growth studies indicate that in the Northumberland Strait area lobsters reach the minimum legal size of 2½ inches carapace length during their sixth growing season when they are about 5¼ years old. Commercial landings at Miminegash, P.E.I., and Tignish, P.E.I., in 1957 were unusually high (Summary No. 1) and it seems probable that this was the result of a good settlement of larvae in the summer of 1952.

The larvae were collected by Captain L. I. Cross on the M. B. Pandalus II. They were sorted and counted by Evelyn R. MacMillan with some assistance from D. E. Graham.

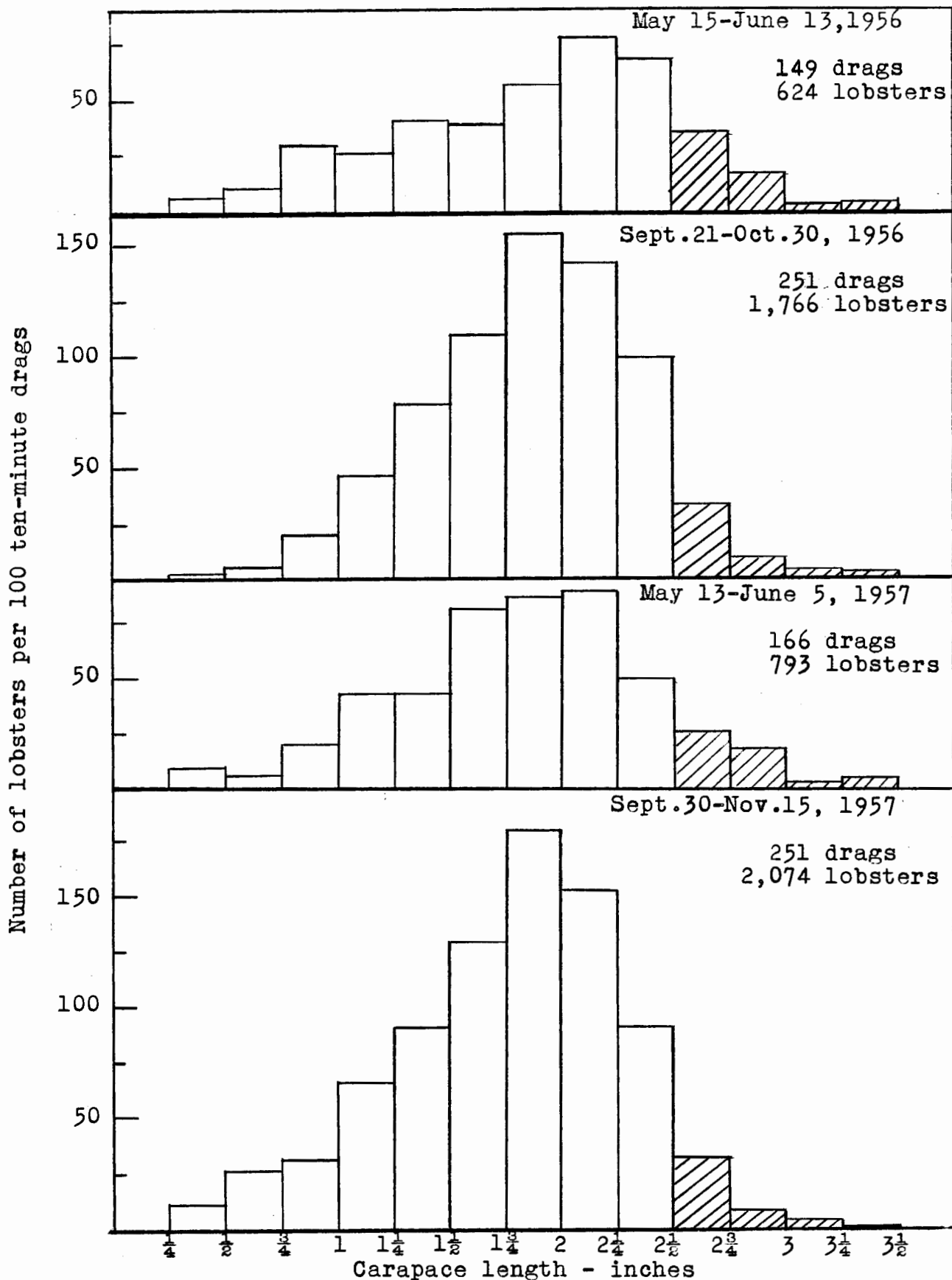
D. G. Wilder

No. 6

RELATIVE ABUNDANCE OF YOUNG LOBSTERS IN NORTHUMBERLAND STRAIT

In the fall of 1952 off Richibucto, N.B., recently settled young lobsters were caught for the first time in a fine-meshed bottom drag. The work has been continued to learn more about the growth, survival and abundance of young lobsters.

From 1952 to 1955 much of the effort was expended in testing new drags and searching for stations where lobsters usually occurred and where bottom conditions would permit dragging. By 1956 a double 4-foot drag, equipped with rubberized canvas chafing



Relative abundance of lobsters off Richibucto, N. B.
Shaded portion represents legal-sized lobsters.

gear, was found acceptable as standard equipment and a series of 14 stations had been selected.

This year, as in 1956, dragging was carried on in the spring and fall, before and after the surface towing program for the free-swimming stages. Most of the fall dragging is done after the close of the commercial fall season. From May 13 to June 5, 793 lobsters were caught in 166 ten-minute drags and from September 30 to November 15, 2,074 lobsters were caught in 251 drags. The relative abundance of the various sizes in 1956 and 1957 is expressed in the accompanying figure as catch per 100 drags.

Since the fall samples are taken after the close of the fall fishery and since there is little or no growth between fall and spring, the sample taken in the spring of 1957 should correspond to that taken in the fall of 1956. The data suggest, however, that lobsters were about 47% more abundant in the fall of 1956. One possible explanation is that lobsters suffer a heavy natural mortality between fall and spring. An alternative explanation that seems to fit the data better is that lobsters feed and move about actively in the fall when the water is warm and are more accessible than they are in the spring when they feed less and spend more time under cover.

If the samples taken in corresponding dragging periods actually represent the relative abundance of lobsters from year to year, they provide a basis for predicting the course of the commercial fishery. Lobsters just under legal size in the spring of 1956 and 1957 would be expected to contribute heavily to the 1956 and 1957 fall fisheries and to the 1957 and 1958 spring fisheries. Those just under legal size in the fall of 1956 and 1957 would contribute to the 1957 and 1958 fall fisheries and the 1958 and 1959 spring fisheries. Commercial landings in this general area were unusually good in the fall of 1956 and 1957 and in the spring of 1957. The dragging operations indicate that lobsters just below legal size were almost as abundant in 1957 as in 1956. There is, therefore, some reason to believe that good fishing in this area will continue to the spring of 1959. This forecast is based on growth estimates and on rather limited dragging data and is, of course, subject to serious error.

The dragging operations were carried on by L. I. Cross in the M. B. Pandalus II. R. C. Murray measured the smaller lobsters and tabulated the data.

D. G. Wilder

No. 7

PREDATORS OF LARVAE AND YOUNG LOBSTERS

The annual towing program off Richibucto, N.B., has shown that lobster larvae suffer high but variable mortalities during the free-swimming period. The possibility that this might be accounted for by variations in the abundance and distribution

of predators appeared to be worth exploring. Rather limited material collected in the summer of 1956 seemed to rule out gulls and terns as serious predators. This year an effort was made to determine the status of herring and mackerel as predators of lobster larvae. Both species are abundant in the Gulf area and both feed on plankton organisms.

From August 18 to September 2, 120 gill net caught herring were collected off Richibucto, N.B. These fish ranged from 21 to 32 cm. fork length with an average length of 26 cm. Most were in spawning condition and apparently had not been feeding actively. No lobster larvae were found in the stomachs.

From mid July to mid August, 75 gill net caught mackerel were collected. These ranged from 33 to 40 cm. fork length with an average length of 36 cm. The stomachs contained relatively little food and much of this was unidentifiable. One third-stage lobster larva was found.

Nothing is known of the natural mortality rate during the lobster's early bottom stages but presumably it is high. The drag used to sample these stages catches various bottom feeding fish. From May 13 to June 5 specimens of 6 species were collected to determine the extent to which they feed on young lobsters. The number of specimens and their average lengths were as follows: shorthorn sculpin 30, 28 cm.; longhorn sculpin 5, 24 cm.; winter flounder 48, 29 cm.; sea raven 14, 29 cm.; lumpfish 3, 29 cm.; and eelpout 3, 56 cm. The partly digested remains of three lobsters were found in the stomachs of two shorthorn sculpins. The estimated total lengths of the lobsters were 8, 10, and 12 cm.

The fish specimens were collected by Captain L. I. Cross. The stomach contents were examined by Sheila Duff, Patricia Flieger, and D. E. Graham.

D. G. Wilder

No. 8

THE CATCHABILITY OF LOBSTERS IN RELATION TO TEMPERATURE

Population studies indicate that the catchability of lobsters is markedly affected by temperature. If the relationship between temperature and catchability can be determined, it would then be possible to derive population estimates by relating the seasonal decline in catch per unit effort to the accumulated catch. One approach to this problem has shown that the activity (walking rate) of lobsters is fairly constant from 10 to 20° C. but falls off rapidly at temperatures below 10° C. (Summary No.9).

A more direct approach is to determine the catch per unit effort from a constant stock of lobsters at different temperatures. However, recruitment through growth and removals by the commercial fishery make it difficult to find a stock that remains reasonably constant. The lobster stock off the Biological

Station although limited is lightly fished and remains relatively constant from fall to spring. Recruitment during this period is presumably at a low level.

Starting in mid September at peak bottom temperatures a string of 40 wooden traps was set off the Station. The traps were fished every day for a week and this process was repeated each month. The lobsters caught were sexed, measured, tagged, and immediately released at the points of capture. The fishing record is as follows:

Period	No. of trap hauls	No. of lobsters caught	No. tagged	Catchability: catch per 100 trap hauls	Average water temperature °C.
Sept. 16-24	186	50	49	27	12.4
Oct. 7-12	175	103	92	59	11.5
Nov. 4-9	176	98	82	56	9.8
Dec. 9-14	175	26	24	15	6.5
Jan. 13-18	171	4	3	2.3	4.1
Totals	883	281	250		

The data indicate fairly constant catchability at temperatures of 10 to 12° C. and a rapid decline as temperatures fall below 10° C.; results that are in general agreement with those obtained in the activity studies. From November 15 to December 14, commercial fishermen caught 11% of the lobsters tagged prior to November 15 and presumably reduced the total stock proportionately. The catchability figures for the last two fishing periods should therefore be adjusted to 17 and 2.6 respectively.

The movements of the tagged lobsters are of particular interest in connection with the proposed Passamaquoddy power project. From September 23 to January 15, 31 of the tagged lobsters were recaptured during the experimental fishing. These had been free for 1 to 71 days. Evidence of movement was, of course, limited by the distribution of the experimental gear but the average movement of these lobsters was only 0.1 miles. An additional 27 tagged lobsters were caught by commercial fishermen. These lobsters had been free for 1 to 77 days and had on the average moved 0.5 miles. The maximum movement was 1.3 miles. The results to date indicate that there is no appreciable movement of adult lobsters out of Passamaquoddy Bay.

The experimental fishing was done from the M. B. Mallotus by W. G. Carson, D. E. Graham, and U. J. Walsh.

D. G. Wilder

No. 9

ACTIVITY OF LOBSTERS IN RELATION TO TEMPERATURE

The relationship between activity of lobsters and temperature is an important consideration in population studies. Lobsters

must be active to enter baited traps and catchability therefore depends on activity. Lobster fishing is carried on throughout the year although in each district it is controlled by seasons. Activity differing with temperature will be reflected in differences in catch per unit effort and will mask true differences in population density between areas, or changes in the population within an area. Activity studies may also aid in explaining short-term variations in catch.

Activity must be considered from two aspects; activity of fully acclimated animals at their acclimation temperature and activity of those that have experienced a sudden change in temperature. The rate of walking in response to a brilliant light was used as a measure of activity.

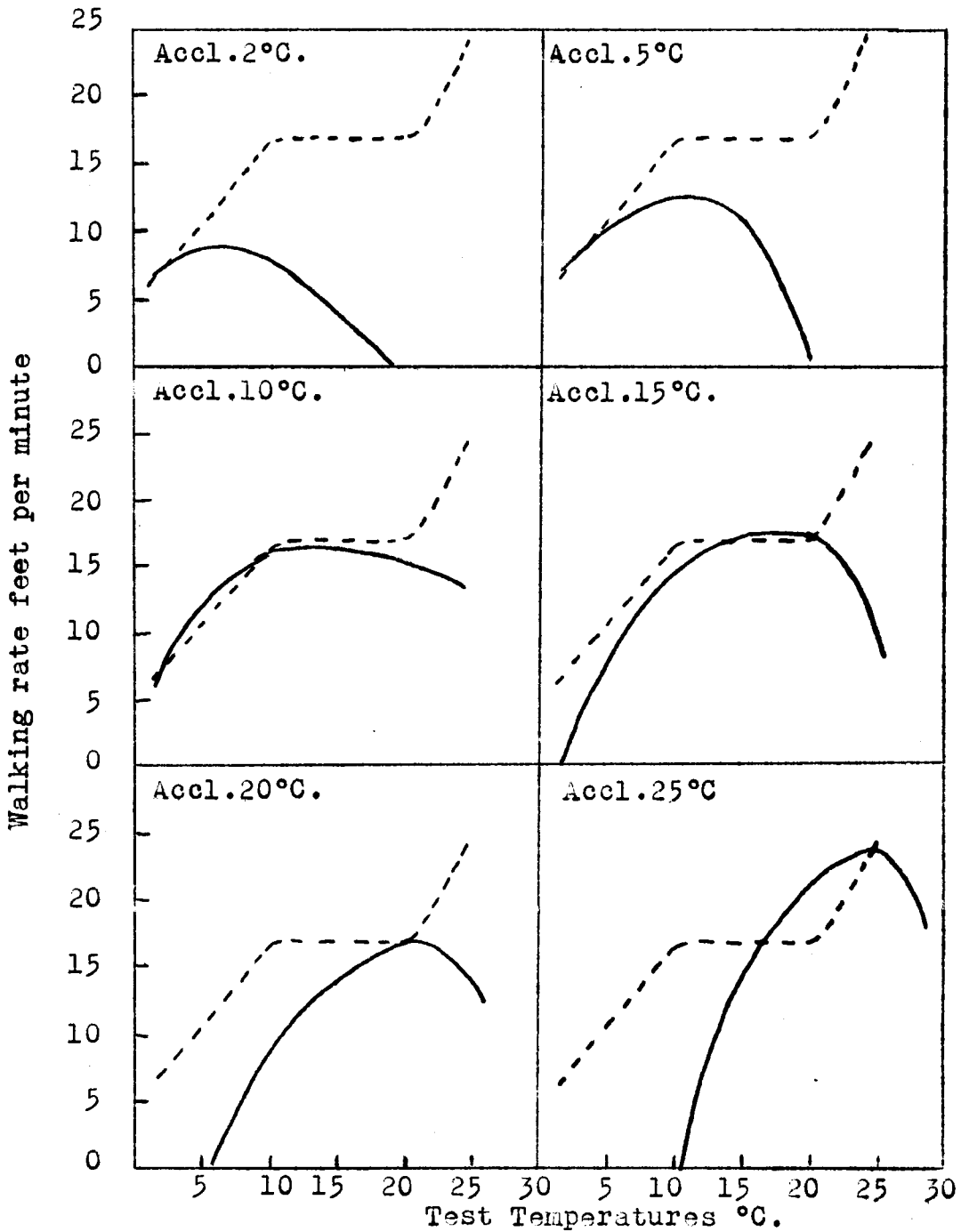
The activity of fully acclimated lobsters is shown as a dotted line in the accompanying figure. Activity increases significantly from 2° to 10° C. Between 10° and 20° C. activity remains essentially constant but increases sharply at temperatures over 20° C. In nature, lobsters are seldom likely to encounter temperatures much higher than 20° C.

These changes in activity suggest that as the acclimation temperature gradually rises to 10° C. (or falls from 10° C.) catchability will steadily increase (or decrease) but will remain essentially constant from 10° to 20° C. Of course, other factors, such as moulting, food supply, and hydrographic conditions will modify catchability at various temperatures.

Changes in activity as lobsters are exposed to sudden temperature changes are shown in the 6 panels of the figure. The relationship between activity and temperature change either up or down depends largely on the general range of acclimation. At low acclimations (2 and 5°) there is moderate activity at 2° C. Maximum activity occurs at temperatures above the acclimation levels (6° to 14° C.), and drops off to zero at 18° to 20° C. At intermediate acclimations (10° and 15° C.) activity is moderate to zero at 2° C. and reaches a maximum at 10° to 20° C. and falls off at higher temperatures. At high acclimations (20° and 25° C.) lobsters are inactive at temperatures up to 5° or 10° C. and reach maximum activity over a narrow range of temperatures at the acclimation level. Further increase in temperature results in a decrease in activity. Presumably activity ceases somewhat below the lethal temperature for intermediate acclimations and close to the lethal level for high acclimations.

In general fully acclimated lobsters are more active than those not acclimated to the test temperature. However lobsters acclimated to 10° C. are somewhat more active at low temperatures than those fully acclimated and lobsters acclimated to 25° C. are more active around 20° C. than those acclimated to 20° C.

The changes in activity that have been demonstrated undoubtedly reflect changes in catchability but the exact relationship between activity and catchability has not been established.



Walking rates of lobsters acclimated to and tested at various temperatures. Rates for fully acclimated lobsters shown by dotted line in each panel for reference.

A field experiment to measure the effect of water temperature on catchability is now in progress and is reported in Summary No. 8.

D. W. McLeese

No. 10

OXYGEN UPTAKE OF THE LOBSTER

Studies of the oxygen uptake of the lobster started during 1956 were continued during the summer of 1957. These studies were made to provide information for estimating adequate water flows for lobster holding units, to acquire basic physiological information important for behaviour studies and to clarify statements in the literature which are not in agreement.

Oxygen uptake of lobsters in relation to acclimation temperature was determined using a modified Scholander apparatus where oxygen removed by the lobster is measured directly. For each temperature tested, the average rate of uptake for 12 to 15 lobsters over an 8-hour period was determined from readings taken at 15-minute intervals. Lobsters were fully acclimated to the test temperature.

The oxygen uptake of "resting" lobsters increases with temperature up to 20° C. and levels off with no further increase up to 25° C. At 20° C. uptake is twice as great (0.04 cc. O₂/gm./hr.) as at 10° C. (0.02 cc. O₂/gm./hr.). There was no apparent difference in uptake related to sex. The results are shown in Figure 1.

Danish workers have reported that oxygen uptake of European lobsters increased up to 28° C. without levelling off. In this case lobsters were adjusted to the test temperatures for only short periods rather than being fully acclimated. Their measurements are of an unstabilized active metabolic rate rather than a stabilized resting rate as determined in our tests.

Oxygen uptake in relation to the amount of oxygen present in the water was measured at 3 temperatures, 14°, 20°, and 25° C. Typical examples for each temperature are shown in Figure 2. At 14° C., the lobsters exhibited two phases of uptake. At oxygen levels below 3 to 3.5 cc./l. the rate of uptake is dependent on oxygen concentration. Above 3 to 3.5 cc./l. uptake is independent of concentration. Half the lobsters tested at 20° C. showed both phases while the other half had only a dependent uptake even at high oxygen levels. The oxygen uptake of all lobsters at 25° C. was directly dependent on oxygen content.

An independent phase of uptake has not been reported previously for either the European or the American lobster, rather a completely dependent uptake at all temperatures has been stressed for both. This point has important ecological implications. Under any set of conditions the metabolism of an animal with completely dependent respiration would be limited by the oxygen concentration in the water, even up to saturation levels. It follows that

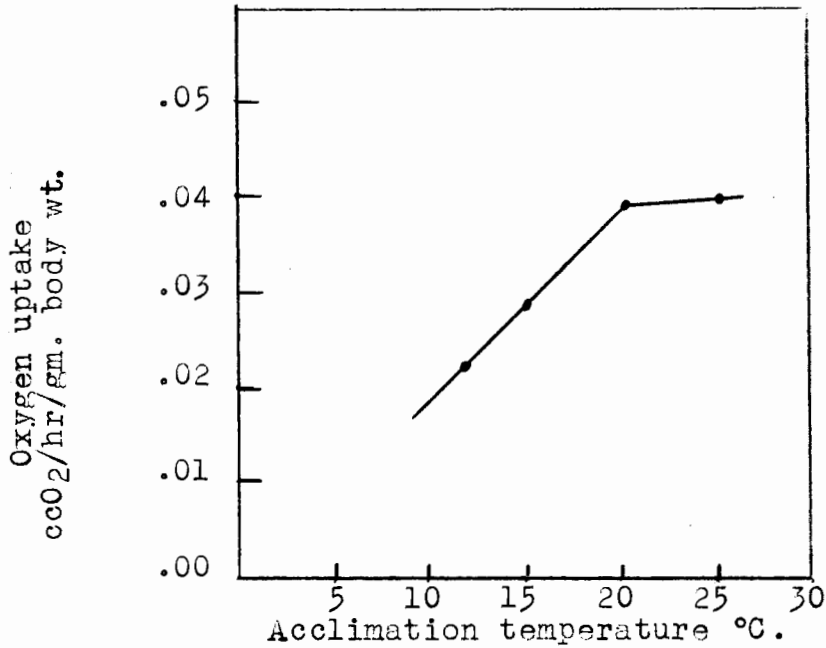


Figure 1. Oxygen uptake of lobsters in relation to acclimation temperature. Each point represents average uptake of 12 to 15 lobsters over an 8 hour period.

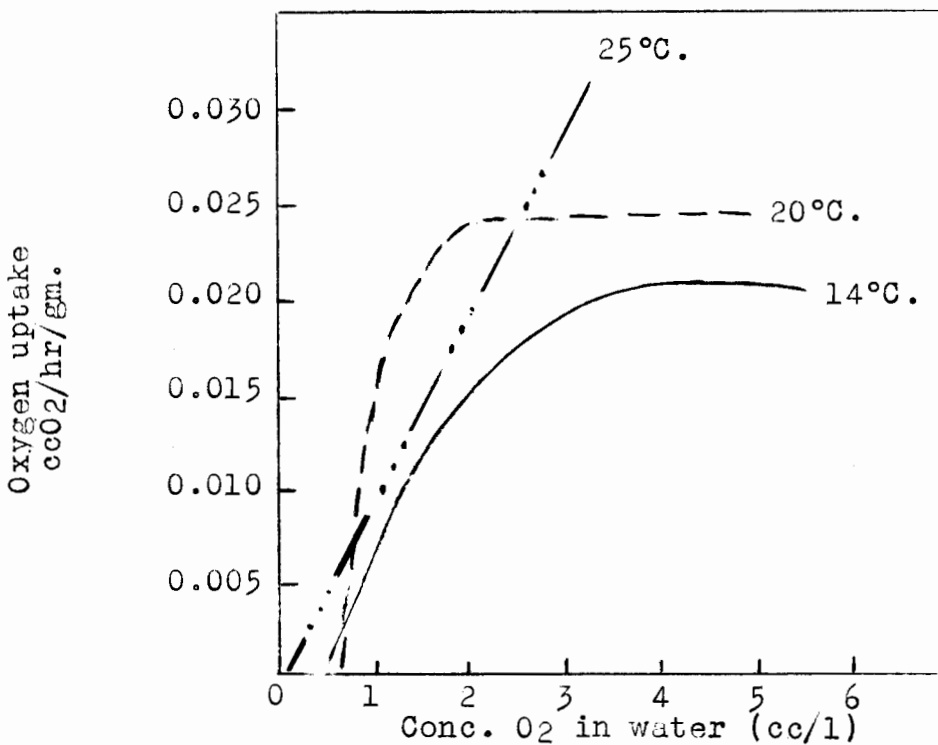


Figure 2. Oxygen uptake in relation to oxygen content at 14°, 20° and 25°C.

activity which is an expression of metabolism would also be limited.

It is planned to expand this work to include a greater range of temperatures, particularly lower temperatures.

Summary of R. D. Lisk's report
by D. W. McLeese

No. 11

LIGHT-WEIGHT METHODS OF PACKING LOBSTERS FOR AIR SHIPMENT

The distribution of live lobsters to markets across the continent has become a major phase of the lobster industry. However, lobsters cannot be expected to remain vigorous for more than a few days when they are out of water. The quality of those reaching distant markets could be improved by faster transportation. Shipment by aircraft is a possible answer but the usual methods of packing are unsuitable for air transport because of excessive weight and leakage. Two methods of packing have been studied recently.

I. Bathurst cardboard container.

The Bathurst Power and Paper Company has designed a light-weight, leak-proof container for 50 pounds of lobsters. The container is a double-walled, corrugated cardboard box covered with aluminum foil for insulation. Ice is sealed in a plastic bag to protect the lobsters from melting ice and to avoid leakage. To improve insulation the box is tightly sealed with tape. It was the aim of the company to keep lobsters in good condition for 36 hours, long enough to fly them to distant markets. However, lobsters weakened and died in a considerably shorter period and the problem was referred to us. Between June 12 and October 30, tests involving more than 800 lobsters were conducted to find out if survival could be improved.

The first test showed that the concentration of carbon dioxide increased many times and the oxygen content of the air was appreciably reduced in the tightly sealed container. The lobsters apparently suffocated. It was found that survival could be improved by flushing the container with pure oxygen, by removing carbon dioxide with a chemical absorber ("Ascarite") or by the addition of two $\frac{1}{2}$ -inch air holes. Ascarite is strongly caustic and therefore difficult to use safely near live animals. Seaweed, normally used in commercial packs, was found to be unnecessary in this tightly sealed container. This resulted in a considerable saving in weight. Depending on outside temperatures up to 20 pounds of ice were required to maintain suitably low temperatures within the box for 36 hours. Drip from ice caused some mortality in these tests and it was necessary to use heavy gauge polyethylene bags. The gross weight for 50 pounds of lobsters and 10 pounds of ice is about 64 pounds. To test the various treatments under actual shipping conditions, a trial shipment of 250 pounds was trucked from St. Andrews, N.B., to Saint John, N.B., on October 29, and then flown to Montreal and return through the co-operation

of Trans-Canada Airlines. During the 30-hour shipment, temperatures inside the boxes averaged 43° F. at an average air temperature of 47° F. On completion of the return flight, over 95% of the lobsters were found to be in excellent condition. The addition of 2 air holes was found to be the simplest, most effective treatment.

II. Dry wood shavings.

A different method, packing lobsters in dry wood shavings, has been demonstrated by two lobster buyers from Belgium. Lobsters were allowed to drain for 15 minutes to remove excess water, then alternate layers of dry wood shavings and lobsters were packed in a simple cardboard carton. Three boxes, each containing 50 pounds of lobsters and 5 pounds of shavings were stored at a room temperature of 50° F. The lobsters were in excellent condition after 2 days' storage. The gross weight for 50 pounds of lobsters was 57 pounds.

To find out how long lobsters could be expected to live in wood shavings at different temperatures, some tests were done at St. Andrews, N.B. Boxes packed without ice were stored at 35°, 45°, and 70° F. Others with 5 pounds of ice sealed in plastic bags were stored at 70° F., and one box without ice and without wood shavings was stored at 35° F. When packed, the temperature inside all the boxes was 50° F. The results are summarized in the following table:

Safe holding time for lobsters at various temperatures

Holding temperatures	Treatment	No. of lobsters tested	Safe holding time
70° F.	Wood shavings	20	Less than 1 day
45° F.	Wood shavings	60	4 days
35° F.	Wood shavings	40	6 days
70° F.	Wood shavings and 5 pounds of ice per box	80	Less than 2 days
35° F.	Without shavings	20	5 days

These tests show that lobsters packed in wood shavings must be kept cool if they are to survive for an appreciable time. The main function of wood shavings is most likely insulation. Five pounds of ice will maintain low temperatures in a wood-shavings pack for 24 hours at air temperatures of 70° F. However lobsters packed without wood shavings and held in a room at 35° F. live almost as long as those packed in shavings under otherwise identical conditions.

A commercial shipment of 12,600 pounds was flown from Saint John, N.B., to Belgium during early December. Air temperatures were low and ice was not needed. Although they were shipped more than 3,000 miles, over 97% remained in excellent condition.

These two methods of packing are both suitable for air shipment. Both are light-weight, leak-proof and insulated and lobsters survive well, provided low temperatures are maintained.

D. W. McLeese

No. 12

TRAPPING BEHAVIOUR OF LOBSTERS

Field tests have shown that at times metal lobster traps do not fish as well as ordinary wooden traps. During August 1957, some observations were made of behaviour of lobsters in respect to factors which might affect their trapping.

The degree of cover provided by a trap could be an important factor. Several glass tubes, half of which were clear and the others with an opaque black coating were placed in a large tank with 12 lobsters. Over a 3-week period, 21 lobsters were observed inside and 3 against the clear tubes. Twenty-eight were inside and 56 against the black tubes. The numbers entering the tubes were not greatly different. There was a tendency for lobsters to move through the clear tubes. More lobsters were attracted to the black tubes but those entering stayed at the opening and blocked the entrance. In nature lobsters may react to light and dark traps in the same way, remaining near and blocking the entrance of dark traps.

It is commonly stated that lobsters avoid metals. To test this, half the bottom of a long narrow tank was covered with a metal sheet. Lobsters in the tank could choose between metal and wood. Aluminum, rusty iron, and galvanized steel were tested. The metals had no noticeable effect on the distribution of lobsters.

The efficiency of traps depends partially on the ease with which lobsters can enter and leave traps through the fishing heads. Some aspects of their ability to climb ramps of various materials, different lengths and angles were observed. One-pound lobsters proceeded over wooden ramps with slopes of 30° to 90° all 7 inches high with little or no difficulty. There was some slipping on the 45° and 50° ramps. Lobsters slipped and could not proceed over a 45° ramp of galvanized steel. They can climb short steep slopes (65° or more) provided they can reach the top edge while the tail is still supported on the bottom. They easily climbed $\frac{1}{4}$ -inch wire mesh ramps (30° and 45° slopes). On twine ramps similar to ordinary fishing heads, legs slipped through the meshes and became entangled. It was only by struggling that the lobsters were able to proceed.

A funnel shaped valve made of wooden strips with sufficient tension to close the opening was tested. Lobsters forced their way through even though a force of one pound was required to open the wooden strips. Another valve with a counter balanced ramp on the bottom was tested. The weight of a lobster was sufficient to tip the ramp and provide an opening into the "trap". Lobsters

went through this valve readily. Both types of valve show some promise but improvements in design are necessary.

Sound vibrations set up in metal traps as they strike rocks or by water currents might disturb lobsters. However no change in behaviour was noticeable when sounds varying up to 100,000 c.p.s. were transmitted directly to them by a waterproofed speaker in a tank. Lobsters continued feeding normally.

Metal and wooden traps were fished experimentally in a shallow tide pool stocked with lobsters. The lobsters did not trap well because they were in a confined space and exposed to abnormal conditions (light, tides, lack of moulting, frequent disturbances). More lobsters entered the metal trap but the numbers were too few to be conclusive.

Lobsters presumably enter traps primarily in response to food. Other behaviour studies have shown that food is not a particularly strong stimulus for lobsters in captivity. The tests with cover, ramps, and valves were not done with food as a stimulus. Stronger stimuli in the confined space of the test apparatus probably resulted in an "escape" reaction. Food or response to food was used in the tests with sound and in the tide pool.

Mr. Powers of the Technological Station, Halifax, supplied and operated the equipment for producing underwater sounds.

Summary of W. E. Guptill's report
by D. W. McLeese

No. 13

TOXICITY OF BUNKER FUEL OIL TO LOBSTERS

Heavy losses of lobsters occurred in Digby Harbour, N.S., in June 1957 after a ship reportedly discharged bunker fuel oil in the harbour. At the time no information was available as to the toxicity of bunker fuel oil to lobsters. In a small scale test at St. Andrews, N.B., 10 lobsters were placed in each of 3 concentrations of bunker fuel oil and sea water and in a control without oil. All 10 lobsters died in less than 3 days in a 1:100 concentration and 9 died over an 8-day period in a 1:1,000 concentration. Over the same period, no deaths could be attributed to oil in a 1:10,000 concentration. Bunker fuel oil is definitely toxic to lobsters at relatively high concentrations.

D. W. McLeese

MOLLUSCAN SHELLFISH SUMMARIES

Oyster disease

Oyster set

Conway Narrows rearing trials

Silt pump trials at Malagash

Saltwater ponds for rearing shellfish

Introduction of European oyster

Boring sponge

Mechanical harvesting of shellfish

Green crab studies

New Brunswick epidemic of paralytic shellfish poisoning--1957

The scallop fishery of eastern Canada

Tolerance of scallops to high water temperatures

Scallop explorations

Shellfish and Passamaquoddy power development

No. 14

OYSTER DISEASE

Field investigations

Field work was planned to:

- (a) reveal spread of epidemics to new areas;
- (b) observe progress of established epidemics;
- (c) observe fate of rehabilitation transfers of resistant Prince Edward Island stock to devastated areas.

(a) Spread of epidemic

In 1957 trays of native oysters were maintained in Caraquet Bay and Miscou Harbour, N.B. and in Bras d'Or Lakes, N.S. Up to this year all these areas have been important producers and disease-free. Miscou Harbour and Bras d'Or Lakes continued so in 1957 but mortalities commenced in parts of Caraquet Bay in mid-summer and continued through the fall. Because local events within Caraquet Bay followed a puzzling course, a map (Fig. 1) is included. Mortalities among bottom oysters were checked on Maisonette leaseholds at A and on public fishery grounds at D. Observations on tray oysters were made at Poirier's Shore (B) and at Upper Caraquet (C). A record of observations appears below.

<u>Place</u>	<u>Date Examined</u>	<u>Number Alive</u>	<u>Number Dead</u>
Poirier's Shore	July 13, 1957	585	14
	Aug. 14	362	223
	Aug. 20	323	38(a)
	Aug. 28	282	35
	Sept. 12	240	42
	Sept. 25	206	34
	Nov. 8	73(b)	21
Upper Caraquet	July 13, 1957	443	4
	Aug. 14	334	109
	Aug. 20	323	11
	Aug. 28	306	17
	Sept. 12	56(c)	7
Maisonette leaseholds	Aug. 20	105(d)	153
Public Fishery	Aug. 20	220(d)	1
	Sept. 5	412(d)	3

- (a) Discrepancies in numbers due to samples removed.
- (b) This is only one of two trays; the other upset in a storm and spilled out oysters since the previous count.
- (c) Pilfering forced abandonment of this station after September 12.
- (d) Dredged samples.

From these data mortality rates during different periods were calculated.

	<u>Poirier's Shore</u>	<u>Upper Caraquet</u>
	mortality %	mortality %
<u>Monthly</u>		
July 13-Aug. 14	38.1	24.6
Aug. 14-Sept. 12	31.7	18.6
<u>Bi-monthly</u>		
July 13-Sept. 12	58.8	38.6
Sept. 12-Nov. 8	33.3	13.0(e)
<u>Seasonally</u>		
July 13-Nov. 8	75.4	46.0(e)

(e) Estimated by extrapolation.

It should be added that up to August 20, the accumulated mortality on the Maisonette leaseholds was 60%; at Poirier's Shore 47%; at Upper Caraquet 28% and on the Public Fishery less than 1%. Mortality on public fishery grounds had not increased by September 5. Nearly a million pounds of oysters were taken in October and November, an unexpectedly high yield. However the local Fisheries Officer reported heavy mortalities on the eastern edge of the public fishery grounds at the close of the fishing season. This report came too late for checking but it seems that many of the oysters marketed this fall would not have lived until another fishing season.

Summary of the Caraquet epidemic shows that:

- (1) Mortalities were heavy around the shores of the western half of Caraquet Bay but slight or absent in the west-central portion.

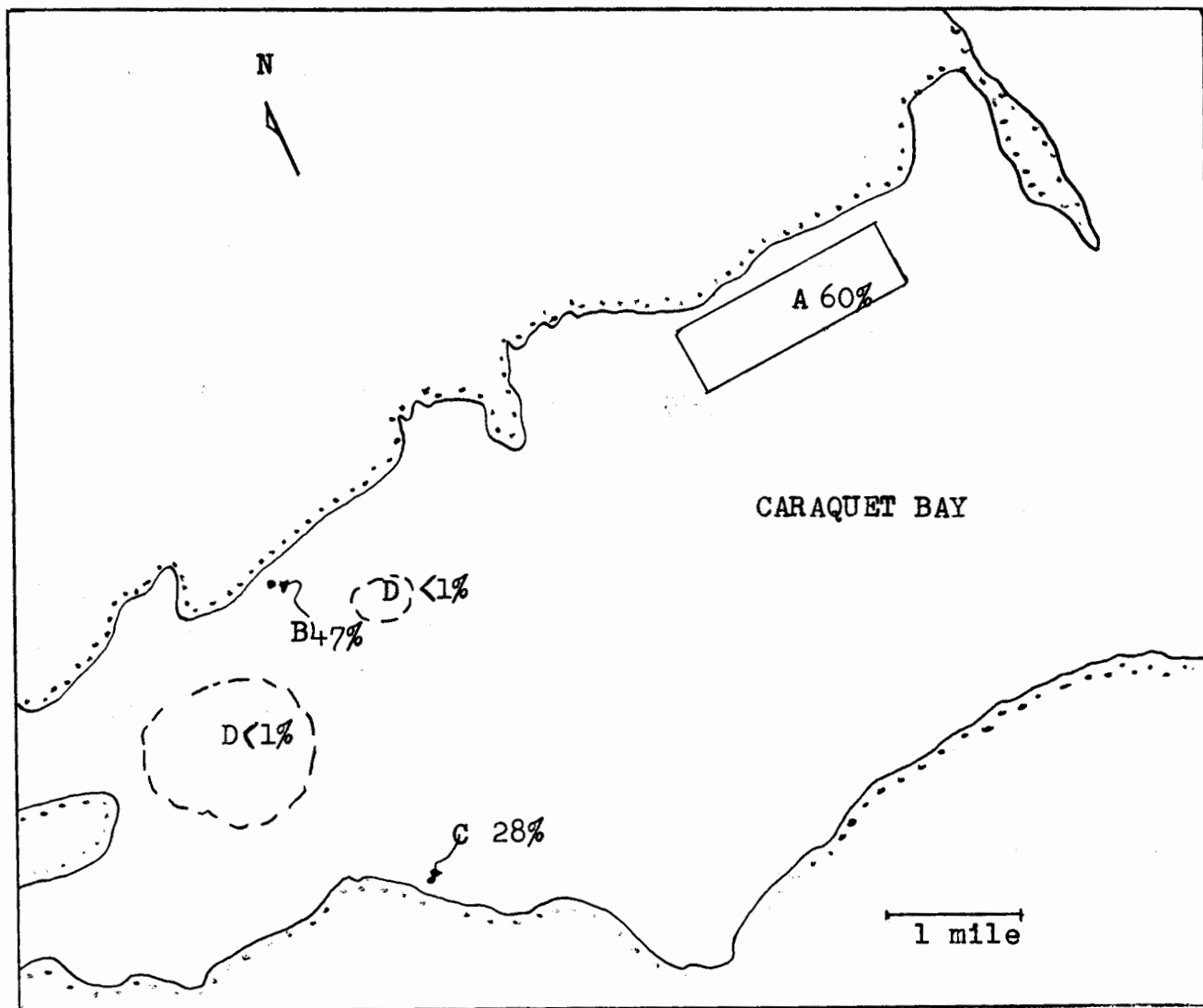


Fig. 1

1957 oyster mortalities in various parts of Caraquet Bay up to August 20.

- (2) Moving around the Bay anti-clockwise from Maisonette to Upper Caraquet, the rate of mortality decreased.
- (3) The onset of mortalities was sudden and the extent more characteristic of second-year than of first-year effects.
- (4) Little or none of the usual shell growth stunting and emaciation of meats was observed. Most oysters grew normally until shortly before death.

We can only speculate about reasons for this atypical course of the epidemic at Caraquet. Developments in 1958 may well be commercially disastrous but they should be scientifically interesting and informative.

(b) Mortalities in established epidemics

In all previously affected areas mortalities continued in 1957 among residual populations and these were measured at all check points. Assuming that mortalities like those in Richibucto River in 1956 and 1957 will occur in later-affected areas, the course of the disease has been predicted (dotted lines and solid circles) by extending the solid line graphs in Figure 2 which describe the observations to date. It will be noted that there is very little deviation except in the case of Poirier's Shore in 1957 (75.4%). This point was ignored in plotting. Graphs like this have important uses.

- (1) From the positions of consecutive points on a graph describing any epidemic it is possible to determine when the disease struck and to predict its future course. For instance from the last two points for Richibucto River (1956 and 1957) it is deduced that disease struck in 1952; that the first heavy mortalities occurred in 1953; that the epidemic is nearly over and will probably terminate in 1958. The striking date deduced in this way agrees well with dating by other means.
- (2) It appears that an epidemic runs its course in about six years. This is the first time that we have been able to even guess at the length of this period.
- (3) From such a graph it is possible to construct another model showing the percentage of pre-epidemic stock which has died up to any given time after the disease strikes (Fig. 3). Actual values for certain dated epidemics are known. Some of these are compared with values predicted from the model.

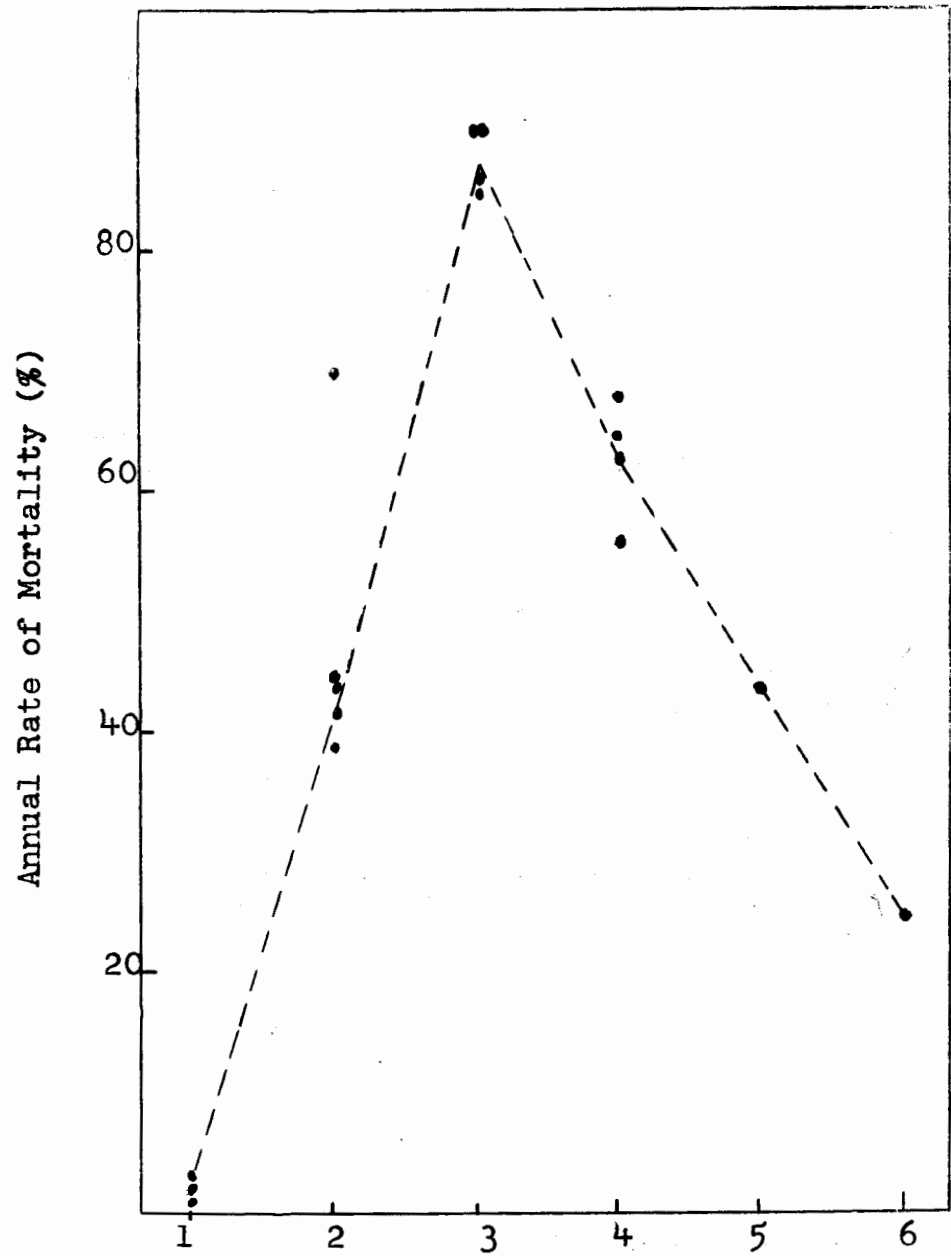


Fig. 2 Age of Epidemic (Years)

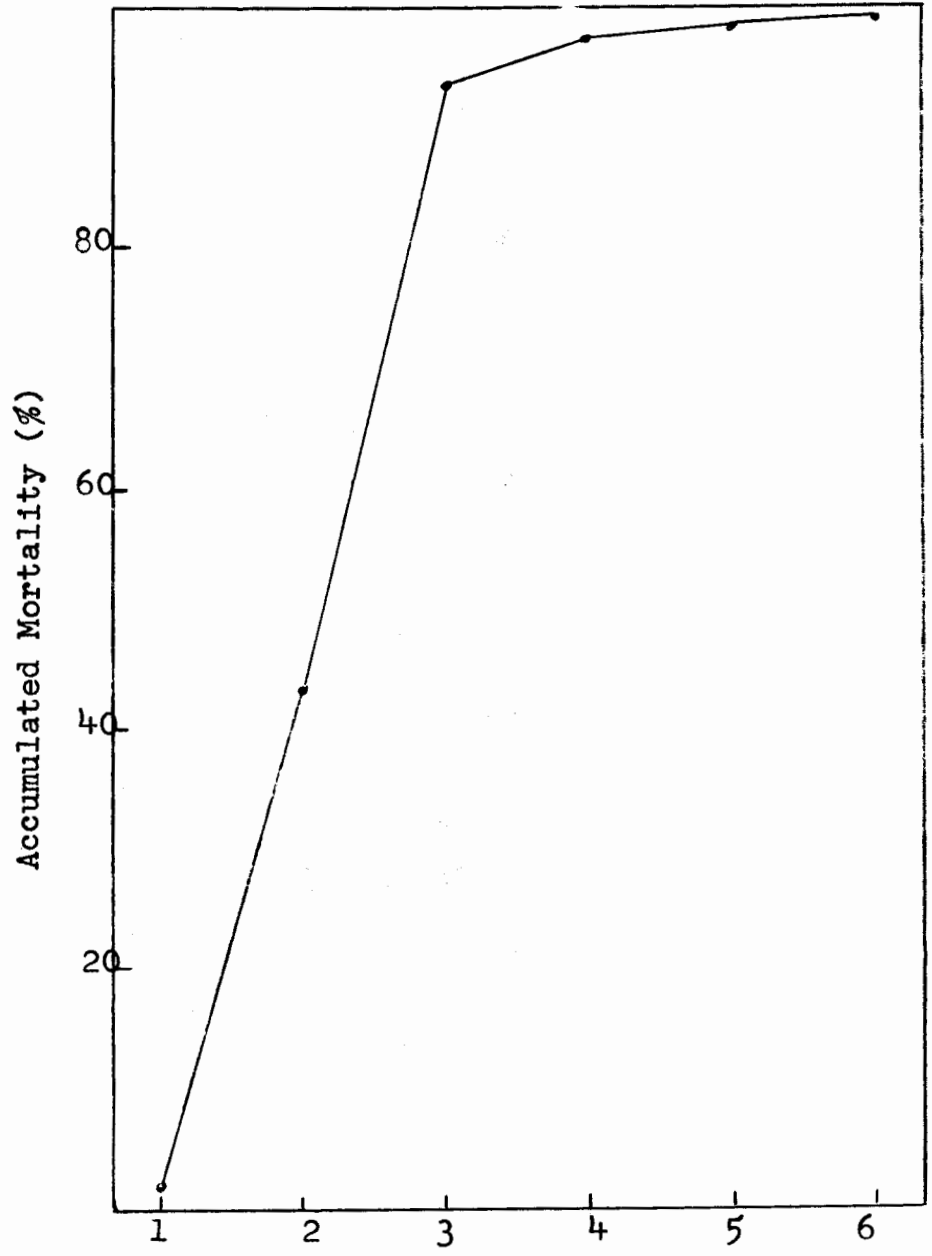


Fig. 3 Age of Epidemic (Years)

Area	% Mortality to end of 1957	
	Predicted Value (Fig. 3)	Actual Value
Shippegan	97.5	97.8
North Shore, Miramichi Bay (Neguac)	93.2	92.5
South Shore, Miramichi Bay (Hardwicke)	97.5	98.2
Malagash	97.5	97.1

It would seem that this model is faithful. If events continue to correspond closely with predictions we estimate that final accumulated mortalities will be about 99%. The corollary is perhaps more important: final survival will be 1% or less of pre-epidemic stocks. This is also the first time we have had reasonable grounds for estimating this value -- previously we have only guessed at it.

We are beginning to understand epidemics and the extent of their devastation. Rehabilitation transfers of Prince Edward Island stock were originally planned to supplement a final residual native breeding stock of 5 to 10%. Now we believe this figure to be closer to 1% and the hoped-for benefits of rehabilitation transfers should be proportionately greater than we expected.

(c) Rehabilitation transfers

In spite of many difficulties transfers of Prince Edward Island oysters were made, as planned, by the Department of Fisheries in May and June, 1957 to Shippegan, N.B. and Malagash, N.S. Samples were held in trays at these places for observation by the Fisheries Research Board. Besides these massive transfers, small-scale experimental transfers were made to trays on the north and south shores of Miramichi Bay, N.B. Similar experimental transfers were made in 1956 to Shippegan, Richibucto River and Malagash and provided information that was most useful in planning the 1957 mass transfers.

In no case has total mortality of 1957 transferred stock exceeded 18%. In most cases it is closer to 5%. Such values are considered typical of disease-resistant oysters. It can be said with some confidence, then, that the Prince Edward Island oysters survive in diseased mainland waters.

In all cases, except at Shippegan, they also spawned, but there were no sets of spat. This, however, does not indicate that the transferred oysters will not breed in their new homes -- 1957 was a year of universally poor sets (Summary 15). At Shippegan sex products matured but the weather was too cold for spawning of either native or introduced oysters. On the whole rehabilitation transfers have succeeded very well and there is

In Crecy Lake the eel is both a predator on and competitor of trout. Attempts are being made to reduce its numbers by trapping in the lake and by preventing access to the lake by the very young eels as they enter it from the sea. There are indications that control may be successful but, because of insufficient time, the trial has not yet given positive results.

Studies at Ellerslie Brook, P.E.I. The effects of forming a pond on a Prince Edward Island trout stream have been tested by placing a dam near the outlet of Ellerslie Brook and by installing two 2-way counting weirs, one just below the dam and the other 650 yards upstream above the head of the 7-acre pond. This arrangement permits good observations on the general behaviour of trout and on their reaction to pond formation. Trout in Ellerslie Brook move up and down through the traps rather freely at most seasons of the year. This seems to rule out the idea of a sea-run race which is believed in by many anglers. There is a net tendency for trout to drop downstream and remain in the pond where a 40% increase in anglers' catches is shown by creel censuses.

Estimates of the population of trout in various parts of the stream is undertaken annually by electro-fishing. It is found that trout older than yearlings move from the stream to the pond, and that there has been a resulting decrease in the average lengths of the older trout in the brook. This loss of large fish has not, however, had an adverse effect on the annual production of fingerlings.

The dam prevents access from the sea to the pond and the brook. The loss of the sea-run trout to the stream has had no noticeable effect on the stream populations.

All the evidence indicates that pond formation improved the utilization of the trout stocks without jeopardizing the production of young in the tributary streams.

Other ponds on Prince Edward Island. Three other man-made bodies of water have allowed useful observations on trout.

Stevensons Pond has an area of about 3 acres. Its lower end is screened. It was drained in June of 1956 and all the trout removed. It was drained again toward the end of September, 1957. The fish removed from it then were those which had entered from the tributary streams during 15 months. There were 1,344 trout weighing 363 pounds or 121 pounds per acre. The data illustrate that this pond, representative of others formed on Prince Edward Island streams, was quickly and well populated from stocks of young trout in the tributary brook. However, indications from other studies in the area show that trout densities up to 800 per acre do not give any evidence of overstocking. Thus that fact and the observation that the trout taken from Stevensons Pond were in very good condition

suggest that better use of the pond's potentialities could have been made with some supplementary planting of hatchery stock.

Wilmot Pond is formed, like others in Prince Edward Island, by an earth embankment across Wilmot Stream. It differs from some of the others by having the overflow diverted through a "run around" which allows the trout freedom of movement between the pond and the estuary. Counting traps were maintained in the run around during open-water periods and the fish tagged as they passed through. Relatively small proportions (15 to 19%) of the trout angled in the pond were sea-run fish. This suggests that most of them make their way quite rapidly into the tributary stream where they are less accessible.

A fill across the mouth of York River for the trans-Canada highway created a 500-acre lake connected to the salt water at high tide by an opening in the causeway. In summer the water is warm and fresh at the surface and saline and cooler below. The bottom water is stagnant and fish cannot live in it. As the surface water is too warm for trout the fish are confined to a narrow wedge between the warm and stagnant layers. It has been recommended that the salt water be excluded in an attempt to increase the amount of suitable living space for trout and provincial authorities have made the necessary arrangements.

Rainbow trout. Rainbow trout have been introduced on Prince Edward Island. They have become established and are extending their territory. In order to compare their development with brook trout, young fish were planted in Simpsons Pond where the performance of brook trout was known. The survivors of 1,172 underyearling rainbow trout released October 11, 1955, numbered 305 after 10½ months and weighed on the average 6.8 ounces. After another year, 167 out of 300 survived and averaged 13.0 ounces. Yearling brook trout only averaged 4.3 ounces in weight. Evidently the rainbow trout is capable of substantially faster growth. The data show that the most efficient cropping of the rainbow trout is as yearlings.

SEAWEEEDS

The seaweeds constitute a very plentiful marine resource in the Maritime Provinces but only one of them is in general commercial use. It is Irish Moss (Chondrus crispus) a red alga. It is harvested as a source of carrageen, which has a variety of uses in the food industries. Work has been mainly confined to assessing the growth of individuals of this plant and to studying the constitution and productivity of the natural population. The work has been continued in 3 areas: the rocky shelving north shore of Prince Edward Island between Cavendish and North Rustico; Curtain Island Reef in Malpeque Bay, P.E.I.; and the shore of Fundy National Park, near Alma, N.B.

spat is irregular and hazardous. This is now the chief obstacle to the production of increased numbers of bedding and of market oysters. It is obvious that our knowledge of the fundamental processes governing maturation of sex products, spawning, survival and settlement of larvae and survival of spat is patchy and inadequate. No great advance in oyster production can be made until we learn to understand and perhaps to control these processes. Commencing in 1958 we plan an intensive investigation of these matters.

Summary of Oyster Set - 1957

Egg-crate fillers

<u>Place</u>	<u>Date</u>	<u>No. of spat *surviving per square inch</u>	<u>Remarks</u>
Bideford River, P.E.I.	July 19-26	0	Did not catch set predicted for July 18.
	Aug. 11	-	Heavy set (Aug. 2) but all newly dead; no count possible.
	Aug. 20	-	Heavy set Aug. 18; no count.
	Sept. 17	4.77	Not a random sample. Very small, newly-set spat. No trace of set of Aug. 18.
	Sept. 27	8.49	All spat probably set about Sept. 20.
	Oct. 5	2.03	Appeared to be all from a set about Sept. 28 or else set of Sept. 20 did not grow.
Paugh's Creek, P.E.I.	Sept. 27	0.21	Same remarks as for same date above.
	Oct. 3	1.72	Same remarks as for Oct. 5 above.
Trout River, P.E.I.	Sept. 27	4.84	Same remarks as for Bideford River.
	Oct. 3	0.39	Same remarks as for Bideford River, Oct. 5.
Freeland, P.E.I.	Oct. 5	0.47	Large spat (20 mm.) known to have set about July 18.
Malagash, N.S.	Sept. 17	0.28	Probably set about mid-August.
	Oct. 17	0.28	Same set grown to 1 mm.
Shippegan, N.B., Gillis Cove and Crowdis Bridge, N.S. - no set throughout season.			

Shaded vs unshaded egg-crate fillers

<u>Place</u>	<u>Date</u>	<u>No. of spat *surviving per square inch</u>	<u>Remarks</u>
Bideford River,	Oct. 5		
Shaded		2.29	Probably set Sept. 28
Unshaded		1.76	Probably set Sept. 28

Shaded vs unshaded mussel shells

Shaded	Aug. 18	1.65	per shell	Mixture of all			
				sets same as	Aug. 2.		
Unshaded	Aug. 18	3.10	" "	" "	" "	" "	" "
Shaded	Sept. 19	0.55	" "	" "	" "	" "	" "
Unshaded	Sept. 19	1.22	" "	" "	" "	" "	" "

* To obtain number of spat per filler multiply by 700

R. R. Logie
A. M. Craig
G. J. Sorger
E. B. Henderson

No. 16

CONWAY NARROWS REARING TRIALS

The Department of Fisheries continued trials of the potential of Conway Narrows bottom for raising separated collector spat to bedding size. (For background see Summary No. 15 to the 1956 report of this Station.) We have so far observed only the results of the Department's efforts, but the continued success of the trials is of such importance that their reporting seems justified.

Spat planted in 1956 survived and grew well. These spat were so small in May 1956 that they could not have been held on the customary one-quarter inch wire mesh in trays. They were a dead loss to ordinary oyster culture techniques. Yet, by the summer of 1957, they had grown sufficiently to attract pickers. This means that many had reached bedding size (1 - 1½ inches long). It is considered that this at least equals, and probably surpasses, the rate of growth on trays. All this was accomplished at no cost in 1957 other than the expense of transportation and the labour of spreading.

In 1957 the sets in Bideford River were late and apparently delicate (Summary 15). By October 5 the spat averaged about one-fiftieth of an inch in length. Nevertheless, some seventy-five barrels of thrashed collectors were planted in Conway Narrows in the first half of October. If any significant numbers of bedding oysters arise from this planting, a tremendous success will have been achieved, since a method of saving and

using late-setting spat will have been evolved. These are ordinarily lost altogether.

In addition, two barrels of mussel shells bearing a light, but better-grown, set of spat were planted in Conway Narrows in September to assess the suitability of this type of cultch in this technique.

R. R. Logie
(from information supplied by
L.A. England and W.E. Oatway,
Department of Fisheries)

No. 17

SILT PUMP TRIALS AT MALAGASH

The background of this work is described in Summary 17 of the 1956 report of this series. This year M.B. Acmaea, a 31-foot, shallow-draught boat was transferred from Ellerslie, P.E.I., to Malagash, N.S., early in July. The silt pump was removed from the scow used last year and mounted on Acmaea's after deck. A short mast was stepped near the stern and equipped with a boom and hoist for manipulating the heavy silt suction head and its hose.

The boom and hoist greatly facilitated the work and Acmaea proved much more manoeuvrable than the clumsy scow. The assembly was used to clear the dyke of a heavy load of silt that has accumulated in the last few years. It cannot yet be represented as efficient but it is working and will be employed in 1958 in its present form to restore the dyke to a useful condition for oyster rearing and to maintain it in that condition in future years.

No doubt we could improve the machine. However, now that it is working, we have decided to use it without further efforts at improvement. Other oyster projects are more demanding and will continue to be for several years.

S. E. Vass

No. 18

SALTWATER PONDS FOR REARING SHELLFISH

Sam Orr Pond is an elaborate tide pool 15 acres in extent and in the Passamaquoddy Bay area about 15 miles from St. Andrews. It has a rocky sill at its mouth at a level such that, at new-moon and full-moon, high tides run in and out but, when the moon is in the first and third quarters, high tides are not high enough to pass over the sill. As a result there are periods, sometimes about a week long, when there is no water exchange between Passamaquoddy Bay and the Pond. These alternate with roughly equal periods of vigorous flushing.

Sam Orr Pond has been under observation for several years and a depth-contour survey was completed in the winter of 1956-57. For the most part it is shallow but there are areas with depths up to 15 feet. In winter it is ice-bound but in summer in periods when there is no flushing, temperatures read 25°C. As a result the Pond harbours a vigorous colony of quahaugs (Mercenaria mercenaria) -- the only known colony on the north shore of the Fundy. It has other biologically unusual features and many hydrographic and physiographic peculiarities. It is very old. The bottom is soft and supports heavy growths of fixed aquatic plants dominated by widgeon grass (Ruppia maritima). The plankton is relatively poor.

The Head of Oak Bay is another interesting saltwater impoundment. It is about 15 miles from St. Andrews, 50 acres in extent and cut off from the St. Croix River (tributary to Passamaquoddy Bay) by a causeway completed in 1955. It is connected with the river by 3 aqueducts through the causeway. Water enters and leaves the Head at every rise and fall of the tide. Summer water temperatures rise to 20°C. which is considerably above those in the St. Croix. In the winter it is ice-bound.

Being a new pond it has a firm bottom with few attached plants and a heavy plankton. So far as is known, no unusual animal populations have established themselves there. Hydrographically it is a more stable environment than Sam Orr Pond and physiographically it exhibits fewer peculiarities, probably because it is young. It may change rapidly in the next few years. Compared with Sam Orr Pond we know relatively little about the Head.

Because of their high temperatures and low flushing rates these two ponds were chosen as trial rearing areas for the European oysters imported in 1957. In the course of the summer we learned a good deal about conditions in them. Many of the hydrographic data are still being analyzed. The more we learn about these ponds the more convinced we are of their important potentialities for producing shellfish -- especially young stock for maturing elsewhere. By temporarily raising the level of the sill at the mouth of Sam Orr Pond and by temporary operation of flap-valves in aqueducts at Oak Bay Head it should be possible to "bottle up" molluscan larvae until they are ready to set and force heavy spatfalls of whatever species we choose to produce. Achievement of this kind of environment management has been the dream of shellfish culturists for generations and currently is the subject of wide-spread research in the U.S.A. We believe these peculiar areas may assume great importance for eastern Canadian shellfish culturists in the next 10 years and we are searching the coast for others like them.

J. C. Medcof and
Joan Mortimer

No. 19

INTRODUCTION OF EUROPEAN OYSTER

The European oyster (Ostrea edulis) was introduced in 1957 with the hope that it would thrive here and permit greater diversification of our inshore fisheries (App. 20, 1955 Rept.). Some communities have been seriously affected by the recent slump in soft-shell clam landings (23 million pounds in 1950, 4 million in 1957). It would be better if they were not so dependent on any one of our few native species that their living standards suffered when that species became scarce.

Different strains of O. edulis are cultured in different parts of Europe. We chose to import young animals that were produced at Conway, North Wales, by the British Ministry of Agriculture and Food in artificial rearing tanks. This strain is resistant to low winter temperatures and free of Dutch shell disease and two intestinal parasites which are common in many parts of Europe and the British Isles. They were spawned in 1955 and averaged close to $1\frac{1}{2}$ inches in diameter.

The shipment of 5,000 animals was transported for 11 days in the cold room of a trans-Atlantic steamer and reached St. Andrews May 21. When placed in seawater tanks here, many were dead or died almost at once. The shells of survivors were carefully cleaned of barnacles and other external growths and the animals were planted in screen-bottomed trays in Sam Orr Pond May 25.

By June 17 there were only 343 survivors. They were divided into equal lots. One was left in Sam Orr Pond, the other moved to another saltwater pond, the Head of Oak Bay. Thereafter relatively few died until freeze-up (208 survivors) and their growth was vigorous -- shell diameter 3 inches. They were very flat and shallow but this is a general feature of all tray-reared oysters. Survival was best at the Head and growth best in Sam Orr.

The heavy initial mortalities are attributed to adverse shipping conditions. It is assumed that late summer and autumn behaviour is indicative of how European oysters would fare here if they were well handled. We have still to see how well they survive winter which is a critical period because European oysters are less resistant to frost than our natives. If they survive well we will consider importing another lot in 1958 by air freight which should be less damaging than sea voyaging.

J. C. Medcof
from report by
Joan Mortimer

No. 20

BORING SPONGE

Measuring Sponge Damage

Since the commencement of boring sponge investigations in 1952, we have sought some objective measurement of sponge damage to oyster shells but it was not until 1956 that Warburton devised one. (See Atl. Prog. Rept., No. 68, pp. 3-8, 1958.) His "Index of Infestation" is the per cent loss of weight of shells on drying. It has limitations e.g. the damage measured may be old and arrested or still actively increasing, again, sand grains in old excavations may affect accuracy of determinations. Nevertheless it is a useful method.

Warburton calibrated verbal descriptions of sponginess against his Index of Infestation from a few observations. After several hundred 1957 determinations we amended his suggestions as follows:

<u>Sponginess</u>	<u>Index of Infestation</u>
Sponge-free or slightly spongy	< 7
Moderately spongy	7 - 20
Very spongy	20 - 30

Survey of Sponge Damage

Using the above criteria a survey of sponge damage in Malpeque Bay was conducted from mid-July to mid-August. All areas showed indices of infestation in the moderate range (7-20) from either dead or living sponge. There were differences within this range, but they seem insignificant. With a few exceptions sponge damage was old -- not the result of current infestation. This bears out the oyster grower's assertion that the sponge nuisance is abating. The highest percentages of infestation by living sponge were in Grand and Bideford Rivers, Bideford Narrows and central Malpeque Bay. These are the areas with the most complaints in recent years, but they cannot be said to be heavily infested now.

There was evidence of some increase in the frequency of living sponge by the end of August. Sponge damage increased rapidly from 1946-56 for reasons we cannot explain. We cannot therefore predict the next flare-up of sponge infestation.

Effect of Sponge on Oyster Condition

Actively boring sponges perforate oysters' shells and affect the meats. Oysters react by capping open perforations with new shell. It has been reasoned that this continual shell repair might result in thinness (poor condition) of oyster meats. Opinions of growers differ on this subject.

We have a reliable means of measuring the condition of oyster meats, the "Index of Condition", developed by Medcof and Needler twenty years ago. In the summer of 1957 the Index of Infestation by sponge and the Index of Condition of meats were determined for about 400 oysters from one location in Bideford River.

No correlation was discovered, but it is necessary to qualify this result by the following remarks:

- (1) Very few sponges were actively perforating shell this year and we would not expect condition of meats to be affected unless the inner faces of the shells were being perforated.
- (2) Spawning produces violent changes in the Index of Condition and could easily mask adverse effects of sponges.

Any future search for a correlation between these two indices should involve large numbers of oysters with a preponderance of those containing actively perforating sponge and should be carried out in early fall when sponges are still boring but when Index of Condition is high and stable at least in non-spongy oysters.

Control Experiments

Oyster growers would like to kill sponges in oysters on their beds by adding a poison to the water. This is an extremely remote possibility.

In 1954, Warburton (Appendix 14, in the Annual Report of this Station for 1954) commenced control experiments on plots on the Bar Bed in Bideford River. In 1955 these were extended to include a much larger plot on the Cooper Bed, further down Bideford River. His method was to remove all infested dead shell and to kill sponge in the shells of living oysters by overnight immersion in fresh water, thus preventing spread of sponge by contact. Under these circumstances re-infestation could only occur through attack by swimming larvae born on nearby infested beds. Warburton predicted that obvious re-infestation would not occur in less than three years and reported that no re-infestation had occurred on either Bed by late August, 1956.

In 1957, the plots were examined, with the following results:

<u>Plot</u>	<u>Year Disinfested</u>	<u>Examined</u>	<u>Per cent of oysters infested by living sponge</u>
Bar Bed Plot 1	1954	July 9, 1957	21
		August 16, 1957	23
Bar Bed Plot 2	1954	July 9, 1957	19
		August 16, 1957	24
Cooper Bed	1955	July 12, 1957	17
		August 16, 1957	17

Thus, Bar Bed control efforts did provide the protection Warburton expected. However, re-infestation on the Cooper Bed has occurred earlier than he predicted. The size of the borings in oysters from all plots suggests that they were present but perhaps not obvious in 1956. We conclude that this treatment does not keep oyster beds sponge-free for more than one year. Also it is very laborious. We must regard it, therefore, as impractical.

Warburton also advocated exposure of infested oysters on intertidal beaches for sponge control. This was given a thorough trial in 1957. Spongy oysters were placed on the bottom at various levels above mean low tide to give varying amounts of low-tide exposure. Tides are erratic in Malpeque Bay and it was impossible to estimate daily exposures because we lacked a tide recorder. To get a clearer idea of the effects of altering exposure time, spongy oysters were placed in trays and hauled above high tide line twice each day for periods equivalent to exposure times they would experience at different beach levels if tidal changes had followed a strict semi-diurnal cycle. At these times tray covers were removed. In both experiments some spongy oysters were kept constantly immersed as controls. The results are tabulated below.

<u>Level on beach</u>	<u>Height above mean low water mark (ft.)</u>	<u>Hours exposed daily (approx.)</u>	<u>Days of treatment to kill all sponge</u>
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On Flats

Close to high water mark	3.3	--	5
Mid-tide level (Exp. I)	2.0	--	5
Mid-tide level (Exp. II)	2.0	--	10
Low mid-tide	1.0	--	44
At low water mark	0.0	0	> 75 (a)
Well below low water mark (control)	---	0	> 75 (a)

<u>Level on beach</u>	<u>Height above mean (low water mark (ft.))</u>	<u>Hours exposed daily (approx.)</u>	<u>Days of treatment to kill all sponge</u>
<u>In Trays</u> (Beach level simulated) (Height simulated)			
At high water mark	3+	24	3
Low mid-tide	1.2	7	7
Low mid-tide	1.0	4	9
Just above low water mark	0.8	3	11
At low water mark	0.4	<1	>90 (a)
Below low water mark (control)	---	0	>90 (a)

(a) No adverse effects noticed.

Conditions are not the same on trays and flats. For example oysters on trays dried completely during exposure whereas on the flat, they were always wet underneath. This may explain the longer sponge-killing times for flats.

Short tray exposures killed in less total exposure times than long tray exposures, although it took more days to build up their exposure times. The sponge's only obvious defense is to withdraw entirely within the oyster's shell and close the osculum. Apparently frequency of withdrawals fatigues the sponge's defenses more than exposure itself.

None of the exposures had any measurable effect on the oysters' Indices of Condition, but in mid-summer the longest exposures on trays killed large numbers of oysters when the experiments were in their seventh day. This method should therefore be used with caution. Mid-tide level exposure is safest. There, complete sponge-kill is probable in five days, certain in ten. Sunlight exposure, drying by sun and wind, and rain effects are all factors in "exposure" as described here. Sponges shielded from sunlight and from rain died as quickly as those that were not. Sponges in oysters in air-tight boxes survived quite a long time. Desiccation seems the important lethal factor in control by intertidal exposure.

There were indications that sponges were not healthy this summer. This clouded the results of control experiments.

In late July, the U. S. Fish and Wildlife Service announced a method of sponge control by immersing spongy oysters for five minutes (not less) in saturated brine. Spraying of oysters on boat deck for longer periods was also reported as effective. This immersion method was tried on Malpeque Bay oysters in mid-August to check:

- (1) the applicability of the method.
- (2) the vigour of our sponges.

Immersion of 3, 5, and 10 minutes were tested. The results exactly duplicated those reported by the U. S. Fish and Wildlife Service. We conclude that this method can be useful to us without modification and that Malpeque Bay sponges were vigorous despite contrary indications.

Brining seems the most practical of all the sponge-control methods we have tested.

- (1) Common salt is generally available, easy to transport and cheap.
- (2) Salt is non-poisonous to humans.
- (3) The treatment is quick and the oysters need not be brought ashore. Tanks can be installed aboard oyster boats.
- (4) It is easy to keep a tank full of brine at full, sponge-killing potency (saturated) by maintaining undissolved salt in it.

We recommend brining to oyster growers for sponge control.

G. J. Sorger and
R. R. Logie

No. 21

MECHANICAL HARVESTING OF SHELLFISH

Work with the Maryland-type escalator harvester and M.B. Cyprina (see frontispiece) is financed by the Industrial Development Service of the Department of Fisheries. As reported last year (App. 18, 1956 report) this digger fished soft-shell clams reasonably well but rates seemed low. After discussion with the Department of Mechanical Engineering, University of New Brunswick, the old pump-motor assembly was replaced by one that supplies the digging head 750 gallons of water per minute at 40 pounds pressure per square inch. This has increased digging speeds one-and-a-half times and practically eliminated digger-head clogging which formerly caused long delays.

Projects were undertaken with the improved digger:

- (1) To assess damage the harvester does to stocks of shellfish left behind in the soil -- particularly soft-shell clams.
- (2) To test versatility of the harvester in fishing other species of inshore molluscs in various types of soil.
- (3) To determine relative efficiency of the harvester as compared with other types of mechanical fishing gear (hydraulic dredge and toothed dredge) and manual methods of harvesting now practised in our areas.
- (4) To demonstrate mechanized harvesting methods to industry and fisheries officials (provincial and federal) where interest was exhibited.

There was no evidence of damage by the escalator harvester to stocks of quahaugs and bar clams left behind in the soil. These are strong, heavy-shelled, mobile species that sink quickly to the bottom and re-establish themselves quickly after disturbance. Soft-shell clams are different. As their name implies, they are fragile. Besides this, they are sedentary in habits and slow in re-adjusting themselves after disturbance. Although our observations indicate that digger damage is less than that caused by currently-used clam forks, they were not convincing. It is proposed to carry out further tests next spring.

The escalator harvester is now quite versatile within its depth range of $2\frac{1}{2}$ to 6 feet. It will fish wherever shellfish occur except in tough clay and in ground that is covered by the densest late-summer stands of eelgrass. It will harvest shellfish (including oysters if adjusted for surface fishing) 15 to 40 times as fast as manual equipment and can be used on grounds where shellfish populations are too sparse to encourage exploitation by present fishing methods (Table). Analysis of capital and

operational costs indicates that escalator diggers would be worthwhile investments in some of our bar clam and quahaug areas, e.g., Neguac, N.B. and Hillsborough Bay, P.E.I. Within their depth range they out-fish dredges which have to be hauled at intervals to dump catches.

Fishing rates of various types of shellfish harvesting gear

<u>Gear</u>	Production (Imperial bushels) per hour of fishing on commercial beds				
	<u>Soft-shell clam</u>	<u>Bar clam</u>	<u>Quahaug</u>	<u>Oyster</u>	<u>Ocean quahaug</u>
Manual Gear (Forks, rakes and tongs)	$\frac{1}{4}$	3	$\frac{1}{2}$	$\frac{1}{2}$	too deep
Escalator Harvester	4	10	10	8	too deep
Hydraulic Dredge (Long Island type)	-	8	6	-	5 ¹
Toothed Dredge (Massachusetts type)	-	-	5	-	10 ²

1. Reported from Ogunquit, Maine.
2. Reported from Cape Cod, Mass.

The hydraulic dredge and toothed dredge which may be used in deeper water in place of the escalator-type harvester are useful at depths up to 100 feet and can take deep-water forms like ocean quahaugs that are inaccessible to other gear. We began tests of their usefulness in 1957, but they are not complete. We hope to complete them in 1958 because there are increasing demands by industry for information on how to exploit vast beds of this species which have recently been discovered in the southern Gulf of St. Lawrence.

Demonstrations of mechanized methods of harvesting shellfish have created much interest and several persons have indicated interest in building gear if the Department of Fisheries will approve its use. A report on gear performance has already been placed before the Department recommending approval of mechanized fishing for all species but soft-shell clams.

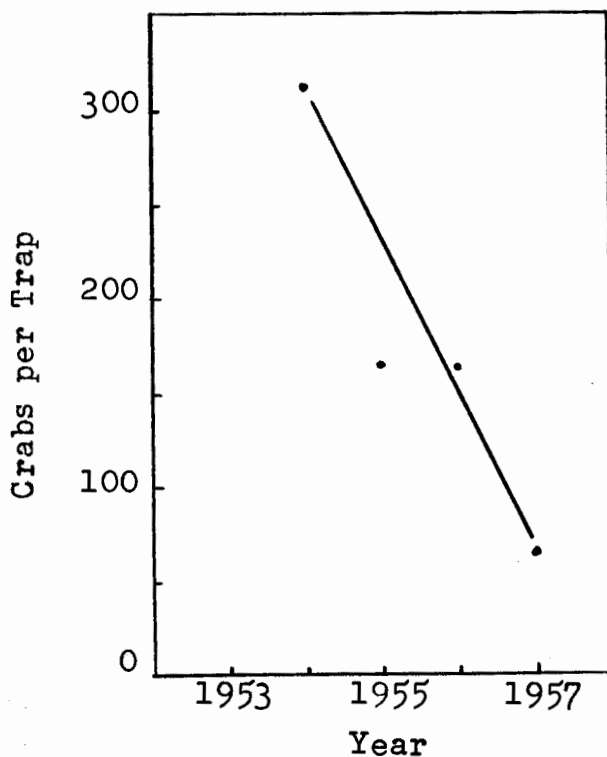
J. C. Medcof and
J. S. MacPhail

No. 22

GREEN CRAB STUDIES

Studies on green crabs which are serious enemies of young shellfish were continued in 1957 with certain modifications. There were monthly trappings in the St. Croix River at half-tide level on the beach, at just below low-water mark and in the deep channel (7 fathoms) near the Biological Station. These confirmed last year's conclusions although the onset of activity was delayed by the cold spring (App. 19, 1956 Rept.). The crab is a littoral and sub-littoral species. It deserts the beaches in late autumn and early winter and passes the winter without much activity below low-water mark but close to shore. It becomes more active in May and re-invades the intertidal beaches.

No observations were made in southwestern Nova Scotia to find if the crab had extended its range eastward. This should be done in 1958.



June to December (inclusive) trapping at Holt's Point yielded 65 crabs per trap-night, indicating a continued reduction in population (Figure) which now stands at about 20% of the 1954 level. The 1956 and 1957 records for the St. Croix River show that there has been a sudden drop there too.

Gulls seem to feed on the green crab more now than three years ago. Broken crab shell litters the rocks where they are accustomed to break their hard food by dropping it from the air. Gull predation may be an important factor in the crab population decline.

One of our staff reports seeing a family of racoons, which grew up near the Station this year, feeding on green crabs in the intertidal zone during the summer. And from late winter to autumn, 1957, the writer has examined much animal dung found above

high-water mark along the shores of Passamaquoddy Bay and identified as that of foxes or racoons. In many cases this was composed almost entirely of skeleton fragments of green crabs. Besides this, a dog in the community developed a keen appetite for green crabs and hunted them on the beach at low tide. It is not suggested that mammals are important in regulating green crab populations. But from the fact that they have learned to eat crabs since 1953 when they first became abundant here, it is reasonable to suppose that some aquatic animals may also have found them good eating.

Changes in aquatic climate may account for the reduction in green crabs as biologists in the State of Maine have suggested but, so far as we can judge, predation alone might account for it.

J. C. Medcof

No. 23

NEW BRUNSWICK EPIDEMIC OF PARALYTIC SHELLFISH POISONING -- 1957

The annual appearance of poison in bivalve molluscan shellfish on the New Brunswick side of the Fundy came early this year (June 23) and for the first time since 1945 a number of people were poisoned. Clams in waters tributary to the Bay were affected as well as the more commonly affected mussels on the open coast of the Fundy itself. Samplings and assays by the Department of Fisheries and Department of National Health and Welfare showed that within ten days toxicity scores of clams in the worst-affected area (Lepreau Basin, 25 miles from Saint John, N.B.) rose from the low hundreds to 17,800 mouse units per 100 grams by June 24. This was very dangerous and the highest recorded since the 1945 epidemic.

The Fisheries Research Board moved experimental lots of oysters and quahaugs to this area (they are not native here) and these accumulated poison the same as native bivalves.

In spite of prominently-posted signs erected by the Department of Fisheries and warning the public of danger, picnickers from Saint John came to Lepreau Basin and dug and ate clams on June 22 and 23. Some took these poisonous shellfish home and distributed them among friends. This accounted for most of the poisonings, although there were a few caused by clams taken from other areas at the same and other times. A total of 31 poisonings was reported and investigated by the writer and Mr. R. M. Bond of the St. Andrews, N.B., unit of the Fish Inspection Laboratory.

After four days' partial recovery, one victim of nearly fatal poisoning (dosage 5,500 m.u.) suffered a recurrence of all her first symptoms including loosening of the teeth, three of which came out. Relapses and loss of teeth have never been reported before. Insistence by another victim that his symptoms appeared immediately after eating shellfish and an experimental test of this (Mr. Bond was the subject) indicated that paralytic poison may be absorbed through the oral mucosa as well as through

lower parts of the digestive tract. This was not appreciated until now. It helps explain the regularity of the order in which certain symptoms of poisoning appear. There were other interesting discoveries and a comprehensive account of the epidemic has been prepared for publication.

There is special need for modifying government efforts to reduce hazards of poisoning because there is reason to expect that risks will be greater in the next 25 years than they have been recently. Conditions are worst when mean annual water temperatures are lowest and hydrographers have predicted a long-term decline.

Better public information would reduce danger and there is need for a longer-range prediction of onset of high toxicities. This might be possible through studies of abundance changes of the causative organism -- a poison-bearing dinoflagellate on which shellfish feed.

J. C. Medcof

No. 24

THE SCALLOP FISHERY OF EASTERN CANADA

A record of recent developments in the rapidly-expanding scallop fishery and some predictions for its future development were included in Summary 20 of the 1956 Annual Report. It apportioned the increase in landings from an average of about 0.70 million pounds from 1941 to 1951, to 2.42 million in 1956, to the large- and small-boat parts of the fishing fleet and predicted general increases to follow. The 1957 landing of 3.41 million pounds warrants further consideration because this evidence for greatly increased activity masks some significant internal adjustments.

The Digby Fishery

Last year's Bay of Fundy catch of 1.12 million pounds was the third highest in the fishery's 40-year history (1.60 in 1936; 1.85 in 1937), and the highest since 1937. The 1957 catch of 1.34 million pounds represents an increase of 0.22 million over 1956. All of this increase took place in the Digby fishery, which in addition compensated for a drop of nearly 80,000 pounds in the remainder of this area, for a total increase of about 0.28 million pounds at Digby.

General talks with fishermen and scattered log-book returns indicate that catch increased partly because the fishing fleet was larger. But in addition to this, catch per boat apparently increased enough to offset a 10 per cent drop in wharf price. Such an increase, with rising fishing effort indicates a substantial increase in the abundance of the stock now being fished there.

This increased abundance and the resulting trend towards increasing catches had been predicted earlier as likely to follow from highly successful sets of young scallops during the series of warm years from 1949 to 1951. We believe, however, that cooler years since then are likely to have resulted in weaker year-classes and that these will soon be forming the primary source of supply for the commercial fishery. We, therefore, believe that Digby landings are now close to their peak and expect that they will soon begin to drop to nearer average levels.

The Northumberland Strait Fishery

This fishery had until 1956 been primarily a small-boat fishery. But in late 1955 a particularly good scallop bed was discovered off Toney River, Pictou County, N.S., and in 1956 large offshore and small local boats fished there together and landed 0.43 million pounds of meats from it. However the success of scallop sets in the Gulf of St. Lawrence is highly variable so that production from any one bed is sporadic. Continuing catches have always depended on the discovery of new beds to offset declining catch from the small, known beds as they are fished down

or die out from natural causes. This type of production which requires relatively large potential mobility of the fishing units has discouraged fishing by the small, lobster-fishing-type of boats and in late 1956 scallop draggers over 65 feet in length were prevented by law from fishing there. There now remains a fleet of small draggers (20 to 30 gross tons) which in 1957 depended primarily on a new bed they discovered in George Bay and on the remaining stocks on the Toney River and Boughton Island beds in the eastern strait. A small bed discovered in late summer off Miminegash was also fished briefly in the autumn. Total Gulf landings of about 0.23 million pounds were a drop of about 0.20 million, almost 50 per cent below last year. They do not seem likely to increase next year unless additional new beds are found.

The Offshore Large-boat Fishery

Because of a regulation excluding all vessels over 65 feet in length from fishing in Northumberland Strait, the fleet of "mobile" draggers which was considered as a unit in last year's report has been divided into two parts, those that fished exclusively in the Strait and those fishing entirely offshore. Since there was no overlap in 1957, operations by the former category are described in the preceding paragraphs and only the latter category need be considered here.

Most of the spectacular 1957 increase in Canadian scallop landings has been made by the offshore fleet, fishing on Georges and St. Pierre Banks. In 1957 it landed 1.84 million pounds, almost double its 1956 landing of 0.93 from the same two beds. The entire increase resulted from increased catches on Georges Bank whence landings this year were 1.69 million pounds compared with 0.70 million last year. A decrease in catch from St. Pierre Bank from 0.23 in 1956 to 0.15 in 1957 is included in the total and accounts for the difference in increase shown by the first two sets of figures.

Data on effort expended by the Canadian fleet fishing on Georges Bank are still too scanty to provide accurate information on stock changes which may have accompanied these catch changes. But the log-book records that we have for this year give an estimate of catch per day which is almost exactly the same as is given by our last year's records. This indicates no measurable change in abundance of the stock being fished. However, it seems quite likely that scallop stocks in any one area on Georges Bank fluctuate in abundance in much the same way that they do at Digby. Their abundance may, indeed, be controlled by similar environmental factors. If so, we must expect an early drop in abundance and catch from the beds which have furnished the bulk of the supply during recent years.

In the past, movements of the Georges scallop fleet from bed to bed may have helped smooth out the general level of landings and thereby masked the importance of year-to-year stock fluctuations. However, with the increases in total effort which

have taken place recently, fewer alternative fishing areas are available and fluctuations in abundance will now show up more markedly in catch. Should the situation be similar to that at Digby, this would mean that a drop in Georges Bank landings is imminent.

This possibility has been recognized and received some discussion by the scientific advisers to the International Commission for the Northwest Atlantic Fisheries. It is essential as a first step in predicting such catch fluctuations and, if possible, in protecting industry against them, to have accurate information on areas fished and on the catch and effort expended. We therefore propose to attempt improvement of our log-book coverage of the operations of the Canadian fleet and to co-operate as fully as possible with the United States Fish and Wildlife Service in a research program which should provide other required basic data.

L. M. Dickie

No. 25

TOLERANCE OF SCALLOPS TO HIGH WATER TEMPERATURES

Experiments designed to describe the giant scallop's tolerance of high temperatures were continued at intervals from the summer of 1956 to December 1957 when the last test of the series was completed. Their primary object has been to further examine the nature of an apparent seasonal change in tolerance which was first studied during the summer of 1956 and reported in Summary 21 of the Annual Report for that year. The time of seasonal minimum temperature resistance of scallops seems to coincide with the water temperature maximum and with the time of occurrence of mass mortalities among western Gulf of St. Lawrence scallops.

The 1957 results are currently being analyzed and compared with results of the 1956 experiments and others that have been performed from time to time since 1953. The 1957 data show a less marked seasonal change than was observed the preceding year and exhibit a delay in development of their seasonal minimum resistance. This difference between the two years may be related to the delay in aestival warming in 1957 and the lower seasonal temperature maximum, although the reliability of the data on which this opinion is based is yet to be assessed.

Reports from scallop fishermen in the Northumberland Strait and observations made during explorations in the Bay of Chaleur describe severe mortalities that have taken place in both areas again in either late 1956 or mid-1957. The repeated occurrence of these mortalities and their detrimental effects on scallop production emphasize the desirability of an early explanation. Temperature phenomena in the area are clearly implicated, indirectly, if not directly.

L. M. Dickie

No. 26

SCALLOP EXPLORATIONS

Scallop explorations, which were a joint undertaking by the St. Andrews Station of the Fisheries Research Board and the Industrial Development Service of the Department of Fisheries, were carried out in 1957 in the Gulf of St. Lawrence and on the offshore Nova Scotian and St. Pierre Banks.

Gulf of St. Lawrence

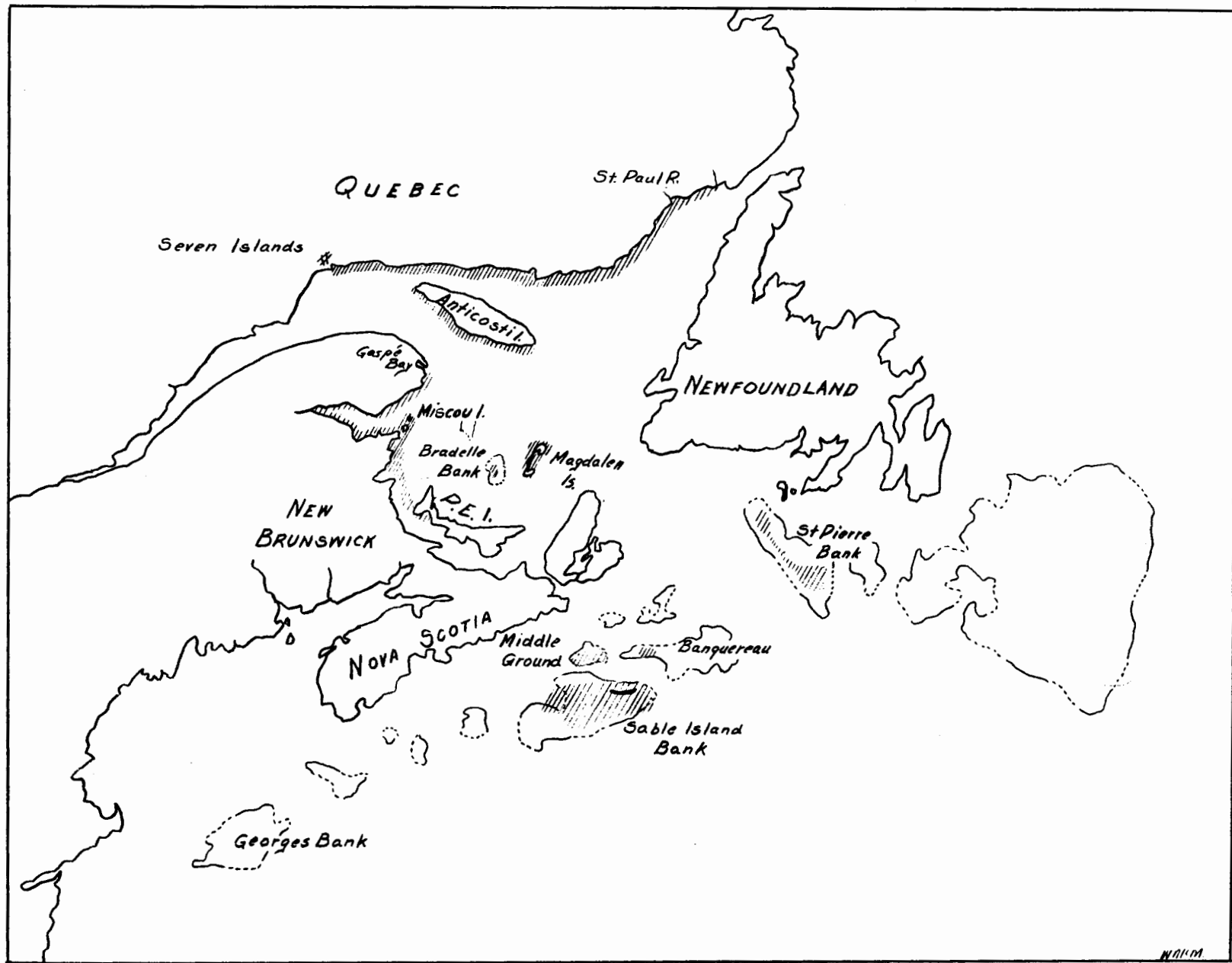
Explorations in the Gulf of St. Lawrence failed to find any commercially-valuable concentrations. Explorations were conducted in two sections: a large scallop dragger from Lunenburg, N.S., the M/V Barbara Jo, (Captain, Douglas Mosher) explored the northern section and the Magdalen Islands area; a medium-size otter trawler from Caraquet, N.B., the M/V Gloucester 37, (Captain, Omer Lanteigne) explored the area from Gaspé Bay to the northern part of Prince Edward Island, including the Bay of Chaleur, and made a few tows in the shallow-water areas of the Magdalens. These explorations were prompted by the presence of small but productive beds in the southern Gulf and Northumberland Strait areas, and the similarity in water and bottom characteristics in the western and northern areas, as well as by reports of unusually large scallop catches by fish draggers, on trawl lines and on the lead-lines of herring and mackerel nets in the regions proposed for explorations.

Operations in the north by the Barbara Jo showed no concentrations in water deep enough for dragging by large boats. Operations in the west by the Gloucester 37 showed that scallops occur on most of the areas from which they had been reported. However, commercially-inviting catches were made on only one area west of Miscou Island and in July. Later in the summer this concentration seemed to have dispersed. The circumstances of the catch change suggested that the catchability of scallops in this area may vary with season and be low in mid-summer. A follow-up survey was carried out during early November. It showed some recovery of catches from the Miscou bed, but no substantial change in catch from any others. We conclude that there is little prospect for an active commercial scallop fishery in the northern or western Gulf and that further exploration would serve little purpose until such time as there is reason to hope for significant changes in the composition of the bottom fauna.

A detailed report of the operations, including the methods, results, and significant biological observations is being prepared as a Manuscript Report of the Biological Stations.

Offshore Nova Scotian and St. Pierre Banks

Offshore operations in 1957, using the Barbara Jo, discovered a small but commercially-valuable, scallop-producing area on the southern part of St. Pierre Bank. However, they



failed to find any concentrations of scallops on the eastern Nova Scotian Banks which had appeared promising from the 1954 survey.

Accumulating evidence suggests that St. Pierre Bank is a more regular "producer" of scallop year-classes than we at first realized. The 1953 explorations discovered a bed which was composed almost entirely of a single year-class, but after the scallop fleet had begun intensive exploitation they turned up small neighbouring areas bearing older or younger classes. The survey this year has shown new productive areas on the southern part of the bank, and, in addition, found at least one strong year-class of small scallops now growing on the recently fished-out, northern part of the bank discovered in 1953. It appears likely, therefore, that the area will continue to produce commercial concentrations of scallops, though they may be sporadic in their occurrence as are haddock year-classes of the area. There may be some value in a comparative study of the early life-history of the two species to detect possible similarities in factors controlling abundance, as an aid in prediction of good sets of both.

Because the scallop-producing areas of St. Pierre Bank are small, and production is irregular, it may prove too expensive for individual Nova Scotia scallop boats to resurvey the areas on their own as long as profitable catches can be made on Georges Bank. However, the distance of the beds from ports in southern Newfoundland is comparatively short. Should scalloping develop in Placentia or Fortune Bays, it may well be that boats operating there could use these newly-discovered, offshore areas as a summer source of supply.

News of this survey was reported by radio and in "Trade News" and details were published as General Series Circular No. 30 from the Biological Station, St. Andrews, N.B., and distributed to industry about 1½ months after completion of the survey. The information was used by several boats in fishing the new bed and commercial landings from the area up until December 31, 1957, are estimated as 154,000 pounds of meats with a landed value of about \$58,000.

L. M. Dickie

No. 27

SHELLFISH AND PASSAMAQUODDY POWER DEVELOPMENT

In the summer of 1957 some basic data were gathered on positions of soft-shell clam populations on intertidal beaches in Passamaquoddy Bay area. Analysis of these in relation to present tidal conditions and a statement, now available from engineers on tidal conditions that would attend power development, are to form the basis for predicting how the clam fishery might be affected. This is the most important commercially-exploited shellfish in Charlotte County, N.B.

A forecast has been made of general hydrographic conditions within the bay following power development. This will be helpful in predicting how other shellfish may be affected. Besides the clam, the sea scallop is now the only other important commercially-exploited species. So far we have no clear views as to whether its fishery would be altered. It is too early for elaborate speculation about the European oyster which was introduced here only in 1957 but we think that power development might improve chances for its culture. However, it may never establish itself.

Another mollusc native to Passamaquoddy that is not ordinarily classed as a shellfish is the shipworm, Teredo. It should be considered because of the immense damage it may cause to unprotected wooden structures in the water. Power development would likely favour great increases in its abundance.

J. C. Medcof

GROUND FISH SUMMARIES

Groundfish research

Preliminary results of mesh regulation in Gulf cod fishery

Mesh selection for cod and American plaice

Gear selection review

Haddock tagging

Cod tagging results

Models of "Gulf" cod fishery

Model of "Lockeport" cod fishery

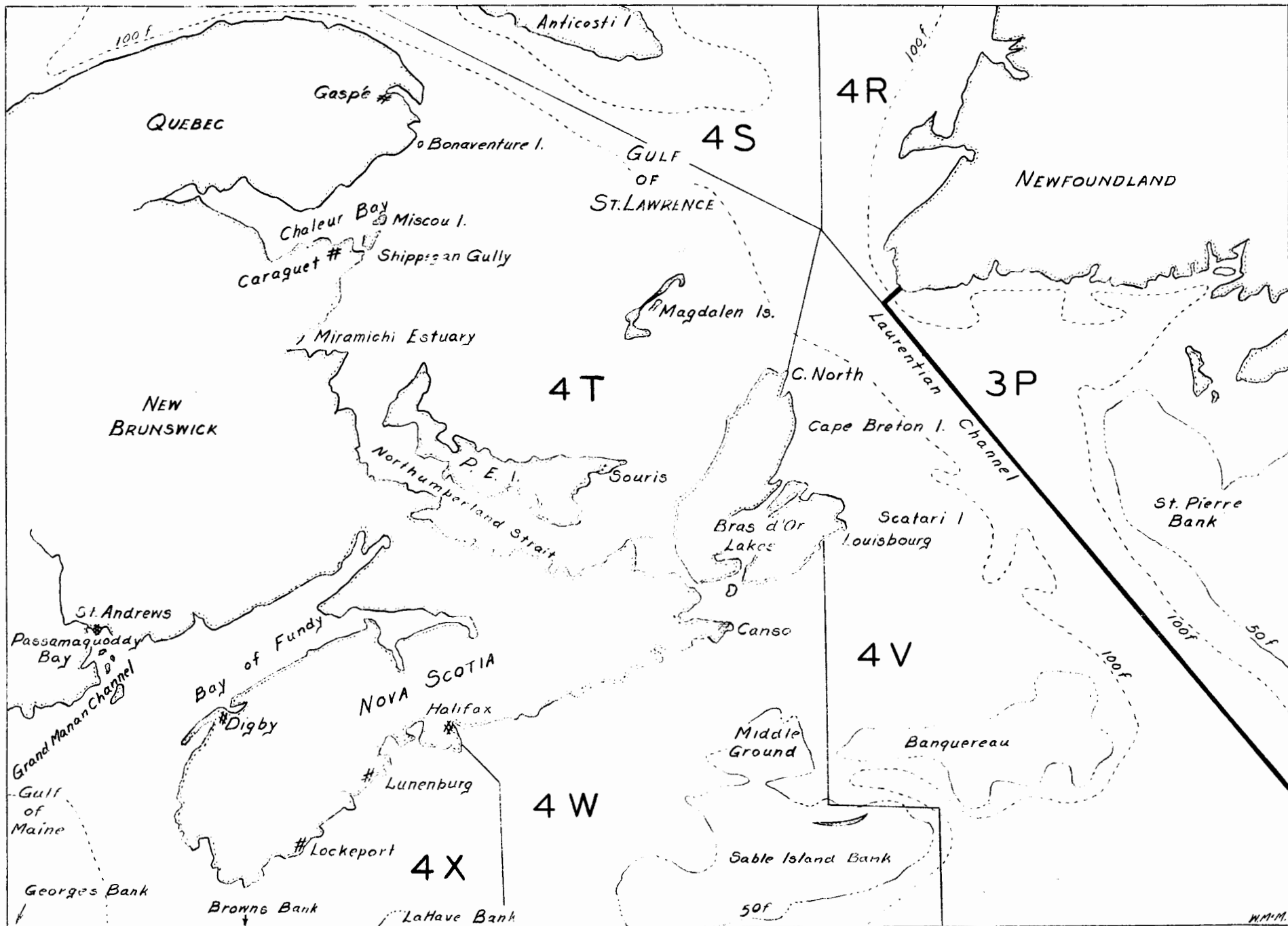
Growth of Gulf cod from tag returns

Cod growth experiment

Gulf census program

Incidence of parasites on Gulf cod

Porrocaecum baseline project



No. 28

GROUND FISH RESEARCH

Groundfish research is directed toward the procurement of increased landings with efficient fishing methods. A variety of projects contributed to this program during 1957:

1. Statistics and sampling. A field staff of 6 was assigned to the task of recording the quantities and sizes of groundfish landed by the commercial fleet in the Maritimes area by type and size class of vessel, month, area of capture, and fishing effort. The data are submitted annually to ICNAF for publication with those of other countries fishing in the Northwest Atlantic Area. The statistics are also published in annual statistical circulars.

During 1957 the statistics staff continued to work closely with the Department of Fisheries and the Bureau of Statistics in the improvement of Maritimes statistics. New developments included the use of purchase slips for collection and compilation of landings statistics, and the use of about 12,000 Kwiksort-Pegbar cards to record statistics for the expanding mobile fleet (vessels over 25 gross tons).

2. Improved fishing methods. The introduction of more efficient fishing methods is now proceeding so rapidly that the Station's program in this field has been reduced. The Provincial Fisheries Offices and the Department of Fisheries are adequately stimulating the development of a fleet which is landing increasing quantities of groundfish with less fishing effort. In 12 years the number of licensed draggers and otter trawlers has increased from about 10 to over 250.

During 1957 information concerning Norwegian jiggers was distributed to Provincial Fisheries Offices, and jiggers were directly introduced in northern New Brunswick. It is expected that the use of this efficient lure will spread without further promotion.

The Danish seining method which was introduced to the Maritimes by the Station in 1948 has now been adopted by 5 commercial vessels. The Station co-operated with the Nova Scotia Fisheries Division by lending seine nets in return for records of fishing operations.

The longlining method which was introduced to the Maritimes by the Station in 1943 has now spread widely throughout Nova Scotia. Sixty-foot longliners compete successfully with draggers of comparable size. The recent adoption of longlining methods by large Lunenburg schooners is being followed with interest.

3. Mesh regulation. The rapid expansion of otter trawling in the Northwest Atlantic Area has increased landings, but at the same time, it has reduced the size at which cod and haddock are first caught, well below the sizes at which groundfish are culled for landing. The seriousness of the resultant wastage of fish at sea is indicated by the facts that half the Maritimes groundfish landings are now taken by otter trawl (the proportion is about two thirds for all

countries fishing the ICNAF Area), and a quarter of the cod and haddock caught by these vessels are commonly discarded at sea as dead or dying fish.

This problem has been one of primary concern to the International Commission for the Northwest Atlantic Fisheries, and since it is principally a problem in the western Subareas 4 and 5, it has absorbed a major part of the Station's research program during recent years.

In 1953 a $4\frac{1}{2}$ -inch mesh regulation was introduced for otter trawlers fishing for haddock in Subarea 5. The Station has been following closely the effects of mesh regulation in this pilot-plant experiment. Conflicting interpretation of results has prevented relaxation of attention to this project.

In 1957 the same mesh size was adopted by Canada for Subarea 4. Development of this regulation required concentration of effort on gear selection studies and prediction of the effects of mesh regulation on landings. During 1957 a series of sea trips on commercial draggers provided information on the initial effects of mesh regulation on the escapement of small cod from large-mesh codends.

4. Population models. In order to predict the effects of further changes in size at first capture or in fishing intensity on groundfish landings, data on recruitment, growth, and mortalities are being compiled in order that models may be constructed for each major fishery. Tagging experiments continue to contribute valuable data. Preliminary models are already indicating the direction of changes in fishing practices required to take greater landings with the minimum amount of fishing effort.

As part of this program, critical examination of age and growth studies has been carried out during 1957. Growth studies based on tagging results, and on scale and otolith methods of age determination, have been compared. Laboratory studies of the effects of food and temperature on growth of cod have been started.

5. Census program. During 1957 a census program for cod and plaice was initiated in the Gulf of St. Lawrence. It is expected that the resultant ecological data will provide the basis for short-term and possibly even long-term prediction of groundfish stocks. This should lead to improved utilization of available resources.

It is anticipated that a census program for haddock will be initiated on offshore Nova Scotia banks in 1958.

6. Porrocaecum studies. Larval Porrocaecum decipiens in fillets continue to seriously interfere with profitable utilization of some groundfish stocks in the Maritimes area. For the first time, a high incidence of infection was observed in cod from Sable Island grounds.

In anticipation that biological control might be attempted by reducing seal abundance in an experimental area, a baseline

nematode incidence project was carried out at Lockeport, N. S.

7. Co-ordination of research. The Station's groundfish program is closely co-ordinated with those of other groundfish laboratories. Scientists participated in 2 International meetings at Lisbon and 1 in Quebec. Liaison with Woods Hole included co-operative boat programs and several exchange visits for tagging studies, training United States biologists to read otoliths, preparation of a gear-selection review, division of data on Subarea 4 haddock, and analysis of data on effects of mesh regulation on Georges Bank haddock. Liaison with the St. John's Station included population dynamics discussions, preparation of a gear-selection review, and reporting of Canadian research to ICNAF. Quebec became an active participant in ICNAF work during the year. The Quebec census program and gear-selection studies are being co-ordinated with those of the Station. Otoliths have been exchanged with a Portuguese scientist. A senior French trawler captain visited the Maritimes, and France has invited a Canadian scientist to go to sea on a French trawler in March, 1958. Research and application of results have benefited greatly from this team-work approach to groundfish problems.

Many of these projects are discussed in greater detail in the following summaries.

W. R. Martin

No. 29

PRELIMINARY RESULTS OF MESH REGULATION IN GULF COD FISHERY

In 1955 the International Commission for the Northwest Atlantic Fisheries (ICNAF) recommended that nets used for cod and haddock dragging in waters adjacent to the southern Canadian mainland (Subarea 4) should have a minimum inside mesh size of $4\frac{1}{2}$ inches, manila twine, when measured wet after use. This mesh size, or the equivalent when other twines are used, became effective for Canada in March, 1957.

The 1957 fishing season was a period of conversion to larger mesh sizes for northern New Brunswick draggers. A few draggers retained small-mesh (3-inch) codends; some adopted intermediate-mesh (4-inch) codends; many used large-mesh ($4\frac{3}{4}$ -inch) codends throughout the season; others converted to this large mesh size about July.

During the period May 26 to August 27, a student assistant, Mr. L. L. MacLeod, made 10 trips to sea on these draggers in order to record the numbers and sizes of cod discarded at sea. In this summary report, his measurements of sizes caught by nets of various mesh sizes are compared with sizes caught by a net with a fine-mesh cover fished on the same grounds by the research vessel J. J. Cowie, and with sizes retained by fishermen for landing. In order to measure the proportion discarded at sea, the numbers of cod in sea catches and landings were adjusted to be equivalent for large cod over 23 inches (59 cm.). Statistics of quantities landed per trip

provide information on the relative efficiency of small- and large-mesh draggers.

In both 1956 and 1957 small-mesh draggers discarded large numbers of cod at sea. Three small-mesh trips to Bonaventure Island grounds in 1957 were directly comparable with 5 small-mesh trips in 1956. Eighteen per cent of the cod caught on the 1956 trips were discarded at sea as compared with 31% on the 1957 trips. The proportion discarded at sea was still greater on shoaler, inshore grounds -- 56% in 1956 (3-inch mesh), and 46% in 1957 (4-inch mesh).

Adoption of large-mesh nets in 1957 greatly reduced the proportion of cod wasted by New Brunswick draggers. The 3 small-mesh trips described above were directly comparable with 3 large-mesh (4 $\frac{3}{4}$ -inch) trips. Discards were reduced from 31% to 12% by numbers and from 10% to 5% by weight on large-mesh trips.

The size compositions of cod caught by 3- and 4 $\frac{3}{4}$ -inch mesh codends on Bonaventure grounds are compared with sizes culled by fishermen for landing in the accompanying figure. It is obvious that, although the large-mesh nets released large numbers of unmarketable cod, the sizes selected by the large meshes still included fish which were smaller than the smallest sizes saved by fishermen for sale. Similar results were found on Shippegan Gully grounds where research vessel catches were compared with sizes caught by a 4-inch mesh dragger and with sizes landed. Here again, large numbers of small cod were released by the 4-inch mesh, but this selection was well below the smallest sizes landed by fishermen in 1957.

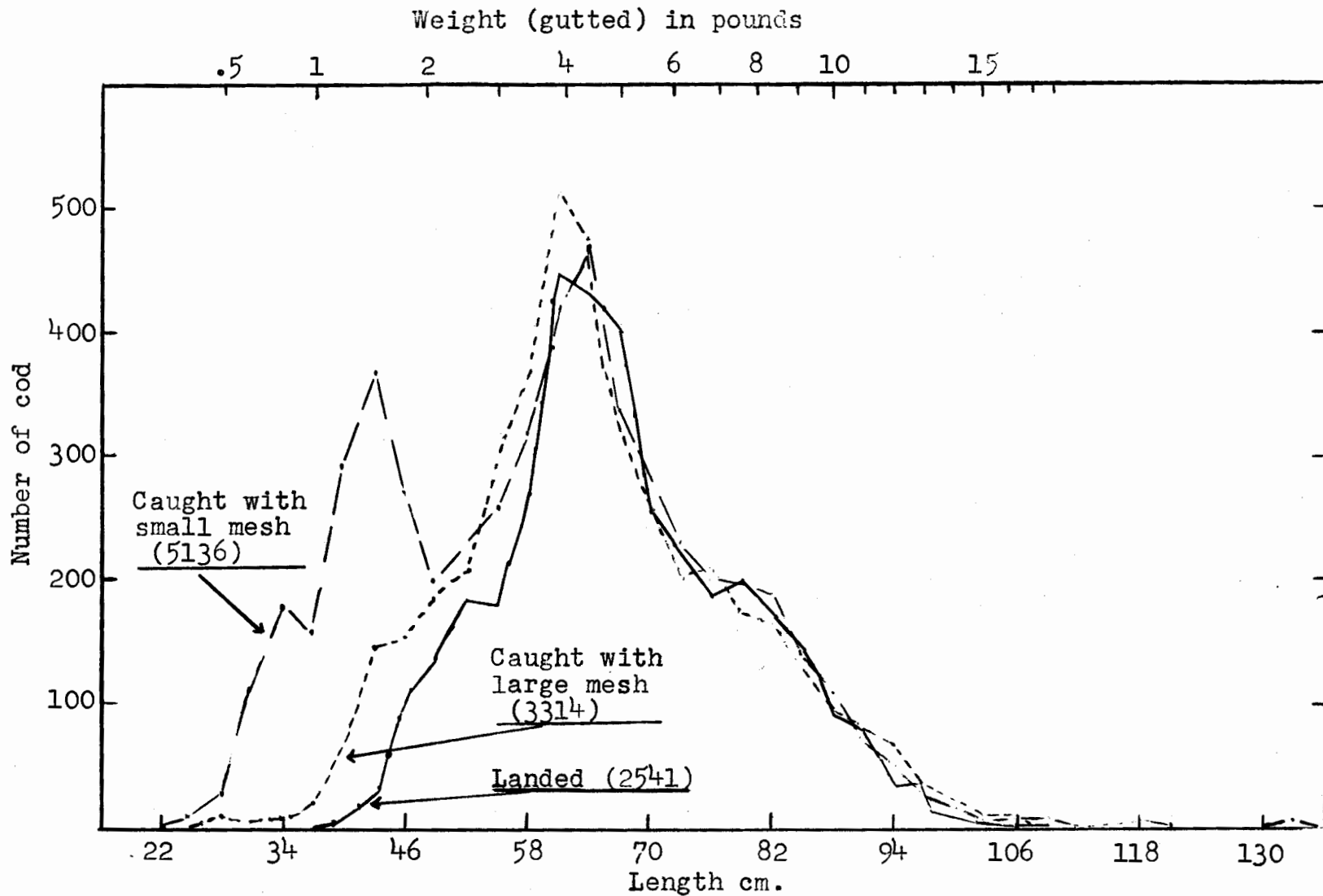
As a basis for calculation of the mesh size which will minimize wastage of small cod at sea, it is useful to determine selection factors --

fish length at which 50% are retained
mesh size in same units of measurement

In these data, the selection factor for cod taken with 100/3 strand manila was about 3.7. This is slightly higher than earlier results from mesh selection experiments with manila twine of 3.5 for cod. A fisherman's cull at 2 pounds gutted weight (19 in. or 48 cm. in length) would require a manila mesh size of 19/3.7 or about 5 1/8 inches. With a selection factor of 3.5, this equivalent mesh size would be about 5 $\frac{1}{2}$ inches.

The relative efficiencies of small- and large-mesh draggers have been compared by compiling statistics of landings per trip by various size classes of New Brunswick draggers for the years 1955 to 1957 in the following table. There is no evidence of decreased landings for draggers which increased their mesh size in 1957. Further studies of landings statistics are required to measure the relative efficiencies of draggers with small- and large-mesh codends.

These preliminary results of mesh regulation for the Gulf of St. Lawrence cod fishery are similar to those achieved earlier



Size compositions of cod caught in 1957 on Bonaventure Island grounds by small- (3-inch) and large- ($4\frac{3}{4}$ -inch) mesh draggers compared with sizes landed by fishermen.

for the Georges Bank haddock fishery (refer ICNAF Annual Proceedings, Vol. 7, 1957) where the number of fish discarded at sea was greatly reduced, and the efficiency of the otter trawlers was slightly increased. In both fisheries it is much too early to see the effect of mesh regulation on total landings.

Groundfish landings per trip by northern New Brunswick draggers

Small- (3-inch), intermediate- (4-inch), large-from-July (4 $\frac{3}{4}$ -inch), and large- (4 $\frac{3}{4}$ -inch) mesh codends were used in 1957. All draggers used small-mesh codends in 1955 and 1956.

Groups of draggers	Gross tonnage	Mesh size in 1957	No. of boats	Groundfish landings per trip '000 lb.		
				1955	1956	1957
Chaleur	26-33	Small	2	15.7	18.1	17.5
		Intermediate	2	18.5	20.1	21.8
		Large from July	1		24.8	21.7
		Large	2	17.9	22.9	19.4
Small Gloucester	34-39	Small	1	27.6	24.6	19.8
		Intermediate	2	32.5	33.4	34.2
		Large from July	5	29.5	29.6	28.6
		Large	5	26.1	26.9	27.4
Large Gloucester	40-49	Large from July	5	31.8	32.3	34.2
		Large	6	37.4	41.1	37.4
Name Boats	50-59	Small	1	...	44.8	40.5
		Large from July	3	...	38.0	34.5
		Large	3	...	31.5	30.2
Special	60	Small	1	56.9	52.2	47.2

Results to date indicate that draggers fishing for cod in the Gulf of St. Lawrence could use to advantage a still larger mesh size of 5 to 5 $\frac{1}{2}$ inches. Wastage of unmarketable fish would be further reduced, and, if many of the released fish were to live and grow to marketable sizes, total landings should increase.

We plan to thoroughly test the effects of a 5 $\frac{1}{2}$ -inch mesh codend on Gulf of St. Lawrence cod dragging. We expect to begin these tests in 1958 from the research vessel J. J. Cowie. Trials may be continued from commercial draggers in 1959.

W. R. Martin
Y. Jean

No. 30

MESH SELECTION FOR COD AND AMERICAN PLAICE

The covered codend hauls of the 1957 Gulf of St. Lawrence census program provide some selection data for cod and plaice. These hauls by the M. V. J. J. Cowie tested single-strand nylon codends of No. 400/3 ply twisted twine and of braided parachute cord. Census requirements often resulted in hauls with unsatisfactory numbers and fish sizes for selection with 3¼-inch and 4-inch codends. Thus, we have arbitrarily omitted hauls with fewer than 50 fish within the selection range for a species. Only cod and American plaice were taken in adequate numbers.

The data have been analyzed to produce selection curves, selection factors, and 25-75% retention length spans.

$$\text{Selection factor} = \frac{\text{fish length at which 50\% are retained}}{\text{mesh size in same units of measurement}}$$

Selection factors of 3.9 for cod and 2.2 for American plaice with the 3¼-inch mesh twisted nylon codend are the same as those obtained in 1955 using the same material, but considerably larger mesh sizes, 4.2-4.8 inches (see accompanying table). The 25-75% retention length span for cod is similar both for small and larger mesh; thus the slopes of the selection curves are similar. For American plaice the slope of the selection curve is slightly steeper for the smaller mesh.

Selection factors of 4.1 for cod and 2.3 for American plaice with the 4-inch mesh braided nylon codend are higher than for the twisted nylon. These differences, while consistent in trend for both species, are not large.

Comparison of selection factors and retention spans for cod and American plaice with single-strand nylon codends.

Species Year	Mesh size (in.)	Selection factors		25-75% retention length span in cm.	
		400/3 nylon	Parachute cord	400/3 nylon	Parachute cord
Cod 1957	3.2	3.9	4.1	7	7
	4.0				
1955	4.2	3.8		6	
	4.4	3.9		8	
	4.7	3.9		6	
	4.8	3.9		6	
Plaice 1957	3.2	2.2	2.3	5	5
	4.0				
1955	4.4	2.2		7	
	4.8	(2.4)		?	

Further census work with braided nylon codends should determine whether the differences are real or not.

The 1957 selection results confirm earlier conclusions that selection factors for meshes of nylon are considerably higher than for those of manila (3.5 for cod and 2.0 for American plaice). The resulting greater escapement of fish through meshes of the same size but of different materials justifies application of different minimum mesh sizes for manila and nylon, as is done in the Canadian cod and haddock mesh regulations.

F. D. McCracken
Yves Jean

No. 31

GEAR SELECTION REVIEW

At the joint meeting of ICNAF, ICES, and FAO at Lisbon in 1957 a small committee was set up to review gear selection problems and results for the ICNAF area. This committee (J. R. Clark of Woods Hole and F. D. McCracken) was asked to report to the 1958 meeting of ICNAF.

The purpose of the review is: to evaluate information about selection now available for various species and gears fished in the ICNAF area; to report concisely what is known about gear selection research in the area; and to evaluate needs for further research in terms of present fishing practices, importance of gear, and importance of species.

Discussions in late August outlined the general approach, format of the report, and division of effort. An interim report on the analyses carried out during the fall of 1957 was presented at the Quebec meeting of Scientific Advisers to ICNAF Panels 4 and 5. Selection data for cod being fished by otter trawl were evaluated in terms of vessel size, size of catch, twine size, net material, etc.

For each material a selection factor

fish length at which 50% are retained
mesh size in same units of measurement

considered most applicable to commercial fishing practice was determined. Selection spans (distance between 25-75% retention lengths) were combined with the selection factor to provide curves for various mesh sizes. These data seem accurate for present regulation mesh sizes, and adequate for considering effects of larger mesh sizes. Data available for other methods of fishing cod remain to be analyzed, although preliminary tabulation of the data shows their scarcity.

Preliminary analysis of mesh selection data for redfish showed considerable variation among results obtained by different workers in the ICNAF area. Among the possible contributory factors are twine size, length of tow, and size of haul. Since the bulk of

the redfish data has been collected by the St. John's Station of the Fisheries Research Board, Dr. Templeman has joined the committee to be responsible for the redfish section of the review.

This review will provide an important reference for considering effects of regulatory steps, and for consideration of general priorities in further gear selection research.

F. D. McCracken

No. 32

HADDOCK TAGGING

During 1957 haddock tagging occupied the major portion of time devoted to groundfish tagging. Haddock were tagged on offshore western Nova Scotia grounds in spring and at the mouth of the Bay of Fundy in autumn months.

Approximately 1,100 haddock were tagged in the LaHave-Browns Banks region in March and April. Haddock were caught by otter trawl from depths of 60-80 fathoms, using the M. V. J. J. Cowie. Tagging was carried out in conjunction with haddock tagging by the U. S. Fish and Wildlife Service in the same region from the Albatross III. This joint tagging was conducted to compare techniques, tag types, and possible difference between condition of fish caught by large and small otter trawls.

In November and December approximately 1,000 haddock were tagged in Passamaquoddy Bay and Grand Manan Channel on the western side of the Bay of Fundy. In addition, about 70 haddock were tagged off Digby on the eastern side of the Bay of Fundy. This latter program was badly hampered by rough weather. All haddock for tagging were taken by otter trawl, using the M. V. J. J. Cowie and M. B. Mallotus (only a few haddock were caught by the Mallotus), from depths of 20-55 fathoms. Haddock tagging in the Bay of Fundy was also a co-operative effort with the U. S. Fish and Wildlife Service, who tagged haddock in the Gulf of Maine as far east as Grand Manan Bank. The results will be of interest to the International Passamaquoddy Fisheries Board.

C. J. Bayers, P. M. Powles, and N. J. McFarlane tagged the haddock.

Percentage recaptures

Details of numbers of haddock tagged, method of capture for tagging, place of tagging, etc., since 1953, and the percentage recaptured up to December 31, 1957, are presented in the accompanying table.

Approximately 40% of the disk-tagged haddock released at Lockeport in 1953 have been recaptured and reported to the end of 1957. Recaptures reported in 1957 were still 6% of the possible number of tagged fish remaining in the water, without any allowance for natural mortality in the 4 to 5 years since tagging.

Percentage haddock tag recoveries by year, tagging region, type of tag, and method of capture for tagging, up to December 31, 1957.

Year tagged	Place	Type of tag	Method of capture	No. tagged	Percentage recaptured					Total recoveries
					Calendar yr. of tagging	2nd year	3rd year	4th year	5th year	
1953	Lockeport	Disk	Handline and Longline	185	8	15	13	7	6	41
1956	Northumberland Strait	Disk	Otter trawl	968	6	7	..	..	..	12
1957	LaHave-Browns	Disk	Otter trawl	1123	1.4	..	..	..	..	1.4
1957	Passamaquoddy Bay and Grand Manan Channel	Disk	Otter trawl	1015	1.7	..	..	..	..	1.7

1
62
1

In the calendar year after tagging (1957) about 6-7% of the haddock tagged in Northumberland Strait were recaptured. This percentage is less than half that reported for the Lockeport haddock tagging for a comparable period (1954). The lower returns from the otter-trawl-caught Northumberland Strait haddock may be related to method of catching fish for tagging, rather than any difference in intensity of fishing. Such a result would be compatible with preliminary conclusions reached for differences between otter-trawl- and hook-and-line-caught cod.

The small number of recaptures from the LaHave-Browns haddock tagging has been disappointing, less than 2% in the 9 months since tagging. The reasons for these low recaptures are not clear. Low returns could result from lack of offshore fishing (the U. S. otter-trawl fishery in the region ceases about the end of April) or there may have been high mortality among haddock caught by otter trawl from deep water (60-80 fm.) for tagging.

To the end of December, recaptures of about 2% of the haddock tagged in the Passamaquoddy Bay region had been reported. However, it is much too early to consider the significance of these recaptures.

Percentage recaptures of haddock tagged from inshore waters have been high compared to previous attempts in the Canadian Atlantic region. Those from Lockeport (higher than any other haddock tagging so far reported) appear sufficiently successful to provide usable fishing mortality rates for that region.

Movements of haddock

Recaptures of haddock tagged off Lockeport in 1953 continue to give a consistent pattern of inshore recaptures in summer and offshore recaptures in winter. Inshore recaptures have been mainly from the Lockeport region, with lesser numbers alongshore to the eastward. Offshore recaptures have been mainly from the LaHave-Browns Banks region.

Recaptures from the 1957 LaHave-Browns offshore tagging have been quite low. Late spring recaptures, during the time of tagging, came from offshore in the tagging region. Of the inshore summer recaptures, approximately 40% were reported from grounds near Lunenburg, N. S., in a region where haddock fishing is not intensive. At the same time, recaptures were low from other inshore grounds (off southwestern N. S.) where larger numbers might have been expected.

Recaptures of haddock tagged in the Passamaquoddy Bay region have been reported mainly from the tagging region. One distant return has been reported from the southwestern Gulf of Maine.

Recaptures of haddock tagged in eastern Northumberland Strait have shown extensive movements of these fish. In September-November, 1956, during tagging and immediately following, recaptures were mainly from the tagging region. In December, 1956,

and January, 1957, recaptures were mainly from west and east coasts of Cape Breton. In February-March all recaptures were from off-shore banks, as far west as LaHave Bank. While some recaptures were still reported from offshore banks in April-May, most recaptures came from inshore grounds off both coasts of Cape Breton, with 1 or 2 being recaptured in the region of tagging. Distribution of recaptures in June continued the same pattern, with most recaptures being reported from traps on the east coast of Cape Breton. After June, the number of recaptures was much reduced. They came from various grounds, but mainly from the southern Gulf in the general area of tagging.

The low number of returns in summer and early fall of 1957 is difficult to explain. The general distribution of fall and winter recaptures shows a large-scale migration of haddock out of the Gulf in winter to offshore banks. Recaptures from May and June suggest that these haddock are returning to the Gulf. It might have been expected that, if this return were completed, recoveries from the eastern Northumberland Strait should have been high in the summer and fall, when haddock fishing is at a maximum there. Instead, recaptures were low from all regions at that time.

In general, the distribution of recaptures from the Northumberland Strait haddock tagging agrees well with results of earlier haddock taggings off the east coast of Cape Breton. They support the conclusion that haddock migrate out of the Gulf in late fall, winter on offshore banks, and return to the Cape Breton region and the Gulf of St. Lawrence in spring.

F. D. McCracken.

No. 33

COD TAGGING RESULTS

Recaptures of tagged cod continue to provide vital statistics of cod stocks from the Gulf of St. Lawrence and inshore Nova Scotia. Processing of the tagging data, including collection, payment of rewards, letters of information and acknowledgment, and entering data on Kwiksort cards, was brought up to date. These data are now in suitable form for studies of movements, growth, and mortalities.

In 1957 about 1,200 cod were tagged in the vicinity of Magdalen Islands, Gulf of St. Lawrence, in late July and early August. Few cod tagged in the Gulf of St. Lawrence off northern New Brunswick and Cape Breton have been recaptured in the Magdalen Islands region. This result suggests that the cod in the Magdalen Islands region may be a separate stock. The 1957 tagging there was designed to test this possibility. A small number of recaptures have been reported, mainly from the tagging region, but it is too early to draw conclusions about cod movements in this region.

All the cod for tagging were caught by the M. V. J. J. Cowie, about three quarters of them by handlining, the remainder by otter trawling. C. J. Bayers tagged all the cod.

Percentage recaptures from earlier taggings

Details of numbers of cod tagged, tag type, method of capture for tagging, place, etc., since 1953, and the percentage recaptured up to December 31, 1957, are presented in the accompanying table. These taggings, recaptures, and conclusions were reviewed in the 1956 summaries. New aspects and conclusions are:

(1) Percentage returns from the Louisbourg and Canso tagging remained high for 3 seasons after tagging, but decreased sharply in 1957. This rapid decrease (also seen for Lockeport cod tag recoveries after the 2nd season) suggests recent loss of tags, probably resulting from growth of the fish. The difference in timing between Louisbourg-Canso and Lockeport is compatible with the slower growth in the eastern regions.

(2) Percentage returns of Gulf of St. Lawrence tagged cod have continued to be relatively low, compared with inshore Nova Scotia cod taggings. As yet, the difference cannot be ascribed to any single factor, since the 2 series of taggings contrast results for international versus local fisheries, migratory versus local stocks, otter trawl versus hook and line fisheries, as well as possible differences in the intensity of the fisheries.

(3) Percentage returns of disk tags have been higher than those of hydrostatic tags for the Gulf of St. Lawrence taggings. However, they are less superior than was observed previously for inshore Nova Scotia taggings. Results for 2 seasons show no important difference in percentage returns between hydrostatic tags attached with stainless steel loops or nylon loops.

(4) Preliminary results show higher percentage recaptures for cod caught by handline than for cod caught by otter trawl for tagging. The difference has been greater for disk-tagged cod than for those tagged with hydrostatic tags. Preliminary considerations suggest higher tagging mortality for otter-trawl-caught fish. Assessment and testing of tag types and tagging techniques are providing the basis for improved tagging methods and higher percentage recaptures.

Cod movements

Recaptures in 1957 of cod tagged off northern New Brunswick confirmed the pattern of movements shown by the 1956 recaptures. The results extend the observations to more than one year and for more than a single group of tagged fish. Tagged cod were again recaptured outside the Gulf of St. Lawrence in winter and early spring, January to April. In 1957, as in 1956, most of these were retaken by European vessels fishing along the 100-fathom contour of the Laurentian Channel. Bad ice conditions in the spring of 1957 presumably resulted in more recaptures being reported from off Scatari, with fewer recaptures between Cape North and the Magdalens than in 1956. Probably for the same reason, numbers of recaptures by European vessels were reduced in 1957. Increased recaptures outside the Gulf by Canadian vessels in 1957 are attributed to increased winter fishing by medium longliners in the Cape Breton region.

Percentage cod tag recoveries by year, tagging region, type of tag, and method of capture for tagging, up to December 31, 1957.

Year tagged	Place	Type of tag	Method of capture	No. tagged	<u>Percentage recaptured</u>				Total recoveries
					Calendar year of tagging	2nd year	3rd year	4th year	
1953	Lockeport	Disk	Handline	608	34	27	5	3	61.5
1954	Louisbourg	Disk	Handline	492	21	21	17	5	50.8
1954	Canso	Disk	Handline	299	25	29	20	3	59.2
1955	Northern N.B.	Disk	Handline	2,650	7	14	8	..	26.6
1956	Northern N.B.	Disk	Handline	482	9	24	..	..	30.5
1956	Northern N.B.	Disk	Otter trawl	922	7	9	..	..	15.6
1956	Cape Breton	Disk	Otter trawl	733	10	6	..	..	15.5
1953	Lockeport	Hydrostatic	Handline	933	24	13	0.7	0.2	34.8
1954	Louisbourg	Hydrostatic	Handline	318	13	14	7	2	32.4
1954	Canso	Hydrostatic	Handline	175	26	14	3	..	38.3
1955	Northern N.B.	Hydrostatic	Handline	1,208	7	10	7	..	21.9
1956	Northern N.B.	Hydrostatic (wire)	Otter trawl	150	10	7	..	..	16.7
1956	Northern N.B.	Hydrostatic (nylon)	Otter trawl	448	8	10	..	..	17.6

(Annual percentages are based on the maximum possible number of tags in the water at the beginning of the year. No allowance has been made for probable natural mortalities.)

Summer recaptures in both 1956 and 1957 came from the Gulf of St. Lawrence, suggesting that most of the cod moving outside in winter returned to the Gulf in summer. Within the Gulf, most recaptures came from the Bonaventure-Miscou area, where the fishery is concentrated. Fewer recaptures have been reported from off Shippegan Gully and the Bay of Chaleur, even though cod were tagged in both these regions. More detailed analysis of summer tag recoveries is necessary before drawing conclusions about the more localized movements of cod off northern New Brunswick.

F. D. McCracken

No. 34

MODELS OF "GULF" COD FISHERY

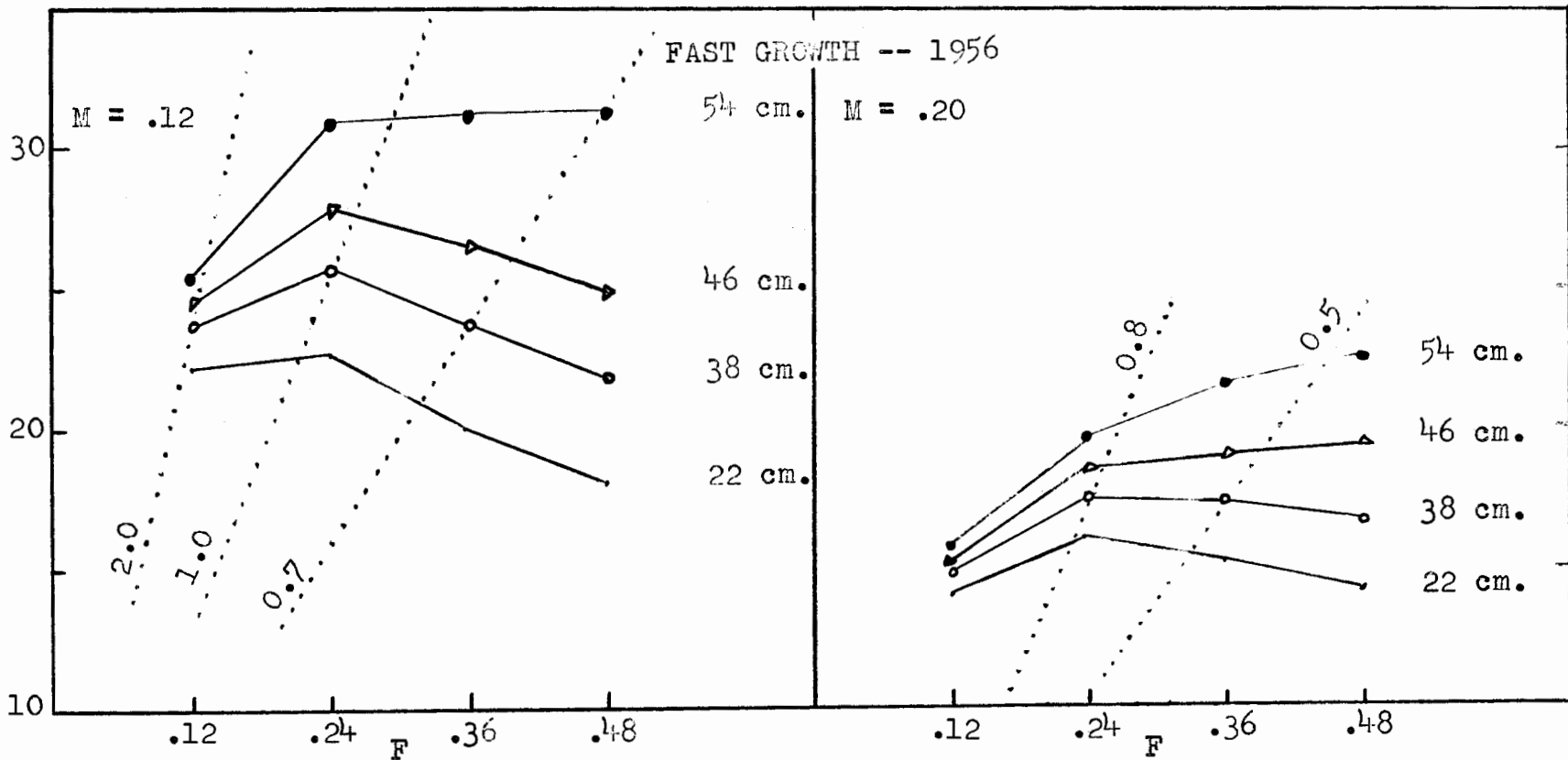
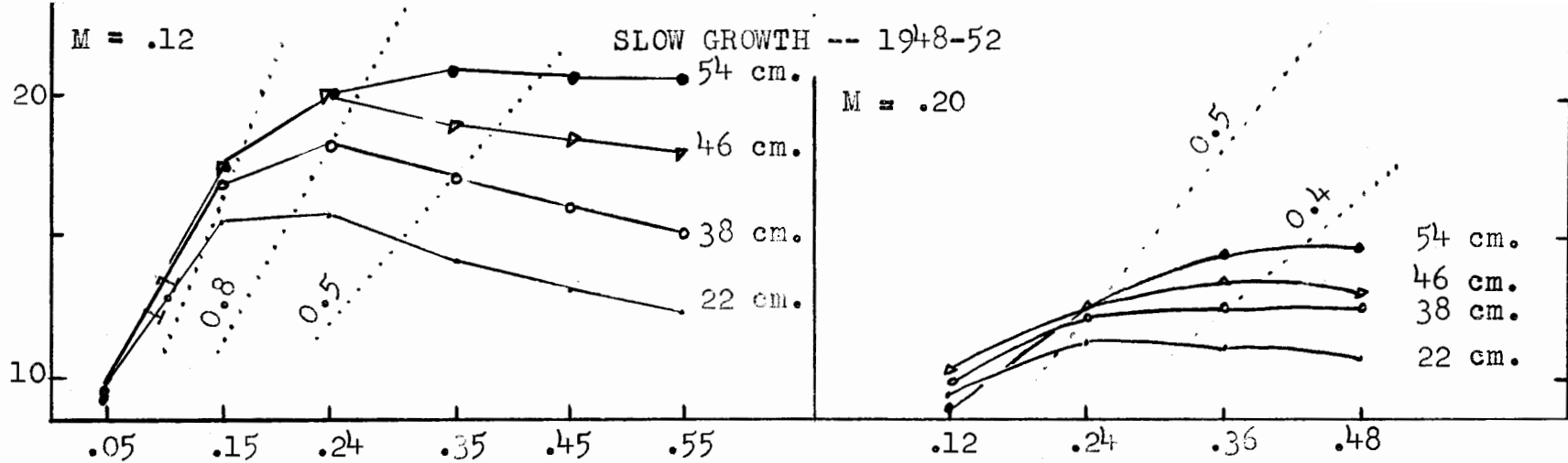
In order to consider the effects of fishing on landings of Gulf of St. Lawrence (Subdivision 4T) cod, a series of models have been calculated (accompanying figure). The important variables involved are size at first capture and fishing intensity. Relative yields of cod have been determined for 2 levels of natural mortality, 2 growth rates, 4 mesh sizes, and a series of fishing mortalities. Yield curves have been drawn for the 4 mesh sizes, and lines representing 3 levels of catch per unit effort are shown for each model.

Yields were calculated on the basis of 10,000 fish, fully recruited to the fishery at 30 centimetres. Further studies may show that calculations should be based on a much higher size at recruitment, for it is known that cod are differentially distributed by size, and that small cod are not as available to commercial fishermen as small haddock.

Age composition and tagging studies are still inadequate for good estimates of mortalities. The size and age compositions for the periods 1948-49 and 1950-53 suggest estimates of 15% and 30%, respectively, for total mortality. An estimate of total mortality rate for the period 1955-56 was only 22% for ages 5 to 10 years (in 1955). This relatively low value resulted from the fact that abundance indices of 2 year-classes of large cod actually increased in 1956. Returns from the 1955 tagging in this area are incomplete. Preliminary analysis suggests that the total instantaneous mortality rate for tagged fish was about .60 (45%). The true total instantaneous mortality rate, as determined from age analysis, appears to have increased with the development of otter trawling to about .40 (33%). On these assumptions estimates of instantaneous tagging, natural, and fishing mortality rates in 1955-56 were each .20 (15%). Models have been calculated for instantaneous natural mortalities of .12 and .20, in order to cover the probable range of natural mortalities.

An examination of the models shows that changes in growth or natural mortality can be expected to have marked effects on the stabilized yield. With a $4\frac{1}{2}$ -inch mesh, at instantaneous natural mortality rate (M) = .12 and instantaneous fishing mortality rate (F) = .24, an increase in growth such as that observed in 1955-56 would increase the yield by about 40%. A decrease in natural mortality from .20 to .12 would have a similar effect on yield at the fast growth rate.

Yield in thousands pounds per 10,000 recruits at 30 cm.



Model of Subdivision 4T cod fishery, relating yield per 10,000 recruits at 30 centimetres to instantaneous fishing mortality rate (F) for 50% retention lengths at 22, 38, 46, and 54 centimetres (equivalent to mesh sizes of 2½ to 6 in.). Models have been constructed for instantaneous natural mortality rates (M) of .12 and .20 and for growth rates observed in 1948-52 and in 1956. Broken lines of equal catch per unit effort (Y/F) are shown.

If growth and natural mortalities remain constant, a change in fishing intensity can be expected to affect the long-term yield. Lines of equal landings per unit of effort have been drawn in order to see the relationship between total yield and catch per unit effort. Catch per unit effort decreases continuously as fishing intensity is increased. Total landings, on the other hand, increase to an optimum and then decrease with increased fishing. Such information is useful for a consideration of greatest profit to fishermen, consistent with maximum landings.

For given growth, natural mortality, and fishing mortality rates, the yield increases as mesh size is increased. The models show that the optimum mesh size is well above $6\frac{1}{2}$ inches if growth is fast, or if growth is slow and fishing intensity is high. With slow growth and low fishing intensity optimum mesh size is about $5\frac{1}{2}$ inches.

The calculated yields are based on catches rather than landings. They do not take account of the fact that some small cod are discarded at sea. Wherever such wastage at sea is substantial, the gain in yield with large-mesh nets will be greater than that shown. We have chosen to ignore this added advantage of large-mesh nets in the models.

The fluctuations in landings of Subdivision 4T cod are consistent with the effects of fishing intensity, size at first capture, and growth rate shown in the models. During depression years prices and landings were relatively low. During war years prices increased, and landings increased toward the optimum. It is assumed that fishing intensity increased with better prices. In post-war years fishing intensity increased, and the size at first capture was reduced as a result of the large-scale conversion from line fishing to otter trawling. During this period total landings and catch per unit of effort decreased. In the period 1954-56 growth rate increased, and landings increased to a record level in 1956.

On the basis of these studies of models and the history of the fishery, it is predicted that the average sustained yield can be increased by increasing mesh size well above the $4\frac{1}{2}$ -inch mesh size currently accepted for Subarea 4. The optimum mesh size may be well above $6\frac{1}{2}$ inches, but more precise information on mortalities is needed before the best size for first capture can be determined.

It will be impossible to measure the effect of the $4\frac{1}{2}$ -inch mesh size on landings of Subdivision 4T cod. Only part of the cod previously discarded at sea are saved by the larger mesh. The change in landings will be small compared with natural fluctuations resulting from variation in recruitment and growth. We believe that even the benefit of a much larger mesh size would be almost as difficult to measure because of the weakness of back statistics, and the large natural variations in yield.

W. R. Martin
J. E. Paloheimo

No. 35

MODEL OF "LOCKEPORT" COD FISHERY

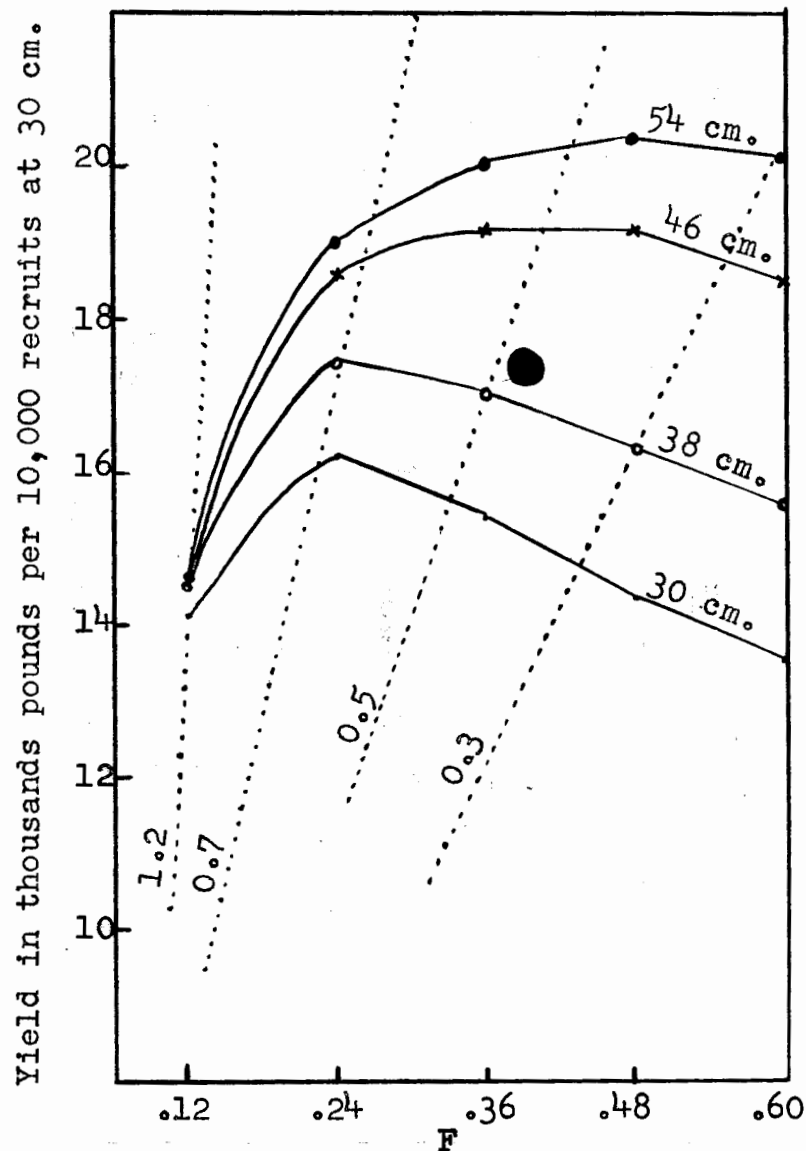
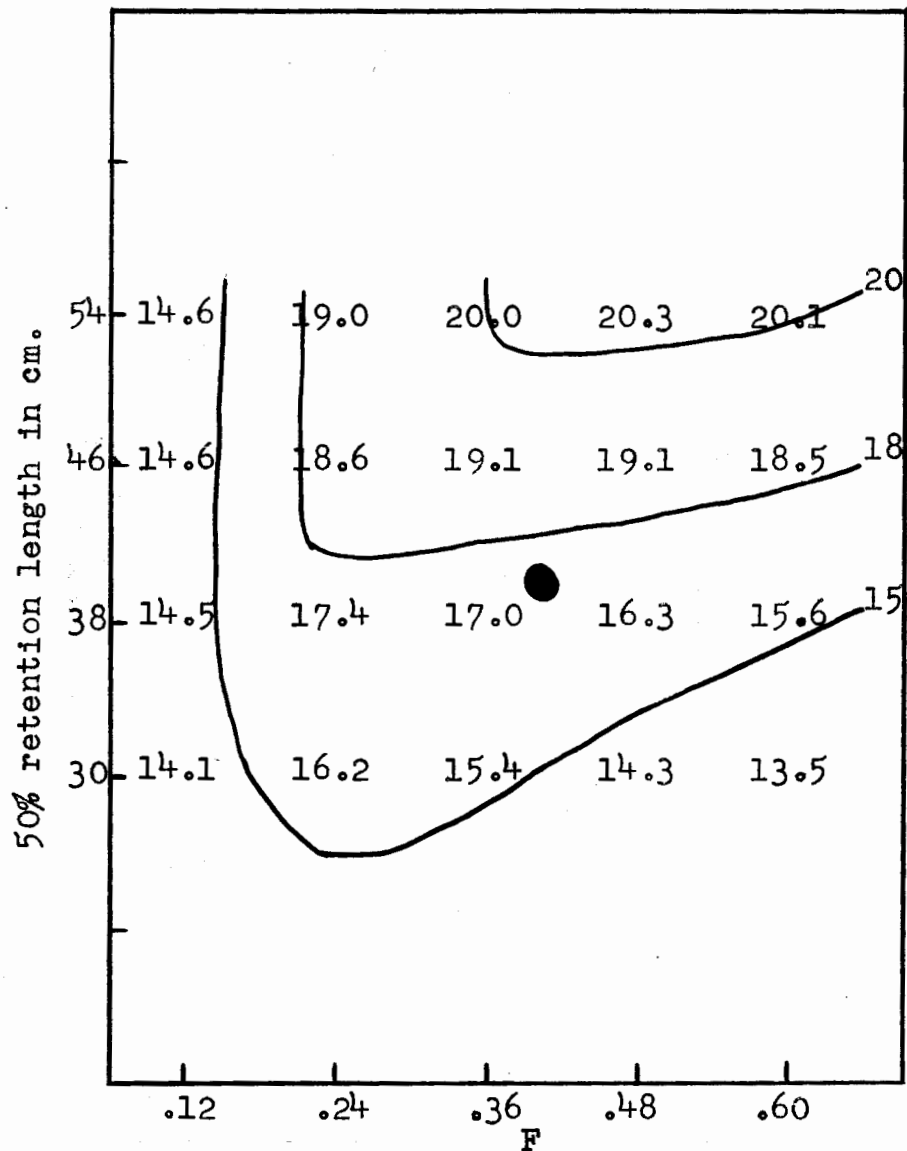
In order to consider the effects of size at first capture and fishing intensity on the yield of Subdivision 4X cod, a model of the "Lockeport" cod fishery has been drawn up. It is presented in two forms in the accompanying figure. Relative yields of cod have been determined for one level of natural mortality, one growth rate, 4 sizes at first capture, and 5 levels of fishing intensity. In one panel an isopleth model is shown. In the other, yield curves are presented for the various sizes at first capture, and lines representing 4 levels of catch per unit effort are shown.

Yields were calculated on the basis of 10,000 cod, fully recruited to the fishery at 30 centimetres. As noted above, this is the size at which cod first enter the commercial fishery in southern Nova Scotia. Cod are normally not fully recruited until they reach a length of about 45 centimetres. A 50% retention length of about 40 centimetres would appear to describe the selection of "Lockeport" cod. Because of the lack of precise information on discards of cod, we have chosen to use a lower size for recruitment. The general conclusions are not affected.

The catch per unit effort, age composition, and tagging data have been used to determine natural and fishing mortalities of "Lockeport" cod. The total instantaneous mortality rate was estimated to be about .60 (45%) for the "summer" seasons. This gave values of .07 (5%) for instantaneous natural mortality rate and .53 (40%) for instantaneous fishing mortality rate. Since this does not take account of tagging mortality, an even lower natural mortality rate is implied. A consideration of confidence limits places the instantaneous natural mortality rate between .00 (0%) and .20 (18%). Fishing mortality was high during the months of May-August, and low during the rest of the year when fishing moved to deeper water, and a different population of cod moved into the area. The estimates of mortality rates were further obscured by the sudden decrease in numbers of recovered tags in the second and third years after tagging, possibly because of losses of tags under conditions of rapid growth. The instantaneous natural mortality rate used in the model was .20.

The 50% retention lengths of 30, 38, 46, and 54 centimetres correspond with mesh sizes of 3.4, 4.3, 5.2, and 6.1 inches. Most of the "Lockeport" cod are caught on #17 Mustad hooks, and these have a 50% retention length, comparable with a 4½-inch mesh, at about 40 centimetres.

A point describing the estimated post-war size at first capture and fishing intensity is marked on the model. The model shows that catch per unit effort and landings can be increased by decreasing fishing intensity, or by increasing size at first capture. The greatest benefit is expected to result from an increase in size at first capture. This might be achieved by using a larger hook size in line fishing and a larger mesh size in otter trawling. If the instantaneous natural mortality rate is lower than .20, the benefit of reduced fishing, or larger hook and mesh sizes, would be greater than that shown in the figure.



Models of southern Nova Scotia cod fishery in Subdivision 4X, relating yield per 10,000 recruits at 30 centimetres to instantaneous fishing mortality rate (F) for 50% retention lengths at 30, 38, 46, and 54 centimetres. The model is based on an instantaneous natural mortality rate (M) of .20, and the average growth rate during the period 1947-56. The model is presented in two forms, with isopleth yield curves on the left and yield curves on the right. A point representing post-war size at first capture and fishing intensity is marked on the model. Broken lines of equal catch per unit effort (Y/F) are shown.

Since data are lacking on the effects of density on natural mortality and growth, optimum size for first capture has not been estimated. Only the direction of change for greater yields is clear.

The wartime increase in landings is consistent with the effects of changes in fishing shown in the model. During the years 1942 and 1943 fishing by United States otter trawlers declined. In Canada, the number of men fishing and the number of tubs of trawl, as shown in annual fisheries statistics for Shelburne County, declined substantially in the years 1941 to 1943. The net result was a decrease in fishing effort, a possible net increase in size at first capture, and a slight reduction in total landings. In 1944 to 1946 the yield was substantially above the long-term average, catch per unit effort was higher than during post-war years, and the average size of cod increased. In post-war years, as fishing intensity increased, landings, catch per unit effort, and average size of cod reverted to pre-war levels.

It might be argued that a few good year-classes could have produced the increased landings observed during the latter part of the war. This appears unlikely since landings increased during the same years in Subdivision 4T and in Subarea 4 as a whole, as in Subdivision 4X, and the year-classes involved must have differed greatly from one area to another because of the very different growth rates in the different populations.

On the basis of these studies of a model and of the history of the fishery, it seems that the long-term sustained yield could be increased in Subdivision 4X by increasing hook and mesh sizes, or by decreasing fishing intensity.

W. R. Martin
J. E. Paloheimo

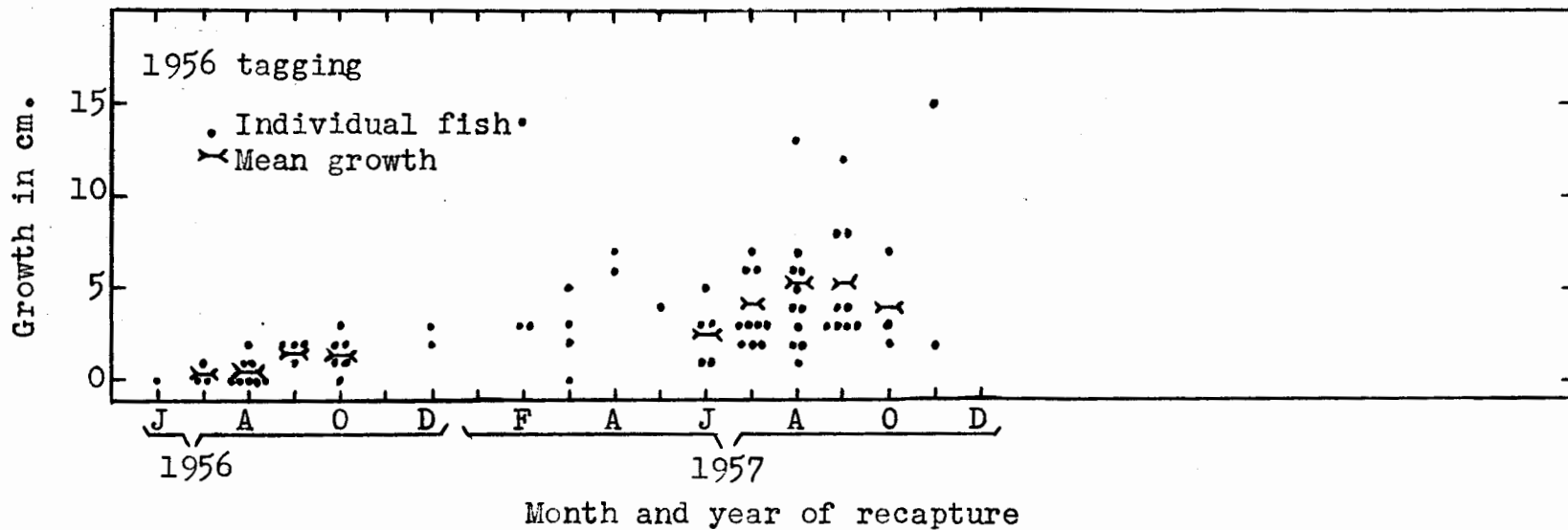
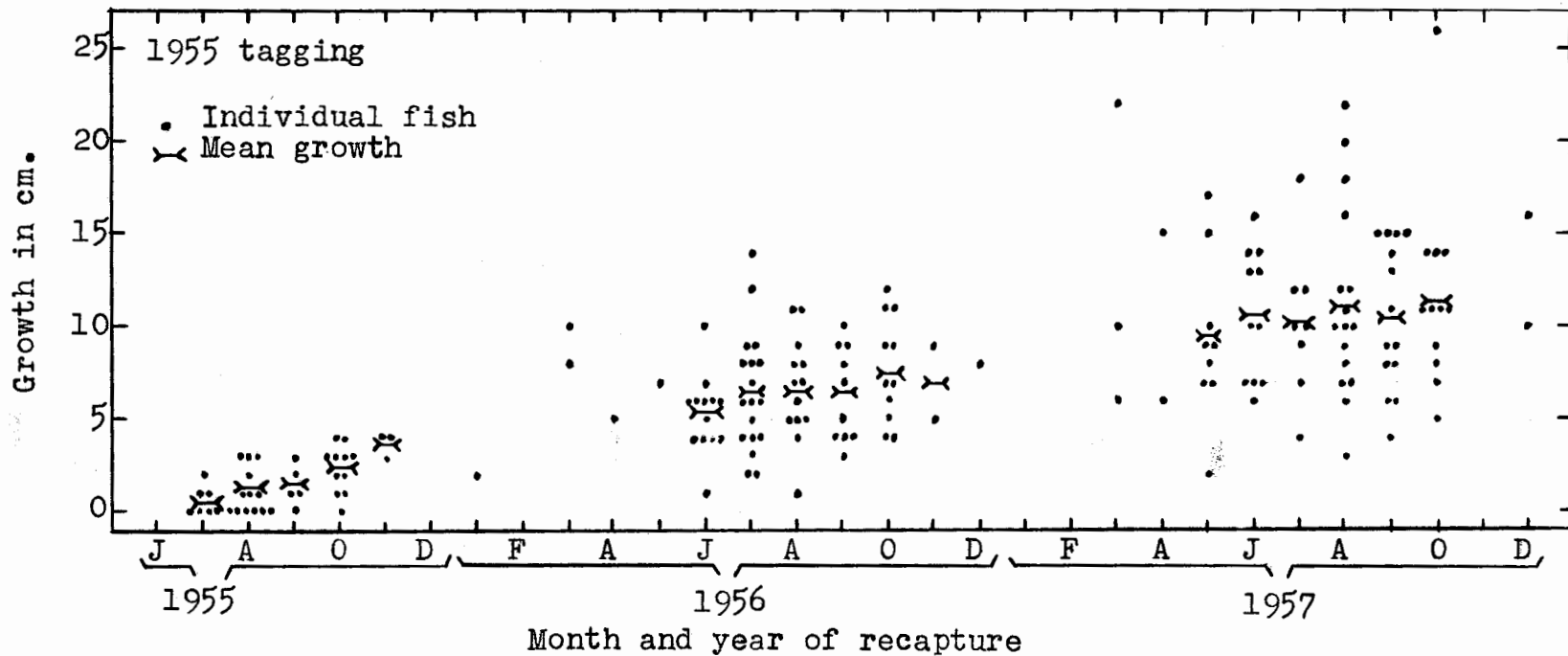
No. 36

GROWTH OF GULF COD FROM TAG RETURNS

Returns of fish lengths with recaptured tags from 1955 and 1956 cod tagging experiments in the northern New Brunswick region of the Gulf of St. Lawrence (Ann. Rept., 1956, Summary 28) have afforded an opportunity for direct measurements of growth of individual cod. The data were split into 2 groups for each year's tagging, one group having initial or tagging lengths of less than 60 centimetres, and the other having lengths of 60-80 centimetres. Comparison of the 2 size groups indicated little difference in growth as related to size at tagging in either year. Accordingly, all data were divided into 2 groups, differing only as to year of tagging.

Growth of these 2 groups is plotted against a time scale of month of recapture in the figure. One hundred and eighty-nine recaptures were available for the 1955 tagging and 74 recaptures for 1956. Since the majority of Canadian fishing effort in the area is expended in the months of May to October each year, most of the recapture data fall into these periods.

Growth of tagged Gulf cod



Examination of data plotted for the 1955 tagging shows that average growth increased from 0.6 centimetres in July to 3.7 centimetres in November of the year of tagging; from 5.3 centimetres to 7.7 centimetres in the summer of 1956; and 9.3 to 11.3 centimetres in the summer of 1957. Similar changes are noted from summer to summer for the 1956 tagging.

There was obviously a substantial amount of growth in the period of low tag returns, November to May. The relatively slow growth evident in the summer months is thought to be related to late spawning and recovery of Gulf cod, peak spawning occurring in the latter half of June. Cod otoliths from the area indicate slow growth in early summer with no formation of opaque edges, associated with fast growth, until August.

Comparison of recaptures from 1955 and 1956 taggings indicates that there was more growth in the 1955-56 season than in 1956-57. Average increments of cod recaptured in the summer of tagging, 1955, ranged from 0.6 to 3.7 centimetres as compared to 0.5 to 1.8 centimetres for 1956. Means for fish tagged in 1955 and recaptured in the following summer ranged from 5.3 to 7.7 centimetres as compared to 2.6 to 5.3 centimetres for cod tagged in 1956 and recovered in 1957. Although available commercial age-length samples indicate slightly more growth than the tagging data both in 1955-56 and 1956-57, they agree in that increments were greater in the former period.

A. C. Kohler

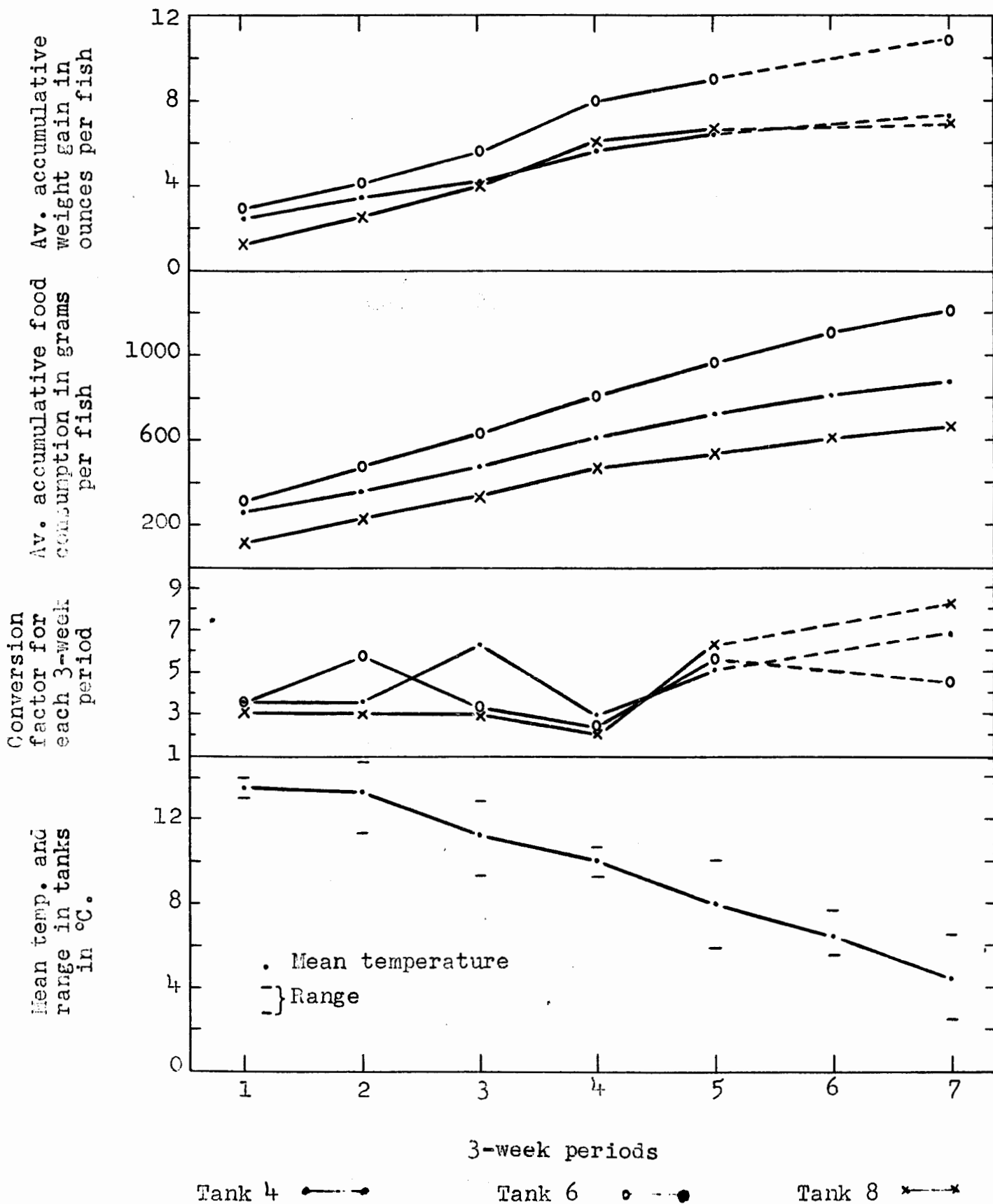
No. 37

COD GROWTH EXPERIMENT

In order to sort out some of the factors affecting the growth of cod, experiments in controlled feeding were started in tanks at St. Andrews in July of 1957. One hundred and one cod, 29-42 centimetres in length, were taken alive from a Lockeport fish trap, and transported to St. Andrews in a tank aboard M. B. Mallotus. On arrival they were divided into a group of small-size and a group of large-size fish. Each of these 2 groups was then divided into 3 equal parts and the 6 resulting groups were placed in puncheon-type tanks.

By means of trial and error elimination, frozen whole herring were selected as a food that was acceptable to these cod, readily available, and at the same time, pieces uneaten were easy to find in the tanks and "weigh back". The fish were fed at 3 different rates. These were a maximum, an intermediate, and a minimum or maintenance level. It was of interest to note the difficulty in imposing these different rates on the tanks of fish. In order to make sure that each fish in a tank had an equal chance to eat, the differences in food offered per tank had to be spaced in time, feeding all they would take once a week, twice a week, and once every 3 weeks. The fish seemed to be able to compensate partially for this by eating more when the feedings were less frequent.

Growth and food consumption of cod in captivity



A record was kept of weight of food eaten, growth of cod in length and weight, temperatures, and general conditions in the tanks. Several fish in each tank were tagged in order that individual, as well as average, records could be kept. Weighing, measuring, and summarization of data were carried out every 3 weeks. Length and weight data were discarded for period 6 due to inaccuracies in measurement.

An indication of overall results from the experiment to January 16, 1958, can be seen in the figure which incorporates data for the 3 tanks of smaller cod:

(1) Growth in each tank is seen to correspond fairly well with food consumption. Fish weights shown for period 4 are slightly high due to incomplete digestion of food before weighing. Maximum rations of 1210 grams (42.7 oz.) of food per fish in tank 6 gave an average increase in weight of 309 grams (10.9 oz.) for 21 weeks.

(2) Conversion factors (herring consumption (grams)/fish weight gain (grams)) varied between 2.1 and 8.4 for fish gaining weight throughout the period. High fish weights for period 4 caused low conversion factors for that period, and high conversion factors for period 5. Variation in conversion factors is also caused by measuring error in weighing live cod. Weights of fish are accurate only to the nearest half ounce.

(3) Average temperatures in the tanks have dropped from 13.5°C. to 4.5°C. with little change in growth or food consumption of maximum-fed fish. There is an indication of a slight drop in periods 6 and 7, but this might be related to an onset of spawning activity. The gonads of 5 fish that died in January were noted to be in a ripening condition.

(4) Preliminary results indicate that rations required to maintain constant weight in cod of about 624 grams (24 oz.) are close to 70 grams (2.5 oz.) of herring per fish over a 3-week period.

Further experimentation and analysis of data are planned to separate effects of temperature, differences between tagged and untagged fish, differences between size groups, and relations to zones in otoliths. At the same time, continuation of the work through a full year will better establish conversion factors and maintenance requirements.

A. C. Kohler

No. 38

GULF CENSUS PROGRAM

A census of the cod and plaice populations of the southwestern Gulf of St. Lawrence was started in 1957. The purpose of this census is to measure recruitment and to determine the influence of environmental factors on the abundance, distribution, and movements of these species. The results should

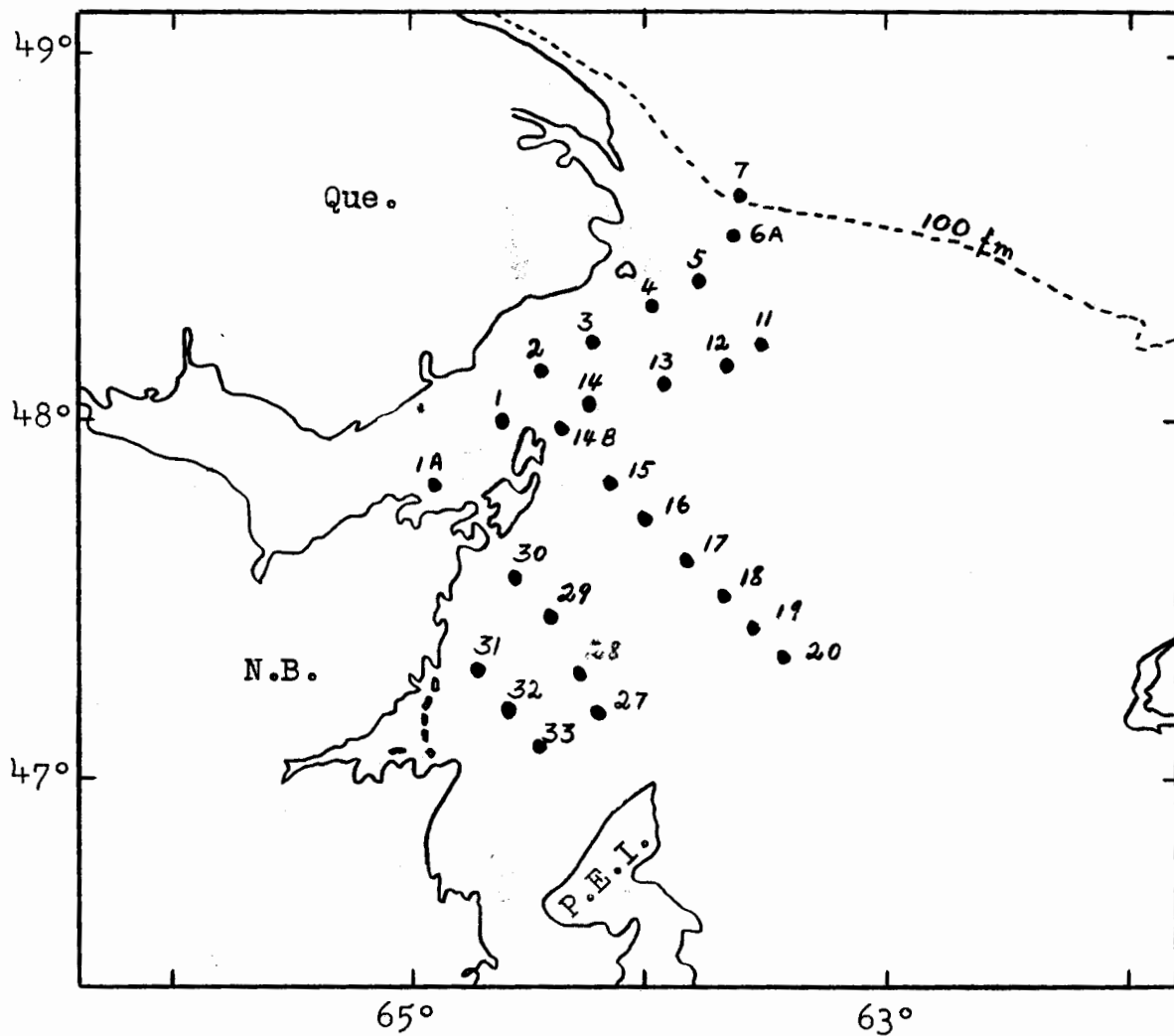


Figure 1. Map of the southwestern Gulf of St. Lawrence showing location of stations covered during the 1957 census program.

lead to short-term predictions of the relative abundance of the stocks available to the fishery.

A number of stations covering the southwestern portion of the Gulf of St. Lawrence were established. The location of these stations is shown in Figure 1.

On the basis of location and depth, stations 3 to 13 were arbitrarily grouped into a northern, deep-water sector. Stations 15 to 33 were grouped into a southern, shallow-water sector. Stations 1A, 1, 14 and 14B were grouped into a so-called Miscou sector.

The field work was carried out from the research vessel J. J. Cowie. A 3/4 #35 Yankee otter trawl with a small-mesh nyak cover was used throughout. Three 45-minute tows were made at each station. Bathythermograph and meteorological observations, such as air temperature, wind direction and force, cloudiness, etc., were recorded at the beginning and the end of each station. Surface and bottom water temperatures were taken before and after each tow.

All cod and plaice were measured to the nearest centimetre. Catches in the codend and the cover were kept separate. On a representative sample (usually 3 cod and 3 plaice of every 10-cm. group) from each tow, sex, maturity, parasites, nature and volume of stomach contents were recorded. Otoliths of both species were kept for age determination.

Between May 22 and October 24, 245 tows were made in the course of 4 complete circuits. A total of 16,210 cod and 21,554 plaice were measured. Otoliths from 3,136 cod and 771 plaice were preserved. A total of 176 bathythermograms were recorded. Most of the observations at sea were made by P. M. Powles.

At this early stage of analysis, it is only possible to report on geographic and seasonal variations in the size composition of cod. The size compositions of the samples caught in the northern and southern sectors at various times in 1957 are shown in Figure 2. Only the stations that were covered during the 4 circuits are included here. Well-defined modes are observed in the length-frequency distribution of the samples caught in the northern and southern sectors from May 22 to June 20. The modes correspond to lengths of 22, 31, 43, and 58 centimetres. Less well-defined modes are seen at 67 and 79 centimetres. The increase in the modal lengths of the cod as the season progressed indicates a growth of 3 to 6 centimetres during the period studied.

As seen in Figure 2, small cod 37 centimetres and below were abundant in the spring in both the northern and southern sectors. They disappeared from the northern sector at the end of June. Small cod also decreased in number at stations 16 and 17, the only 2 stations of the southern sector that were covered at that time. An analysis of the catches at station 1 (west of Miscou) on June 24 suggests that some of the small cod moved into Chaleur Bay.

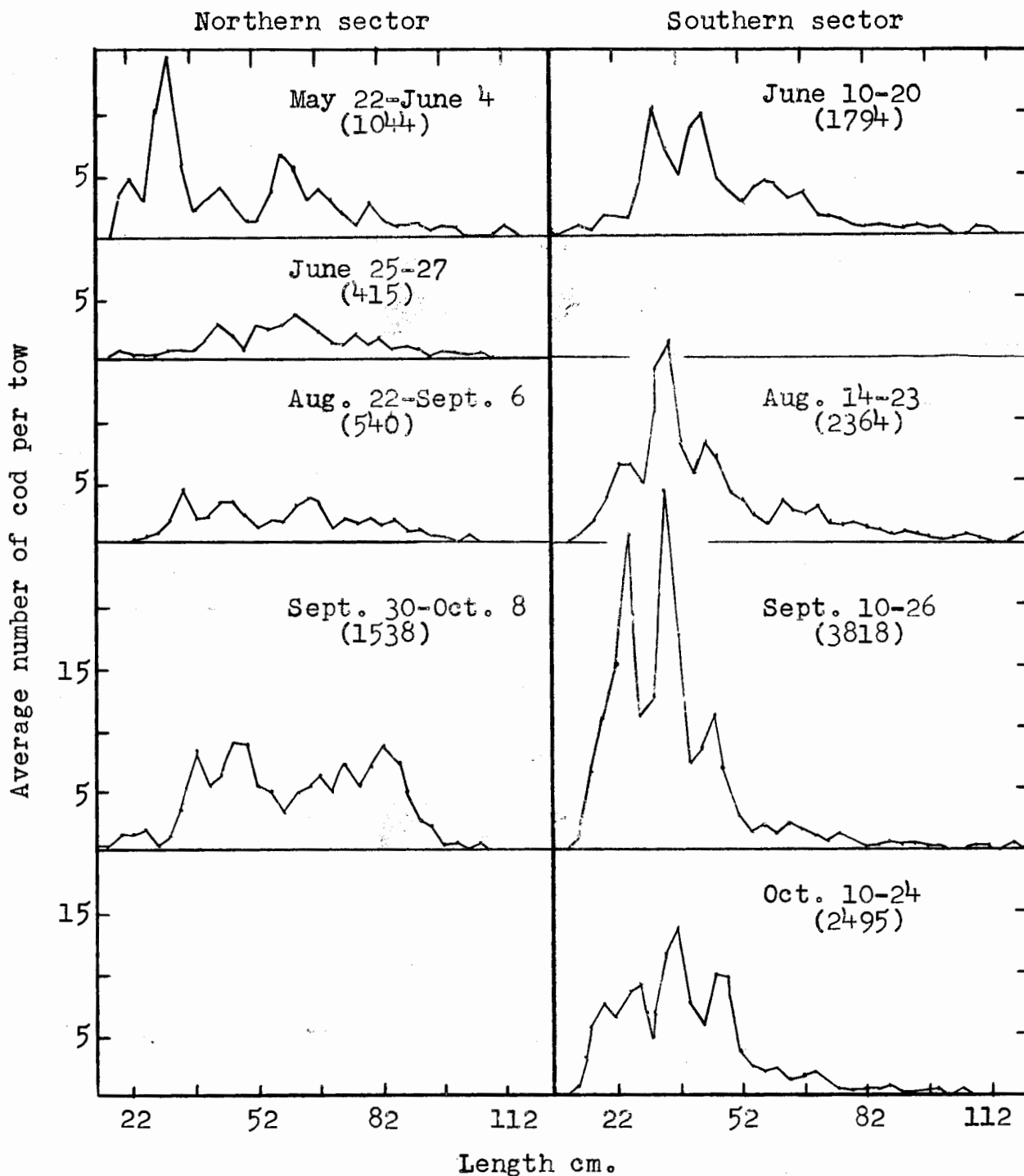


Figure 2. Size compositions of cod caught in the southwestern Gulf of St. Lawrence with covered codend from May 22 to October 24, 1957. Frequencies adjusted to three 45-minute tows per station. Number of fish in brackets.

From mid-August on, small cod were caught again in both northern and southern sectors, although in much smaller numbers in the northern than in the southern sectors.

It is anticipated that further analysis of the data on age composition, spawning and feeding habits in relation to environment, seasonal incidence of parasites and tagging, will result in a better knowledge of cod populations of the southwestern Gulf of St. Lawrence.

Yves Jean

No. 39

INCIDENCE OF PARASITES ON GULF COD

Lernaeocera branchialis

Preliminary studies of the parasitic copepod, Lernaeocera branchialis, were carried out as part of the cod census program (Summary 38). Examination of cod gills revealed that the overall incidence of the parasite was 2.0%. However, the incidence varied with the size of the fish, as seen in the table below:

Length of cod in cm.	No. of cod examined	No. of <u>Lernaeocera</u>	% incidence
10-20	214	3	1.4
21-30	325	9	2.7
31-40	420	11	2.6
41-50	488	15	3.1
51-60	502	9	1.8
61-70	464	7	1.5
71-80	376	5	1.3
81-90	217	3	1.4
91	157	1	0.6
<u>Total</u>	<u>3163</u>	<u>63</u>	<u>2.0</u>

Cod from 21-50 centimetres long were most heavily infected, while very few cod over 90 centimetres were infected. It seems that cod become infected at a fairly early age. Considering that Lernaeocera remains on a fish for 2 or 3 years, re-infection becomes less probable once a cod has reached the length of say 50 centimetres.

The degree of infection was highest in inshore waters, (up to 10%), especially off Miscou Island. The records showed that lumpfish (Cyclopterus), the intermediate host of the parasite, were captured in the same inshore waters. Inshore incidence compared closely to that reported by the St. John's Station for inshore Newfoundland waters, but was not as high as figures reported by the U. S. Fish and Wildlife Service for inshore Gulf of Maine. The incidence of Lernaeocera on offshore cod for all 3 regions, however, was fairly similar, lying at 2% or less.

Clavella

Clavella is a parasitic copepod commonly found in the buccal cavity, on the gills, anus, and fins of the Atlantic cod. Its specific taxonomy is still in doubt. Some authors claim that individuals found on various parts of the host belong to different subspecies or even to different species. Others class them as one species. In the present study, the location of each parasite on the host was recorded. They were treated, however, as one species, Clavella uncinata (O. F. Müller).

The overall incidence of Clavella on Gulf cod in 1957 was 41.4%. The percentage of infection seemed to vary with the size of the host. Cod over 40 centimetres showed 50.2% incidence. Cod below 40 centimetres showed only 20.4% incidence. Cod 10 to 20 centimetres in length had very few or no Clavella attached to them.

The geographical distribution of Clavella was even over the area surveyed. There was no difference in infection between inshore and offshore fish, probably because there is no intermediate host to limit the distribution of the parasite. Fluctuations were observed, however, in the degree of incidence throughout the season. After an initial low incidence in May in the northern sector (Summary No. 38), Clavella had increased considerably by the end of June. The incidence remained at a high level until the end of the season. In the southern sector, on the other hand, the incidence of Clavella was generally high at the beginning of the season, and decreased as the season progressed.

P. M. Powles

No. 40

PORROCAECUM BASELINE PROJECT

In order to establish a baseline of Porrocaecum infection in western Nova Scotian cod, the incidence of nematodes in the flesh of small cod (10-60 cm.) was determined for a number of samples collected from Lockeport grounds. About 900 cod were caught by the M. B. Mallotus during 2 periods in 1957: May 17-June 25 and August 17-September 6. These cod were mainly taken from 3 inshore, shoal areas: Ram Island, Gull Rock, and Outer Farm Ledge. Some cod were caught further offshore in deeper water.

For comparison, inshore samples of cod were taken from 3 Gulf of St. Lawrence areas, Magdalen Islands, Shippegan Island, and Miramichi grounds. About 200 cod were taken from each area by the M. V. J. J. Cowie during the period July 25-August 8, 1957.

For each cod, length, otolith age, and numbers of nematodes were determined. Most of the Lockeport samples were examined by Scott. Technicians Bayers and Fraser assisted with August samples. Bayers examined the Gulf samples. Condon read the Lockeport otoliths, and Powles read the Gulf otoliths.

Lockeport samples

Five hundred and seventeen of the Lockeport nematodes were preserved and identified. Over 95% were larval Porrocaecum. The remainder were larval Anisakis.

In August, 79% of the nematodes observed at Lockeport were found in the portion of the fillet corresponding to a commercial fillet. The remainder were in the part of the fillet which is discarded in commercial practice.

Two types of cod were recognized on the basis of colour differences, a red and a normal type. Red cod were found only at the 3 inshore stations. The proportion of red cod in the populations at each inshore station increased from about one third in June to about two thirds in August. The incidence of nematodes in June was usually greater in red cod than in normal cod. In August no consistent difference was apparent. The incidence was lower in August than in June in most samples of red cod. This trend was not evident in the samples of normal cod.

The incidence of nematodes and mean lengths of cod in age-groups II to V for the 4 areas sampled, all within 5 miles of the Lockeport Whistle Buoy, are presented in the accompanying table. The samples are not separated by colour or by season in this table.

In each area the incidence was generally higher in the older age-groups. The amount of the increase varied with the locality, being greatest in the Ram Island samples, and least in the Offshore samples. The cod from the farthest inshore stations, Ram Island and Gull Rock, were more heavily infected than those from the Outer Farm Ledge or Offshore. This apparent independence of inshore and offshore groups is supported by the greater average lengths of each age-group and the younger age composition of cod from the inshore stations.

Gulf of St. Lawrence samples

Comparable data for samples collected off the Magdalen Islands, Shippegan Island, and the Miramichi Estuary are also presented in the accompanying table.

In general, both incidence of nematodes and growth in all 3 samples of Gulf of St. Lawrence cod were lower than those of inshore Lockeport samples, but similar to the Offshore samples. However, as noted in earlier examinations of older, commercial-sized fish, the 5-year-old Gulf cod along the New Brunswick shore are more heavily infected than offshore Lockeport cod of the same age.

There was more uniformity among the 3 widely-separated samples of Gulf cod, in numbers of nematodes per cod and in growth, than in the various samples of Lockeport cod. This is consistent with tagging results which show extensive seasonal migrations of Gulf cod in contrast to the non-migratory Lockeport cod.

Incidence of nematodes and mean lengths of cod in 4 successive age-groups of cod from 4 areas near Lockeport, N. S., and 3 areas in the southern Gulf of St. Lawrence, 1957.

Area	Age-group	No. of cod	Mean length cm.	Mean no. worms	% incidence	75% range of number of worms ^a
Lockeport						
Ram Island	II	60	37	1.4	63	0-3
	III	140	44	4.4	71	0-9
	IV	46	51	8.0	78	0-22
Gull Rock	II	116	34	1.3	48	0-3
	III	125	44	2.9	77	0-6
	IV	40	49	8.7	73	0-9
Outer Farm Ledge	II	38	33	0.34	29	0-1
	III	112	41	1.6	56	0-3
	IV	72	49	2.9	79	0-6
	V	34	55	1.7	77	0-3
Offshore	II	6	29	0.67	67	0-1
	III	21	39	1.1	52	0-3
	IV	17	46	1.3	71	0-3
	V	10	53	1.0	50	0-3
Gulf of St. Lawrence						
Magdalen Islands	II	44	29	0.95	16	0
	III	54	36	0.31	24	0-1
	IV	58	47	1.0	54	0-3
	V	27	54	1.2	52	0-3
Shippegan Island	II	31	29	0.36	26	0-1
	III	61	36	0.74	52	0-2
	IV	63	47	1.4	71	0-3
	V	31	54	3.3	90	1-5
Off Miramichi Estuary	II	28	29	0.18	18	0-1
	III	55	37	0.68	44	0-3
	IV	71	47	1.6	82	0-3
	V	33	54	3.6	88	1-5

^aThis value is the range in numbers of worms in the central 75% of the fish in a sample.

Relationship to seals

Few seals were seen around Lockeport. The principal areas of harbour seal concentration were inshore, around Black Point and Potter's Ledge, which are close to Ram Island. As noted in earlier studies, there appears to be a relationship between the inshore distribution of seals and the inshore distribution of the most heavily infected cod.

Within the Gulf samples we find a lower incidence of nematodes for the Magdalens area than in the Shippegan-Miramichi area. If the harp seal, which appears during winter months in great numbers north of the Magdalen Islands, were an important host of adult Porrocaecum, we would rather expect a higher incidence of nematodes at Magdalens than along the New Brunswick shore. The harbour seal and the grey seal are undoubtedly important vectors of adult Porrocaecum in the Gulf of St. Lawrence, as well as along the south coasts of Nova Scotia and Newfoundland. These results are consistent with our observations of the highest recorded incidences of nematodes in cod of the Bras d'Or Lakes and inshore Lockeport, where we find seals but not harp seals.

Proposed biological control

On the basis of a 12-year study of the life-history of Porrocaecum decipiens, we are convinced that eradication of seals is the only possible means of biologically controlling the codworm which is so costly to the fresh and frozen groundfish industry.

Although we believe that the harbour and grey seals are the major vectors of adult P. decipiens, the importance of harp seals is not yet clear. An expensive monthly sampling of harp seals during their winter and spring life in the Gulf of St. Lawrence would be required to clarify this point.

The present small bounty on harbour seals has little effect in seriously reducing their abundance. It is estimated that the annual bounty kill of adult harbour seals in the Maritimes area is about 2% of the population. There is no bounty at all on the infectious grey seal. A repeated doubling of bounties at regular intervals for both of these species, together with special hunting parties during pupping seasons, might reduce the population of seals sufficiently to significantly reduce the seriousness of the Porrocaecum problem. The effect of seal eradication could be tested in an experimental area.

A suitable area for experimental biological control of Porrocaecum would be in western Nova Scotia where the harbour seal is the only known vector of the adult nematode. An intensive program of seal control in this area, along with a careful sampling and examination of cod, would demonstrate the practicability of reducing the incidence of P. decipiens in fish by reducing the numbers of seals.

If industry and government decide that such an experimental seal control program is worth while, it will be necessary to evaluate the results by carrying out a long-term study of the

incidence of nematodes in young cod for a sample area such as Lockeport. The 1957 baseline results should be checked again immediately prior to implementation of a seal control program.

Apart from publication of results, the Station's Porrocaecum life-history project has been completed. Continuation of the Porrocaecum baseline project will depend on action re experimental eradication of seals.

W. R. Martin
D. M. Scott

HERRING SUMMARIES

Passamaquoddy investigations

Herring statistics

Population studies

Herring migrations

Behaviour studies

Plankton

Exploratory fishing

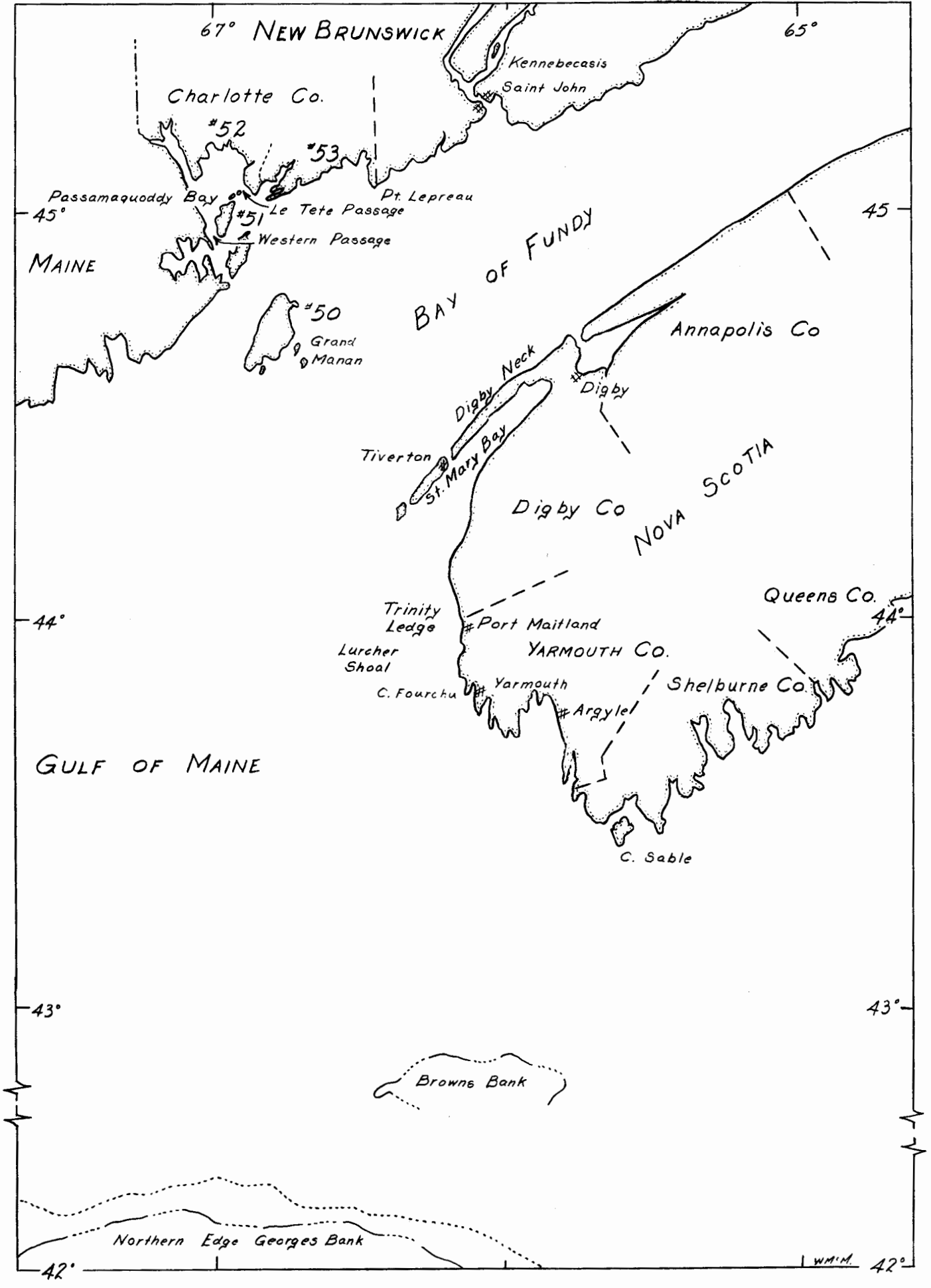
Herring catches in relation to environment

Southwest Nova Scotia herring investigation

Relative abundance of herring larvae

Herring explorations in Newfoundland

Gear experiments



PASSAMAQUODDY INVESTIGATIONS

No. 41

The major efforts of the herring investigation in 1957 were concerned with carrying out a program of research and statistics designed to implement the terms of reference of the International Passamaquoddy Fisheries Board. This Board has been charged with the responsibility of determining "the effects which the construction, maintenance, and operation of the tidal power structure proposed might have upon the fisheries in the area". The program is planned and co-ordinated by a Committee of Canadian and U.S. scientists and carried out co-operatively by the Fisheries Research Board of Canada and the U.S. Fish and Wildlife Service. Co-operation applies particularly to pooling resources of vessels and technical personnel for more efficient field operations but also includes scientific collaboration in analyses of data and interpretations of results.

The Passamaquoddy program places major emphasis on herring investigations since this species makes up more than 80% of the total landings in the area concerned. Studies of catch, fishing-effort and capital investment statistics (Summary 42) are designed to determine the past and present status and relative importance of the fishery in various parts of the Passamaquoddy region. The biology of herring in all stages of its life history is studied to determine the existence, characteristics and amount of mixing of herring stocks (Summary 43); the pattern of local movements and migrations (Summary 44) and the effect of variations in environmental factors, such as light, temperature, salinity, and water currents on the behaviour of herring (Summary 45). Studies of hydrographic conditions including temperature, salinity and surface currents (Trites, Annual Report AOG) are made to provide an understanding of the herring's environment. Plankton investigations provide information on the availability of food organisms and the drift of young herring (Summary 46).

The program includes an assessment of possible effects of damming on other commercial species in the area.

S.N. Tibbo

No. 42

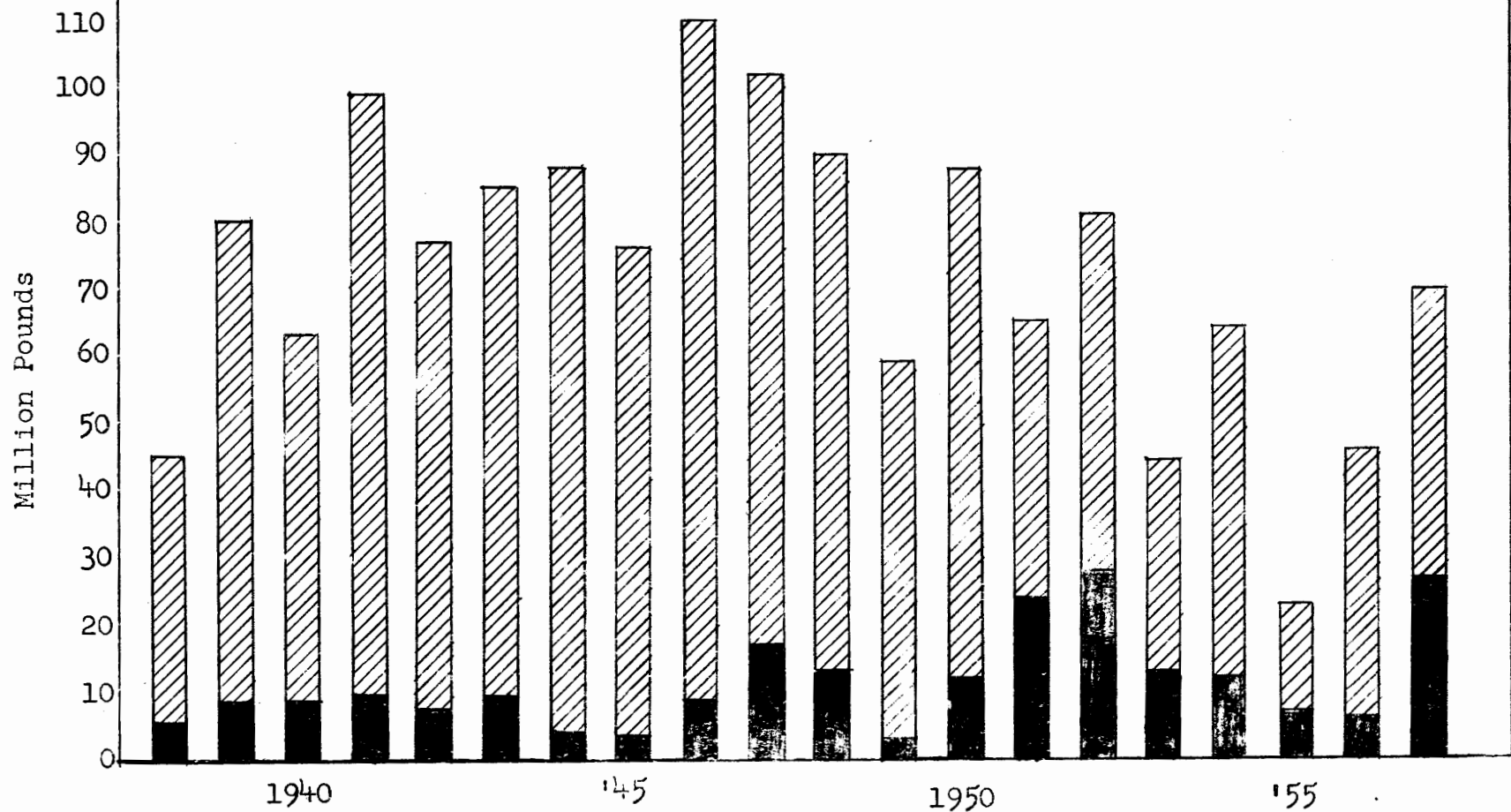
HERRING STATISTICS

In 1957 and for the first time, detailed daily records of herring catches by individual weirs and seines in Charlotte and Saint John Counties, New Brunswick, were obtained throughout the fishing season. The Economics Service of the Canadian Department of Fisheries co-operated in a statistics survey of these counties covering the period 1956 and 1957 with particular emphasis on the capital value of equipment, receipts and operating costs of the herring and other fisheries. Sample records of individual weir catches from 1946 to 1956 are being obtained. The survey covers approximately one third of the fishermen and 112 have already been interviewed. Two of these operate purse seines, 21 are lobster fishermen, and 89 are weir operators, most of them with an interest in a number of weirs.

Tabulations have been made of the numbers of weirs and weir

Herring Landings, Charlotte County, 1937-'57

Black portions - Passamaquoddy landings (Fish. Dist. #52)



sites in these two counties. The number of sites totals 1,079 including 255 in Grand Manan and 60 in Saint John County. For Plan No. 2 proposed by the Passamaquoddy Engineering Board there would be 236 sites inside the dams in the high level pool and 48 sites in the low level pool. However, during the last 12 years 100 of the high level pool sites and 25 of the low level pool sites have not been licensed. In 1957, 371 licences were issued, 81 licensed weirs were not built, 249 weirs were productive and it is assumed that the other 41 licensed weirs made no catches. Of the 249 effective weirs, 61 were in the high level pool, 9 in the low level pool, 110 immediately outside the dams, 49 at Grand Manan and 20 in Saint John County.

Landings in 1957 from daily catch records totalled 79.5 million pounds of which 69.1 million were taken in weirs and the remainder in purse and beach seines. There were also 8.2 million pounds landed but not identified by place of capture. Some of these fish may have been caught on the Nova Scotian side of the Bay of Fundy.

Landings from weirs began in February, increased to a peak in September and dropped to zero in December. Ninety-three (93) per cent of the landings were made from July 1 to October 31. The most productive month was September when 23.7 million pounds were landed.

Seine landings occurred in 2 periods, January to May and July to November, inclusive. About 7 million pounds were landed in the first period with the peak occurring in February and March while about 4 million pounds were landed during the second period with the peak in September.

Considering the landings in respect to the dam sites, the catches in the high level pool amounted 24.7 million pounds and 0.8 million pounds in the low level pool. Of the remaining 44.0 million pounds, 18.1 were caught at Grand Manan, 5.4 in Saint John County and 20.5 million pounds immediately outside the dams.

The average annual landing per weir varied from 90,000 pounds in the low level pool to 511,000 pounds in the high level pool. The average landings for all weirs inside the dams was 457,000 pounds and for those outside the dams 207,000 pounds.

Catches of herring in Charlotte County over the 20-year period from 1938 to 1957 inclusive have varied from 22.8 million pounds in 1955 to 109.8 million pounds in 1946 (see figure). The average annual landing for this period was 72.7 million pounds. The part of the catch taken inside Passamaquoddy Bay (District #52) averaged 15.8% or slightly more than one sixth of the total for Charlotte County. The 1957 landings for the County were slightly (4%) below average but the catches in District #52 were nearly 2½ times greater than the average and made up more than 37% of the total catch for the year.

R.A. McKenzie

No. 43

POPULATION STUDIES

A study of populations of herring is being carried on to

determine whether those fish in or near the Passamaquoddy region comprise one or several groups, and what degree of intermixing occurs. Samples are obtained from commercial fisheries and from special fishing experiments. During 1957 there were 76 samples from the Passamaquoddy area, 2 from Georges Bank, three from Grand Manan and one from Machiasport, Maine. Analyses of the data are incomplete but progress within the year included 12,806 herring measured, 1,568 scale samples read and 3,328 vertebral counts made.

Area	Number samples	Number fish	Range (means)		
			Length (cm.)	Age (yr.)	Vertebral count
Outer "Quoddy" (East)	29	4,744	9.4-17.3	1.0-1.7	54.8-55.6
Outer "Quoddy" (West)	2	380	11.2	1.0	55.4
L'Etete Passage	25	3,414	9.9-19.5	1.0-2.1	55.4-55.6
Western Passage	1	100	15.4	1.9	-
Inner Bay (East)	11	1,523	9.5-17.4	-	55.1-55.6
Inner Bay (West)	8	1,260	11.2-18.3	1.1	55.4-55.5

The table gives a break down of sampling within the "Quoddy" region and the degree of variation in mean lengths, mean ages and mean vertebral counts throughout the 1957 season. Outside the "Quoddy" region there were 6 samples totalling 1,385 individual fish. Mean lengths varied from 12.7 cm. at Grand Manan to 32.2 cm. on Georges Bank. Mean vertebral counts for two samples from Grand Manan were 55.5 and 55.7 and for one sample from Georges Bank 55.4.

Comparisons of samples within and between areas have not been completed and only tentative conclusions have been reached. Even at this stage, however, it is almost certain that more than one population of herring is fished in the "Quoddy" region.

There is no obvious geographical segregation of populations within the area. One possible explanation of the observed differences in sample means is that there are several groups of herring that migrate freely within the area but do not intermingle to any great extent. For example in the eastern part of the outer "Quoddy" area mean lengths of samples increased somewhat irregularly but steadily from 9.7 cm. in February to 11.8 cm. in May. Mean lengths in June were 4.5 cm. greater than in May. This increase cannot be accounted for by growth alone and must have resulted from sampling a different stock of herring. Further evidence of population differences is found in analyses of length data which show that fish of the same age within a sample often have a bi-modal or poly-modal length frequency distribution.

Indistinct annuli and secondary checks make scales from herring in the Passamaquoddy area difficult to interpret. However, different scale patterns have been observed within and between samples and this may prove to be a valuable tag in the identification of stocks. An interesting and valuable observation from scale examinations is that considerable new growth on the scales is evident in January. In contrast studies of scales from herring in other areas has shown that the physiological winter corresponds closely with the calendar winter and new scale growth usually starts in late May or early June.

Vertebral counts have so far not been treated mathematically but the means of samples differ by as much as 0.8 vertebrae. There are indications that vertebral counts of samples in areas adjacent to Passamaquoddy Bay are significantly lower than those in the entrance to the Bay and those inside the Bay. There is a slight tendency, as the season progresses, for mean vertebral counts to increase in one area and decrease in another. It has also been observed that, within a sample, the larger fish have higher vertebral counts. While many of these results are inconclusive they support the hypothesis of a heterogenetic stock of herring in the Passamaquoddy region.

S.N. Tibbo

No. 44

HERRING MIGRATIONS

A small laboratory tagging experiment during the winter of 1956-57 was sufficiently encouraging to warrant a trial of an opercular smelt tag and field experiments were begun in June, 1957. Before doing so, however, an investigation of the possibilities of recovery of tags was carried out by placing 349 tagged herring in the conveyer system at Connors' plant, Black's Harbour on June 5. The return of 77% of these tags showed that a high percentage of the tags could be recovered in commercially operated canning plants.

Field taggings were carried out with the help of the U.S. Fish and Wildlife Service at Boothbay Harbor, Maine, and from June 20 to November 21, 37,495 herring were tagged (see Table).

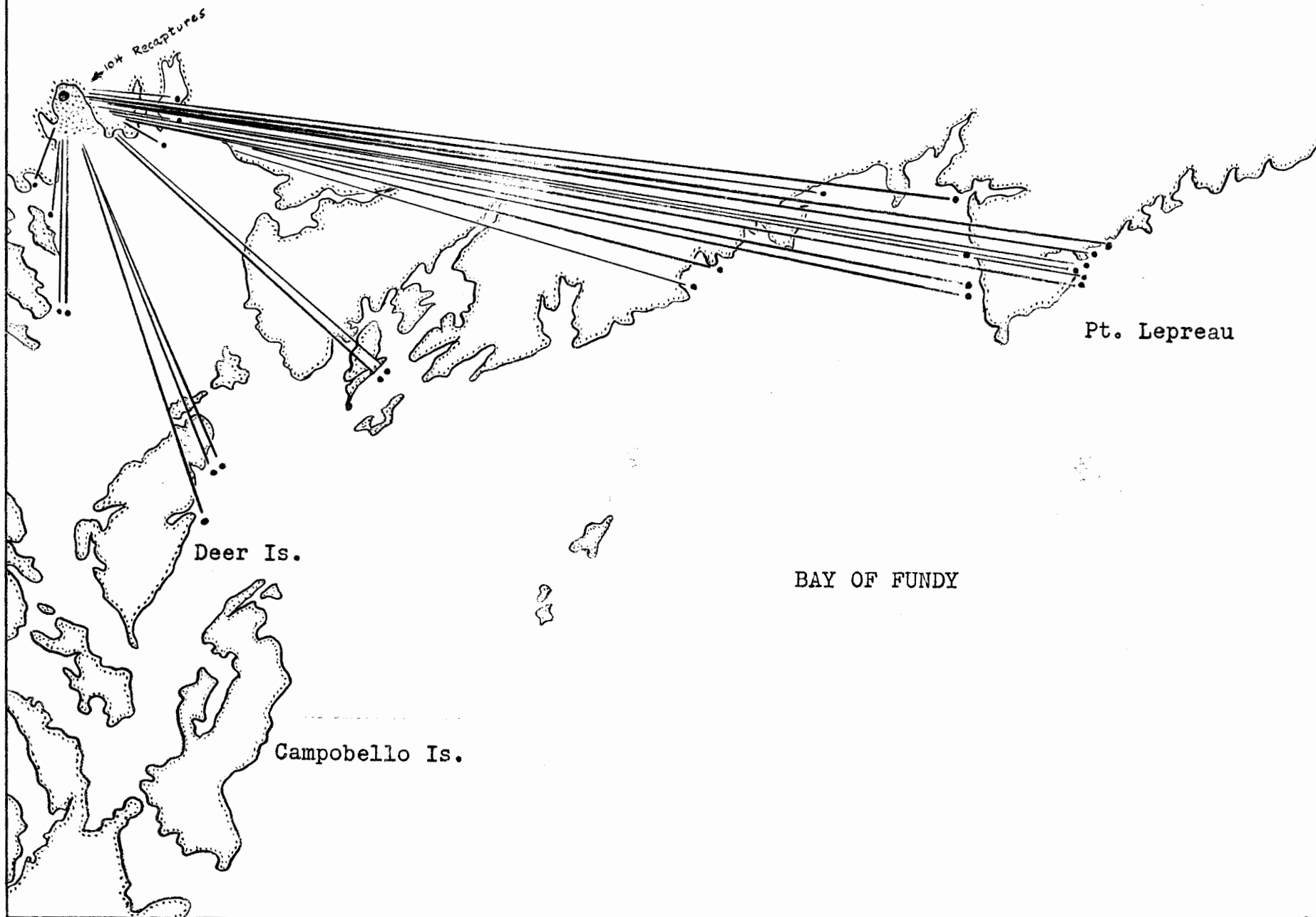
Seven hundred and ninety-two (2.1%) recaptures were made. Fifty-four of them lacked complete information. Of the other 738, 75% were recaptured within 10 days of release, 11% in the next 10 days, 5% in the third 10 days and most of the remainder within another month. However, 3 were at large as long as 2½ to 3 months.

About 78% of the recaptures were made within 5 miles of the tagging site and 11% from 5 to 10 miles away. The recaptures continued to decline with increasing distance to the most distant one which was about 55 miles away in a straight line from the tagging site.

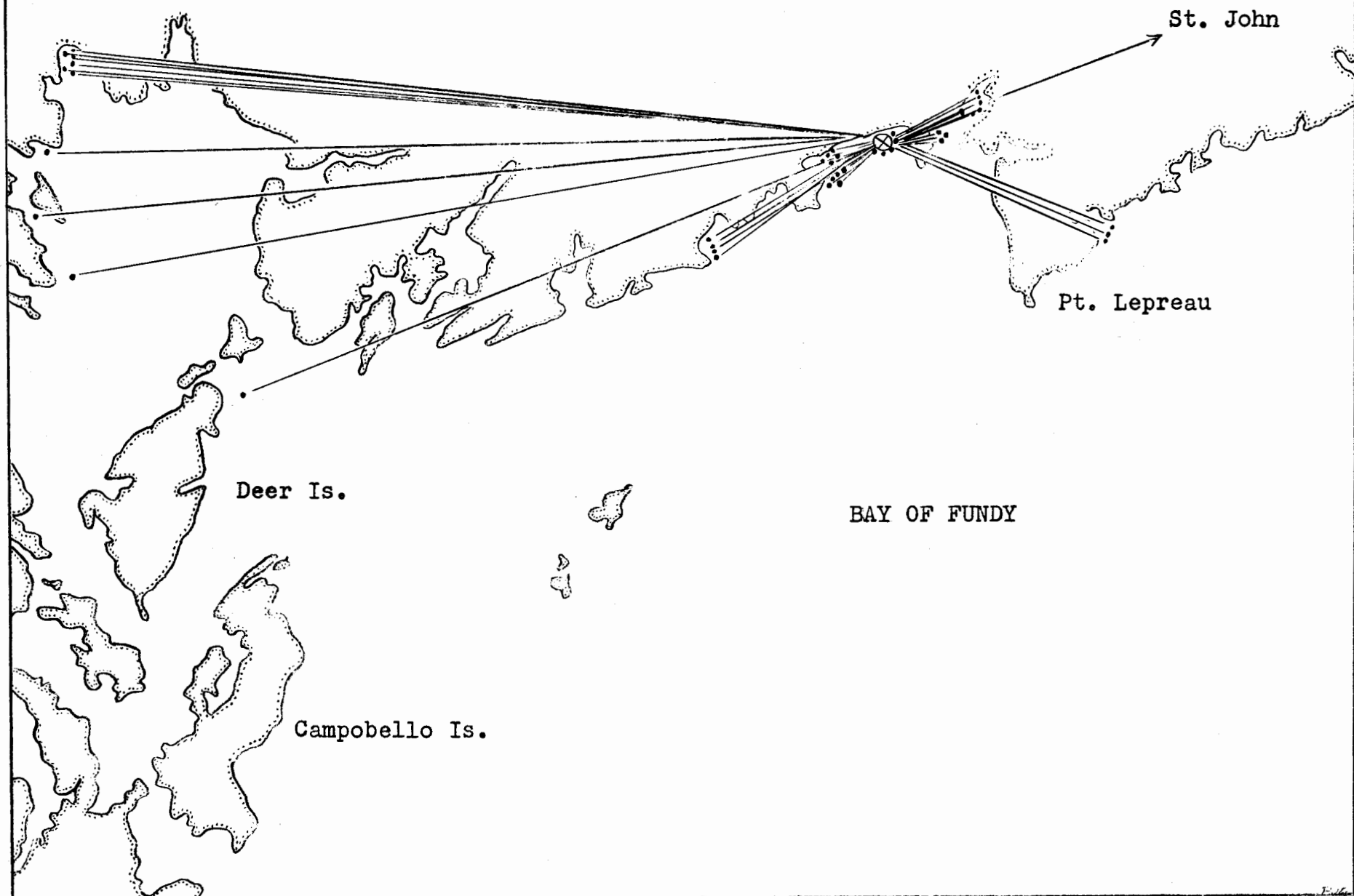
In the first 10 days following tagging only about 15% were taken more than 2½ miles from the tagging site. However, this percentage increased rapidly till by the fourth 10-day period, and thereafter, all the recaptures were made more than 2½ miles from the tagging site.

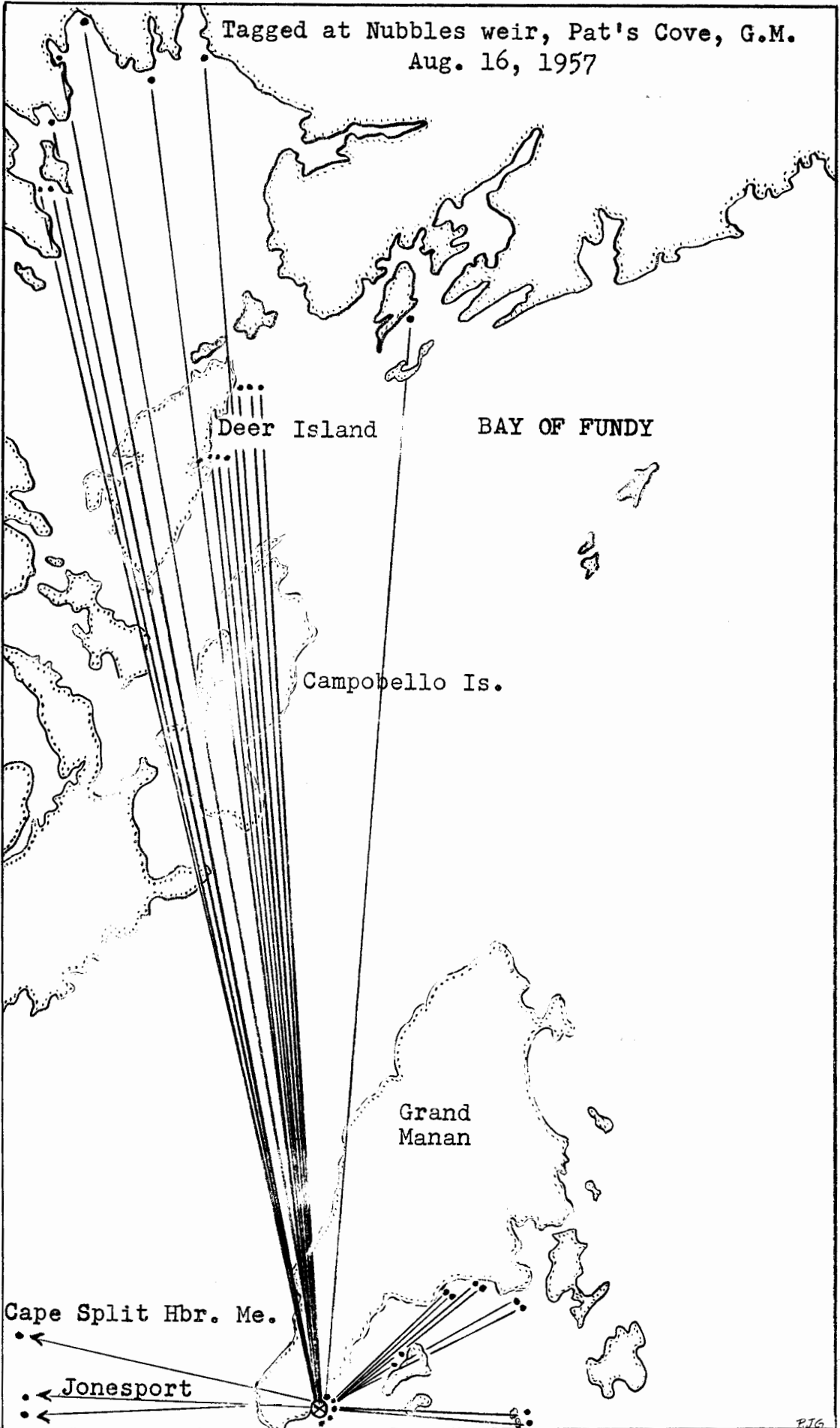
No recaptures have as yet been made from the Nova Scotian tagging and only local ones (with one exception) from the coast of Maine. Recoveries from the different taggings in Charlotte County waters show that herring move both in and out of Passamaquoddy Bay,

Tagged at Apple Tree weir,
July 9, 1957



Tagged at Harvester weir,
July 23, 1957





Herring taggings and recaptures, 1957

Area	Tagged	Recaptures	
		Number	Per cent
Western Nova Scotia	4,936	0	0
Point Lepreau	2,183	58	2.7
Passamaquoddy, Can.	16,167	306	1.9
Passamaquoddy, U.S.	5,849	140	2.4
Grand Manan	2,973	36	1.2
Coast of Maine	5,387	252	4.7
	37,495	792	2.1

coming from Grand Manan (2 uncertain recaptures of herring going to Grand Manan) as well as both coming from and going to the shore of the Bay of Fundy as far east as Saint John. There was no movement from the Passamaquoddy area to the outer coast of Maine but one tagged fish moved from the coast of Maine to Point Lepreau. Movements of herring as shown by recaptures from two lots of tagged fish are illustrated in the accompanying figures.

In general, most of the movement appeared to be into Passamaquoddy Bay. This conclusion is supported by the heavy fishery carried on at the head of this Bay during most of the summer and autumn.

R.A. McKenzie

No. 45

BEHAVIOUR STUDIES

An investigation into the behaviour of herring was begun in September 1957. This included laboratory experiments of behaviour in respect to currents and studies of the depth distribution of herring as indicated by sonic sounder recordings.

Laboratory studies.

For experimental purposes a stock of live herring was obtained from a weir off Pagan Point. The tanks used to hold this stock are all supplied with running sea water and an air supply. The herring are fed twice daily on a macerated cat food-mussel mixture to which yeast and terramycin are added before feeding as described by Farrin, Scattergood and Sindermann (U.S. Dept. Int., F.W.S. Prog. Fish. Culturist, 19 (4), 188-189, 1957). Under these conditions the herring are healthy and suitable for experimental work.

The herring were divided into two groups, 52 being placed in a glass tank 98" x 25" x 23" deep and 66 in a wooden tank 106" x 57" x 48" deep. The glass tank was found to be unsatisfactory as the fish swam so vigorously and continuously against the glass that considerable damage was caused to the anterior region of the head. In the glass tank mortality in the first and second weeks was 6% and 13% respectively compared with a mortality of 0% and 3% for fish kept in

otherwise similiar conditions in the wooden tank. The mortality of the herring placed in the wooden tank up to February 4th, 1958. (19 weeks after capture) was only 9% in spite of a transfer to a smaller wooden tank at the end of December.

Preliminary trials with apparatus designed to investigate the herring's behaviour in water currents showed that if resting pools containing still water were present together with a lateral passageway in which water was flowing the variable time spent by the herring in the still pool made recording of their responses difficult. A second arrangement, in which two pools with slowly flowing water were connected together through a parallel sided passage in which the water flowed more swiftly, was unsatisfactory as the fish only altered their orientation in the wide pools. When the passage was replaced with an hour-glass shaped constriction formed by transparent plastic sheets, the herring refused to pass from one pool to the other even in the absence of water flow. Spot measurements of current speed which would be necessary in such an arrangement also presented difficulties. Trials in which still water was suddenly caused to move were unsatisfactory as the herring reached the end of the tank, where it was in any case forced to turn, before the water flow had been established. In an apparatus presenting a choice of similar passages, one with still water and one with flowing water, the herring's choice appeared to be governed by factors other than the current flow.

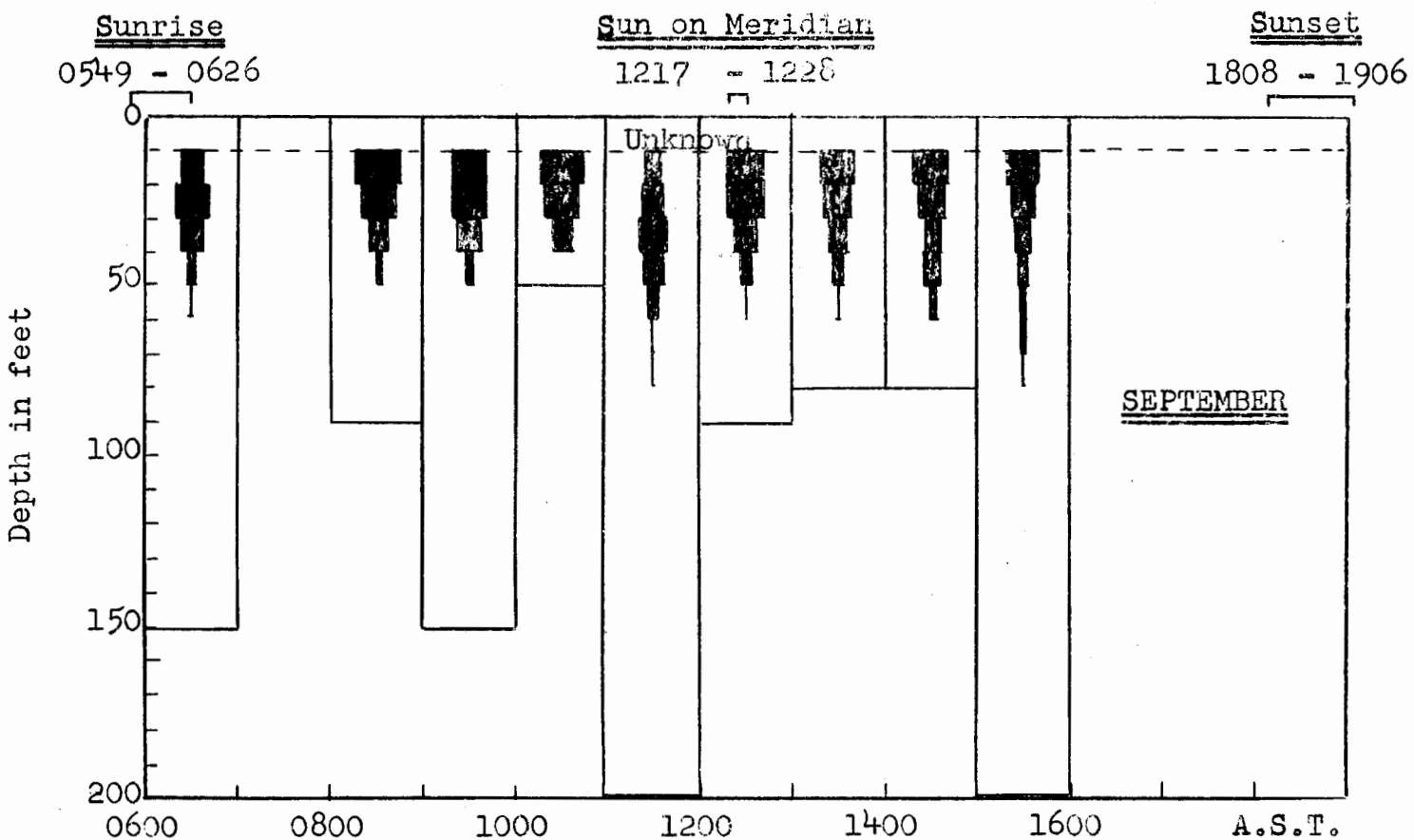
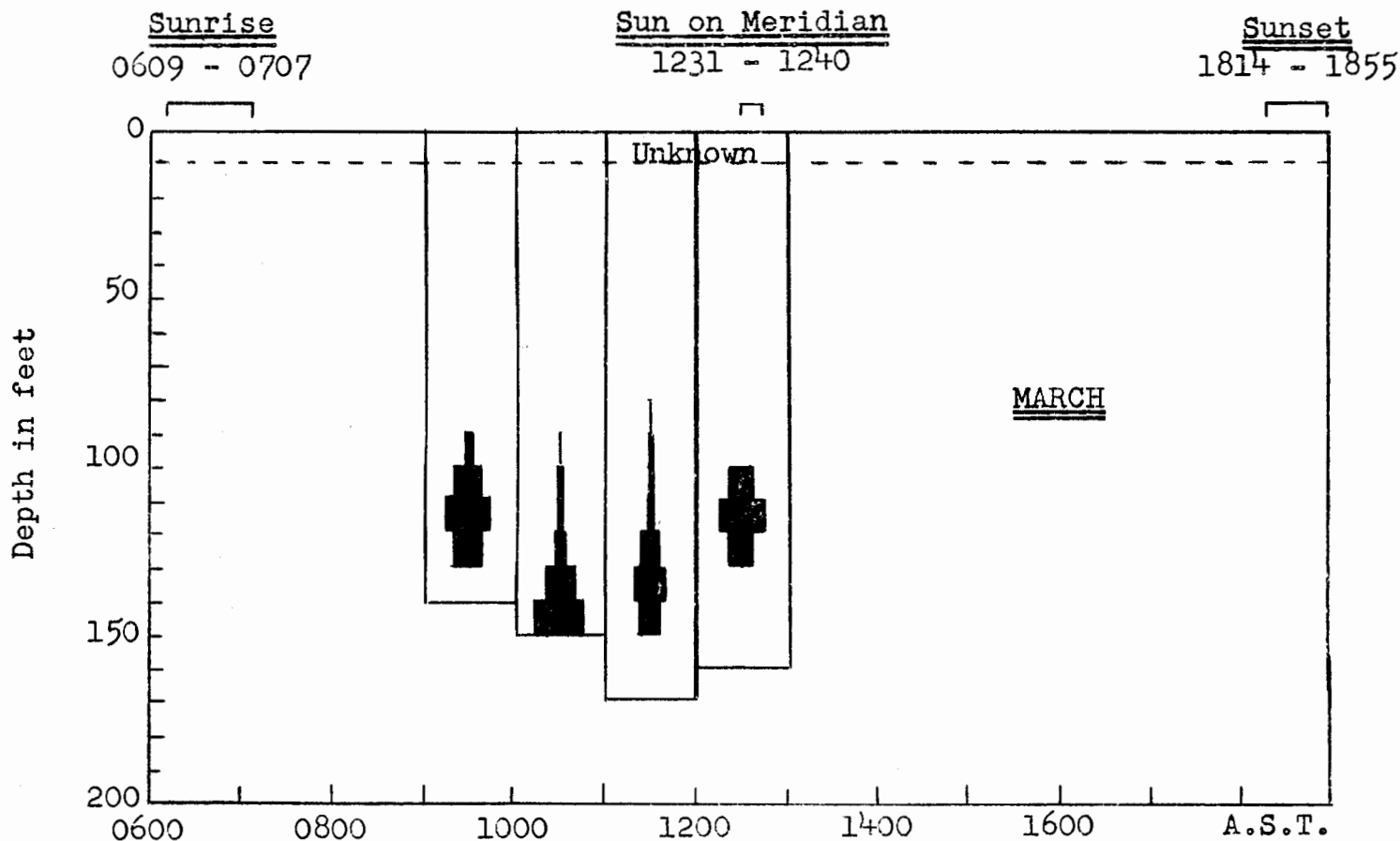
The apparatus which was finally selected has the following features. It is uniform in cross section and allows part of the water to be recirculated. In preliminary trials this recirculation was shown to raise the maximum current speed from 6 to 8 cm./sec. A uniform current speed is ensured by incorporating a constant level device in the inflowing stream. Provision is made for presenting the sides and bottom of the tank either uniformly black or in bold black and white stripes thus altering the features of the visual field. The observer is screened from the fish. With this apparatus the orientation of herring in currents of various speeds, changes in this orientation with time, with different temperatures and sizes of fish and with changes in the visual field can be determined.

A circular activity tank to record changes in spontaneous activity with changes in temperature, light intensity, time of day and fish size has also been designed but is not yet in operation.

Field studies.

In a preliminary investigation into the seasonal and diurnal variation in depth of herring shoals echo sounder records made in Passamaquoddy Bay between 1951 and 1957 were examined. These records bear a grid of lines spaced at 1-minute intervals horizontally and at 10-foot intervals vertically. Using this grid the proportion of squares bearing fish traces to the total number of squares in each 10 foot depth zone was determined. All the records for each hour of the day were treated together for every month.

The records for these years covered only the daylight hours between 0600 and 1800 hours and even in this restricted range were not complete for any month. However, there were sufficient traces



Vertical distribution of fish in Passamaquoddy

Bay in March and September 1951-'57.

to show that, during the day, fish shoals in Passamaquoddy Bay were in deep water in the winter and early spring and near the surface (10 to 40 feet) for the rest of the year. The appended graphs for March and September illustrate this change in distribution. The width of the "kite" in each depth zone represents the percentage of the total fish traces recorded in that hour which occur in each depth zone, after applying a correction to the lower zones to compensate for their lesser extent. The sound dome of the echo sounder is located on the bottom of the boat and hence the records give no information on the presence or absence of fish in the upper 10 feet.

In January, traces of fish shoals were found at all levels, from 10 feet down to shoals adjacent to the bottom in 110 feet of water. A single February record showed fish in mid-water at 60 to 75 feet. On March 7, 1956, large shoals up to 50 feet thick were found along the Perry shore, most shoals extending down to the bottom at 130 to 150 feet. A tow of 1 hour 5 minutes made at the same time with a bottom trawl gave 3,000 pounds of herring. In April the fish shoals were still in the deeper water, mainly between 60 and 100 feet but by May and throughout the summer months until September more than 70% of the fish traces occurred in the upper, 10 to 40 ft. zone during daylight hours. The single records for October and November show that more than half of the fish traces still occur in the 10 to 40 ft. zone. There were no satisfactory records for December.

If the proposed dams are built across the entrances to Passamaquoddy Bay the extent to which they interfere with the movements of herring in and out of the Bay will depend in part on the depth of the herring shoals. For this reason it is important that this picture of the seasonal vertical movements of fish shoals be extended by additional records, especially for the winter months. It is equally important that more information be obtained of diurnal changes in the location of fish shoals.

V.M. Brawn

No. 46

PLANKTON

As a partial background for the current studies on herring larval distribution the collections (about 500 tows) at stations Prince 5 and 6 were examined for the years 1947-1957 inclusive and 28 larvae, 9 mm. to 49 mm., were found. More than half of these larvae were taken in November and December with the remainder in March, May, June, and September. Seven were found at Prince 6 inside, and 21 at Prince 5 outside Passamaquoddy Bay.

In the 1957 plankton collections fish larvae were frequently found, but only 2 herring larvae were taken in a total of 294 tows made at the 14 stations during 21 cruises covering the Quoddy region. Both specimens were taken at station 3 just east of Deer Island; 1 in April 42.0 mm. long and 1 in October 14.5 mm. long.

To supplement information gained from the collections in the Passamaquoddy area 3 cruises were carried out in the Bay of Fundy and the Gulf of Maine, one in September, one in October and one in November using both metre nets and Hardy recorders.

In September only 1 herring larvae was taken, a 12 mm. specimen taken off Yarmouth. In October a few larvae were found off Yarmouth, larger numbers along the Nova Scotian side of the Bay of Fundy and fewer on the New Brunswick side--a total of 1,095 being taken. The October cruise yielded 347 herring larvae with the heaviest concentration being found on the northeastern part of Georges Bank. A medium concentration off Cape Fourchu extended northward, becoming heavier at the head of the Bay of Fundy on the Nova Scotian side and much lighter in the centre of the Bay and on the New Brunswick side at the head of the Bay. Light concentrations were also found just south of Penobscot Bay and east of Cape Small in Maine.

Comparing the metre nets with the recorder collections shows 1,442 herring larvae taken by the former and 12 by the latter method. The pattern of distribution of the larvae was found to be the same in the two methods for the same cruise.

In both the October and November collections (only 1 larvae in September) 78% and 93% respectively were taken at night.

The larvae may be classified re length as follows, --

	<u>October</u>	<u>November</u>
6.5-9 mm.	124	125
10-19 mm.	803	169
20 mm. +	<u>166</u>	<u>51</u>
	1,093	345

In October there was a tendency for a greater proportion of the larger larvae to be taken at night while in November the reverse occurred.

The Kennebecasis has been considered to be somewhat similar physically to the expected conditions in Passamaquoddy Bay if dams were installed. Plankton collections from the May, August, and December cruises in the Kennebecasis show the volumes of herring food to be very small and only 2 herring larvae (18 mm. and 26 mm.) were taken, both in December and at different stations.

The following groups in the plankton were considered as the more important items of herring food: copepods, euphausiids, sagittae, amphipods and annelids. Other less important items were pteropods, gastropods, barnacle larvae, cladocerans, appendicularians, crab and other decapod larvae as well as eggs. Non-food items consisted of juvenile and adult forms of ctenophores, coelenterates and salps.

In the Bay of Fundy and Gulf of Maine plankton collections, relatively little food was found in September although rich concentrations of food were found in the western part of the Gulf of Maine off Penobscot Bay as well as off south west Nova Scotia. In October the largest volumes of food were found on the New Brunswick side of of the outer part of the Bay of Fundy. The bulk of the copepods was found around the mouth of the Bay of Fundy. Heavy concentrations of food organisms were found in November in the open waters of the Gulf of Maine. Near shore and over the entire Bay of Fundy the volumes

were much smaller.

A comparison of the distribution of the herring larvae and food volumes shows that most larvae were found in areas of average food abundance while fewer larvae were taken both where the food organisms were scarce as well as very abundant.

The mean monthly volumes of herring food for the Quoddy region in 1957 have been determined and from a high concentration in January, due chiefly to the abundance of copepods, (Calanus finmarchicus), the plankton volumes decreased steadily through February and March. In April the volume of plankton increased because of an abundance of crab and barnacle larvae with a further increase in June due to pulses of Calanus finmarchicus, juvenile euphausiids and crustacean larvae. The volumes of food in July decreased considerably but in August they were up again due to the presence of many adult euphausiids. This level of food volume was maintained in September by another small pulse of Calanus finmarchicus while the peak for the year occurred in October because of a very large pulse of the copepod Centropages typicus. A decline in November continued into December to give the lowest volumes for the entire year.

The accompanying charts give a comparison at roughly comparable periods of the volumes of food inside and outside Passamaquoddy Bay in 1956 and 1957. The total volume of the herring food items in the plankton was roughly equal in the May to August periods of these two years. However, there were important differences. In 1956 only about 10% of the plankton was taken inside the Bay while in 1957 about 35% or 3 to 4 times as much was obtained inside Passamaquoddy Bay. Month by month only a small fraction was obtained inside in 1956 compared to appreciable fractions in 1957. In 1956 the peak volume occurred in late June both inside and outside the Bay. In 1957 the peak inside occurred in mid July but outside the peak occurred in mid August. It is interesting to note that along with this greater volume of plankton inside the Bay in 1957 a heavy herring fishery was carried on at the head of this Bay during most of the summer in contrast to a poor fishery in 1956.

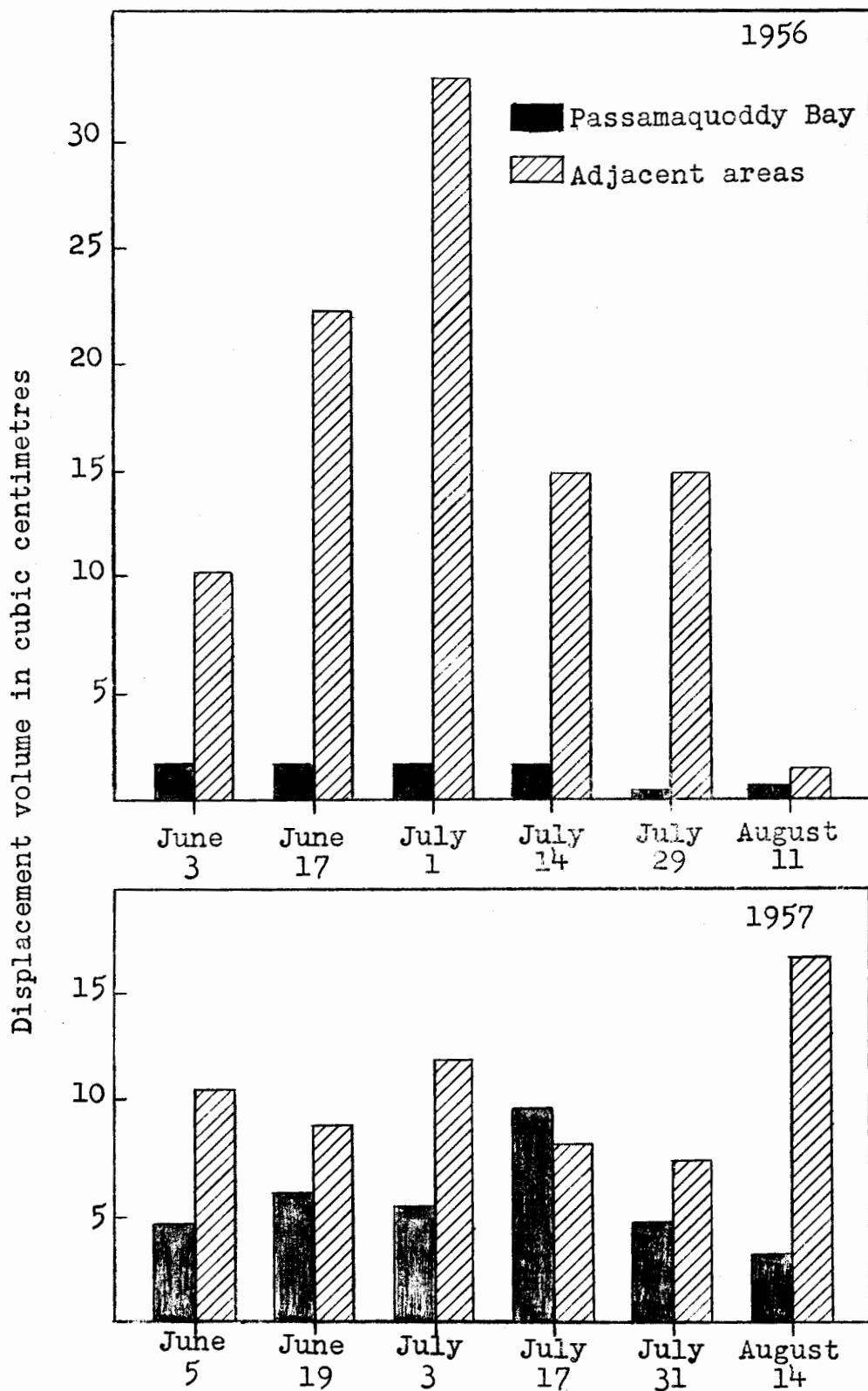
J.E.H. Legare

No. 47

EXPLORATORY FISHING

The commercial herring fishery in and around Passamaquoddy Bay is carried on chiefly with weirs that are built out from the shore. Some purse seining is done but it too, is within a few hundred feet of the shore. In an attempt to learn something of the distribution and abundance of herring in the open waters of the Bay and adjacent areas special fishing experiments were carried out during the year. In addition there were three short cruises in Kennebecasis Bay on the Saint John River system and one cruise to Georges Bank.

During the latter part of May, Dutch herring trawls were used from the M.V. Harengus inside the Western entrance to Passamaquoddy Bay. Herring catches amounted to 50 to 70 pounds per tow. Small quantities of haddock, cod, flounders and skate were also taken.



Plankton concentrations in the
Passamaquoddy Region, 1956 and 1957.

In mid August, curtain gill nets, graduated-mesh gill nets and mid-water trawls were used from the chartered vessel Betty Lou IV in Passamaquoddy Bay. Only small numbers of herring (maximum 23) were taken in the gill nets and no fish of any species in the mid-water trawls. Throughout October a single boat, mid-water Larsson trawl was used from the Harengus in and around Passamaquoddy Bay. No fish were caught despite indications of their presence on the echo-sounders.

During the planning of the Passamaquoddy Investigations it was noted that Kennebecasis Bay might be expected to have some of the physical characteristics of Passamaquoddy Bay after power dams were installed. For this reason four seasonal cruises were proposed and three were completed in 1957. The major effort involved collections of hydrographic data (Trites, Annual Report AOG) but some plankton and fishing records were obtained. Fishing was done with gill nets, line trawls and Dutch herring trawls and catches included small quantities of herring, gaspereau, sturgeon, tomcod, winter flounder, eel, smelt, hake, cod, whitefish, sculpin, shrimp, redfish and stickle-back.

During 1955 bottom trawl fishing on the Northern Edge of Georges Bank gave evidence of a large spawning population of herring in that area during late August and early September. Mature fish, some of them in the ripe and running stage, were taken in quantities of 2,000 to 5,000 pounds per tow at depths of 60 to 90 fathoms. Smaller, but substantial quantities were taken in the same area in mid August, 1956. The one cruise to Georges Bank in 1957 was made chiefly to obtain samples for population studies but did confirm the presence and abundance of a spawning stock in the area. The largest catch for a single tow was estimated to be 17,000 pounds.

S.N. Tibbo

No. 48

HERRING CATCHES IN RELATION TO ENVIRONMENT

A study of the herring landings in the Passamaquoddy region shows that year by year there is great variation in the availability, and possibly the abundance, of herring. During the last 20 years the annual Canadian landings in Passamaquoddy Bay (District #52) have varied from 3.0 million pounds in 1949 to 28.1 million pounds in 1952, a variation of almost 10 times. In various subdivisions of the Bay average weir catches in 1957 varied from zero to 675 thousand pounds.

The explanation of these tremendous fluctuations is urgently needed to predict the changes in the fisheries of the region if dams are to be installed at the mouth of Passamaquoddy Bay. Accordingly, some initial comparisons of catches have been made with meteorological, hydrographic, and biological conditions in the area. Past data on temperatures (air and water), rainfall (river run-off), winds, sunshine, cloud-cover, etc., have been examined to see if any relationship exists between such factors and the abundance, distribution, or movements of herring in the "Quoddy" region.

In the 73 comparisons that have been made so far, no

significant correlations have been discovered. Analyses to date have been concerned chiefly with temperatures and river discharge versus catches in the statistical subdivisions of Charlotte County, and in the county as a whole. Plankton collections over a 20-year period are being examined and wind data assembled for a continuation of this study.

R.A. McKenzie

No. 49

SOUTHWEST NOVA SCOTIA HERRING INVESTIGATIONS

The herring fisheries in Digby, Yarmouth, and Shelburne Counties are undergoing a rapid expansion. Landings have increased steadily from 16.8 million pounds in 1948 to 42.0 million pounds in 1957. Increased fishing activity in these areas was undoubtedly influenced by a scarcity of herring on the west side of the Bay of Fundy between 1952 and 1956. However, with a return to normal catches in New Brunswick and Maine in 1957, expansion of the fishery in Nova Scotia has continued. Markets have become available for the increased herring landings through an improvement in the demand for herring for food products in Yarmouth County, and through expansion of meal and oil plants and pet food canneries in Maine.

A study of the biology of herring in southwest Nova Scotia that was originally intended to provide a background for offshore and offseason explorations has been directed to following the course of this expansion, with particular attention being given to any changes that may take place in the size and age composition of the stocks, and in the annual recruitment. Mr. E.G. Sollows, resident technician in the area, has had major responsibility for data collections and preliminary reporting.

The fishery

The most important development in 1957 was the use of purse seines for catching adult herring offshore. This took place chiefly in the Digby area, but substantial purse-seine catches were made in the Trinity Ledges and Lurcher Shoals areas. Although statistics do not separate landings by type of gear, it is certain that purse seines accounted for most of the 16.7 million pounds caught in the Digby Neck area. This quantity of herring is more than 8 times the average catch at Digby Neck from 1947 to 1956.

In Yarmouth County anchored gill net catches were generally poor throughout the season and drift netters accounted for approximately two thirds of the catch. In Shelburne County where weirs and shore seines have been the chief methods of capture for several years, landings were below average. Herring were reported to be abundant in the area and a single shore seine catch made nearby at Argyle was estimated at 1,000 hogsheads (1 million pounds).

In general, throughout Digby, Yarmouth, and Shelburne Counties the supply of herring is greater than the demand and fishermen are frequently unable to sell their catches.

Length and age studies

Routine sampling of commercial catches for length, age, and vertebral count analysis was continued throughout the year. In the 24 samples that were examined, mean lengths varied from 27.8 to 34.3 centimetres. This is similar to the values obtained in 1956 (27.9 to 33.3 cm.) and in 1955 (30.6 to 34.2 cm.). It must be pointed out that most of the samples were obtained from gill nets, which are selective for size, and these mean lengths may not be representative of the stock as a whole. There is no evidence, however, of any decrease in length composition with increased exploitation. Age and vertebral count analyses have not been completed, and no report is available at this time. Ripe and running herring appeared first in a sample taken on August 27, and spawning was still in progress on October 4.

Spawning and early development

The commercial fishery in southwest Nova Scotia depends chiefly on late summer and fall spawning stocks. There are some spring spawnings in the area, but little is known of them. In 1957 efforts were directed towards discovering the location and extent of spring spawnings, and the distribution, abundance, and growth of herring larvae generally.

The first direct evidence of spring spawnings was obtained from Port Maitland and Tiverton where ripe and running herring were caught in gill nets on May 23 and 24. Lobster fishermen in this area occasionally find herring eggs on their traps in April. Herring larvae 9 to 12 millimetres long were taken in St. Mary Bay on May 24, and this supports the belief that spawnings do occur in April. However, the major spawnings usually occur from mid August to early October, and larvae of from 5 to 20 millimetres are abundant throughout the area in September and October. With the approach of winter, growth is slow and development beyond the larval stage does not occur until the following year. In late March and early April, 24 larvae, 25 to 30 millimetres long, were taken in St. Mary Bay. From May 4 to 10, 686 larvae from 35 to 60 millimetres long were taken in the same area. By mid June the average size had increased to 64 millimetres (232 larvae). Above this size they disappear from plankton tows. There is evidence, however, from collections taken from cod and pollock stomachs that the larvae reach a length of 90 millimetres by mid September when they are approximately one year old.

General

The importance of continuing these studies is apparent both from the point of view of following any effects of increased fishing effort on size and age composition of the stocks, and to test an hypothesis that the Nova Scotia populations contribute substantially to the fishery for juvenile herring in Saint John and Charlotte Counties in New Brunswick.

S.N. Tibbo

No. 50

RELATIVE ABUNDANCE OF HERRING LARVAE

In an attempt to discover whether a relationship exists between the abundance of herring larvae and subsequent recruitment to the commercial fishery, studies of annual variations in larva abundance have been carried on since 1951. The material was provided by Dr. D.G. Wilder and consisted of a sample of plankton collections for lobster larvae that were taken in the west entrance to Northumberland Strait in the Gulf of St. Lawrence. The tows were made with a rectangular 12 foot by 3 foot plankton net towed at the surface and were each of 30-minutes duration. The examination of tows and the sorting and counting of larvae was carried out by Miss P.J. Gibson. The number of tows examined and the number of larvae caught each year were as follows:

	<u>Period</u>	<u>No. of tows</u>	<u>Total No. of herring larvae</u>	<u>Average catch per tow</u>
1951	June 16-July 15	125	9,324	74.6
	July 18-Sept 21	213	0	0
1952	June 2-July 15	42	79,709	1897.8
	July 16-Sept 23	64	11	0.2
1953	June 15-July 15	35	29,958	855.9
	July 16-Sept 16	68	1	0.01
1954	June 16-July 15	36	5,588	127.4
	July 16-Sept 15	82	14	0.2
1955	June 15-July 15	46	18,758	407.8
	July 18-Sept 16	50	0	0
1956	June 15-July 14	54	1,706	31.6
	July 16-Sept 13	87	0	0
1957	June 15-July 15	73	2,375	32.5
	July 16-Sept 26	77	84	1.1

Comparisons of larval abundance are based on the results of tows taken up to and including July 15 since at about this time they are either large enough to escape the plankton net or have descended into deeper water layers.

Assuming that the average catch of herring per tow is indicative of the production of larvae, it is obvious that the variations from year to year are considerable. The small catches of larvae in 1956 and 1957 might be explained as resulting from a fungus disease that caused heavy mortalities and hence could have reduced the spawning population considerably. There is, however, no such simple explanation for the observed differences from 1951 to 1955. Commercial catches were relatively stable during these years with a maximum variation of 11.2 per cent, (20.0 to 22.4 million pounds) whereas, the average catch of larvae varied from 74.6 to 1897.8.

Since commercial landings may be more closely related to availability and/or market demand than to abundance, it is proposed to study variations in year-class strength within the spawning stock. Earlier (1946-1949) studies of herring populations in the Gulf of St. Lawrence have shown that the fish become spawning adults chiefly in their fourth or fifth year of life and hence, it is timely to compare

variations in larval abundance with the year-class composition of of the adult stock.

S.N. Tibbo

No. 51

HERRING EXPLORATIONS IN NEWFOUNDLAND

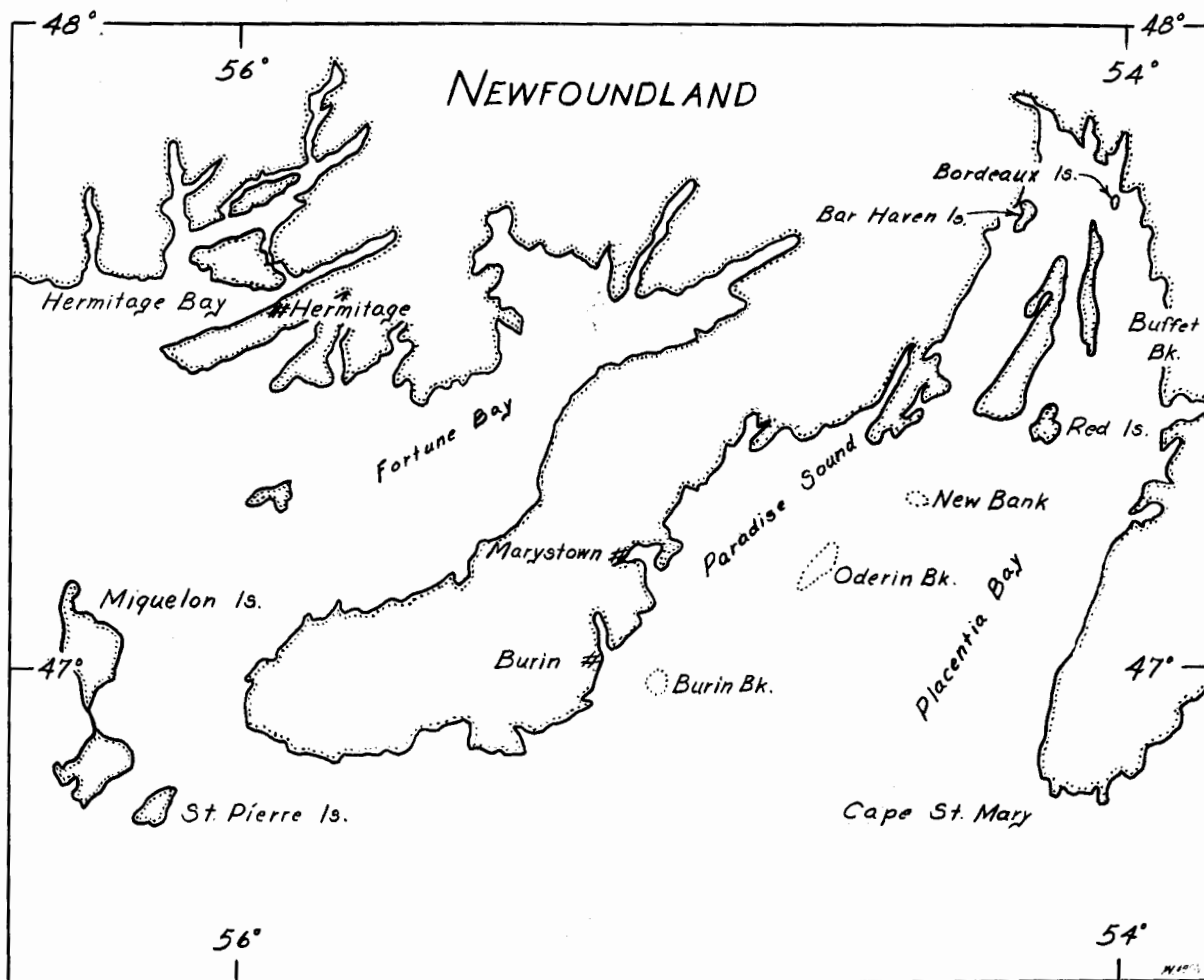
Detailed statistics of the herring fishery in Newfoundland are not available prior to 1953, but it is probable that landings along the south coast have exceeded 80 million pounds in some years. Where details are available slightly more than half the total catch is made on the south coast. In 1946, for example, the total Newfoundland landings amounted to 163 million pounds. In recent years, however, the catch on the south coast has declined rapidly. In 1953 it amounted to approximately 20 million pounds and in 1956, 3½ million pounds. During the 1957 season the fishery was almost a complete failure.

Biological studies of herring in the Fortune Bay area show that the stock is made up of accumulations of many year classes and the average age of fish in the commercial catch is from 10.4 to 11.6 years. The mortality rates, both natural and fishing, are therefore low and hence the decrease in landings (assuming no change in fishing effort) probably resulted from changes in availability rather than in abundance.

Explorations to discover the whereabouts of the stocks on which the fisheries have depended and to determine the distribution of immature fat herring during the summer months were carried out in Fortune and Hermitage Bays in 1956 and in Placentia Bay in 1957. These projects were supported financially by the Industrial Development Service of the Department of Fisheries. In 1956 the total catch of herring amounted to 31,925 pounds, an average of 55.6 pounds per net per night's fishing. For successful commercial operations the average catch would have to be, at least, 200 pounds per net.

A summary of the 1957 operations is contained in the accompanying table. As in 1956 the explorations consisted of setting a fleet of drift nets at various locations throughout the area. The nets were set during the evening and hauled back the following morning. Plankton tows and temperature observations were made at each fishing station and at intermediate points. Light and weather conditions were recorded and echo sounders were employed almost continuously. Samples of herring from the catches were examined for size and condition.

Altogether there were 36 drift-net sets with 20 nets each 37½ yards long and 360 meshes deep used for each set. Stretched mesh sizes were 2¾" and 2 7/8" and equal numbers of each mesh size were used. The total catch amounted to 15,990 pounds of herring and 367 pounds of other species, chiefly mackerel. No substantial quantities of herring were taken at any time. The largest single catch amounted to 2,870 pounds in a set on Oderin Bank during the night of June 24. Plankton tows throughout the area indicated a scarcity of food organisms but in 89 tows 402 herring larvae were



Summary of drift net fishing in Placentia Bay, Newfoundland. May to September, 1957.

Locality	No. of sets	Total No. of nets used	Total catch (lb.)	
			Herring	Others
Cape St. Mary	2	40	1955	35
Red Island	3	60	3080	-
Buffet Bank	3	40	323	-
Bordeaux Is.	4	80	805	7
Bar Haven	5	100	390	4
Paradise Sound	4	80	8	54
New Bank	4	80	1970	175
Oderin Bank	3	60	3010	70
Marystown	4	80	3068	22
Burin Bank	4	80	1341	-
			<u>15,990</u>	<u>367.</u>

caught. Length measurements were made on 45 samples of herring and included 5,463 individuals. Mean lengths varied from 34.4 to 36.7 cm. in the 2 $\frac{3}{4}$ " nets and from 36.1 to 37.8 cm. in the 2 $\frac{7}{8}$ " nets.

Weather conditions were generally poor with fresh to strong S and SW winds prevailing, especially during the latter part of August. This curtailed operations considerably since in winds of more than 15 to 20 knots the vessel drifts too fast for effective fishing.

There are indications that the spawning season in Placentia Bay extends over a considerable portion of the summer. Ripe, running and recently spent fish were taken as early as June 10 and as late as August 2. Spawning appears to take place earlier at the head of the bay and on the west side from Paradise Sound to Eurin Bank.

These experiments have contributed very little towards an understanding of the decline in the winter herring fishery and offer little prospect for a successful drift-net fishery in Placentia Bay during the summer months.

A new approach to the problem may be necessary and should include an intensive study of the biology of the herring stocks throughout the area.

S.N. Tibbo

No. 52

GEAR EXPERIMENTS

In many localities, chiefly within the Gulf of St. Lawrence, it has been shown that drift nets are considerably more effective for catching herring than anchored gill nets. This applies particularly, however, to summer seasons when herring are in open water areas and are more widely dispersed than during spawning seasons and in the winter.

During the late fall of 1956 arrangements were made with the Industrial Development Service and the Newfoundland Department of Fisheries for an experiment to test the effectiveness of drift nets during the winter and spring herring fishery on the south coast of Newfoundland. The nets were supplied by the Industrial Development Service and the provincial authorities made arrangements for their use by a fisherman (Mr. Bert Strickland) in Hermitage Bay. A condition of the arrangement was that reports on the operation of the gear be supplied to the Fisheries Research Board at St. Andrews.

Reports have been received regularly and a summary of the operations (see table) shows that from January to June drift nets were set on 43 occasions. The nets were set some distance from the shore, attached to the boat and allowed to drift from late evening until early morning on the following day. Average catches in April and May were as good as could be expected and are considered adequate for commercial fishing. The very large catches in June are indicative of heavy concentrations of herring that might support a purse-seine fishery.

<u>Month</u>	<u>No. of sets</u>	<u>Total no. nets used</u>	<u>Total catch lbs.</u>	<u>Av. catch/net lbs.</u>
January	3	15	Nil	Nil
February	2	10	Nil	Nil
March	4	20	20	1
April	8	36	8330	231
May	13	64	15325	241
June	13	65	40390	621

A comparison between drift nets and anchored nets used in the same general area clearly demonstrated the superiority of the drift nets. Over one 4-day period in April when 20 drift nets caught 7,855 pounds (av. 393 lb./net), 34 anchored nets caught only 1750 pounds (av. 52 lb./net). Over a 5-day period in May, 6,710 pounds of herring were taken in drift nets (av. 268 lb./net) but no herring whatsoever in anchored nets (number not reported).

Since the drift nets are only 25-30% more expensive than anchored nets, and the same boats and number of crew members can be used for each, it would seem reasonable to recommend a general introduction of the drift-net method to this fishery.

S.N. Tibbo

TROUT SUMMARIES

General summary of trout investigations

Fertilization and predator control to improve angling in soft-water Maritime lakes

Control of the eel in a New Brunswick lake

Pond formation on trout streams to improve angling

Estimates of trout and salmon populations in Ellerslie Brook, Prince Edward Island

Population of a Prince Edward Island pond with brook trout from its tributary stream

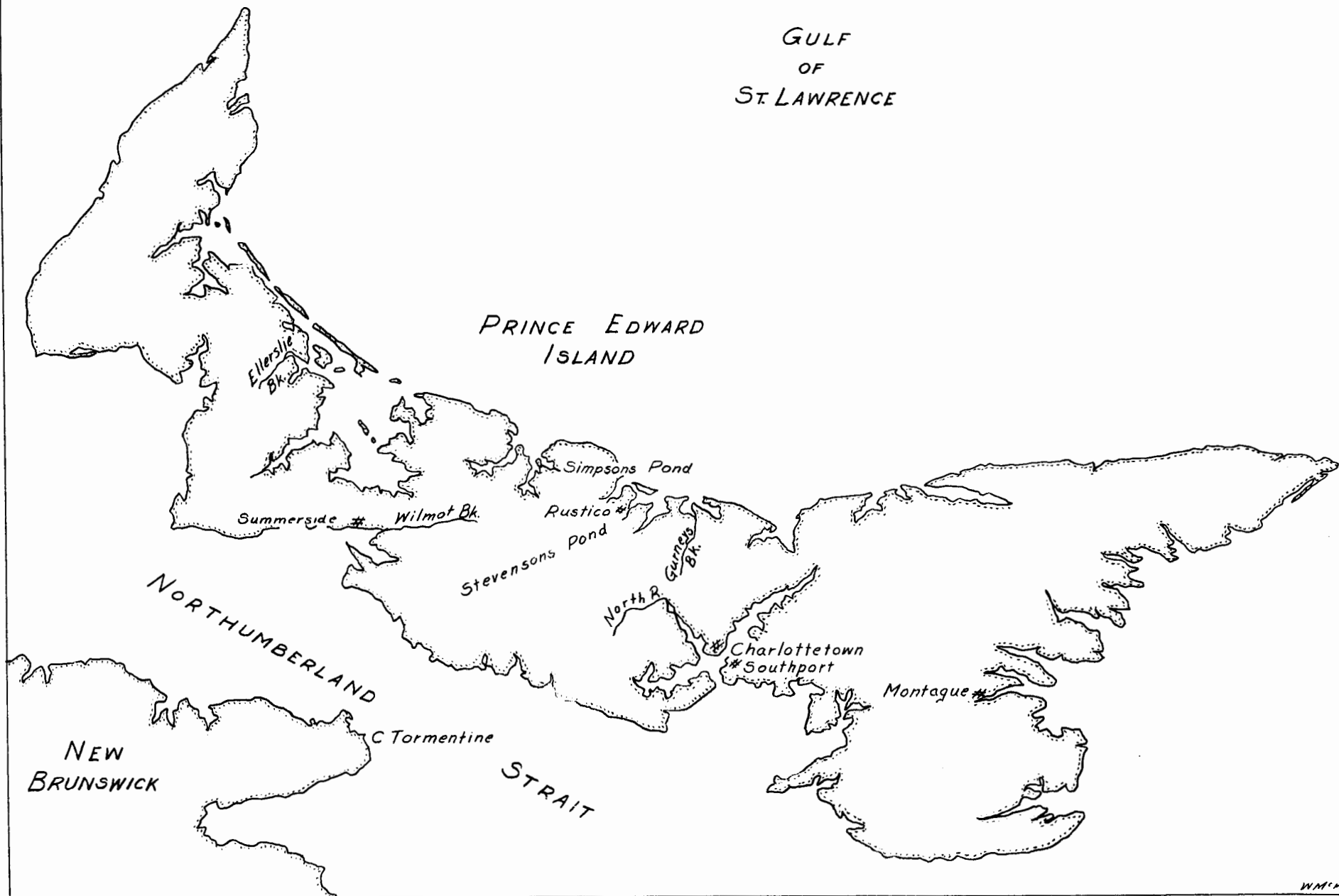
Movements and yield of trout to anglers at Wilmot Pond, Prince Edward Island

Trout in a small artificial lake on Prince Edward Island

Rainbow trout in a Prince Edward Island pond

GULF
OF
ST. LAWRENCE

PRINCE EDWARD
ISLAND



No. 53

GENERAL SUMMARY OF TROUT INVESTIGATIONS

The sport fishery of the Maritime Provinces is an important asset, now of high value and with proper management and exploitation potentially of greater value. The objective in research of the trout fishery is to improve production and yield to anglers under increasing angling pressure. To achieve the objective research has largely been directed to alterations of natural environments in waters of different productive levels which are representative of extensive Maritime areas.

Stocking waters of low to high productive levels augmented the existing supply of trout for anglers only to a minor degree. Concurrent application of fertilization, control of fish-eating birds and mammals and control of cannibalism to a shallow non-productive soft-water lake, representative of many in the Maritimes' mainland, resulted in a higher productive level and a marked increase in yield of brook trout to anglers. Stocking was effective and necessary. Control of non-sport fish in Maritime lakes by poison increased trout production, but only commensurate with the trophic level of the waters. Ponds formed in hard-water spring-fed streams are highly productive of trout, and improve the availability and yield of trout to anglers from a stream system. Where the brook trout moves to salt water, a pond formed on the stream markedly reduces the sea runs, especially where size of pond is large in relation to size of the tributary stream and stock of young fish.

Research is continuing in the direction of (1) manipulating environments to increase production of trout where low, (2) improving utilization of existing stocks, and (3) effecting better utilization of waters by acceptable sport species with higher survival and growth potential than brook trout. Limnological studies have shown that the fresh waters of the Maritime area can be usefully classified on a regional basis with respect to quality of waters for trout production, referable to the character of the underlying geological formation. Research should be sufficiently diversified to overcome natural deficiencies in trout production and utilization peculiar to the different limnological regions.

M. W. Smith

No. 54

FERTILIZATION AND PREDATOR CONTROL TO IMPROVE ANGLING IN SOFT-WATER MARITIME LAKES

The majority of fresh waters in New Brunswick and Nova Scotia, particularly the lakes, are soft waters. This signifies that the productive capacity of these waters is low. Fish production, including that of trout, is limited. Angling success for trout in these waters soon declines when they are subjected to appreciable fishing effort.

The waters of 50-acre Crecy Lake, New Brunswick, were enriched with commercial fertilizers in an attempt to increase the food supply for trout and thereby the production of trout. This lake is quite representative of many Maritime soft waters. Trout were planted since natural spawning was inadequate to insure sufficient stock to demonstrate effects of the procedure. Fertilization materially improved the growth of trout in Crecy Lake, but survival declined with increased predation by fish-eating birds and mammals attracted to the lake in greater numbers by the consistent annual stocking. Control of these predators was initiated, and extended later to reduction in the number of eels (Summary 55) and older trout. Characteristically for Maritime lakes, most of the trout are caught by the anglers during the spring months. Deferment of the opening date for angling from April 15 to June 1 was made in one year (1956) to learn if better summer angling success could be obtained. The results of these procedures are summarized in the accompanying tables.

The more important results of the various actions at Crecy Lake are herewith summarized:

1. Fertilization significantly increased the quantity of trout foods. Favourable effects of the fertilizers persisted for about five years.
2. The growth of the trout was improved above that encountered in lakes of the area. Fingerlings planted in early September provided trout of suitable angling size by the next spring.
3. Control of predators markedly increased the survival of the planted trout -- from less than one to a high of 42 per cent of planted fingerlings to the anglers' catches.
4. Deferment of opening of angling season to June 1 resulted in better catches to later dates in the summer, but the total catch was much lower (Table III).
5. Since 1951, the average cost of each trout taken by the anglers has approximated 75 cents, falling to about 45 cents when all management procedures were applied and the yield highest. The costs were for the stock of fish and for guardian services.
6. The improved angling was realized when the several procedures were concurrently applied -- stocking, fertilizing and predator control.

Table I. Growth and survival of planted trout in Crecy Lake.

	Year of Stock planting	Number planted	Average length (in.) when planted	Average length (in.) when angled the following year	Percentage survival to anglers' catches
Yr.	1944	675	11.5	14.4(1946)	0.9
Yr.	1945	812	7.5	10.1	10.1
Lake fertilized in June, 1946					
F.	1946	6,701	3.2	8.5	4.3
Yr.	1946	659	8.4	11.4	16.8
F.	1947	6,684	2.9	9.3	0.8
Yr.	1947	675	8.4	12.2	3.9
F.	1948	6,575	2.4	8.4	0.4
Yr.	1948	675	6.4	11.9	1.8
Control of fish-eating birds and mammals begun in August, 1949					
F.	1949	6,750	2.6	7.5	1.9
Yr.	1949	675	7.3	10.5	28.5
Trapping of eels in lake begun in June, 1950					
F.	1950	6,750	3.3	6.7	19.8
Yr.	1950	675	7.3	9.8	45.3
Second fertilization in June, 1951, and stocking rate doubled					
F.	1951	14,160	3.2	6.8	11.7
Yr.(1)	1951	674	10.1	10.4	81.9
Yr.(2)	1951	675	7.0	8.7	36.2
F.	1952	13,438	2.6	6.6	16.1
Yr.(1)	1952	675	10.5	11.3	85.0
Yr.(2)	1952	675	8.4	10.3	88.4
F.	1953	13,390	2.9	6.1	22.0
Yr.(1)	1953	675	9.8	10.3	79.4
Yr.(2)	1953	675	7.8	8.5	55.9
No yearling trout planted and number of older trout in the lake reduced by netting in 1954					
F.	1954	13,227	3.9	6.1	41.9
F.	1955	13,540	3.4	6.0	21.0
F.	1956	12,970	3.7	5.9	33.5

F. - fingerlings; Yr. - yearlings

Table II. Yield of trout to anglers from Crecy Lake.

<u>Year</u>	<u>Number caught</u>	<u>Number per rod-hour</u>	<u>Pound per acre</u>
1943	166	0.4	2.2
1944	148	0.5	1.5
1946	139	0.6	1.4
1947	425	1.0	3.6
1948	110	0.3	1.6
1949	39	0.2	0.9
1950	264	0.6	2.9
1951	1,441	1.4	6.4
1952	2,418	1.6	11.4
1953	3,276	1.9	18.1
1954	4,074	2.6	12.9
1955	5,623	3.2	10.7
1956	2,989	1.9	6.2
1957	4,602	2.0	8.2

Table III. Catch of trout from Crecy Lake in relation to season.

	<u>Number 1955</u>	<u>Number 1956*</u>
April 1-15	1,598	-
April 16-30	1,830	-
May 1-15	1,431	-
May 16-31	412	-
June 1-15	176	1,987
June 16-30	104	444
July 1-15	57	345
July 16-31	11	109
August 1-15	4	61
August 16-31	0	13
September 1-15	0	30

* Opening of angling season deferred until June 1.

M. W. Smith

No. 55

CONTROL OF THE EEL IN A NEW BRUNSWICK LAKE

The Amercian eel (Anguilla) is predacious and is a competitor of trout for food where the two species occur together. The eel is often a prominent member of the fish fauna in Maritime fresh waters. Control of the species is desirable for improvement of trout production.

The eel is catadromous. It is possible to reduce or destroy eel populations in lakes by trapping and poisoning but such lakes are soon re-populated by the annual runs of young eels into fresh water. A more effective long-term measure of control would be to prevent the entrance of the young eels into lakes. The practicability of this measure is being tested at Crecy Lake, New Brunswick.

In 1951 a barrier was erected in Crecy Lake outlet. The barrier consists of a low dam and a sluice over which all of the overflow from the lake is channelled, to drop about two feet into the stream bed below.

Also since 1950 eels have been captured in Crecy Lake by traps and set-lines. This effort provides information on the eel population persisting in the lake and on the effectiveness of such fishing methods. Data on the eels captured in traps and on set-lines are given in Table I. Few small eels have been captured although the gear would appear suitable for taking them. Most of the eels captured were of a size that run from the lake (Table II), or in other words, were individuals that had largely completed their life in the lake. Accordingly, fishing proved of limited value since it did not remove the young eels which still had years to spend in the lake. A general decline in the number of eels captured, as well as in the rate of capture, suggests a smaller population present in the lake in late years.

Table I. Eels captured by traps and set-lines in Crecy Lake.

<u>Year</u>	<u>Number caught</u>	<u>Number per unit of gear</u>	<u>Mean length (cm.)</u>	<u>Total weight (lb.)</u>
1950	237	0.7 (trap)	42.4	124.0
1951	105	0.5 "	38.0	28.5
1952	405	0.7 "	40.7	130.7
1953	144	0.4 "	40.7	51.7
1954	92	0.2 "	39.8	29.6
1955 traps	50	0.01 "	42.5	17.0
set-lines	218	1.1 (10-hook set-line)	44.3	95.0
1956 traps	2	0.04 (trap)	44.5	18.5
set-lines	62	0.5 (10-hook set-line)		
1957 traps	29	0.2 (trap)	40.7	24.9
set-lines	42	0.5 (10-hook set-line)		

Table II. Outward migrating eels captured in outlet trap at Crecy Lake.

<u>Year and Season</u>	<u>Number caught</u>	<u>Mean length (cm.)</u>	<u>Total weight (lb.)</u>
1950 Spring	90	32.7	17.0
Fall	105	38.5	78.8
1951 Spring	55	34.0	11.6
Fall	357	36.4	103.9
1952 Spring	41	34.4	8.1
Fall	328	36.0	77.4
1953 Spring	33	44.2	20.2
Fall	409	36.3	93.8
1954 Spring	69	46.0	27.4
Fall	337	37.1	84.9
1955 Spring	8	39.3	4.8
Fall	126	37.3	16.1
1956 Spring	31	36.8	7.3
Fall	126	35.6	28.0
1957 Spring	154	35.6	41.3
Fall	47	44.3	26.2

Eels have been taken as they leave the lake in a trap installed in the outlet and operated throughout the year. Since at approaching maturity all eels will eventually leave the lake, the numbers captured in the outlet trap will then be the gauge of success of the control methods. The numbers taken in the outlet trap for the period 1950-57 are given in Table II.

The majority of eels leave Crecy Lake when six to eight years of age. The barrier against the entrance of the young was installed in 1951. Accordingly it is yet too soon for the barrier to have had its full effect upon the lake population. However, the smaller numbers captured from the lake and in the outlet trap during the last two or three years indicate some effect.

From 1950 to 1957 inclusive, 1,167 pounds of eels have been captured at Crecy Lake. Anglers removed 2,281 pounds (weight at capture less weight when planted) of trout during the same period. Assuming that the food consumed by eels had been available to trout and that the conversion into fish flesh is of the same order for the two species, the trout production, as expressed by yield to anglers, could have been about 50 per cent greater than was realized. The estimate is crude, yet gives expression to the effect of eel competition on trout production.

No. 56

POND FORMATION ON TROUT STREAMS TO IMPROVE ANGLING

Pond formation as a management procedure to improve the trout fishery of a stream system is under study at Ellerslie Brook, Prince Edward Island. As with other streams of the area, the brook trout is anadromous in Ellerslie Brook. Thus, the study involves not only the movements of the trout within the stream but also between fresh and salt water. The yields of trout to anglers from the stream system before and after pond formation provide indices of the practical value of the procedure.

Ellerslie Brook provides a good trout habitat and it may be considered representative of the small productive streams of the region. Ellerslie Brook has an effective length for trout production of about $4\frac{1}{2}$ miles.

The movements of the trout have been studied by installing two-way fish-traps (1) near the head of tide at the mouth of Ellerslie Brook in 1946, and (2) 650 yards up-stream in 1950. A dam was built in 1952 just above the lower traps and a 7-acre pond formed. The upper traps are situated immediately above the pond.

The traps have been operated throughout the year and tended daily. Each trout moving through the traps is measured and jaw-tagged with a serially-numbered circular tag. After the pond was formed, the trout moving up-stream through the lower traps were transferred into the pond until December 31, 1955. After that date, all trout moving in from salt water have been excluded from the pond and the stream above. A creel census has been maintained on the stream system during each angling season.

The numbers of trout counted through the traps are given in Tables I and II. Most prominent runs of trout into the brook from salt water have occurred in April, June-July and the fall, and out of the brook in May and during the fall and early winter. Many of the runs of trout are associated with changing water levels in the brook and rise and fall of water temperature in the brook and estuary. However, simultaneous runs of trout of comparable sizes into and out of the brook show that the reactions of the fish to environmental factors may be complex. The developmental stages in osmoregulation in relation to salt water, and of maturity, contribute to the complexity. Nevertheless, analyses of the data are providing much understanding of the movements of brook trout that will be of value in management. There is no evidence, for instance, of a stream as distinct from a sea-run "race" of brook trout.

Pond formation has had a marked influence upon the movements of trout. In general, the pond on Ellerslie Brook has materially assumed the role of the estuary in providing a sizable body of water into which the trout may run from the stream. The observations lend support to the contention that the movements of

young trout are basically to larger living quarters which, before pond formation, was the salt-water estuary. With pond formation a larger proportion of the trout population in the Ellerslie system has remained in fresh water. The sea-run has been definitely reduced. Further, as shown in Table II, relatively few trout leave the pond for the stream above. However, population studies in the stream, as well as the number of trout moving down-stream into the pond, indicate that the stream remains well seeded without appreciable recruitment from below. The small run of trout downward through the upper traps in the fall in 1957 reflects unusually low water conditions, poor for fish movements, and a smaller stream population, below the average for several years.

Table I. Numbers of brook trout counted through the traps at the mouth of Ellerslie Brook.

	<u>April-May</u>		<u>June-July</u>		<u>Fall-Winter</u>	
	<u>Up</u>	<u>Down</u>	<u>Up</u>	<u>Down</u>	<u>Up</u>	<u>Down</u>
1946	-	-	902	97	1,110	2,049
1947	629	197	879	81	1,100	1,038
1948	78	88	563	15	491	1,706
1949	952	1,463	876	153	447	1,315
1950	950	465	460	39	126	1,136
1951	131	186	316	55	263	389
Pond formed in summer of 1952						
1952	657	108	321	10	0	45
1953	58	211	187	131	150	550
1954	334	413	626	44	53	155
1955	179	14	86	3	6	14
1956	99	16	151	9	42	128
1957	16	110	25	5	29	225

Table II. Numbers of brook trout counted through traps on Ellerslie Brook above pond.

	<u>April-May</u>		<u>June-July</u>		<u>Fall-Winter</u>	
	<u>Up</u>	<u>Down</u>	<u>Up</u>	<u>Down</u>	<u>Up</u>	<u>Down</u>
1950	-	-	-	-	240	1,596
1951	198	400	280	241	180	275
Pond formed in summer of 1952						
1952	465	45	161	42	59	1,139
1953	16	513	39	180	43	697
1954	46	195	11	254	158	613
1955	0	475	0	54	8	691
1956	0	145	2	102	39	1,634
1957	28	147	1	138	9	214

The results of the creel censuses are given in Table III. Prior to pond formation the average annual catch of trout was 1,478, at a rate of 1.8 fish per rod-hour. Since the pond has been formed, the average catch has been 2,073 trout at 1.2 per rod-hour. Thus, in average, there has been a 40 per cent increase in the number of trout cropped by anglers from the Ellerslie system since pond formation. The increased catch has resulted from a greater effort by the anglers. The pond and the pool below the dam have attracted more anglers than previously fished the stream.

Table III. Creel censuses of trout from the Ellerslie Brook system.

	<u>Number caught</u>	<u>Number of rod-hours</u>	<u>Number per rod-hour</u>
		Before pond formation	
1947	1,141	749	1.5
1948	1,086	708	1.5
1949	1,942	1,131	1.7
1950	1,608	884	1.8
1951	1,461	695	2.1
1952	1,628	716	2.3
		After pond formation	
1953	1,981	1,325	1.5
1954	2,949	2,452	1.2
1955	1,718	1,676	1.0
1956	2,047	1,605	1.2
1957	1,669	1,259	1.3

The catch of trout in 1957 was lower than any since the pond was formed in 1952. It is not clear whether the lower 1957 catch is beginning to reflect the more intensive cropping of trout from the Ellerslie system after pond formation since the 1957 angling season on Prince Edward Island as a whole was poorer than most years.

With the results to date, it may be concluded that pond formation, by retaining the trout in readily accessible areas to the anglers, substantially improved the utilization of the trout stocks. This was realized with a diminution in the number of sea-run individuals, but without jeopardizing the production of young trout in the tributary streams.

M. W. Smith

No. 57

ESTIMATES OF TROUT AND SALMON POPULATIONS IN ELLERSLIE BROOK, P.E.I.

Investigations begun in 1947 have been continued to date to evaluate the stocks of trout and salmon in Ellerslie Brook and to determine ultimately the effect of pond formation upon them. The study areas, together with their effective lengths in summer for the production of trout and salmon are as follows:

Ellerslie Brook proper	4,700 yards
Northwest Branch of Ellerslie Brook	550 yards
Southwest Branch of Ellerslie Brook (Hayes)	2,200 yards

Pond formation in late summer of 1952 reduced the effective length of Ellerslie Brook to 4,000 yards.

Methods of Assessment

Prior to 1950 Schnabel type estimates were made by marking and recapture. From 1950 through 1957 estimates were made by capturing all the fish in each sample area by electrofishing. With the exception of the 450-yard area in Hayes Brook the sample sections were 50 yards long.

Estimates of Trout Populations

The estimates for the study areas are given in Table I.

The upper and lower parts of the Ellerslie system differ in size of stream, amount of cover and character of the bottom. Most of the sample sections are in the lower area. As a result the estimates are biased by the failure of the samples to be truly representative of the population as a whole. In recent years the fishing equipment has been modified to fish more effectively in the more inaccessible areas of the upper part of the system.

In 1957, 500 additional yards were sampled in the upper area. More extensive sampling will be done in 1958.

The total annual standing crops of trout in 13 sample sections and in the 450-yard section of the tributary Hayes are given in Table II.

Some features of the data in Tables I and II may be noted.

1. The numbers of trout fluctuated considerably from year to year. Annual fluctuations in the number of older trout in Hayes Brook were appreciably less. This was due in large part to the constancy in the number of hiding places in Hayes Brook suitable for older trout. Changes in individual sections brought about by freshets and windfalls resulted in marked annual fluctuations in the number of trout in these sections.

2. In some years the numbers of fingerlings in the sample sections were insufficient to provide the numbers of yearling trout in succeeding years. Stocks of yearlings were maintained by movements of trout into the sections.
3. Following pond formation in 1952 most of the trout older than yearlings moved from the stream system into the pond. These movements have continued in subsequent years. Few trout have moved from the pond into the stream. Since 1952 approximately 80% of the trout older than fingerlings have been yearling fish in the annual stream populations. This has brought about a decrease in the average lengths of the older trout stocks.
4. The loss of the larger trout has not had an adverse effect upon the annual stocks of fingerlings.
5. Sea-run trout have been barred from the system since January 1, 1956. To date this has had no noticeable effect on the stream populations.

Effect of Pond Formation

The effect of pond formation has been a reduction in the age and size of the older trout stocks. Their numbers have not been noticeably affected. There has been no adverse effect on the number of fingerlings. The loss of sea-run trout to the stream has had no noticeable effect on the stream populations.

Estimates of Salmon Populations

Before the pond was formed the brook had an effective length in summer of 2,300 yards for the production of salmon. Pond formation reduced this to 2,000 yards. Estimates of salmon populations are given in Table III.

Table III. Estimates of salmon populations in Ellerslie Brook.

<u>Year</u>	<u>Salmon Fry</u>	<u>Salmon Parr</u>
1949	4,260	2,910
1950	780	5,230
1951	250	1,350
1952	-	1,000
1953	-	123
1954	1,762	64
1955	4,350	788
1956	-	2,654
1957	-	500

Table I Estimates of trout populations in Ellerslie Brook, Hayes Brook and Northwest Branch of Ellerslie Brook.

Year	Ellerslie Brook			Hayes Brook			Northwest Branch		
	Effective stream length (yard)	Number of fingerlings	Number of older trout	Effective stream length (yard)	Number of fingerlings	Number of older trout	Effective stream length (yard)	Number of fingerlings	Number of older trout
1947	4,700	no estimate		2,200	2,900	1,700	no estimate made		
1948	"	"	"	"	3,600	1,700	"	"	"
1949	"	5,900	7,900	"	2,600	1,400	"	"	"
1950	"	6,200	6,500	"	1,600	1,100	550	140	210
1951	"	2,700	4,300	"	800	2,000	"	460	250
1952	"	7,300	4,900	"	3,000	1,800	"	200	120
1953	4,000	3,800	5,200	"	1,500	1,800	"	40	140
1954	"	4,300	3,700	"	2,300	1,400	"	230	60
1955	"	6,100	5,900	"	3,700	1,900	"	230	140
1956	"	5,800	7,600	"	2,900	2,300	"	no estimate made	
1957	"	3,000	4,300	"	1,700	1,800	"	50	200
Mean		5,011	5,589		2,564	1,718		193	160
S		1,605	1,493		721	325		142	64
Coefficient of variation %		32	27		28	19		74	40

Table II Annual standing crops of trout in the same 13 section of Ellerslie Brook and in the Hayes Brook study area.

Year	Ellerslie Brook Proper				Hayes Brook 450-yard Area			
	Number of fingerlings	Average fork length cm. (inches)	Number of older trout	Average fork length cm. (inches)	Number of fingerlings	Average fork length cm. (inches)	Number of older trout	Average fork length cm. (inches)
1951	496	6.8 (2.7)	596	13.6 (5.4)	166	6.4 (2.5)	418	13.2 (5.2)
1952	1,059	6.4 (2.5)	661	13.8 (5.4)	611	6.1 (2.4)	372	15.4 (6.1)
1953	718	6.4 (2.5)	960	11.7 (4.6)	308	6.3 (2.5)	362	11.1 (4.4)
1954	702	6.7 (2.6)	639	12.8 (5.0)	468	6.3 (2.5)	294	12.9 (5.1)
1955	1,139	6.3 (2.5)	1,115	12.5 (4.9)	758	6.1 (2.5)	383	11.4 (4.5)
1956	890	6.8 (2.7)	1,363	12.2 (4.8)	580	6.8 (2.7)	467	11.4 (4.5)
1957	552	6.7 (2.7)	874	12.3 (4.9)	350	6.3 (2.5)	363	11.1 (4.4)
Mean	793		887		463		380	
S	245		283		203		53	
Coefficient of variation %	31		32		44		14	

There were no fry in the stream in 1957. The 500 parr in the stream were practically all 2+ fish.

The presence or absence of salmon fry or parr in the stream has had no noticeable effect on the trout populations.

The movements of salmon in Ellerslie Brook are discussed in Summary 66.

J. W. Saunders

No. 58

POPULATION OF A PRINCE EDWARD ISLAND POND WITH BROOK TROUT FROM ITS TRIBUTARY STREAM

Ponds formed on Prince Edward Island streams, when of suitable size and depth, provide good angling. Native stock for such ponds is recruited from the tributary streams. Data on the extent and rapidity with which the ponds are populated from native trout in the tributary streams comprise part of the information necessary to evaluate and apply pond formation as a management procedure. Coupled with information on the productive capacity of the ponds, assessment of recruitment from tributaries permits judgment, for instance, on the need of stocking from outside sources to realize as much of the productive capacity as possible.

Stevenson's Pond (area, 3 acres) was drained in June, 1956, and all trout removed. It was again drained on September 26-27, 1957, and the number and weight of trout in the pond determined. The trout present in September, 1957, had entered the pond over the preceding 15 months. As judged from observations on the movement of trout in Prince Edward Island streams, it seems likely that most of the trout moved into the pond during the fall of 1956 and late spring, 1957. The pond was screened to prevent escapement of the fish down-stream.

The number of trout taken from Stevenson's Pond when drained in September, 1957, was 1,344. Individual weights were obtained for a representative sample (637). The estimated total weight of the standing crop was 363 pounds, or 121 pounds per acre. Length frequencies are given in Table I. The larger proportion of the trout were of suitable angling size. Eighty-three per cent of the fish were 6 inches or more in fork length.

The tributary stream from which the trout in Stevenson's Pond were recruited has an approximate length of 3 miles. A part of the standing crop in the pond was produced in the stream. The majority of trout in Prince Edward Island streams first move down-stream into ponds (or salt water) when large yearlings or when 2 years of age. These trout are about one-quarter the average weight (4.3 oz.) of the trout taken from Stevenson's Pond. Thus, the portion of the standing crop found in the pond, but produced in the stream, was roughly 90 pounds, or 30 pounds per acre.

Table I. Length frequencies of brook trout from Stevenson's Pond.

<u>Fork length in inches</u>	<u>Number</u>	<u>Percentage of total number</u>
Under 6	233	17
6 - 7	201	15
7 - 8	193	14
8 - 9	217	16
9 - 10	202	15
10 - 11	220	16
11 - 12	66	5
Over 12	12	1

If Stevenson's Pond had not existed, most of the downward-moving trout would have gone to salt water. If Stevenson's Pond had not been screened, a portion of the trout would have left the pond. These statements are based on our general knowledge of the movements of trout in Island streams. The significant point to be made is that the high standing crop found in Stevenson's Pond would have been less, and possibly appreciably less, if the pond had not been screened to prevent escapement of the trout over the dam.

The production of trout in Stevenson's and other similar Island ponds has been previously studied by assessing the growth and survival with varying but known densities of stock. With initial densities of yearling trout from 400 to 800 per acre, no significant differences were found in growth rates, indicating that the higher density was still below the carrying capacities of the pond. The density of trout in Stevenson's Pond in 1957 was of the order of the higher populations previously studied. Although the standing crop found in 1957 may be considered high, it may, however, be inferred that the pond was capable of supporting more trout than entered from the stream, and, to obtain full utilization of the pond's productive capacity, supplementary stock was needed from outside sources. This view is supported by the excellent condition of the trout when removed from the pond in 1957. The trout had an average weight of 4.3 ounces and an average fork length of 8.1 inches.

M. W. Smith

No. 59

MOVEMENTS AND YIELD OF TROUT TO ANGLERS AT WILMOT POND,
PRINCE EDWARD ISLAND

Brook trout are anadromous in Prince Edward Island waters. Artificial ponds on Island streams often make good fishing areas. When ponds are held by dams which are provided with spill-ways, the return of sea-run trout to the ponds and their tributaries is prevented. Under the auspices of the

Government of Prince Edward Island fishing ponds have been created on streams by putting earthen embankments across stream valleys at suitable points. The overflow from such ponds is directed into a new stream around one end of the embankment. The overflow stream is unobstructed and its gradient is not so great as to prevent the upward movement of trout. It has been anticipated that these ponds would make more trout accessible to anglers by serving at least as temporary holding areas for fish moving up- and down-stream. How well this type of pond functions as a fishing area is under study on Wilmot Stream. In- and outward movements of trout are determined by capture in a two-way fish-trap installed at the point where the overflow stream leaves the pond. Each trout entering the traps is measured and jaw-tagged. A creel census is maintained. The census is thorough for the pond and the immediate area below, but less complete for the stream above the pond.

The traps have been maintained for the periods from June 14, 1956, to January 4, 1957, and from April 17, 1957, to January 15, 1958. Records of movements are given in Table I. Quite apparent in these is the disparity between number of movements into and out of the pond. Lack of spring records in 1956 provides partial explanation for that year but not for 1957. The records for the latter year suggest considerable recruitment of stock from the area below the pond but from where has not been ascertained. The stream is tidal to the foot of the embankment and there is only one small stream entering the tidal area.

The trap records show that the trout moves freely up and down the overflow stream that by-passes the embankment holding the pond.

Table I. Movements of trout through Wilmot Pond traps.

	1956		1957	
	<u>Up</u>	<u>Down</u>	<u>Up</u>	<u>Down</u>
April	-	-	1	86
May	-	-	10	658
June	1,566	39	1,366	11
July	575	2	412	1
August	9	0	8	7
September	30	17	36	18
October	177	71	65	27
November	139	173	143	318
December	1	140	20	172
Total	2,497	442	2,061	1,298

Angling data are given in Table II. The pond provided good fishing. The greater portion of the catches consisted of untagged trout which had entered the pond from the tributary stream but had not run to salt water. Those that came up-stream and were tagged contributed 19 per cent in 1956 and 15 per cent

in 1957 to the anglers' catches in the pond. The overflow stream functioned well in permitting large numbers of trout to move into the pond from the estuary. However, these trout made the minor contribution to the anglers' catches from the pond, suggesting that the pond did not function too well in holding the sea-run trout on their way up-stream. During the angling season in 1957, about 1,800 trout moved up-stream into the pond and were tagged. There was an unknown number of trout in the pond that had been previously tagged. During the angling season in 1957, there were only 282 tagged trout caught by the fishermen from the pond. The catchability of trout may be affected to an undetermined degree by tagging. However, it is known that tagged trout are readily taken by anglers. Thus, tagging is not considered a major factor in conditioning the observed low yield of tagged trout to anglers. Rather movement into the tributary stream is considered to have been the major determining factor.

Table II. Angling results for Wilmot Pond.

	-----Captured-----			% of marked trout among total taken <u>in pond</u>
	<u>in pond</u>	<u>outside pond (mainly below)</u>	<u>per rod-hour</u>	
1956	1,397	638	1.1	19
1957	1,880	802	1.0	15

The mean fork length of the trout that moved through the traps is given in Table III. Scale readings have shown that age I trout had a mean length of 14.8 cm.; age II, 17.3 cm., and age III, 22.3 cm. On the whole, the trout were young fish. This observation is in agreement with our general observation that most of the trout in Prince Edward Island waters are short-lived.

Table III. Mean fork length of trout moving through Wilmot Pond traps.

	<u>April-May</u>	<u>June-August</u>	<u>September-December</u>
<u>1956</u>			
Up	-	15.6 cm. (6.1 in.)	18.3 cm. (7.2 in.)
Down	-	12.8 cm. (5.1 in.)	15.7 cm. (6.2 in.)
<u>1957</u>			
Up	16.3 cm. (6.4 in.)	16.6 cm. (6.5 in.)	19.1 cm. (7.5 in.)
Down	15.1 cm. (5.9 in.)	13.7 cm. (5.4 in.)	14.3 cm. (5.6 in.)

M. W. Smith

No. 60

TROUT IN A SMALL ARTIFICIAL LAKE ON PRINCE EDWARD ISLAND

The causeway carrying the Trans-Canada Highway over the mouth of York River has formed a small (500 acres) artificial lake on what was formerly a tidal estuary. Salt water can enter the empoundment at high tide via a sluic through the causeway. The sluic is provided with a sluice that permits trout to move into or out of the lake.

At the request of the Provincial Government, a preliminary survey was made in 1956 to determine how well trout move through the sluice, as well as to determine the suitability of the lake as a trout habitat. Further observations were made in 1957.

In both years the waters were sharply stratified with respect to salinity and temperature in summer. Decomposition of organic matter in the salt water, stagnated below about 6 feet in depth, resulted in a depletion of dissolved oxygen. Fairly complete mixing of the water in the lake takes place in late September.

Trout were netted from the lake in the summers of 1956 and 1957. They were found only in a shallow layer wedged between the lower oxygen-deficient strata and the warm surface waters.

Fewer trout were captured in 1957 than in 1956. Surface waters were cooler in 1957 and sea-run trout in the July run-in were able to continue on through the shallow area at the head of the pond. High temperature at the head of the pond in 1956 acted as a barrier to their movements into the feeder streams.

Unfavourable conditions in the lake for trout result largely from the empoundment and stagnation of salt water. It has been recommended that the inflow of salt water be stopped. The Provincial Government closed the sluice in October, 1957.

Further observations will be made in the spring, summer and fall of 1958.

J. W. Saunders
M. W. Smith

No. 61

RAINBOW TROUT IN A PRINCE EDWARD ISLAND POND

As a result of introductions, the non-indigenous rainbow trout has become established in a number of Prince Edward Island stream systems. The species is anadromous and is gradually widening its distribution into other streams. Both the indigenous brook trout and the introduced rainbow must now be considered in the development of the Island sport fishery. Both are desirable sport fish. It is pertinent to ascertain how well the rainbow trout

survives and grows in Prince Edward Island waters, whether this species more effectively utilizes the productive capacity of the waters than the native brook trout, and what are the predator and competitor relationships between the two species.

To obtain information of these sorts, preliminary studies were undertaken in Simpson's Pond, Prince Edward Island (2.3 acres). Data are available for this pond on the survival and growth of brook trout.

On October 11, 1955, 1,172 underyearling rainbow trout were planted in Simpson's Pond. They were prevented from escaping by barriers at the head and foot of the pond. After a 10½-month period, on August 29, 1956, the survival and growth of the planted trout were assessed by draining the pond.

On August 29, 1956, 300 of the 305 rainbow trout captured upon draining the pond were re-planted. The survival and growth of these fish were assessed by again draining the pond on September 24, 1957. The results of these operations are summarized in the following table.

Growth and survival of rainbow trout in Simpson's Pond, Prince Edward Island.

	<u>Number</u>	<u>Average fork length (in.)</u>	<u>Average weight (oz.)</u>	<u>Per cent survival</u>
When planted:				
Oct. 11, 1955	1,172	5.2	1.1	-
When recovered:				
Aug. 29, 1956	305	10.0	6.8	26
When re-planted:				
Aug. 29, 1956	300	10.0	6.8	-
When recovered:				
Sept. 24, 1957	167	12.6	13.0	56 (from 1956) 14 (from 1955)

On September 22, 1955, yearling brook trout removed from the pond had an average fork length of 8.5 inches and a weight of 4.3 ounces. By comparison, the rainbow trout grew faster and as yearlings attained an average length of 10.0 inches and a weight of 6.8 ounces. An inherent faster growth rate, or an ability to utilize the food supply more effectively on the part of the rainbow in comparison to the brook trout, or both, appears manifest.

The total weight of the 1,172 rainbow trout planted in 1955 was 82.0 pounds; that of the 305 individuals recovered in 1956 was 129.8 pounds. The net gain in weight in the pond was 47.8 pounds or 20.8 pounds per acre. The net gain in weight of the 300 trout planted in 1956 and recovered in 1957, when there were 167 survivors, was 8.1 pounds or 3.5 pounds per acre. Both number and weight are considerations in angling. In this instance, more angling would have been provided for fish of suitable angling size by cropping the rainbow trout as yearlings (1956) rather than as two-year-olds.

During the 1956-57 period brook trout entered the pond from the tributary stream as a result of a defective screen which permitted entrance but not escape of fish. On September 24, 1957, the standing crop of brook trout in the pond was 671 individuals, weighing 96.1 pounds (41.8 pounds per acre). These fish had an average fork length of 7.1 inches. Thus, rainbow and brook trout co-existed in the same pond, each in good numbers. The extent of the competition for food between the two species and its possible effects on either population are, of course, not known.

M. W. Smith

SALMON SUMMARIES

Atlantic salmon statistics

Lampreys in the Miramichi River

Runs of salmon into the Miramichi River

Recoveries of salmon tags and marks applied in 1957, Miramichi area, N.B.

The movements of Atlantic salmon in Ellerslie Brook, Prince Edward Island.

The behaviour of young Atlantic salmon

Smolt marking on several salmon rivers and recovery of marked adults

The development of practical merganser control

The use of hatchery stocks to remedy specific deficiencies

Adequacy of salmon stocks

Effects of spruce budworm control on salmon and other fishes in New Brunswick

Effects of DDT spraying in northern New Brunswick on adult salmon

Changes in Miramichi River insect populations after DDT spraying

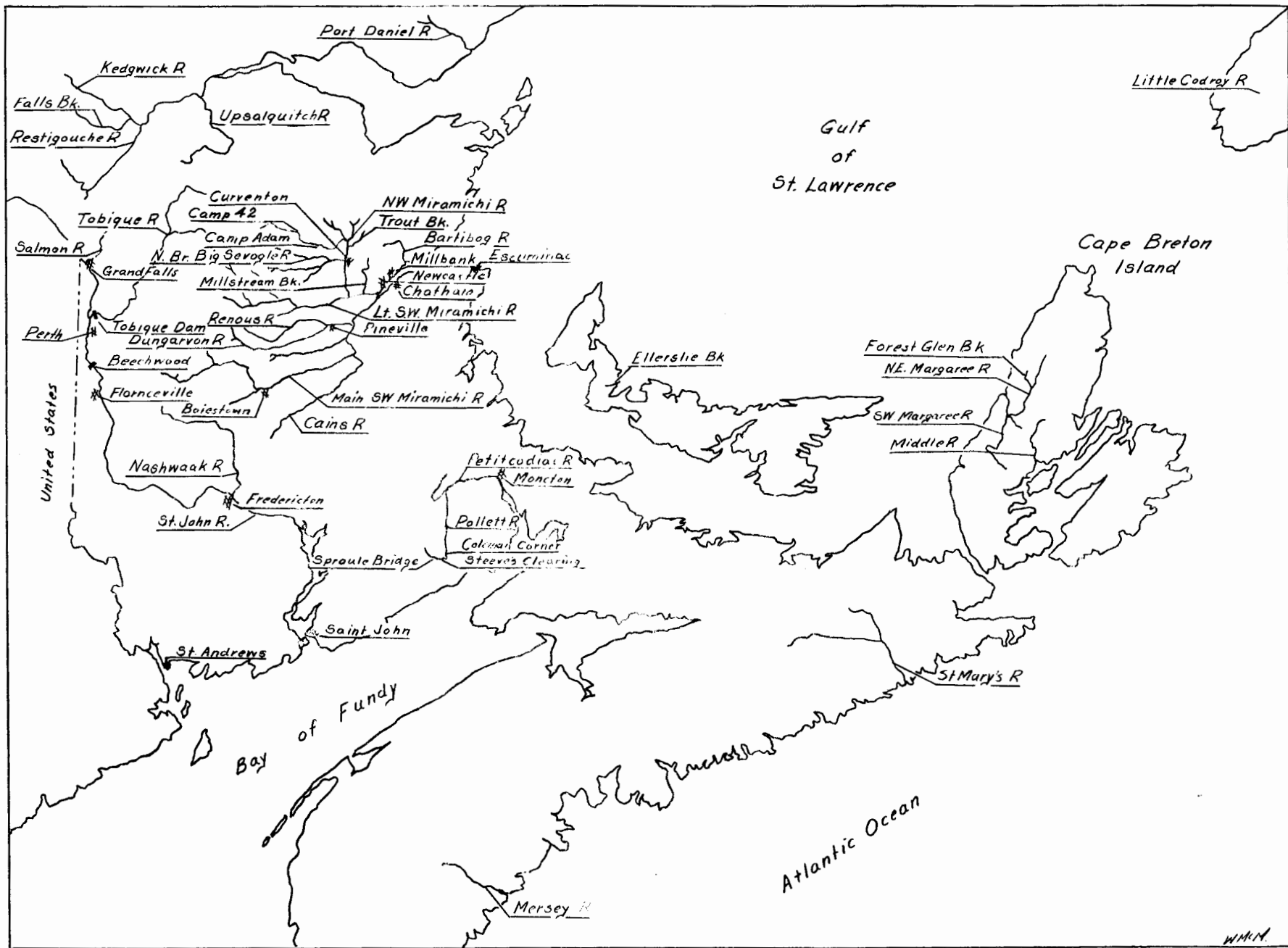
Comparative effects of the insecticides DDT and Malathion on young salmon

Food of young salmon as affected by DDT spraying in the northwest Miramichi River

Introduction of aquatic insect larvae to the north branch Big Sevogle River, N.B.

Hydro-electric developments and Saint John River salmon

Inter-group liaison and public relations



W.M.N.

No. 62

ATLANTIC SALMON STATISTICS

Statistics on salmon catches in the Atlantic Provinces by commercial fishermen and anglers in 1957 have been studied in comparison with those of recent years. These records are obtained for the Maritime Provinces and Newfoundland by protection officers of the Federal Department of Fisheries and are forwarded for analysis to the St. Andrews Station. Details of commercial landings in Quebec are obtained from monthly reports published by the Provincial Government.

Commercial landings

Figure 1 shows the total landings by weight since 1949 in salt water bordering Quebec, the "Maritime Region" and Newfoundland, as well as sub-totals for the several large areas which contribute them. The "Maritime Region" extends from Cape Gaspé, Quebec, around the three Maritime Provinces to the New Brunswick-United States border. The exact boundaries of its three areas have been stated in previous reports. Present regulations restrict commercial fishing to salmon over 3 pounds in Quebec, Prince Edward Island, and Nova Scotia, and to 5 pounds in New Brunswick. Thus many of the grilse (1-sea-year fish) are protected. Such restriction is not yet in effect in Newfoundland where salmon down to 12 inches in length can be retained. The most significant feature of the 1957 landings from nets was the increase in the totals for the "Maritime Region" and Newfoundland by about 20% over the 1956 totals. Although the 1957 catch was still only about half the 1950 level, most commercial fishermen were well pleased with the availability of fish. Newfoundland fishermen were seriously handicapped early in the season by ice which blocked the inlets for an unusually long time. The Quebec total was about 15% below the 1956 level. This seemed to be associated with late arrival of salmon, so that June landings were unusually low. In July and August, however, salmon seemed to be unusually plentiful but by that time fishing effort had decreased somewhat.

Angling catches

The numbers of salmon caught by anglers from 1949 to 1957 in the "Maritime Region" as a whole and on the most important rivers within this region are shown in Figure 2.

The total catch of over 39,000 fish in 1957 was 20% lower than in 1956, yet near the average of the past 9 years. The decrease was mainly due to the lower catch in the Gulf Area where the Miramichi River is the chief contributor. Because of unusual enthusiasm of most Miramichi camp owners and anglers over the 1957 angling season, these statistics were surprising when first received in the fall. A breakdown of the Northumberland County fraction of the Miramichi catch by months and types of salmon, recently obtained from the Department, has been made into a graph (Fig. 3). About three-quarters of the Miramichi watershed lies within Northumberland county; only the headwaters of the Southwest

Figure 1. Commercial Landings of Atlantic Salmon in Canada.

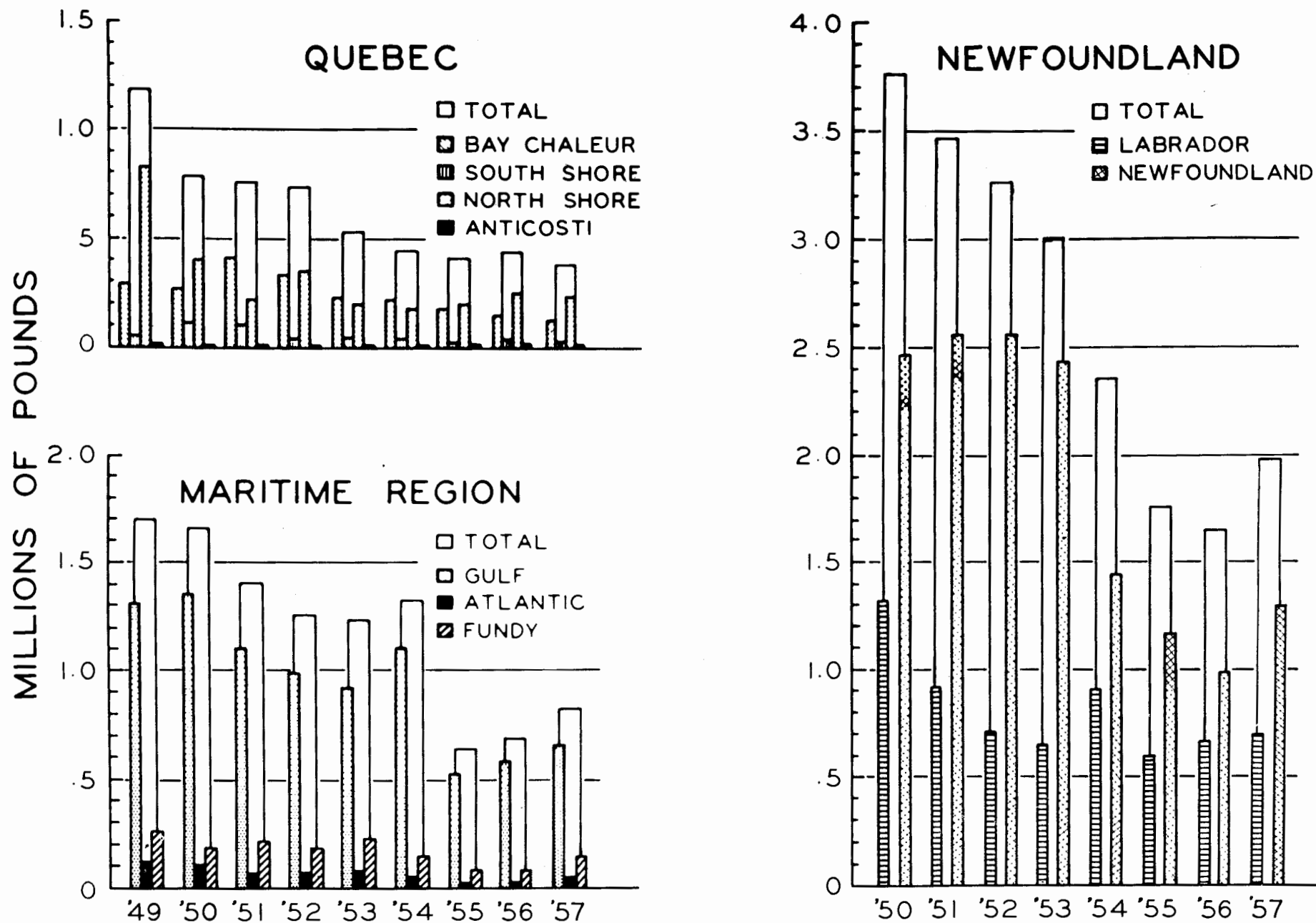
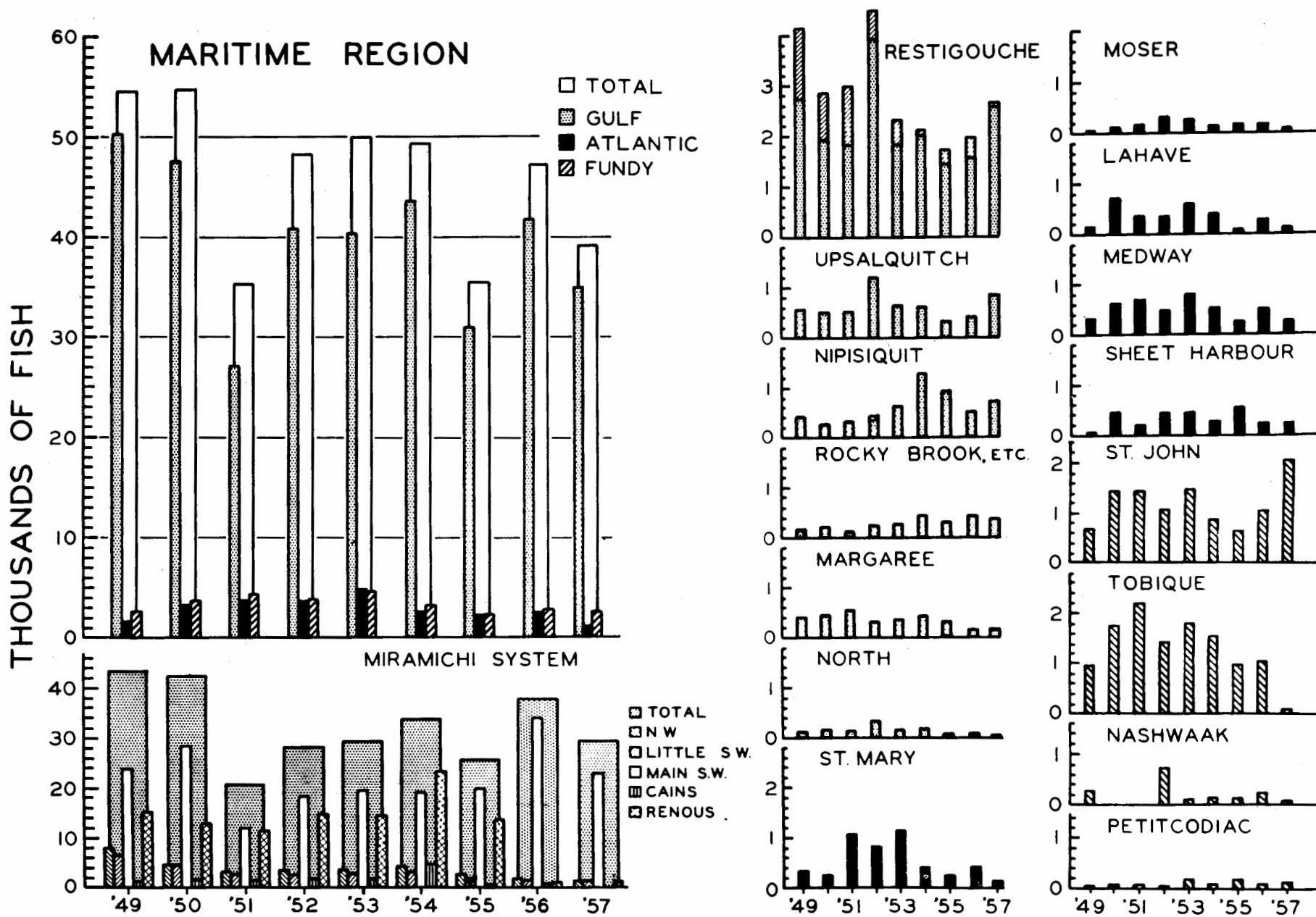


Figure 2. Angling Catches of Atlantic Salmon in the Maritime Region of Canada.



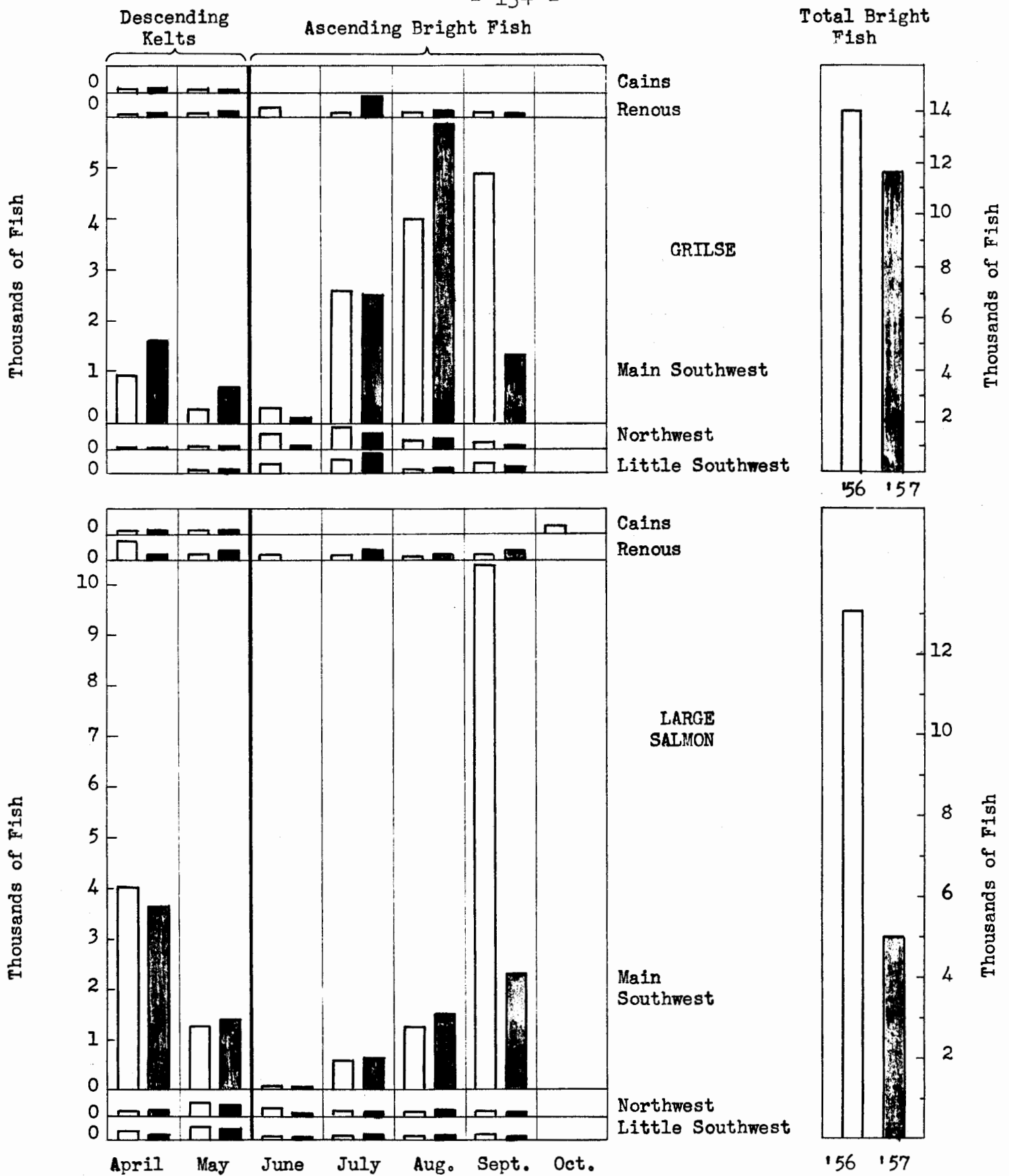


Figure 3. 1956 and 1957 catches of Atlantic salmon by anglers in the Northumberland County part of the Miramichi River system, N.B.

Miramichi tributary pass through Carleton and York Counties. A reasonable explanation for the lack of agreement between public opinion and the statistics is provided by these additional data. Apparently the Miramichi anglers, particularly those fishing the Main Southwest and its tributaries, were highly impressed by the 1957 season because more large salmon were caught during July and August than in the good 1956 season. Also, on the Main Southwest the catch of grilse in August, 1957, exceeded the 1956 catch by 30% while the July catch of grilse was about the same in the 2 years. The unusually good angling during this mid-summer period was associated with above-normal river outflow in the Miramichi area. In September, reports from anglers and our research sampling and counting trap records showed that an abundance of salmon entered the river from the sea. It was, however, much more difficult to hook and land them than in 1956, likely because of unusually low water which prevailed through September.

Statistics on the catches of kelts or "black salmon" between April 1 and May 24 in the Northumberland County part of the Miramichi system in 1956 and 1957 are shown in the left part of Figure 3. They were fish which entered the river in the preceding years, 1955 and 1956 respectively, to spawn. Of all the black salmon angled in Northumberland County, the Main Southwest produced 88% in 1956 and 85% in 1957. On this tributary 20% of the total angling catch of all kinds of salmon was made up of black salmon in 1956, and the proportion was 35% in 1957. On other Miramichi tributaries where the total catch of salmon was much smaller, black salmon sometimes comprise a higher proportion of the total. The percentages ranged from 24 to 56% in 1956 and from 26 to 90% in 1957. The biological justification for such fishing of kelts is that a very small percentage (not over 10%) can be expected to survive a further period in the sea and be found later anywhere. The fishing is of great economic value to the Province of New Brunswick.

The following table gives statistics which recently became available on angling catches in Newfoundland.

Newfoundland salmon angling catches in numbers of fish

<u>Year</u>	<u>Newfoundland</u>	<u>Labrador</u>	<u>Total</u>
1953	15,983	(Not recorded to this time)	15,983+
1954	8,703	754	9,457
1955	8,462	3,191	11,653
1956	15,582	404	15,986
1957	20,449	1,587	22,036

The fisheries officers have pointed out that the recent increases in reported catches do not necessarily reflect a greater abundance of salmon. They may indicate increased fishing effort associated with improving availability of streams and better facilities for obtaining statistics. In any case it is reassuring to know that

at least 22,000 salmon were caught there by anglers in 1957. This, however, only approximates the 1957 catch of "bright" salmon in the Miramichi River, N.B. It is to be expected that the Newfoundland salmon angling industry can be developed considerably, since many extensive river systems in the province are populated by salmon.

C. J. Kerswill

No. 63

LAMPREYS IN THE MIRAMICHI RIVER

As in 1956 adult salmon entering the Miramichi River in 1957 were inspected for lampreys and lamprey scars. Checks were again made at the estuarial sampling trap near Chatham and at the counting fence at Curventon on the Northwest Miramichi River. In the estuary 51 salmon (0.66% of those examined) either had small living lampreys attached to them or bore lamprey scars. No salmon were found with large adult lampreys attached. At Curventon 4 salmon (0.25% of the total) had scars. These figures compare with 0.46% and 0.15% respectively at the same sites in 1956.

In the Miramichi estuary small (6 to 11 in. long) lampreys are common in the late summer and fall and at that time they are occasionally found feeding on adult salmon. During the spring and summer signs of lamprey attacks are scarce. In fresh water larger lampreys were occasionally taken in the salmon counting fence traps, particularly during June and July. Most of them were moving downstream. They were never found attached to salmon in the traps.

These records indicate that lampreys are not a serious menace to adult salmon in the Miramichi River.

M. H. A. Keenleyside

No. 64

RUNS OF SALMON INTO THE MIRAMICHI RIVER

Summary 57 of the 1956 Annual Report contained tables summarizing data on adult salmon runs obtained since the start of operations in the Miramichi River area at an estuarial sampling trap and 2 upriver counting fences. The commercial type trap-net has been operated from May to mid-November since 1954 at Millbank, N.B. It resembles local gear used by the public except for a smaller mesh size to retain grilse. Counting fences to provide records of both up-stream and down-stream migrants for as much as possible of the open-water period were first installed in 1950 a few miles above head of tide on 2 tributaries, the Northwest Miramichi (at Curventon) and the Dungarvon (at Pineville). In 1956 the Dungarvon fence was discontinued and arrangements were made to install in 1957 a new counting fence on the Northwest Miramichi at Camp Adams, about 40 miles above the Curventon fence. Time of installation of these traps in the spring is affected by water height and pulpwood drives. Removal in the fall occurs usually between November 5 and 10, depending on time of ice

formation.

All past records of total yearly counts of grilse and large salmon at the Millbank and Curventon traps are shown in Figure 4. The run of both grilse and large salmon through the Miramichi estuary has almost doubled over the past four years, as indicated by records at the sampling trap. In the same period the run of grilse through the Northwest Miramichi counting fence at Curventon has fallen in 1956 and 1957 to about one quarter the 1954 and 1955 level. The run of large salmon here in the last 2 years has been about one half the 1954 and 1955 levels. This decrease, particularly in grilse on the Northwest Miramichi, is attributed to the effects on young salmon of the 1954 aerial spraying of DDT, as discussed in Summary 72. Noticeable effects of DDT sprayings on catches of Miramichi adult salmon by the public are not expected before 1960 because widespread spraying of the watershed did not begin until 1956 (Summary 73). The increase in adult runs as indicated by the estuarial trap records is likely a result of the experimental merganser control operations which were started on the whole Miramichi system in 1954. This was followed by noticeable improvement in parr survival, but interpretation of the effects on adult salmon is now handicapped by the counter effects of DDT sprayings, as discussed in Summary 73.

The following table permits a comparison of data on ascending salmon obtained in 1956 and 1957 at Millbank and Curventon, and a comparison of 1957 counts at these traps with the new upriver trap at Camp Adams.

Grilse	Before		During		After		Total	
	<u>open season</u> 1956	<u>open season</u> 1957	<u>open season</u> 1956	<u>open season</u> 1957	<u>open season</u> 1956	<u>open season</u> 1957	1956	1957
Estuarial sample trap (Season June 5-Aug. 3)	06	07	1151	1335	2390	2520	3541	3885
Curventon counting fence (Season June 5-Sept. 30)	_1	_2	694 ⁴⁺	400 ⁵⁺	81	475	775 ⁺	875 ⁺
Camp Adams counting fence (Season June 5-Sept. 30)		03		534		26		560
Large Salmon								
Estuarial sample trap	296	37	241	520	3097	3344	3367	3867
Curventon counting fence	31	_2	208 ⁴⁺	164 ⁵⁺	351	542	562 ⁺	706 ⁺
Camp Adams counting fence		03		145		6		151

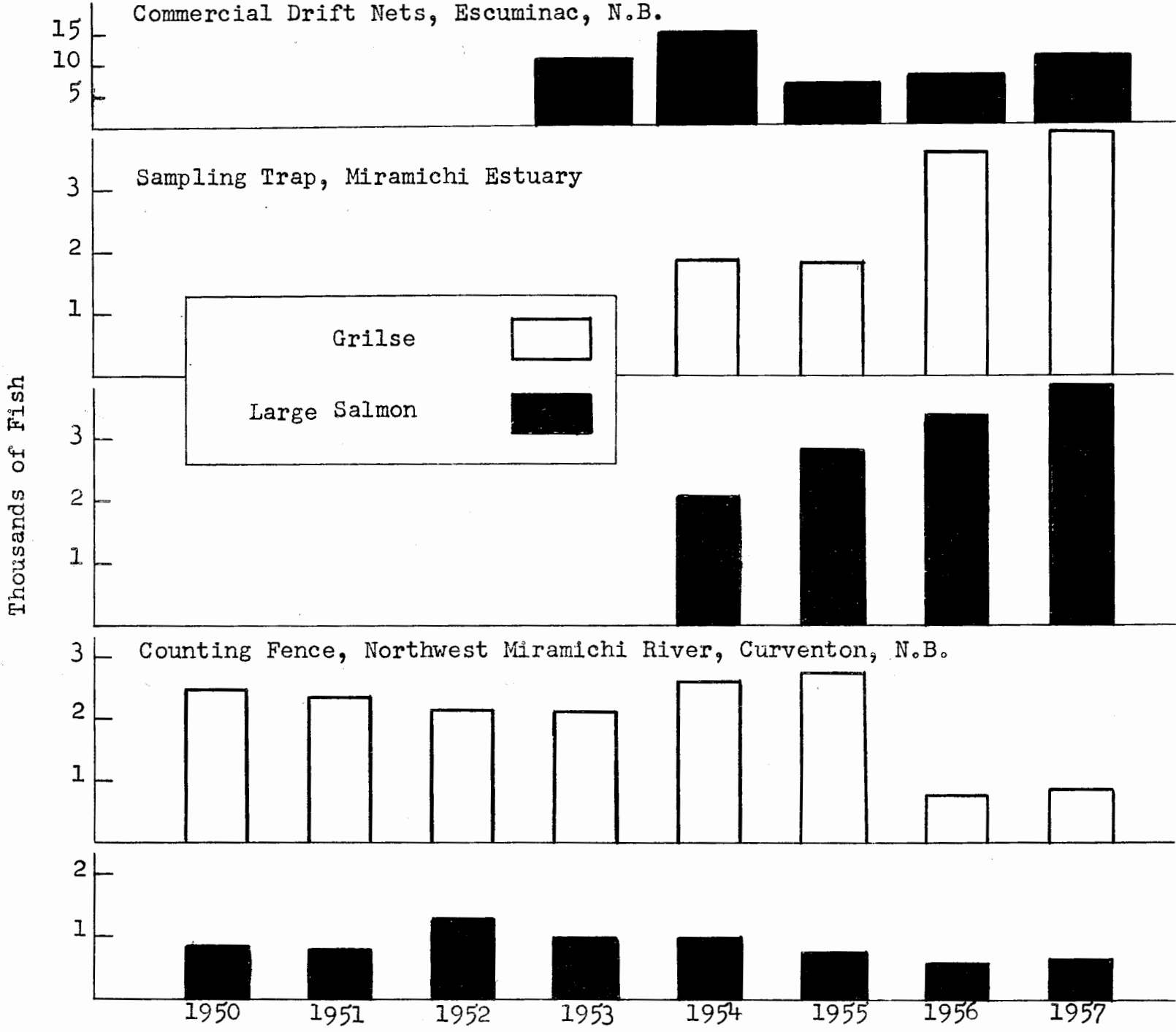


Figure 4. Variations in annual run of salmon in Miramichi area, N.B., as shown by counting traps and drift nets.

1. Fence not completed until June 5 owing to pulpwood drive.
 2. Fence not completed until June 4 owing to pulpwood drive.
 3. Fence completed on May 29.
 4. Fence incomplete June 15-18 owing to flood.
 5. Fence incomplete July 16-21 owing to flood.
 6. Trap in operation May 18.
 7. Trap in operation May 8.
-

The 1956 and 1957 estuarial sample trap records are typical of all the years of operation, in showing inward movement from the sea of only a few large salmon and no grilse before the opening of the commercial season on June 5. The catch of about 250 to 500 large salmon during the legal season agrees well with the annual catch of commercial trap-nets operated here by the public. The plentiful grilse run during the June 5-August 31 period contributes greatly to angling catches after the fish reach fresh water. From September 1 to mid-November an abundance of large salmon as well as grilse comes in from the sea. Except for the present threat of inadequate spawning stocks owing to recent DDT sprayings, it is possible that some of this late run could be fished commercially without risk of insufficient spawning escapement. Many are taken by anglers before the season closes on September 30 for most of the Miramichi area, and on October 15 in some tributaries.

Comparison of the 1957 records at Curventon and Camp Adams shows that a large proportion of the grilse and large salmon passing the lower fence are able to reach the upper one. It was surprising to find that the number of grilse reaching Camp Adams exceeded the number checked through the lower fence, but it can be explained by incompleteness of the Curventon fence from July 16 to 21 at the peak of the grilse run. Very few of the grilse and large salmon passing through the Curventon trap after September 1 reached the Camp Adams trap. This confirms the common belief of local anglers that "late" run salmon do not usually reach headwater areas. The 1957 season may not have been typical in this respect because unusually low water conditions prevailed through September and October. Conditions probably did not favour vigorous upstream movement of salmon to reach distant spawning areas. The new counting fence at Camp Adams promises to provide much useful information on general behaviour and specific movements of salmon in this area.

C. J. Kerswill

No. 65

RECOVERIES OF SALMON TAGS AND MARKS APPLIED IN 1957,
MIRAMICHI AREA, N.B.

From May 21 to August 15, 1957, Mr. G. W. Cooper applied white button tags to 145 large salmon taken in the estuarial trap net at Millbank. Of these, 15 recoveries were reported by November, 1957, in catches by commercial fishermen and anglers and one was recorded at our Northwest Miramichi counting fence at Curventon. Although the total number of tags applied was small, and tagging ended before the start of the plentiful late run of fish, the recaptures show many interesting features of salmon behaviour in the area. Some of these points have been indicated by previous tagging and marking data obtained here.

The accompanying Figure 5 shows the points of recovery and the period which elapsed between application and recovery of each tag.

Significant points brought out by these data are:

1. All of the tags taken by anglers were recovered in the Southwest Miramichi tributary. This likely reflects only the greater fishing effort and catch here than in the Northwest Miramichi, which was particularly evident in 1957.
2. Salmon reached the upper waters of the Southwest Miramichi to be angled within 4 to 5 weeks of passing through the estuary. The longest journey was to Juniper, a distance of 115 miles, where a salmon was caught 41 days after being tagged.
3. Two recaptures in the area below the tagging site support a conclusion about salmon behaviour derived from the recent marking experiments, namely that salmon of various river origins often wander in and out of different estuaries.

Between June 26 and November 4, 1957, 92 salmon ascending the Northwest Miramichi were marked at the Curventon counting fence by knotting short lengths of fine coloured plastic tubing around the base of a few rays at the front of the dorsal fin. Several colours of tubing were used alone and in combinations, to differentiate the time of application into periods of one to several weeks, depending on availability of salmon at the trap. At the new Camp Adams trap 40 miles above Curventon, all ascending salmon were examined carefully for these marks. By November 6 when the Camp Adams trap was removed, only 2 marked fish had reached this point. These had been marked on June 27 and they were recaptured on July 5 and July 8. Failure of any fish marked at Curventon later in the season to reach Camp Adams by November 6 agrees with the trap records discussed in Summary 64. More detailed marking experiments of this type involving these 2 counting fences on one tributary are planned for 1958.

C. J. Kerswill

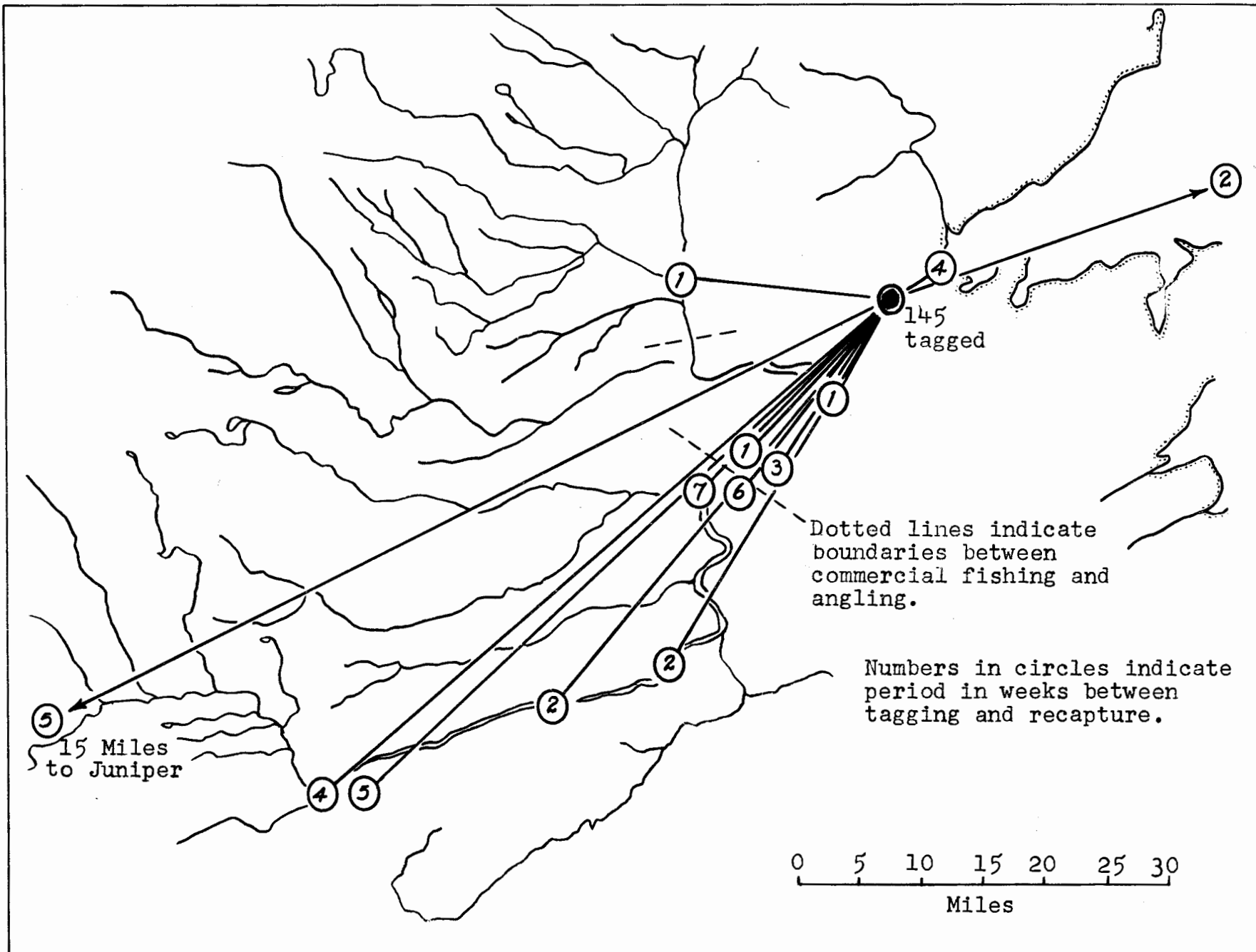


Figure 5. Recoveries of tags applied to salmon at Millbank, N.B., in 1957.

No. 66

THE MOVEMENTS OF ATLANTIC SALMON IN ELLERSLIE BROOK,
PRINCE EDWARD ISLAND

In connection with a study of the effects of pond formation on the trout populations of Ellerslie Brook, Prince Edward Island, data concerning the movements of salmon have been gathered.

The two-way fish traps in Ellerslie Brook are described in Summary 56. The pond was formed on Ellerslie Brook in the late summer of 1952.

Movements of Adult Salmon

In some years salmon enter Ellerslie Brook during the first 2 weeks of November and spawn. From the fall of 1952 through the fall of 1954 spawners were removed from the estuarial trap and placed in the pond. The numbers of salmon counted into the system and those that wintered in fresh water are presented in Table I.

Some features of the data in Table I may be noted:

1. Females outnumbered the males in all of the years. The average fork lengths of the males and females were 72 and 74 centimetres respectively.
2. Prior to pond formation the spent salmon descended into the estuary within 2 weeks. Following pond formation there was a marked tendency for the salmon to stay in the pond.
3. It was found that females shed their eggs in the pond but there was no evidence of successful spawning there.

Movements of Salmon Parr

The numbers of parr that moved through the traps annually are presented in Table II.

The prominent fall movements down-stream were made by ripe male parr. The parr moving in the fall represented from 5 to 10% of the stream population of parr in different years.

Parr recorded down through the A trap (Table II) descended into the estuary. This occurred in both spring and fall. The movement was more prominent in the fall. The parr that moved into the stream from the estuary in the fall (Table II) were fish that had descended into the estuary in the past spring or fall. During the summer months parr would encounter salinities in excess of 20 parts per thousand in the estuary.

Table I. Numbers of adult salmon counted into Ellerslie Brook and the number that spent winter in fresh water.

Year	Number of salmon			Number of salmon that spent winter in fresh water
	♂	♀	not sexed	
1947	-	-	6	1
1948	-	-	37	1
1949	4	5	4	-
1950	4	5	-	-
1951	-	-	-	-
1952*	-	1	-	1
1953	5	14	-	9
1954	3	14	-	10

*Pond formed in late summer 1952.

Table II. Spring and fall movements of salmon parr through Ellerslie counting fences.

	Spring				Fall			
	B(stream) traps		A(estuarial) traps		B(stream) traps		A(estuarial) traps	
	Up	Down	Up	Down	Up	Down	Up	Down
1947	Not operating		2	5	Not operating		15	7
1948	"	"	1	9	"	"	4	13
1949	"	"	2	20	"	"	6	18
1950	"	"	1	13	44	210	9	13
1951	-	5	-	-	21	34	11	5
1952*	7	1	1	-	87	51	-	1
1953	-	4	-	-	2	23	1	-
1954	-	1	-	-	4	5	-	-
1955	-	-	-	-	-	7	-	-
1956	-	-	-	-	5	227	13	32
1957	-	13	-	2	-	2	-	39

*Pond formed in late summer 1952.

Movements of Salmon Smolts

The numbers of smolts that moved annually from the Ellerslie system are given in Table III.

Following pond formation it was noted that smolts descending into the estuary from the pond were, on the average, larger than those descending into the pond from the stream.

All of the smolts (83) descending into the pond in the spring of 1957 were marked. The run of smolts from the pond into the estuary numbered 90 fish; 23 of these were marked fish. The 67 unmarked smolts were from the parr that had moved into the

pond in the fall of 1956 (Table II). The pond had a marked retaining influence on the stream smolts.

Table III. Number of salmon smolts that moved from brook into estuary and from brook into pond.

<u>Year</u>	<u>Number into pond</u>	<u>Average fork length cm. (inches)</u>	<u>Number into estuary</u>	<u>Average fork length cm. (inches)</u>
1949			215	14.1(5.6)
1950			653	12.5(4.9)
1951			590	13.2(5.2)
1952			320	14.7(5.8)
1953	159	13.3(5.2)	224	14.7(5.8)
1954	5	15.5(6.1)	20	16.5(6.5)
1955	Nil		Nil	
1956	96	12.5(4.9)	124	18.2(7.1)
1957	83	12.1(4.8)	90	12.9(5.1)

Two particular points of general interest to salmon research are (1) that a good proportion of the parr in the stream run to salt water as parr and (2) that the pond had a definite retaining influence on the downward movement of smolts.

J. W. Saunders

No. 67

THE BEHAVIOUR OF YOUNG ATLANTIC SALMON

During July and August, 1957, a preliminary study was made of the behaviour of young salmon held in aquaria. The purpose was to become familiar with the various types of activities shown by young salmon in an undisturbed environment. This should eventually lead to a detailed cataloguing and description of all the behaviour patterns of the species, including the adult fish. This type of knowledge can be invaluable in understanding the activities of salmon when they are faced with unnatural, man-made conditions.

The fish were observed in 2 large aquaria set up near the salmon counting fence at Curventon, on the Northwest Miramichi River, N.B. Conditions in the aquaria were made to resemble those in the river as closely as possible. Salmon fry and parr were seined from the river and held in large pens until needed. All observations were made from inside canvas hides so the fish were not disturbed by movements of the observer.

The following types of activities were observed and recorded in detail: (1) Resting position. In general, young salmon rest with the lower fins, but not the ventral body surface touching the substrate, facing the current, in fast water, at some distance from other fish. (2) Social behaviour. Young

Atlantic salmon are aggressive, territory-holding fish. An individual stays in a limited area most of the time, returning quickly to the same resting place after snapping up food or chasing away approaching fish. A variety of postures and movements typical of aggressive encounters between fish were observed. (3) Feeding. Living food is generally taken in nature and in aquaria. Young salmon will take non-living food such as ground liver if it is kept moving by water currents, or if they have become conditioned to it. (4) Activity under low light intensity. Movements around the aquaria and feeding increase as the light intensity falls during the evening.

It is hoped to continue these observations during 1958 and to supplement them with work in the laboratory where conditions such as light and temperature can be controlled. Photography is an indispensable aid to an understanding of some activities, especially those performed at high speed. With a detailed repertoire of the basic behaviour patterns of young salmon as a background, further progress can be made in solving some of the urgent problems facing the Atlantic salmon; problems such as survival of smolts during seaward migration, competition between salmon and brook trout where they occur together, differences between hatchery and wild salmon, reactions of young salmon to changes in the fresh water environment due to increased silting, pollution, etc.

M. H. A. Keenleyside

No. 68

SMOLT MARKING ON SEVERAL SALMON RIVERS AND RECOVERY OF MARKED ADULTS

This project was given high priority when a revised research programme for Atlantic salmon was developed in 1950 under review of the newly organized Federal-Provincial Co-ordinating Committee.

The main objective was to find out the extent to which the smolts produced by typical salmon rivers contribute to the catch of adult salmon in various commercial and sport fisheries over the whole coast, and to spawning stocks. It was believed that such information would be of fundamental importance in developing a sound management programme comprising fishery regulations and suitable "manipulation" techniques.

The field work of this project has been conducted energetically. It has comprised, (a) annual operation by the Board in the Miramichi River system, N.B., of 2 smolt and adult traps on tributaries since 1950, plus estuarial smolt and adult sampling traps since 1952, to provide estimates of total smolt runs and returning adults; (b) continued operation of a smolt trap on the Pollett River, N.B., used before 1950 in connection with earlier production studies, and an adult trap since 1952; (c) annual operation by the Quebec Government of a smolt and salmon counting trap on the Port Daniel River, Gaspé Peninsula; (d) annual operation by the Board's Station at St. John's, Nfld., of two-way smolt and salmon traps on the Little Codroy River; (e) a widespread search

for marked adult salmon over the whole Atlantic area in commercial and sport fishing catches, organized at the St. Andrews Station where data are received and rewards are paid; (f) collection of scales from all marked salmon and from samples of unmarked salmon caught in various areas, with information on the proportion marked among samples of salmon which can be examined carefully.

The numbers of smolts marked from 1950 to 1956 at all places were given in Summary 58 of the Annual Report of the St. Andrews Station for 1956. In 1957 smolts were trapped on only one Miramichi tributary, the Northwest Miramichi. This year only 799 native smolts were marked here owing to the combined effects of DDT spraying in reducing smolt production and trapping difficulties caused by a heavy pulpwood drive. It was possible to mark an additional 1,033 smolts resulting from an experimental planting of large hatchery fingerlings. On the Pollett, 10,157 were marked, on the Port Daniel, 1,023, and on the Little Codroy approximately 8,700. In 1957 a total of 670 marked adult salmon taken in commercial and angling catches were reported to St. Andrews by December.

The laboratory and office work required for proper handling of all the scale-reading and analysis of data has taxed available staff to the limit. Only in November, 1957, did enough personnel of the right calibre become available on the St. Andrews staff to read scales. This resulted from (a) a transfer to full-time employment in the salmon investigation of technicians Jones and Irving who have worked since 1954 on salmon during the summers; both have been needed for the smelt investigation in the winters, and (b) the appointment in May, 1957, of E. J. Schofield as technician to fill a vacancy created by the resignation of R. J. Wiley in September, 1956. Very helpful instruction of these staff members and a new Quebec salmon investigator, Mr. J. Bergeron, was provided by Dr. A. A. Blair during a 3-week visit to the St. Andrews Station, starting November 26, 1957. Reading of our accumulation of salmon scales was almost completed by March 1, 1958, and it is hoped that this will permit full analysis of all available data during 1958. Much of the difficulty in keeping up with analysis of these data has been caused by diversion of effort to other projects that have assumed importance in the salmon investigation since 1954. These include the study of effects on salmon populations of DDT spraying, and more recently the effects of St. John River power dams.

Although only a few smolts could be marked in 1957 on the Northwest Miramichi River, an estimate of the total smolt run from the whole Miramichi system has been made again. A total of 1,832 smolts from natural production and hatchery plantings were marked as they passed the Curventon trap. Of these, 19+17=36 were recaptured in the estuary among a total of 25,154 smolts trapped between May 21 and June 28 (apparently covering the whole period of smolt descent here). This gives an estimated total smolt production in 1957 of 1.3 million, which appears reasonable. Previous estimates were: 1951, 1.7 million; 1953, 0.8 million; 1954, 1.5 million; 1955, 1.3 million; 1956, 2.0 million.

In 1958 it is planned to operate a temporary smolt trap on the Cains River, the only Miramichi tributary that has not been sprayed extensively so far with DDT. There are poor prospects now for trapping a sufficient number of smolts on other branches of the Miramichi River.

C. J. Kerswill

No. 69

THE DEVELOPMENT OF PRACTICAL MERGANSER CONTROL

The Board has twice demonstrated that intensive control of fish-eating birds, especially mergansers, on salmon streams can give greatly increased production of seaward-migrating smolts. The first study was on the Margaree River, N.S., in 1936-37; the second on the Pollett River, N.B., between 1947 and 1953. Experimental procedure may not, however, be directly transferable as a method of practical management.

Four experiments on "practical control". (1) Following the Margaree study the Department inaugurated a modified system of control on that stream. Parr, as indicated by several Board examinations in succeeding years, did increase in abundance. But the control was neither intensive enough when operating, nor extensive enough in seasonal duration to ensure carrying these increases through to the smolt stage. The operation appeared to be hampered, in part, by the use of ineffective personnel appointed to the control crew for reasons of political expediency. Ten years later, when fishing in the Margaree had not improved noticeably, the program was suspended upon recommendation by Board staff.

(2) A second attempt at developing practical control was begun in 1950. At this time the results of intensive studies on the Pollett were emerging. Using experience gained there by the Board, and with the Board advising, the new experiment was set up on the Northwest Miramichi River. Parr populations were followed here and in another Miramichi stream, the Dungarvon. Good increases of parr followed. Owing to trapping difficulties associated with increased pulpwood drives it could not be determined whether or not these carried over to the smolt stage. In 1952 and 1953 there were increases in adult salmon entering the Northwest, but not the Dungarvon. The increases came at the correct time to be associated with early benefits from merganser control. With this promising situation, control was expanded to the entire Miramichi system in 1954.

(3) This third experiment involved the assembly of a larger crew, who worked under a Departmental officer previously trained as a Board employee. As on the Margaree, political considerations entered into the selection of crew personnel. The Board undertook annual assessment of parr in several parts of the system.

The year 1954 also saw the beginning of wide-spread DDT spraying over Miramichi forests. This has since been shown to

greatly reduce production of young salmon (Summaries 72, 73, and 74. The loss of parr by this means has been so severe that salmon are likely to decrease to a very low ebb until after 1961 at the earliest. Hence no conspicuous benefits to fisheries from bird control are likely to accrue before then.

However, increases in Miramichi parr were noted in all areas previous to the application of spray. These increases were much more noticeable in the areas assigned to some hunters than in others. It was, in fact, possible to trace areas of less effective control through the Board's studies of parr. Whether the program has been sufficiently effective to ensure increases in parr carrying through to the smolt stage can be determined only by further measurement.

(4) A fourth study of practical control was started on the St. Marys River, N.S., in 1953. Here control is being done by a Departmental Protection Officer assisted by one local resident. The objective was to test this method of control directly against fishing returns. It is now apparent that more systematic documentation of the effort and study of intermediate results would have been desirable. Preliminary beneficial results, which should have occurred in 1956 and 1957, have not been identified.

Does control have a cumulative effect on mergansers? If merganser populations in limited areas tend to be self-perpetuating, then progressively less effort should be required to realize the optimum benefits from control. The attractive hypothesis that such is the case has emerged from the Miramichi and St. Marys efforts. However, data gathered over longer periods on the smaller areas of the Northwest Miramichi and the Pollett suggest that such an hypothesis should be viewed with caution. Table I gives the number of birds removed annually from each area. Rapidly declining incidence, as reflected by the number killed, is conspicuous for both the St. Marys and the Miramichi system. The Northwest Miramichi shows such an order only after control on the Miramichi system became general. The Pollett shows no such order at all.

Table I. Mergansers removed in each calendar year from salmon streams where control was applied.

<u>Year</u>	<u>St. Marys River</u>	<u>Miramichi system</u>	<u>Northwest Miramichi</u>	<u>Pollett River</u>
1948	-	-	-	18
1949	-	-	-	81
1950	-	-	64	40
1951	-	-	75	69
1952	-	-	112	76
1953	187	-	126	55
1954	424	1,028	61	51
1955	240	436	7	51
1956	113	178	3	52
1957	87	107	5	68

Observations on the Pollett have indicated a strong and direct relationship between parr populations and merganser incidence (Summary 59 of the 1956 Ann. Rept.). Miramichi parr have decreased concomitant with DDT spraying since 1954, Summary 72. Hence, scarcity of parr for food could have contributed to the recent decline of merganser incidence in the Miramichi area, though not, as far as is known, on the St. Marys River.

Further, young mergansers are greatly dependent on large aquatic insects for food during their first few days of life, and will starve in a few days if deprived of food (Bull. 116). Such insects have been largely killed off in sprayed areas (Summary 74). The Department's officer in charge of Miramichi field operations remarked that the few merganser broods reared in sprayed areas in 1957 contained less than half the normal complement of birds. Spraying, then, may well have contributed directly to the observed decline in mergansers.

Mergansers banded in summer as young by the Canadian Wildlife Service in the Miramichi area have been taken in the autumn in southern New Brunswick. The Pollett, with local broods no longer being reared, probably receives its autumn complement of mergansers from northern areas, including northern New Brunswick where spraying has been done.

In Table II data are presented showing the abundance of parr and the associated merganser kills on 2 streams, together with the annual extent of spraying in northern New Brunswick. Table III gives the results of a mathematical analysis of the inter-relationships among these factors. This provides fairly good evidence that merganser incidence has depended on parr abundance; there is even stronger evidence that the decrease in merganser incidence is associated with the extent of DDT spraying. That it does not reflect a general decline in the Maritime area is suggested by the numbers found on the Margaree this year in comparison to 8 and 21 years ago, referred to below. Certainly it would be premature to conclude that the decline in abundance of mergansers has resulted from bird control operations alone.

The importance of effective programs and personnel.
Some of the principles, and problems, involved in transforming an investigational technique into a practical form of fisheries management emerge from the 4 attempts to develop practical bird control. (1) It is basic that the effectiveness of such predator control programs be measured by their success in providing protection to the prey throughout the entire period of vulnerability of the prey -- in this case right to the smolt stage. Effects on predator populations are of secondary importance. (2) Control programs should, at the present stage, either provide adequate protection through to the smolt stage, or at least contribute to the development of a useful procedure. Documentation of effort and results is required for analysing the degree of success attained in these aims. (3) There should be periodic review of programs, to assure that they meet the requirements of effectiveness and economy. (4) Another governmental Department is charged, by International Convention, with protection of

mergansers. Hence, control for fisheries interests involves a degree of inter-departmental co-operation. (5) Bird control is a specialized operation, requiring for effectiveness a high degree of skill and conscientious application on the part of personnel. Use of temporary employees appointed for political considerations has not given generally effective results.

Table II. Mergansers removed in experimental control operations, local abundance of young salmon, and extent of DDT spraying in northern New Brunswick.

Year	<u>Northwest Miramichi</u>		DDT spraying in northern New Brunswick (in thousands of acres)	<u>Pollett River</u>	
	number of mergansers removed per year	abundance of parr per 100 sq. yd.		number of mergansers removed Sept.-Dec.	abundance of parr per 100 sq. yd.
1948	-	-	-	7	5
1949	-	-	-	54	9
1950	64	10	-	11	8
1951	75	23	-	41	12
1952	112	29	186	21	2
1953	126	34	1,811	42	12
1954	61	11	1,141	21	4
1955	7	3	1,124	9	2
1956	3	37	1,974	14	14
1957	5	34	5,500	8	15

Table III. Relationships between yearly kill of mergansers on the Northwest Miramichi, abundance of parr in that stream, and extent of DDT spraying in northern New Brunswick; and between autumn kill, which involves southward migration, of mergansers on the Pollett, abundance of parr in the Pollett and same DDT spraying as above. (Analysis of data from Table II.)

	<u>Northwest Miramichi</u>		<u>Pollett</u>	
	Partial correlation coefficient	Probability of correlation occurring by chance	Partial correlation coefficient	Probability of correlation occurring by chance
Mergansers and parr	0.713	.05 < P < .1	0.512	.1 < P < .2
Mergansers and DDT	-0.790	.02 < P < .05	-0.747	P = .02

A proposed fifth experiment, on the Margaree River, N.S.
A new study of salmon-merganser relationships has been started on the Margaree River. This is a co-operative effort among the Canadian Wildlife Service, the Department of Fisheries and the Board. It is planned that the experiment should include a more

comprehensive study of the response of both mergansers and salmon to the control program that has heretofore been made. This program was opened in 1957 with surveys of both merganser and young salmon populations on the Margaree. Parallel observations were made on nearby Middle River. The latter will serve as an additional base line for judging changes in abundance of fish and birds. In addition, studies on other adjacent streams will provide wider scope for examination of merganser movements in connection with control.

The Wildlife Service, assisted by Fisheries personnel, took chief responsibility for studies of mergansers. Ground surveys were found to be the most effective means of assessing merganser populations in this area. The operation of catching young mergansers for banding was under the technical advice of the Board. Methods and gear used were originally developed on the Bartibog River in 1950, in co-operation with both the Wildlife Service and the Department. They were subsequently improved on the Pollett River by the Board. With the additional experience gained in Cape Breton this year it is now feasible to undertake as extensive banding programs as may seem desirable. Actual banding of the birds and recording of data were done by the Wildlife Service. A new colour-tag developed by the Wildlife Service was placed on the largest birds, for ready identification in the field. The results of the merganser studies are summarized in Table IV. The total of 199 birds counted this year when compared to the "150 or more" estimated by the Board in 1936 and again in 1949 suggests a fairly constant population over the years. The Wildlife Service has established liaison with the Department for the purpose of gathering additional information on merganser incidence in the study areas throughout the year.

Table IV. Mergansers counted during ground surveys, and number of these subsequently banded on 2 Cape Breton Island streams, 1957

	Ground surveys	Banding operations		
	(Aug. 14-19)	(Aug. 21-28)		
	number <u>counted</u>	number <u>caught</u>	leg <u>bands</u>	leg bands & <u>colour tag</u>
Margaree River				
Northeast Margaree	92	45	42	19
Southwest Margaree	44	0	0	0
below Margaree Forks	<u>63</u>	<u>32</u>	<u>28</u>	<u>6</u>
Total Margaree	199	77	70	25
Middle River	<u>26</u>	<u>10</u>	<u>10</u>	<u>9</u>
Total	225	87	80	34

Studies of fish populations were under the technical supervision of the Board and assisted by Department of Fisheries personnel. A summary of the data obtained is given in Table V. At the time of this study native mergansers had not had opportunity to exert more than about one third of their annual tax on fish populations. Consideration of the data for individual sampling stations indicates that large, pre-smolt parr were scarce in areas where local broods of mergansers were able to feed relatively undisturbed by human traffic. The general picture suggests that merganser control should benefit salmon production here greatly.

Table V. Fish populations found in Cape Breton salmon streams, excluding deep pools, July 22-Aug. 3, 1957. Figures are averaged numbers estimated per 100 sq. yd. of stream bottom. °Salmon fry were so small that many were not caught, hence these are minimum values. Northeast Margaree, 7 stations; Southwest, 2; Middle River, 3.

	<u>Salmon</u>		<u>Other fish</u>		
	<u>°fry</u>	<u>small parr</u>	<u>large parr</u>	<u>trout</u>	<u>eels</u>
Margaree River					
Northeast Margaree					
Forest Glen Bk.	20	24	15	7	2
main stream	22	27	9	3	2
Southwest Margaree	10	3	2	0	14

overall Margaree	18	20	10	3	5
Middle River	40	20	14	1	2

It is planned that there will be at least one more year of such basic studies before control is commenced. Details of control procedure and assessment of results are still under consideration by the three Services involved.

P. F. Elson

No. 70

THE USE OF HATCHERY STOCKS TO REMEDY SPECIFIC DEFICIENCIES

Four papers summarizing the Board's researches on maintaining adequate stocks of young salmon have been published in the Canadian Fish Culturist for December, 1957. Two of these deal specifically with use of hatchery stocks. Wide-spread DDT spraying has seriously depleted native stocks in the 3 most important New Brunswick salmon systems, the Miramichi, Tobique and Restigouche (Summary 73). The only way that such deficiencies can be alleviated is by planned use of hatchery stocks. Production in the upper Saint John system may yet be damaged by recent hydro-electric developments. Here, too, judicious use of hatchery stock

could fill smolt deficiencies pending productive research on better remedies. With these considerations in mind, studies on the use of hatchery stocks, which were suspended following 1953 plantings in the Pollett, were re-opened there in late 1956.

Reinforcing deficient underyearling populations. In July, 1956, underyearling salmon were found in the Pollett at an average density of 4 per 100 sq. yd. of stream bottom. This could not yield the maximum rate of 5 smolts per 100 sq. yd., which must usually be preceded by parr densities of 8 or 10. Since there had already been 2 years of experimental light spawning to give survival values, it was decided to attempt a calculated reinforcement of these 1956 fry with hatchery stocks. Previous studies in both the Pollett and Miramichi fields had indicated that about 15 native August underyearlings should yield the required 10 2-year-old pre-smolt parr. The Pollett deficiency was therefore about 11 underyearlings per 100 sq. yd. Planting studies had indicated that 30 to 35 hatchery underyearlings 3 to 4 cm. long and planted in late August should amply fill this deficiency. This meant about 150,000 hatchery fry for the entire experimental 10 miles of river. It was decided to plant 100,000 in order to get good reinforcement while still being able to observe optimum survival rates. The adipose fin was removed from 9% of the planted fish in order to establish subsequent survival rates.

The fish received from the hatchery averaged 7.2 ± 0.9 cm. long instead of 3 to 4 cm. This was slightly longer than the native fish at 6.9 ± 0.7 cm. Planting was done on Sept. 20-21 instead of 1 month earlier as in previous experiments. With an early fall, water temperatures were about 50°F . at planting, 10°F . lower than before. This was enough to cause restricted activity of the salmon and greatly restricted activity of associated predacious eels. In fact, an intensive study of the food of eels on planting sites immediately after liberation of these salmon showed that eels had eaten only a small fraction of the numbers which eels took from previous plantings. This favourable condition was probably a function of both the size of the planted fish and low temperatures. Electro-fishing studies carried on until mid-November showed good dispersal of the fish from planting sites. The survival rate over these 2 months was at least 30%.

The survival rate of the planted fish to July, 1957, has been calculated on the basis of marked fish found during the annual census. Planting was done at an average overall density of 23 per 100 sq. yd. In July the average density of planted stocks was 13. This survival rate is between 55 and 60%, and more than double the rate used for calculating requirements. In addition, a small proportion of these fish descended in 1957 as 1-year-old smolts.

Two tentative conclusions about stocking rates appear to be emerging from this experiment. (1) Effective reinforcement of native stocks can be obtained by combining previously determined survival values with measured deficiencies in natural stocks of

underyearlings. (2) Late autumn plantings of large, healthy fish may give twice as good survival rates as "ordinary" fish planted in late summer. This observation is in keeping with results recently obtained on trout in California.

Dispersal of yearlings at planting sites. Fish larger than underyearlings are required to remedy some natural deficiencies. The Conservation and Development Service now concentrates much of its effort on rearing young salmon to the yearling stage. Studies on the amount of dispersal at planting required to assure the best survival of underyearlings have been reported previously. In 1957 a study of the dispersal requirements of yearlings was started on the upper Pollett River. This experiment will utilize the same plan and location as the work on underyearlings. Three different plantings of marked fish will be made in each of 3 years and the results checked at the regular smolt fence 15 to 20 miles downriver. If, however, no important differences appear to be emerging after the second year, the experiment may be terminated. The underyearling experiment showed no difference accruing from great dispersal. The 1957 operation is recorded in Table I.

Table I. Hatchery reared Atlantic salmon yearlings given different degrees of dispersal at planting in the upper Pollett River, Sept. 11, 1957, and plan for remaining plantings

	Fins <u>removed</u> <u>1957-59</u>	Mean length (cm.) and <u>stan. dev.</u>	Number in <u>sample</u>	Number <u>planted</u>	Planted over <u>stream length (yd.)</u>		
					<u>1957</u>	<u>1958</u>	<u>1959</u>
Coleman Corner	Right pelvic	13.8 \pm 2.3	122	978	2	200	20
Steeve's Clearing	Both pelvics	13.3 \pm 1.8	109	991	20	2	200
Sproule Bridge	Left pelvic	12.5 \pm 2.0	100	1,000	200	20	2

Planting large fish for early smolt production. In one of the papers referred to above, an hypothesis was advanced that smolts could be produced in a given year by planting parr which would exceed 10 cm. (4 in.) total length in the preceding autumn. This hypothesis was based on studies of parr in hatcheries and on examination of scales of migrating smolts taken from widely separated fields. The hypothesis received practical testing in 1957.

Of the 99,000 underyearlings planted in the Pollett in 1956, a number exceeded this 10 cm. limit at the time of planting. The proportion of such fish in the sample preserved for measurement was $\frac{3}{4}$ of 1%. This would indicate ($P < .05$) a total of about 750 such fish, of which 68 would have been marked by removal of the adipose fin. Fifty-nine 1-year smolts bearing this mark were recorded during the 1957 smolt run. Preliminary inspection of their scales shows that nearly all of these smolts were 10 cm.

long or longer at the end of their first year of growth, when they were planted. As smolts, they averaged 13 cm. long, some 3 cm. shorter than the usual Pollett 2-year smolts. The run, measured in this way, amounts to 85% of such fish planted. This implies both an excellent survival rate over the winter, and an equally successful rate of smolt production from the planted stock which met the size qualification.

Smolt-planting experiments. In the same publication another hypothesis was advanced regarding planting for early smolt migration -- that in addition to meeting certain size requirements fish must be planted in time to descend during the normal period of smolt migration. This, too, was tested in 1957. Similar experiments were set up on both the Pollett and Northwest Miramichi Rivers. Large yearling salmon from the Saint John hatchery, where growth is rapid, were used. They were graded for size by the usual hatchery technique. A minimum length of $4\frac{1}{2}$ inches (11.5 cm.) in mid-May was specified, in order to allow for some spring growth having occurred. This was later reduced to $4\frac{1}{4}$ inches (10.8 cm.) in order to get a substantial number of fish. Half of the fish were marked by removal of the right pelvic fin, half by removal of the left. A plan to clip also the dorsal fin was abandoned because most of the fish had already lost their dorsal fins through "nibbling" by their brothers in the hatchery ponds. Fish with the first mark were planted 12 miles above counting weirs towards the end of May; those with the other mark were planted in the same places in early September. The results are summarized in Table II.

Table II. Hatchery reared Atlantic salmon 1-year smolts planted in the Pollett and Northwest Miramichi Rivers in 1957 and recorded in counting weirs 12 miles down-stream.
°Sample from trap 45 miles below planting

Date of planting	<u>Pollett</u>		<u>Northwest Miramichi</u>	
	<u>Spring planting</u>	<u>Autumn planting</u>	<u>Spring planting</u>	<u>Autumn planting</u>
Date of planting	May 22	Sept. 11	May 29	Sept. 5
Numbers planted				
preserved sample	102	95	0	60
mean length	12.5 cm.	16.4 cm.	same as	16.3 cm.
and stan. dev.	+1.1 cm.	+1.6 cm.	Pollett	+1.5 cm.
planted	4,998	3,891	5,100	3,940
Number migrating	2,066	0	1,227	0
measured sample	all	-	49	-
mean length	13.8 cm.	-	°13.7 cm.	-
and stan. dev.	+0.9 cm.	-	+0.8 cm.	-
Period of migration	May 23- June 23	Sept. 12- Nov. 26	May 30- July 8	Sept. 6- Nov. 10

Preliminary scale examination of the fish planted in the Pollett in May, and of the resulting 2,066 smolts, indicates that about 2,250 of the 5,000 planted had reached or exceeded the 10 cm. length in the preceding autumn; most of the smolts also were in this category. Thus 90% of the fish fulfilling the requirements of the size hypothesis descended as smolts at the proper season. In a sample of the Miramichi smolts collected 45 miles below the planting station, again most had met the size specification (most were, in fact, about 1 cm. longer than the Pollett fish at the end of their first year).

But in neither stream did any of the autumn-planted fish descend before winter, even though they were much larger at planting than their brothers planted in the spring.

The rate of production from the Miramichi spring planting was a little over 50% of those fish which were large enough to make smolts -- about half as good as from the Pollett. The difference may have been due, at least in part, to post-spraying conditions in the Miramichi, where large insect forms are now lacking. Smolts taken 1 month after planting in the Pollett showed excellent growth after liberation, with a few wide-spaced typical smolt circuli at the outer ends of their scales. Comparable fish from the Miramichi showed relatively little growth with closely-packed circuli resembling a typical "winter" band. Because the majority of smolts in both streams descended within a week or two of planting, these growth differences have not had a chance to appear in the data of Table II. About 85% of the smolt passed through the upper Miramichi fence were again recorded at a fence 33 miles down-stream. The pattern of runs at both fences suggests that about 4 days were used in the trip.

These experiments show that it is possible to reinforce smolt runs by plantings made before or during the normal season of smolt descent, but not much later.

The following standards are suggested as being likely to produce the desired result.

Minimum size for smolt plantings: if graded in autumn or winter (preferable to spring grading), 4 inches; if graded after spring growth commences, 4½ inches to mid-May and 5 inches towards the end of May. These limits should assure most of the stock migrating.

Time for smolt plantings: in the southern Maritimes smolt plantings should probably be made no later than June 1, and in northern parts no later than the middle of June. The majority of natural smolts has usually descended by these times.

In line with the results of these studies, existing possibilities for increasing winter growth rates of salmon stocks in the Florenceville hatchery have been brought to the attention of the Conservation and Development Service.

P. F. Elson

No. 71

ADEQUACY OF SALMON STOCKS

Studies in 3 areas. The numerical relations between runs of adult salmon and the adequacy of resulting young continue to receive study in both the Pollett and Miramichi fields. In addition, a study of Tobique stocks was begun in 1957. While undertaken primarily to assess the possible effects of hydro-electric developments (Summary 78) this study should eventually contribute much valuable information on stocking requirements. Aside from offering somewhat different physical conditions than either the Pollett or the Miramichi, the Tobique study also offers a chance to learn something of the possible values of controlling eels. This is because both the Beechwood and Tobique dams appear likely to restrict up-stream movement of eels. Except where there are such barriers, eels appear to be particularly abundant in Bay of Fundy drainages. Data on this aspect should accumulate with the continuance of seining programs such as initiated in 1957.

Basic production and survival values, from the Pollett. The sixteenth year of the Board's salmon studies on the Pollett was completed in 1957. This is regarded as a "field laboratory" where basic studies of production can be made without interfering with established fishery interests. The backlog of information now available greatly enhances its value for this purpose.

There have been 3 light spawnings, an intermediate one, and in 1957 a very heavy one in the 10-mile main experimental stretch. Both in 1956 and 1957 adult salmon were brought into the area from places 20 or more miles distant. This was done to assure the required numbers, which were not being received through the Denil fish-pass at the lower end of the area. In 1957 a total of 1,062 salmon were thus introduced from other parts of the Petitcodiac system, while 327 entered through the fishway.

Most salmon enter the Petitcodiac late enough in the season for sex to be determined from external appearance. Thus the potential egg deposition brought to the experimental area can be calculated. Fry and parr resulting from this egg deposition are estimated from the results of summer seining programs; smolts are counted as they migrate seaward in the spring.

In 1957 spring growth of young Pollett salmon was delayed by cool weather. Fry were so small at the time of seining that they were not captured as thoroughly as in most years. Consequently 1957 estimates of fry are probably too low. In late 1956 a moderately heavy planting of hatchery underyearlings was made, to supplement a deficient native population. The planted fish were as large as the native stock, and much more numerous. Their survival rate to 1957 was twice as great as expected (Summary 70), while the survival of the native stocks was somewhat less than anticipated. The resulting parr crop is the heaviest on record, by 20%. This situation may well have contributed some extra mortality to both native and planted stocks. Up to now only

2 year-classes of these native fish have descended as smolts. Parr-smolt data are available, however, for 7 additional year-classes resulting from hatchery plantings. All Pollett data dealing with production of smolts from potential egg deposition are presented diagrammatically in Figure 6.

The average production from potential eggs to under-yearlings is 5%, including the low 1957 fry counts (Figure 6A).

The average production rate of parr from underyearlings is about 60%. This includes the 1957 parr, which may have been unduly depressed, as noted above (Figure 6B).

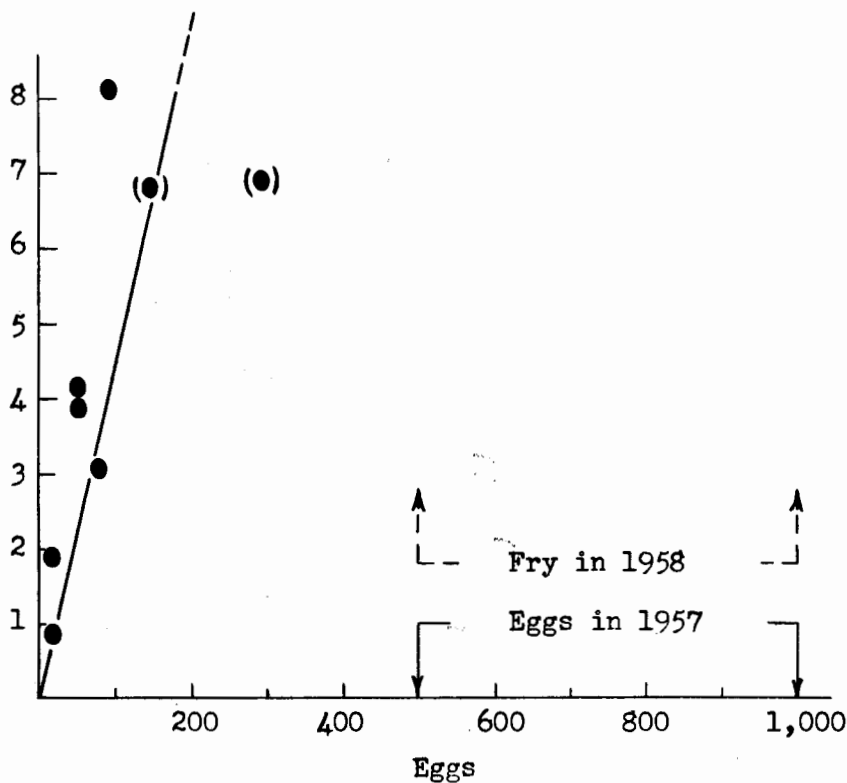
The average production rate of smolts from parr (most smolts here are 2-year-olds) is 50%. The data so far available make it appear, at first glance, that this value pertains throughout the range of parr densities studied. However on closer inspection of Figure 6C it will be noted that the observed values of smolt production were almost as high when preceded by 6 parr per 100 sq. yds. as from heavier parr densities. Possibly the survival rate indicated by the sloping line in Figure 6C cannot properly be allotted over the entire range of densities. As indicated in the figure, the smolt run of 1958 should provide the best check yet on this matter.

Combining the above information, the optimum rate of production from potential egg deposition to smolts appears to lie between $1\frac{1}{2}$ and 3%, for this part of the Pollett. The optimum rate of smolt production from the river appears to be about 5 smolts per 100 sq. yd., and this would be obtained from potential egg deposition at rates between 200 and 350 eggs per 100 sq. yd. Quite possibly eggs at any heavier rate than 200 would be unnecessary in most years. This was the value suggested in earlier reports.

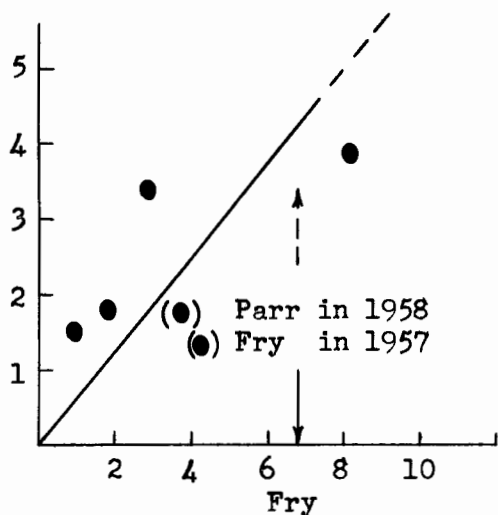
Status of stocks in important fishery areas. The Miramichi system contributes about half of Maritime salmon. Numbers of entering adults and of young at various stages have been followed on the Northwest Miramichi since 1950, and on the Dungarvon from 1952 to 1956. Good production on a general level was prevented before 1954 by lack of merganser control (Summary 69) and since then by the effects of DDT spraying (Summary 72). Average survival rates to August underyearlings have been:

Average survival rate from potential eggs to fry

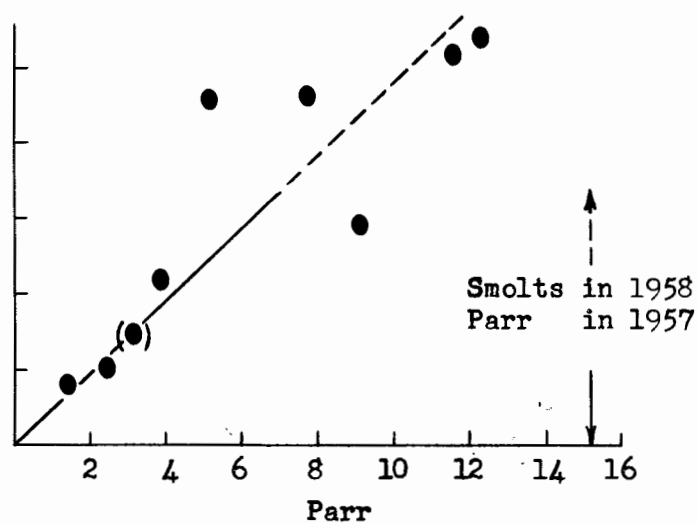
	<u>entire stream</u>	<u>in and below sprayed areas</u>
before spraying	8%	-
year with spraying	4%	1%
year after spraying	31%	-



A. Rate of production of underyearlings from potential egg deposition. Survival rate = 5%



B. Rate of production of pre-smolt parr (in 2nd year) from native underyearlings. Survival rate = 60%



C. Rate of production of smolts from parr which have lived in river 1 year or more (both hatchery and native stocks included). Survival rate = 50%

Figure 6. Survival rates between different stages of young Atlantic salmon, as observed in a 10-mile stretch of the Pollett River. All figures are estimates of average numbers per 100 sq. yd. of stream bottom. 1957 values in brackets -- see text.

The high survival rate for the year after spraying has been measured only once, in 1955, but in both the Northwest and Dungarvon then. Underyearlings in 1958 will have met similar spraying conditions. The survival rate observed in 1958 (Northwest only) will throw needed light on responses to post-spraying conditions.

Growth of underyearlings in the first post-spraying year was quite up to standard; but there is some indication that growth of yearling and older parr may have been restricted because the larger insects on which older parr usually feed have been greatly reduced (Summary 74). Such a situation could delay smolt transformation a year or more.

In general, potential egg deposition in these streams has been at rates between 150 and 300 eggs per 100 sq. yd. This has been demonstrated, here, to give large parr at the rate of 10 per 100 sq. yd., which should assure maximum smolt production. Spawning stocks must therefore be judged to have been more or less adequate. But as a result of spraying they are likely to decline until 1962 at the earliest (Summary 73). They may then be too low to give recovery in 1 generation. While unfortunate for fisheries, the condition will provide a most useful opportunity for studying stock requirements.

Stocks in the Tobique system, an important angling area, are also likely to decrease to a low ebb in 1961 as a direct result of spraying (Summary 78). It appears that in any case adult stock here may not have been as heavy, relatively, as in the Miramichi. But young salmon this year appeared to be about as abundant as on the Miramichi under comparable conditions of spraying (Summary 72 Figure 7).

P. F. Elson

No. 72

EFFECTS OF SPRUCE BUDWORM CONTROL ON SALMON AND OTHER FISHES IN NEW BRUNSWICK

Introduction

Each spring since 1952 large forest areas of northern New Brunswick have been sprayed with DDT in efforts to control a spruce budworm epidemic. The DDT has been mixed with a special solvent oil and sprayed from airplanes at a concentration of one-half pound of insecticide per acre. Some areas have been resprayed at intervals of 1, 2 or 3 years. In 1957 over 5 million acres of New Brunswick woodland was sprayed, much of it for the second or third time.

Since 1950 the Fisheries Research Board of Canada, through its Biological Station at St. Andrews, has carried out an annual fall census of the young salmon in parts of the Miramichi River system of central New Brunswick. This program has involved sampling the fish populations by seining with electro-fishing

at the same localities each year. Censusing began on the Northwest Miramichi River in 1950, was extended to the Dungarvon River in 1952 and to the Renous and Cains Rivers in 1955. In 1957 the work on the Dungarvon River was discontinued and censusing began on the Tobique River, the most important salmon angling tributary of the Saint John River. A total of 34 census stations is involved: 10 on the Northwest Miramichi, 6 on the Dungarvon, 5 on the Cains, 3 on the Renous and 10 on the Tobique.

Effects of DDT spraying on young salmon

The relative abundance of young salmon in the Northwest Miramichi each year since 1950 is shown in Figure 7. Data from the first year of censusing (1957) on the Tobique River are included in the figure for comparison. All data are shown as numbers of fish per 100 square yards of river bottom. The fish are separated into 3 groups on the basis of size. The smallest fish are fry, or underyearlings. Parr less than 10 cm. total length are classed as small parr; those over 10 cm. as large parr. In general, but not in every case, these 3 size groups correspond to the first 3 years of life. In the Miramichi River system most young salmon go to sea as smolts at the beginning of their fourth year.

Populations of all 3 size groups of young salmon in the Northwest Miramichi increased gradually between 1950 and 1953. This increase is probably related to the experimental merganser control which has been carried out on the river since 1950.

All the data obtained from population assessments on four branches of the Miramichi River since 1950 are summarized in Table I. The table includes the Northwest Miramichi data contained in Figure 7, but not the Tobique data. Fluctuations in abundance of young salmon over the larger area have been similar to those on the Northwest Miramichi. In years when DDT was sprayed populations of young salmon in streams within sprayed areas have been reduced. This reduction has been greatest among the fry. The year after the first spraying, with no further spraying in the same areas, fry were very abundant. Small and large parr have always been scarce in the year after spraying owing to heavy mortalities among the smaller fish in the year of spraying. In areas where no respraying was done for 2 or 3 years fry populations were similar to pre-spray levels. Parr, however, were more numerous, reflecting growth and survival of the large fry class of the first post-spray year. Also, since much of the natural food of small and large parr is reduced by DDT spraying, these stages grow more slowly than usual. Thus, some parr in these areas may take longer than usual to reach smolt size and may be included in the same size class for 2 consecutive years.

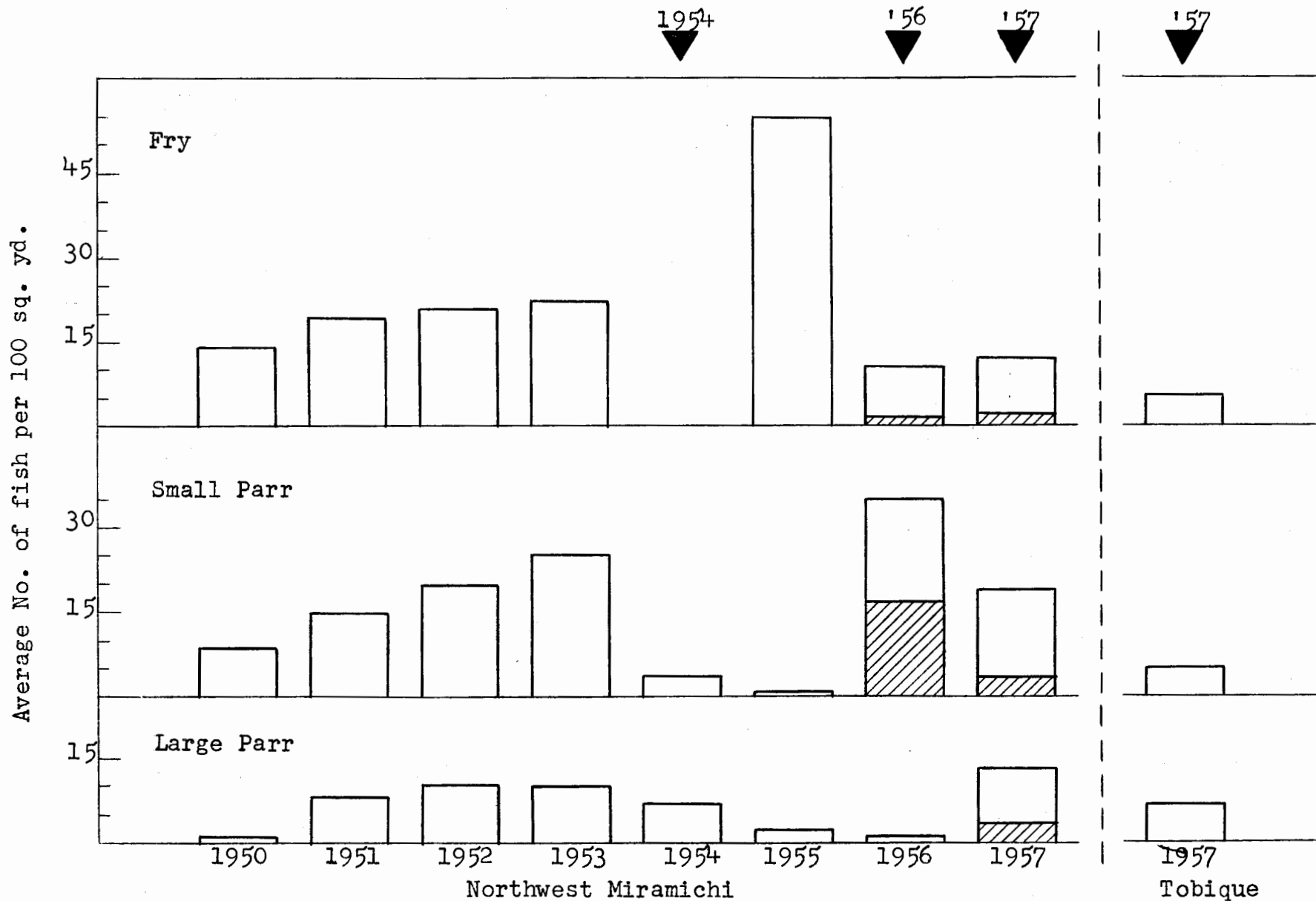


Figure 7. Abundance of young salmon in the Northwest Miramichi and Tobique Rivers. Solid triangles indicate years when DDT was sprayed in the area. Cross-hatching indicates proportion of fish found in sprayed part of the Northwest Miramichi.

Table I. Salmon abundance in the Miramichi River since 1950.

	Number of stations studied	Average no. fish per 100 sq. yd.		
		Fry	Small parr	Large parr
<u>Before spraying</u>	58	23.5	16.7	8.1
<u>Same stations after spraying</u>				
Year of spraying	34	2.5	9.4	3.7
*1 year later	17	50.8	0.6	2.8
*2 years later	6	24.2	43.9	2.6
*3 years later	3	27.8	48.4	29.7
*No further spraying.				

Effects of DDT spraying on other fishes

During the annual censusing of young salmon several other species of fish are taken regularly. Changes in abundance of these species have also occurred following DDT spraying. The relative abundance of brook trout, eels and 4 species of "minnows" (Cyprinidae) in the Northwest Miramichi River since 1953 is shown in Figure 8.

In the Northwest Miramichi trout are found mainly in the headwaters, a section of the river that was sprayed in 1954 only. They were scarce in 1954, recovered gradually until in 1956 they were more numerous than before spraying, and by 1957 were present in about average numbers again (Fig. 8). Only data for yearling and older trout are included in the figure. Fluctuations among these age-groups have been similar to those among salmon parr in this headwater section of the river. They were most abundant 2 years after spraying, when spraying was not repeated.

Before spraying eels were found in moderate numbers only throughout the Northwest Miramichi. They appear to have been severely affected by the DDT spraying. Their numbers were reduced in 1954 and in 1956 and by 1957 none at all were found.

Four species of Cyprinidae are included under the heading "minnows". These are the black-nosed dace (Rhinichthys atratulus), the common shiner (Notropis cornutus), the fallfish (Semotilus corporalis) and the chub (Couesius plumbeus). These fish are found only in the lower part of the Northwest Miramichi River, where spraying occurred in 1954, 1956 and 1957. They have remained abundant throughout this period and were particularly numerous in 1956. The relative proportions of the 4 species in this river have been approximately the same during this period. Dace are about 10 times as abundant as each of the other species.

1954

'56

'57

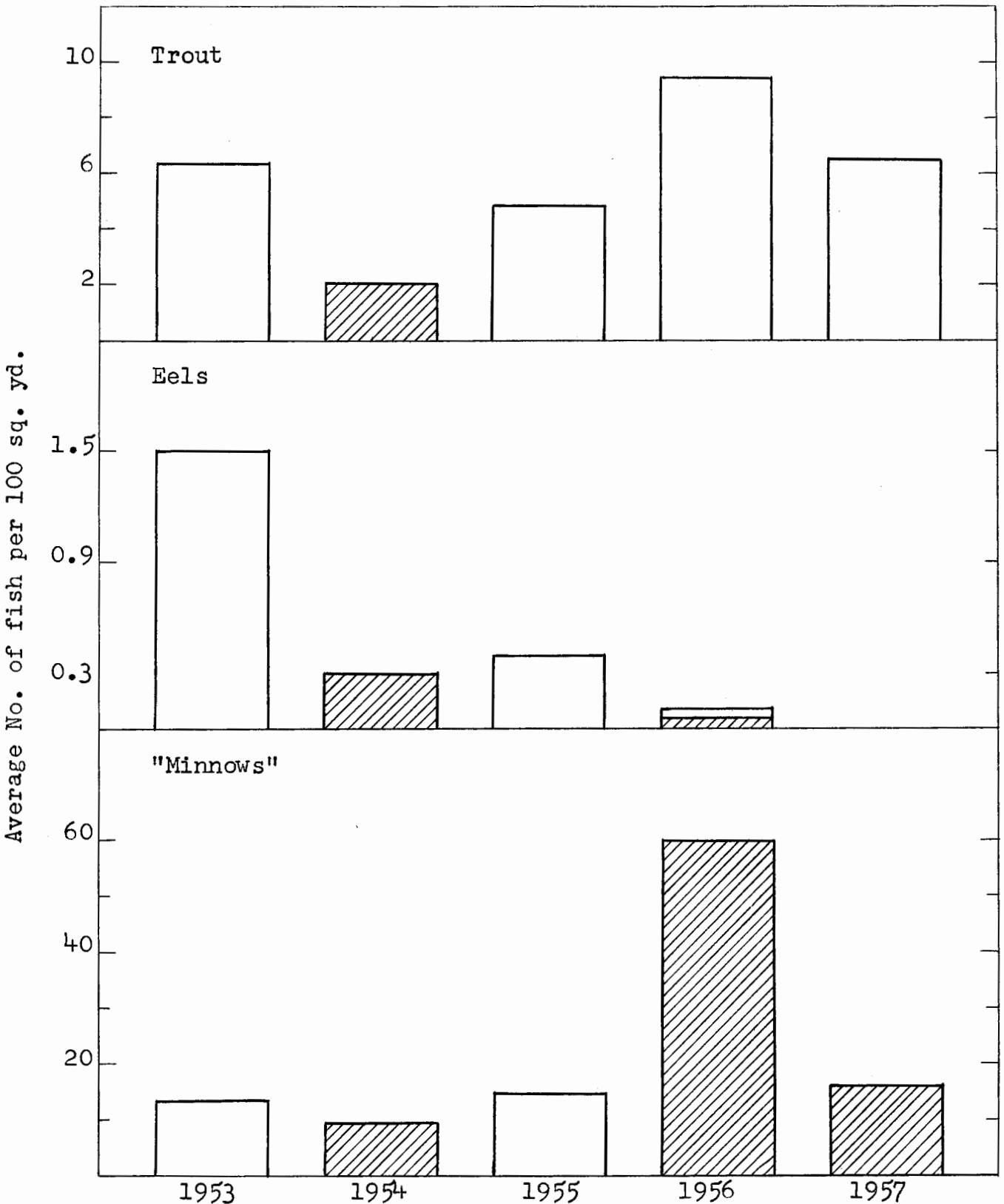


Figure 8. Abundance of fish in the Northwest Miramichi River. Symbols as described in legend to Figure 7.

Conclusion

Several species of fish in New Brunswick rivers have been adversely affected by the wide-spread application of DDT in the province as a control agent for spruce budworm. Young salmon, trout and eels are reduced in number following spraying. Four species of cyprinids appear to be relatively unaffected by the spray. Salmon populations appear to recover if spraying is not repeated over the same areas for an interval of at least 3 years. With more frequent re-spraying 1 age class of salmon can be affected more than once and smolt production from rivers in the area will be seriously curtailed.

M. H. A. Keenleyside and
P. F. Elson

No. 73

EFFECTS OF DDT SPRAYING IN NORTHERN NEW BRUNSWICK ON ADULT SALMON

The effects of DDT spraying on young salmon and the stream insects which are their main food have been shown by recent Fisheries Research Board studies, mostly in the Miramichi River system, N.B. It is important to attempt to use this information to forecast the effects of past sprayings on future stocks of adult salmon that will be available to commercial fishermen and anglers.

The problem of forecasting involves among other things: (1) the long life cycle of Atlantic salmon, commonly 6 years to give large salmon of 8 to 12 pounds weight, of which the last 2 are spent in the sea outside the scope of investigation; (2) error in using commercial and angling catches as the only available index of abundance of salmon for much of the affected area, since these are affected greatly by weather and water conditions, skill of fishermen, etc.; (3) absence of quantitative data on stocks of young salmon of various year-classes for affected rivers except the Miramichi where intensive sampling started in 1950, and the Tobique where similar work started in 1957.

A preliminary analysis of the situation for Miramichi, Restigouche and upper Saint John salmon has been made by (1) measuring on a map the total areas of watershed available to salmon; (2) measuring the proportion of each area affected by DDT in each year since 1952; (3) calculating the percentage kill of each of the 3 different size groups of young salmon on the basis of Northwest Miramichi observations, and thus obtaining the percentage survival to large (pre-smolt) parr in the various years; (4) converting these indices for large parr to adult grilse and large salmon, on the basis of trap records for the Miramichi and Tobique, and angling records for the Restigouche and upper main Saint John River. The results are shown graphically in Figure 9.

For the Miramichi the forecasts of stock abundance can be made with fair confidence because many data are available on young salmon, and runs of adults through sampling and counting

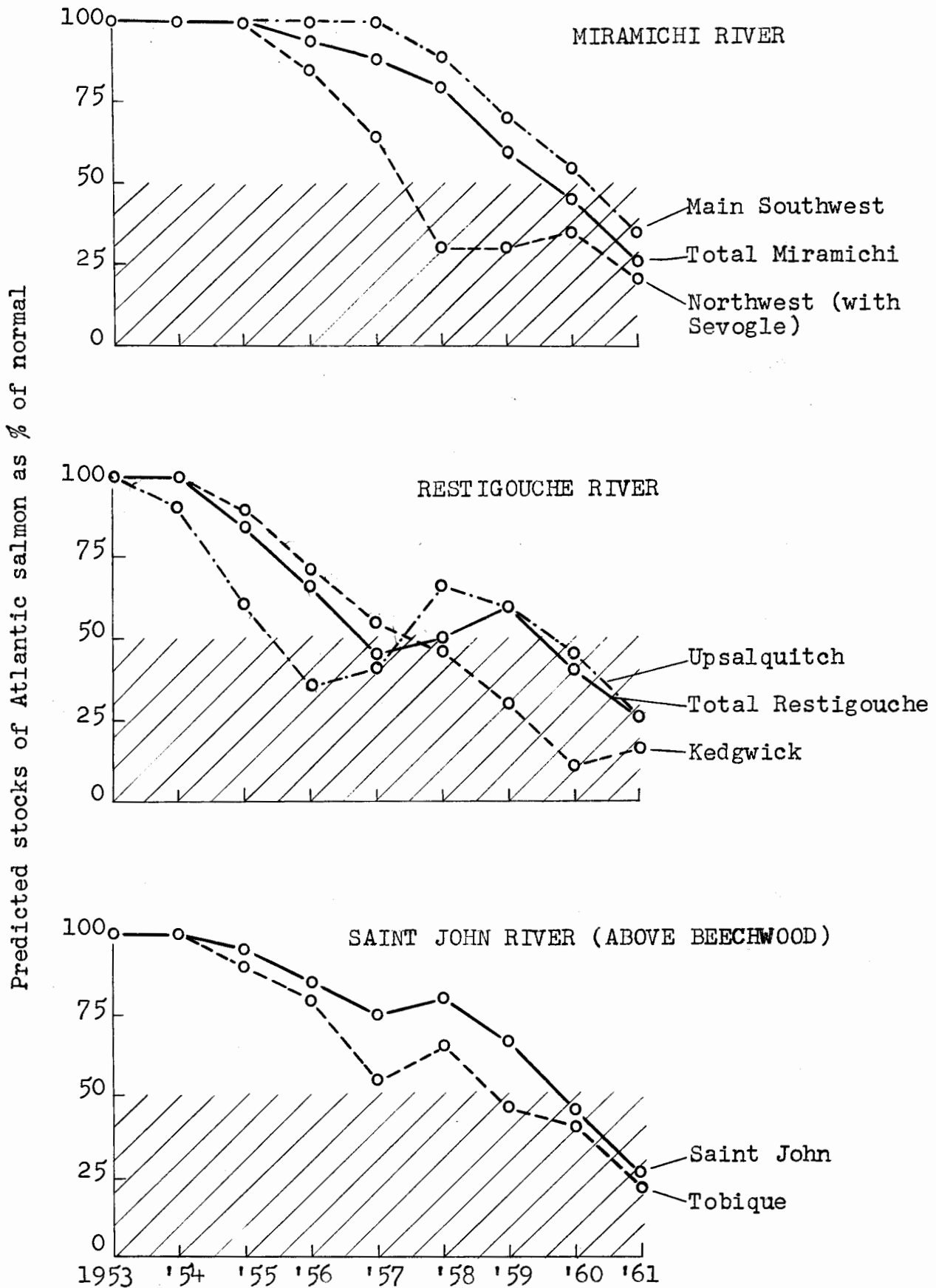


Figure 9. Probable decline of Atlantic salmon stocks caused by DDT spraying, 1952-1957, in 3 New Brunswick rivers.

traps. Conditions which affect catchability of adults while known at least in part, can scarcely be forecast. Because of spraying of the Northwest Miramichi in 1954 (1/3 the total Miramichi drainage) a decline in the stock of grilse originating here would be expected to start in 1956 and continue to 1959 for 2-sea-year salmon affected as fry in 1954. Later sprayings here and elsewhere on the system in 1956 and 1957 would contribute to continued drastic reduction and it is expected that by 1961 the adult stock will be only 25% of the normal level prior to 1955. Because of variable conditions affecting fishing success, particularly in angling, it is expected that decreases in stock down to 50% of normal level may not be apparent in catches. Thus the public may not be aware of the DDT effects on general Miramichi fishing until 1960. The effects of the 1954 spraying of the Northwest Miramichi have been obvious, however, in 1956 and 1957 trap records which are low by comparison with records for the whole system which showed increases in these 2 years.

In the Restigouche area a decline in adult stocks would be expected starting in 1955, with the level for the whole system falling to 50% in 1957, recovering somewhat in 1958 and 1959 and then falling off to the 25% level by 1961. For the upper Saint John above Beechwood a decline starting in 1955 should reach the 50%-of-normal level by 1960 and the 25% level by 1961.

It is important to realize that for 2 or 3 years yet the serious effects of recent DDT spraying on young salmon in northern New Brunswick are unlikely to be apparent in the level of fishing success enjoyed by the public in most areas.

The harmful effects of spraying can likely be overcome to some extent by judicious plantings of hatchery stock and transplanted stream insects. Both these methods of rehabilitating salmon rearing waters are currently receiving intensive study with the Board's program.

C. J. Kerswill and
P. F. Elson

No. 74

CHANGES IN MIRAMICHI RIVER INSECT POPULATIONS AFTER DDT SPRAYING

Sampling of the insect fauna of several branches of the Northwest Miramichi River was continued in 1957. This program was initiated in 1955, 1 year after the watershed of the river was sprayed with DDT for the first time. Collection and treatment of data were essentially the same in 1957 as in the 2 previous years. Adult insects emerging from the water were caught in square yard cage-traps and removed daily for 5 days a week, from early June to early September. Three traps were set out at each sampling station. One new station was established this year, bringing the total to 4. These were North Branch Big Sevogle River, Trout Brook, Millstream Brook and Northwest Miramichi River at Camp 42.

A large part of the Northwest Miramichi watershed was sprayed in 1957. However, through an agreement between the Fisheries Research Board and Forest Protection Ltd. (the company responsible for spraying) 3 of the 4 sampling stations were left unsprayed. The North Branch Big Sevogle station was the only one inside the spray area this year. It was also sprayed in 1954. The Trout Brook station was sprayed in 1956 only and the Camp 42 station in 1954 only. Millstream is the control for this project. It has not been sprayed to date.

Figure 10 shows the emergence of insects during the summer of 1957 at the Sevogle and Millstream sampling stations. The effect of the spraying which occurred on June 17 and 18 in the Sevogle area, is clear. A large emergence in early June dropped to almost nothing after spraying and insects did not begin to emerge in numbers again for about 6 weeks. The emergence of insects in the control stream (Millstream) was heavy throughout the summer.

A summary of the data collected at all 4 sampling stations in 1957 is presented in the table. In general, the results of the previous 2 years' work have been confirmed. All groups of insects are adversely affected by the spraying. Diptera larvae begin to recover 1 to 2 months after spraying, and then reappear in large numbers. The larger types of insect larvae recover much more slowly, if at all. This leads to a marked qualitative change in the insect fauna of sprayed streams. Whereas the insects emerging from a sprayed stream, particularly 1 or more years after spraying, may be more numerous than those from an unsprayed stream, the small forms (Diptera) are proportionately more abundant in the former. Thus, the total volume of insects emerging from the sprayed stream is less than that from the unsprayed. The resulting decrease in bulk of insect food available for salmon is obvious.

Among the larger insects the caddisflies are the most severely affected by spraying. This differential effect of the DDT on the various types of insect larvae was first noticed in 1955 and has been repeated each year since then. Very few caddisflies were taken in 1957 on the 3 streams that have been sprayed. At the Camp 42 station, unsprayed since 1954, recovery of caddisflies has been limited to a few of the smallest types, and even they were scarce this year. This may affect the growth of salmon parr in this region since caddisflies formed an important part of their diet in the Northwest Miramichi River before spraying occurred.

As in previous years, Dr. F. P. Ide of the University of Toronto assisted greatly with the planning and general supervision of this project. He visited the Miramichi area early in

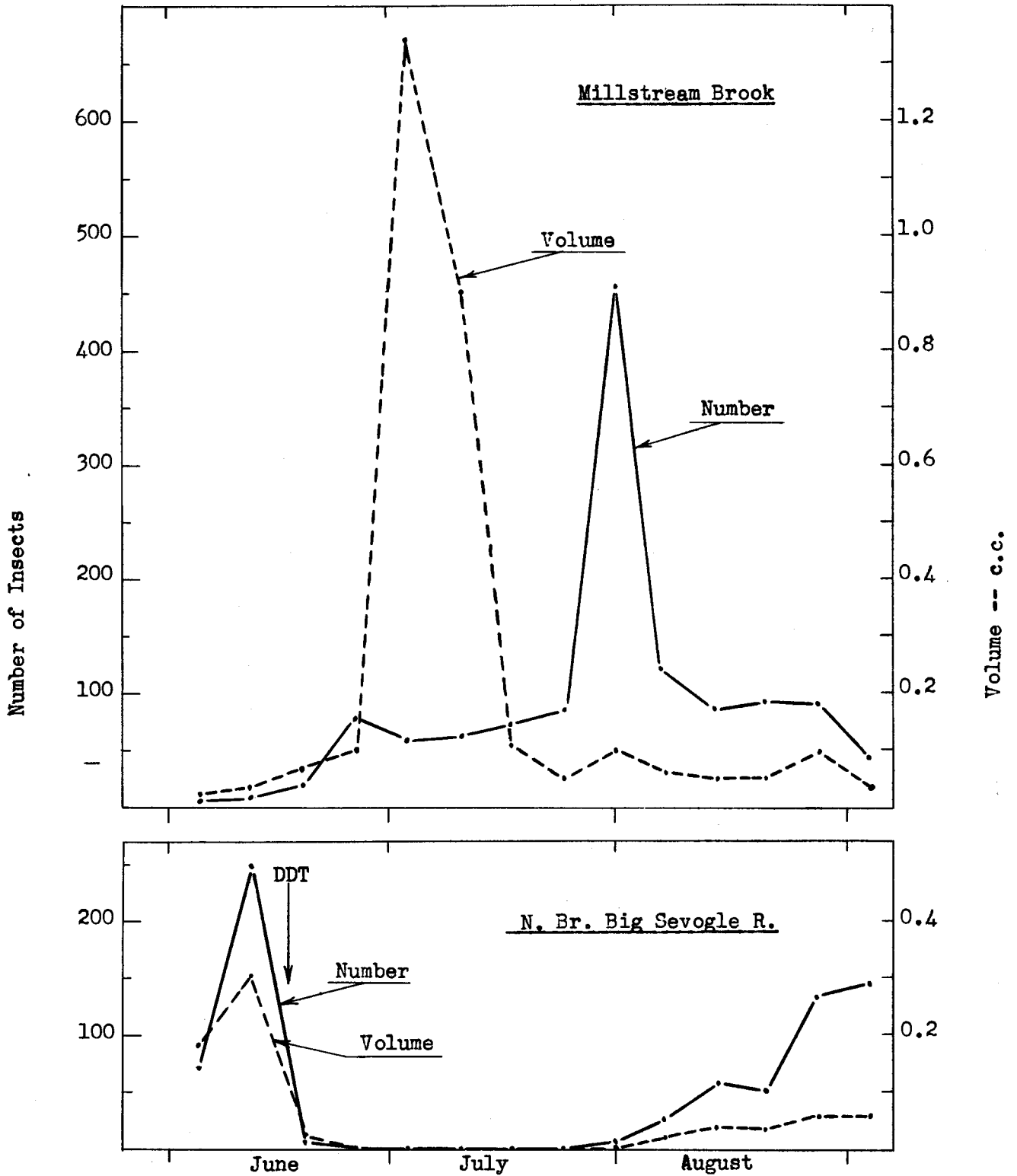


Fig. 10. Weekly change in number and volume of insects emerging daily into square yard cage-traps in two branches of the Northwest Miramichi River. Each point is the average of from four to six 24-hour collections per square yard.

Insects emerging per square yard from early June to early September, 1957, compared on a 60 day basis.

Percentage Representation

Stream	Year of spraying	Cage-trap	Percentage Representation						Misc. Diptera	Total nos.	Total vol.	
			Ephemeroptera	Plecoptera	Trichoptera	Chironomidae	Simuliidae	c.c.			Vol./nos.	
Trout Brook	1956	T _I	0.4	0.4	0.1	98.6	0.3	0.14	12,778	3.01	.0002	
		T _{II}	7.6	1.2	0.8	83.4	5.9	1.1	2,600	4.53	.0017	
		T _{III}	6.2	0.8	0.5	83.3	7.9	1.3	2,764	1.99	.0007	
Millstream Brook	unsprayed	M _I	4.4	3.5	2.2	88.4	0.1	1.5	6,448	11.85	.0018	
		M _{II}	3.1	3.3	2.5	90.0	0.1	1.0	5,754	10.15	.0018	
		M _{III}	3.7	2.7	2.9	89.0	0.2	1.5	4,448	6.17	.0014	
N'west Miramichi -Camp 42	1954	N _I	9.9	0.6	0.1	88.8	0.3	0.3	5,345	4.8	.0009	
		N _{II}	6.6	0.5	0.1	92.6	0.1	0.1	9,425	8.2	.0009	
		N _{III}	13.8	2.7	0.5	81.4	1.0	0.7	3,065	4.1	.0013	
No. Branch Big Sevogle	1954 1957	S _{III}	1.4	4.9	0.1	92.7	0.7	0.1	3,755	4.5	.0012	
		S _{IV}	1.7	2.1	0.1	94.9	0.9	0.2	3,873	3.2	.0008	
		S _V	4.0	1.6	0.4	90.9	2.7	0.4	1,352	1.8	.0011	

the season and again in early September. The routine collections of insects at the cage-traps and laboratory analyses were ably carried out by Student Assistants F. Yamamoto and J. W. Malia.

M. H. A. Keenleyside and
C. J. Kerswill

No. 75

COMPARATIVE EFFECTS OF THE INSECTICIDES DDT AND MALATHION
ON YOUNG SALMON

It is now widely recognized that large-scale aerial spraying of DDT against the spruce budworm in New Brunswick has been harmful to fish living in rivers within sprayed areas. It has been suggested that another insecticide, Malathion, is equally effective against the budworm, but is less harmful to fish. There is no direct evidence on the latter point regarding Atlantic salmon. Accordingly, bio-assays were carried out in May, 1957, to determine the relative toxicities of DDT and Malathion to young salmon. The work was done at the Curventon counting fence on the Northwest Miramichi River. Test fish averaging 9 cm. fork length were caught in the river with seines and held in pens until required. DDT and Malathion were mixed with solvent oil in the same proportions as in the DDT spray used against the budworm. The same type of oil used in the aerial spraying was used in all tests. The mixtures were diluted with river water to required concentrations.

The median tolerance limit (TL_m), or that concentration killing one-half a sample of fish in a given time, was the measure of toxicity used. For DDT the estimated 24-hour and 48-hour TL_m values were 0.049 and 0.047 p.p.m. respectively. For Malathion both 24- and 48-hour TL_m values were estimated as 0.033 p.p.m. Thus, Malathion was slightly more toxic to young salmon than DDT under these experimental conditions.

These tests do not show directly what the effects on salmon would be if Malathion were used instead of DDT to control the spruce budworm. Other factors, such as concentration and form of the insecticide, type of solvent oil, and the form the insecticide is in when the fish come in contact with it, are all important in determining the danger to fish. However, it is clear that when present in river water at similar concentrations, Malathion is no less toxic to young salmon than DDT.

M. H. A. Keenleyside

No. 76

FOOD OF YOUNG SALMON AS AFFECTED BY DDT SPRAYING
IN THE NORTHWEST MIRAMICHI RIVER

The effects of the 1954 and 1956 DDT sprayings of the Northwest Miramichi River on the food of young salmon were assessed by stomach analyses of fry and yearling parr from the area. A total of 202 fish was examined. Some were collected in 1953, the year before the river had been sprayed, and others were collected in 1956. They were collected in August and September each year. Of the 6 collection stations the upper 4 were within the 1954 spray zone and the lower 3 within the 1956 spray zone. Thus, 1 station was sprayed both years.

Among fry the most noticeable change in diet between 1953 and 1956 was the lack of caddisflies and stoneflies in 1956. In 1953 fry from all stations ate caddisflies, as well as mayflies, stoneflies and chironomids. In 1956 mayflies and chironomids were still common in fry stomachs but no caddisflies were found in fish from stations sprayed in 1954 and very few in fish from stations sprayed only in 1956. Stoneflies were practically absent from the 1956 series.

Parr showed a more varied diet than fry, both in pre- and post-spray years. Caddisflies were much scarcer in the 1956 series and those that were present were small types. Stoneflies were also scarcer in the 1956 series. Mayflies and chironomids were plentiful in each series, the latter particularly so in 1956. The most striking change in the parr diet was the great increase in snails, water mites and worms eaten in 1956. These animals were very scarce in the 1953 series and the parr appear to utilize them as food after the larger insect larvae are reduced by DDT.

This work was done during the 1956-57 academic year at the Department of Zoology, University of Toronto, by 2 undergraduate students, R. Simmons and U. Paim, who were employed on a casual basis. They were supervised by Dr. F. P. Ide, who wrote and submitted the report on which this summary is based.

M. H. A. Keenleyside

No. 77

INTRODUCTION OF AQUATIC INSECT LARVAE TO THE NORTH BRANCH
BIG SEVOGLE RIVER, N.B.

Spraying of the watershed of several branches of the Northwest Miramichi River with DDT in order to control an epidemic of spruce budworm has resulted in marked changes in the insect fauna of these streams. Compared to unsprayed streams the numbers of insects are relatively great, but the bulk, or total volume, is low. The Diptera larvae and other smaller types of insects are affected less severely than most larger forms for a number of reasons. Populations of many of the larger types,

which are important in the diet of young salmon, are slow to recover from spraying. The North Branch Big Sevogle River is a good example of a stream affected in this way, due to 2 sprayings with DDT, one in 1954 and another in 1957. Accordingly, it was chosen as a site for an experimental introduction of insect larvae from Millstream Brook, an unsprayed tributary of the Northwest Miramichi, where the larger aquatic insects are abundant.

The transfer was made by taking stones to which numerous insect larvae were attached from the bed of Millstream to the insect sampling station on the Sevogle River. At that point 3 cage-traps which had been sampling the emerging adult insects since early June provided a continuous check on the survival of the introduced forms. Three identical cage-traps were placed in the Sevogle 100 yards up-stream from the first set to record any up-stream movement of introduced insects.

The transfer was made on August 2, 1957, 44 days after the Sevogle River watershed was sprayed with DDT. The stones were lifted carefully from Millstream, and placed in wooden racks which were then stacked in the back of a jeep. During the 1½-hour trip to the Sevogle River the insect larvae were kept moist by sprinkling the stones regularly with water. Two such trips were made, the jeep carrying 1 cubic yard of stones per trip. At the introduction site the stones were placed in and around the lower set of 3 cage-traps. They were put in the water oriented in approximately the same direction with respect to current flow as they had been in Millstream. Thus, larvae which were attached to stones by cases oriented in relation to the direction of the current were not immediately swept away. Also, a baffle held up-stream from the introduction site helped to slow down the water flow and increase the chances of insects remaining in place.

Although it is too early to evaluate the long-term effects of the experiment, early results are encouraging. During the month following introduction, 4 types of insects were found in the lower cages where the Millstream stones had been placed. None of these had been found before at the Sevogle sampling site, but all were common at Millstream. They were a crane-fly, a may-fly and 2 caddisfly species. The crane-fly was the most abundant of the 4, and therefore shows the best evidence of successful introduction. None of these 4 species was found in the upper set of cage-traps, indicating that no immediate up-stream movement of the introduced larvae occurred. The introduction will be followed up in 1958 by continuous sampling at the 2 sites on the Sevogle River. This should give evidence on the success of the introduced forms in establishing themselves in their new environment.

The transfer of stones on August 2 involved much physical effort. It was shared by all available personnel of the Atlantic salmon staff, including E. J. Schofield, I. M. Jones, E. C. Tucker, T. Jellinek, J. Malia, M. H. A. Keenleyside and C. J. Kerswill. Dr. F. P. Ide contributed greatly in the preliminary planning of the project. The field preparations

were largely undertaken by Student Assistant J. Malia, who also kept the detailed record of activities, and made a rough draft of the full report.

M. H. A. Keenleyside

No. 78

HYDRO-ELECTRIC DEVELOPMENTS AND SAINT JOHN RIVER SALMON

In Europe hydro-electric developments on salmon streams have seriously curtailed, in many cases practically eliminated, local stocks of salmon. The Mersey River of Nova Scotia was once a good salmon stream, but following fairly complete conversion for hydro-electric purposes its stocks have shrunk to negligible proportions. Recent developments on the Saint John River in New Brunswick may now constitute a threat to Saint John stocks. These now yield some 3,000 salmon a year to anglers as well as supporting a sizeable commercial fishery. This system, although perhaps not fully utilized, has, below Grand Falls, the largest area adapted to raising salmon of any river in the Maritime Provinces (Figure 11). In 1957, through co-operative efforts of the Board and the Department of Fisheries, steps were taken to open an investigation on the possible implications of these industrial developments for Saint John salmon. Results of the studies should eventually have significance also for evaluating any future proposals to convert other salmon rivers for hydro-electric purposes.

The co-operative study has involved during the past year:

- (1) Preliminary observation of descending smolts at the dams;
- (2) Counting and tagging adults at the dams;
- (3) Assessment of young salmon in the Tobique system, the principal tributary which is above both the Beechwood and Tobique Narrows dams;
- (4) Evaluation, based on consideration of both the Saint John and other systems, of the potential of the Saint John as a salmon-producing system and the probable effects of the impoundments.

These efforts have made it possible to form tentative conclusions now, regarding some of the probable effects of the 2 impoundments. Of still more value, they provide a rational basis for developing future attacks on the problem. A summary of the past year's results follows.

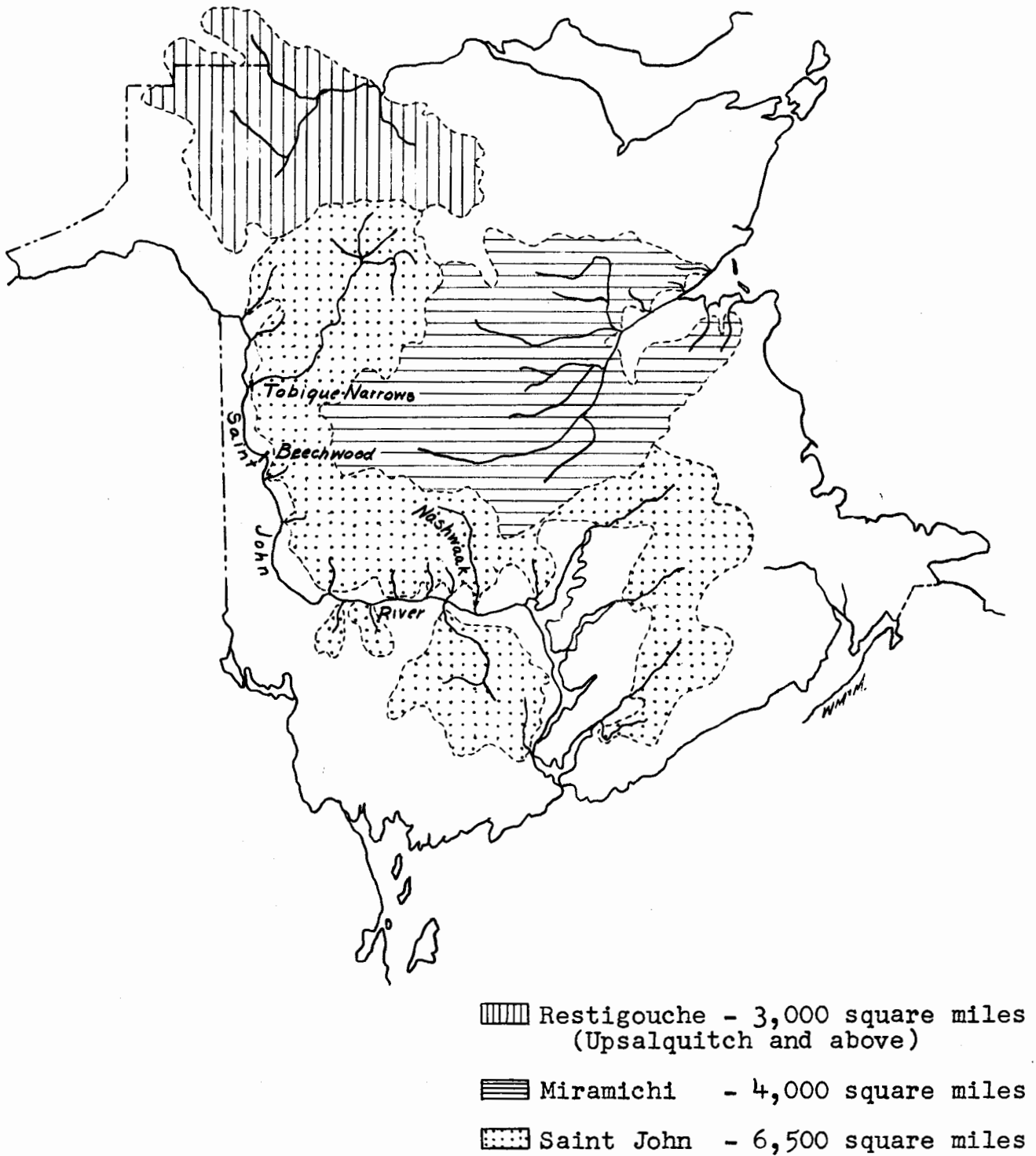


Figure 11. Approximate salmon-rearing areas of 3 principal river systems in New Brunswick.

Loss of rearing areas. The proportionate losses of rearing areas as a result of flooding are approximately:

for the Tobique system,	1/20 of former rearing areas
for the Saint John above Beechwood, including the Tobique	1/7 of former rearing areas
for the Saint John from the Nashwaak up, including the Tobique	1/20 of former rearing areas
for the entire system (commercial stocks)	under 1/20 of former rearing areas.

For the most part these losses of stock should be almost negligible to fisheries, in the face of other, and natural fluctuations. The actual loss of fish in this way will probably not exceed 100,000 or 200,000 smolts per year. Replacement of this number is well within the existing capacity of the present hatchery system of the Department.

Access for mature salmon. The means of access above both dams, for mature salmon, appear to be adequate to maintain stocks for angling and reproduction at their present levels. Salmon apparently use the fishway at the Tobique dam readily. They also enter the Beechwood elevator in good numbers when water discharge conditions approximate those for which the unit was designed. In 1957 this condition did not apply until late in the autumn. Delay between these 2 devices was of the average order of only 8 days to negotiate the 20 miles or so of head pond and pass through the upper fishway.

Loss of smolts in head ponds. The conditions which descending smolts meet in the head ponds and at the dams may well deplete the total stocks. Losses at these places could come about through (1) delay and loss to predators in head ponds; (2) bodily abrasion as the tender smolts pass over dams; (3) injury by violent pressure changes as the fish pass through turbines. The first 2 factors seem obvious spheres for investigation. Little information on the physiology of pressure changes is available for fish. But a sudden drop in pressure of 18 pounds per square inch is sufficient to cause the formation of gas bubbles in human tissues (the "bends" of deep-sea divers). Fish passing through the turbines of these dams must undergo almost instantaneous releases of pressure amounting to from 25 to perhaps 45 pounds per square inch. Losses so induced could be secondary, through the action of predators on injured smolts, as well as primary.

Losses from DDT a complicating factor. Large parts of the rearing areas above these dams have been subjected to DDT spraying in recent years. Hence, decreases in stocks in the immediate future cannot be attributed solely to the dams. The probable decreases resulting from the spraying programs are forecast in Figures 12 and 13. Forecasts are based on

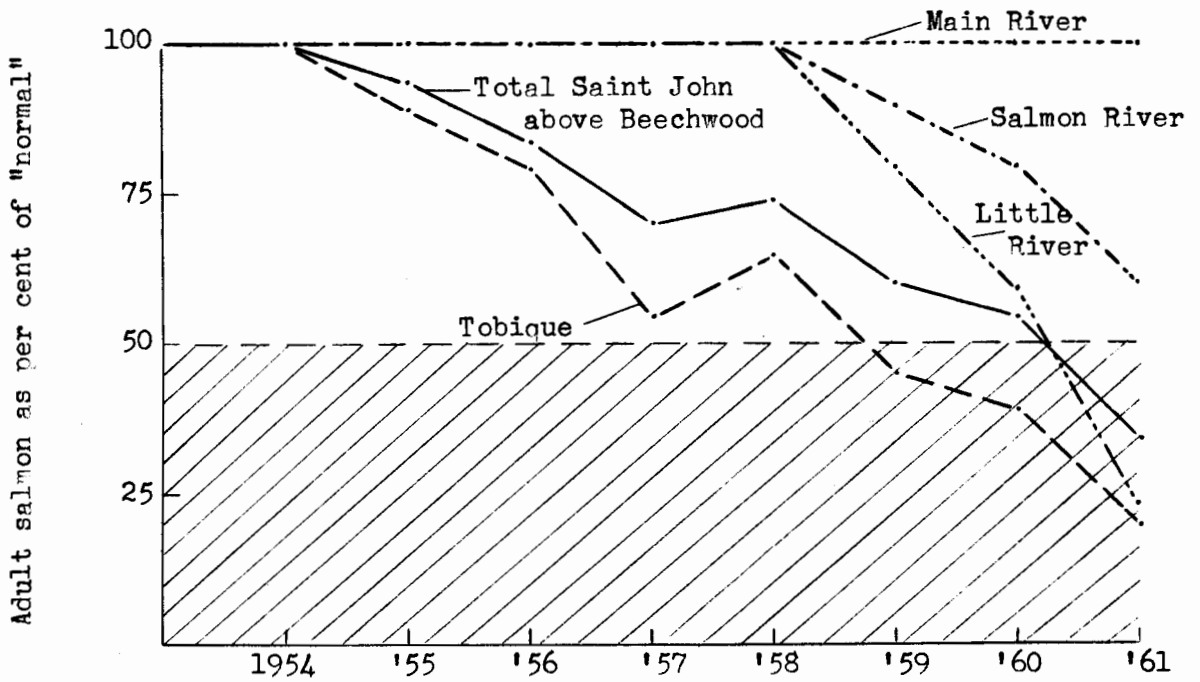


Figure 12. Expected stock of adult salmon for various components of the Saint John River system. Stock are measured as percentage of what they would have been if stream drainages had not been sprayed with DDT in the years 1953-1957. Stock values also assume smolts will return in the ratio of 2 grilse to 1 salmon, as shown in the Tobique fishway and by Saint John angling catches.

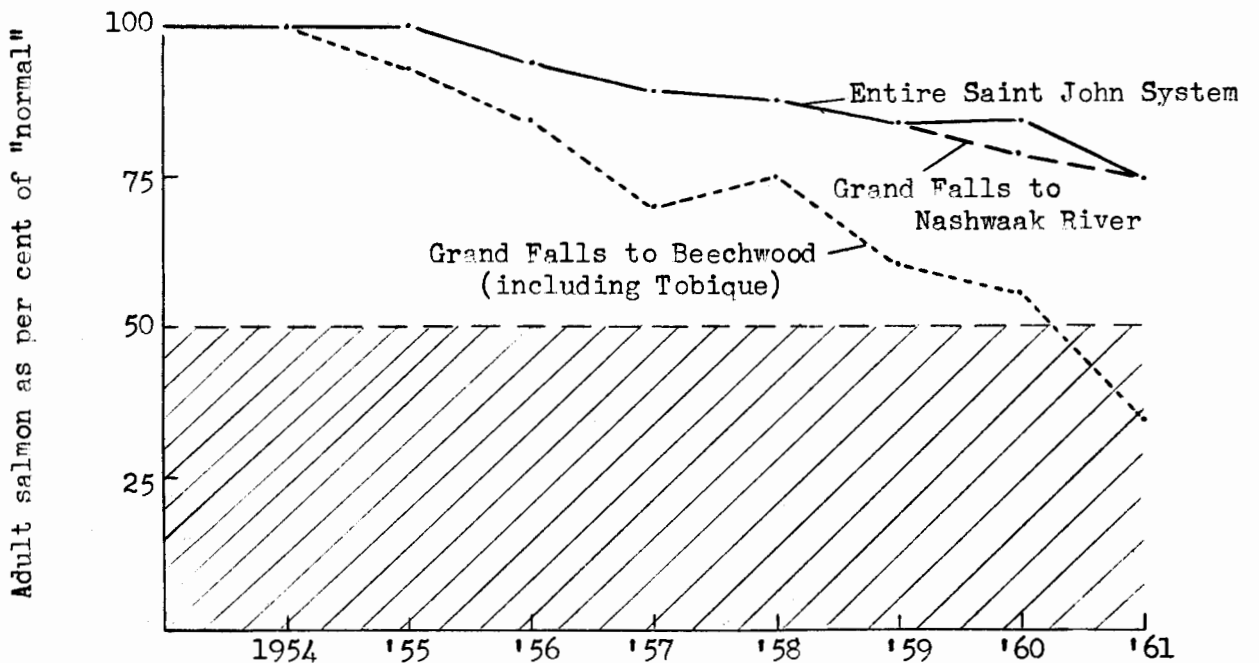


Figure 13. Expected stocks of adult salmon for the Saint John River measured as a per cent of what it would have been if various parts of the drainage basin had not been sprayed with DDT in the years 1953 to 1957. It is assumed that, as shown in Tobique fishway and angling catches, smolts return as grilse or 2-sea year salmon in a ratio of 2 grilse : 1 salmon.

consideration of the areas sprayed, the observed effects of spraying on different stages of young salmon and the known facts about ages of returning adults in this system. On this basis alone it is to be expected that by 1961 Tobique stocks will drop to about 1/5 of what they would have been without spraying. Total stocks above Beechwood should drop to about 1/3 of what they would otherwise have been. But total stocks for the entire system (the resource for commercial fisheries) should not be cut below 3/4 of their normal value by spraying. Particularly favourable conditions for survival and for fishing during the next 4 years could alleviate the situation somewhat. But drastic declines in some areas seem almost inevitable.

Possible effects of impoundments on fisheries. Because of the large rearing areas, potential if not now in actual use, below Beechwood, only fisheries which depend heavily on stocks from above Beechwood appear to be in any serious danger from the hydro-electric impoundments. Such fisheries are: angling above Beechwood, including in the Tobique, and angling between Beechwood and the Nashwaak River to a lesser extent. The commercial fishery seems unlikely to lose more than about 1/4 of its stock in this way. At their worst, effects of the impoundments might well be of the general order of those now expected to occur in 1961 from DDT spraying.

Direction of future research. Future research on this problem should involve assessment of young stocks above and below the impoundments. Assessment of adults at the dams should be continued, with tagging studies included. But particular emphasis should be placed on acquiring knowledge of the behaviour and survival of descending smolts at the impoundments.

P. F. Elson

No. 79

INTER-GROUP LIAISON AND PUBLIC RELATIONS

In 1949 a Federal-Provincial Co-ordinating Committee on Atlantic Salmon was established to encourage the development of an effective research and management program and the production of more salmon for use by the public. A possible weakness of earlier research work had been concentration on the salmon problems of a number of relatively small streams, and usually only a short period of investigation in any one area. While much useful fundamental information was obtained in about 25 years of such work, the fishing public, and particularly anglers on large rivers like the Miramichi felt strongly that the salmon fishery, which had declined sharply since the last peak in abundance in 1930, was being ignored by the government. Stimulated by the new Committee a comprehensive program was developed. It was decided to continue most of the research projects already in progress, but to undertake several new studies involving production of young salmon by a series of typical salmon rivers and their utilization in fisheries over a wide area. The Provincial Governments were encouraged to participate in the program, and an

effort was to be made to assure the closest possible liaison between the research and management staffs. To meet demands from the public for more information on the salmon situation, it was agreed that considerable effort should be spent in publishing semi-popular accounts and in addressing meetings of various groups. The writer has assumed responsibility for most of the latter. Other senior staff of the St. Andrews salmon group have contributed greatly by visiting new problem areas, advising on techniques for new topics of investigation, and undertaking to carry out various phases of the research program. Field technical staff carry the responsibility of maintaining support of local anglers and commercial fishermen required to carry out many aspects of the field work. To assure co-ordination of the research program a meeting of a Scientific Sub-committee has been held each winter at St. Andrews, with the Station Director as Chairman and the writer as Secretary.

Except for preparation of reviews for publication, the following statement of activities by senior staff of the St. Andrews Station in 1957 includes only those in which outside travel was involved. At St. Andrews there were several meetings with senior staff of the Fish Culture Development Branch, Saint John, N.B., and others.

Effects of DDT spraying

April - Fredericton, N.B. (Kerswill, Keenleyside, Ide): Meeting with Forest Protection Ltd., Canadian Department of Agriculture, N.B. Department of Lands and Mines to decide joint arrangements to determine effects of past and future sprayings in northern N.B.; agreement reached to exempt from spraying 80 square miles of Northwest Miramichi watershed above new Fisheries Research Board counting fence at Camp Adams.

May - Vancouver, B.C. (Kerswill): Meeting with biologists of Department of Fisheries and B.C. Game Commission to finalize techniques for determining effects of new spraying projects on Vancouver Island on Pacific salmon, based on Miramichi experience.

September - Newcastle, N.B. (Kerswill, Keenleyside, Ide): Meeting with same group as in April to review effects of 1957 spraying on budworms and salmon.

January - Ottawa. (Hart, Kerswill, Keenleyside, Ide): Meeting arranged by Canadian Department of Agriculture attended by 45 staff members of Fisheries Research Board, Department of Fisheries, Department of Agriculture, Department of Northern Affairs and National Resources, Forest Protection Ltd., and various B.C. and Quebec organizations to review knowledge of effects of spraying and to try to adjust operations to lessen injury to fish; new inter-departmental committee formed to meet regularly in Ottawa, and also a new working group to meet in February.

February - Fredericton (Kerswill, Elson): Meeting with same group as in April, to review plans for 1958 spraying and checking of effects.

March - Fredericton (Kerswill, Elson, Keenleyside): Meeting of above group plus officials of Science Service, Ottawa, Ontario, to finalize arrangements to investigate possibilities of new insecticide, DDD.

Effects of water storage dams

March - Perth, N.B. (Kerswill): Meeting of Tobique Fisheries Protective Association to help Department of Fisheries officials explain probable effects of new Beechwood power dam and 4-year-old Tobique Narrows power dam on availability of salmon to anglers in upper areas.

April-May - British Columbia (Kerswill): Two-day fish-power symposium at University of British Columbia, followed by tour of several problem areas in Fraser Valley and in State of Washington to obtain familiarity with Pacific salmon research and management operations associated with power, water supply and irrigation dams and diversions.

June, October - Upper Saint John River (Elson, Keenleyside, Kerswill): Visits with N.B. Electric Power Commission officials and biologists and engineers of Department of Fisheries at Beechwood and Tobique Narrows dams to discuss salmon problems and advise on methods of determining effects and of remedying situation.

August, March - Fredericton (Kerswill, Elson, Keenleyside): Meetings with N.B. Electric Power Commission and Department of Fisheries to advise re giving evidence in court proceedings in pending lawsuit between Tobique riparian owners and the N.B. Electric Power Commission (defendant); a proposal for an experimental improvement of facilities for descending smolts was submitted to the Power Commission.

Predatory bird control

July - Margaree River, N.S. (Elson, MacFarlane): Conference with Canadian Wildlife Service and Fish Culture Development Service on procedures for new predatory bird studies; co-operative seining program with Department of Fisheries, to estimate young salmon populations prior to anticipated new experiment needed to demonstrate effects of merganser removal on adult salmon because the Miramichi experiment is now confused by DDT spraying.

August - Margaree River, N.S. (Elson): To advise Canadian Wildlife Service biologist on the technique of capturing mergansers for banding in above co-operative merganser control experiment.

Liaison with other research groups

June - Pollett River and Moncton, N.B. (Hart, Kerswill, Elson, Keenleyside): Meeting with Drs. Swanson and Webster of Cornell University to consider possibilities for new joint salmon research on Restigouche River; followed by visit of Webster, Kerswill, Elson to Miramichi and Restigouche Rivers and selection of Falls Brook, tributary to Restigouche as suitable site for new program if funds and staff become available.

August - Little Codroy River, Nfld. (Elson): Discuss salmon field techniques with Newfoundland Station staff, particularly adult and smolt trapping, and seining with electrofishing to estimate populations of young.

August - Port Daniel River, and Grand Rivière, P.Q. (Kerswill, Keenleyside): Inspection of salmon field work by staff of Quebec Department of Fisheries and discussion of data being obtained in co-operative program.

November - Orono and Machias, Maine; Narraguagus and other salmon rivers (Kerswill, Elson, Saunders): Discuss possibilities for closer liaison with Maine salmon and trout investigations, inspect hatchery operations and field techniques, and give advice on latter based on Canadian experience.

Public information

May (Kerswill): Semi-popular account of salmon research highlights in 1956 for June issue of "Trade News".

September - Boiestown (Kerswill): Addressed Annual Dinner Meeting of Miramichi Salmon Association, reviewing salmon-power problems in Europe and British Columbia.

February - Ottawa (Kerswill): Illustrated review of 1957 salmon research highlights to joint meeting of Co-ordinating Committee on Atlantic Salmon and its Advisory Committee, the latter comprising representatives of salmon fishing industry from all Atlantic Provinces where salmon are fished commercially and for sport.

June (Elson): Four articles submitted for Canadian Fish Culturist reviewing recent research findings that contribute to salmon management; published December, 1957.

January - Montreal (Keenleyside): Paper reviewing findings to date on effects of aerial DDT spraying in northern New Brunswick on stream fishes, presented to Northeastern Wildlife Conference after presentation at C.C.F.F.R. meeting in Ottawa.

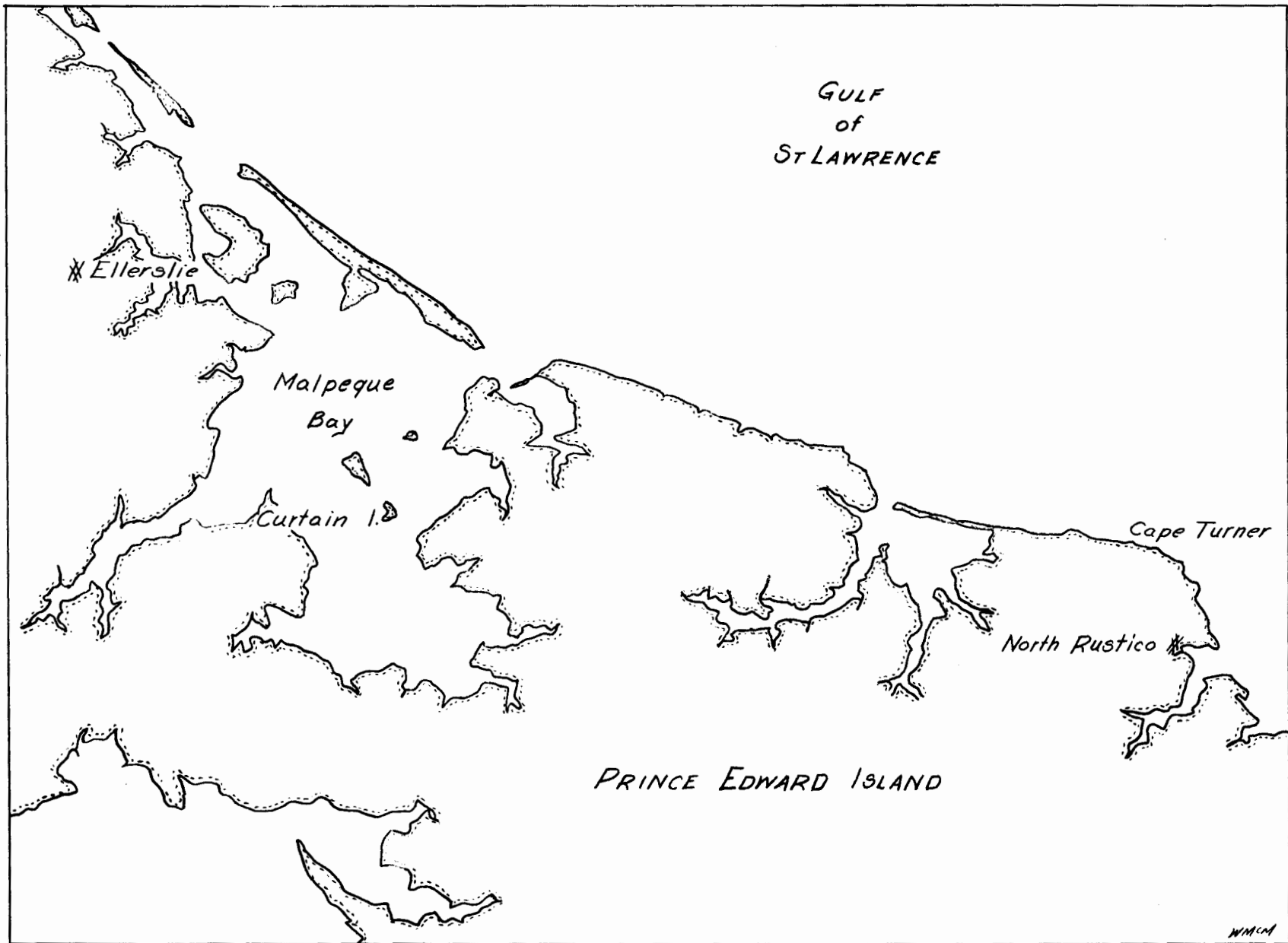
C. J. Kerswill

SEAWEEEDS SUMMARIES

Rate of growth of Irish Moss

The constitution and productivity of the Chondrus population

The marine flora of Prince Edward Island and New Brunswick



RATE OF GROWTH OF IRISH MOSS

Rate of growth in area and length of individual Chondrus specimens has been studied since the summer of 1955 by photoprinting the plants with Ozalid paper. This method was described in the 1955 Annual Report. Beginning in 1956, some of the rocks on which study specimens were growing were partly embedded in large concrete blocks. This was done to prevent loss of plants during storms in which the small rocks are often moved about on the bottom by wave action. These blocks are hauled by block and tackle to the surface and into the boat, the Clupea H., for study; we have been assisted in this by personnel from the Ellerslie Sub-Station. This method has proved successful and all rocks can now be removed.

At Curtain Island in Malpeque Bay, 148 specimens were measured in September 1956. On May 9 and 10, 1957, as soon as possible after the ice left the shore at Ellerslie, the blocks were raised and the plants photoprinted. Measurements were made again at intervals through the summer. Other plants were measured at intervals through the summer at Cape Turner and Doyle's Cove, P.E.I., and at Alma, N.B.

Conditions at Cape Turner and Doyle's Cove, both on the exposed north shore of P.E.I., are essentially the same; the plants were at a depth of about 10' M.L.T. on flat ledges of rock. Curtain Island Reef position is similar, but because it is in Malpeque Bay it is less exposed, slightly warmer in summer, and the water is covered by ice and snow for most of the cold winter months.

Rate of increase in length during the summer growing season was of the same order again in 1957 as in 1954, 1955, and 1956: approximately 0.2 mm./day/plant. The information and comparisons reported here this year deal mainly with change in area of the plants; area measurements can be put on a yield basis more readily than length measurements. The mean daily rates of growth at each study area are given in Table I(a) for the summers of 1955, 1956, and 1957 as increase in area per unit area of a plant per day. The mean rate is of the order of 0.010 cm²/cm²/day/plant for plants in all four study areas; the rate of growth is variable in all locations but does not differ appreciably from place to place.

Mean rates of growth (area) over successive periods of time are given in Table I(b) for plants on Curtain Island Reef in Malpeque Bay. These results are shown graphically in Figure 1 for the period from May, 1956, to August-September, 1957. There is a rapid rise to a maximum rate of growth in the spring. This is coincident with: the period of high insolation and long day; clear, cool but warming water; minimum numbers of annual epiphytes; low plankton density; and high runoff of mineral-bearing surface water from the melting snow on the land. The rate of growth falls slowly through the summer and autumn and is at a minimum during the cold dark winter months. At this study area it must be very

Table I. Rate of growth in area of individual Chondrus plants

(a) Summer growth in all localities studied

<u>Location</u>	<u>Year</u>	<u>No. of plants</u>	<u>Duration (days)</u>	<u>Increase in area*</u>	
				<u>Mean</u> (cm ² / day/plant)	<u>s.d.</u> (cm ² / day/plant)
Fundy Park	1956	5	102	0.0078	± 0.0026
Fundy Park	1957	16	90	0.0123	± 0.0030
Doyle's Cove	1955	15	16-70	0.0067	± 0.0037
Doyle's Cove	1956	20	62	0.0095	± 0.0032
Doyle's Cove	1957	12	70	0.0108	± 0.0036
Cape Turner	1955	24	15-79	0.0143	± 0.0102
Cape Turner	1956	20	74	0.0094	± 0.0025
Cape Turner	1957	15	33	0.0123	± 0.0061
Malpeque Bay	1956	16	30	0.0118	± 0.0058
Malpeque Bay	1957	55	26-31	0.0108	± 0.0047

(b) Growth during successive periods of time -- Curtain Island Reef, Malpeque Bay, P.E.I.

Period

(1)	4/6/56-4/7/56	16	30	0.0118	± 0.0058
(2)	4/7/56-22/8/56	7	49	0.0066	± 0.0035
(3)	22/8/56-16/9/56	13	25	0.0066	± 0.0068
(4)	11/9/56-10/5/57	75	240	0.0025	± 0.0013
(5)	9-10/5/57-4/6/57	55	26-31	0.0118	± 0.0065
(6)	4-10/6/57-17-19/7/57	59	38-45	0.0108	± 0.0047
(7)	17-19/7/57-27-28/8/57	49	40-42	0.0056	± 0.0028

* (increase in area of plant over period)
(mean area of plant during period) X (duration in days).

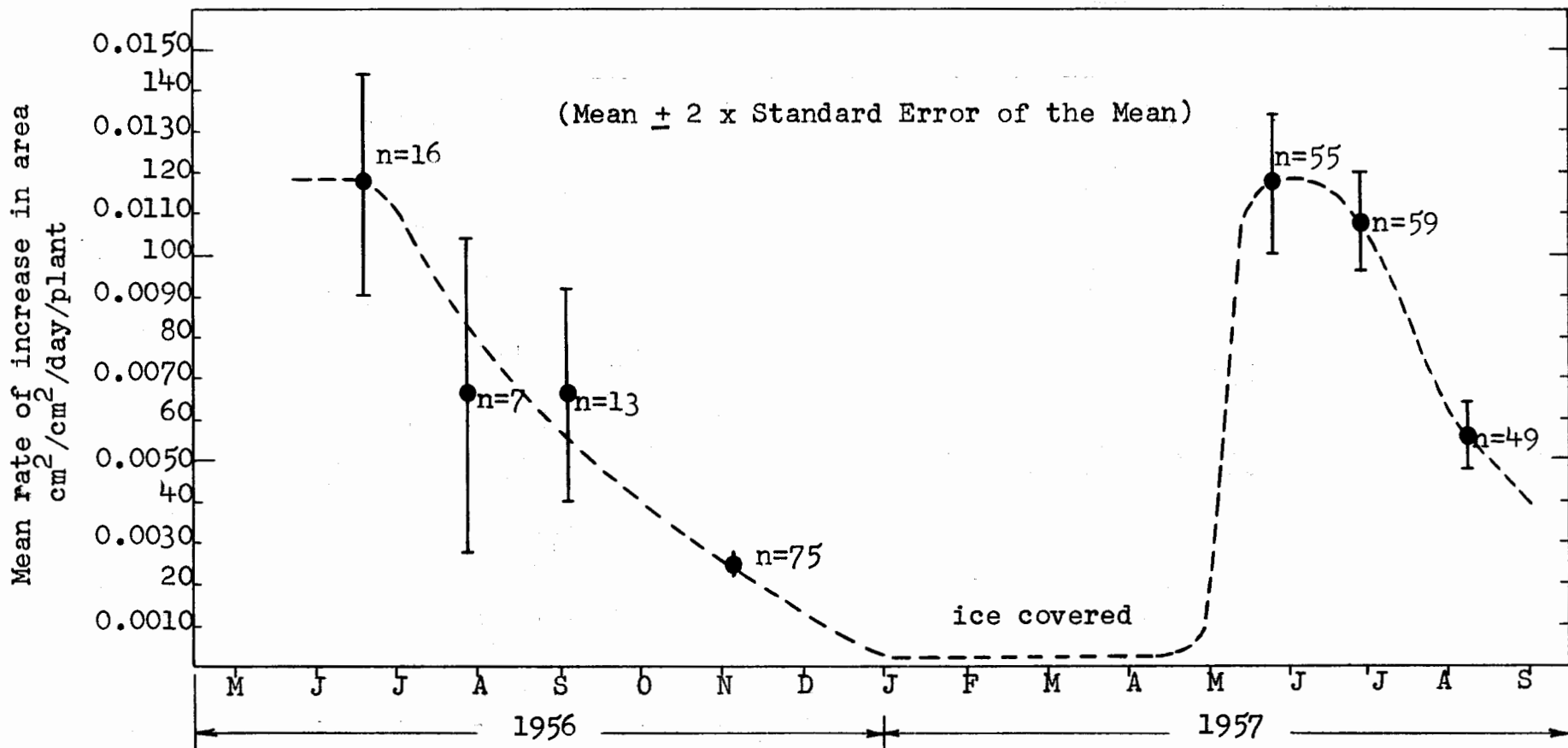


Fig. 1. Rates of growth in area of Chondrus plants at Curtain Island, Malpeque Bay, P.E.I., over the course of the year.

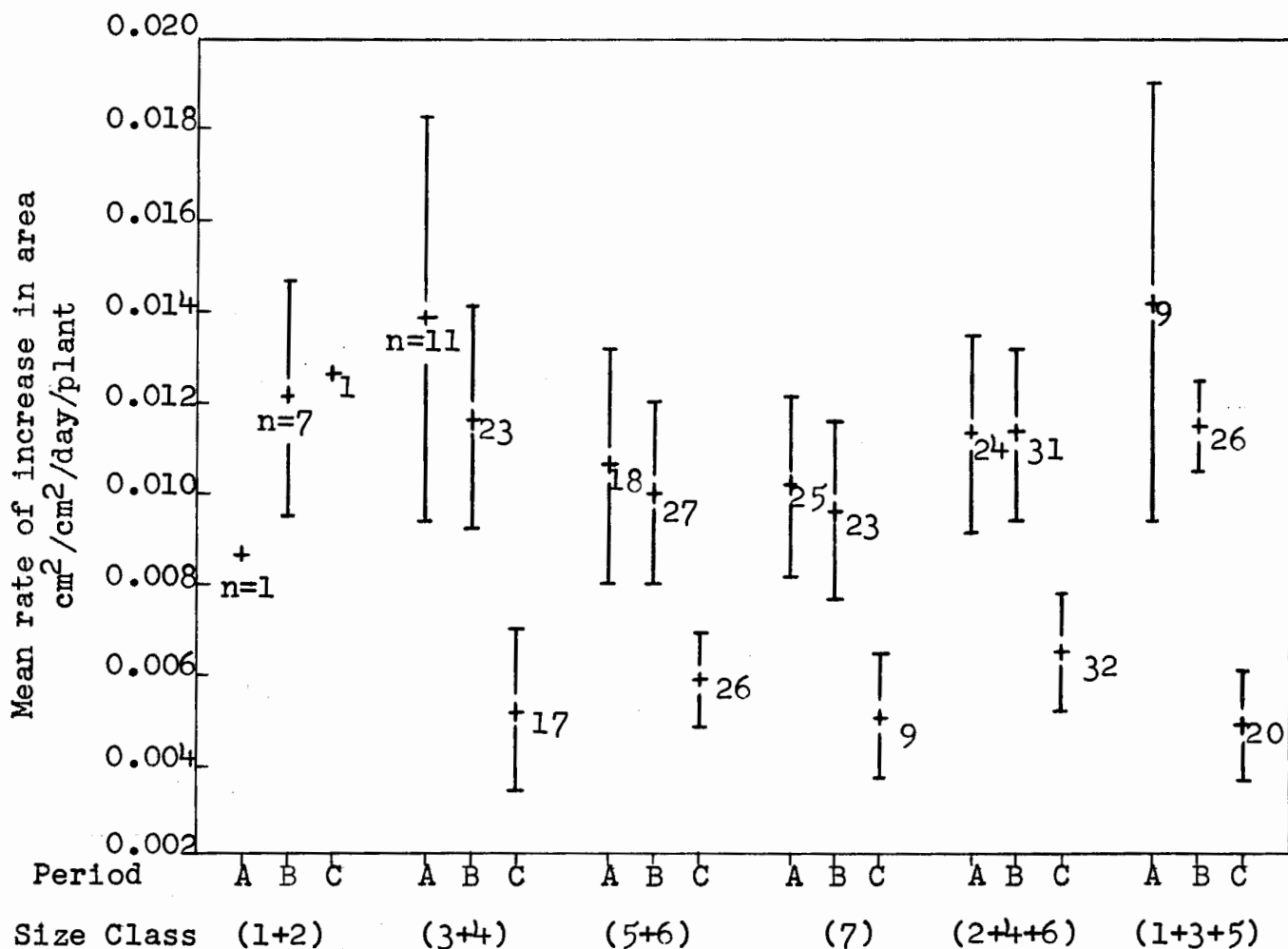


Fig. 2 Mean rate of area increase of Chondrus plants from Malpeque Bay, P.E.I., grouped by "size-development" classes; summer 1957.

Dice-Leraas diagram, mean \pm 2 x standard error of the mean;

Periods: A = May-June; B = June-July; C = Aug.-Sept.

Numbers are numbers of individuals in each sample.

nearly zero beneath the ice and snow that cover Malpeque Bay.

The mean growth rates of specimens from Curtain Island Reef, grouped in "size-development" classes, are compared in Figure 2, a Dice-Leraas diagram in which the mean plus and minus two times the standard error of the mean is plotted for each set of measurements. Overlap indicates that the sets of measurements compared were withdrawn from the same "population", lack of overlap indicated that they were not; this is at the 95% level of probability (Dice and Leraas, Contrib. Lab. Vert. Genet., Ann Arbor 3: 1-3, 1936). In Figure 2 the rates are shown to be essentially the same amongst:

- (1) Classes 1 and 2, small, unbranched specimens;
- (2) Classes 3 and 4, small, slightly branched (1-3X);
- (3) Classes 5 and 6, medium-large (<10 cm.), much branched (>3X); and
- (4) Class 7, large (>10 cm. tall), much branched (>4X);

and also, grouping by length or height only, amongst:

- (1) Classes 1, 3 and 5, short (<6 cm.);
- (2) Classes 2, 4 and 6, longer (6 - 10 cm.);
- (3) Class 7, tall (>10 cm.).

Clearly, on the other hand, rate of growth is in all classes less in late summer than in early summer.

A. R. A. Taylor

No. 81

THE CONSTITUTION AND PRODUCTIVITY OF THE CHONDRUS POPULATION

Semi-permanent quadrats were established on the sea bottom near North Rustico, P.E.I., in June of 1956. An area three metres by four metres, at a depth of about 10' M.L.T., was laid out as 12 quadrats, one metre square each, marked by metre squares of yellow painted pipe, and iron pins driven into the bottom. The Chondrus population here was studied by photography, and by diving, removing the plants from sample quadrats, collecting them in bags and bringing them to the surface. The harvesting treatment was meant to simulate complete raking; most specimens shorter than 2 cm. were left, as well as some longer ones which were missed; a few specimens were always lost while collecting into the bag. Later, the other species of algae were separated from the Chondrus and fresh weights were determined. The Chondrus specimens were sorted into size-development classes and counted, then all groups were dried in an oven at 105°C. and weighed.

Four quadrats were cropped in 1956, two (A and B) in June, and two (C and D) in late August; one of the June quadrats (B) was again "harvested" in August. All the specimens were counted in quadrats A and B; the composition of C and D was

estimated by withdrawing samples; specimens from D disintegrated on moistening after oven-drying and results from D were not considered reliable.

The size-development classes have been set up arbitrarily as follows:

- Class 1 - unbranched specimens, shorter than 6 cm.,
- 2 - unbranched specimens, longer than 6 cm.,
- 3 - specimens branched 1-3 X, shorter than 6 cm.,
- 4 - specimens branched 1-3 X, longer than 6 cm.,
- 5 - specimens branched more than 3 X, shorter than 6 cm.,
- 6 - specimens branched more than 3 X, longer than 6 cm.,
- 7 - specimens much branched, longer than 10 cm.,
- 8 - unclassifiable fragments;

these are still considered as provisional classes.

In the summer of 1957 sampling of this study area was extended: (1) by sampling new unharvested quadrats for more information about the natural population, and (2) by sampling quadrats which had already been harvested to learn what effect harvesting had on the composition of the population, and how quickly a new crop developed. Quadrats harvested this year had an area of 0.25 square metre each; this was done so that the one metre square quadrats originally sampled could be sampled again after successive periods of time. All results have been adjusted to the basis of one metre square for reporting purposes. Thirteen samples have been taken from the natural population; eight samples have been taken from the harvested areas.

The mean density of specimens of all sizes removed from the 12 quadrats in the unharvested natural population was 3,800 (s.d.± 1,630) specimens per square metre. The mean weight (oven dry) was 367 (s.d.± 187) gm. per square metre. The population was found to be distributed among the size-development classes as shown in Table II. Number of individuals per class is reported as mean percentage for 12 sample percentages. Classes 1, 3 and 6 make up 75% of the population and vary least from their mean %. Classes 4, 5 and 7 are more variable in number. Class 2 is a small and variable component.

The method of removing the specimens leaves a large number of small ones. An estimate of numbers of specimens on the bottom would have to take this into account. A careful check has not been made on this, but it is likely that one quarter to one half of the specimens in Classes 1 - 4 are left. This largely depends on: (1) the perseverance of the collector, (2) the number of clumps of associated specimens that come off completely. The harvesting of Chondrus in raking removes the large specimens while leaving the smaller ones (except where large clumps pull away from the soft sandstone) and probably fewer small specimens are taken

Table II. Distribution of the population of Chondrus among size-development classes, north shore, P.E.I.

Class	A. <u>Number of individuals</u> (means of 12 samples)		B. <u>Weight as percentage of total sample</u> ¹
	%	s.d. %	
1	22.1	±10.3	2.80
2	0.6	± 0.6	0.09
3	21.5	±11.6	6.30
4	8.8	± 4.1	5.84
5	10.9	± 7.5	7.20
6	32.0	± 8.3	57.78
7	4.1	± 2.5	19.98

¹Derived by multiplying the mean % number of individuals (A) by the mean weight per individual for the class (Table III) and then expressing each class value (weight) as a percentage of the total.

Table III. Mean weight per Chondrus specimen for each size-development class, north shore, P.E.I.

	Class						
	1	2	3	4	5	6	7
Mean ² gm.	0.0122	0.0386	0.0258	0.0584	0.0582	0.1590	0.4291
s.d.	± 0.0017	0.0139	0.0060	0.0085	0.0103	0.0352	0.1187
No. of quadr.	16	10	16	16	16	16	13

²Mean determined from means for number of quadrats available.

in raking than in these tests (in Table II approximately 50% of the individuals are in classes 1 - 4, the classes of smaller specimens less likely to be raked up). It can be concluded that more young growing specimens will be left on the bottom than are removed by raking.

The percentage of weight in each class as oven dry weight (B) was determined by multiplying each mean % number of individuals (A) by the corresponding mean individual weight (Table III) and then expressing each class value as a percentage of the total. In contrast to the distribution of number of individuals by classes, the distribution of the weight of crop by classes shows 85% of the weight of the crop in the three classes of oldest individuals 5, 6 and 7.

A reduction in weight of crop on harvested areas occurs in the succeeding year. Ratios of current weight of crop to previous weight of crop were determined for eight quadrats. The mean value of this ratio is 0.245 (s.d. ± 0.135 , $n=8$). The number of individuals does not seem to be depleted; the ratio of the number of individuals in the second sampling divided by the number of individuals in the first sampling is 1.10 ± 0.58 . The increase may be sampling error, or it may be the result of proliferation from the holdfast.

These data have been extracted from an incomplete analysis. Further information will be obtained about the composition of the population by comparing the numbers of individuals of different size classes in the clones, or clumps with common holdfasts.

A. R. A. Taylor

No. 82

THE MARINE FLORA OF PRINCE EDWARD ISLAND AND NEW BRUNSWICK

Marine plants have been collected at all localities visited whenever opportunity allowed. Specimens are being held currently in the herbarium of the University of New Brunswick at Fredericton. We plan to place a reference collection in the museum of the Biological Station, St. Andrews, N.B.; and to exchange specimens with other collections. As yet the collection is small, about 400 specimens, representing 25 species from the Bay of Fundy, 38 from the north shore of Prince Edward Island, and 19 from the south shore of Prince Edward Island.

In this collection we have several new records of red algae: Order Nemalionales, Scinaia furcellata (Turn.) Bivona, collected from shells and rocks at a depth of 25' M.L.T. off the north shore of Prince Edward Island near North Rustico on August 23, 1957; Order Ceramiales, Dasya pedicellata C. Agardh, and Griffithsia globulifera Harvey, collected annually in August in the shallow inlets of Malpeque Bay, P.E.I., at a depth of 5 - 8' M.L.T., and Trailiella intricata (J. Agardh) Batters, collected annually as the commonest epiphyte on Chondrus and Phyllophora, on the north and south shores of Prince Edward Island.

Dr. L. W. Hillis, N.R.C. Post-Doctoral Research Fellow in Biology at the University of New Brunswick has commenced a floristic study of the marine algae in the Bay of Fundy and on Prince Edward Island. This will greatly extend our knowledge. We plan to work co-operatively and are extending facilities to her whenever possible.

A. R. A. Taylor

FAUNAL RECORDS

Bulletin on Canadian Atlantic fishes

Records of unusual species from the Atlantic Coast, 1957

MATHEMATICAL STATISTICS

A method of estimating natural and fishing mortalities

The effect of mesh regulations on Georges Bank haddock

Estimates of the lobster population sizes at Tignish, P.E.I.

Catchability of tagged lobsters in relation to temperature and activity at Tignish, P.E.I.

Analysis of groundfish landings and effort statistics

GEAR RESEARCH

A small, experimental tunnel-stern boat for use in shallow harbours of Prince Edward Island (M.B. Mytilus)

No.83

BULLETIN ON CANADIAN ATLANTIC FISHES

The need for a general account of the Atlantic Coast fishes, has been expressed from time to time. Such an account may be useful to administrators, educators and the general public. The preparation of the text of such a Bulletin is under way. The area to be covered is the east and northeast coast of Canada from the International Boundary to Hudson Strait; and from the shore line to the 500 fathom contour at the edge of the continental shelf. Anadromous species involve contiguous fresh waters.

For each species the text will include a description of the fish, with distinguishing features indicated separately, a statement of the general range and of the Canadian distribution in more detail. When information is available, the life history is being dealt with under headings of migrations, breeding, growth rate, food, enemies, abundance and, if the species is commercially valuable, its importance is defined.

As at February 20, 1958, drafts have been prepared for 108 species. These include most of the commercially important ones such as herring, salmon, smelt, cod, haddock, halibut and their close relatives. Some 140 species remain to be treated; among these are the mackerel, redfish, tuna, swordfish, striped bass and wolf-fish. The remainder have little, if any, commercial importance and their life histories are little known. Consequently it is estimated that at least half of the text for the Bulletin has been prepared.

A. H. Leim

No.84

RECORDS OF UNUSUAL SPECIES FROM THE ATLANTIC COAST, 1957

The following species of invertebrates and fishes have been reported in 1957-58.

Echinodermata

Leptasterias polaris borealis (Perrier). Starfish.

Six-rayed starfish from the Bay of Chaleur were identified as probably belonging to this subspecies by Miss A. M. Clark at the British Museum of Natural History.

Mollusca

Zirfaea crispata (Linnaeus). Rough piddock.

One specimen was found by Captain L. Cross while dragging at the western end of Northumberland Strait in May, 1957. Whiteaves considered this species to be rare in the Gulf of St. Lawrence,

where he recorded it from Orphan Bank and from points in the estuary of the St. Lawrence.

Pisces

Raja erinacea (Mitchill). Little skate.

This is a very common skate. Specimens, collected by Mr. R. A. McKenzie in Miramichi Bay, agreed with the description of R. ocellata in tooth and alar spine characteristics. Examination by Mr. W. C. Schroeder, Museum of Comparative Zoology, and by Dr. Sarah Wheatland, Yale University, indicate that they represent a local race of what they consider to be R. erinacea.

Coregonus clupeaformis (Mitchill). Whitefish.

A specimen, 32 cm. long, was caught by the M. V. Harengus in the Long Reach, St. John River, N.B., on August 28, 1957. Identification was confirmed by Dr. W. B. Scott, Royal Ontario Museum of Zoology. Whitefish were reported in the lower St. John River by Perley, a century ago, but they are rarely seen.

Pomatomus saltatrix (Linnaeus). Bluefish.

A specimen, 35 cm. long, was caught in a weir at Black Rock Point, Kings County, N.S., on August 12, 1957. It was identified by Mr. L. R. Day.

Prionotus evolvans (Linnaeus). Striped Sea Robin.

This species is rarely found north of Cape Cod and no previous Canadian records are known. Nevertheless, three specimens were received in 1957. (1) A 26 cm. specimen from Harbour du Loutre, Campobello, N.B., September 13. (2) A 28 cm. specimen from Leonardville, Deer Island, N.B., October 4. (3) Another specimen was caught in an otter trawl among the Murr Ledges, off Grand Manan, N.B., November 30.

Tautogolabrus adspersus (Walbaum). Cunner.

Cunner are so rarely taken on the New Brunswick side of the lower Bay of Fundy that the capture of one by Mr. H. C. White, at the Biological Station wharf, St. Andrews, N.B., on September 25, 1957, is noteworthy. As is usual, when any are taken, it was large, 31 cm. long.

Balistes carolinensis Gmelin. Triggerfish.

A specimen, 36 cm. long, was caught 15 miles southeast of Devil's Island, N.S., September 26, 1957. The specimen was forwarded by Dr. W. J. Dyer.

A. H. Leim

No. 85

A METHOD OF ESTIMATING NATURAL AND FISHING MORTALITIES

The most commonly used measure of the survival rate in a fish population is the ratio of the index of abundance of a year-class one year to the index for the next year. From a number of estimates of the survival rate at different levels of fishing the (instantaneous) natural and fishing mortality rates can be obtained by a method described by Beverton and Holt. Roughly speaking, the method amounts to plotting the total instantaneous mortality rates, as determined from the survival rates, against the effective effort and by fitting a regression line to the points. The total instantaneous mortality rate when the effort is nil, as extrapolated from the regression line, is then the estimated instantaneous natural mortality rate. The instantaneous fishing mortality rate is obtained by multiplying the slope of the line by the effort.

However, when there is no good index for the effective effort and when the vulnerability fluctuates considerably from year to year, there may be considerable error involved in such estimates. To avoid marked effects of changes in the vulnerability, F. E. J. Fry¹⁾ has used "virtual" population estimates in place of indices of abundance. He defines a virtual population estimate of a year-class at a given age as the total contribution of the year-class by numbers to the fishery in subsequent years.

Virtual population size of a year-class is determined partly by the year-class abundance, partly by the effective effort expended toward the year-class, and partly by mortalities due to natural causes. Two such estimates are comparable indices of abundance only when the fishing intensity, the vulnerability and the natural mortalities have been the same during the years of largest contributions of the year-classes to the estimates. For this reason virtual population size estimates cannot be used to determine natural mortality as its estimation assumes considerable fluctuations in fishing intensity. The idea as such, however, is useful and a method has been devised to correct for the varying fishing intensity. The method will work even if we have data for three years only, and it can be used to replace the Beverton and Holt type of estimate. It has the advantage of employing the observational data more efficiently.

The new method involves first of all calculating estimates of the sizes of a number of year-classes at successive ages with approximate values of the natural and fishing mortality rates. These estimates can then be used to determine the survival rates.

1) Assessment of mortalities by use of the virtual population. Contributions to Joint Scientific Meeting of ICNAF/ICES/FAO 27 May - 3 June 1957, Lisbon. P. 15

The (natural) logarithms of these survival rates are then plotted against the fishing effort and a regression line is fitted to the points. From the fitted line new values of the natural and fishing mortality are obtained which can again be used to arrive at better approximations of the size of the year-classes at different ages. The procedure is repeated until the successive estimates of the mortalities do not change significantly.

To calculate the size of a year-class at some given age we let the subscript t stand for year, N_t for strength of a year-class at the beginning of the year t , and C_t for catch from that year-class in the year t . Using the international notation for the instantaneous mortality rates (i.e. qf_t for the fishing and M_t for the natural mortality rate) we may then write

$$C_t = \frac{qf_t}{qf_t + M} (N_t - N_{t+1})$$

or
$$a_t C_t = N_t - N_{t+1} \quad \text{where} \quad a_t = \frac{qf_t + M_t}{qf_t}$$

Let $t = 1$ be the year when the year-class is at the age at which we want to calculate its size and $t = n$ be the last year for which we have statistics. Thus, we have

$$\sum_{t=1}^n a_t C_t = N_1 - N_{n+1} = N_1 \left[1 - \exp. - \sum_{t=1}^n (qf_t + M_t) \right]$$

i.e., the weighted sum of catches (in numbers) divided by the expression in the square brackets gives an estimate of the size of the year-class, N_1 .

The iteration calculations required by this method have been programmed for an electronic computer and in the near future the method will be applied to several fish stocks to obtain better estimates of the fishing and natural mortalities.

It is noted that this method has arisen as a response to some of the discussions in the joint Scientific Meeting of ICNAF, ICES and FAO held in Lisbon, May 27 - June 3, 1957.

J. E. Paloheimo

No. 86

THE EFFECT OF MESH REGULATIONS ON GEORGES BANK HADDOCK

Before the mesh regulations for haddock were put into effect on Georges Bank (ICNAF Subarea 5) it was planned to measure their effects by comparing the yields from year-classes of comparable size before and after the regulations. When similar regulations were introduced on Nova Scotia and Newfoundland Banks

(ICNAF Subareas 4 and 3) it was frankly admitted that on account of the small benefits expected and of the weak pre-mesh regulation statistics, no such measurement would ever be possible and the only measure of the effects would have to come from evidence obtained from the Georges Bank fishery.

To establish the effect of the regulations to the extent that it can be done at this early date, a paper "The effect of mesh regulations on Georges Bank haddock fishery" was presented in the Joint Scientific Meeting of ICNAF, ICES and FAO, Lisbon, 1957. It concluded that present estimates indicate a benefit from 19 to 42%.

When the method presented in Summary 85 was applied to the available data, quite different estimates were obtained. According to our calculations the 1952 year-class is about equal in strength to the 1948 and far greater than the 1950 year-class. It appears to be 28 to 30% larger than the 1950 year-class and about 1 to 3% smaller than the 1948 year-class at the age of two. At the third birthday the 1952 year-class is again almost equal to that of 1948 and 36% larger than the 1950 year-class.

The previous figures of benefits from 19 to 42% were based on the estimates that the 1952 year-class is about 90% of the 1948 year-class and about equal to the 1950 year-class at the second birthday. When these figures are changed to conform to the new year-class estimates the range from 19 to 42% benefits shrinks down to 8 to 11% benefits with rather wide but unknown confidence limits. These estimates do not include the savings resulting from the discards of one-year-olds on which little data are available.

These figures are in no way final as some of the data are still being evaluated by U. S. Fish and Wildlife Service at Woods Hole. However, the estimate of the 1948 year-class will always contain an unknown error as only a rough upper limit of the numbers discarded is known. Moreover, the natural and fishing mortalities will never be known at ages one and two because these ages are not fully recruited and besides are heavily discarded. On these accounts it is doubtful whether the effects of the regulations will ever be ascertained to any high degree of confidence.

J. E. Paloheimo

No. 87

ESTIMATES OF THE LOBSTER POPULATION SIZES
AT TIGNISH, P.E.I.

The lobster investigation has studied the Tignish lobster fishery since 1945 by collecting statistics on catches, on sizes landed, on number of trap hauls, and on the geographical distribution of the fleet. About 1,000 legal-size lobsters have been tagged every year early during the lobster season. Between 40% and 70% of these tags are returned by fishermen in the course of the two-month season from May 1 to June 30. Since 1948 bottom

temperatures have also been recorded usually at 5 and 10 fathoms about once a week over the season.

If we assume that the catchability of lobsters is constant over the two-month season, we may write

$$(1) \quad k (N - C_t) = (\Delta C/TH)_t$$

where N is the population size at the start of the season, C_t is the accumulated catch from the start of the season up to the t^{th} time interval, $(\Delta C/TH)_t$ is the catch per trap haul during the t^{th} time interval, and k is a constant.

For the purpose of the calculations the two-month lobster season was broken into three-day periods, and C_t and $(\Delta C/TH)_t$ were calculated for each period. N was then obtained by fitting formula (1) to the data by least squares. The results are tabulated in the accompanying Table.

An independent estimate of N is obtained from the numbers tagged and recovered. In this case we may write

$$(2) \quad \frac{X_t}{N - C_t} = \frac{x_t}{\Delta C_t}$$

where X_t refers to the number of tags in the water at the start of the t^{th} three-day period and x_t to the number of tags recovered during the t^{th} three-day period. If we assume that the catchability of tagged and untagged lobsters is the same, then both are being removed at the same rate and we may write

$$\frac{X_t}{N - C_t} \sim \frac{X_{t_0}}{N - C_{t_0}}$$

where t_0 refers to the start of the study period (usually May 11 and in one case May 17). This date has been picked to give what seemed sufficient time for the lobsters tagged, usually between May 1 and May 7, to readjust and mix with the rest of the population.

N is now obtained by writing $p = 1 / N - C_{t_0}$ and estimating p by least squares fit from

$$p X_{t_0} \sim \frac{x_t}{\Delta C_t}$$

In fitting the p , ΔC_t 's have been used as weights. The confidence limits of N are obtained in the usual manner. The results are tabulated in the Table.

Lobster Population Size Estimates,
Tignish ('000 lb.)

<u>Year</u>	<u>From catch data</u>	<u>From tagging data</u>	<u>Limits from tagging data</u>	
1945	1,209	1,514	1,268	2,075
1946	1,020	1,318	1,167	1,667
1947	1,039	698	563	986
1948	3,921	601	464	915
1949	531	772	624	967
1950	725	760	663	888
1951	1,057	752	648	976
1952	1,023	943	773	1,228
1953	4,186	973	844	1,161
1954	511	507	382	755
1955	710	774	661	961
1956	-	1,014	878	1,214

Comparison between the population size estimates shows wide discrepancies. The fact that estimates from the catch and effort statistics are in some cases much higher than those from the tagging data suggests that catchability is increasing with the fishing season probably in relation to the warming up of the water.

There is no guarantee that even the population estimates obtained from the tagging data fall within the confidence limits as many of the assumptions inherent in any tagging study may not be filled. To see whether the tag returns follow a Poisson distribution the values of the summation

$$\chi^2 = \sum \frac{(x_t - \bar{x}_t)^2}{\bar{x}_t}$$

were calculated; \bar{x}_t refers here to the expected number of tag returns; $\bar{x}_t = \Delta C_t X_t / N_t$. In all cases the χ^2 value obtained were higher than expected from a Poisson distribution. This indicates a contagious distribution of tags within the population. Also, the values of $x_t / \Delta C_t$ were tabulated. One would expect that these would fluctuate around the mean value in a random manner. This was not the case however, but there was a tendency to get unusually long runs when consecutive values of $x_t / \Delta C_t$ were below or above the mean. Part of this is perhaps due to the fact that it takes longer than first anticipated before the tagged lobsters have settled down. Further analysis with breakdown of tag returns by days and areas tagged is required.

J. E. Paloheimo

No. 88

CATCHABILITY OF TAGGED LOBSTERS IN RELATION TO
TEMPERATURE AND ACTIVITY AT TIGNISH, P.E.I.

At Tignish, P.E.I., during the lobster season from May 1 to June 30, bottom water temperatures have been recorded weekly since 1948. The temperatures have been measured usually at 5 and 10 fathoms except in the first two years when only one measurement at 10 fathoms was taken each week. An attempt has been made to correlate the catchabilities of tagged lobsters with these temperatures and also with the corresponding activity indices (walking rates) of lobsters. The activity indices have been obtained from Dr. D. W. McLeese.

Catchability is defined as the fraction of the population caught by one unit of gear. In this case it is the fraction of tags recovered from the total number of tagged lobsters in the water per trap haul. The number of trap hauls is

$$(1) \quad \Delta C_t / (\Delta C / TH)_t$$

where ΔC_t is the total catch during the t^{th} time interval (three-day period) and $(\Delta C / TH)_t$ is the estimated catch per trap haul. The last figure $(\Delta C / TH)_t$ is based on statistics from part of the fleet only. The fraction of the tags caught is given by

$$(2) \quad x_t / X_t$$

where x_t is the total number of tags recovered during the t^{th} three-day period and X_t is the total number of tags in the water at the start of the t^{th} three-day period. The catchability, denoted by y_t say, is now obtained by dividing expression (2) by (1). This gives

$$(3) \quad y_t = \frac{x_t (\Delta C / TH)_t}{X_t \Delta C_t}$$

The catchabilities, the y_t 's, have then been correlated with temperatures and with activities. In correlating the y_t 's and temperatures, only those periods in which the weekly temperature measurements fall are used. The activity indices have been interpolated (Dr. McLeese) for the intermediate periods also and consequently all the data from the start of the study period (May 11 to May 17) have been used. The resulting correlation coefficients have been tabulated in the accompanying table.

Correlation coefficients of catchabilities of tagged lobsters with temperatures and with activity indices. Population size estimates corrected for changing catchability, Tignish, P.E.I.

<u>Year</u>	<u>Corr. coeff. r, between catchabilities and temperature</u>	<u>Degrees of freedom</u>	<u>Corr. coeff. r, between catchabilities and activities</u>	<u>Degrees of freedom</u>	<u>Population sizes '000 lb.</u>
1948	.464	6	.688	14	634
1949	.704	5	.862	13	459
1950	.013	5	.091	16	674
1951	.137	5	.249	15	548
1952	.873	7	.890	14	925
1953	.893	7	.769	15	1,865
1954	.563	4	.689	14	431
1955	.862	6	.672	14	703
1956	.487	6	.704	16	882

The correlation of the catchabilities with the activities is slightly better than with the temperatures while the difference is not significant. In general, both of the correlation coefficients seem to be significant except in 1950 and 1951. No explanation, at this stage of the study, can be given why these two years are different.

When the population sizes (Summary 87) were estimated from the catch and catchper trap haul statistics, no allowance was made for the changes in the catchability. Since the activity index is correlated with the catchabilities of tagged lobsters in most of the years, we may modify the equation (1), Summary 87, and write

$$(4) \quad a_t k (N - C_t) = (\Delta C/TH)_t$$

where a_t is the activity index during the t^{th} period, k a constant, N the population size, and C_t and $(\Delta C/TH)_t$ are as before. The N has been derived from the above equation (4) by fitting the catch data by the least squares method. The values of population size obtained are recorded in the above Table. Reference to the Table of Summary 87 indicates that these estimates are far closer to the estimates from the tagging data than those which did not allow for the changing catchability. But still three estimates fall outside the confidence limits given by the tagging study. The discrepancies may result from many causes. First of all, the activity indices may not be accurately enough correlated with the catchabilities, or then perhaps there may be some systematic errors in the tagging study. The inquiry is continuing.

J. E. Paloheimo

No. 89

ANALYSIS OF GROUND FISH LANDINGS AND EFFORT STATISTICS

Groundfish statistics of landings and effort are recorded on trip cards for the mobile offshore fleet. On these cards the name of the boat, its size class, gear, date, area fished, total landed catches by species, and the main species caught, along with the detailed information on effort, are recorded. The cards are summarized annually for submission to ICNAF by subdivisions, gear, size class of boat, and by months.

The Canadian (or U. S.) ICNAF statistics as published by ICNAF are of hardly any use in determining indices of abundance of any one species. In isolated cases in the past when such indices have been needed, the data have been extracted directly from trip cards by untested methods. A study directed toward obtaining reliable indices of abundance was undertaken last summer when Mr. D. Brown, under the supervision of Dr. Martin and the writer, analysed ICNAF data extracted from the 1953-56 ICNAF summary statistics, and from 1956 trip cards. The year 1956 was selected for detailed study because it was the first year when mobile fleet statistics were recorded on Kwiksor cards. The major implications of the study are set out below.

The published statistics classify groundfish vessels by size in groups of 0-25, 26-50, 51-150 gross tons, and over 151 gross tons. Each of these groups includes boats which use quite different net sizes, e.g., the 51-150 gross ton class consists of boats using Yankee 35, 36, 41A and 41 and Peter Carey nets. A somewhat more homogeneous grouping would perhaps be from 0-25, 26-70, 71-200 gross tons and over 201 gross tons.

Without any study, it is recognized that the redfish trips and landings therefrom should be listed separately in any summary. Also, the summary of landings and effort done for our own purpose should be done quarterly, as little value was found in detailed monthly breakdown.

For the purpose of analysis the boats were classified by net size and all the comparisons were done between or within nets. Within each net size the gross tonnage varies greatly, e.g., the boats using Yankee 41 range from 135 gross tons up to 400 gross tons. No significant correlation, however, was found between (landed) catch per hour dragged and gross tonnage within any of the nets. Neither did we find any significant differences in catches per hours dragged between adjacent net sizes.

Two different units of effort (hours dragged and days fished) were examined to see which measure of effort is more closely correlated with catch. In all cases studied it was found that the measure of relative accuracy was greater for hours dragged than for days fished. The difference was quite small (less than 5%) however, and because of the greater ease of employing catch per day fished, it was used in many cases in spite of its slightly greater variability.

To obtain the effort expended toward each major species, the trips (or part of the trips) should ideally be classified as cod, haddock, etc. trips. In practice, however, the intention of the skipper is not so well defined, nor do we have any information on it. To find out if the present practice of classifying a trip as cod, haddock, or flounder trips if more than 40% (sometimes 50%) of the total is of that species had any basis in fishing practice the following analysis was carried out: The percentages of cod, haddock, and flounders in otter trawl landings from subdivisions 4V and 4W were compiled separately by areas, and by boats, using Yankee 35 and Iceland 1½ nets. The data were plotted as histogram frequencies. These frequency curves were rather smooth, and in not a single case could we separate an isolated group of trips as cod, haddock, or flounder trips. We conclude that information on abundance of a species and on effort directed toward it are combined in these frequencies and that there is no a priori way of separating them.

These histogram frequencies were tested, for each species, for the homogeneity of samples (i.e., for the difference) between nets and subdivisions. In almost all cases the difference was statistically significant. Further work has to be done on the validity of these tests, also results of similar tests over several years have to be compared. Should these findings remain unchanged it would indicate genuine differences in the efficiencies of nets for catching different species or perhaps that there are economic differences in the operations of boats which use different types of nets. However clearcut conclusions from this study are complicated by the changes in the relative abundance of different species and by shifting market demands.

Because cod, haddock, and flounder are often mixed in catches and "pure trips" are almost non-existent, an attempt was made to measure the extent to which they are mixed. To this end, the partial correlation coefficients between cod, haddock, and flounder weights per trip were calculated separately for boats with Yankee 35 and Iceland 1½ nets in subdivisions 4V and 4W. The correlations found differed markedly between nets and subdivisions. Again, some consistencies should be obtained over several years' data to draw any conclusions.

It is concluded that for abundance studies (a) all the past data should be analysed, (b) net size appears to be more useful than gross tonnage for classifying otter trawlers, (c) assignment of catches and effort to species may be aided by considering economic factors, (d) redfish trips should be summarized separately, (e) quarterly rather than monthly statistics are adequate.

The great variability of landings-effort statistics is very discouraging to the scientist studying indices of abundance. Continued analyses and special research surveys are required to find ways and means of measuring abundance; and these studies must be carried out since indices of abundance are basic to any study of the factors affecting populations and landings.

No. 90

A SMALL, EXPERIMENTAL TUNNEL-STERN BOAT FOR USE IN SHALLOW HARBOURS OF PRINCE EDWARD ISLAND (M/B "MYTILUS")

In 1954 a small experimental work boat was built by R. L. MacLean of High Bank, P.E.I., from plans designed by Eldredge-McInnis, Inc., of Boston, Mass. Funds for the project were provided from the Industrial Development Service Vote. On launching in May, 1955, the boat was turned over to the Director of Fisheries, Department of Industry and Natural Resources, Charlottetown, who along with officers of the Research Board's Sub-Station at Ellerslie, P.E.I., supervised trials by reliable fishermen. It was hoped by the P.E.I. Fisheries Development Committee that the design of the boat would prove attractive to fishermen and would eventually replace the more cumbersome, deeper-draught, shore-built boats. It was felt that adoption of all or some of the new design would help improve the lot of the fishermen and would relieve the federal government from frequent dredging of many small harbours about the coast.

The experimental model is 24' 10" long with a breadth of 10' and a draught of approximately 20". It is propelled by an Acadia Model HLXB 25 h.p. diesel engine. Cost was just under \$3,000 complete with trap hauler and auxiliary engine. It is of marine plywood construction over an oak frame.

Shore-built boats vary greatly in sizes in the different areas but in general are longer, narrower with greater draught requirement. Propulsion is usually provided by a converted car engine. Cost varies also with areas but on the average is somewhat less than half the cost of the experimental model. In general, fishermen build boats to suit the particular conditions they encounter in the area in which they operate.

Tests in 1955 were conducted by Mr. Jerome Sutherland of Red Point, P.E.I. General performance and utility of the boat were found to be good. It demonstrated a high carrying capacity, shallow-draught and appeared lighter to haul out than the conventional models in that area. Some disadvantages came to light also. Using groundfish trawl gear, difficulty was encountered because of the wide bow and it was the fisherman's opinion that the pay-off of the boat justified about 6 feet more in length. Tests in 1956 were delayed because of unusual ice conditions and were foregone entirely because of involvement of staff in other urgent matters. In 1957 tests were conducted by Mr. Charles MacKenzie of Cable Head, P.E.I. These tests revealed that the boat was very satisfactory for carrying and hauling traps. It provided a very sturdy platform. The boat performed well running before the sea but proved very wet running into the sea. It was found to be too heavy to be used in this particular area where the shore-built boats are lighter and frequently must be hauled and launched daily.

No further trials seem indicated at present. Fishermen have been made aware of this particular design in the test ports and along the coast while proceeding to these areas. It does not appear that there are any outstanding advantages that will be adopted by fishermen immediately for their shore-built boats.

Consideration is being given to using the boat in 1958 for joint Department-Board oyster work at Orangedale or Malagash, N. S.

J. A. Rogers