FISHERIES RESEARCH BOARD OF CANADA

BIOLOGICAL STATION

ST. ANDREWS, N.B.

ANNUAL REPORT

and

INVESTIGATORS' SUMMARIES

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REPORT FOR 1958-59 OF THE BIOLOGICAL STATION, ST. ANDREWS, N. B.

by J. L. Hart, Director

The Biological Station at St. Andrews aims to meet the needs in marine and freshwater research of the Maritime Provinces. A large proportion of the research effort is directed to insistent problems in fishery management. Accordingly, less effort and funds than desirable remain for more basic research.

Management problems are of several kinds. For resources that are in use, fish populations must be studied to suggest the best ways of conducting the fishery. This may require detailed life-history studies of fishes and of ways in which fishing gear operates. For resources that are not used, or are little used, research involves availability of the resource, where it is concentrated in commercial quantities, and suitable fishing gear. In many cases, especially but not exclusively in fresh water, management may consist of altering the environment. Examples of changing the environment would be the formation of impoundments in streams, fertilization of waters, hatching fish in hatcheries, pond holding of fish for planting, pond culture, predator control, and establishing dams for developing hydroelectric power. All these must be considered and evaluated. Most industrial changes in environment are deleterious. Methods of assessing and alleviating these are being established.

The Station's research program involves work in many places through the Maritimes. In some instances locations are determined by urgent local problems. More frequently, locations have been decided upon because they were especially suited to establishing principles for general application throughout the region. The administrative headquarters for the Board's biological work in the Maritimes is situated at St. Andrews. Data from field stations are analysed and reported there, and the continuing ready availability of cool, highly saline water makes it an excellent location for basic laboratory research on the conditions influencing the abundance and movements of many commercial species. A sub-station at Ellerslie, P.E.I., for oyster research, was set up in 1930 to restore the oyster stock after its depletion by disease early in the century and has been continued since as a good centre for oyster research for the region. Research on Irish Moss is also centred at the Ellerslie Sub-station. A statistical office is maintained in Halifax, N.S., to make preliminary analyses of groundfish catch data. These are both collected locally and fed in from subsidiary offices in Sydney and Lunenburg. An observer stationed at Yarmouth, N.S., follows the effects of a growing fishery on herring stocks in southwest Nova Scotia. Studies on the very important salmon runs of the Miramichi River are co-ordinated through a year-round office in Chatham, N.B. Counting weirs at Curventon and Camp Adams in the

Northwest Miramichi and estuarial traps at Millbank are operated on a seasonal basis from Chatham. The main section of the Pollett River does not admit adult salmon. Since complete control of seeding is possible, the river is particularly useful for propagation experiments. Work along these lines is carried out from a field headquarters in Elgin, N.B. Counting weirs in Ellerslie Brook, P.E.I., permit studies of the effects of various management practices on native populations of trout and salmon. A variety of trout management techniques is being tried with assistance of the Fish Culture Branch of the Department of Fisheries. Yields to anglers are followed at Crecy Lake, N.B.

Field work is carried out year after year from temporary headquarters at several points. Caraquet, N.B., is an important base for groundfish research. Lobster populations are studied annually at Port Maitland, Fourchu, and Gabarus, N.S., and at Tignish and Miminegash, P.E.I. Work on annual abundance of lobster and herring larvae in Northumberland Strait is based at Richibucto, N.B. Demonstration stations at Shippegan, N.B., and Malagash, N.S., operated by the Fish Culture Branch of the Department of Fisheries were bases for testing the success enjoyed by transferring stocks of immune oysters to disease-ravaged New Brunswick and Nova Scotia. Clam Harbour, N.S., is the site for special tests with the mechanized clam digger, and Sam Orr Pond, N.B., for main trial plantings of European oysters.

The main shore research bases mentioned above are supplemented by various station vessels which give mobility and extended the range of operations. The Harengus (84 ft) was attached to the pelagic fisheries studies during the early part of the year and worked from the Bay of Fundy to Georges Bank. Later, work was carried out on Nova Scotia Banks for the groundfish investigation. The J. J. Cowie (70 ft) worked in the southwestern Gulf of St. Lawrence and in Bras d'Or Lake. Work on young lobsters in Northumberland Strait was carried out by the Pandalus II (50 ft). The Mallotus (54 ft) and Clupea H. (30 ft) have been invaluable as service boats at the St. Andrews and Ellerslie stations. The light shallow-draft Cyprina (35 ft) was specially constructed to accommodate the mechanized clam digger. The Mercury (45 ft), the Betty Lou IV (42 ft) and the Paula Marie (56 ft) were chartered for work in Passamaquoddy area. The Board's new research vessel, the 177-foot A. T. Cameron was available for the Station's work during January to March. It allowed studies that would have otherwise been impossible, and demonstrated the desirability of full-time use of an all-year-round offshore vessel.

The main building at the Station has recently been augmented by a three-floor, 135 x 42 ft, addition. This provided much needed fire-proof laboratory and office accommodation.

LOBSTER

Lobsters are an important source of revenue to thousands of inshore fishermen throughout the Maritimes whose assets are skill and enterprise rather than extensive investment in gear and boats. They provide a cash income that is very important in the regional economy.

Population studies. The object of management in the lobster fishery is to approach best use of the resource. This involves combining large catch and high unit value. Fortunately these objectives can be sought together. There is evidence--not yet conclusive--that the greatest yield of lobsters comes from allowing them to grow to moderate size before harvesting. In addition larger lobsters usually command a better price. The indication that product value might be increased by size regulation is clear. The fishery lends itself to management in this way since the traps bring the catch to the surface undamaged. Size limits are an important part of the fishery regulations. Their effects on the lobster stock are followed by population studies in representative areas.

The fisheries around Tignish and Miminegash, P.E.I., are representative of the southern Gulf of St. Lawrence. Because of local conditions for growth and the intensive fishery, they are highly productive of canning lobsters but large ones are relatively uncommon. The size limit was increased to 2 1/2 inches carapace length in 1953. The landings at both ports have increased substantially since 1954, possibly because of improved protection of sub-legal sizes. In addition, survivors of a better than usual year brood are now being recruited to the fishery. An unexpected 20% decrease in Tignish, 1958, landings is possibly a direct result of intense illegal fishing in the summer of 1957. Further decreases may occur when poor 1953 and 1954 broods reach legal size. However, test drags off Miminegash in the fall of 1958 give hopeful indications for 1959. Enforcement problems in this area are difficult since a high proportion of the lobsters caught are below legal size.

The neighbouring ports of Gabarus and Fourchu, N.S., in Cape Breton were selected for a comparative study of the effects of size limits. At Fourchu, the size limit has remained virtually unchanged since 1947. It restricts landings to those sizes acceptable to the live lobster trade. At Gabarus, appreciably smaller size limits have been in effect since 1940. In 1956, a plan approved by fishermen was adopted to increase the size limit each year. Unfortunately, this plan coincided with a natural decline in Cape Breton lobster stocks. Many fishermen blamed their reduced catches on the size-limit increase already adopted. As a result, the plan for further increase was dropped after 2 years. Landings at both ports improved somewhat in 1958 but the plan is still in abeyance.

Size regulations in Yarmouth County, N.S., have remained essentially the same for 25 years. Studies of change in the lobster population under ordinary conditions of exploitation with the same regulation have been based in Port Maitland, N.S. From 1950 to 1956, landings declined steadily but have recovered slightly in the past 2 years. Since 1950 the fleet dropped from 43 to 25 boats. As a result, catch per boat has remained at a relatively high level and has increased appreciably in 1957 and 1958.

Theoretical treatment of effects of changing fishing practices is considered under the heading Mathematical Statistics.

Studies of early stages. In Northumberland Strait, studies on lobsters of fishable size are supplemented by work on newly-hatched and sub-legal lobsters.

When first hatched, lobster larvae swim freely close to the surface of the water for about 2 months after which they settle on the bottom. Special gear allows quantitative collections of juvenile stages. Information on early stages is collected on an annual basis to show what relationship exists between the amount of spawn hatching and numbers of legal lobsters recruited to the fishery 4 or 5 years later. In 1958, both hatch and survival were below the 10-year average. Consequently, relatively few larvae reached the stage of settling on the bottom.

Research hauls on the bottom in spring and fall allow a censusing of lobster populations. There were good showings of "just sub-legal" lobsters in 1958. As many of these will be of legal size in the following year, this is taken to augur well for the 1959 fishery.

Handling and holding lobsters. As about half of the Canadian lobster catch is marketed alive, a great deal of attention has been given to satisfactory conditions for holding and shipping lobsters. Much has already been learned and placed at the disposal of the industry. Information concerns tolerance of extremes in temperature, salinity, and oxygen, and their interrelationships. Work was continued during 1958 on temperature acclimation, oxygen consumption in water and in air, and survival in air.

Earlier work has shown that recent temperature history of a lobster has a marked effect on its tolerance to temperature. Lobsters are said to be acclimated when they have lived long enough at a particular temperature to stabilize their temperature tolerance. Acclimation upwards from 8.5°C to 15°C is complete in 18 days, from 15°C to 20°C in 8 days, and from 20°C to 25°C in 5 days. Upward acclimation progresses most rapidly at high temperatures. By adding acclimation times for two consecutive 5°C jumps, the time necessary for acclimation from 15°C to 25°C is found to be 13 days. Earlier work showed that acclimation in one step from 14° to 23° took 22 days. This indicates that acclimation proceeds faster when lobsters are subjected to a series of small temperature changes.

The oxygen requirements of lobsters under various conditions are important in estimating holding capacities for commercial storage units. These were studied during the summers of 1957 and 1958. Oxygen needs varied markedly with temperature. Oxygen uptake for lobsters acclimated and tested at 25°C is double that for lobsters acclimated and tested at 5°C. The relationship between oxygen uptake and oxygen content of the water is more complex. Uptake increases with temperature at all levels of oxygen content. At any one temperature, a marked decrease in uptake occurs at low oxygen levels (3 cc per litre). Aside from this, uptake at high temperatures depends on oxygen content throughout the whole range, but at lower temperatures, uptake is constant over all higher levels of oxygen. Sudden temperature changes have a pronounced effect on oxygen uptake. Uptake for lobsters acclimated to 13°C and suddenly transferred to 5°C was twice that of lobsters acclimated to 5°C.

Knowledge of oxygen utilization in air is especially important in assessing shipping techniques. Tests were carried out on lobsters held in air of high relative humidity. They showed that oxygen utilization was greatest between 10°C and 12°C, fell off toward 5°C and approached zero at 25°C. At higher temperatures, oxygen uptake is insufficient to maintain life and lobsters die. Lobsters are evidently not well adapted to using atmospheric oxygen as greatest uptake in air is only about 57% of that in water at the same temperature. Sudden changes in temperature affect oxygen uptake in air markedly. Lobsters acclimated to 10°C and held in air at 20°C do not utilize oxygen and weaken rapidly.

Survival of lobsters in sealed containers was tested under varying conditions of temperature, oxygen, and carbon dioxide. Under experimental conditions, lobster survival was improved in an atmosphere of pure oxygen or with carbon dioxide removed. Other tests suggest that best survival in air will occur at temperatures not higher than acclimation temperature and at temperatures below 20°C.

Air shipping of lobsters. Tests using different light-weight containers and insulators have been continued. The most effective insulators proved to be styrolite beads, with wood shavings second. Their use seems to merit further investigation.

Inactivating lobster claws. When lobsters are to be stored, their claws are plugged so that they can't open for fighting and destroying each other. However, plugs cause deterioration in nearby flesh and their use is prohibited in some European countries. Two alternative methods of inactivating claws were examined. They consist of cutting the extension tendon of the lobster's claw and using rubber bands to hold claws closed. Cutting tendons caused extra mortality--presumably from loss of blood. Rubber bands gave results comparable to plugging. The method has merit if a suitable method of applying bands can be established.

OYSTER

Oysters are capable of adding to incomes of Maritimers living in areas where summer water temperatures are high. As oysters can be cultivated, knowledge of the factors controlling their abundance can be put to direct use. The Station's main research is, accordingly, devoted to developing methods of favouring the various steps in oyster reproduction and growth. During the last few years attention has been diverted from the main line of research by pressing problems arising from epidemic disease.

Disease studies. About 8 years ago a lethal oyster disease, called Malpeque disease, with high morbidity crossed Northumberland Strait from Prince Edward Island where it was endemic and where the stock is immune. An epidemic swept along the mainland shore. Late in 1957 it invaded the public fishery at Caraquet, N.B., and reached epidemic proportions in 1958. About 87% of the 1957 population there is now dead. On the north shore of Miramichi Bay, disease spread both east and west from a focus at Neguac so that fisheries at Tabusintac and Oak Point now cease to exist. Miscou Island, N.B., and Bras d'Or Lake, N.S., are now the only unaffected stocks left in the Maritimes.

In order to hasten rehabilitation in affected areas, immune brood stock from Prince Edward Island has been transferred to affected areas by the Department of Fisheries. After recommending this as a remedy, the responsibility of the Fisheries Research Board has been to evaluate the rehabilitation program. The Department's program called for mass transfers beginning in the summer of 1957 and ending in 1959. So far 6,000 barrels have been moved. Results are promising. Transferred oysters have survived well and spawned copiously. In some areas they have produced spat. Mainland oysters have grown poorly and spawned little, if at all. It remains to be proved that the spat collected is disease resistant. "With high hopes for the future no prediction regarding it is ventured." In the meantime a vigorous search for the elusive causative organism has been underway and is still proceeding.

Mortality from a second and unknown cause is affecting Malpeque Bay, P.E.I. This was heavy in 1956 and 1957 on deep-water beds and light on shallower beds. Accurate assessments of the situation were begun in 1958. So far oysters which were retained on deep-water beds showed poorer condition, growth, and survival than imports or shallow water test animals. Tests are being continued through the critical winter months.

Oyster culture studies. Attention is now being changed back to studies of positive culture methods. As a first step in a detailed study of spat collection, distribution of larvae was studied in the Bideford River. Tentative general conclusions are (1) that oyster larvae are not uniformly distributed, (2) all stages have the same distribution, and (3) there is no change in vertical distribution with tide.

The prediction of time of spatfall is important as it can give oyster growers reliable indications of when to put out clean cultch to catch spat. Observations during 1958 showed that studies of the percentage of dry weight of the oysters cannot be depended upon to demonstrate times of spawning activity and hence to forecast spatfalls. During 1958 plankton examinations in Bideford River gave good indications of the times of spatfall there but in other areas where plankton sampling was less regular forecasts were not reliable enough to be useful.

Other observations have turned up promising leads, for examples: In one comparison spat survival was found to be much higher in offshore locations than inshore. There are good indications that cultch texture and/or colour affects its efficiency. There are indications that a source of early spat has been discovered. Mussel shell is holding out promise as a practical cultch.

Laboratory growing of spat has demonstrated a great disparity of growth rate among young spat starting at equal size. Disparities on October 24 among spat that were of equivalent size on August 11 were from 1.5 to 8.7 m. This raises many important practical questions about patterns of growth and mortality and concentrations of food.

Conway Narrows studies. One of the problems of the oyster industry is to bring young oysters through from the spat stage to a size where they can be planted successfully on growing ground. This was formerly done on trays but tray culture is no longer feasible economically. Tests in the channel of Conway Narrows give promise that it may supply an extensive area where suitable growth can take place without undue danger of smothering by silt or from starfish predation. Characteristic features of Conway Narrows are its shallow depth about 1 or 2 feet at mean low water and small tidal fluctuations of about 3 1/2 feet on spring tides. Water temperatures of 21°C to 24°C are common in July and August. The bottom soil is sandy and relatively free of silt (less than 5% silt and clay on the Wentworth grade scale). There is a light variable covering of eelgrass, and small starfish, while present, are scarce. Full-scale tests of the area as a nursery ground are proposed and other suitable areas are being sought.

European oysters. Observations were continued on European oysters introduced to Sam Orr Pond in 1957 and on a supplementary shipment brought in by air freight in 1958. European oysters wintered well in Sam Orr Pond but failed to survive in Oak Bay where excessive cold fresh water evidently killed them. Spawning took place in Sam Orr Pond but the resulting larvae failed to survive to spatting stage. There is some evidence that protozoan parasites are directly or indirectly responsible for the deaths that do occur. The oysters are being tested for resistance to Malpeque disease.

CLAMS

Clams contribute to the incomes of those living by the sea and to the variety of native foods available in the Maritimes for local use and export. In recent years there has been a decline in clam stocks. This has had a variety of causes. The Board's investigations indicate that a main one is that use of common hand tools for clam digging works against the best interests of conservation. In recent years attention of the clam investigations has, accordingly, been given to the development and testing of a better method of harvesting clams.

Mechanized harvester. The mechanized harvester is designed to wash clams out of the soil onto an escalator which carries the catch to the surface where it can be picked over and valuable parts of the catch retained. After 2 years of developmental work, its mechanical operation was satisfactory, and it was accepted as useful equipment for harvesting bar clams and quahaugs. It was not until 1958 that it could be critically tested on soft-shell clams. The results show: (1) That the escalator digger buries very few of the small clams it disturbs (less than 10%), and those it does bury are close to the surface where they are unlikely to smother. (2) Almost all the undersized clams that the escalator disturbs are returned to the track from which they were dug and most to within 50 feet of the place of origin. (3) Of those that are returned about 4% are too severely damaged to be able to dig back into the soil and will die. More than 90% are not seriously affected by the digger. This is emphatically better than the 40 to 60% destruction of undersized clams caused by use of hand digging tools.

Ocean quahaug. The ocean quahaug (*Arctica islandica*) is widely distributed in North Atlantic waters but is seldom seen because it favours (with us) depths of 10 to 20 fathoms. Exploratory fishing for this species with hydraulic and other types of dredges was undertaken. Trials with the hydraulic dredge led to the conclusion that ocean quahaugs could be harvested at the rate of 75 bushels per day and trial operations by a commercial operator, who was assisted in rigging out, confirmed this opinion (90 bushels a day). Non-hydraulic dredges fished equally well on soft bottom but were ineffective on hard bottom.

SCALLOP

The scallop fishery in Canada is of great and growing importance. From 1941 to 1951, it averaged about 700,000 lb.

In 1957, the catch was 3,410,000 lb of which 1,690,000 came from Georges Bank. This was more than twice the Georges Bank landing of the preceding year and was succeeded by some 2,500,000 lb in 1958. United States landings were about 18,000,000 lb. The continued heavy exploitation has raised fears of overfishing and with it the prospects of international control.

Provisional observations show that the sizes of scallops differ markedly from bed to bed but that this is not shown in records of Canadian wharf landings because of fishing practices. Fishing practice aboard Canadian vessels also partly disguises changes in abundance because smaller scallops which are ordinarily discarded are shucked when catches are light. Present indications are that ring-size in scallop drags could be increased beyond a 3-inch diameter without severely interfering with present landings. However, the long-term advantage of increasing ring-size remains to be demonstrated.

Laboratory tests on scallops show that they can be adversely affected by rapid upward temperature changes such as may occur in the southern Gulf of St. Lawrence. The effects may be direct or indirect. Hydrographic changes large enough to produce direct mass mortality have been observed. These are less common than sub-lethal changes which cause inactivity and debility among scallops and may inordinately increase their susceptibility to predators.

GROUNDFISH

The groundfish include many species. Prominent among them are cod, haddock, redfish, halibut, pollock, plaice and other flounders. Among them they provided nearly six hundred million pounds in the Maritimes and Quebec in 1957. This catch is about two thirds of the total landings in the region. Because the fishery is so large, quite small percentage improvement in its operations can result in a substantial increase in returns. For this reason, the attention of the investigation is directed toward increasing landings, reducing financial risks, increasing fishing power, and improving the quality of the products.

For the most part, the groundfish fishery is in international waters and the Canadian fleet exploits the same stocks of fish as other nations. All these countries share an objective to make the best use of the fish stock. To forward this ideal, Canada works in co-operation with ten European countries and the United States through the International Commission for the Northwest Atlantic Fisheries (ICNAF). Co-ordinated programs of research by member countries are considered by the Commission in recommending regulations to member countries. Much of the Canadian program in groundfish research is carried out to meet the needs of ICNAF.

Only more urgent problems can be met in any one year. During 1958 attention was directed toward: studies on amounts and sizes and ages of fish caught and landed; migrations of cod and haddock; future recruitment of cod and haddock; gear selection on cod, haddock, and plaice, and the effects of mesh regulation; plaice life history; and parasites affecting fish acceptability. Other studies have of necessity been held in abeyance during the year.

Catch statistics. The interpretation of catch statistics to meet Canadian and international needs calls for analysis on the basis of species caught, area and time of fishing, gear used, and extension of fishing effort. Fisheries Research Board staff meet these needs by applying information obtained from log books and fishermen interviews.

Total groundfish landings on the Canadian Atlantic coast (excluding Newfoundland) have increased from 480 million pounds round fresh weight in 1952 to 585 million pounds in 1957. Most of the increase is attributable to the continued growth of the otter trawl fleet which now takes about half the groundfish landings. Conversion from line fishing to otter trawling changed the relative importance of the species landed. In 1933 the groundfish catch was largely cod. By 1957, although cod landings had increased, they accounted for only half the groundfish landings.

The increased intensity of the fishery has been accompanied by decreasing catches of groundfish per unit of fishing effort and by a decline in the size and age of fish in the landings.

So as to assess changes in the status of the groundfish fishery, trends in length and age have been followed systematically. The average size of cod in dragger landings from the south-western Gulf of St. Lawrence dropped to 3.8 pounds in 1958, the lowest since small draggers were introduced in 1947. In 1958 the dominant age group was 5 years, and less than 15% of the cod landed by draggers were older than 8 years. On Nova Scotia grounds, the broods produced in 1949 and from 1952 to 1955 dominated cod catches.

Growth in captive cod. Observations in nature indicate that the response of cod to variations in food supply are reflected in the success of the fishery. Laboratory tests confirmed the impression that this could be the case. Cod fed maximum amounts over a year increased in length and especially weight more than those fed on smaller rations. Proportional growth was faster among small cod than among larger ones on both diets. Under the conditions of the experiment, cod transformed herring fed to them into cod flesh in a ratio between 2.1 and 2.4 to 1.

Tagging studies. Tagging to demonstrate migration patterns have been done on cod, haddock, and plaice.

In all, 2,112 cod caught by hand line, otter trawl, and traps were tagged around Magdalen Islands. There were indications from returns that fish from traps had a better chance of survival. Comparisons of tagging methods showed somewhat better returns for disc tags than for more loosely attached hydrostatic tags. Recoveries of these tags show a well defined pattern of seasonal movements that fits in well with conclusions based on tags put out on other fishing grounds. In general, cod move out of the Gulf of St. Lawrence into deeper water in the winter and back into the shallow water of the Gulf during the summer.

Few haddock (38) were tagged during 1958 but returns from previous taggings have been analysed. The taggings considered were in Northumberland Strait, the Browns-LaHave area, Passamaquoddy Bay, and the entrance to the Bay of Fundy.

Returns from Northumberland Strait haddock tagging show a pattern of migration similar to the one shown for cod in the same region. Winter recaptures came from banks offshore from Nova Scotia. Spring and late fall returns were mainly from the east coast of Cape Breton. For the remainder of the year, recaptures were scattered but most came from eastern Northumberland Strait.

The Browns-LaHave tagging supports evidence of other kinds that there is little movement of fish across the Fundian Channel towards Georges Bank. There was evidence of a northwest movement in the direction of Lockeport, N.S., during the winter following tagging. Most returns came from the tagging area.

Five hundred plaice were tagged, 320 southeast of Shippegan Gully and 180 northeast of Miscou Island, both in the southwestern Gulf of St. Lawrence. High returns from the Shippegan tagging indicate an intense fishery and there were early indications of a northward offshore movement during the summer.

Gulf census. The cod survey in the Gulf of St. Lawrence that started in 1957 was continued in 1958. It is designed to allow forecasts of recruitment and to assess effects of environmental factors on the abundance, distribution, and movements of cod and plaice. The censusing program has not continued long enough to justify confidence or precision in forecasts based on it. However, if fish are recruited in the same way in 1959 as in 1958 it may be anticipated that the catch will again be made up mainly of 5-year-old cod and that as a result there will be no appreciable change in size of cod landed.

Haddock survey. A survey of groundfish populations on offshore Nova Scotian banks was begun in 1958. Like the Gulf census, it has the objectives of leading to short-term prediction of relative abundance of fish to the fishery and of determining the effects of environmental factors on numbers and behaviour of groundfish species. Experimental tows with covered nets showed relative numbers of commercial and undersized fish in catches.

Results obtained in the 1958 survey hold no especially bright hopes for the immediate future. The brood of haddock produced in 1952 has been the most prominent in commercial catches from the Nova Scotia banks since 1956. It was particularly important to Canadian landings through the years 1956 and 1957. Preliminary observations on the 1958 haddock fishery show that the 1952 brood has been cut down during the summer months. No good brood has appeared in the fishery to replace that of 1952. It seems unlikely that the moderate broods coming up can provide a really lucrative fishery.

<u>Selection and savings gear studies</u>. A practical way to manage the groundfish resource is through regulating mesh sizes used in trawl nets. This has been shown to release smaller fish before they are brought on deck and exposed to handling injuries. Scientific advisers to the International Commission for the Northwest Atlantic Fisheries have advised that the Commission recommend a minimum mesh size of 4 1/2 inches for cod and haddock fishing in the waters surrounding the Maritime Provinces (ICNAF Sub-area 4). As a result, each of the member governments has enacted appropriate legislation. In addition, specifications have been proposed for the chafing gear in general use to permit the release of small fish, and still prevent unnecessary wear on the nets as they are being hauled aboard, loaded with fish. Effects of these regulations are being kept under review, and the situation is being followed to determine whether further changes in regulation might prove advantageous.

Studies on cod in the southwestern Gulf of St. Lawrence in 1958 showed that average discards by small-mesh (3 to 4 1/2-inch) draggers were 23% by number and 9% by weight. Discards by large-mesh (4 3/4-inch) draggers working on the same grounds were 12% and 5% respectively. These results confirm those of 1957. They indicate that 4 3/4-inch mesh codends allow the release of about half of the small cod discarded from small-mesh codends.

Possible effects of employing a 5 1/2-inch mesh for cod in the southwestern Gulf of St. Lawrence were studied. Results of such a test depend upon culling practices in vogue and sizes of fish to be found on the fishing grounds. Under conditions prevailing in 1958 and anticipated for 1959, use of 5 1/2-inch mesh would probably result in a small immediate reduction in the amount of fish landed and is not recommended. Longer term advantages may exist and should be considered as data become available.

Wastage of haddock by commercial trawlers using 4 1/2-inch mesh codends was studied on the Nova Scotian banks. The amount caught and discarded differs according to the way in which the fish are to be handled. Smaller fish are retained for landing round than for landing dressed. In general 4 1/2-inch mesh nets released virtually all haddock below commercial size.

A mesh size appreciably larger than the 4 1/2-inch manila twine specified to meet ICNAF requirements would release significant quantities of currently marketable haddock.

Use of top-side chafing gear is a fairly general practice among the groundfish fleet in the Northwest Atlantic. The way in which it may be applied to the net is accordingly recommended in detail by the ICNAF. A series of tests of nets with and without the chafing gear applied as recommended showed that there was no significant interference with release of fish by netting applied as authorized.

Methods of assessing groundfish regulations. It is important that effects of any regulations on fish stock and catch can be demonstrated beyond question. Accordingly, much effort has been directed to methods of establishing the extent of the benefit (if any) obtained by applying mesh regulations in the ICNAF area. Most attention has been directed to ICNAF Sub-area 5 where a minimum 4 1/2-inch mesh regulation has been longest in effect and where most and best data apply.

Difficulties in assessing changes arise from absence of data on discards prior to regulation, and from annual variations in availability of young fish and in mortality. Theoretical studies indicate that effects of future mesh regulations can be measured more readily by providing study boat data both before and after enactment of new regulations. A system for avoiding misinterpretation arising from errors in age reading has been developed.

Porrocaecum studies. The study of *Porrocaecum decipiens*, a parasite which detracts from the market quality of cod, was reduced during 1958 to an effort to fill in details in its life history. Collections of small shrimp-like mysids were made in the Bras d'Or Lake, where *Porrocaecum* is known to be abundant in cod. The mysids were found to contain a variety of parasites that resembled *Porrocaecum*. Careful examination showed that many of them were not in fact the parasite which was of interest but that some of them are probably young stages of *Porrocaecum*.

PELAGIC FISHES

The pelagic fishes of the waters around the Maritime Provinces are little known and under-used. Factors controlling availability and abundance of none of the species have yet been critically studied and except for the fishery for sardine herring in the Bay of Fundy region exploitation makes little use of the potential. Even in the Bay of Fundy region it is possible that more aggressive fishing techniques could utilize the resource more effectively. Pelagic fishes, accordingly, merit careful investigation to determine the size of the resource, when and where they may be accessible to commercial exploitation, and at what level they can sustain a fishery.

During 1957 and 1958, work on pelagic fishes has been concentrated on the herring of the Passamaquoddy area and the Bay of Fundy generally in an attempt to deduce the probable effects on the herring fishery there of placing dams at the entrance to Passamaquoddy Bay in order to develop hydroelectric power.

Herring statistics in the Passamaquoddy region. In the last 2 years, data on herring landings in Passamaquoddy Bay and its approaches have been collected in such a way as to relate them to the sites of proposed tidal power dams near the entrances to the bay. It is proposed to place these dams so as to have a high pool (Passamaquoddy Bay) to be filled at high tides and a low pool (Cobscook Bay, etc.) to be emptied at low tide. Power will be developed continuously at a power house situated between the two pools. Information has been collected and analysed in close collaboration with the Economics Service of the Department of Fisheries.

In 1958, 269 weirs were built as against 290 in 1957. Of the 269, 66 were in the high-level pool, 9 in the low-level pool, 76 in the approaches to Passamaquoddy Bay, 37 in the eastern section of Charlotte County, 64 at Grand Manan, and 17 in Saint John County. There were 13 purse seiners and 31 drag seiners licensed in 1958 as compared to 17 and 22 respectively in 1957.

Total herring landings in Charlotte and Saint John Counties in 1958 amounted to about 36 million pounds or slightly more than 40% of the 1957 catch and only 47% of the 1937-1957 average.

Comparison of 1957 and 1958 landings according to gear shows that whereas weir landings decreased considerably, drag- and purse-seine catches kept up well.

Landings from weirs began in February and increased to a peak of 9.2 million pounds in September. July, August, and September provided 85% of the total weir catch. Drag seining was confined to the period from July to October and took about 2.4 million pounds. Purse seining was done in all months except May and June. Landings of 3.0 million pounds in March and 3.5 million pounds in September accounted for most of the total purse-seine catch of 7.9 million pounds.

When localities of the catch are related to the dam sites, it is found that in 1958 about 9.0 million pounds of herring were taken from the proposed high-level pool, 0.4 million pounds from the low-level pool, 3.7 million pounds immediately outside the Bay, 8.9 million pounds in the eastern section of Charlotte County, 6.9 million pounds at Grand Manan, and 6.9 million pounds in Saint John County.

An economic survey of the herring fishery in the Passamaquoddy area carried out by the Economics Service of the Department of Fisheries showed the average investment in a weir and its associated gear to be $5,982. The average replacement cost of a purse-seine unit is $24,866.

<u>Herring tagging and movements</u>. During 1958, 79,794 herring were tagged in 34 lots. The work extended from March 3 to September 24 and from western Nova Scotia to the coast of Maine and Point Lepreau. The tags were thin strips of coloured celluloid hooked through slits in the fishes' opercula.

Altogether 2,739 tags were recovered, 60% within the first 2 weeks. About 61% of the recaptures were made within 5 miles of the tagging site. About 3% showed movements of 15 to 55 miles. Movements in and out of Passamaquoddy Bay were quite general. However, movements from the Passamaquoddy area to the coast of Maine were restricted--the only indications being the recovery in Cobscook Bay of one tag put on in Passamaquoddy Bay and the recovery on the outer Maine coast of a Cobscook Bay tag.

<u>Herring behaviour and survival</u>. Herring behaviour in relation to currents was studied by towing groups of fish in fish-net cages and observing them by underwater television. Two television units were employed, the first in co-operation with the United States Fish and Wildlife Service and the second through the courtesy of the National Research Council of Canada.

At current speeds below a minimum value probably near 0.8 feet per second, fish circled the cage without reference to the current. As the speed of the cage relative to the water increased, herring formed a group in the upstream end of the cage and close to its bottom. They swam from side to side, always turning upstream when meeting the walls. Orientation of the herring into the current became more pronounced as velocity increased, and the side to side deviations decreased until they were slight or irregular. With further velocity increases, the swimming speed of the herring increased until it reached a maximum when the fish, still heading upstream and swimming vigorously, slowly lost ground, tail first until they were swept against the mesh of the cage.

Maximum swimming speed was subject to special consideration. It is defined as the speed at which 50% of the herring fail to keep pace with the cage over one minute when swimming at an increasing rate. Such conditions might be found in nature where herring near the bottom are stemming an increasing tidal flow. All currents above the maximum swimming speed will be able to move the herring in the direction of flow.

Maximum swimming speeds probably depend upon water temperatures and were found to vary with fish size. The tests were carried out between 11.6 and 12.4°C. Maximum swimming speeds ranged from 1.8 knots to 2.8 knots for 6-inch and 11-inch fish respectively.

Herring tolerance of high temperature was tested. Fish caught in water of 9.6°C and presumably acclimated to temperatures between 9 and 10°C were used in the experiment. The upper lethal limit is defined as the temperature at which 50% of the herring die within 48 hours. It was found to be 21°C for small herring (3 1/2 to 5 inches) and between 19°C and 21°C for 7- to 12-inch fish.

Ability of herring to withstand sudden changes in depth was tested by lowering caged herring (5 1/2 to 8 1/2 inches long) to a depth of about 150 fathoms at about 1.7 feet per second, and raising them again at about 2.6 feet per second. Observations on fish for 2 hours after the treatment showed no indications of unusual behaviour. It is concluded, accordingly, that moderately rapid changes in depth from surface to 150 feet have no ill effects.

Plankton studies in relation to herring. Plankton studies in the Bay of Fundy and the Gulf of Maine have been undertaken to show general distribution of young herring and of the small floating animals they feed on.

During 1958, plankton collections were made at 14 stations that were occupied on each of 22 cruises carried out in the Passamaquoddy area. In addition, routine collections for the years 1941 to 1945 inclusive were examined. There were 3 special spring cruises from Grand Manan to St. Mary Bay, 3 offshore cruises in the Bay of Fundy and Gulf of Maine, 15 exploratory cruises at the entrance to Passamaquoddy Bay, and bi-weekly surface tows at the Lurcher Lightship.

Results indicate that herring larvae are not produced in Passamaquoddy Bay. A few larvae have been found in the area but indications are that they move in on the flood tide probably through Western Passage.

Special spring cruises around Grand Manan and St. Mary Bay gave no indications of newly-hatched larvae such as would be expected from spring-spawning fish.

Offshore results indicate that major herring spawnings occur off the southwest coast of Nova Scotia and on the northern edge of Georges Bank. The drift of larvae, as indicated by non-tidal surface currents and increasing size as the distance from the spawning area increases, suggests that Nova Scotia and probably Georges Bank spawnings contribute to commercial stocks of herring in inshore areas of southern New Brunswick.

Food of herring was found to be widely diversified and to vary with locality. Inside Passamaquoddy Bay herring were feeding extensively on characteristic Bay forms. Outside feeding seemed to be less active and to be mostly on offshore types. In general the pattern of feeding follows closely the relative abundance of plankton in the region. Heavy feeding in June was followed by a decrease in July and August, a sharp increase in September, followed by a decrease in October. In late November, there was a slight renewal of feeding activity corresponding to an increase in abundance of plankton at that time.

Exploratory herring fishing. Herring fishing in both southern New Brunswick and Maine is carried on chiefly by weirs and bar seines close to shore. As a result little is known about the offshore distribution and abundance of herring. Exploratory fishing experiments were carried out in an attempt to increase knowledge on these points.

Bottom trawling on the northern edge of Georges Bank in October took moderate catches of spawning herring for the fourth successive year. In January, small catches of large fish evidently recovering from autumn spawning were taken in small quantities (up to 350 lb per drag, average 150 lb).

Dutch herring trawls and gill nets took herring in Kennebecasis Bay, but a wide variety of gear types failed to take herring in the passages leading into and out of Passamaquoddy Bay.

Throughout the summer months, surveys with sonic sounders were carried out at weekly intervals throughout Passamaquoddy Bay. They showed that in general the greatest concentrations of herring are in the open areas away from small coves and inlets where weirs are located. This conclusion is supported by the catching of at least 2,250,000 lb of herring by commercial purse seines in the middle of the Bay in September.

Abundance of herring larvae in the Gulf of St. Lawrence. An annual assessment of the abundance of larval herring in Northumberland Strait has been continued. It is based on the average numbers of larvae per tow at stations sampled in connection with lobster larvae surveys. The abundance in 1958 is the lowest in the 8 years of the program and may reflect a reduced spawning population caused by the epidemic fungus disease that swept the area in 1955 and in 1956. The bearing of small spawning and consequent small larval production on subsequent recruitment to the commercial fishery has not been demonstrated.

Southwest Nova Scotia herring fishery. In 1958 Nova Scotia herring landings amounted to 102 million pounds of which about 87 million were taken in Digby, Yarmouth, and Shelburne Counties. This was more than double the amount taken in southwestern Nova Scotia in 1957. The increase is chiefly owing to successful purse seining for sardine-size herring in St. Mary Bay and the eastern part of Yarmouth County. Routine sampling of commercial catches for length, age, and vertebral number was continued throughout the year. Analyses of these data are incomplete, but there is no indication of decline in size or age composition for samples obtained from the gill-net fishery. Otoliths show that the majority of fish taken in the area are autumn spawners with ages ranging from 2 to 9 years.

Experiments on herring fishing methods. As herring constitute an inadequately used resource, attention is directed to improving catching methods. Tests with drift nets in Hermitage Bay, using gear supplied by the Industrial Development Service, have been continued and give consistently promising results. From April through June, catches averaged from 197 lb per net night (April) to 333 lb in May. It is believed that introduction of drift netting on the south coast of Newfoundland would increase present landings substantially.

Swordfish studies. The Canadian fishery for swordfish is important and growing. Catches in 1957 and 1958 exceeded five million pounds and had landed values in excess of one and one quarter million dollars. In 1939, the catch was less than 1.8 million pounds. During 1957, 220 boats contributed to the landings. Fifty-two of these were small boats operating close inshore and close to home ports. The remaining 168 were larger longliners, schooners, and draggers capable of fishing on Georges Bank or the Grand Banks.

During field observations it was found that most of the swordfish harpooned had stomachs full to half full of food. It consisted of lancetfish, lanternfish, and rosefish. In most cases the food was fresh and not broken up. Because the species eaten are deep-water forms, it seems evident that the swordfish had been feeding at considerable depth and had come quickly to the surface where they were caught.

SALMON

The east coast of Canada is an important stronghold for the world's dwindling supply of Atlantic salmon. Famous angling rivers are found in the Maritimes area. Commercial fisheries provide salmon for both local and distant menus. Dual use of a single resource lends urgency to the need for facts in managing the fishery. Administration is complicated by a sharing of authority among federal and provincial government agencies. The situation is met by having research and management programs reviewed by a Federal-Provincial Co-ordinating Committee. Research programs are agreed upon and tackled co-operatively although most of the work is undertaken by the Fisheries Research Board.

The research program during 1958-59 may be considered under a variety of headings. First, and basic to other considerations, is analysis of fishing statistics. They define the problems and provide indices of success in meeting them.

Second is consideration of the migrations of Atlantic salmon and assessment of their tendency to return to their natal stream. This is supplemented by a study of movements of mature salmon in the Miramichi River. Third is the study of the best way in which to produce smolts both by hatchery planting and natural reproduction. Fourth is the study of the effect of forest insecticides used to combat spruce budworms on salmon and how ill effects can be avoided. Finally is the study of the effects of hydroelectric development in the Saint John River and the effects of impoundments in general.

Statistics. Catch data collected by appropriate federal and provincial agencies show good landings in 1958 by both commercial fishermen and anglers. Commercial fishing in Quebec showed a 49% increase over 1957 landings. In the Maritime Region, commercial landings were up by 33%. Increase was general throughout the region with the Gulf of St. Lawrence area up 27%, the Fundy area 67%, and the Atlantic area 8%. The 1958 total in Quebec was just more than half a million pounds--the highest since 1953. In the Maritime Region, the 1958 total landing of over 1,100,000 lb continued the steady improvement since 1955 when the catch fell below 700,000 lb.

The 1958 angling catches were the highest recorded since 1949 when the present system of collecting catch statistics was instituted. Over 65,000 fish were taken in the Maritime Region. This represented an increase of 66% over the previous year. The improvement in the case of angling was 61% in the Gulf of St. Lawrence area, 42% in the Fundy area, and 265% in the Atlantic area. Angling pressure during 1958 was very high. As a result the catches per rod-day on various rivers showed less improvement over the previous year. In general, water conditions in 1958 were favourable for ascent of salmon and for angling. These facts may have been largely responsible for improved catches, rather than a significant increase in the abundance of fish.

The progress of salmon (2-sea-year or older fish) and grilse (1-sea-year fish) into the Northwest Miramichi River was followed at three check points. They are an estuarial trap at Millbank, and counting fences at Curventon 6 miles above tide-water and at Camp Adams, 33 miles farther up.

At Millbank in 1958 more than twice as many grilse were taken as in 1957. This increase was chiefly made up of very large catches following the commercial fishing season.

At the Curventon fence, the grilse count was about three times as high as in 1957 and the increase occurred during the angling season. The increase was unexpected because the estimated population of large parr (2-year-old fish) in the Northwest Miramichi in 1956 was smaller than in 1955 as a result of DDT spraying. Ordinarily these fish would have produced grilse returning in 1958 and 1957 respectively. Recent detailed studies of scales have shown that many young salmon that were classified as small parr (1-year-old fish) in 1956 and which were very abundant, later grew rapidly enough to become smolts in 1957 and to migrate seaward with fish a year older. There was an improved run of large salmon at Curventon late in the angling season but the total run was down. The low run was an expected result of DDT spraying.

Counts at Camp Adams reflect those at the lower Curventon fence. Grilse were plentiful and salmon relatively scarce and both were available during the angling season.

Additional information about movement of fish into the Miramichi River was gained by tagging at Millbank and Curventon. Fish were tagged in both 1957 and 1958 at Curventon. Recoveries were markedly higher in 1958. This is probably because of greater exploitation. Salmon were evidently taken more readily in set nets during 1958.

Tagging showed great variability in the migration patterns of different fish. Some were recovered 70 miles upstream within 2 weeks. Others were taken a few miles from Millbank, 2 months after tagging. Three salmon tagged on September 18, 1958, were retaken 30 miles upriver at Curventon 2, 12, and 43 days later.

At Curventon, 259 grilse and 24 large salmon were tagged. Recoveries gave a minimum estimate of the number of grilse recaptured at 8.4%. The average time taken for grilse to travel the 33 miles from Curventon to Camp Adams was about 20 days.

<u>Homing in salmon</u>. In 1953 and 1954, about 25,000 salmon smolts were marked by distinct fin clips at Curventon and about 20,000 on the Dungarvon River--a tributary of the Southwest Miramichi. Recoveries from these markings have been given special attention during 1958. They show that salmon known to be of Miramichi origin are taken both as grilse and older salmon over a wide area extending to Newfoundland and Labrador. It is estimated that about one third of the total catch of Miramichi fish is in Newfoundland and Labrador nets. Although commercial fisheries in the Miramichi estuary took a mixture of fish from the two tributaries, recaptures by angling farther upstream of 69 marked fish showed pronounced segregation. Forty-nine of 51 Northwest-marked fish were recovered from that tributary and 16 out of 18 Dungarvon-marked fish came back from the Southwest Miramichi.

<u>Use of hatchery stock to supplement native salmon</u>. Previous work by this Station has shown that a reasonable objective for smolt production is 5 per 100 square yards of river bottom where stocks are protected from onslaughts by mergansers. To produce this number of 2-year-old smolts requires about 8 native

parr or 12 native underyearlings per 100 square yards. Alternatively it calls for about 35 hatchery underyearlings because they experience difficulty in getting established.

It may be anticipated that in nature because of over-fishing, catastrophe, pollution, etc., the numbers of under-yearlings or parr present may occasionally be inadequate to make full use of the smolt potentiality of the river. Effectiveness of remedial measures is being explored.

In 1956, the native fingerling population in the Pollett River was found to be 6.8 fish per 100 square yards. This was supplemented by a planting of 99,000 large underyearlings (23 per 100 square yards). Presumably because their size was larger than expected (and larger even than that of the native stock) the planted fish survived well and at the expense of the native stock. The rate of smolt production from the area was up to expectation, 5.4 per 100 square yards, 1.0 from native stock, and 4.4 from hatchery plantings. Effectiveness of well grown hatchery supplements is strongly indicated.

Researches associated with DDT. In 1954, aerial spraying of spruce and balsam stands in the Miramichi watershed was begun to control ravages of spruce budworm which threatened to destroy the forests. It very soon became evident that both salmon and aquatic insects on which they feed were being destroyed too. For the last 4 years, a significant part of the research effort for salmon has been devoted to assessing effects of the use of forest insecticides.

Studies on the effects on aquatic insects were continued in 1958 at four collecting sites. Although there are variations between sites, the area as a whole still shows a low volume of aquatic insects with midges predominating. However, at one site larger caddisflies showed signs of revival and mayflies continued their comeback, first indicated in 1957.

Food studies on young salmon complement studies on aquatic insects. Underyearlings normally consume immature stages of chironomids (midges), and smaller forms of mayflies. Parr at both stages tend to feed on caddisflies and large stoneflies. Lack of these stages could have serious effects on growth of later stages of pre-smolt parr.

Detailed growth studies on young salmon in DDT-sprayed watersheds show that survivors of fish sprayed as underyearlings, as yearlings, or as 2-year-olds will be below normal size at the end of the year. Compensatory growth in subsequent years more than makes up the loss in first and second year fish. There is reason to believe that the increased growth can lead to migration as smolts at a younger age than usual.

During 1958, in co-operation with the Forest Biology Division of the Department of Agriculture and with the assistance of Rohm and Haas Co. of Canada, Ltd., a search was begun for insecticides that would be effective in controlling budworm but have no ill effects on salmon or stream insects. Several poisons were found ineffective against budworms, and it appears that future tests should be directed to improving the DDT formulation. Investigation along these lines should be continued. The budworm epidemic has collapsed but there will be others. Further experiments should be undertaken soon to establish satisfactory control techniques before they are needed.

Effects of hydroelectric developments. Increasing use of the Saint John and other rivers for hydroelectric development has turned attention to the effects on anadromous fish when natural water flows are altered.

In association with biologists of the Department of Fisheries and with the New Brunswick Electric Power Commission studies have included: (1) The assessment of young salmon populations above the Tobique dam. These studies are complicated by DDT spraying in the area. They showed many more underyearlings in 1958 than in 1957. (2) The smolt hold-up at Beechwood and methods of by-passing smolts. At present, the delays above the dam led smolt to suffer in well-being. Methods of reducing delay are being explored. (3) Establishing a creel census for the Tobique flowage to assess the effects of the dam on fish species other than salmon and especially predatory fish.

Formation of a pond in Ellerslie Brook to give better trout angling has provided opportunity to observe the effects of an impoundment on salmon movements in a small stream. The pond was found to block the passage of adult salmon upstream and deter their return to sea after spawning. Parr tended to concentrate in the pond and may become smolts a year later than normally. Small smolts in 1957 were retained in the pond for a year but in 1958 larger smolts showed no evidence of being held up. It is evident that quite small impoundments (7 acres) can interfere with the customary movement of salmon at several stages.

TROUT

The trout fishery is important in the Maritime Provinces both as a tourist attraction and for relaxation of residents. As the fishery is inland and frequently in quite small bodies of water, it is susceptible to man-made changes in environment. Some of the changes are damaging but others can be brought about deliberately to increase use of the trout resource. Most of the work in trout research is devoted to exploring various approaches to resource management with the intentions of increasing production and accessibility of trout. Some of the methods of management tested were planting hatchery stock, fertilizing water, control of predators, making impoundments, and introducing exotic species.

Crecy Lake. Experiments on unproductive Crecy Lake in the poor acid soils of southern New Brunswick showed that, even although spawning grounds were inferior, the introduction of hatchery stock was little use unless the potential of the lake was increased by adding fertilizers, and the lake's yield retained for anglers by controlling activities of predatory mammals and birds in the area. Eels are a predator in the lake. An attempt to reduce their numbers in the lake by trapping and by keeping out young elvers with a barrier at the lake's outlet is under way. Some reduction in the number of eels seems evident but successful control is not yet assured. Studies of making the best use of the potential at Crecy Lake and Kerr Lake are being continued with the use of rainbow trout instead of native speckled trout. Former procedures with speckled trout are to be repeated in detail with rainbow trout so as to allow valid comparisons.

Ellerslie Brook. The short spring-fed streams of Prince Edward Island running through fertile land are highly productive of trout. There the first problem is to make fish accessible to anglers. This has been successfully attempted by damming Ellerslie Brook and some other streams close to their outlets. At Ellerslie Brook the situation has been closely followed since 1946. It has been found that formation of a 7-acre pond did in fact greatly increase the availability of fish with the result that the nursery stream is now unable adequately to supply the pond with fish. A pond relatively smaller (15 acres) in relation to the size of larger Wilmot Stream was less successful in attracting trout to remain for angling. It is suggested that where pond size is small in relation to stream, screening may be desirable to retain fish in accessible water.

Stevenson's Pond. At Stevenson's Pond (6 acres) observations on numbers and condition of the whole trout population have been possible. Observations indicate that the tributary stream system is insufficient to supply fish to utilize fully potentialities of the pond for producing trout. Use of supplementary hatchery stock seems indicated. Further study is necessary to show the best number of outside fish to introduce.

Simpson's Pond. At Simpson's Pond (2.3 acres) productivity of the introduced rainbow trout is being studied. Incidentally it was found that the introduction caused no effects on brook trout in the same waters. Indications so far are that rainbow trout grow faster than brook trout under similar conditions.

Natural fluctuations. Since 1947 the population of brook trout in Ellerlsie Brook and neighbouring streams has been followed closely. The variations observed are of value in assessing other situations. Annual variations in numbers of under-yearlings are evident and of much the same order of magnitude in

Hayes and Ellerslie Brooks. In years when stocks were low in the Ellerslie system, they were found to be low in many other streams in the region. When frazil ice conditions were severe in winter and spring, stocks of underyearlings were low in the following summer.

Silting and scouring produced marked changes in the brook. When part of the brook became silted, trout population there fell off. Scouring usually proved beneficial to producing older trout as pools are deepened and banks undercut, thus increasing cover. Brush also provides good hiding places for trout. After cover was removed from an area of stream, a decrease in trout stocks was noted.

Trout have strong territorial tendencies. When the older trout population of a pool was doubled by stocking, about 50% of the new trout moved out within 48 hours. Few of the resident population moved from the pool.

There was no indication of competition between trout and salmon for living space. They have different habitats.

Trout older than yearlings move from Ellerslie Brook into the pond but there is little reverse movement. This has brought about a decrease in the average size of older trout in the stream. The productivity of the stream has not been affected by pond formation. During the past summer, the stock of fingerlings and older trout in the stream were at pre-pond levels.

Tolerance of underyearlings to salt water. In Prince Edward Island, young salmon and trout are known to move into the salt water of the estuary. A series of experiments under artificial conditions showed that low salinities are tolerated and provide a measure of acclimation to full salinity which is complete in the case of salmon. Both salmon and trout tolerate simulated estuarial conditions with alternately full (28‰) salinity and fresh water at 6-hour intervals. Tolerance to salt water is much reduced by injuries involving loss of scales. Further and more precise studies along these lines are indicated to guide the use of estuaries in rearing young salmon and trout.

ALEWIFE

The alewife is available in great numbers in Maritime rivers and their estuaries during its spring-spawning migration. It has been relatively neglected by industry but recently the pet food industry has placed it in great demand. New Brunswick landings increased from a 7.4 million pound average in the 1943-46 period to 29.4 million pounds in 1951-54. Since then catches and availability have dropped, causing concern about continuity of supply. A preliminary survey of the species was begun in 1958 in co-operation with the Protection Branch of the Department of Fisheries.

The investigation took the course of examining in detail samples carefully taken by Fisheries Officers. Examination and analysis is not yet complete but to date it shows that early-run fish (late April) differ from May and June samples in length, eye size, and vertebral number. The later samples are indistinguishable in these respects. Spawning fish ranged in age from 4 to 7 with 5-year-olds dominant. Scale examination suggests that most fish are mature at 4 or 5 and spawn each year thereafter.

SEAWEED

Of the immense resources in seaweed that abound on Maritimes shores only two provide regular products for sale. One is dulse that supplies a small demand from local enthusiasts and expatriates. The other is Irish Moss (Chondrus). This red alga is a regular article of commerce and the source of the carrageen used extensively as an emulsifying agent. The latter was accordingly selected for investigation.

The growth and replacement rates of Irish Moss are under study to provide information that applies to managing this resource. Growth is most rapid from May to July and falls off through the remainder of the summer. Small unbranched individual plants seem to grow fastest. Cropping (by experimental plucking) in one year markedly reduces the weight of yield from the same area a year later.

BULLETIN ON ATLANTIC COAST FISHES

Progress is being made in meeting a long felt need for an authoritative book on marine and anadromous fishes of the Canadian Atlantic Coast. A general account is about half done of fishes on 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. The completed book will include illustrations and keys.

POLLUTION

Freshwater and shore animals are subject to man-made changes in their environment. These changes can be beneficial or harmful, direct or indirect. Examples of beneficial changes are the fertilization of Crecy Lake, the formation of trout fishing ponds on Prince Edward Island, both mentioned in this report, or in the remedial construction of fishways around dams or impassable falls.

Unfortunately, examples of harmful changes are more numerous. Many of them act both directly and indirectly. Hydroelectric dams and other structures not only obstruct up- and downstream movements of anadromous fishes, but also have indirect effects. The impoundment above a dam may foster predators, may further interfere with migration, and can be expected to render spawning grounds unusable since percolation of water through the substrate is reduced. DDT spraying of forests not only kills fish directly but also kills the aquatic insects on which young salmon live through the first 2 or 3 years of life, thus altering the whole biological economy. Lumbering and agricultural practice change run-off patterns and create silting situations that spoil spawning areas and alter stream faunas. Even more obvious is the effect of turning untreated domestic and industrial sewage into natural waters. All these alterations become deleterious to fish. Most of them are also distasteful to man. All of them are being broadly considered under the heading of pollution.

In 1958, the St. Andrews Station took its first step in the consideration and remedy of pollution. The main emphasis was placed on a "base-line" survey of the Saint John River and chosen tributaries. Results are to be used for predicting and assessing future damage to fish by changes in river usage. Sizeable municipalities lie on this river system, and further expansion is planned for industry and hydroelectric development. The amount and nature of the animal life on the river bottom were defined in the free-flowing section of the river and in the impoundments above the Beechwood and Tobique dams. Reported sites of pollution at East Florenceville, Woodstock, and Aroostook Rivers were checked. A study of Saint John River profiles leads to the conclusion that the reduction in over-all river area will be tolerable at the 1,000 cubic feet per second proposed as a minimum release from Beechwood. However, shallow areas may be the most severely affected, and the most important for fish life. Habits of anadromous fish in the main river should be studied to determine whether reduced water levels and velocity of flow over shoals will cause stranding of fish or mortality of eggs.

MATHEMATICAL STATISTICS

Fisheries work involves many quantitative considerations. Diverse data complicated by many sources of error must be carefully evaluated in reaching conclusions for application. Even more difficult is the necessity to forecast the results of changes in regulations from the imperfect information that is available in fisheries work. These evaluations and forecasts call for the special training of a mathematical statistician.

During 1958, theoretical consideration was given to the lobster fishery at Tignish in an effort to establish total and natural mortality rates and population growths. These estimates, used in a steady state model, were considered in forecasting effects of changing fishing practices. Conclusions must be accepted with some caution because of uncertainty in data on which they are based. They indicate that if total fishing effort were reduced by 50% from that currently in effect, the yield of lobsters would be reduced by only 15% while the catch per trap haul would almost double. Tentative conclusions concerning the effects of raising the lower size limit depend upon the estimate of natural mortality rate. Unless this is about 20% or lower, appreciable benefits cannot be predicted.

MAKING THE WORK KNOWN

With increased demands from government and industry for information about the fisheries, the Station has continued to develop research programs, in consultation with provincial and federal departments of government and with other nations. The work of investigation was shared in the International Commission for the Northwest Atlantic Fisheries, the International Passamaquoddy Fisheries Board, the Interdepartmental Shellfish Committee and the Federal-Provincial Salmon and Trout Research and Management Committee. These and other co-operative efforts have increased the amount and applicability of scientific results. To make these results known and to encourage their use, the Station has directed increasing effort toward their prompt distribution to fishermen, the fishing industry, branches of government, and fellow scientists. Information was spread by visits, meetings, letters, memoranda, addresses, radio, television, and through writings in trade journals, newspapers, magazines, and in the Board's circular, progress report, journal and bulletin series. There is a continuing need to spread information about the Station's scientific work, and efforts toward this end will be continued and increased.

STAFF LIST BY INVESTIGATIONS

(April 1, 1958 to March 31, 1959)

Staff other than seasonals or term are classified as of March 31, 1959. Those employed for Industrial Development Service are marked IDS; those employed for International Passamaquoddy Fisheries Board project are marked IPFB.

Director	J. L. Hart, Ph.D.
Director's Secretary, Clerk 4	W. E. Young
Assistant Director, Senior Scientist	L. R. Day, M.A.

Groundfish Investigations

Principal Scientist in charge	W. R. Martin, Ph.D.
Associate Scientist	L. M. Dickie, Ph.D.
Associate Scientist	Y. M. L. Jean, Ph.D.
Associate Scientist	F. D. McCracken, Ph.D.
Assistant Scientist	A. C. Kohler, M.Sc. (educational leave from Oct. 2/58)
Assistant Scientist	P. M. Powles, M.Sc.
Technician 3	D. N. Fitzgerald
Technician 3	G. J. W. Sullivan
Technician 1	M. F. Fraser
Technician 1	R. M. MacPherson
Technician 1	N. J. McFarlane
Technician 1	R. J. Thurber
Assistant Technician 2	Irma I. Thompson
Stenographer 3	C. Ruth Garnett
Stenographer 3	Shirley W. DeLong (from April 21/58)
Stenographer 3	Joy Sutherland (to May 22/58)
Associate Scientist - Term	D. M. Scott, Ph.D. (May 15 - Sept. 12/58)
Technician 1 - Term	G. W. Condon, B.Sc. (from May 23/58)
Assistant Technician 1 - Term	Reta M. Greenlaw (Jan. 2 - March 31/59)
Student Assistant	L. L. MacLeod (May 14 - Sept. 15/58)
Student Assistant	W. E. Russell (May 19 - Aug. 29/58)
Port Observer - Part-time	F. Berrigan
Port Observer - Part-time	R. C. MacMillan

Anadromous Fishes

(a) Salmon Investigations

Principal Scientist in charge	C. J. Kerswill, Ph.D.
Associate Scientist	P. F. Elson, Ph.D.
Associate Scientist	M. H. A. Keenleyside, Ph.D.
Technician 2	E. J. Schofield
Technician 1	P. R. Graves
Technician 1	I. M. Jones

Assistant Technician 3	W. G. Irving
Assistant Technician 2	H. P. Barchard
Assistant Technician 2	L. R. MacFarlane
Stenographer 1	Elizabeth D. McAuley
Associate Scientist - Term	F. P. Ide, Ph.D. (May 21 - June 24/58)
Assistant Technician 3 - Term	G. W. Cooper (Apr. 1 - Nov. 29/58)
Assistant Technician 3 - Term	E. F. Thompson (June 2 - Aug. 15/58)
Assistant Technician 2 - Term	W. H. MacLean (Apr. 1 - Nov. 29/58)
Assistant Technician 1 - Term	H. D. Clark (Apr. 1 - July 15/58)
Assistant Technician 1 - Term	W. R. Currie (Apr. 1 - Sept. 30/58)
Assistant Technician 1 - Term	J. H. King (Apr. 1 - July 15/58)
Student Assistant	D. H. Betts, B.Sc. (May 26 - Sept. 3/58)
Student Assistant	J. K. Brundritt (May 29 - Sept. 5/58)
Student Assistant	G. D. Maddison (May 20 - Sept. 15/58)
Student Assistant	J. E. McInerney (May 5 - Sept. 5/58)
Student Assistant	E. L. Mills (May 14 - Aug. 29/58)
Student Assistant	F. T. Yamamoto (May 14 - Sept. 19/58)
Netman - Prevailing Rates	A. G. Steeves (Apr. 2 - Dec. 8/58)
Netman - Prevailing Rates	E. C. Tucker (Apr. 1 - Nov. 29/58)
Casual employees	

(b) Trout Investigations

Senior Scientist in charge	M. W. Smith, Ph.D.
Assistant Scientist	J. W. Saunders, M.Sc.
Technician 1	C. R. Hayes
Assistant Technician 3	C. Williams
*Assistant Technician 2	Mary Holmes
Student Assistant	Jean Y. R. Baird (May 14 - Aug. 28/58)
Pond Guardian - Part-time	W. A. Simpson
Pond Guardian - Part-time	J. Stevenson
Casual employees	

* Also general laboratory assistance

Crustacea

Lobster Investigations

Principal Scientist in charge	D. G. Wilder, Ph.D.
Associate Scientist	D. W. McLeese, Ph.D.
Assistant Scientist	R. J. Gibson, B.A. (from Sept. 3/58)
Technician 2	R. C. Murray
Technician 1	U. J. Walsh
Assistant Technician 3	D. E. Graham
Clerk 2	Evelyn R. MacMillan
Student Assistant	Patricia A. Holt (May 16 - Sept. 1/58)
Student Assistant	R. D. Lisk, A.M. (May 28 - Aug. 29/58)
Assistant Technician 1 -Term IDS	H. L. Cunningham (to May 31/58)
Assistant Technician 1 -Term IDS	E. A. King (to May 31/58)
Assistant Technician 1 -Term IDS	H. D. Penney (to May 31/58)
Stenographer 1 - Casual	Hazel L. Grant (Apr. 30 - May 9/58)

Pelagic Fishes

Senior Scientist in charge	S. N. Tibbo, M.A.
Associate Scientist	R. A. McKenzie, M.A.
Assistant Scientist IPFB	Vivien M. Brawn, M.Sc.
Assistant Scientist	J. E. H. Legare, M.A.
Technician 1 IPFB	A. W. Holt
Technician 1 IPFB	H. A. Smith
Technician 1	E. G. Sollows
Assistant Technician 3 IPFB	A. W. Brown
Assistant Technician 3 IPFB	C. F. Monaghan
Assistant Technician 2 IPFB	Cariene D. Burnett
Assistant Technician 2	Phyllis J. Gibson (to Dec. 31/58)
Assistant Technician 2 IPFB	Delphine C. MacLellan, B.Sc.
Assistant Technician 1 IPFB	C. A. Dickson
Assistant Technician 1 IPFB	L. D. Gardner
Assistant Technician 1 IPFB	R. S. Hendricks
Stenographer 1 IPFB	Mary J. Fitzgerald (to May 16/58)
Stenographer 1 IPFB	Janet L. Mahoney (from May 20/58)
Stenographer 1 IPFB	R. Charlene Stuart (from June 9/58)
Technician 1 - Term IPFB	M. E. MacLean (from Oct. 1/58)
Student Assistant IPFB	M. E. MacLean (May 15 - Sept. 30/58)
Student Assistant	G. M. Somerville, B.Sc. (May 27 - Sept.8/58)

Mollusca

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

(a) Clam and Scallop Investigations

Associate Scientist in charge	N. F. Bourne, Ph.D. (from March 18/59)
Technician 3	J. S. MacPhail
Assistant Technician 2	Esther I. Lord
Junior Scientist - Term	Barbara L. Shaw, M.A. (May 22 - Sept. 9/58)
Technician 1 - Term IDS	E. C. Durkee (May 23 - Nov. 28/58)
Student Assistant	Joan E. Mortimer, B.Sc. (June 2 - Sept.29/58)
Casual employees	

(b) Oyster Investigations

Associate Scientist	R. R. Logie, Ph.D.
Assistant Scientist	R. E. Drinnan, B.Sc. (from June 25/58)
Technician 2	S. E. Vass, B.Sc.
Assistant Technician 3	E. B. Henderson
Maintenance Supervisor 1	K. R. Oatway
Associate Scientist - Term	W. B. Stallworthy, Ph.D. (May 15 - Sept.12/58)
Student Assistant	Kathleen J. Blenkhorn, B.Sc. (June 3 - Sept.12/58)
Student Assistant	Wilhelmina Van Walbeek (May 20 - Aug. 29/58)
Casual employees	

Pollution Studies

Assistant Scientist in charge	J. B. Sprague, M.A. (from June 3/58)
Technician 1	D. L. Peer, B.Sc. (from Oct. 1/58)
Casual employees	

Mathematical Statistician

Associate Scientist in charge	J. E. Paloheimo, M.A. (educational leave from Sept. 23/58 - Feb. 13/59)
Student Assistant	Norma E. Brown (May 20 - Sept. 8/58)

Seaweeds Investigations

Associate Scientist in charge - Term	A. R. A. Taylor, Ph.D. (May 20 - Sept. 30/58)
Student Assistant	R. de M. Cattley (May 15 - Sept. 23/58)

Taxonomy

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

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

Senior Scientist in charge	L. R. Day, M.A.
Technician 1	P. W. G. McMullon
Clerk 2	M. Beryl Stinson
Student Assistant	Patricia W. Flieger (May 20 - Sept. 12/58)
Student Assistant	Noreen B. Keith (May 20 - Sept. 19/58)

Administration and Maintenance

Administrative Officer 3 in charge	J. A. Rogers, A.C.B.A.

Accounts, Purchases, Stores and Personnel

Principal Clerk	W. D. Burton
Clerk 3	Frances L. Stinson
Stenographer 2	Charlotte A. Gibson
Storeman 1	B. H. Foster

Director's Secretary, Mail, Files and Switchboard

Clerk 4 in charge	Winifred E. Young
Clerk 2	Dorothy M. McLaughlin
Stenographer 2	M. Barbara Stickney
Stenographer 1	Margaret A. Harriott
Clerk 1 - Term	Flora L. Langley (May 1 - Oct. 15/58)

Maintenance, Services and Boats (St. Andrews)

Technician 4 in charge	H. Y. Brownrigg
Maintenance Supervisor 3	F. E. Purton
Maintenance Supervisor 1	R. A. Greenlaw
Caretaker 4	K. W. Johnston
Caretaker 3 (Watchman)	H. E. Lee
Caretaker 3 (Groundsman)	D. A. Stinson
Caretaker 3 (Nets, maintenance, etc.)	C. S. Tucker
Maintenance Helper	J. F. Johnson
Truckman	G. F. Wentworth
Cleaning Service Man	K. H. Murray (from May 15/58)
Laboratory Helper	K. H. Murray (to May 14/58)
Laboratory Helper	C. E. Teakles (from May 20/58)
Carpenter - Prevailing Rates	H. C. Hillman
Carpenter - Prevailing Rates	F. M. Langley (from May 21/58)

M/V "J. J. Cowie"

Technician 2 (Capt.)	C. J. Bayers
Engineer	B. W. Hart
Cook-deckhand	A. L. Surette
Twinehand	I. A. Cottreau (to Mar. 31/59)
Twinehand	E. B. Fevens (Apr. 10 - Dec. 11/58)

M/V "Harengus"

Technician 3 (Capt.)	H. H. Butler
Chief Engineer	H. Yarn
2nd Engineer	I. M. Corkum
Mate	W. R. Hooper (to Dec. 31/58)
Mate	E. A. Mason (from Feb. 1/59)
Boatswain	E. A. Mason (to Jan. 31/59)
Boatswain	Vacant (from Feb. 1/59)
Cook-steward	E. T. Hull
Seaman	W. R. Hooper (from Jan. 1/59)
Seaman	W. J. Horne
Seaman	C. A. Jacobs
Seaman	F. R. Johnson (to Jan. 30/59)

M/B "Mallotus"

*Technician 1 (Capt.)	W. G. Carson
Assistant Technician 1 - Term	C. B. Graham (May 20 - Oct. 10/58)

*Responsible to Assistant Director for technical aspects of work

M/B "Pandalus II"

Technician 1 (Capt.)	L. I. Cross
Engineer	J. O. Allain (Apr. 1 - Nov. 11/58)
Cook-deckhand	A. S. Hawkins (Apr. 15 - Nov. 7/58)

OCEANOGRAPHY

Atlantic Oceanographic Group

Senior Scientist	L. M. Lauzier, D.Sc.
Associate Scientist	W. B. Bailey, B. Sc.
Associate Scientist	N. J. Campbell, Ph.D.
Associate Scientist	R. W. Trites, Ph.D.
Assistant Scientist	A. E. H. Collin, M.Sc. (returned educational leave May 2/58) (on educational leave from Nov. 6/58)
Assistant Scientist IPFB	F. D. Forgeron, B.Sc.
Junior Scientist IPFB	J. R. Chevrier, B.Sc.
Technician 3	J. G. Clark
Technician 1	J. H. Hull
Technician 1	G. B. Taylor
Assistant Technician 3	C. C. Cunningham
Assistant Technician 3	T. A. Grant
Assistant Technician 1	R. K. Robicheau
Stenographer 2	Maureen R. Horgan (to Jan. 30/59)
Stenographer 2 - Term	Jean E. Clinch (Feb. 11 - ar. Sept. 30/59)
Associate Scientist - Term	D. G. MacGregor, M.A. (June 19 - Sept. 16/58)
Assistant Technician 2 - Term IPFB	W. A. Johnstone (May 21 - Sept. 29/58)
Assistant Technician 1 - Term	C. B. Graham (Oct. 1 - Nov. 28/58)
Student Assistant IPFB	B. L. Blackford (May 23 - Sept. 5/58)
Student Assistant IPFB	R. L. Campbell (May 12 - Sept. 12/58)
Student Assistant	Ruth J. Coates (May 15 - Sept. 12/58)
Student Assistant	J. E. Curtis, B.Sc. (May 20 - Sept. 9/58)
Student Assistant IPFB	H. D. Henderson (May 20 - Sept. 12/58)
Casual employees	

Part-time -- Lighthouse Observers

D. L. Collins, Entry Island, M.I.
R. A. Doucette, Lurcher Lightship
M. R. MacKenzie, Borden, P.E.I.
D. M. Wilson, IPFB, Lepreau, N.B.

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).
F. D. McCracken, Ph.D. (Toronto).
A. C. Kohler, M.Sc. (McGill). On educational leave from October 2.
P. M. Powles, M.Sc. (Western Ontario).
D. M. Scott, Ph.D. (McGill). Term, May 15 to September 12.

Herring

S. N. Tibbo, M.A. (Toronto).
R. A. McKenzie, M.A. (Toronto).
Vivien M. Brawn, M.Sc. (Dunelm).
J. E. H. Legare, M. A. (British Columbia).

Lobsters

D. G. Wilder, Ph.D. (Toronto).
D. W. McLeese, Ph.D. (Toronto).
R. J. Gibson, B.A. (Dublin). From September 3.

Mathematical Statistics

J. E. Paloheimo, M.A. (Toronto). On educational leave September 23 to February 13.

Mollusca

J. C. Medcof, Ph.D. (Illinois).
R. R. Logie, Ph.D. (Rutgers).
N. F. Bourne, Ph.D. (Toronto). From March 18.
R. E. Drinnan, B.Sc. (London). From June 25.
Barbara L. Shaw, M.A. (Western Ontario). Term, May 22 to September 9.
W. B. Stallworthy, Ph.D. (Toronto). Term, May 15 to September 12.

Pollution

J. B. Sprague, M.A. (Toronto). From June 3.

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 20 to September 30.

Trout

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

Other

Llewellya W. Hillis, Ph.D. (Michigan). Volunteer investigator.
Marshall Laird, D.Sc. (New Zealand). Volunteer investigator.
R. J. McIntyre, M.Sc. (Canterbury, N.Z.). Volunteer investigator.
B. B. Parrish, B.Sc. (Reading). Special Consultant.

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). From educational leave May 2. On educational leave November 6.
F. D. Forgeron, B.Sc. (St. F.X.).
J. R. Chevrier, B.Sc. (Laval).
D. G. MacGregor, M.A. (Oxon.). Term, June 19 to September 16.

PUBLICATIONS

(April 1, 1958, to December 31, 1958)

Bailey, W. B. On the dominant flow in the Strait of Belle Isle. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1163-1174.

Bond, R. M., and J. C. Medcof. Epidemic shellfish poisoning in New Brunswick, 1957. Canadian Medical Association Journal, Vol. 79, pp. 19-24.

Campbell, N. J. Recent oceanographic activities of the Atlantic Oceanographic Group in the Eastern Arctic. Atlantic Prog. Rept., No. 69, pp. 18-21.

Campbell, N. J., and A. E. Collin. The discolouration of Foxe Basin Ice. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1175-1188.

Clark, John R., Frank D. McCracken, and Wilfred Templeman. Summary of Gear Selection Information for the Commission Area. International Commission for the Northwest Atlantic Fisheries Annual Proceedings, Vol. 8, (for 1957-58), pp. 83-99.

Dickie, L. M. Recent trends in the scallop fishery of eastern Canada. Atlantic Prog. Rept. No. 70, pp. 31-34.

Dickie, L. M. Effects of high temperature on survival of the giant scallop. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1189-1211.

Hart, J. L. Some Sociological Effects of Quota Control of Fisheries. Canadian Fish Culturist, No. 22, pp. 17-19.

Hart, J. L. Fisheries Research Board of Canada, Biological Station, St. Andrews, N.B., 1908-1958. Fifty years of research in aquatic biology. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1127-1161.

Huntsman, A. G. Shubenacadie salmon. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1213-1218.

Jermolajev, E. G. (nee Kossiackine). Zooplankton of the inner Bay of Fundy. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1219-1228.

Kerswill, C. J. Regulation of the Atlantic Salmon Fisheries. Canadian Fish Culturist, No. 22, pp. 7-12.

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Kerswill, C. J., P. F. Elson, and M. H. A. Keenleyside. Investigation and Management of Atlantic Salmon in 1957. Part I. The Research Programme. Canadian Department of Fisheries, Trade News, Vol. 10, No. 12, pp. 4-18.

Kerswill, C. J. A program to ensure Salmo salar's future. The Atlantic Salmon Journal, Sept. 1958, No. 3, pp. 28-31.

Kohler, A. C. The validity of otolith age determinations for haddock (Melanogrammus aeglefinus L.) from the Lockeport, N.S., area. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1229-1238.

Kohler, A. C., and J. R. Clark. Haddock scale-otolith comparisons. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1239-1246.

Lauzier, L. M., and R. W. Trites. The Deep Waters in the Laurentian Channel. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1247-1257.

Lauzier, L. M. Surface sea water temperatures along the Canadian Atlantic Coast, 1954-1957. Atlantic Prog. Rept. No. 71, pp. 8-12.

Leim, A. H. Fatness of small herring in the Bay of Fundy. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1259-1267.

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.

Martin, W. R. Summary of Research, 1957. International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, Vol. 8, 1957-58, pp. 22-26.

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McCracken, F. D. French Trawler Methods. Canadian Department of Fisheries, Trade News, Vol. 11, No. 3, pp. 8-10.

McCracken, F. D., and John R. Clark. Observations on the Cod Fishery in the Gulf of St. Lawrence during the Spring of 1958. (Condensed). International Commission for the Northwest Atlantic Fisheries, Annual Proceedings, Vol. 8, (for 1957-58), pp. 99-100.

McKenzie, R. A., and B. E. Skud. Herring migrations in the Passamaquoddy region. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1329-1343.

McKenzie, R. A. Age and growth of the smelt, Osmerus mordax (Mitchill), of the Miramichi River, New Brunswick. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1313-1327.

McKenzie, R. A., and S. N. Tibbo. Herring tagging in the Bay of Fundy (June to August, 1957). Atlantic Prog. Rept. No. 70, pp. 10-15.

McLeese, D. W. Air shipments of lobsters. Canadian Department of Fisheries, Trade News, Vol. 10, No. 9, pp. 5-6.

McLeese, D. W., and D. G. Wilder. The activity and catchability of the lobster (Homarus americanus) in relation to temperature. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1345-1354.

McLellan, H. J. Energy considerations in the Bay of Fundy system. J. Fish. Res. Bd. Canada, Vol. 15, No. 2, pp. 115-134.

Medcof, J. C., and L. W. Thurber. Trial control of the greater clam drill (Lunatia heros) by manual collection. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1355-1369.

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Medcof, J. C., and Joan E. Mortimer. Introducing European oysters to the Maritimes. Atlantic Prog. Rept. No. 71, pp. 27-29.

Medcof, J. C. Useful publications for oyster farmers of the Maritimes. Fisheries Research Board of Canada, St. Andrews Biological Station, Circular, General Series, No. 32, 3 pp. (French and English versions.)

Paloheimo, J. E. A method of estimating natural and fishing mortalities. J. Fish. Res. Bd. Canada, Vol. 15, No. 4, pp. 749-758.

Paloheimo, J. E. Determination of natural and fishing mortalities; analysis of tag records off western Nova Scotia. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1371-1381.

Powles, P. M. Studies of reproduction and feeding of Atlantic cod (Gadus callarias L.) in the southwestern Gulf of St. Lawrence. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1383-1402.

Scott, D. M. Observations on marine birds off southwest Nova Scotia. Canadian Field Naturalist, Vol. 73, No. 1, pp. 15-20.

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. Canada, Vol. 15, No. 4, pp. 495-516.

Smith, M. W. Prince Edward Island Trout Fishery. The Department of Industry and Natural Resources. Charlottetown, P.E.I., April 5, 1958, 15 pp.

Also published in "The Guardian", Charlottetown, P.E.I., April 1, 1958, pp. 9 and 11.

Smith, M. W., and J. W. Saunders. Movements of brook trout (Salvelinus fontinalis (Mitchill)) between and within fresh and salt water. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1403-1449.

Tibbo, S. N., J. E. Henri Legare, Leslie W. Scattergood and R. F. Temple. On the occurrence and distribution of larval herring (Clupea harengus L.) in the Bay of Fundy and the Gulf of Maine. J. Fish. Res. Bd. Canada, Vol. 15, No. 6, pp. 1451-1469.

Warburton, F. E. Control of boring sponges on oyster beds. Atlantic Prog. Rept. No. 69, pp. 7-11.

Warburton, F. E. Reproduction by fused larvae in the boring sponge, Cliona celata, Grant. Nature, Vol. 181, No. 4607, pp. 493-494.

Warburton, F. E. Boring sponges, Cliona spp., of eastern Canada, with a note on the validity of C. lobata. Canadian Journal of Zoology, Vol. 36, No. 2, pp. 123-125.

Warburton, F. E. The manner in which the sponge Cliona bores in calcareous objects. Canadian Journal of Zoology, Vol. 36, No. 4, pp. 555-562.

Wilder, D. G., and R. C. Murray. Do lobsters move offshore and onshore? Atlantic Prog. Rept. No. 69, pp. 12-15.

Wilder, D. G. Regulation of the lobster fishery. Canadian Fish Culturist, No. 22, pp. 13-16.

MANUSCRIPT REPORTS
(to March 31, 1959)

Atlantic Oceanographic Group. Canadian drift bottle data, Atlantic Coast. MS Rept. Series (Oceanographic and Limnological), No. 15, 80 pp.

Black, W. F. Biology of mysids of the Great Bras d'Or. 1. Station list, occurrence, mysids as fish food, vertical distribution. MS Rept. Series (Biological), No. 671, 37 pp.

Collin, A. E. An oceanographic study of Prince Regent Inlet, the Gulf of Boothia and adjacent waters. MS Rept. Series (Oceanographic and Limnological), No. 13, 66 pp.

Collin, A. E. A Field Report of the Oceanographic Activities on I.G.Y. Drift Station "Bravo". MS Report Series (Oceanographic and Limnological), No. 33, 12 pp.

Dickie, L. M., and C. D. MacInnes. Gulf of St. Lawrence Scallop Explorations--1957. MS Rept. Series (Biological), No. 650, 62 pp.

Huntsman, A. G. Salmon values. MS Rept. Series (Biological), No. 649, 16 pp.

Leim, A. H. Distribution of herring larvae in the lower Bay of Fundy and adjacent waters. MS Rept. Series (Biological), No. 652, 8 pp.

Lisk, R. D. The effects of temperature and oxygen concentration on oxygen uptake of the American lobster in air and water. MS Rept. Series (Biological), No. 662, 60 pp.

Logie, R. R. Epidemic disease in Canadian Atlantic oysters (<u>Crassostrea virginica</u>). MS Rept. Series (Biological), No. 661, 97 pp.

Parrish, B. B. An Appraisal of the Passamaquoddy Herring Problem. A report on Consultative Services. MS Rept. Series (Biological), No. 668, 34 pp.

Steele, D. H. Fishes taken in the Laurentian Channel, Gulf of St. Lawrence, between the Bird Rocks and the Saguenay River, 1953 and 1954. MS Rept. Series (Biological), No. 651, 32 pp.

Warburton, F. E. Outline of boring sponge investigations in Malpeque Bay, P.E.I., 1952-1956. MS Rept. Series (Biological), No. 655, 21 pp.

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(including those published between Dec. 31, 1958, to Mar. 31, 1959)

Black, W. F. Biology of mysids of the Great Bras d'Or. XII. Dajus mysidis Kroyer (Isopoda, Dajidae) a parasite of mysids. Canadian Journal of Zoology.

Bousfield, E. L., and A. H. Leim. The fauna of Minas Basin and Minas Channel. Contributions from the National Museum of Canada.

Campbell, N. J. An International Geophysical Year Project of the Atlantic Oceanographic Group. Atlantic Prog. Rept.

Dickie, L. M. Effects of temperature on survival and distribution of the giant scallop (Abstract). Trans. Amer. Fish. Soc. Vol. 88.

Keenleyside, M. H. A. Effects of spruce budworm control on salmon and other fishes in New Brunswick. Canadian Fish Culturist.

Keenleyside, M. H. A. Insecticides and Wildlife. Canadian Audubon, Vol. 21, No. 1, pp. 1-7.

Kohler, A. C. Growth and parasites of cod during a year in captivity. Atlantic Prog. Rept.

Laird, Marshall. Caliperia brevipes n. sp. (Ciliata: Peritricha), epizoic on Raja erinacea Mitchill at Saint Andrews, New Brunswick. Canadian Journal of Zoology.

Logie, R. R. Oyster Farming in Eastern Canada. Canadian Audubon.

Logie, R. R. P.E.I. oysters spearhead battle against disease. The Guardian, Charlottetown, P.E.I., February 27, 1959, Second Section, pp. 3-4.

MacPhail, J. S. Shell fish harvesting turns to mechanization. The Guardian, Charlottetown, P.E.I., February 27, 1959, Second Section, pp. 4 and 8.

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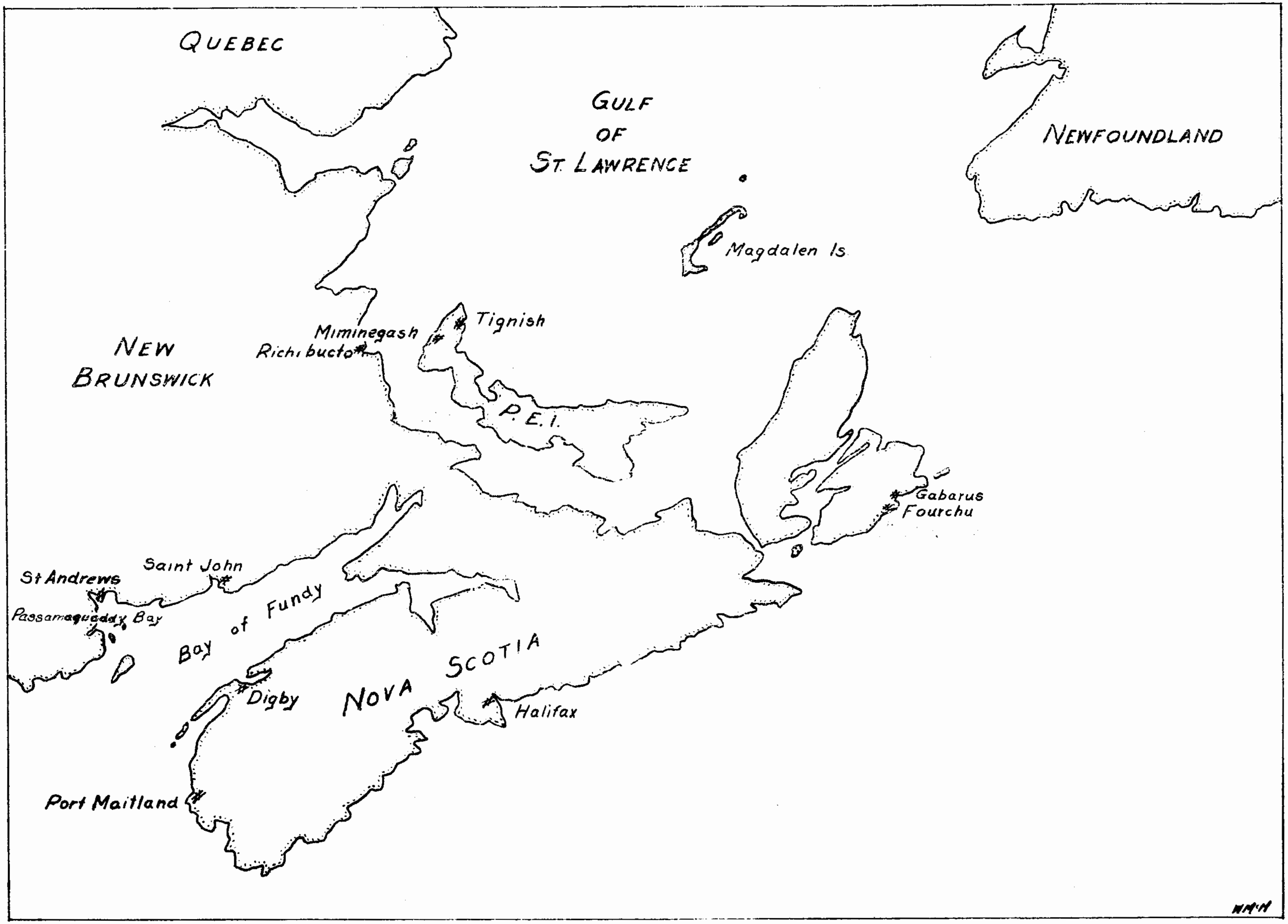
LOBSTER SUMMARIES


QUEBEC
GULF OF ST LAWRENCE
NEWFOUNDLAND
Magdalen Is
Tignish
Miminegash
Richibucto
NEW BRUNSWICK
P.E.I.
Gabarus
Fourchu
Saint John
St Andrews
Passamaquoddy Bay
Bay of Fundy
NOVA SCOTIA
Digby
Halifax
Port Maitland
HMH

No. 1

LOBSTER INVESTIGATIONS

Research to provide the biological basis for wise use of our lobster resources has for several years been carried out along four major lines of investigation as follows.

I. Population studies. Field studies of the commercial fisheries at five or more ports have been carried out annually since 1944. The work includes collection of detailed catch and effort statistics, measurements of sample catches, taggings and growth studies. A detailed mathematical analysis of the Tignish, P.E.I., data is nearing completion (Appendix 93). Tabulation of the Miminegash, P.E.I., and Port Maitland, N.S., data in preparation for similar analyses is well under way. A new growth study involved the marking of 5,079 lobsters off Gabarus, N.S., in the spring of 1958. First returns of these marked lobsters are expected in May 1959. Experimental fishing off St. Andrews to determine the relationship between catchability and temperature was terminated in April. The data in conjunction with laboratory studies of activity have been published in the Journal. Other features of the population studies are considered in Appendix 2.

II. Studies of larvae and post larvae. The primary purpose of this work, which is considered in more detail in Appendices 3 and 4, is to determine whether the commercial fishery can be predicted from our estimates of larval and post larval abundance. Prospects of identifying a relationship seem best with the unusually successful 1952 year-class which may have contributed heavily to the peak fishery in 1957-58. If a relationship can be clearly established, a modified program may be considered worth continuing on an indefinite basis as a service to the industry.

III. Gear improvement. Fairly intensive work to develop savings gear and a more durable efficient trap has been carried on from time to time. During the past year, however, we have done little more than act as advisors to Department of Fisheries personnel in their tests of aluminum traps. One cylindrical aluminum trap of radical design built according to our suggestions by an Amherst, N.S., firm was tested off Miminegash, P.E.I. This trap fished poorly. Unfortunately, it was lost before it could be modified in an attempt to improve its performance.

IV. Factors affecting the survival and behaviour of lobsters. Active work in this field over the past 10 years has provided the knowledge on which various advances in the care and handling of live lobsters have been based. During the past year, emphasis was placed on the oxygen requirements of lobsters in air and in water and on their ability to acclimate to temperature changes under various conditions (Appendices 6 and 7). A thorough study of the factors involved in the survival of lobsters out of water was also started this year (Appendices 8 and 9).

Technicians R.C.Murray, U.J.Walsh, and D.E.Graham did the field work and preliminary tabulation in connection with the population studies. Mr. Paloheimo, assisted by Norma E. Wiley and the lobster investigation staff, has undertaken the mathematical analysis of the Tignish data. R.J.Gibson, Assistant Scientist, joined the staff in September to assist with such analyses. The field collections of larvae and post larvae were made by Capt. L.I.Cross in the 50-foot M.B.Pandalus II. These collections were processed in the laboratory by Evelyn R. MacMillan and R.C.Murray. Dr. McLeese with student assistants R.D.Lisk and Patricia A. Holt conducted the studies of lobster survival.

D.G.Wilder

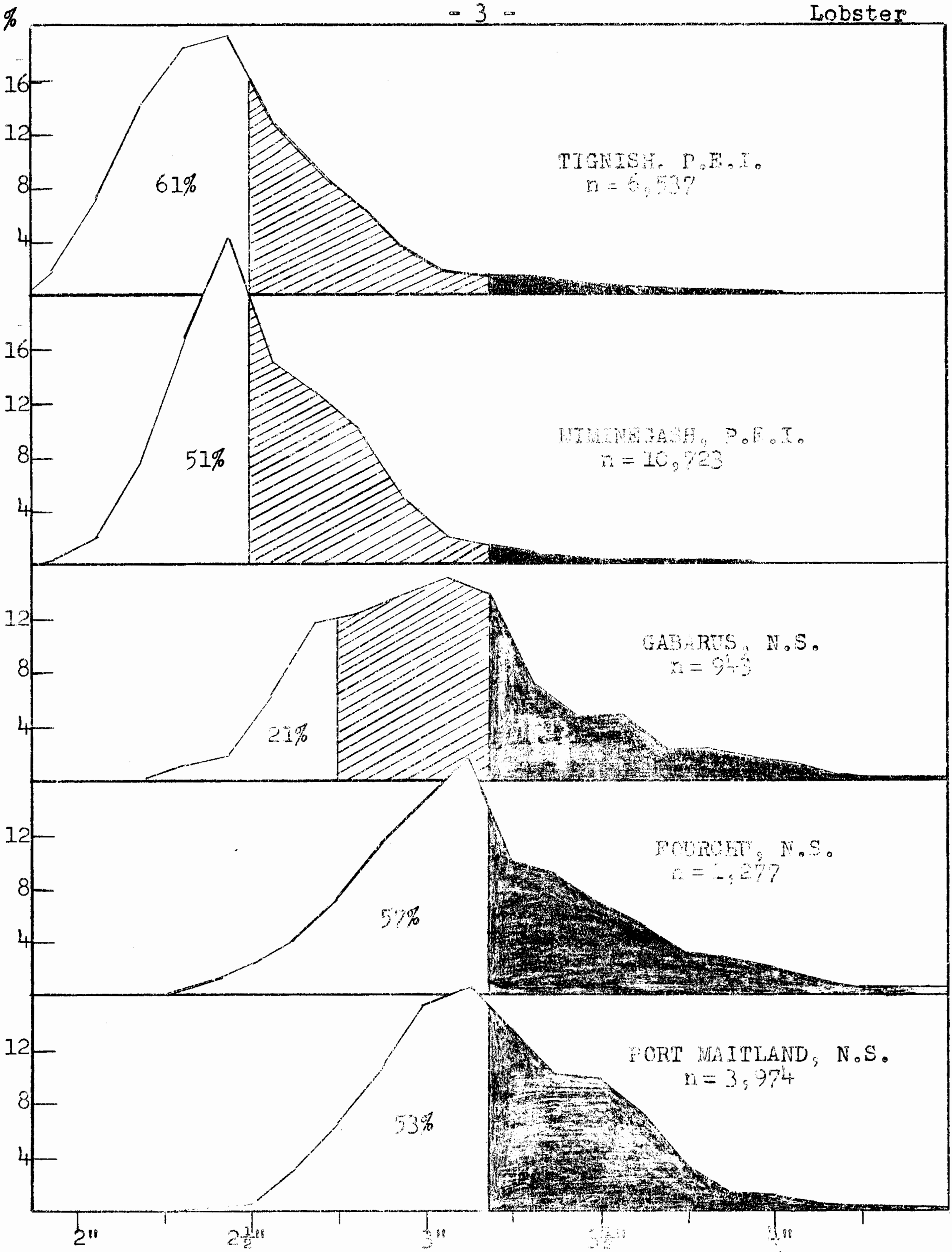
No. 2

LOBSTER POPULATION STUDIES

Lobster population studies were continued in 1958 at five ports. Comparable data for 13 to 15 years on landings, effort, size distributions and rates of exploitation are now available for these ports. As an illustration of some important differences in the fisheries of these areas the size distributions in 1958 are plotted in the accompanying figure.

Tignish and Miminegash, P.E.I. These ports near the northern tip of Prince Edward Island are typical of the small-lobster areas of the southern Gulf of St. Lawrence. The major difference in their lobster fisheries is the season which at Tignish extends from May 1 to June 30 and at Miminegash from August 10 to October 5. Landings at both ports have increased substantially since 1954, possibly because of improved protection of sub-legal sizes and because of the unusually good larval settlement in 1952. An unexpected 20% decrease in the Tignish 1958 landings is possibly a direct result of intense illegal fishing in the summer of 1957. Further decreases may occur when the poor 1953 and 1954 year-classes reach legal size. However, bottom dragging off Miminegash this fall revealed a good stock of sub-legal lobsters and suggests good fishing in 1959. On the average, over half the catch by count at each port is below legal size. Towards the end of the season 80% or more may be sub-legal. This abundance of short lobsters contributes appreciably to the difficulties of enforcing size limits in such areas. The bulk of the legal catch is made up of canner-size lobsters. The fisheries are so intensive that relatively few lobsters reach the generally more valuable market sizes.

Gabarus and Fourchu, N.S. These contiguous ports on the outer coast of Cape Breton Island were selected for a



Percentage carapace length distribution of lobsters at 5 study ports.
Sub-legal — white; Canners — cross-hatched; Markets — black.

comparative study of the effects of size limits. At Fourchu the size limit has remained virtually unchanged since 1947. It restricts the legal catch to those sizes acceptable to the live lobster trade. At Gabarus appreciably smaller size limits have been in effect since 1940 but in 1956 a plan, approved by the fishermen, was adopted to increase the size limit slightly each year. Unfortunately this plan coincided with a natural, general decline in the Cape Breton lobster stocks. Many fishermen, however, ascribed the decline in their area to the size-limit increases already adopted. As a result the plan was dropped after two years. Landings in both the Gabarus and Fourchu areas improved slightly in 1958 but there have not yet been suggestions of further size-limit increases off Gabarus. As may be seen from the accompanying figure the size limit now in effect at Gabarus is small in relation to the size composition of the catch.

Port Maitland, N.S. These Yarmouth County lobster grounds are representative of the highly productive south-western Nova Scotia area. Lobster canning was abandoned over 25 years ago with the introduction of a size limit about equivalent to the one now in effect. On the average, over half the lobsters caught are below legal size but the percentage varies greatly in relation to depth and time. From 1950 to 1956, landings declined steadily but have recovered slightly in the past two years. Since 1950 the fleet has dropped from 43 to 25 boats. As a result the catch per boat has remained at a relatively high level and has increased appreciably in 1957 and 1958.

D.G.Wilder

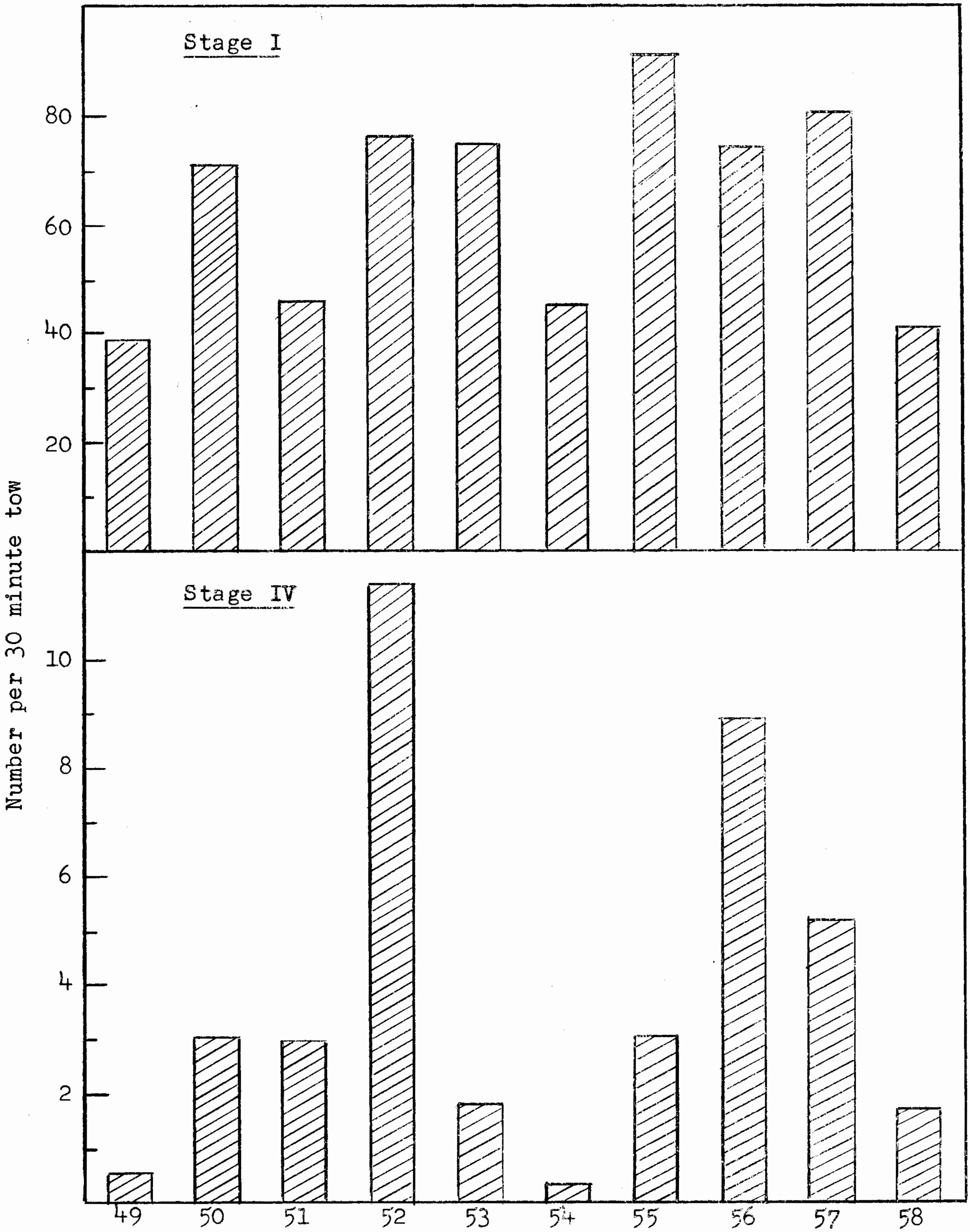
No. 3

THE RELATIVE ABUNDANCE OF LOBSTER LARVAE IN NORTHUMBERLAND STRAIT

Each summer since 1948, plankton tows for lobster larvae have been made in the Northumberland Strait area between Richibucto, N.B., and Miminegash, P.E.I. The purpose has been to determine the seasonal occurrence, growth, mortality rates, and relative abundance of the four free-swimming larval stages. The specially designed wedge-shaped plankton net is made of grit gauze, 16 meshes to the inch. It is 12 feet by 3 feet at the mouth and 25 feet long. The numbers of larvae caught in 503 half-hour tows in 1958 were as follows:

Towing period	Number of larvae				
	Stage I	Stage II	Stage III	Stage IV	Total
June 16-Sept.15	13,077	2,705	1,672	481	17,935

As an index of the relative abundance of the first and last larval stages, the catch per tow is plotted in the



Relative abundance of Stage I and Stage IV lobster larvae 1949 to 1958 accompanying figure. The data for 1948 have been omitted because the mesh size differed. In 1958 both the hatch and survival were below the 10-year average. Consequently relatively few larvae reached the fourth stage.

The study of possible relationships between larval settlement and subsequent commercial production is seriously hampered by difficulties in age determination. Commercial landings off Miminegash in 1958, in the immediate area of these larval collections, were the highest in over 14 years. This may be a result of the unusually large larval settlement in 1952. If so, a decline in the commercial catch should be anticipated when the relatively poor 1953 and 1954 year-classes reach legal size.

D.G.Wilder

No. 4

RELATIVE ABUNDANCE OF YOUNG LOBSTERS IN NORTHUMBERLAND STRAIT

Each spring and fall since 1952 a fine-meshed net has been dragged off Richibucto, N.B., to learn more about the growth, survival, and relative abundance of young lobsters. By 1956, after much testing of gear and bottom conditions, the equipment was standardized and a series of 14 stations selected. In 1958, from May 6 to June 12, 1,019 lobsters were caught in 220 ten-minute drags and from September 16 to October 22, 2,034 were caught in 241 drags. The relative abundance of the various sizes during the past three years, expressed as the catch per 100 ten-minute tows was as follows:

Carapace length	Number per 100 drags					
	1956		1957		1958	
Inches	Spring	Fall	Spring	Fall	Spring	Fall
<1	48	49	48	23	33	65
1-1½	71	140	65	126	86	156
1½-2	151	300	97	257	166	307
2-2½	153	288	144	245	141	251
2½-3	30	59	58	45	46	42
>3	10	7	7	6	7	5
Totals	463	843	419	702	479	826

In general the catch per drag is greater in the fall than in the spring. This is probably a reflection of seasonal differences in behaviour and availability rather than a true difference in abundance. Fourth-stage larvae declined in abundance from the summer of 1956 to 1958. This is not reflected in the relative abundance of the smallest size group of young lobsters in the fall drags. Lobsters just below the legal carapace length of 2½ inches should contribute importantly to the fishery the following year. The good catches of sub-legal lobsters in 1958 suggest that commercial landings in this area in 1959 should approximate the record 1958 catch. Popular opinion has held that legal-sized lobsters do not occur in this area during the spring. The dragging operations show they are just as plentiful in the spring as they were at the close of the previous fall season.

D.G.Wilder

No. 5

METHODS OF INACTIVATING LOBSTER CLAWS

To reduce injuries and mortalities among live lobsters during storage and shipment the claws must be inactivated. In North America this is usually accomplished by inserting a small wooden or plastic plug into the joint of the claw. This plugging is usually done by the fishermen, sometimes as the lobsters are caught but often when they are landed. The method is effective, cheap and fast. In time, however, the meat near the plug turns black and off flavours develop. With prolonged storage the shell itself may disintegrate in the plugged area. In addition, certain European countries prohibit plugging on the questionable grounds of cruelty. This latter objection is, however, of increasing concern to our dealers since there appears to be a growing seasonal market in Europe for live Canadian lobsters.

To explore other methods of inactivating the claws, unplugged market-size lobsters were obtained from southern Nova Scotia in March and shipped to St. Andrews. On March 27 these were divided into four lots of 50. Both claws of one lot were plugged with standard machine-made one inch by one-quarter inch birch plugs. The claws of the second lot were banded with one inch by one-half inch natural rubber bands of the type formerly used in Canada to a limited extent and now used quite widely in Europe. The extensor tendons of the third lot were cut so the lobsters could not open their claws. The fourth lot was untreated and served as a control. All lobsters were tagged with serially numbered tags.

The four lots were stored separately in tanks of running sea water. Each tank was checked visually each day and any dead lobsters examined and recorded. Once a week the tanks were drained and the lobsters removed to provide more detailed information on injuries and mortalities. The lobsters were fed about once a week. When the experiment was terminated on August 8 after 133 days the percentage mortalities were as follows:

Plugged	Banded	Cut tendons	Untreated
54%	56%	78%	98%

These results clearly show the value of inactivating the claws and indicate that plugged or banded lobsters survive better than those with cut tendons. Bleeding (5 to 35 cc.) associated with the tendon cutting operation may be partially responsible for the higher mortalities. The generally high mortalities in all lots are undoubtedly related to the frequent handling.

Only one band and four plugs were lost showing that both last well for four months. However, both bands and plugs were deteriorating by the end of the experiment and could not be expected to perform efficiently for much longer. There was no indication that claws were lost as a direct result of any of the treatments.

For periods up to four months rubber bands inactivate lobster claws as effectively as wooden plugs. They do not damage the meat and are acceptable in all countries. They are, however, slower and more difficult to apply and are probably more costly than plugs. For these reasons they are unlikely to become popular among fishermen unless a simple method of applying them can be developed.

D.C.Wilder

No. 6

OXYGEN CONSUMPTION OF THE LOBSTER

To obtain information basic to an understanding of survival and behaviour, the study of oxygen uptake of lobsters was continued. The results are of immediate practical importance for estimating oxygen requirements and holding capacities of commercial storage units.

Oxygen uptake in water

During the summers of 1957 and 1958 the oxygen uptake of lobsters was determined at approximate 5°C. intervals at acclimation temperatures ranging from 5° to 25°C. Average readings based on 9 to 12 individual lobsters are shown in Figure 1. Oxygen uptake for lobsters acclimated and tested at 25°C. is double that for lobsters acclimated and tested at 5°C.

Uptake in relation to oxygen content of the water was measured at approximate 5°C. intervals at acclimation temperatures ranging from 5° to 25°C. Average readings based on eight individual lobsters exposed to decreasing levels of oxygen at each acclimation temperature are shown in Figure 2. Oxygen uptake increases with temperature at all levels of oxygen content. At any one temperature, a marked decrease in uptake occurs at oxygen levels lower than about 3 cc./l. The relationship is complex because uptake is dependent on content over the entire range of oxygen at high temperatures and is independent of content at the higher levels of oxygen at lower temperatures.

Sudden temperature changes have a prounounced effect

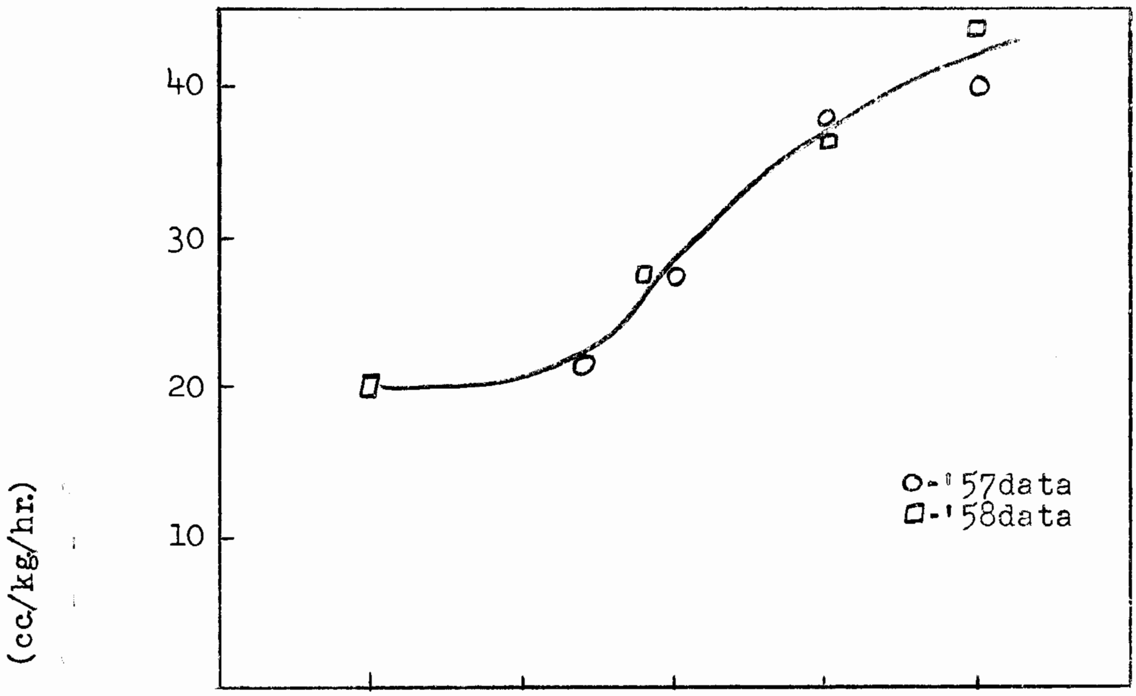


Figure 1 - Average oxygen uptake of lobsters in relation to acclimation temperature.

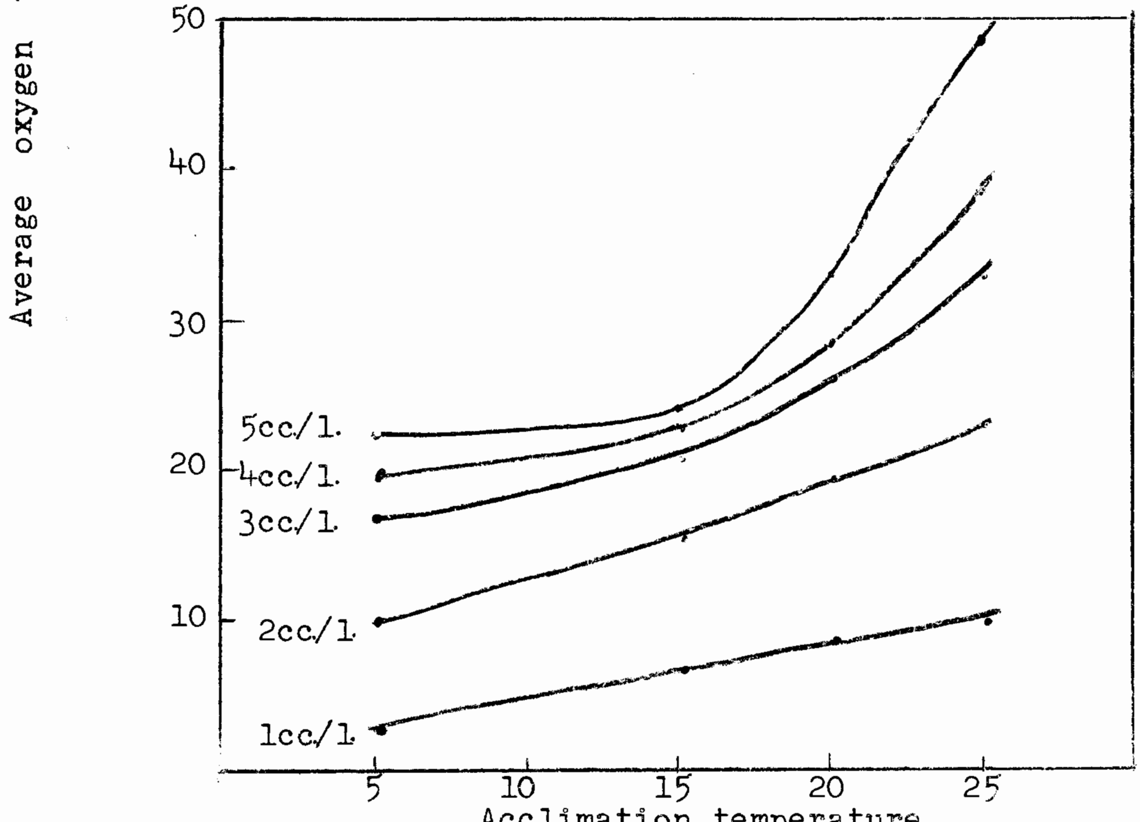


Figure 2 - Average oxygen uptake of lobsters in relation to acclimation temperature and to oxygen content of the water.

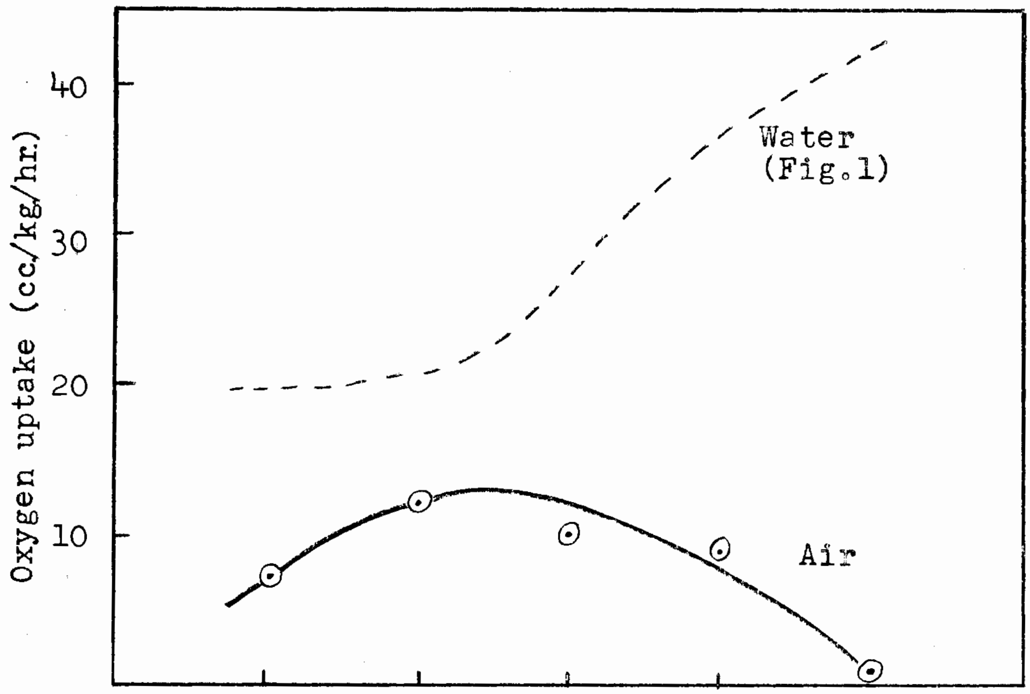


Figure 3 - Average oxygen uptake of lobsters in air in relation to acclimation temperature.

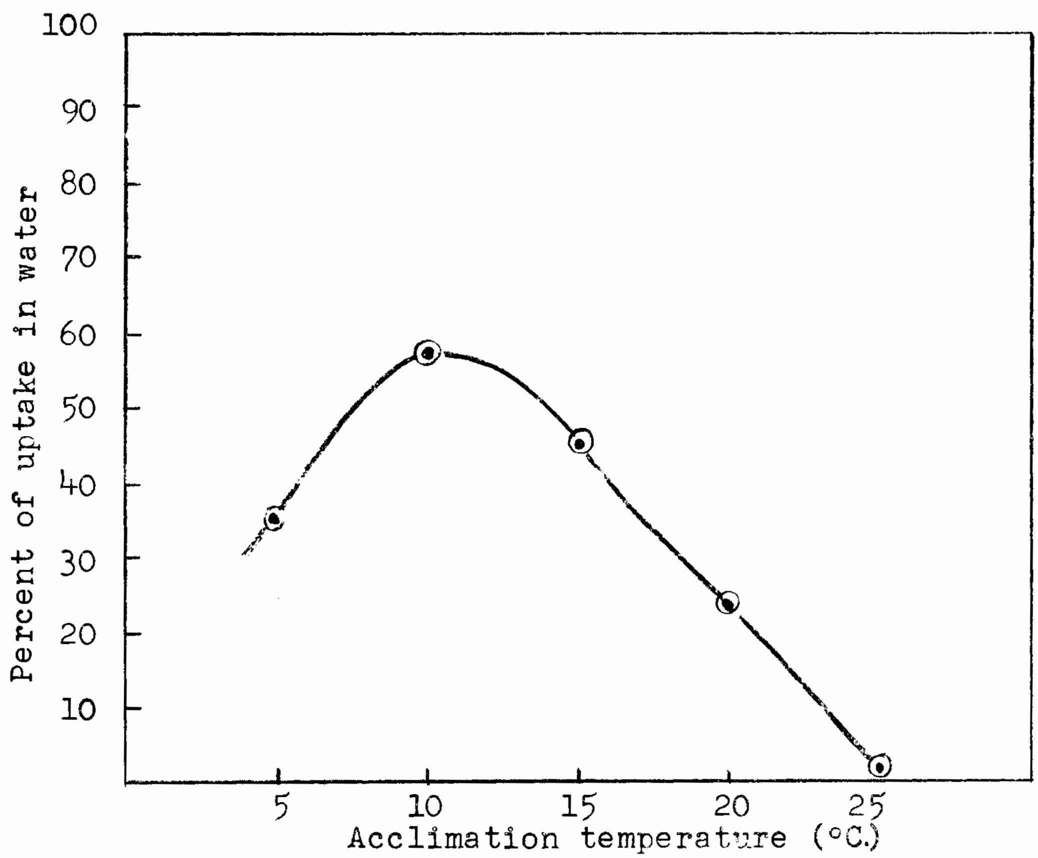


Figure 4 - Average oxygen uptake of lobsters in air as a percentage of that in water in relation to acclimation temperature.

on oxygen uptake. The uptake of lobsters acclimated to 13°C. and suddenly transferred to 5°C. water was twice that of lobsters that had been acclimated to 5°C. before testing.

Oxygen uptake in air.

The oxygen uptake of 8 to 12 individual lobsters in air was determined at 5°C. intervals at acclimation and test temperatures ranging from 5° to 25°C. High relative humidity, between 85 and 100%, was maintained during the tests. The results are shown in Figure 3. The uptake in air reaches a maximum value at 10° to 12°C., and approaches zero at 25°C. Uptake decreases at temperatures below 10 to 12°C. As shown in Figure 4, when uptake in air is presented as a percentage of uptake in water at corresponding temperatures, the greatest uptake in air (at 10 to 12°C.) is only about 57% of that in water. The percentage uptake is 35% at 5°C., and 2% at 25°C. At moderately high temperatures, oxygen uptake will be insufficient and result in the death of lobsters.

A sudden change in temperature has a pronounced effect on uptake in air. Lobsters acclimated to 10°C. and held in air at 20°C. do not utilize oxygen and weaken rapidly.

Water flows or aeration necessary to maintain high oxygen contents in commercial storage units for live lobsters can be estimated from these results for various loads and temperatures.

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

No. 7

TEMPERATURE ACCLIMATION IN THE LOBSTER

Acclimation is known to have a marked effect on many aspects of the survival and behaviour of lobsters. A limited knowledge of temperature acclimation was obtained several years ago and the study was revived this summer to provide a thorough knowledge of acclimation. An understanding of acclimation rates involves a study of changes in tolerance to high and low temperatures for upward and downward changes in temperature.

Observations on gain and loss of heat tolerance for sudden temperature changes of about 5°C. upwards and downwards were made over the temperature range 8° to 25°C. Acclimation is judged to be complete when average survival time at a lethal high temperature becomes constant.

As shown in the accompanying figure acclimation upwards from 8.5°C. to 15°C. is complete in 18 days, from 15° to 20°C. in 8 days and from 20° to 25°C. in 5 days. Upward acclimation progresses most rapidly at the higher temperatures. By adding acclimation times for two consecutive 5°C. jumps,

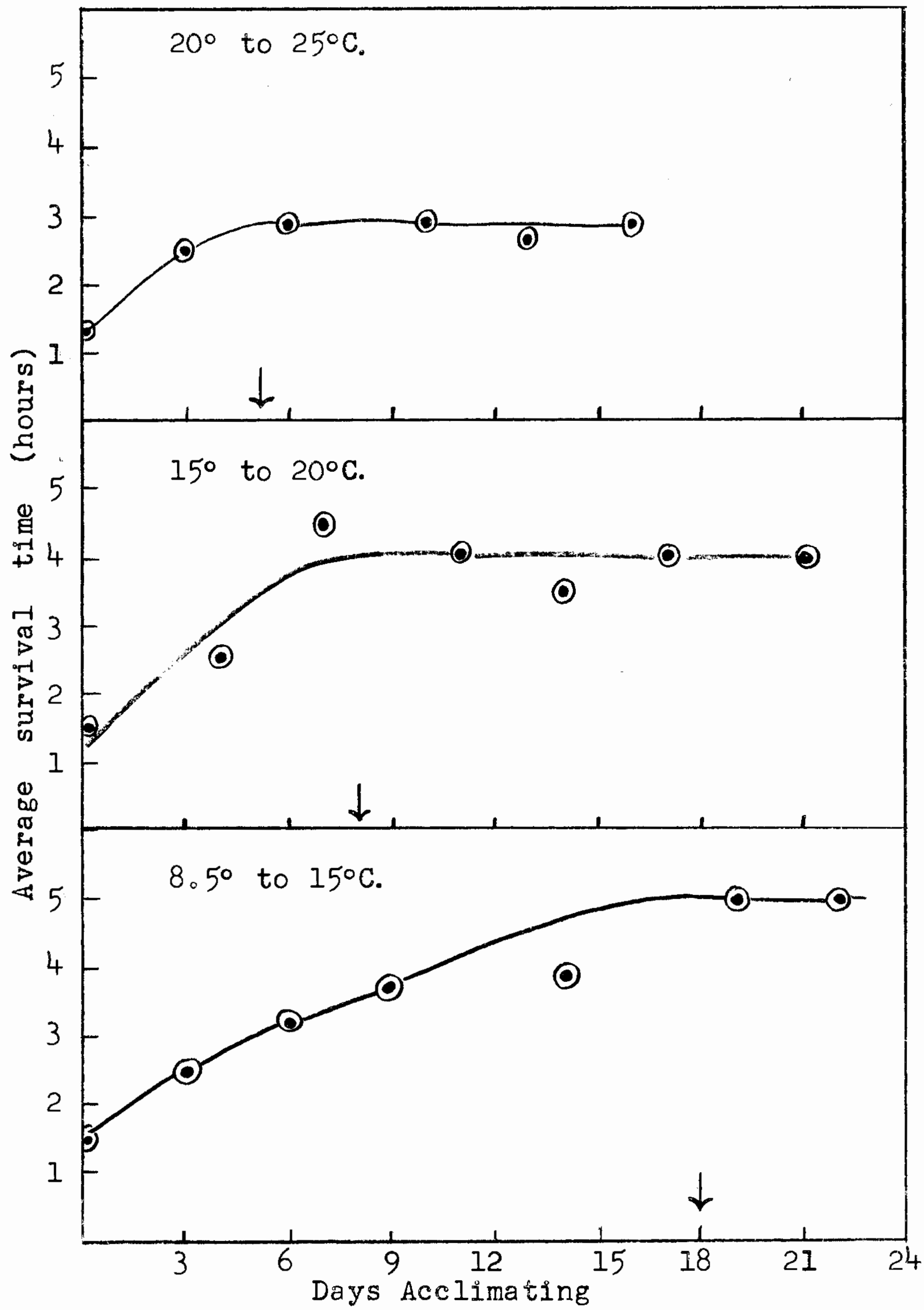


Figure 1 - Gain of heat tolerance for lobsters acclimating to approximate 5°C. increases in temperature over the range 8.5°C. to 25°C.

acclimation for the total 10°C. change from 15° to 25°C., would be complete in 13 days. Our earlier work showed, however, that acclimation to a sudden change from 14° to 23°C. required 22 days. This suggests that acclimation proceeds faster in the same general range of temperatures in response to small rather than large stepwise temperature increases.

The results for downward acclimation over the same temperature range were variable and further work is required before definite conclusions may be reached. Further studies will cover a wider range of temperatures for upward and downward temperature changes and the rates of loss and gain of cold tolerance.

Summary of P.A.Holt's report
by D.W.McLeese

No. 8

LIGHT-WEIGHT METHODS FOR PACKING LIVE LOBSTERS

A demand for suitable light-weight methods of packing live lobsters, particularly for rapid transport over long distances by air is steadily growing. Two containers, a cardboard container insulated with aluminum foil (Bathurst container) and a cardboard carton with dry wood shavings have proved successful for commercial-sized shipments provided low temperatures are maintained. Depending on outside temperatures, up to 20 pounds of ice will maintain suitable temperatures for 36 hours in the Bathurst container.

Tests to determine the effectiveness of various amounts of ice in wood shavings packs are summarized in the following table. Room temperature averaged 23.5°C. for 24 hours and temperature in the boxes was 12.5°C. when packed.

Weight ice (lb.)	Number of lobsters	Final temp. at 24 hr.(°C.)	Temp. increase °C.	% Weak and dead	Unmelted ice (%)
10	50	19.2	6.7	18	35
15	50	17.2	4.7	6	57
20	50	16.8	4.0	8	40

The larger quantities of ice resulted in smaller temperature increases and smaller numbers of weak and dead lobsters. However the ice was not effective in keeping the boxes uniformly cool. A definite temperature gradient from top to bottom was evident. Uniform cooling and more efficient use of the ice could be obtained by distributing the ice throughout the packages in small waterproof units.

Relative insulation qualities of various materials

To determine the relative insulating qualities of wood-shavings, curon sponge, vermiculite and styrolite beads for use as light-weight packing material for live lobsters, 10 lobsters were packed in each of four similar boxes each containing a different material. The boxes were packed at 3°C. and stored at a room temperature of 20.5°C. for 24 hours without ice. The temperature increase was followed. The results are summarized as follows:

Material	Density (lb./cu.ft.)	Final temp. at 24 hr. °C.	Temp. increase °C.	No. weak and dead
Wood shavings	3 lb. 14 oz.	17.5	14.5	4
Curon sponge	1 lb. 5 oz.	18.0	15.0	10
Vermiculite	5 lb. 5 oz.	18.2	15.2	5
Styrolite beads	2 lb. 2 oz.	16.0	13.0	6

Temperature increase was the least with styrolite beads and approximately the same for the other three materials. In addition styrolite beads settled less during the holding period affording greater protection for the lobsters in the top layer.

Survival of lobsters was not expected to be satisfactory because of high temperatures during the test. However, survival in curon sponge was considerably less than in the other materials. A second test, using 20 lobsters in curon sponge under similar test conditions resulted in 19 weak and dead lobsters. Curon itself is not toxic to lobsters and the reason for the higher mortality is not understood.

When expanded, styrolite beads form a solid light-weight material that is used as insulation. Two styrolite boxes with different wall thickness (¾ inch and 1 inch) were tested using 35 and 33 lobsters respectively. The boxes were packed at 3°C. and stored at 20.5°C. for 30 hours. Temperatures in these boxes remained 4° to 5°C. lower than in a similar pack without insulation. Percentage of weak and dead lobsters was high in this test because of high temperature, accumulation of CO_2 and decrease in O_2 in the tightly sealed boxes. Accumulation of CO_2 and decrease in O_2 can be prevented by small air vents without seriously altering the insulation qualities of the styrolite box.

Cost, density, ease of handling and lobster quality are important considerations for economical commercial use of the materials. Wood shavings and styrolite plastic in box form offer promising leads for future development in shipping techniques for Canadian lobsters.

D.W. McLeese

No. 9

PRELIMINARY OBSERVATIONS OF LOBSTER SURVIVAL IN AIR

The live lobster trade has developed as such because lobsters will remain alive for several days in air under certain conditions. A study of the physiological needs and limitations imposed by a non-aquatic environment could lead to improved shipping conditions, thereby reducing losses and extending the safe shipping time. Some preliminary observations have provided promising leads for further work.

Air respiration

Oxygen uptake in air is only 57% of uptake in water at 10°C. and the respiration rate declines until it is only 2% of that in water at 25°C. Weakening and death in air may be caused by the build up of an oxygen debt. Some tests using sealed containers to compare survival in an oxygen atmosphere with survival of lobsters in air are summarized in the following table:

Number of lobsters	Treatment	Duration of test (hr.)	Condition of lobsters	CO_2 %	O_2 %
2	air at 20°C.	19	2 dead	1½	19
2	O_2 at 20°C.	19	2 vigorous	0	21+
1	air at 15°C.	22	dead	1	21
1	air at 15°C.	35	dead	2	18
1	O_2 at 15°C.	47	vigorous	2	21+
1	O_2 at 15°C.	47	vigorous	6	21+
2	air at 15°C.	29	2 weak	3	18
2	air + ascarite at 15°C.	29	2 vigorous	0	17
2	air + activated charcoal, 15°C.	29	2 weak	4	16
2	O_2 at 15°C.	29	2 vigorous	5	21+

Lobsters live longer in a sealed container without air renewal when exposed to an oxygen atmosphere. Accumulation of CO_2, as oxygen content is reduced, contributes to weakening and death in air. If CO_2 is removed chemically as it is produced, lobsters can withstand up to a 20% reduction in oxygen content, in air. In an oxygen atmosphere, gradual accumulation of CO_2 up to 5 or 6% does not weaken the lobsters over a 47-hour period.

Survival in relation to temperature

During fishing and packing for shipment lobsters may be exposed to air temperatures higher or lower than the water temperatures where they had been living. The effect of short exposure to various air temperatures on survival is summarized in the following table:

Acclimated temperature °C.	Test temperatures (air)(°C.)	Number of lobsters	% dead
8-hour exposure			
10	10	8	0
15	15	8	0
20	20	8	0
25	25	8	0 (100% weak)
10	20	8	100
5-hour exposure			
12	12	14	17
12	18	16	16
12	19	11	27
12	21	7	60

Lobsters acclimated and tested at the same temperatures remained vigorous for 8 hours in air up to 20°C. All lobsters weakened in air at 25°C. Those acclimated to 10°C. and held in air at 20°C. died within 8 hours. Lobsters acclimated to 12°C. and tested at air temperatures from 12° to 21°C. for 5 hours showed higher mortalities at the higher temperatures.

These results suggest that best survival in air will occur at air temperatures not higher than the acclimation temperature, and definitely not higher than 20°C. On the basis of other observations temperatures lower than the acclimation temperatures are probably preferable especially for longer storage.

It is planned to expand this work to establish lethal levels and resistance times for lobsters in relation to air composition and temperature.

D.W.McLeese

MOLLUSCAN SHELLFISH SUMMARIES

No. 10

SHELLFISH INVESTIGATIONS

The shellfish investigators are faced with problems that are highly diversified. The scallop fishery on Georges Bank involves us in most of the problems that concern any fishery that is subject to international regulation. The "domestic", inshore fisheries for scallops, clams, quahaugs and "wild" oysters create all the problems of conservation--size limits, gear regulations and fishing seasons--that arise in domestic fisheries for other types of fish. The species just mentioned are occasionally or regularly eaten raw and are commodities in international trade. Consequently they present us and the Department of Fisheries and the Department of National Health and Welfare, who work with us, with public health problems, domestic and international (sewerage pollution and paralytic shellfish poison). The oyster is the only commercial fish on our coast that is cultured and culture involves a whole gamut of problems that are unique to that fishery. They require the operation of this Station's only Sub-Station and involve us in many time-consuming housekeeping problems. Because there are nearly 1,500 oyster culturists on our coast who require advice and information from time to time, shellfish investigators are constantly being drawn into contacts with individual growers because many of our efforts are of direct concern to them. We are also in constant communication with the Department of Fisheries which administers the oyster culture programs and with its Experimental Oyster Farms whose operators look to us for co-operation.

Besides attending to these matters we conduct explorations for unused stocks of species of shellfish that are regularly exploited (bar clams) or for stocks of species that are not but could be exploited (ocean quahaugs). We study diseases of shellfish and fortunately have been able to combat one of them, the Malpeque disease of oysters. We develop new types of fishing gear such as the mechanical shellfish harvester. We try to predict the effects of public works developments like causeways and tidal power dams on our fisheries. And we look for ways of increasing shellfish production by experimenting with exotic species that may be adaptable to our areas. To keep up-to-date in all these matters we must not only investigate, we must also keep informed by reading extensively and by travel. Last autumn the Program Head visited molluscan shellfish industrial and research centres in British Columbia and Washington State.

These assignments are most demanding and it is understandable that our investigators are very busy. We are pleased to share our burdens now with Mr. R. E. Drinnan, formerly engaged in shellfish research by the British Ministry of Agriculture, Fisheries and Food. This is the first time since 1946 when Dr. Logie took charge of the Sub-Station, that he has had an Assistant Scientist or Associate Scientist to assist him as his predecessors had. We are confident now in tackling the more deep-seated problems of the oyster industry. We are sorry to say good-bye to Dr. L. M. Dickie who joined the groundfish investigators last spring. For many years he has been a staunch support and inspiration to our group and we hope his successor will have a share of Dr. Dickie's qualities. We also hope that he will join us soon because we have been short-handed for ten months.

The appendices which follow partly illustrate how our efforts were distributed in the year just past. We have also been active in investigational projects not mentioned in appendices (e.g., green crab studies) and we have contributed to the proceedings of:

(1) The International Convention for the Northwest Atlantic Fisheries

(2) The International Passamaquoddy Fisheries Board

(3) The Interdepartmental Shellfish Committee which has international relations

(4) The National Shellfisheries Association (U.S.A.)

(5) Department of Fisheries Maritime Area Conference of Protection Officers

(6) U.S. Fish and Wildlife Service Special Conference on East Coast Oyster Mortalities

(7) Advisory Committee on the Oyster Fishery in the Maritimes Area

(8) Prince Edward Island Oyster Growers Association.

Most of these contributions have stressed applied aspects of our work but besides these we have contributed to the literature by publishing papers on both academic and immediately practical results of our work. As further means of disseminating our results, we have been interviewed on T.V. programs, presented numerous radio addresses, held newspaper interviews, vetted script for newspapers, addressed public meetings and prepared blue-print drawings of the mechanical shellfish harvester. These last were executed by Mr. Ronald Greenlaw of the maintenance staff and have excited much favourable comment among prospective builders.

We have worked hard and some of the tasks have not been pleasant or easy. But we do have a satisfying feeling of having effected some advances in knowledge, understanding and human relationships and of having improved physical standards of living in our fishing communities.

J. C. Medcof

No. 11

OYSTER DISEASE

Mortalities in New Brunswick and Nova Scotia continued in 1958. In all previously affected areas oysters continued to die, although at lesser rates in some places. Disease invaded Caraquet Bay public fishery late in 1957 and reached epidemic proportions in 1958. About 87% of the 1957 population of this bed is now dead. On the north shore of Miramichi Bay, disease spread both east and west from the Neguac focus to encompass the Tabusintac and Oak Point beds. No accurate figures of mortality are available, but both fisheries ceased to function in 1958.

Mortality in central Malpeque Bay was heavy in 1956 and 1957 on deep-water beds and light on shallower beds near the mouth of Bentinck Cove. Previous studies were all based on drag samples but in 1958 experimental lots were placed in trays on the beds for closer observation. Little Rock Bed was selected as typical of deep-water ground and Little Island Bed as representing shallower beds. Separate trays on each bed contained (a) about 400 oysters from the bed itself; (b) about 400 healthy young oysters from Conway Narrows. In addition, a lot of 400 Little Island oysters was placed in a tray on Little Rock. The reciprocal transfer would have been desirable, but was considered too risky. Observations on survival, condition, and growth commenced June 6, 1958. Results for the period up to September 27 appear in the table below.

Area of origin	Area of placement	% Surviving to Sept. 27, 1958	Condition	Growth
Little Rock	Little Rock	89.0	Poor	Poor
Conway Narrows	Little Rock	92.5	Good	Good
Little Island	Little Rock	93.7	Good	Good
Little Island	Little Island	98.4	Good	Good
Conway Narrows	Little Island	97.1	Good	Good

Little Rock natives hardly grew at all and had thin translucent meats. All other lots grew well and had meats in good condition. All lots on Little Rock Bed showed poorer survival than those on Little Island Bed, but, since the poorest survival is still fairly good, these differences are not significant yet. The greatest mortalities on beds like Little Rock have occurred over-winter and in the spring. The experiment is continuing and we shall be on the watch for such changes.

Rehabilitation transfers of Prince Edward Island brood stock to affected mainland areas were continued by the Department of Fisheries in 1958. The program of transfers is now about 60% complete. Sub-Station personnel have evaluated these for success where local controls were maintained (Table).

Obviously survivals have been strikingly higher among transferred Prince Edward Island oysters than among mainland natives. Conditions in 1958 were good and Prince Edward Island transplants grew well and spawned copiously and produced spat in some places. Mainland oysters grew poorly and spawned little, if at all.

The spat we caught could have arisen from any of three possible crosses: (1) native x native; (2) native x P.E.I.; (3) P.E.I. x P.E.I. On the basis of numbers of parents and of their spawning condition, the last of these is believed to have predominated and to yield resistant spat. We shall test their disease-resistance in 1959 and succeeding years. Last year we caught a set only at Malagash and tested it this year. The last two entries in the table show no clear evidence that they are resistant. Further data are necessary.

Area of origin	Area of placement	Experiment commenced	% Survival to end of 1956	1957	1958
Shippegan, N.B.	Shippegan, N.B.	Aug. 8, 1956	19.8	7.7	5.1
East River, P.E.I.	Shippegan, N.B.	Aug. 8, 1956	98.6	80.5	76.3
Shippegan, N.B.	Shippegan, N.B.	June 12, 1957		37.5	1.0
Summerside, P.E.I.	Shippegan, N.B.	June 12, 1957		86.9	81.5
*Shippegan, N.B.	Shippegan, N.B.	May 16, 1958			32.5
Summerside, P.E.I.	Shippegan, N.B.	May 26, 1958			96.2
Neguac, N.B.	Neguac, N.B.	July 12, 1957		44.5	14.9
Bideford River, P.E.I.	Neguac, N.B.	July 12, 1957		98.5	89.0
Neguac, N.B.	Neguac, N.B.	June 24, 1958			86.2
Summerside, P.E.I.	Neguac, N.B.	June 24, 1958			96.4
Hardwicke, N.B.	Hardwicke, N.B.	June 13, 1957		69.3	30.6
Bideford River, P.E.I.	Hardwicke, N.B.	June 4, 1957		97.9	82.8
Hardwicke, N.B.	Hardwicke, N.B.	June 23, 1958			65.7
Summerside, P.E.I.	Hardwicke, N.B.	June 23, 1958			92.1
Mill Creek, N.B.	Mill Creek, N.B.	July 11, 1957		75.2	24.7
Bideford River, P.E.I.	Mill Creek, N.B.	July 11, 1957		99.5	95.0
Mill Creek, N.B.	Mill Creek, N.B.	May 22, 1958			94.6
Summerside, P.E.I.	Mill Creek, N.B.	May 22, 1958			98.6
Malagash, N.S.	Malagash, N.S.	Aug. 9, 1956	76.5	26.6	15.0
East River, P.E.I.	Malagash, N.S.	Aug. 9, 1956	98.0	85.1	79.1
Malagash, N.S.	Malagash, N.S.	May 15, 1957		62.7	21.5
Summerside, P.E.I.	Malagash, N.S.	May 15, 1957		95.5	90.5
Malagash, N.S.	Malagash, N.S.	July 15, 1958			81.6
**Malagash, N.S.	Malagash, N.S.	July 15, 1958			77.0

* Two year olds from a slightly different location. Not strictly comparable to other native Shippegan lots.

** Separated native spat of 1957 year-class.

In Neguac Bay, Mill Creek, and Malagash Basin the survival of natives from spring to freeze-up in 1958 approximated that of resistant Prince Edward Island stock transplanted in 1958. This suggests that the epidemic has about run its course in these areas.

Laboratory work on the pathogen continued. The technique of bleeding from the heart was greatly improved. It was possible to decide that blood of healthy oysters is bacteriologically sterile on the media used, while that of diseased oysters exhibits a generalized bacteremia. There may be a bacterial pathogen but so far we can conclude only that healthy oysters have a good anti-bacterial defense which breaks down in this disease.

The faeces of healthy and diseased oysters also differ both in their appearance and bacterial flora. Further work is necessary to discover why.

It will be recalled from 1957 that a fungus was cultured with ease from diseased tissues placed in Ray's Medium. We planned to study the morphology and identity of this fungus in 1958. No success whatever was achieved in culture in Ray's or any other mycological medium. We plan to continue looking for this fungus next year because a similar or identical organism has been associated with recent outbreaks of oyster disease in the United States.

R. R. Logie
E. B. Henderson
Wilhelmina van
Walbeek

No. 12

OBSERVATIONS ON LARVAL DISTRIBUTION IN BIDEFORD RIVER

In 1958 a new effort was made to describe the distribution of oyster larvae and its quantitative and qualitative variation with time and environmental conditions in Bideford River. An understanding of these would permit better predictions of spatfall, rational placing of spat collectors and is basic to any attempt at controlled spat production.

The field work was carried out by Dr. W. B. Stallworthy and Mr. S. E. Vass. Great numbers of plankton samples were collected by pumping water through silk nets simultaneously from a number of water levels, at 3-foot intervals from top to bottom of the river. These samples were taken from a boat running across a horizontal transect of the river. The examination of the samples is still under way.

Because the investigation was new, much time was spent in devising equipment and procedures and in adjusting programs to fit the problem as it revealed itself. Sample-to-sample variations in abundance of larvae were so great as to demand more intensive sampling than was carried out. Consequently few critical data are available especially for late-stage larvae which were least frequent though of greatest interest in our investigation. Nevertheless, some general conclusion appears.

(1) Oyster larvae are not uniformly distributed but show both vertical and horizontal variation in their concentration.

(2) All age groups show the same distribution in any transect. This can be claimed with reasonable certainty for all but the latest stages.

(3) There was no detectable change with tide in the vertical distribution of larvae.

We can improve the sampling program and it is proposed to continue the work in 1959 and following years. The problems involved are at the very core of the oyster industry.

R. E. Drinnan

No. 13

SPATFALL PREDICTION

Last year the per cent dry weight of oyster meats dropped sharply after spawning. This year we investigated the possible utility of this relationship for spatfall prediction. Observations were made on oysters from Bideford River, P.E.I.; from Orangedale (Bras d'Or Lakes) and Malagash, N.S., and from Shippegan, N.B.

At Bideford samples of ten oysters from three areas were collected at 2-4 day intervals and the per cent dry weight of the meats obtained by weighing before and after drying at 100°C. The samples from other areas were less frequent but were treated in the same way.

There were many fluctuations in per cent dry weight of Bideford oysters but these were not consistently related to spawning activity although often coincident. The same was true for the other areas studied. The disparity between 1958 and 1957 results may reside in differing spawning behaviour in the two years. In 1958 there was little indication of periods of spawning separated by periods in which none occurred. Rather a picture of a steady level of spawning over a long period emerged.

Because observations on per cent dry weight cannot be depended on to detect spawning activity, they cannot be used in predicting spatfall.

Prediction of spatfall at Bideford was carried out by the usual routine--determining the size-composition of larval populations, then extrapolating from modal sizes on known growth curves.

Larvae were first seen in plankton tows taken July 5 when water temperature had exceeded 20°C. for some 5 days, after rising steadily from 14°C. on June 16. More larvae were found in subsequent tows and we predicted a light spatfall on or about July 27; a heavy set July 28 to August 1, another peak August 12 to 14, and a light set August 24.

To check the reliability of these predictions we made daily counts of spat settling on scallop (Placopecten) shells suspended at 2-foot vertical intervals from the Sub-Station wharf. There was a continuous spatfall from July 23 to August 27 with peak intensity (50 spat/shell/day) July 29 to August 18. This pattern corresponds very well with that observed at other stations in the area (see Summary No. 14). Predictions were precise and provided 17 days' advance notice of major spatfalls.

This year's close agreement between predicted and observed spatfall should be viewed with caution. Predictions of intensity of spatfall are usually based on the observed abundance of rather young larvae. Whole broods of larvae may perish or, if they survive, they may settle with a so-far unpredictable patchy distribution.

Predictions for other areas, based on similar, though less intensive larval sampling, were almost completely unrelated to subsequently observed spatfall. This almost certainly reflects inadequate sampling. Improvements can be suggested from what we learned this year about vertical and horizontal variations in larval abundance in Bideford River.

R. E. Drinnan
Kathleen Blenkhorn

No. 14

SPATFALL STUDIES

Spat collecting stations were established to determine the precision of spatfall predictions and to gain information on behaviour and distribution of setting larvae. Stations were located along 3 transects in Bideford River and Paugh's Creek, coinciding with sections from which most plankton samples were obtained. Positions of stations were selected to assure adequate sampling of shallow and deep water.

Clean, uniform-sized (4 in. diameter) scallop shells (Placopecten) weathered for 1 year were suspended at collection stations concave surface downwards, in a vertical series at 1-foot intervals from high water level to the river bottom. These shells were changed at 3- or 4-day intervals, dried in air and stored for examination when time permitted. The results are still being assessed.

Spat first appeared July 21 to 24, and appreciable numbers were first caught July 29 to August 1. Spatfall rose sharply to a maximum August 5, declining slowly until August 17. Shells exposed August 20 to September 5 caught some spat, showing that late-season sets do occur.

Many spat on July 29 to August 1 collectors were dead when brought in, leaving empty, translucent shells pale yellow-green in colour. These had grown little or not at all in the first 1 to 4 days of their spat life. This early mortality continued throughout the spatfall period. Approximately 9% of the spat examined were dead but in some samples 90%.

Close study of records for Paugh's Creek stations shows that mortalities were greatest (90%) in the inshore shallows and least (<20%) in offshore positions (depths up to 10 ft.). There are records for this area from former years, of mortalities immediately after settlement and of poor post-settlement growth followed by late-season mortality. Obviously we are dealing here with a major industrial problem that should be better understood.

Several shells were examined on both surfaces to discover preferences by setting oyster larvae. Outer convex surfaces deeply ridged and dark in colour which faced upwards in our tests presented a marked contrast with the smooth, white, inner surface which faced downwards. Approximately 70% of the catch was taken on the upper surface and 30% on the lower. When upper and lower surfaces are identical, larvae generally show preference for lower surfaces. These observations show that the surface texture also regulates the efficiency of cultch--a fact that is often overlooked.

This year's spatfall studies throw new light on the problems of commercial collection of spat. It is proposed to continue the work in 1959.

S. E. Vass

No. 15

SPATFALL ON COMMERCIAL COLLECTORS

Spatfall in 1958 was better than average, all things considered. Results of observations are summarized in the accompanying table. No counts were made on Shippegan and Orangedale collectors because the spat were separated early to provide stock for disease-resistance studies.

In spite of heavy disease mortalities of native parent stocks at Shippegan, N.B., and Malagash, N.S., there was some spatfall in both areas. This is attributable to spawnings by introduced, disease-resistant stocks from Prince Edward Island in 1957 and 1958.

For the third year in succession Freeland, P.E.I., collectors bore some very large spat indicating undetected early spawnings. The superior quality of early-caught spat warrants closer observation of this area in 1959. It may assume an important place in spat collection programs conducted by the Department's Experimental Oyster Farm at Ellerslie.

Netherlands oyster culturists make extensive use of mussel shells as cultch by spreading them on the bottom immediately before spatfalls. In 1956 and 1957 this technique gave poor returns at Ellerslie apparently because of heavy silting. The 1958 success with mussel shells held off the bottom in slings is heartening because some of our growers who cannot or will not prepare egg-case filler collectors may be persuaded to use mussel shell.

Spat caught on mussel shells in Bideford River in 1957 and planted on the bottom in Conway Narrows have grown well this year but the problem of how to handle them to produce single oysters remains to be solved.

Spatfall on Egg-Case Filler and Mussel-Shell Collectors

Location	Date	Catch (No. spat/filler)	Remarks
Shippegan, N.B.	-	light	Spat separated before counts could be made.
Malagash, N.S.	Oct. 23	25 to 882	Highly variable.
Orangedale, N.S.	-	light	Spat separated before counts could be made. Collectors badly fouled.
P.E.I. Areas			
Freeland	Aug. 14	183	Diameter 2 to 15 mm. Mode 9 mm.
	Sept. 23	262	Diameter up to 40 mm. Mode 12 mm.
Paugh's Creek	Aug. 8	305,000	
	Sept. 23	2,450	
	Jan. 13(1959)	2,570	Diameter $<$ 10 mm.
Bideford River	Aug. 14	7,620	Mode 0.45 mm.
	Sept. 23	1,488	Diameter 2 to 15 mm. Mode 7 mm.
	Jan. 13(1959)	1,588	Diameter $<$10 mm.
Mussel Shells held in chicken wire and fish netting slings			
	Sept. 13	12/shell	Diameter 4 to 8 mm.
	Oct. 14	11/shell	
	Oct. 22	6/shell	Apparently some frost damage.

R. E. Drinnan

No.16

LABORATORY GROWTH AND MORTALITY OF SPAT

A knowledge of factors affecting spat survival and growth is desirable in any spat-production program. Our special need for it became quite clear from observations on commercial spat collectors in the early part of the 1958 season. Growth and survival appeared poor (See Summary No.14).

To obtain some measure of these under conditions approximating those in the field, spat were held in laboratory tanks supplied continuously with sea water. This allowed assessment of mortality and of growth of individual spat. To get stock for observation, scallop (Placopecten) shells were suspended from the station wharf for the 24-hour period of August 7. Four days after setting, 25 surviving spat on each of eight shells were randomly selected and numbered. By starting observations on the fourth day we avoided the early mortality which had been observed in the field. Starting earlier would have necessitated the handling of very large numbers of spat.

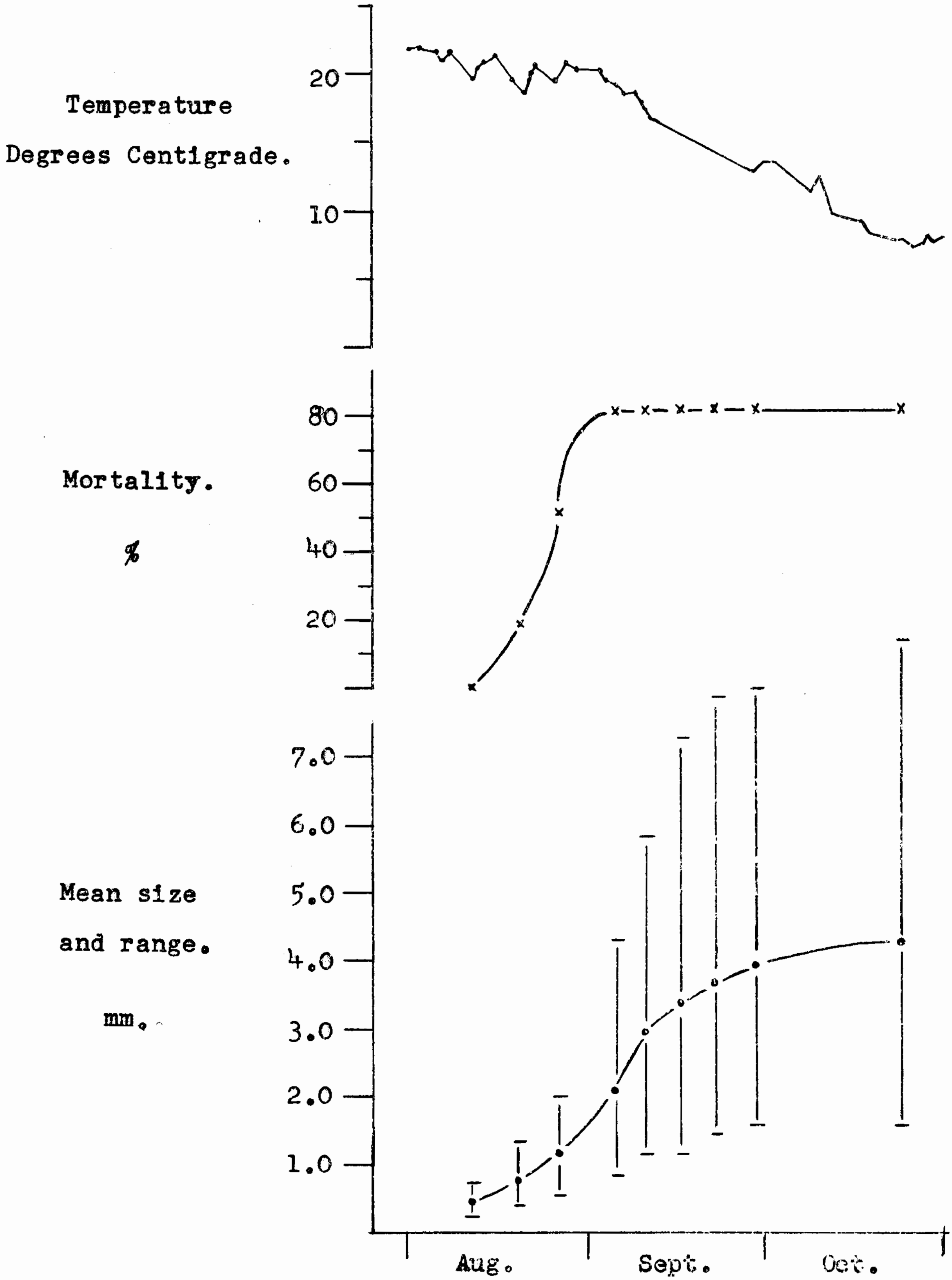
The spat were examined and measured at intervals of approximately seven days until October 24. The figure shows mortality (calculated from all the spat), mean size (calculated from the 38 survivors to October 24), and tank temperatures throughout the period.

The mortality rate was relatively constant from the 3rd to the 25th day after setting with a maximum between the 11th and 18th.

The average growth rate of survivors increased up to the 27th day and thereafter declined until growth ceased in October. The range in the sizes of these spat, all of the same age, increased enormously as the experiment progressed. They were approximately the same size on August 7 but on October 24 the smallest and largest measured 1.5 and 8.7 mm.

Tank temperatures were generally above 20°C. until the 25th day when they began a steady decline. This change was coincident with cessation of mortality and reduction in growth rate. Growth ceased in the region of 12°C.

These studies suggest lines along which further investigation should be directed. The vast individual variation in growth during the first season raises many questions about patterns of growth at all ages that have the greatest importance in oyster culture. The growth study should be continued. The mortality pattern is equally mysterious. Such factors as concentration of possible foods must be considered as survival factors in future work.



Tank temperature and mortality and growth of laboratory-reared oyster spat - Ellerslie, P.E.I., 1958.

R. E. Drinnan

No. 17

ECOLOGICAL SURVEY OF THE CONWAY NARROWS OYSTER BEDDING AREA

The Conway Narrows experimental area consists of about 175 acres at the northwestern end of the shallow lagoon sheltered by the barrier bar which extends between Malpeque and Cascumpeque Bays. Plantings of spring-threshed oyster spat made there in May of 1953 and again in May of 1956 by the Department of Fisheries were extraordinarily successful in producing high quality oysters for bedding on leases. During the past season the area was studied to determine its characteristics, to facilitate finding similar areas, and to assess the requirements for future study.

The study area was closed to picking to prevent any disturbance of the remaining natural and experimental stocks of oysters. It is being set aside as an experimental reserve by the Department of Fisheries to develop methods of oyster culture appropriate for the area.

Hydrographic Conditions

The water is shallow, about 1 ft. to 2 ft. deep at M.L.T., and the tidal fluctuation is small (about 3½ ft. at spring tides). As a result of this the water temperature is generally closer to air temperature than the water in the gulf outside the barrier bar. The water warms quickly in sunlight; temperatures of 21-24°C. were common during July and August. Very little direct information is yet available about winter conditions; ice is said to be slow in forming and to be relatively thin but there may be great variation from year to year. Winter conditions are being observed this year. The salinity is almost identical with that of adjacent gulf waters (approximately 27‰) and varies closely with it. Currents are slow, the fastest observed being about one-half m.p.h. in the middle of the lagoon during ebb tide. They are slower near the shores and at the bottom.

Soil

The soil is sandy and relatively free from silt. More than 85% of the sediment is "medium or fine sand" (Wentworth grade scale) and less than 5% "silt and clay". Samples of the top 6 inches of soil were taken in the experimental area and in some of the similar areas being explored. Sieve analyses have been made on some samples. An analysis of soil texture at the site of the 1956 planting is given below.

Particle diameter range	Name of grade	% of sample by weight
Above 4 mm.	pebbles	0 (occasional)
2-4	granules	1
1-2	very coarse sand	2
0.5-1	coarse sand	3
0.25-0.5	medium sand	33
0.125-0.25	fine sand	56
0.062-0.125	very fine sand	3
Below 0.062	silt and clay	2

Penetrometer readings were made to describe the firmness of the floor of the lagoon. The readings are of doubtful value because of technical difficulties in the use of the penetrometer. A pressure of 2 to 3 lb. was required to drive a 1 cm.^{2} flat disc 5 cm. into the bottom. Small local variations occurred but generally firmness was uniform. The bottom here had properties similar to those of the shoreward eelgrass fringe of the beach at the Biological Sub-Station at Ellerslie. The bottom sediments there showed the same textural distribution as was observed ten years earlier (1948).

Vegetation

There is a light general covering of eelgrass (Zostera marina) over the area. The density is variable: from 0-50 shoots per 625 cm.^{2}. The average density over the experimental area was about 400 shoots per m.^{2}. The plants are short and narrow-leaved; the mean height of the longest leaf of the plants sampled was 11 cm., and each individual shoot had about five leaves at any one time during the summer. This light cover of short eelgrass plants is probably important in maintaining the stability of the bottom in spite of wave and ice action; the silt load in the water is not sufficient to develop a muddy bottom amongst the eelgrass plants.

Algae encountered on the bottom were: Chaetomorpha linum, Cladophora, Enteromorpha, Ulva lactuca, (green algae); Chorda filum, Eudesme, Fucus, Stilophora and Sphaerotrichia, (brown algae); Ceramium, (red alga). Fucus and Chondrus occurring attached to large rocks, were rare.

Potential Predators or Competitors

Small starfish, up to 2½ in. in diameter, were present but relatively scarce. From two transects across the lagoon (each about 0.5 m. by 500 m.) I would estimate the population of starfish to be 0.08 starfish/m.^{2}. Starfish were considered unable to live successfully at high temperatures and it had been hoped that this area would remain free from them. The starfish found here survived the warm temperatures (24°C.), and larger healthy starfish of 4 to 5 in. diameter were found feeding on mussels growing on pilings at the Biological Sub-Station at water temperatures of 22°C. Starfish may well be a potential problem here.

The following animals of possible importance also occurred: the rock crabs, Cancer irroratus; slipper limpet, Crepidula fornicata; common mussel, Mytilus edulis; and moon-shell, Polynices heros. Other common animals observed were eels, flounders, razor clams, periwinkles and various species of snails. One of the marked characteristics of the area is the relative scarcity of shellfish and yet the excellent quality of the few oysters present.

Exploration

Transplants of 1956 oysters and of 1958 spat were made to two new areas in the experimental reserve to test its general suitability for rearing young oysters. Additional areas in Conway Narrows lagoon and in the lagoon between Lennox Island and the barrier bar were examined and appeared suitable. Transplants were made to two promising locations in Conway Narrows lagoon several miles distant from the study area. Attempts to catch oyster spat on collectors in the study area were unsuccessful.

Recommendations

More information should be obtained from hydrographic conditions, survival of oysters, size of predator populations, fertility, and winter conditions. Tests should be made to discover the best techniques for utilizing the area for the production of seed or bedding oysters. New areas should be sought by looking for similar conditions and then by testing with transplanted spat and oysters.

A. R. A. Taylor

No. 18

INTRODUCTION OF THE EUROPEAN OYSTER

This year observations on survivors of the 1957 introduction of European oysters (Ostrea edulis) from North Wales were continued and a second test lot was brought over.

Winter survival of the oysters imported in the spring of 1957 (App. 19, 1957 Rept.) was tested in Sam Orr Pond and Oak Bay. Although both areas freeze over during winter, water temperatures at depths greater than three feet remain at or above 0°C. because of tidal exchange with Passamaquoddy Bay. Survival in Sam Orr Pond was 100% and in Oak Bay zero. The Oak Bay mortality is attributed to a January thaw which reduced salinities to below the tolerance limit. The excellent survival in Sam Orr Pond shows that in our waters European oysters can stand long exposure to zero, or near-zero temperatures, if salinities remain high.

Although growth was less this summer, conditions of meats and shell shape improved and there was a heavy spawning. Last year these oysters tended to be thin and small-meated, their shells were fragile and flat and they were too young to spawn. The spawners this year released their larvae August 1 to 12. From August 5 to 12 there was no tidal exchange in the pond and conditions were optimal for larval retention. Nevertheless, the larvae grew little and disappeared soon after release. They seem to have died. There was heavy flushing of the pond by high tides beginning on August 14 and no larvae were found thereafter. Collectors set out soon after the larvae first appeared caught no spat. Chances for a set would have been better with a larger population of spawners. Apparently the pond did not afford satisfactory conditions for larval development this year.

A second shipment of 5,000 two-year-old Welsh oysters from the British Ministry of Agriculture, Fisheries and Food arrived by air freight in April 1958. These oysters fared much better than those sent by steamer in June 1957. The survival after a month was 50% as compared with 5% last year. Dr. Marshall Laird of the Institute of Parasitology examined some of the dying animals. Protozoans he found in them may be directly or indirectly responsible for the losses. The oysters were placed in wire-bottom trays in Sam Orr Pond where growth during the summer was excellent. Average diameter increased from 1½ to 3 inches, the same as last year. In late summer two samples were shipped to Ellerslie, P.E.I. One lot was placed in laboratory aquaria and the other in a tray submerged in Bideford River. They grew well until November with little mortality. The purpose of this transfer was twofold. We want to know whether this species can stand lengthy exposure to sub-zero water temperatures which are characteristic of Gulf of St. Lawrence oyster inlets, and whether they are susceptible to the Malpeque disease. The answers to these questions will tell us if and in what areas European oysters can be grown on this coast. We plan to return these oysters to St. Andrews next year before they spawn. These tests were planned for last year but survivors of the 1957 importation were too few. This delayed parts of our program by a year. Another lot was transplanted in mid-autumn to the lower part of Oak Bay where it is most saline. It is hoped that these will fare better than similar 1957 transfers.

We plan to test Sam Orr Pond for larval survival again in 1959 and we hope to discover the cause of failures. Pending results of tests for Malpeque disease resistance, we shall also look for better areas where large-scale importations may be planted in 1960 if this proves desirable. For these purposes we plan to obtain another test lot of young oysters from Wales next spring.

Joan E. Mortimer

No. 19

SALTWATER PONDS FOR SHELLFISH CULTURE

In 1957 we studied Sam Orr Pond to determine its suitability for shellfish culture and described its unusual physiographic faunal and floral characteristics (App. 18, 1957). In 1958 we studied its hydrography and its broods of shellfish larvae. Circulation, tidal characteristics, and flushing rates regulate the success of broods throughout their pelagic life.

Accurate records of all tides entering the pond were obtained from a recording tide gauge and temperature and salinity records were carefully spaced to permit their correlation with tide gauge records. Special hydrographic observations during complete tidal cycles (flood and ebb) were made when tides were in the neap, intermediate and spring phases, to discover circulation patterns.

Temperatures are highest at neap periods when there is a pronounced vertical gradient. This practically disappears at spring tides. Fresh water, discharged into the pond by a small brook, does not penetrate more than 2 feet below the surface where a distinct halocline is frequently observed.

The history of broods of larvae of shipworms, (*Teredo navalis*), as well as of European oysters was followed carefully in 1958. Neither species is found in the plankton of surrounding areas. Broods were completely flushed out of the pond by tides exceeding the sill level by 1½ feet and broods were significantly depleted by tides that exceeded the sill level by only 1 foot.

Efficient culture of lamellibranchs in the pond would seem to require a dam at the sill to prevent flushing and to "bottle up" larvae until after they grow to spatting size. Before considering any construction it is important to discover whether the pond is a suitable environment for larval growth and survival. A critical determining factor is the supply of plankton on which larvae feed. Gross features of the plankton appear from net tows made this summer. Diatoms are rare but dinoflagellate populations showing vertical stratification, are frequently dense. For next summer we plan to study productivity and nutrition in the pond, and in particular to determine the concentration of "u-flagellates" available to the larvae as food. This is of fundamental importance in assessing Sam Orr Pond as an area for shellfish culture. We shall continue small-scale observations at Oak Bay for comparisons.

Joan E. Mortimer

No. 20

DAMAGE TO SOFT-SHELL CLAM STOCKS BY ESCALATOR DIGGER

Occasional observations on flats where our mechanized digger has been operated have indicated that it does little damage to those clams in its path which are too small to be marketed. But this conclusion was too vague to serve as a basis for advice to the Department of Fisheries on the wisdom of legalizing the use of this type of digger. In 1958, therefore, we attempted a precise measure of the damage it does.

The work was done at Clam Harbour, N.S., using clams ranging in size from 1¼ to 1¾ inches in length. For identification their shells were all marked with Volger's ink. The machine was set to dig at the commercial-fishing depth of 15 inches and otherwise run as if it were being operated in commercial fishing. The test was carried out in three stages.

In the first stage the marked clams were killed in formalin to prevent them from burying themselves after they passed through the machine. Groups of these were then released in the digging scoop when the machine was in full operation at high tide on a flat that is exposed at low tide. Most of the clams sifted through the mesh of the escalator belt and dropped back to the bottom without ever coming to the surface of the water. About one-third of them passed on up the belt and dropped off the end into the water. At the next low tide we recovered, on the average, 90% of the clams that were released in each group and we mapped the pattern of their scattering over the beach in relation to the point of release. Most were in the track left by the digger. We also counted the numbers with broken shells. Some were damaged, seemingly in the conveyor system. The work was easy because the digger obviously buried very few and because those it did not bury could not dig in and were plain to see.

In the second stage of the test, marked, formalin-killed clams were planted in plots on the intertidal beach at low tide. They were set out uniformly at 9 per square foot and at "normal" depths in the soil. At the next high tide the escalator digger was run through each plot and at the following low tide the damage to the clams and their scatter patterns were worked out as before. The recoveries were again very high. Apparently some clams are damaged by the lip of the scoop as it moves through the soil and before they enter the conveyor system.

In the third stage, living, marked clams were planted as in the second stage and the digger was passed through the plots at the next high tide. When the flats were visited at the next low tide, a few clams were found on the surface and they all had broken shells. By probing and digging in the softened soil in the digger track we were able to find almost all the clams the digger had displaced. These had already dug back into the soil and appeared none the worse for their experience. Again we mapped their scatter patterns and got counts of damaged and undamaged clams. The shells of several of those counted as damaged seem to have been broken by the probing and digging.

Some of our results are summarized in the accompanying table:

Results of digging trials with escalator-type digger and marked clams

Recovered clams	"Killed" clams released in digging scoop	"Killed" clams planted then dug	Live clams planted then dug
% found in digger track	87	90	98
% broken	2.5	4	6

The results indicate that:

(1) The escalator digger buries very few of the small clams it disturbs (less than 10%) and those it does bury are close to the surface where they are not likely to smother.

(2) Almost all the under-sized clams the escalator digger disturbs are returned to the track, the ground from which they were dug, and most of them were deposited within 50 feet of the very spot in which they were living before disturbance.

(3) Of those that are returned, approximately 4% are too severely damaged to be able to dig back into the soil and will die. More than 90% are not seriously affected by the digger.

It is to be admitted that relatively small and isolated areas were involved in these tests. But it will be recalled that in similarly small areas we found digging with ordinary clam forks is highly destructive of the small clams left behind in the soil --40 to 60% of the stock is killed. From this it seems likely that we could realize heavier yields of soft-shell clams from our flats if we harvested them with escalator diggers than if we continued to harvest them with conventional hand tools.

J. S. MacPhail
J. C. Medcof

No. 21

STUDY OF GEORGES BANK SCALLOP FISHERY

Since 1952 annual landings of scallop meats from Georges Bank have increased rapidly to new high levels so that this fishery is now economically the most valuable of all fisheries in ICNAF Subarea 5. United States landings rose from about 12.0 million pounds in 1952 to over 18.0 million in 1955 and have remained at about this level since. Canadian landings were less than 0.3 million pounds annually before 1952, but reached about 2.5 million in 1958. Increases apparently result from increased scallop fishing effort, rather than from heavier landings by individual boats, and industry has become concerned that the heavier fishing may lead to "overfishing" of its resource. Because of the international character of the fishery, scientists of ICNAF countries have been asked to co-operate in a study of the status and prospects of the fishery. Specifically, they have been asked to judge the merits of an increase in mesh size of scallop dredges as a measure to ensure continuation or even increases in the present high landings.

Canadian boats fish primarily on scallop stocks on eastern Georges, to the southeast of those fished most heavily by the United States. Our studies have been chiefly directed to the fishery in the former locality. In co-operation with scientists of the United States Fish and Wildlife Service, records of catch and fishing effort are being collected, and sea trips are made to provide a basis for abundance and mortality studies.

Preliminary results indicate that there are remarkable differences in the density and size distribution of scallops from bed to bed. These differences show up in records of catch per haul gathered during sea trips, but not in record of wharf landings. Landings show relatively little variation apparently because with present abundance, the fishing power of the vessels keeps the shucking facilities saturated most of the time and higher catches result in higher discards. Differences in landing from one boat to another are therefore principally the result of differences in the shucking power, and in the sizes of scallops saved from the catch.

In areas of the highest catch, the mean selection size was about 100 mm. shell height while in areas of smaller total catch, the selection size dropped to 95 mm. The selection range was narrow in areas where large scallops predominate, but wide in areas where there were larger numbers of small scallops, some of which were included in landings. This flexibility in cull-size seems to be an important factor in cushioning landings against major effects of variations in density and abundance of scallops.

These data indicate that mesh-size could be increased considerably above the 3-inch inside diameter currently used (mean selection size about 72 mm.) without seriously affecting present landings. However, the long-term benefit of such a change depends upon improving the survival among small scallops released from capture. Data on survival among the discards are scanty, but present indications are that it is relatively high, and probably little affected by the handling and exposure they receive. There is, furthermore, no good estimate of current fishing mortality rates. The long-term advantages of increasing mesh size are therefore open to question.

Increasing mesh size would probably decrease the amount of trash accumulated in drags and increases their efficiency as was shown for the Digby area (Appendix 26, Annual Report for 1952). Such increased efficiency might improve landings in periods of scarcity of scallops, when landings would not be limited by shucking power to the extent that they are now. However, before recommending an increase in mesh size we should weigh possible long-term benefits, against the disadvantages of reducing the flexibility in fishermen's choice of what sizes are worth shucking.

L. M. Dickie

No. 22

HYDROGRAPHY AND MASS MORTALITIES OF SCALLOPS IN THE GULF OF ST. LAWRENCE

Analysis of a series of experiments designed to describe the giant scallop's tolerance of high water temperature was completed in 1958. High temperatures are directly lethal. Upper lethal temperatures are raised by about 1.7°C. per day by acclimation to high temperatures, but loss of the state of acclimation to high temperatures is very slow, requiring more than 40 days in tanks and possibly as much as 3 months in nature. There appears to be a seasonal change in susceptability to high temperatures; upper lethal temperatures were lower in summer than in winter. Minimum upper lethal temperatures were theoretically 18.8°C. for scallops in summer condition, and 20°C. for scallops in winter condition, although actual upper lethals are probably never less than 20°C. because loss of high temperature acclimation is so slow. Maximum upper lethals ranged from 23.5°C. to 25.3°C. for scallops in summer and winter condition respectively.

Within the zone of thermal tolerance sudden increases or decreases in temperature may arrest scallop activity. After exposure to increased temperatures, recovery of normal activity was rapid but after exposure to sudden decreases in temperature, recovery was very slow. The debility resulting from sudden temperature changes within the zone of thermal tolerance seems great enough to increase their susceptibility to predators. Sudden temperature changes within the zone of tolerance may therefore be indirectly "lethal".

Records for the Gulf of St. Lawrence show that water temperature changes which can kill scallops directly or indirectly may occur frequently in areas where mass mortalities have been observed. Furthermore, hydrographic phenomena which can produce such sudden changes in the vicinity on scallop beds, have been described. However, there are no direct observations of temperatures on scallop beds at times when mass mortalities have taken place. Records of mortalities and of hydrographic conditions are being compiled to assess the relative importance of temperature changes that are (1) directly lethal, (2) debilitating and indirectly lethal.

L. M. Dickie

No. 23

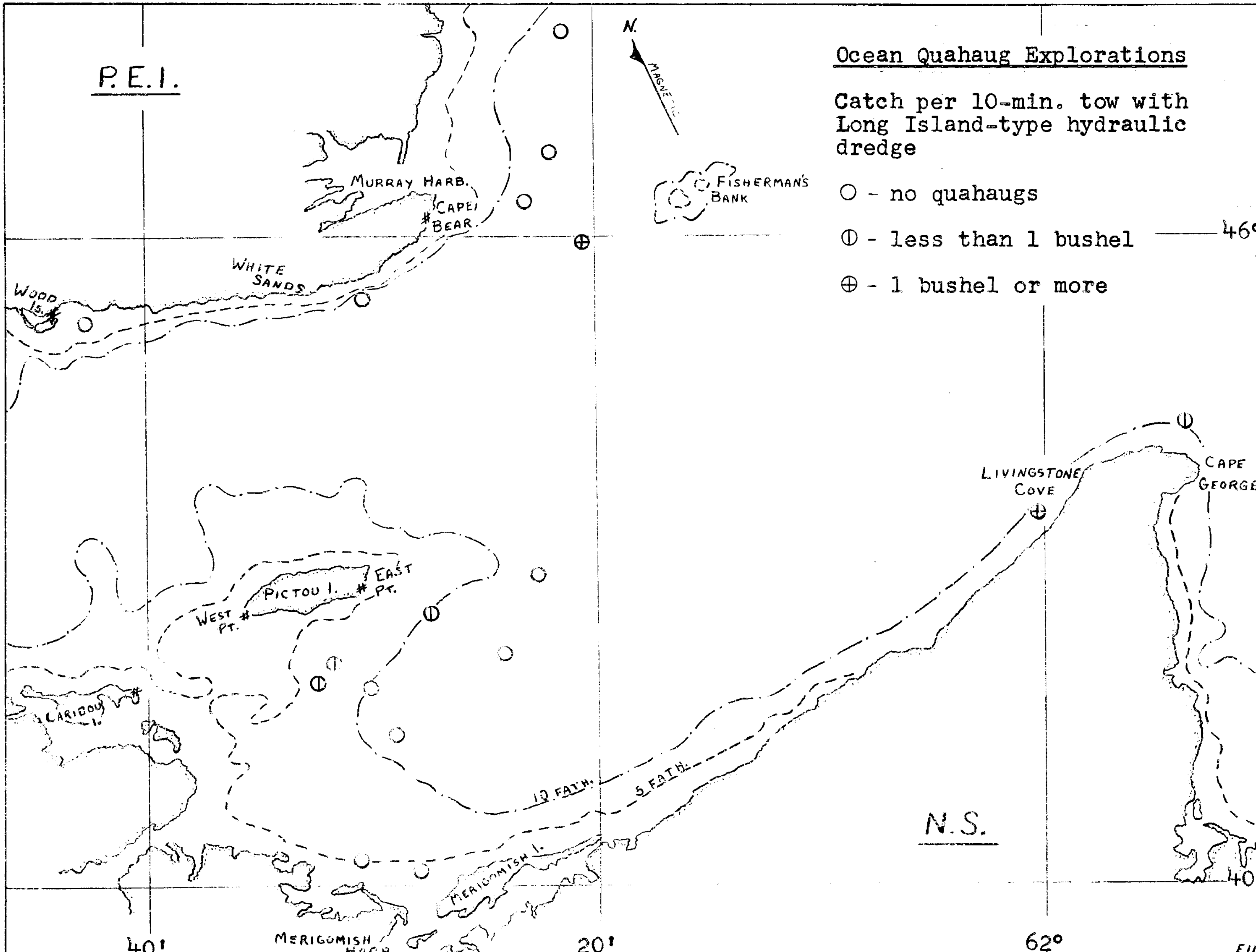
EXPLORATIONS FOR OCEAN QUAHAUGS IN NORTHUMBERLAND STRAIT

Ocean quahaugs (Arctica islandica) are widely distributed in moderately deep North Atlantic waters but few of our people have ever seen them and none are marketed in Canada. Reports of fishermen and a one-day search for them with improvised gear in November 1956 convinced us that they were abundant at depths of 12 to 20 fathoms in the eastern entrance to Northumberland Strait. The bottom seemed too hard to be fished with a conventional non-hydraulic quahaug dredge. But the quality of the catch was high and samples submitted were approved by one firm which ordinarily uses bay quahaugs (Mercenaria mercenaria) in its products.

This year we organized and supervised a systematic exploration and trial fishing for this species financed by the Industrial Development Service of the Department of Fisheries. A 65-foot dragger, M/V Paula Marie (Francis Doucette, skipper) was chartered for the month of August and equipped with a Long Island-type hydraulic dredge, 300 feet of (4 in. diameter) pressure hose, 300 feet of manila tow rope (5 in. circumference) and the pump-motor assembly capable of delivering 750 gallons of water per minute at 40 pounds pressure per square inch borrowed from our mechanical clam digger, M/B Cyprina. Mr. Earl Durkee, engaged as a technician by the Department of Fisheries, was immediately responsible for the work.

A hydraulic dredge has a series of water jets at its forward end. These do the actual digging and wash shellfish into the body of the dredge which follows along in the trench cut by the jets. For the first few days of operation we were accompanied by Mr. Clifford Varin of the Fire Island Sea Clam Company, Long Island, N.Y. He has had long experience in rigging and operating hydraulic dredges and taught us very quickly how to use our gear. We found good fishing off Cape Bear, P.E.I., in 17 fathoms.

To start with we compared catches made in a long series of hauls in this area over a buoyed course using combinations of different boat speeds, pump pressures, volumes of water delivered to the dredge nozzles and different digging-depth adjustments of the dredge. The animals are shallow burrowers for it was unnecessary to dig deeper than 4 or 5 inches to get good catches


Ocean Quahaug Explorations
Catch per 10-min. tow with Long Island-type hydraulic dredge
○ - no quahaugs
⦶ - less than 1 bushel
⊕ - 1 bushel or more
P. E. I.
N.
MAGNETIC
MURRAY HARB.
CAPE BEAR
FISHERMAN'S BANK
WHITE SANDS
WOOD IS.
46°
LIVINGSTONE COVE
CAPE GEORGE
EAST PT.
PICTOU I.
WEST PT.
CARIBOU I.
10 FATH.
5 FATH.
N.S.
MERIGOMISH I.
MERIGOMISH HARB.
40'
20'
62°
40'
EIL

of undamaged quahaugs. The boat had to be operated at very low speeds (about 1 mile per hour) or it pulled the dredge out of its furrow and caught nothing. With these settings catches rose steadily from practically nothing, to an average of 4 bushels per 10-minute haul, as water pressures and volumes were increased from low values to the limits of the capacity of our pumping system. From the relationship worked out, it appeared that our catches could be doubled by raising the capacity to 1,500 gallons per minute at 100 pounds pressure. Pumps of this capacity are regularly in use in the United States for fishing bar clams.

A full day's fishing off Cape Bear simulating commercial operations yielded us 75 bushels which should permit profitable operations with prices for shellfish at present levels.

We took many fishermen, fish dealers and fish processors out with us to demonstrate this method of fishing which is new to our coast. This left us only a little time to explore other areas. We found few ocean quahaugs off Pictou Island, N.S. But we towed over only a small part of vast unexplored areas in this region that would seem from charts to be suitable habitats for the species. We found none off Merigomish and none off Cape George, N.S. But we did make catches of 1 bushel per tow in Livingstone Cove, N.S., on soft bottom. In this area we tested a New Bedford-type (non-hydraulic) quahaug dredge. It fished as well as the Long Island hydraulic dredge here but when we tried it on hard bottom it caught only about a third as much as the Long Island dredge and broke the shells of one-third of its catch. (See figure.)

Last autumn we assisted one operator, who accompanied us on several of our demonstration cruises, to rig and operate similar gear off Cape Bear. He was able to take up to 90 bushels a day. We hope a fishery for ocean quahaugs will develop.

J. S. MacPhail
J. C. Medcof
E. Durkee

No. 24

SHELLFISH AND PASSAMAQUODDY POWER DEVELOPMENT

Damming for power would alter habitats of shellfish living inside Passamaquoddy Bay in many ways. The most important would be:

(1) Reduction in tidal amplitude,
(2) Reduction in flushing rate,
(3) Increase in summer water temperatures.

The extents of these changes have been forecast by engineers and hydrographers. And we have been asked to predict, on the basis of their forecasts, just how stocks of commercially-important shellfish would be affected.

Shipworms (Teredo navalis) are not ordinarily rated as shellfish but they are bivalve molluscs with planktonic larvae. It is not generally known that they occur here but we found them in two inlets tributary to Passamaquoddy. They spawn at 15°C. With the expected increase in summer temperatures they would quickly spread from present foci and become abundant throughout the Bay. Reduced flushing would retain the larvae in the Bay and favour abundance. Economically they would quickly become the most important mollusc in the area. All wooden structures exposed to sea water would require regular and expensive protection against them.

Clams (Mya arenaria) are the most important shellfish now marketed from the Bay. This summer we studied their vertical distribution on tide flats, plotted beach contours, with assistance from Mr. A. J. Johnstone, and made forecasts. Damming would completely submerge present clam beds and eliminate the clam fishery until such time as young clams could establish themselves at higher levels in a new and much smaller intertidal zone. The area that would be suitable for them would be about one-eighth the size of the present stocked area. And it would take 4 to 6 years for clams to settle and grow to marketable size in the new bed. It would probably be 10 years before they were sufficiently abundant to harvest. When harvested they would probably yield $6,000 per year instead of $45,000 which is the long-term average. Changes in temperature and flushing rates would have minor effects on the populations.

Scallops (Placopecten magellanicus) would be favoured by reductions in flushing and increases in water temperature. The larvae should develop faster so that fewer should be swept out of the Bay before they grew to settling size.

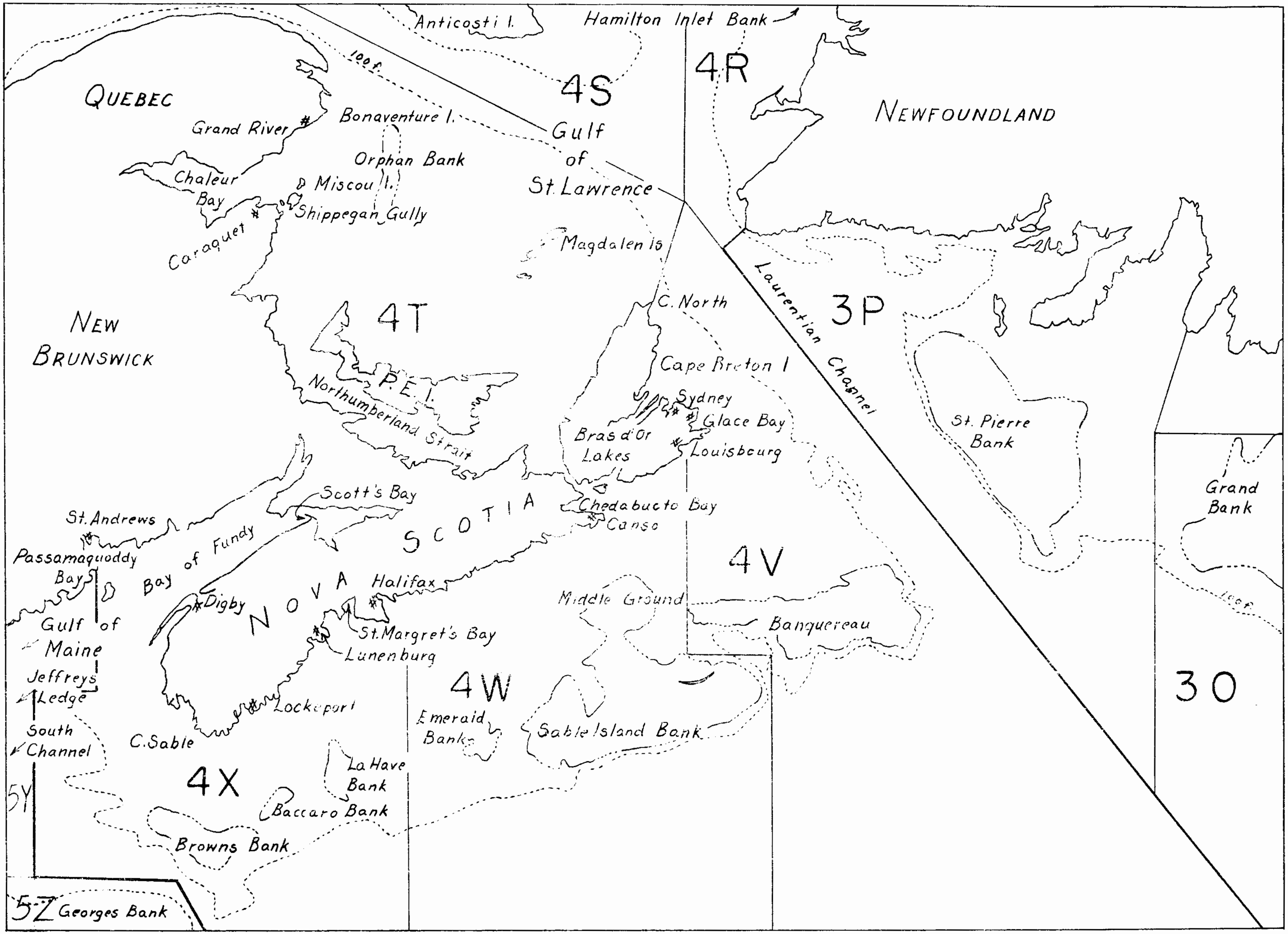
European oysters (Ostrea edulis) should find temperatures favourable for reproduction and growth after damming. They spawn at 15°C. and it is too cold for them now. We are not sure, however, that they will establish themselves on this coast.

The native oyster (Crassostrea virginica) would probably find the water too cool even after damming. They spawn at 20°C.

Other molluscs (e.g., the deep-water clam, Yoldia) living in the Bay are preyed upon by haddock and thus have an indirect economic importance. It is difficult to say how this mixed group would react to changes.

J. C. Medcof
Barbara Shaw

GROUNDFISH SUMMARIES



Anticosti I.
Hamilton Inlet Bank
100 f.
4S
4R
Newfoundland
Quebec
Grand River
Bonaventure I.
Gulf of St. Lawrence
Orphan Bank
Chaleur Bay
Miscou I.
Shippegan Gully
Caraquet
Magdalen Is
Laurentian Channel
3P
C. North
4T
New Brunswick
Cape Breton I
P.E.I.
Northumberland Strait
Sydney
Glace Bay
St. Pierre Bank
Bras d'Or Lakes
Louisburg
Grand Bank
Scott's Bay
Scotia
Chedabucto Bay
Canso
St. Andrews
Passamaquoddy Bay
Bay of Fundy
4V
Nova
Halifax
Middle Ground
Banquereau
100 f.
Digby
Gulf of Maine
St. Margret's Bay
Lunenburg
Jeffreys Ledge
4W
3O
Lockeport
Emerald Bank
Sable Island Bank
South Channel
C. Sable
La Have Bank
4X
5Y
Baccaro Bank
Browns Bank
5Z
Georges Bank

No. 25

GROUNDFISH RESEARCH

Total landings of groundfish from waters contiguous to the Canadian Atlantic coast have now reached two billion pounds. Canada takes more than one billion pounds, a catch which is shared equally by Newfoundland with the other Atlantic provinces. On the Canadian Atlantic coast, the landed value of groundfish is about half that of all marine species.

The potential for increased total profits is the primary interest of the groundfish investigation. The various research projects are directed toward different aspects of this goal:

1. Increased landings. During the past 25 years, groundfish landings in Canada (excluding Newfoundland) have increased fairly steadily by some 300 million pounds. Greater landings are anticipated. For each major stock of the important groundfish species, we are studying optimum size for first capture and optimum fishing intensity, as background for making best use of the resources available. Effects of changes in fishing practices, such as different gears and larger mesh sizes, are being assessed. Density-dependent effects on recruitment, growth,and mortalities are of current interest.

2. Reduced risk. Predictions of fluctuations in abundance are useful in reducing the risk involved in fishing operations. Tagging programs are helping to clarify seasonal variations in concentrations of fish. Survey projects are providing knowledge of the strength of pre-recruit year-classes as a basis for making short-term predictions of changes in abundance. Correlations with hydrographic factors permit longer-term predictions, associated with climatic changes.

3. Increased efficiency. As landings increase, abundance of groundfish decreases. Costs of fishing have increased more rapidly than price of fish. Fishing for groundfish must compete with other progressive industries. For all of these reasons profitable fishing requires the most efficient methods available. During 1958 we have continued to assist the Development Service and Provincial Fisheries Offices with commercial trials of methods explored by the Station. Danish seining, pair trawling, gill netting, power-dory longlining, and Norwegian jigging all received attention. In otter trawling, the advantages of manila over cotton, large meshes over small, and loose chafing gear over tight, were explored. A trip on a large French otter trawler provided useful information on more efficient trawling methods. Trial and error exploration of known fishing methods appears to be reaching the point of diminishing returns. Further progress in this field will require research in gear technology and fish behaviour.

4. Increased price. Attractive fish products of high quality lead to high demand and increased prices. Elimination of fish parasites is one method of increasing profits from groundfish. Life-history studies of the troublesome round worm, *Porrocaecum decipiens*, were completed during 1958. Experimental control of this parasite, by killing seals, has been recommended.

Progress in these fields of research has been accelerated by co-ordination with other agencies. Statistics have been improved by working closely with the Economics Service of the Department of Fisheries and the Bureau of Statistics. Industry has been most helpful in providing log records, recovered tags, and accommodation for personnel at fish plants and at sea. Close liaison was maintained with neighbouring groundfish research groups at St. John's, Grand River, and Woods Hole. Participation in the research and management program of the International Commission for the Northwest Atlantic Fisheries has broadened our understanding of groundfish resources, and total production from the ICNAF Area has increased substantially.

W. R. Martin

No. 26

STATISTICS AND SAMPLING

Six members of the groundfish staff are employed to collect and compile data on commercial landings. They collect catch statistics and sample landings for size and age composition.

Statistics of area fished, gear fished, and fishing effort are collected by means of log books and interviews from the mobile fleet. At the Halifax statistics office these records are combined with purchase-slip statistics, collected by the Department of Fisheries, on trip cards. The cards are of Kwiksort-Pegbar design to facilitate analyses. During 1958, data on the 1957 cards were transferred to IBM cards by the Bureau of Statistics in order to explore the advantages of further mechanization.

These records are used to provide an annual statistics report to ICNAF, and detailed catch and effort data for the principal populations of each major groundfish species.

Recent trends in landings are shown in Figure 1. Total groundfish landings on the Canadian Atlantic coast (excluding Newfoundland) have increased from 480 million pounds, round, fresh weight, in 1952 to 585 million in 1957. Most of the increase is attributable to a larger otter trawl fleet, which now takes about half the total groundfish landings. The increased landings have been taken from Nova Scotian grounds and the Gulf of St. Lawrence, rather than from the more distant Grand Banks.

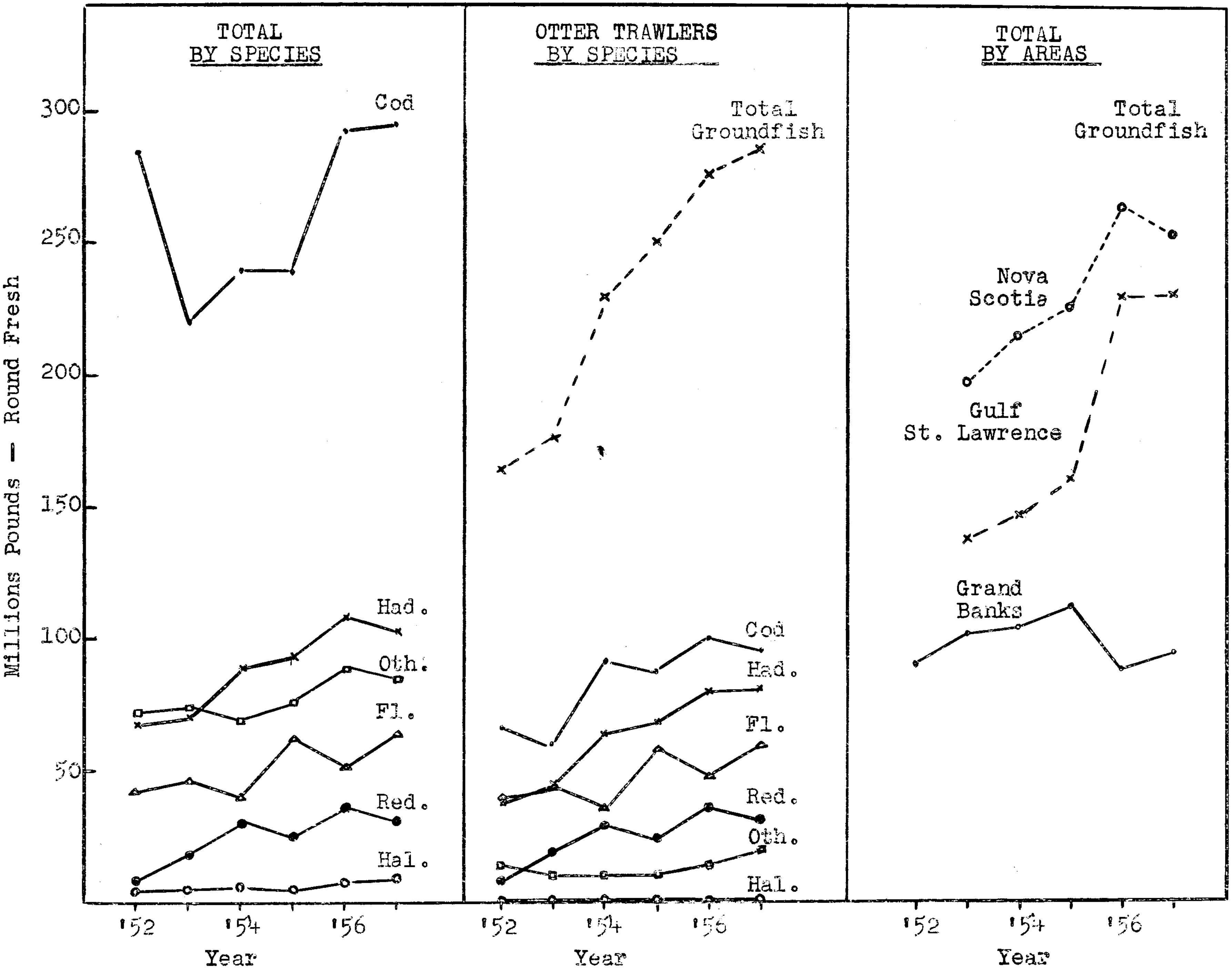


Figure 1. Groundfish landings, Canada (excl. Newfoundland), 1952-57.

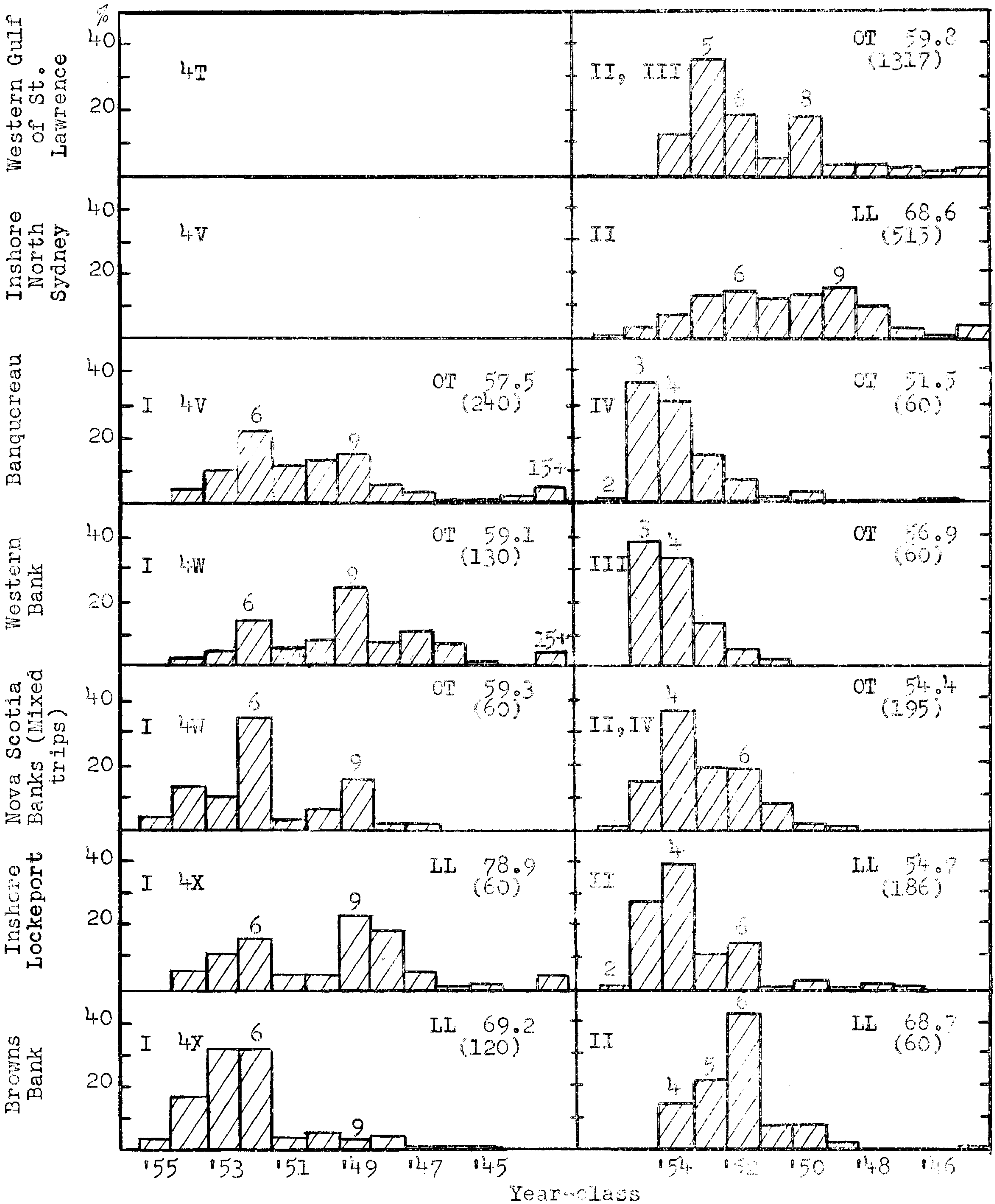


Figure 2. Cod age composition, Subarea 4, 1958. I (Feb.-Mar.); II (May-July); III (Aug.-Oct.); IV (Nov.-Jan.); OT (otter trawl), LL (longline), followed by mean length of sample in cm.; number of otoliths (about 1/5 of cod measured) in brackets.

The recent upward trend is part of a long-term increase in groundfish landings. In 1933 the total catch was only 250 million pounds, less than half current landings. Much of the increase resulted from the greater importance of otter trawlers. In 1933 most groundfish were taken by hook and line, and otter trawl landings were less than 20 million pounds. By 1957 otter trawl landings were 285 million pounds, about half the total groundfish catch. This conversion from line fishing to otter trawling changed the relative importance of species landed. In 1933 the groundfish catch was largely cod. By 1957, although cod landings had increased, they accounted for only half the groundfish landings. Haddock, plaice, redfish, halibut, and pollock were the other important species.

Increasing exploitation has been accompanied by decreasing catch per unit of effort of groundfish. In the Gulf of St. Lawrence, for example, cod catches by "Gloucester" class draggers have declined from about 40 to about 20 thousand pounds per week. Similarly, redfish catches by large otter trawlers have dropped below 2 thousand pounds per hour of dragging, and these vessels have extended their range of operations to Hamilton Inlet Bank, off Labrador, in order to maintain profitable fishing.

Increased landings have also been associated with smaller and younger fish in commercial landings. Steak cod (over 10 lb.) no longer contribute substantially to landings. The average size of cod in dragger landings from the southwestern Gulf of St. Lawrence dropped to 3.8 pounds (59.8 cm.) in 1958, the lowest point since small draggers were introduced to the Gulf fishery in 1947. In 1958 the dominant age-group was 5 years, and less than 15% of the cod landed by draggers were older than 8 years (Fig. 2).

Sampling of the major groundfish species was continued in 1958. About 19 thousand cod and 26 thousand haddock were measured. Otoliths were taken from one fifth of the fish measured.

Seasonal and geographic variations in the age composition of 1958 cod landings, as read from otoliths by Mr. Condon, are shown in Figure 2. The 1949 and the 1952-55 year-classes have been dominant on Nova Scotia grounds; the 1950 and 1953 year-classes in the southern Gulf of St. Lawrence. Throughout most of the year, the various cod fisheries in ICNAF Subarea 4 depend mainly on small, young, immature cod. Older, mature cod are taken from spawning concentrations during the first quarter of the year.

These statistics and sampling data on commercial landings form the basis for assessment of the status of the groundfish fisheries. Mr. Sullivan is in charge of the statistical work, and Mr. Fitzgerald controls the sampling program. Messrs. Fraser of Lunenburg, MacPherson of Sydney, and Thurber of Halifax carry out most of the field program. Mrs. DeLong assists with the compilation of statistics at Halifax.

W. P. Martin

No. 27

COD GROWTH IN TANKS

Experimentation on the controlled feeding of cod (Ann. Rept. 1957-58, No. 37) was terminated on September 4, 1958, with the accumulation of 54 weeks of continuous records. A preliminary analysis of the data was made by extracting figures for a year (52 weeks) of feeding and growth in three tanks of large-size and three tanks of small-size cod.

In order to separate food requirements for growth from food requirements for maintenance, one tank each of large and small fish was kept on rations that maintained them at a constant weight. Figures extrapolated from 45 weeks of data showed that for the large-size cod 48.5 ounces of frozen, whole herring were required to keep their weight constant for the year. The initially smaller cod used 41.5 ounces for maintenance during the same period.

An examination of growth data from the other tanks showed that increases in length and weight were greater for cod fed maximum amounts than for those on intermediate rations (see following table). Differences were more noticeable in weight than in length measurements. It was also evident that at both feeding rates, the ratio of growth in weight to initial weight was greater for the small-size groups of cod.

Average growth of cod and use of food during one year in captivity

Rate of feeding	Initial size		Growth Lth.	Growth Wt.	Food consumed	Food for maintenance	Food for growth	Convers. factor
		Oz.	In.	Oz.	Oz.	Oz.	Oz.	
Maximum	Lge.	26.7	4.3	26.2	106.7	48.5	58.2	2.2
Maximum	Sm.	15.7	5.6	24.6	96.5	41.5	55.0	2.2
Intermediate	Lge.	26.4	4.0	16.0	87.3	48.5	38.8	2.4
Intermediate	Sm.	15.8	3.5	13.3	69.0	41.5	27.5	2.1

By subtracting estimated maintenance rations from amounts of food consumed, average quantities of food used for growth of individuals in each of the four tanks were calculated. These figures were then divided by mean growth in weight to give conversion factors from food weight to fish weight. The table shows that these factors were very similar for varying combinations of sizes of fish and feeding rates. Both large and small cod on maximum rations converted food used for growth at the rate of 2.2 ounces of herring weight to 1 ounce of cod weight. Fish on intermediate rations showed a slightly poorer conversion in large than in small cod. In general, we may state that conversion factors for cod making intermediate to maximum growth range from 2.1 to 2.4 on a diet made up exclusively of whole herring.

A. C. Kohler

No. 28

MAGDALEN ISLANDS COD TAGGING

Results of cod tagging at the Magdalen Islands for the combined years of 1957 and 1958 have yielded new information on cod stocks in the Gulf of St. Lawrence. Tagging data for the period up to December 31, 1958, have been processed by the use of Kwiksort cards which provide swift access to data on movements, growth, and mortalities.

In late July and early August 1957, C. J. Bayers tagged 1,201 cod from the M. V. J. J. Cowie. The cod were caught close to the Magdalens, about three quarters of them by handline and the remainder by otter trawl. Following leads suggested by earlier tagging studies, 911 cod were tagged by the writer in the latter part of May 1958. They were obtained from cod and herring traps along the southeast coast of the Magdalen Islands.

Percentage recaptures

Details of the capture, number tagged, tag type, and recaptures for the two years up to December 31, 1958, are shown in the accompanying table. These results show higher recaptures for handlined cod than for those caught by otter trawl. Disk tags gave higher returns than hydrostatic. Over a four-month period, August to November in 1957 and 1958, trapped cod gave higher returns in 1958 than either handlined or otter-trawled cod did in 1957. There are many variables to consider in such a comparison, but it is thought that tagging mortalities of cod tagged from traps are probably lower since the fish were in vigorous condition at the time of tagging.

Movements

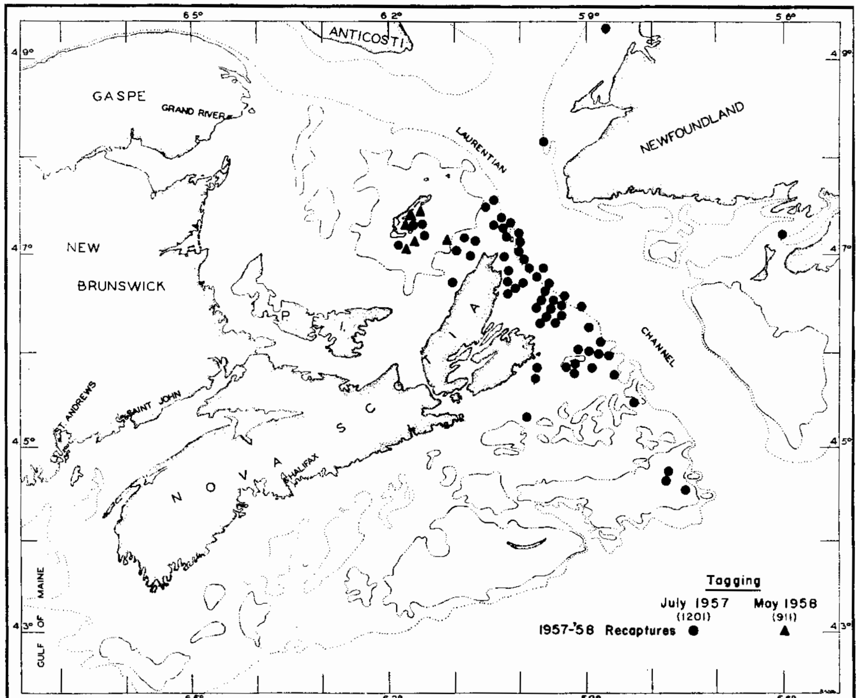
The locations of recoveries in 1957 and 1958 are shown in the accompanying figure. The first returns of cod tagged in July 1957 showed up close to the tagging area. Former studies showed few returns of cod tagged off northern New Brunswick and Cape Breton Island around the Magdalens, suggesting the existence of a separate stock in this latter area. However, from January to April, tagged fish were recaptured outside the Gulf along the 100-fathom contour down as far as Banquereau. The following

Magdalen Islands cod tag recoveries by year, type of tag, and method of capture, up to December 31, 1958.

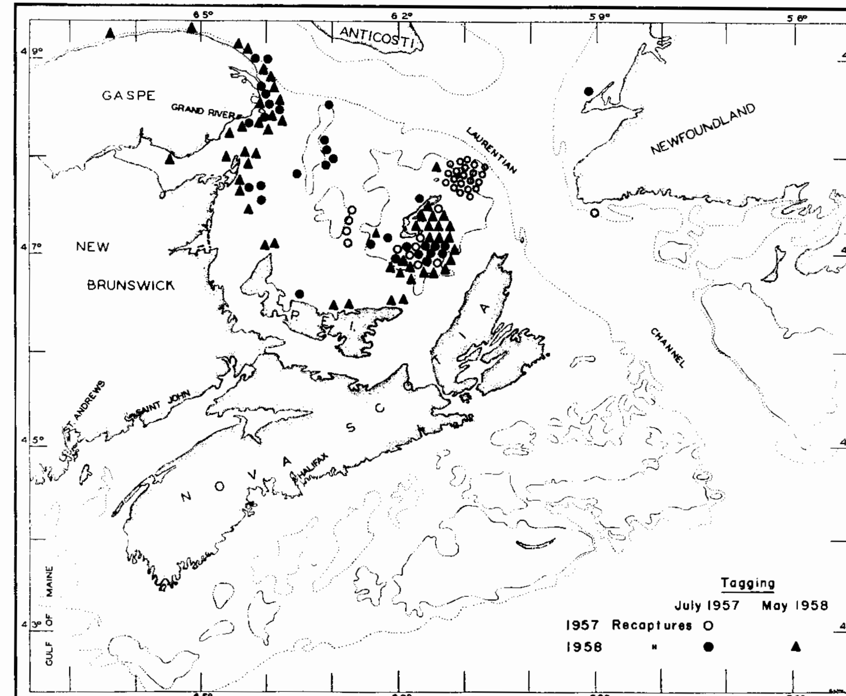
Method of capture	No. tagged	Tag type	1957 No. recovered	1957 % recovered	1958 No. recovered	1958 % recovered
1957 tagging						
Otter trawl	175	Hydrostatic	8	4.6	14	8.4
Otter trawl	295	Disk	5	1.7	26	9.0
Total	470		13	2.8	40	8.8
Handline	425	Hydrostatic	19	4.5	40	9.9
Handline	306	Disk	11	3.6	40	13.6
Total	731		30	4.1	80	11.4
GRAND TOTAL	1,201		43	3.7	120	10.4
1958 tagging						
From cod and herring traps	911	Disk	...	...	88	9.7

Recaptures of Cod Tagged at Magdalen Islands in 1957 and 1958

Recaptures from December to May



Recaptures from June to November



spring returns came in from the original tagging area, and later in the summer spread through the Gulf of St. Lawrence with concentrations at Bonaventure and Miscou Islands. Cod tagged in May 1958 spread through the Gulf in the same summer, starting in June. The 1957 cod were apparently tagged too late in the summer to show a northern movement into the Gulf during the same summer. These patterns of movements out of the Gulf into deeper water in winter, and into shallower water of the Gulf in summer are in general agreement with other tagging experiments carried out in the Gulf of St. Lawrence. Magdalen Islands cod appear to be part of the New Brunswick-Cape Breton cod stock.

Although two seasonal migration patterns appear clear, it should be remembered that fishing intensities probably exaggerate the picture. The Gulf fishery is in spring to fall only when waters are ice free, while the Laurentian Channel fishery off Cape Breton is largely in winter and early spring. In 1958 about one quarter of the winter returns were by European vessels, Spanish, French, and Portuguese, while the remainder and nearly all summer returns were by Canadian boats. The small amount of ice in the winter of 1958 favoured the winter fishery and the higher returns by Canadian vessels.

P. M. Powles

No. 29

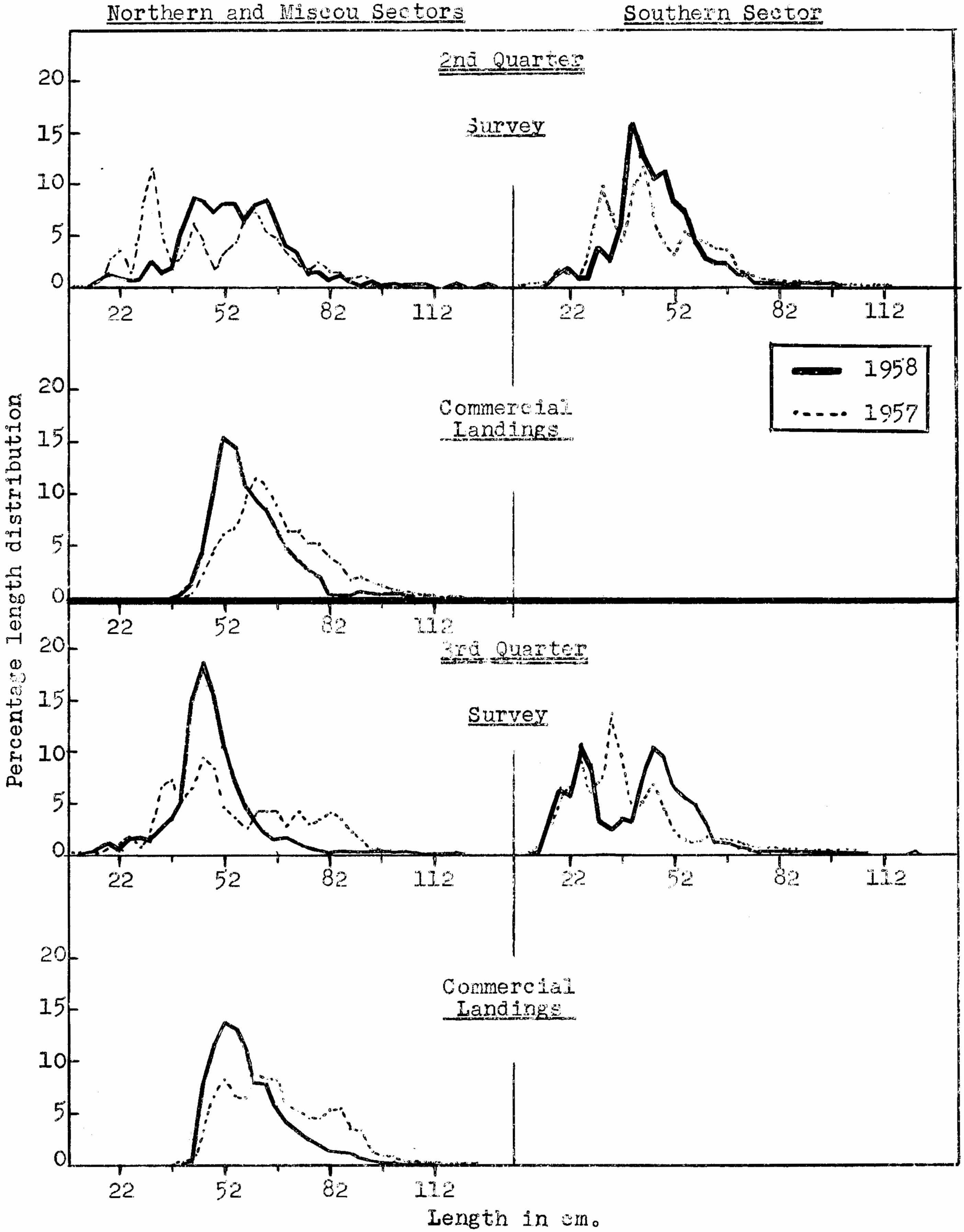
GULF COD SURVEY

The Gulf cod survey started in 1957 (Ann. Rept. 1957-58, No. 38) was continued in 1958. Field observations were carried out on the research vessel J. J. Cowie (Capt. C. J. Bayers). A 3/4 Yankee 35 otter trawl with a 1¼-inch mesh cover was used throughout. In addition to observations on length, maturity stages, parasites, and stomach contents, a survey of the bottom fauna at some stations and of plankton (eggs and larvae) at all stations was made in 1958.

From May 24 to November 28, 156 forty-five minute tows were made. A total of 5,163 cod were caught. The average number of cod per tow was much lower in 1958 than in 1957: 33 compared with 82.

Size composition

The size compositions of cod caught in the northern and Miscou sectors and in the southern sector of the area surveyed during the 2nd (May to July) and the 3rd quarters (August to October) of 1957 and 1958 are shown in the accompanying figure. The size compositions of cod landed at Caraquet, N. B., during the corresponding periods are also shown. Frequencies are expressed in percentages.



Size compositions of cod caught with a covered codend (Gulf Survey) and of cod landed by commercial draggers at Caraquet, N.B., during the 2nd and 3rd quarters of 1957 and 1958.

The modal sizes observed in the commercial landings appear in the survey catches also. In the 2nd quarter of 1957 landings showed a mode at 61 cm. This corresponds to the 55 to 61 cm. mode of the survey catches during the same period. Similarly, the modal sizes of 61 and 85 cm. in the landings of the 3rd quarter of 1957 correspond to the ones at 61 and 82 cm. in the survey catches of the northern and Miscou sectors during the same period. In 1958 the modal size of landings in both the 2nd and 3rd quarters was 52 cm. This corresponds to the length mode at 46 to 52 cm. in the survey catches of 1958.

The figure also shows that small cod -- modal sizes of 22 and 31 cm. in the 2nd quarter and 25 and 34 cm. in the 3rd quarter -- formed a smaller proportion of the survey catches in 1958 than in 1957.

Growth

Preliminary age determinations indicate that the modal lengths of 22, 31, and 43 cm. in the survey catches of the 2nd quarter of 1957 belong to the 1955, 1954, and 1953 year-classes, respectively. The 19-cm. group caught in the southern sector during the 3rd quarter of 1957 presumably belongs to the 1956 year-class. By following these modes from one quarter to the next, some idea of the growth of Gulf cod is obtained. These are shown in the following table:

Modal sizes in cm. of some year-classes in the 1957 and 1958 survey catches

	1957		1958	
Year-class	2nd quarter	3rd quarter	2nd quarter	3rd quarter
	Northern and Miscou sectors			
1955	22	25	31	?
1954	31	37	46	46
1953	43	46	55	?
	Southern sector			
1956	--	19	22	25
1955	22	25	31	?
1954	31	34	40	46

These figures indicate a growth of about 9 to 12 cm. a year in Gulf cod of age-groups 1 to 4.

Prediction

On the basis of the data shown in the table, cod 43 to 46 cm. long (1953 year-class), caught during the 1957 survey (see figure), appear to make up the bulk of the commercial landings in 1958 when most cod were 52 cm. long and 5 years old.

Similarly, the 46-cm. cod (1954 year-class) observed in the 3rd quarter of the 1958 survey, especially in the northern and Miscou sectors, are expected to be 52 to 55 cm. long (5 years old) in 1959.

As seen in the figure, more than twice as many cod 46 cm. long (1954 year-class) as cod 52 to 55 cm. long (1953 year-class) were present in the survey catches of the 3rd quarter of 1958. If the 1958 survey catches are an indication of the relative strength of these two year-classes, it is anticipated that the 1954 year-class will replace the 1953 year-class as the dominant one in the 1959 landings in northern New Brunswick. As in 1958, the bulk of the 1959 landings will be made up of 5-year-old cod. As a result, no appreciable change from the small average size of cod landed in 1958 is anticipated in 1959.

Yves Jean

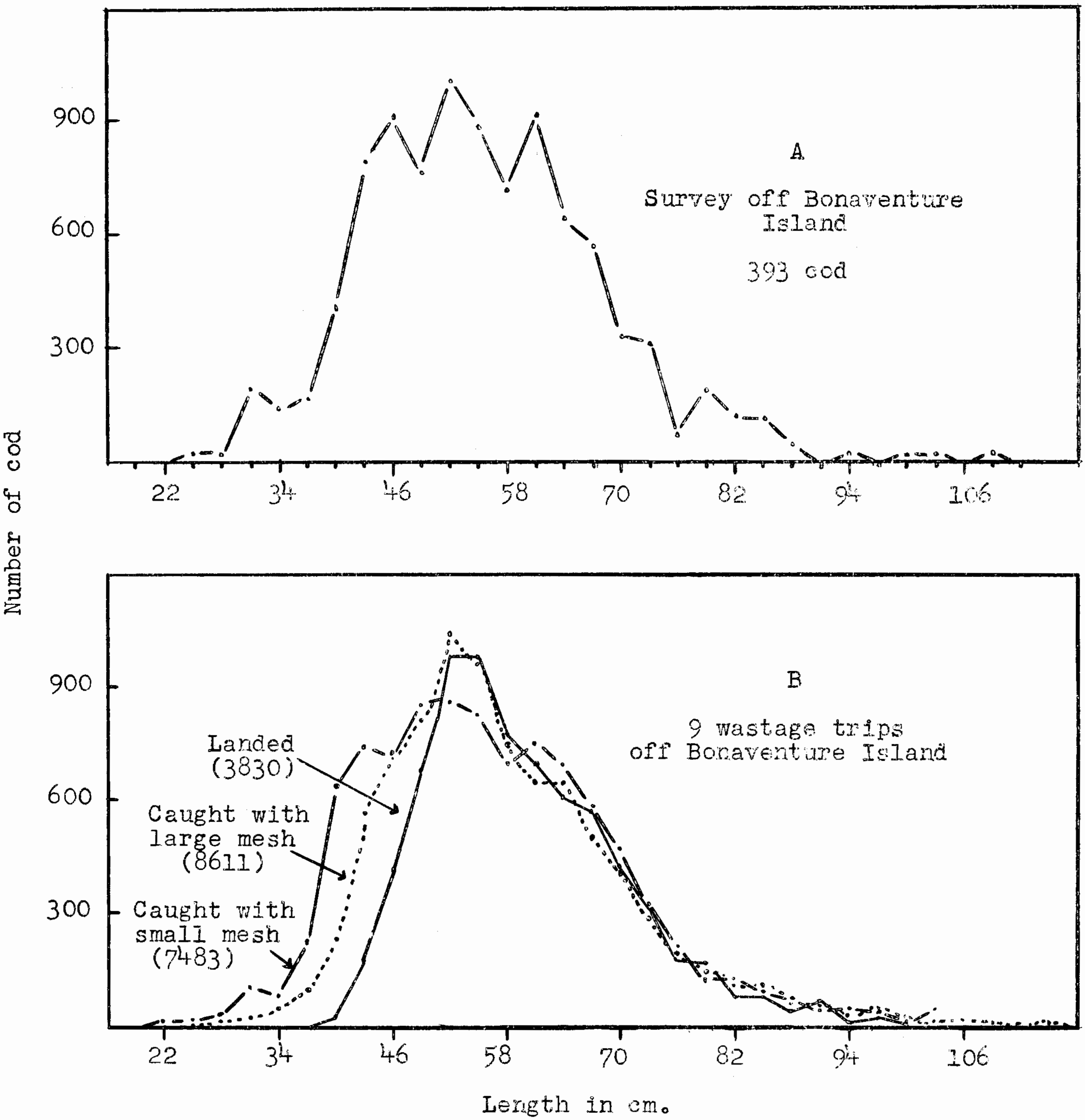
No. 30

SELECTION STUDIES ON GULF COD

Up to about July 1, 1958, codends of a mesh size smaller than the 4½-inch regulation were still in use in northern New Brunswick. After that date, however, most draggers used codends averaging 4¾ inches in mesh size. It was therefore possible, as in 1957, to study the selection of various mesh sizes during commercial fishing operations. The results were compared with those of fine-mesh survey studies and a mesh selection experiment with a 5¾-inch mesh manila codend.

From May 26 to August 16, an observer, W. E. Russell, made 10 trips aboard commercial draggers. Four trips were made on draggers using small-mesh (3 to 4¼ in.) and 5 trips on draggers using large-mesh (4¾ in.) codends. These draggers fished mostly on the Bonaventure Island grounds. A tenth trip was made in Chaleur Bay. Sea samples of up to 2,000 and shore samples of about 400 cod were measured for each trip. The 1957 data indicated that fish as large as 59 cm. were discarded by commercial draggers. For this reason, sea and shore samples were equalized above 59 cm. (Ann. Rept. 1957-58, No. 29). In 1958, however, few fish below 50 cm. were discarded. Sea and shore samples were therefore equalized above 50 cm.

By comparing the numbers of cod caught and the numbers of cod landed in 1958, percentage figures for discards were obtained. The average discards on 4 trips by small-mesh draggers off Bonaventure Island were 23% by number and 9% by weight. The discards on 5 trips by large-mesh draggers on the same fishing grounds averaged 12% by number and 5% by weight. These results confirm those of 1957. They indicate that 4¾-inch mesh codends allow the escape of a substantial number of small cod, and reduce discards by about one half. This is also evident in the lower portion of the accompanying figure where



Size compositions of (A) cod caught with covered codend, and of (B) cod caught with small-mesh (3 to 4¼ inch) and large-mesh (4¾ inch) codends, and of cod landed in northern New Brunswick in 1958. All frequencies equalized above 50 cm. Number of fish in brackets.

the size compositions of cod caught by small- and large-mesh codends are plotted against size compositions of cod landed during 9 wastage trips. Size compositions of cod caught with a fine-mesh codend (No. 29) are shown in the upper portion of the figure for comparison.

In order to consider the potential for releasing still greater numbers of small cod which are currently wasted, the selectivity of a larger-mesh codend was tested in 1958. The mesh selection experiment was carried out on the research vessel J. J. Cowie with a 5¾-inch mesh 75/4-ply manila codend with a fine-mesh cover. The length at which 50% of the cod escaped was 48 cm. A selection factor

$$\left(\frac{\text{50\% retention length}}{\text{average mesh size}}\right) \text{ of 3.3 was found.}$$

When sizes of cod caught with 4¾-inch codends during normal fishing operations were compared with sizes of cod caught with smaller meshes -- 3 to 4¼ inches -- selection factors ranging from 3.3 to 3.7 were found.

In predicting the effects on landings of mesh sizes larger than the 4¾ inch presently in use, variations in selection factor as well as in size composition, commercial cull and fishing efficiency of larger-mesh codends must be taken into account. For instance, the 50% cull point for 10 wastage trips in 1957 varied from 44 to 55 cm. (average 50 cm.). This point varied from 43 to 50 cm. (average 46 cm.) for 10 wastage trips in 1958. In order to measure the maximum and minimum effects of 5- and 5½-inch mesh on landings, the lowest selection factor, 3.3, was applied to the 1957 catch data for large fish and a high commercial cull point. An increase of 5% in fishing efficiency was assumed. Similarly, the highest selection factor, 3.7, was applied to the 1958 catch data for smaller fish and a lower commercial cull point. No increase in efficiency was assumed. The results are shown in the following table:

Estimated effects of 5- and 5½-inch mesh on discards and landings in northern New Brunswick

50% cull point cm.	Selection factor	Efficiency increase in %	% discards by number 5" mesh	5½" mesh	Initial effects on landings in % weight 5" mesh	5½" mesh
50	3.3	5*	12	6	+4	+ 4
46	3.7	0	1	0	-5	-15

*for fish above 100% cull point, i.e., 59 cm.

The above table shows that, with the current size composition of catch and culling practices, most unmarketable sizes of cod would be released by 5½-inch mesh nets. The initial effects of a 5-inch mesh on landings would probably range from a loss of about 5% to a gain of about 4%. Initial effects of a 5½-inch mesh on landings would probably range from a gain of about 4% to a loss of about 15%. The long-term effects would depend on survival and growth of the cod that escape from the large meshes.

Since no appreciable change in the size composition and cull size is anticipated for 1959, the use of a $5\frac{1}{2}$-inch mesh might lead to appreciable initial losses of commercial-size cod. On the other hand, discards would be reduced to negligible quantities, and survival and growth of released fish might more than compensate for initial losses.

Further observations on the effects of the regulation mesh size ($4\frac{1}{2}$ in.) appear to be desirable before commercial trials with a larger mesh size are undertaken.

Yves Jean

No. 31

PLAICE STUDIES

Investigations of the American plaice, Hippoglossoides platessoides, were carried out in conjunction with the 1958 cod survey program in the southwestern Gulf of St. Lawrence. A tagging program was initiated and regular samples were taken at three of the survey stations representing different depths. Two additional samples were obtained from within the Bay of Chaleur by Dr. A. Marcotte of the Marine Biological Station, Grand River, P. Q.

Tagging

A number of plaice were tagged to initiate studies of mortalities, movements, and growth of this important species. In the latter part of June, 320 plaice were tagged southeast of Shippegan Gully in the locality shown in Figure 1. The writer tagged them from the M. V. J. J. Cowie which fished at a depth of 30 fathoms with a 3/4 #35 Yankee otter trawl. To date, 86 tags or 27% have been recovered. This indicates a rather high rate of exploitation, although it should be noted that fishing intensity in the particular area of tagging during 1958 was slightly higher than former years.

Tagged plaice were retaken during their first summer in numbers very closely related to the numbers of each length tagged, except for small plaice. Only 15% of those plaice under 30 cm. were recaptured. The 50% retention point for the $4\frac{1}{2}$-inch manila codend used by commercial boats is 23 cm., a figure too low to be the primary cause of low recaptures. It is felt that low recaptures at lengths below 30 cm. were due to tagged plaice being overlooked by the fishermen. Very few fish below this length are landed at plants, whereas many are caught and discarded at sea.

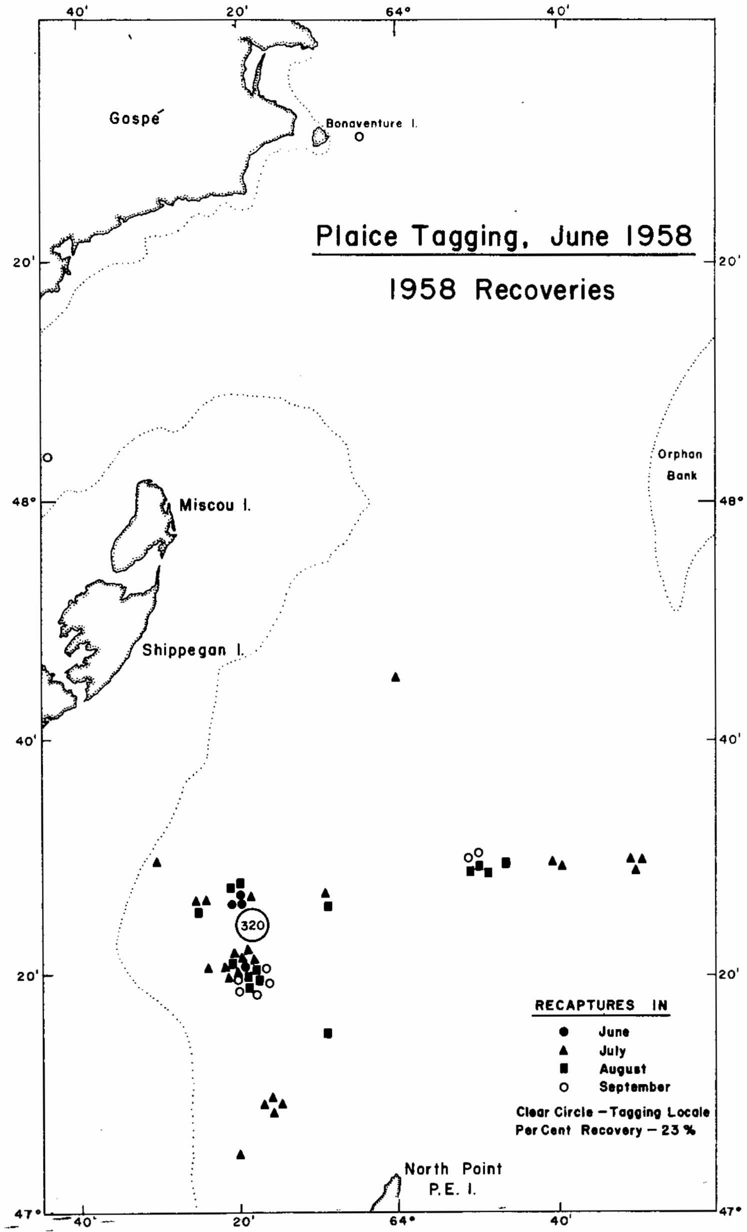


Figure 1.

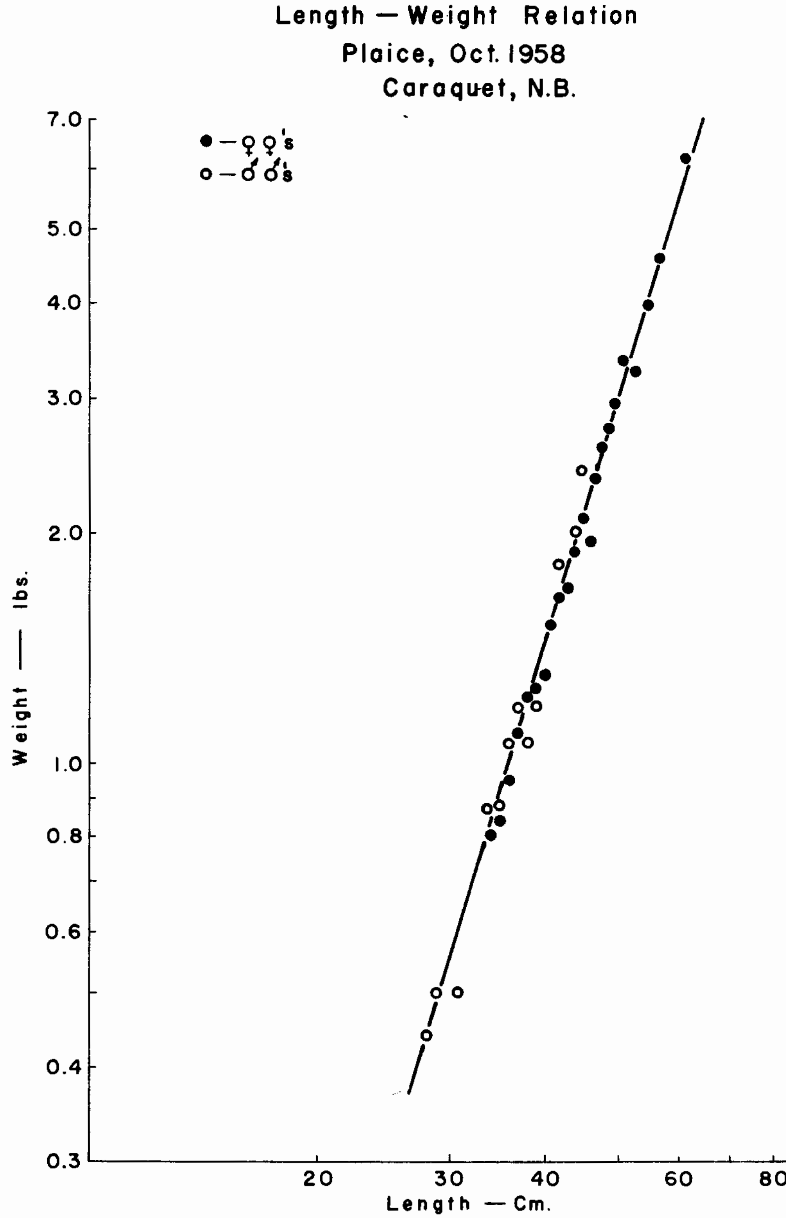


Figure 2.

There were indications of movement offshore and away from the area of tagging during the summer, but the majority of plaice appeared to remain within the immediate tagging area. Two plaice recaptured in September had moved about 100 miles north, one to the Bay of Chaleur and the other to Bonaventure Island. No returns in which the location of recapture was questionable have been plotted in Figure 1.

In October, 180 plaice were tagged northeast of Miscou Island in a depth of 30-40 fathoms, and 147 were tagged east of Orphan Bank in 50-60 fathoms. Plaice of lengths between 15 cm. and 25 cm. were marked with dagger tags, while disk tags were used on fish above 22 cm. in length. It is hoped by this overlap to obtain information on the relative efficiency of dagger tags. Five disk tags have been returned to date, all from the area of tagging, while as yet, no dagger tags have been recovered. However, fishing in the area ceased shortly after the end of October and will not be resumed until spring.

Sampling

Approximately 1,200 plaice were sampled by recording the length, sex, and state of the gonads. The otoliths were removed from one third of these and food organisms were noted.

Spawning took place mostly during May and into June. Plaice appeared to reach the spawning phase earlier in the shallow water of the Bay of Chaleur than in the slightly deeper water around Miscou Island. Since early sampling at the deep-water station gave small catches, consisting mostly of immature fish, further work will have to be done along this line to ensure that the samples taken are representative of stocks present in the area. Female gonads began to ripen again in the same order with respect to areas, starting in September in the shallow waters and October in the deeper waters.

Size at maturity for females was roughly equal over the area, at 35 to 40 cm. Definition and interpretation of the male sexual stages require further studies if we hope to compare areas with respect to size at maturity.

Otolith readings and growth data from tagging will provide further information on whether real differences exist within the plaice stocks in the southwestern Gulf of St. Lawrence. Present indications are that there is one large stock of plaice in this area, with small local variations.

Studies have also been initiated in length-weight relations of plaice, a sample of which is plotted on a log-log scale in Figure 2. The sample was taken in October from Bonaventure and Miscou Island grounds. A straight-line relationship was obtained with a slope of 3.3. No differences between males and females or between the two areas are apparent.

P. M. Powles

No. 32

HADDOCK TAGGING

Only 38 haddock were tagged in 1958, but returns from earlier taggings have provided new information about haddock stocks and migrations. Details about the haddock taggings in 1956 and 1957 are summarized in the following table:

Areas, times, and number of haddock tagged in 1956-57.

Region	Tagged Year	Tagged Month	Number	Method of capture
Northumberland Strait	1956	Sept.-Oct.	968	Otter trawl
Browns-LaHave	1957	Mar.-Apr.	1,123	Otter trawl
Passamaquoddy Bay	1957	Nov.-Dec.	1,015	Otter trawl
Grand Manan Channel / Digby Neck	1957	Dec.	70	Otter trawl

Total recaptures through 1958 have reached about 13% of those tagged in the 1956 Northumberland Strait tagging; about 4% for the 1957 Browns-LaHave Bank tagging; and about 16% for the Passamaquoddy-Bay of Fundy tagging. All these were tagged with plastic disks attached dorsally through the flesh.

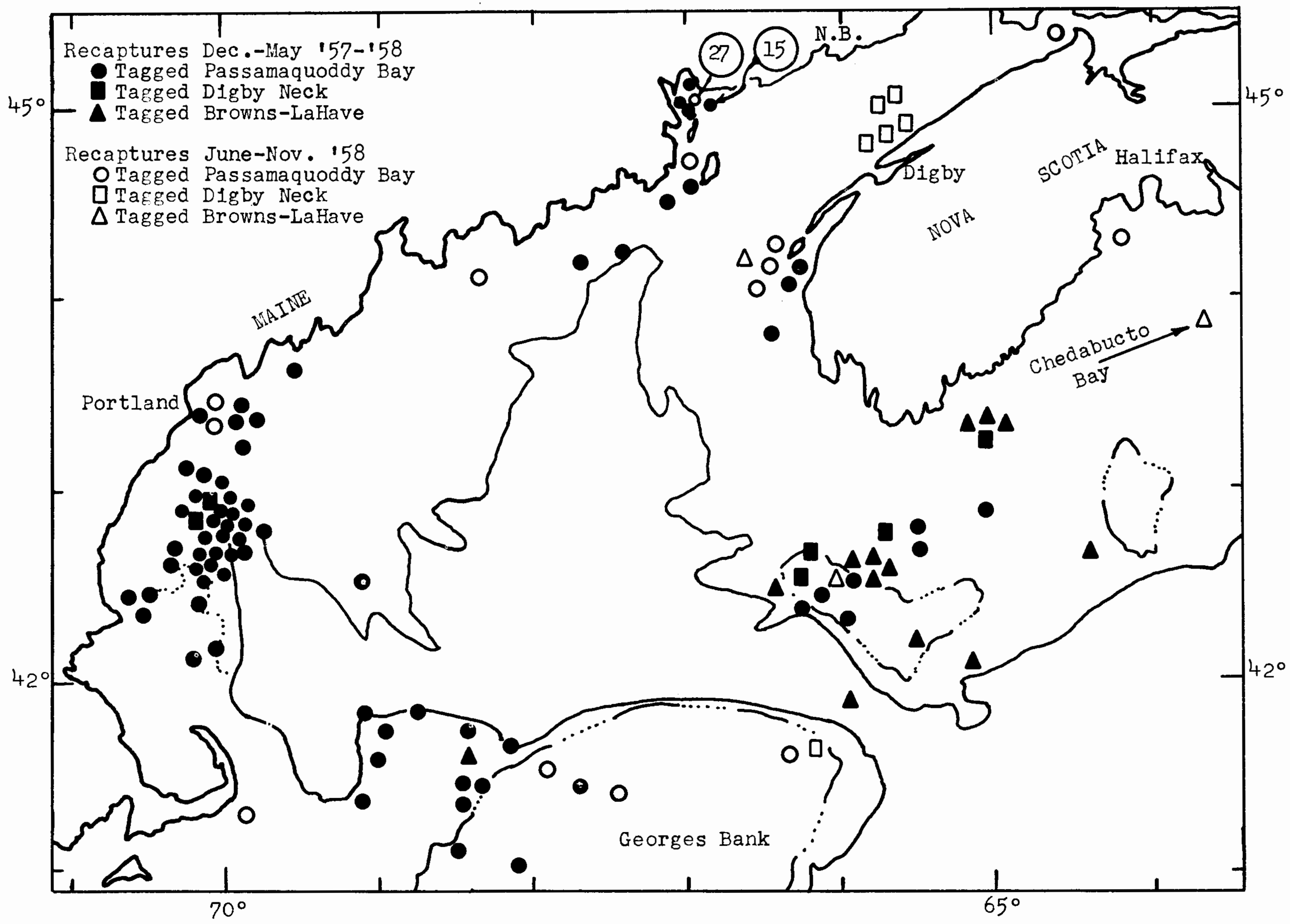
Northumberland Strait tagging

Recaptures in 1958, while lower than in 1957, show the same seasonal pattern of distribution (described in last year's report). Winter haddock recaptures came from banks offshore from Nova Scotia; spring and late fall recaptures were mainly from the east coast of Cape Breton. For the remainder of the year, recaptures were scattered but most came from the region of tagging, around eastern Northumberland Strait.

Browns-LaHave and Bay of Fundy taggings

Locations of tagged haddock recaptures between December 1957 and November 1958 are shown in the accompanying figure. During the winter of 1957-58, of 13 reported recaptures, 9 came from the region of tagging, 3 from off Lockeport, N. S., and 1 from deep water of the South Channel region in the Gulf of Maine. Only 3 haddock were recaptured in the summer of 1958, 1 from Digby Neck, 1 from Browns Bank, and 1 from Chedabucto Bay. Recaptures during the summer of 1957 (not shown in figure) were low and mainly from inshore grounds off western Nova Scotia.

Haddock tagged at the mouth of the Bay of Fundy scattered widely during the succeeding winter (see figure). Of those tagged in the Passamaquoddy Bay area, many were recaptured around Jeffreys Ledge and the South Channel region of the western Gulf of Maine. Significant numbers were also reported recaptured from the area between Digby Neck and Browns Bank. Of 70 haddock



Recaptures of haddock tagged in 1957.

tagged off Digby, 6 were recovered in this period, 2 from Jeffreys Ledge and 4 from Browns-Baccaro Bank area.

In the summer of 1958, recaptures of Passamaquoddy Bay tagged fish were mainly from the region of tagging. An occasional recapture was reported from off Cape Cod, Georges Bank, Digby Neck, Scott's Bay, and St. Margaret's Bay. Three of the Digby Neck tags were retaken, 1 on Georges Bank and the other 2 toward the head of the Bay of Fundy.

Discussion

Results from all the summer and fall haddock taggings have shown extensive seasonal migrations. The results suggest a fall-winter movement to the west and south, and a return movement by the following summer to the tagging region.

That Browns Bank and Georges Bank haddock are separate stocks has been postulated on the basis of differences in growth, age, and size composition and vertebral counts (the deep-water Fundian Channel between these banks is suggested as a barrier). The results from tagging on Browns Bank (and U.S. tagging on Georges) support this postulation. Only 2 haddock tagged on Browns-LaHave have been retaken on Georges and South Channel in a year and a half following tagging.

Results from the winter tagging on Browns Bank indicate a local stock with some fish moving in summer to inshore grounds west of Cape Sable. However, results of a haddock tagging at Lockeport (1953) and these taggings in the Bay of Fundy suggest that concentrations of fish from both these regions help support the winter-spring haddock fishery in the Browns-LaHave region. Problems concerning mixing of stocks may be further resolved if tagged haddock continue to be recaptured in fair numbers for several years.

F. D. McCracken
C. R. Garnett

No. 33

HADDOCK SURVEY

In August 1958 a survey of groundfish populations on offshore Nova Scotian Banks was begun. The survey program is aimed at measuring recruitment and determining the influence of environmental factors on the abundance, distribution, and movements of groundfish. The results should lead to short-term predictions of the relative abundance of fish to the fishery. They also provide material to assess growth rates of young fish not available from commercial landings. These data are necessary for considering the population dynamics of the stocks.

The area surveyed was limited to regions of Emerald and Sable Island Banks where the main species caught was haddock. From August 13 to 28, the M. V. Harengus (Capt. H. H. Butler) made 48 tows of 45-minutes duration at the 30 stations shown in Figure 1. For all tows a #36 manila trawl (60-ft. headrope) with a nylon codend of 4 5/16-inch mesh was used. The codend end was covered with a loose, 1½-inch mesh cover of Nyak.

Haddock, cod, and on occasion other species, if they predominated in the catch, were measured to the nearest centimetre. Whole catches were measured where possible, and if they were too large, the catch was sampled. Catches in codend and cover were recorded separately. These data provided incidental information about selection of the codend. On a representative sample from each tow (usually 2 fish from each 5-cm. length group) information about sex, gonad development, parasites, and food was recorded.

Results

In the shallow water around Sable Island, 10-20 fathoms, haddock around 20 cm. in length were most numerous (Fig. 1). Probably these were the 1957 year-class (age determinations have not been analyzed yet). Other sizes of haddock were not caught in large numbers. In deeper water, 20-45 fathoms, smallest haddock were reduced in numbers, but haddock of intermediate size, with modes at 30 and 40 cm., were numerous. Larger haddock, 48 cm. and over, were not as numerous as from similar depths on top of Emerald Bank. In still deeper water (45+ fathoms) southwest and west of the banks, haddock around 20 cm. recurred again along with fair numbers of large haddock, but intermediate sizes were scarce. In the deepest water northeast of Emerald Bank only redfish were taken.

Small numbers of cod were caught at almost all stations where haddock were taken but not in the shallow water on the west bar of Sable Island.

The data on parasite infestation and food organisms have not been extensively analyzed. Only a few specimens of the parasitic copepod, *Lernaeocera branchialis*, were seen on cod gills and none on haddock. The parasitic copepod, *Clavella* sp., was more common, occurring on the gills, anus, fins, and in the buccal cavity of both species. However, their occurrence did not follow any easily recognizable pattern which could be used to recognize stocks.

Haddock were feeding chiefly on bottom invertebrates. These included sea urchins, molluscs, hermit crabs, and sand dollars. Other species of invertebrates, such as isopods, amphipods, euphausids, and mysids were common. Fish were not an important part of the food in these collections.

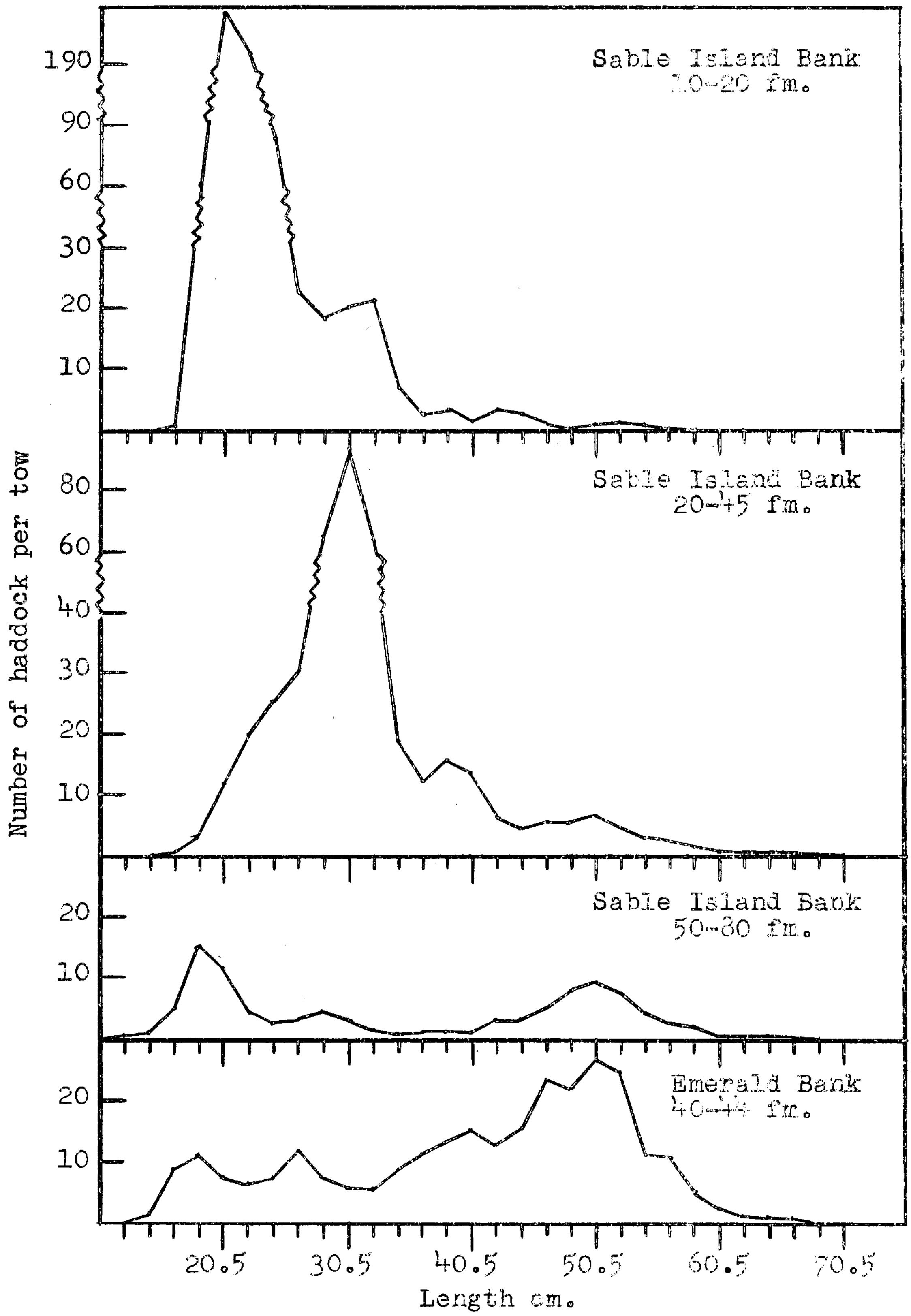


Figure 1. Size composition of haddock by depth -- Subdivision 4W, August 1958.

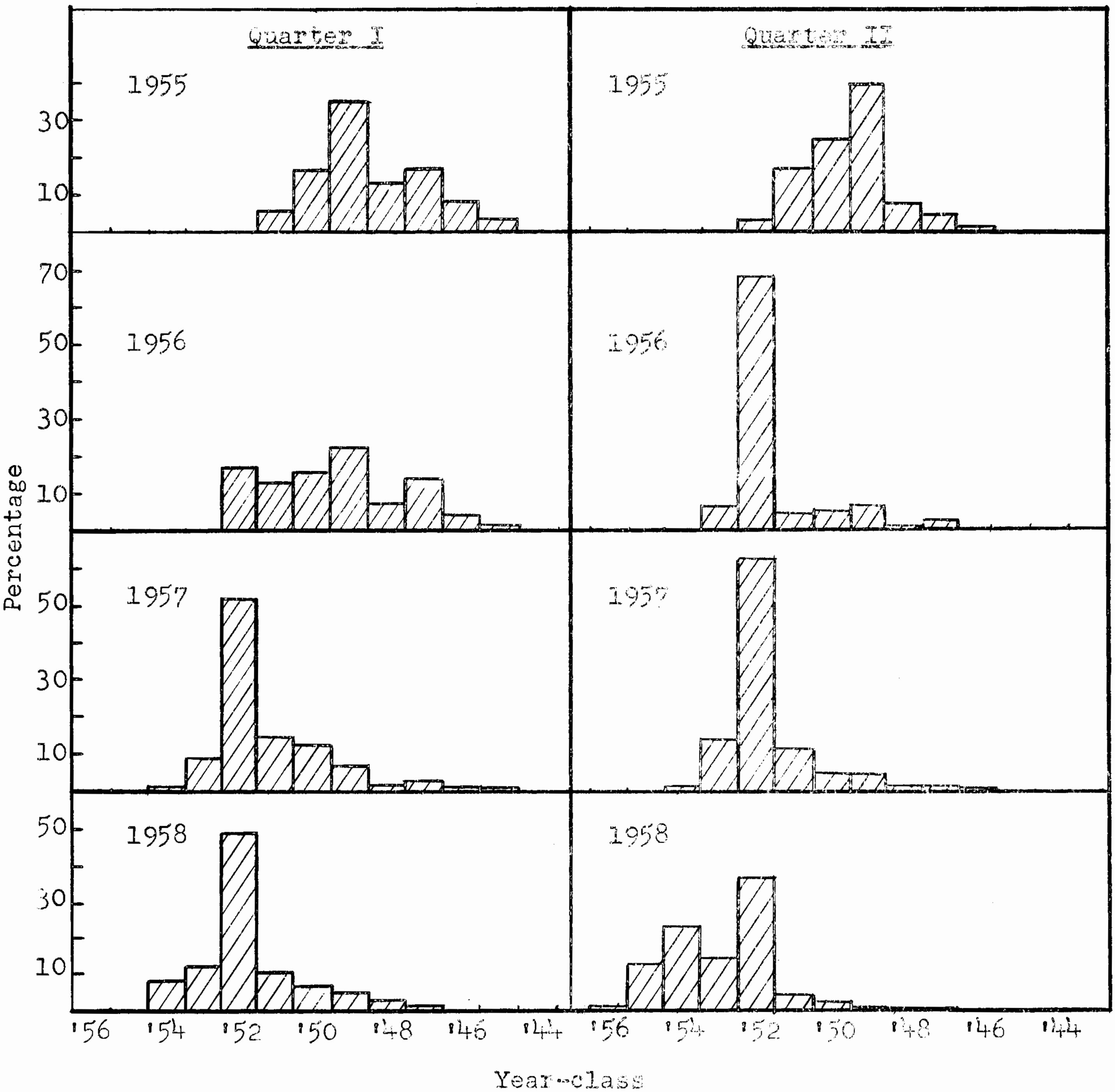


Figure 2. Age composition of haddock in otter trawl landings from Subdivision 4W.

Discussion

Although the size distribution of haddock has been presented in relation to depth, there does not appear to be a simple relation to any one environmental factor. Bottom temperatures are also related to depth, with warmest water in the shallows around Sable Island, coldest water on top of the banks in moderate depths, and warmer water recurring again deeper. However, the absence of haddock northeast of Emerald Bank, and the apparent concentration of haddock on top of Emerald Bank, are not satisfactorily explained by either depth or temperature as limiting factors. Further exploration of variations in other environmental factors and of the seasonal distribution of haddock is planned.

Until 1958, measures of abundance of year-classes depended mainly upon sampling for age and length of haddock landed by commercial vessels. The surveys begin to provide information about younger and smaller fish which should become useful for prediction of commercial landings.

The 1952 year-class of haddock has been dominant in samples of the commercial landings from Nova Scotian Banks since 1956 (Fig. 2). It has been particularly important to Canadian landings from offshore banks throughout the years 1956 and 1957. Preliminary accounts of the 1958 haddock fishery suggest that it has been reduced during the summer months. No outstanding year-class since that of 1952 has appeared in the fishery.

F. D. McCracken
N. J. McFarlane

No. 34

HADDOCK DISCARDS

Between May 23 and August 25 a student assistant, L. L. MacLeod, made six trips on commercial trawlers from Nova Scotian ports. Five trips were on large otter trawlers from Halifax, the sixth on a smaller otter trawler from Glace Bay. Fishing was mainly on Banquereau, Sable Island Bank, and Middle Ground in ICNAF Subdivisions 4V and 4W.

Sample measurements of haddock catches have been compared with samples of landings to obtain calculations of quantities and sizes of discards. In addition, estimates of catches and discards for all species were recorded for each tow. Estimates of quantities of haddock caught and landed are summarized in Tables I and II.

Discards from trips in which all haddock landed were gutted are summarized in Table I. Discards ranged from 3 to 7% by weight and 6 to 15% by number. Calculated total discards for all three trips were about 5% by weight and 10% by number. These calculations agree well with visual estimates by the observer who estimated discards of from 3 to 12% by weight.

Groundfish

Discards from trips in which part of the haddock landed were round (ungutted) are summarized in Table II. Best calculations for the round haddock portion of trips D and E are that 2 to 4% by weight were discarded. Discards were lower than for the "gutted" trips, A, B, C. Calculations agree with the observer's visual estimates.

Table I. Discard estimates from "gutted" haddock trips, May-August 1958; mesh size 4½ inches or more; top chafing gear of netting and/or cowhide.

Trip	Weight landed	No. landed	Weight caught	No. caught	% discarded each trip		% weight discarded (sea estimates)
	Cwt.	'00	Cwt.	'00	Wt.	No.	
A	955	392	1027	461	7	15	3
B	530	220	554	247	5	11	12
C	1390	592	1432	630	3	6	4
Total	2875	1204	3013	1338	4 to 5	9 to 10	

Table II. Discard estimates from "round" haddock trips, May-August 1958; mesh size 4½ inches or more; top chafing gear of netting.

Trip	Weight landed	No. landed	Weight caught	No. caught	% discarded each trip		% weight discarded (sea estimates)
	Cwt.	'00	Cwt.	'00	Wt.	No.	
D							
gutted	251		398	not	37	56	34
round	449		468	estimated	4	12	5
	700	300	866		(14)		18
E							
gutted	27		41	not	33	47	12
round	563		575	estimated	2	5	2
	590	332	616		(3)		1
Total	1290		1482		9		

Calculations of the discards during the gutted portion of trips D and E are much less adequate. Changes in cull between the round and gutted portion of the trips affect the application of the shore samples to this portion of the trip. For the gutted portion of trip D, discards were calculated at 37% by weight (observer's estimate 34%). For trip E, calculated discards are

33% for the gutted portion of the trip; observer's estimates are only 12%.

Discussion

Numbers of discards depend upon the size composition of fish available to the fishery, selection by the gear, and culling by the fishermen. All these are variable and depend upon area, season, mesh size, and market conditions.

Previous sampling for wastage in 1951-52 showed that commercial small-mesh nets (about 2 7/8 in.) were catching haddock of about 30 cm. in length in quantity. Discards in the summer of 1951-52 ranged between 40 and 60% by weight. Virtually all haddock below 40 cm. and some up to 45 cm. in length were discarded.

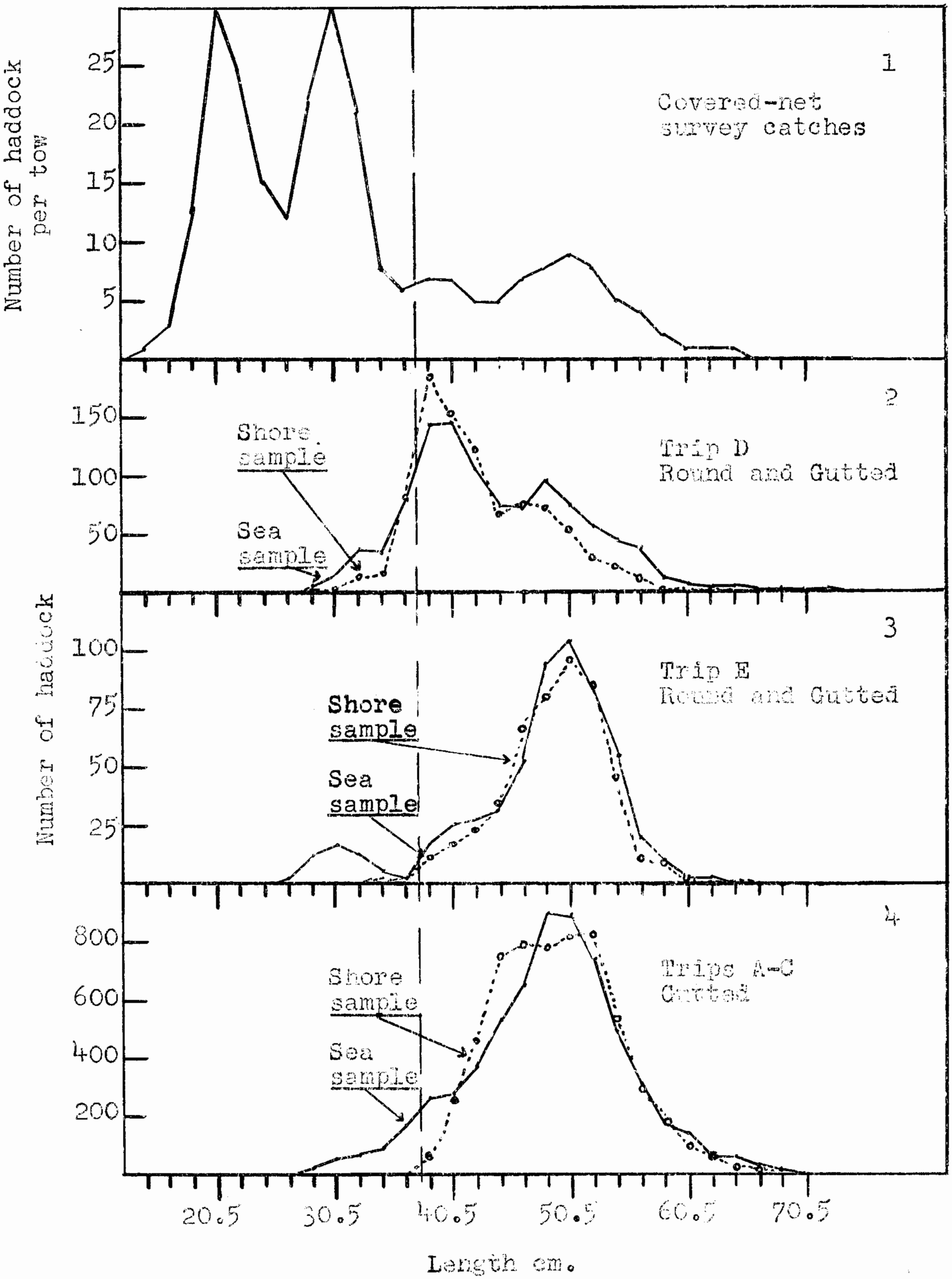
In 1958, discards were much below 1951-52 levels. Small fish were still found on the grounds fished by commercial trawlers. Results of the covered-net survey on Sable Island Bank showed haddock of about 30 cm. in length to be numerous (see accompanying figure). These would have been taken and discarded by small-mesh commercial nets, but were being released by large-mesh nets of 4½ inches or more.

Most haddock caught by the large-mesh nets in 1958 were being landed (see figure). Culling practices have changed quite markedly since 1951-52. While haddock were being saved round, virtually all fish down to 38 cm. were being saved. Even when haddock were being gutted, virtually all haddock down to 40 cm. were saved.

It appears that the large-mesh nets of 4½ inches or slightly more are functioning to release virtually all haddock below commercial size. They are also releasing some haddock between the 35-40 cm. range, although the data from these commercial trips are too variable to allow selection curves to be drawn. Probably some haddock being released could be landed as round haddock, but selection by the 4½-inch mesh approximates the cull for gutted haddock. It appears that mesh sizes appreciably larger than 4½ inches, manila twine (or equivalent), would release fair quantities of currently marketable haddock.

Other species

Estimated weight of discards for some other commercially important species are summarized in Table III. About 13% of the cod caught were discarded, all under about 2 pounds in weight. Almost all the pollock caught were landed. On early trips all yellowtail were discarded, principally as a result of the chalky condition of the flesh. As the season progressed, discards decreased to about 5% for the final trip. Discards of witch were negligible. About 20% of the smaller redfish were discarded.



1. Haddock lengths, Sable Island Bank, covered-net survey.
2-4. Haddock lengths caught and landed by commercial otter trawlers from Subarea 4, May-August 1958.

Of non-commercial species, relatively small quantities of skate and silver hake were caught and all were discarded.

Table III. Discards of species other than haddock, estimated from observer's log records.

Species	Estimated weight caught	Weight landed	Estimated % weight discarded	Remarks
	Cwt.	Cwt.		
Cod	1449	1254	13	Fish below 45 cm.
Pollock	544	543	0.2	
Yellowtail	721	322	64	All sizes, chalky, discards decrease with time after spawning.
Witch	266	256	4	
Redfish	51	41	20	

F. D. McCracken

No. 35

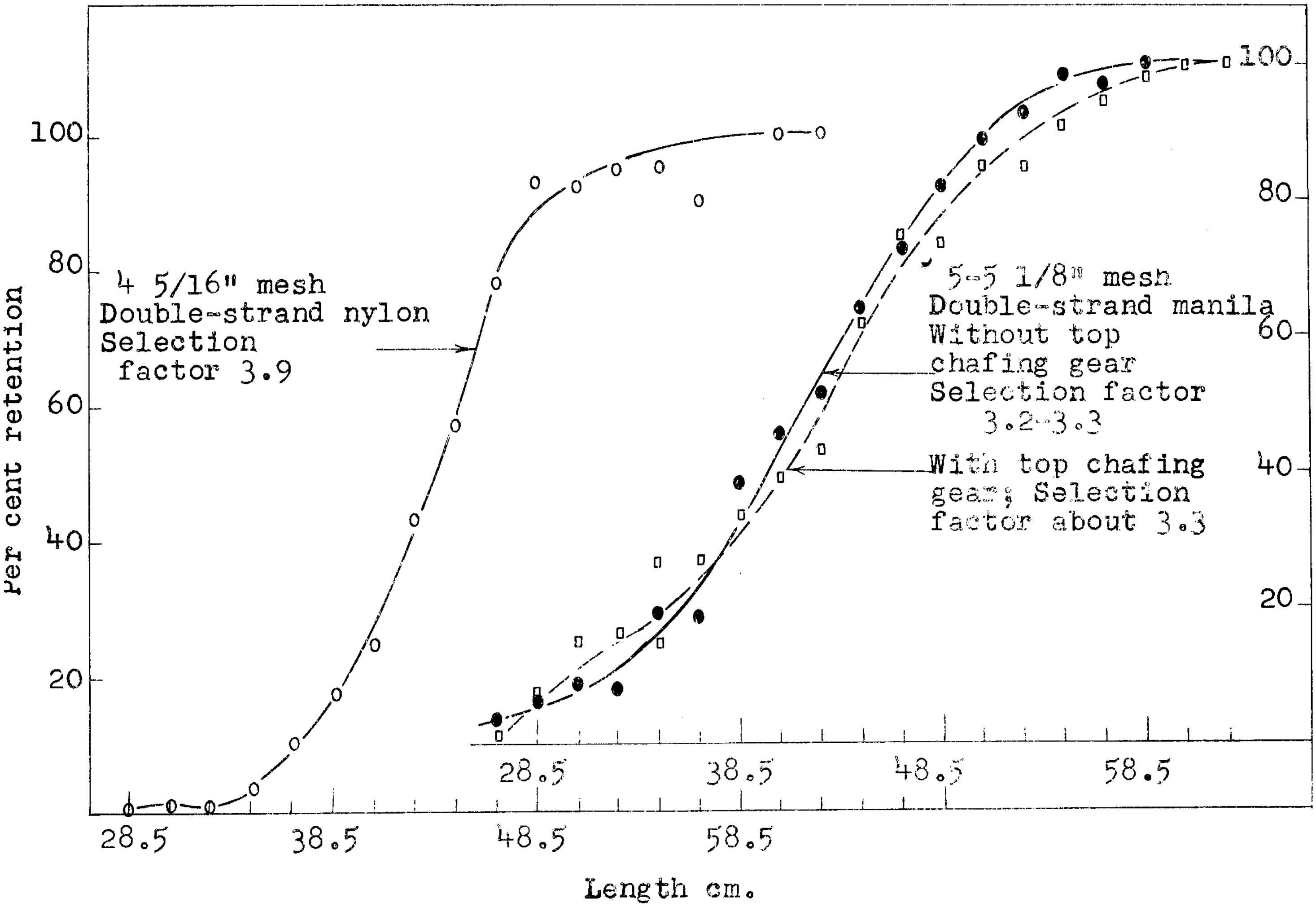
SELECTION AND CHAFING GEAR STUDIES

Mesh selection studies were continued on a reduced scale in 1958. Information about selection for a 4 5/16-inch mesh nylon codend was obtained incidentally during the haddock survey on Sable Island Bank. In addition, between September 3-6, tests of topside chafing gear were made on Emerald Bank, where catches were mainly haddock. Further tests of topside chafing gear followed discussions of this problem at the 1958 meeting of ICNAF. Conclusions at this meeting were: that topside chafing gear is widely used; that information about effects on escapement is weak; and that top priority should be given to covered-net trials with the type of topside chafing gear specified by ICNAF.

Methods

For these experiments the M. V. Harengus towed a #36 manila trawl (60-ft. headrope) in tows of 45-minutes duration. Twenty-one tows during the haddock survey, with a nylon codend of double-strand, 85-yard braided twine, seem suitable for obtaining selection results. For all experiments a cover of 1½-inch stretched mesh Nyak twine was used.

For the chafing gear experiments a double-strand manila codend of 75-yard, 4-ply twine was used. Mesh size averaged about 5 inches with considerable variation along the length of the codend. The aft quarter, which seems most



Selection curves for haddock with nylon and manila codends. (Note transposition of both horizontal and vertical scale.)

important to escapement of fish with moderate catches, averaged about 5 1/8 inches. Twelve successful tows were made with the covered codend alone, then 8 tows with topside chafing gear added.

ICNAF specifications for chafing gear were used. The chafing gear was 18 meshes long, of new netting, attached across the codend 4 meshes ahead of the splitting strap, and along the laceage to 3 meshes from the codline mesh. Internal mesh diameter of the chafing gear became about 4 7/8 inches. Visual inspection indicated that about the 4 aftermost meshes were clear. The top chafing gear was 1½ times the width of the codend, although the width was not wholly effective since the cover over the whole was only about 1/3 wider than the codend itself.

All mesh measurements of codends and chafing gear were made with the wedge-shape gauge specified by ICNAF.

Results

Catches throughout were chiefly of haddock. About 3,000 haddock were taken in the 21 tows with the 4 5/16-inch mesh nylon codend. Numbers within the selection range of this mesh size seem adequate. The resulting selection curve is shown in the accompanying figure. The 50% retention length for the 4 5/16-inch nylon mesh was about 43 cm. and the selection factor about 3.9 (selection factor =

$$\frac{\text{50\% retention length cm.}}{\text{mesh size cm.}}).$$

During the chafing gear experiments catches of haddock averaged about 1,000 pounds per tow. Selection curves for tows without top chafing gear and for those with top chafing gear are compared in the figure. There was little difference between the results of the two experiments. The 50% retention length with top chafing gear was slightly higher, about 42 cm. versus 41 cm., than without top chafing gear. This small difference is attributed to experimental error and possibly to a slight increase in mesh size during the course of the experiment. Selection factors for the manila codend were about 3.2-3.3 (variation in mesh size along the length of the codend reduces the precision of this estimate).

Results of these experiments continue to show a markedly higher selectivity for nylon than for manila. Previous experiments indicated that codends of 4-inch mesh, single-strand nylon, and 4 3/8-inch, double-strand, heavy twine nylon were equivalent in selection to a codend of 4½-inch, double-strand manila. The current experiment with a medium-weight nylon twine indicates that for this netting a 4-inch, double-strand mesh is equivalent in selection to a 4½-inch mesh manila.

Earlier experiments have shown that a double-layered codend reduced escapement of fish. They have also shown that a chafing gear about 10% wider than the codend reduced escapement. However, the current experiment has shown that chafing gear 1½ times the width of the codend, and to ICNAF specifications described above, did not reduce escapement.

F. D. McCracken

No.36

ASSESSING EFFECTS OF THE GEORGES BANK MESH REGULATION

As recommended by the ICNAF Committee on Research and Statistics, the staff of the Biological Station, St. Andrews, N. B., has continued to co-operate with the staff of the Woods Hole Laboratory of the U. S. Fish and Wildlife Service in studies aimed at assessment of effects of the Georges Bank haddock mesh regulation. At the time this regulation was adopted by ICNAF, the Georges Bank haddock fishery was believed to be one of the few for which data were available to permit establishment of an accurate baseline from which to measure changes in catch. It also appeared that this fishery was simple enough to allow collection of adequate follow-up data. These features made it a study of special importance since no adequate assessment of effects of a fishery regulation has yet been made. Progress reports on certain aspects of the co-operative study were presented to the June 1958 Annual Meeting of ICNAF.

In the belief that effects of the mesh regulation can best be demonstrated by comparing yields from year-classes of known size before and after regulation, recent investigations have been devoted to estimation of mortality rates and abundance of year-classes when they are young enough to be directly affected by the change in mesh size. The earlier work which had predicted an increase of 30 to 40% in long-term yields had developed estimates of mortality of the 4- to 8-year-old fish and used them as a basis for prediction. However, the mesh regulation was designed to delay capture from age 1½ to age 2½ years, and recently there have been indications of changes in mortality rate with age. Such results suggest that extrapolation of mortality rates from old to young fish may be unjustified.

Studies during the year have indicated that:

1. Because data on discards, hence total catches, are not available prior to 1951, the validity of estimates of mortality and abundance of the 1½- to 2½-year-olds of the 1948 and earlier year-classes depends on the accuracy with which we can calculate discards from a series of data on the size compositions of landings, combined with the information on discards which has been collected since 1950. At least two apparently objective methods have been suggested for calculating catches of 2- to 2½-year-olds, but there is no satisfactory means of detecting possible early changes in culling practices.

2. Calculations of abundance of year-classes at early ages are complicated by remarkable changes in availability of young fish from season to season and from year to year. These appear especially likely to affect catches of 1½- to 2-year-olds so that calculated abundance of fish younger than age 2 may have little resemblance to the actual.

3. Studies of mortality estimates derived from fisheries statistics show that the catch data contain sufficient unidentified variation to give discouragingly wide confidence limits. Unless some of the sources of variation can be identified and eliminated, it is possible that errors of estimation will approach or even exceed the order of magnitude of changes predicted to result from the regulation.

4. Recent increases in average size and weight of fish landed appear to be greater than can be accounted for on the basis of a change in growth rate alone, and may be a first positive sign of long-term benefit from the regulation.

Some of the problems encountered during the analyses may eventually be solved through greater refinement of the data. For example, the data used so far have been weighted annual total catches for all Georges Bank. Some of the sources of variability in mortality rate estimates may become apparent if the data are broken down into smaller time and area units. Preliminary studies of models have also indicated that some of the variability may be associated with errors in age determination. In addition, it has been shown that errors in estimates of mortality of young haddock may have been introduced by calculating average mortality over several age-classes if, instead of random variations, there are trends in mortality with age or time.

Methods of measuring and accounting for errors from these and other sources are being investigated to permit improved accuracy in assessment of effects of mesh regulation by the system of comparing yields before and after regulation. Alternative methods of assessment are also being sought.

L. M. Dickie

No. 37

A NEW ROLE FOR STUDY BOATS IN ASSESSING EFFECTS OF MESH REGULATION

The accepted method for detecting effects of a mesh regulation is to compare a series of pre- and post-regulation catches, corrected for differences in year-class abundance and mortality between the two periods. This requires collection of detailed catch and effort statistics over a sufficiently long period so that confidence limits of the estimates of abundance and mortality are narrow enough to permit us to detect changes in catch of the size predicted to result from the regulation. A study fleet using the old mesh size is operated for a short time after the regulation to ensure that there are no remarkable changes in relative availability of fish to new gear and to measure any changes in efficiency that take place.

Experience to date indicates that the length of the series of pre-regulation data that we need before this method can produce the precision necessary for measurement of effects of regulation may be prohibitively long for most fisheries. Even for the Georges Bank haddock fishery, where a particularly long series of data is being analyzed, the degree of precision is discouragingly low. It appears almost certain in this case that even if our methods should eventually permit us to demonstrate the predicted relatively large difference in catch before and after regulation, we shall not be able to detect what will probably be relatively smaller departures of the actual catch from the expected.

Aside from sampling errors in age determination and incomplete data on catch and effort, the precision of mortality and abundance estimates from catch statistics varies directly with (1) the coefficient of correlation between mortality and effort, (2) the number of time intervals over which mortality rates are measured, (3) the amount of variation in effort during the study period. The coefficient of correlation is affected by many unidentified sources of variation, among the most important of which are probable changes in availability of the stocks from time to time. Precision can sometimes be improved by lengthening the period of observations, although this frequently increases the first error component. However, the investigator generally requires a long series of data anyway in order to have sufficient variation in effort to permit separation of the fishing and natural mortality rate components.

Where long series of pre-regulation data are not available, it appears possible that appropriate use of a study fleet during the period of change may be made to measure effects of mesh regulation with a precision at least as great as that afforded by the method just described. This alternative approach involves the introduction of a variable-sized study fleet to fish with the new proposed mesh size. Using the mortality estimates from detailed statistics of both sections of the fleet, it is proposed that we should calculate how much would have been caught by the fleet using either type of gear alone. The difference in calculated catches is a direct measure of the effect of a gear change since the fleets will have been fishing the same year-classes.

The calculations and the tests involved in this alternative method are of exactly the same type as are used in the current methods of analysis when two types of gear are in use. However, there appear to be several advantages in the new approach. The most important is that if a small study fleet using the new mesh is introduced before a regulation and then a study fleet is exempted to use the old mesh after the regulation is enforced, we have introduced the maximum possible variation in fishing effort on the small sizes of fish directly affected by the mesh change. This gives maximum precision in the estimation of mortality and abundance at these critical early ages. Since the two types of gear fish the same stocks, it may also be possible to study the changes in availability which affect the correlation between effort and mortality. Furthermore, although the length of time required for the study will differ from fishery to fishery, precision comparable to that obtained by present analytic methods can probably be obtained in significantly shorter time.

It must be recognized that, at best, the precision of estimates of mortalities and abundance from catch data is low, so that our chances for measuring effects of a mesh regulation by this method alone are poor, no matter what analytic procedures are used. It seems likely, therefore, that any intensive study of the type proposed here should make provision for other means of measuring mortality and abundance. Chances for success would be much improved if a study boat program were accompanied by a tagging program and was done in an area where the biology of the species fished was well understood.

L. M. Dickie

No. 38

EFFECTS OF MISTAKES IN AGE DETERMINATION ON MORTALITY ESTIMATES

It is well known that there are errors made in the assignment of ages to fish from readings of annuli on scales and otoliths, especially among older fish. Studies reported by Gulland (1955) have shown that average mortality and growth rates derived from these data may not be much in error, provided that the precision of readings does not vary markedly from age to age, and the average mortality rate is taken over a sufficiently large number of year-classes. However, in calculations designed to compute mortalities from catch statistics, we frequently wish to compare the apparent mortalities for different year-classes or to derive mortality estimates from relatively short series of data. Errors in age readings may introduce substantial errors in analyses of these special situations.

A preliminary examination has been made of the consequences of mistakes in age determination in a situation such as that of the Georges Bank haddock fishery where we wish to determine abundance of individual year-classes in a regular succession of alternately weak and strong broods. The magnitude of age determination errors may be judged from studies by Kohler and Clark (1958) comparing differences in the readings from scales and otoliths from Georges Bank haddock. These studies have indicated that from ages 2 to 8 the disagreements in age assignment are symmetrical about the mean values. That is, there seems to be no bias towards reading fish at these ages consistently older or younger than they are. The distribution of scale ages at a given otolith age may therefore be taken as an index of the distribution of errors at that age. (Error distributions may be similarly derived from the distribution of otolith ages at a given scale age.) Using errors of the magnitude shown by this study, models have been constructed which compare the actual and distorted age distributions for fluctuating fisheries, and mortality rates have been recalculated from the distributions.

The results show that, as expected, the overall average mortality rates derived from the actual and distorted age distributions were identical. However, if calculations are made on the strong or weak year-classes alone, mortality rates are significantly over- or underestimated respectively, and the averages may be similarly biased if a preponderance of weak or strong year-classes is used to obtain the overall average. Furthermore, errors of the magnitude used in these models are sufficient to explain the apparent levelling of initially different year-class strengths which has been observed among Georges Bank haddock year-classes between ages 2 and 8. A system for correcting the distortion in situations where a strong year-class is preceded and followed by weak year-classes has been suggested. The importance of such errors and the practicality of introducing corrections should be studied for a greater variety of situations.

L. M. Dickie

No. 39

PORROCAECUM INFESTATION IN COD IN CAPTIVITY

The examination of the cod remaining at the end of the growth experiment (No. 27) included inspection of the two fillets and skeletal section of each fish for larval nematodes (*Porrocaecum decipiens*). D. N. Fitzgerald, who was experienced in the technique of examination, carried out the observations. The results for 29 cod showed 38% of the fish were infected, 21% of the fillets and 17% of the skeletal sections from the fish contained worms. D. M. Scott (Prog. Rept. Atlantic Coast Sta., No. 48, p. 10) has shown that *Porrocaecum* does not occur in herring. Since these cod were fed exclusively upon herring for the previous year, it is unlikely that they became infected after they were confined to the tanks. The incidence found in these cod was similar to that found in 1957 in cod from areas adjacent to the trap from which they were taken. It is inferred that the tank cod carried these worms from the time they were taken from the trap at Lockeport.

It was noted that an unusually large percentage of the worms (33%) were found on the skin side of the fillet. Scott has shown that the worms migrate from the stomach to the body cavity then into the cod musculature. The current observations indicate that the nematodes continue to move through the musculature away from the body cavity towards the epidermis.

A. C. Kohler

No. 40

INCIDENCE OF NEMATODES IN CRUSTACEANS FROM THE BRAS D'OR LAKES IN 1958

It has been known for several years that mysids in the Bras d'Or Lakes were infected with larval nematodes. Less than 20 specimens of nematodes have been available for identification. None appeared to be Porrocaecum and all that could be identified were Contracaecum. The possibility still exists that mysids or some other crustacean might serve as primary intermediate hosts for P. decipiens. Accordingly, in 1958, further collections of mysids were made in the Bras d'Or Lakes.

Seven collections were made in July 1958 from three localities in the Bras d'Or Lakes. One sample came from Baddeck Bay, two from near Coffin Island, and four from near Kempt Head.

Incidence of nematodes

Each crustacean was examined for nematodes. The examination consisted of the removal of the carapace and an inspection of the cephalothoracic region. The abdomen of each animal was examined but was fully dissected only in large specimens (larger than 3 cm.).

One hundred and twelve nematodes were found. Thirty-four were free in the jars in which the crustaceans had been preserved. Assuming that these nematodes had originated from the preserved crustaceans, the incidence of nematodes was approximately 1.3% $(\frac{112 \times 100}{8400})$. The distribution by hosts of the remaining 76 nematodes is shown in Table I. Three groups of crustaceans were infected: mysids, euphausids, and decapods. A single nematode was usually present in an infected host. However, 2 nematodes were found in each of 6 mysids, and 1 mysid contained 3 nematodes. Because of the preponderance of mysids in the collections, it was not surprising to find that most nematodes occurred in 4 species of mysids. Sixty-two of the 71 nematodes found in mysids could be assigned to definite species of mysids.

Most nematodes (47) were found in N. americana; 9, 2, and 1 nematodes were found respectively in M. mixta, M. stenolepis, and E. erythrophthalma. In view of the scarcity of N. americana relative to the other mysids, the percentage incidence of nematodes was obviously much higher in N. americana.

Infected mysids were most common in the Kempt Head area. This can be attributed to the fact that N. americana was more common in that area than in the vicinity of Coffin Island.

All the nematodes were larvae less than 15 mm. in length. All but 5 showed the generic characteristics of Contracaecum. The remaining 5 are of particular interest to the present investigation as they belonged either to Porrocaecum or to Anisakis. It may be noteworthy that 4 of these nematodes came from M. mixta and M. stenolepis, but none was definitely from N. americana. The fifth came from a mysid whose state of preservation was too poor to permit generic determination. Further, it is interesting that 4 of 11 nematodes found in the genus Mysis were either Porrocaecum or Anisakis. All 50 nematodes from Neomysis were Contracaecum.

Table I. Numbers of nematodes found in various crustaceans from the Bras d'Or Lakes, July 1958.

Locality and date	Mysis mixta	Mysis stenolepis	Neomysis americana	Erythrops erythrophthalma	Mysid sp.	Euphausid sp.	Decapod sp.	Free in jar
Baddeck Bay								
July 8	...	...	...	...	...	...	...	...
Coffin Is.								
July 10	...	...	...	...	1*	...	...	1
July 16	...	1*	3	...	...	...	...	...
Kempt Head								
July 9	...	...	9	...	2	2	...	3
July 10	5*	...	17	...	3	2	...	7
July 16-17	3	1*	13	...	...	...	1	12
July 19	1*	...	5	1	3	...	...	11
Total	9	1	47	1	8	4	1	33

*indicates the distribution of nematodes of the genera Porrocaecum or Anisakis.

Table II. Length in millimetres of certain characters of larval Porrocaecum or Anisakis recovered from mysids.

Specimen no.	Total length	Oesophagus	Ventriculus	Intestinal caecum	Oes./Vent. %
2	4.3	0.66	0.39	-	168
52	4.6	0.81	0.56	?	146
64	4.7	0.62	0.45	0.16	138
23	5.5	0.70	0.41	-	171
3	8.5	1.0	0.56	0.08?	179

Each of the 5 Porrocaecum or Anisakis was too small or too poorly preserved to permit dissection. An intestinal caecum was present in one nematode and probably in another. No intestinal caecum was apparent in the remaining 3 nematodes. On this basis, these specimens could be either Anisakis or Porrocaecum larvae in which the caecum had not yet developed. There is slight evidence favouring the latter possibility. First, the ratios of the length of the oesophagus to that of the ventriculus

(Table II) resemble those determined by Templeman *et al.* (1957) for *Porrocaecum* rather than those of *Anisakis*. Templeman showed that this ratio was usually less than 180% for *Porrocaecum* but more than this for his specimens without a caecum. My own unpublished studies on *Anisakis* showed that in 75% of the specimens the oesophagus was more than twice as long as the ventriculus. Secondly, there is no host of adult *Anisakis* known to occur regularly in the Bras d'Or Lakes.

In conclusion, two main points have been established by the present study. First, nematodes which are probably *Porrocaecum* occur in mysids in the Bras d'Or Lakes. Secondly, euphausids and decapods are also hosts of nematodes in this region. To establish the frequency with which *Porrocaecum* occurs in mysids and other crustaceans in this region, it would be necessary to collect much larger numbers of crustaceans. It would also be desirable to make collections at different seasons of the year.

D. M. Scott

PELAGIC FISH SUMMARIES

General summary of pelagic fish investigations

The Canadian swordfish fishery

The food and feeding habits of swordfish

The southwest Nova Scotia herring fishery

Abundance of herring larvae in the Gulf of St. Lawrence

Herring drift-net experiments

An electrofishing experiment

Herring landings in the Passamaquoddy region

The economics of the "sardine" fishery of Charlotte County

Herring tagging experiments

Herring migrations and surface drift

Studies of herring behaviour

The survival of herring under environmental extremes

The distribution of herring larvae in the Bay of Fundy and the Gulf of Maine

The distribution of plankton in the Quoddy region

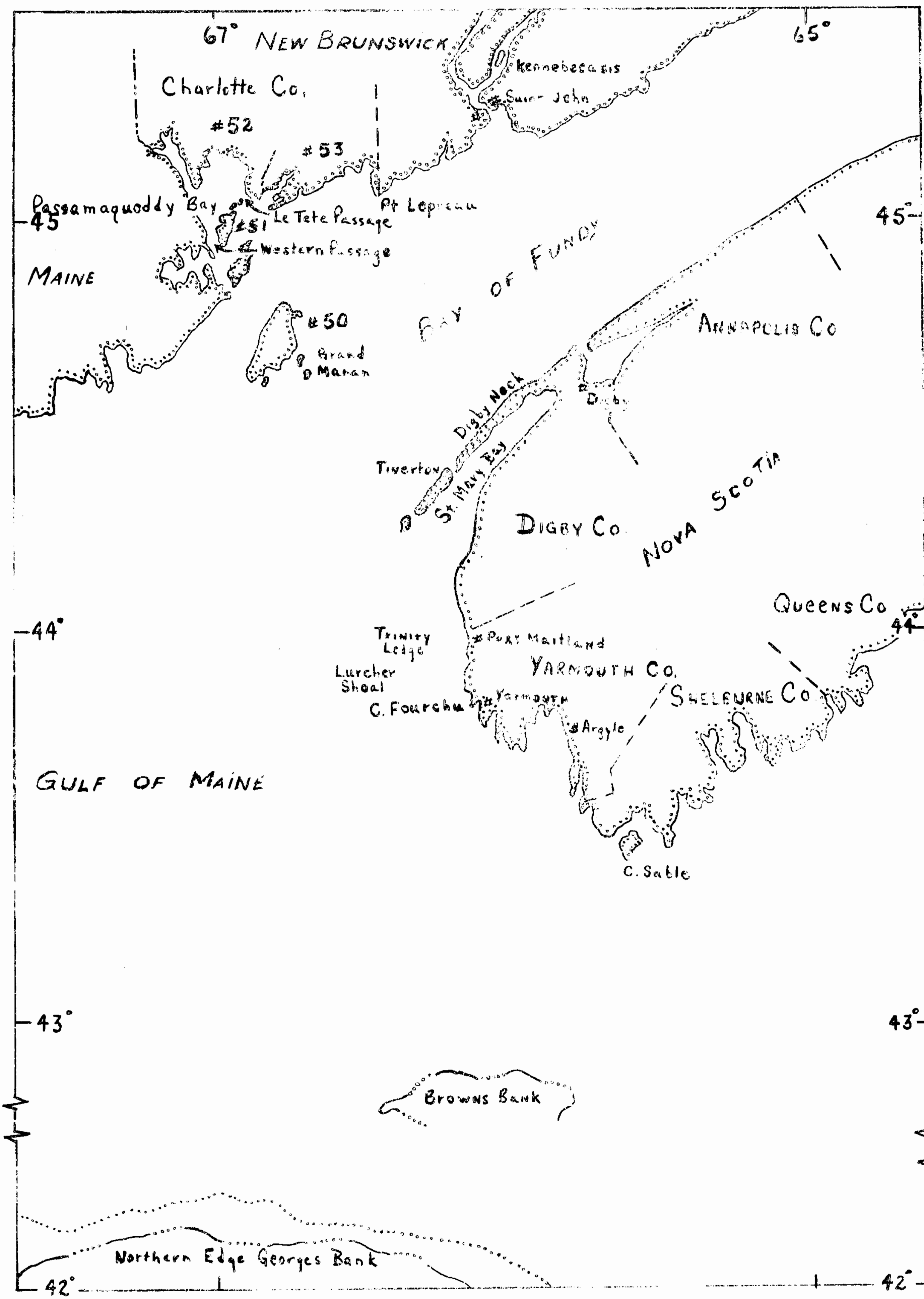
The food of herring in Passamaquoddy Bay

Exploratory fishing for herring

Herring catches in relation to environment

The length and age composition of Charlotte County "sardines"

Length-weight relationships for "sardines"


67°
New Brunswick
65°
Kennebecasis
Saint John
Charlotte Co.
#52
#53
Pt Lepreau
Passamaquoddy Bay
45
#51
Le Tete Passage
Western Passage
45°
Maine
Bay of Fundy
#50
Grand Manan
Annapolis Co
Digby Neck
Digby
Tiverton
St. Mary Bay
Nova Scotia
Digby Co.
Queens Co
44°
44°
Trinity Ledge
Port Maitland
Yarmouth Co.
Lurcher Shoal
C. Fourchu
Yarmouth
Shelburne Co
Argyle
Gulf of Maine
C. Sable
43°
43°
Browns Bank
Northern Edge Georges Bank
42°
42°

No. 41

GENERAL SUMMARY OF PELAGIC FISH INVESTIGATIONS

Pelagic fish research in 1958 continued to be concerned chiefly with a program of research and statistics designed to meet the needs of the International Passamaquoddy Fisheries Board in predicting the effects which the proposed Passamaquoddy power project might have on the fisheries of the area. This program began in 1957 and will be completed during the summer of 1959. Most of the projects are carried out co-operatively by the Fisheries Research Board of Canada and the United States Fish and Wildlife Service, particularly in the pooling of equipment and personnel for field operations, although scientific collaboration in analysis of data and interpretation of results is included. Efforts by the Research Committee of Canadian and United States scientists in planning and co-ordinating the program and in progress reporting included four regular meetings of the Research Committee; two regular and two informal meetings of the International Passamaquoddy Fisheries Board; four meetings of the Joint Engineering and Fisheries Committee; one joint meeting of the Engineering and Fisheries Boards; three meetings of the International Joint Commission; two meetings of the Sub-Committee on Anadromous Fishes; two meetings of the Sub-Committee on Economics and two meetings of the Sub-Committee on Final Reports. The program, as a whole, was reviewed and appraised critically in consultation with Mr. B. B. Parrish of the Scottish Home Department who was employed for this purpose from mid June to mid July.

Major emphasis continued to be placed on the herring fisheries which make up more than 80% of the total fish landings in the area. Studies of catch, effort, investment, and income statistics were intensified and improved. Total landings in Charlotte and Saint John Counties were 60% below the previous year's catch. Net cash returns for weirs ($1,779) and for purse seines ($27,263) in 1956 and 1957 showed purse seining to be significantly more profitable than weir fishing. Studies of migrations were accomplished by tagging and releasing 79,794 herring of which 2,739 (3.4%) were recaptured. Experiments to establish behaviour patterns and the survival of herring under environmental extremes have provided valuable data for prediction of the effect of power dams on existing fisheries. Explorations for larval herring and the distribution and abundance of planktonic forms provide a basis for determining the source of the stocks and their method of transport to the fishing areas. Fishing experiments, the relation of catch to environment and the length, weight, and age composition of the commercial catches rounded out the biolcgical program. Studies of hydrographic conditions including temperature, salinity, and currents (Trites, AOG Annual Report 1958-59) are included in the investigation.

Pelagic fishes

In general, the pelagic fishes of the Atlantic Coast are only lightly fished and, as a group, constitute the major potential for expansion of the fishing industry in the region. Studies have been carried on for several years to discover ways and means of making better use of these resources. Efforts along these lines were restricted in 1958 to following the rapid expansion of the herring fishery in southwest Nova Scotia and to the observation of two gear experiments on the south and west coasts of Newfoundland. Landings of herring in south-west Nova Scotia increased from 16.8 million pounds in 1948 to 86.5 million pounds in 1958. Particular attention is given to changes that may take place in the size and age composition of the stocks and in the annual recruitment. An experiment in Hermitage Bay, Newfoundland, demonstrated the value of the drift-net method of fishing and preliminary results of an electrofishing experiment in Port au Port Bay, Newfoundland, were encouraging. Studies of the abundance of herring larvae in the Gulf of St. Lawrence indicated an extremely low larval production in 1958.

A study of the fishery and biology of swordfish was initiated in 1958. The nature of the fishery has changed from a small-boat inshore fleet to an offshore fleet of larger vessels that are capable of searching for swordfish over a wide area. Catches in 1958 exceeded 5 million pounds, a threefold increase since 1939.

During the year liaison with other government agencies and public relations that occupied the attention of the pelagic fish group included co-operative projects with the New Brunswick Department of Industry and Development, the Woods Hole Oceanographic Institution, the Maine Department of Sea and Shore Fisheries, the National Research Council, the United States Fish and Wildlife Service, and the Economic Service of the Department of Fisheries. Consultative services were made available, particularly to Bonda Foods and Sea Weed Products of Yarmouth, Nova Scotia, and B.C. Packers of Clark's Harbour, Nova Scotia, in proposed expansion of the herring processing industry. Canadian Pacific Steamships, Saint John Marine Transports, and the Department of Transport have co-operated in carrying out research projects. Fishermen, industry personnel, and Department of Fisheries Protection and Inspection officers have provided statistics of catch, investment and income, and substantial assistance in tagging experiments. Asian visitors to the Station were briefed on the work of the pelagic fish group and arrangements made for observation of activities in the field. Advice and consultation on smelt problem in the Great Lakes were provided the Central Station of the Fisheries Research Board and a discourse on the Atlantic smelt fishery was made to the Department of Fisheries District Protection Officers' Conference in Halifax. A two-day herring symposium was sponsored as part of the 50th Anniversary celebrations of the St. Andrews Station.

S.N. Tibbo

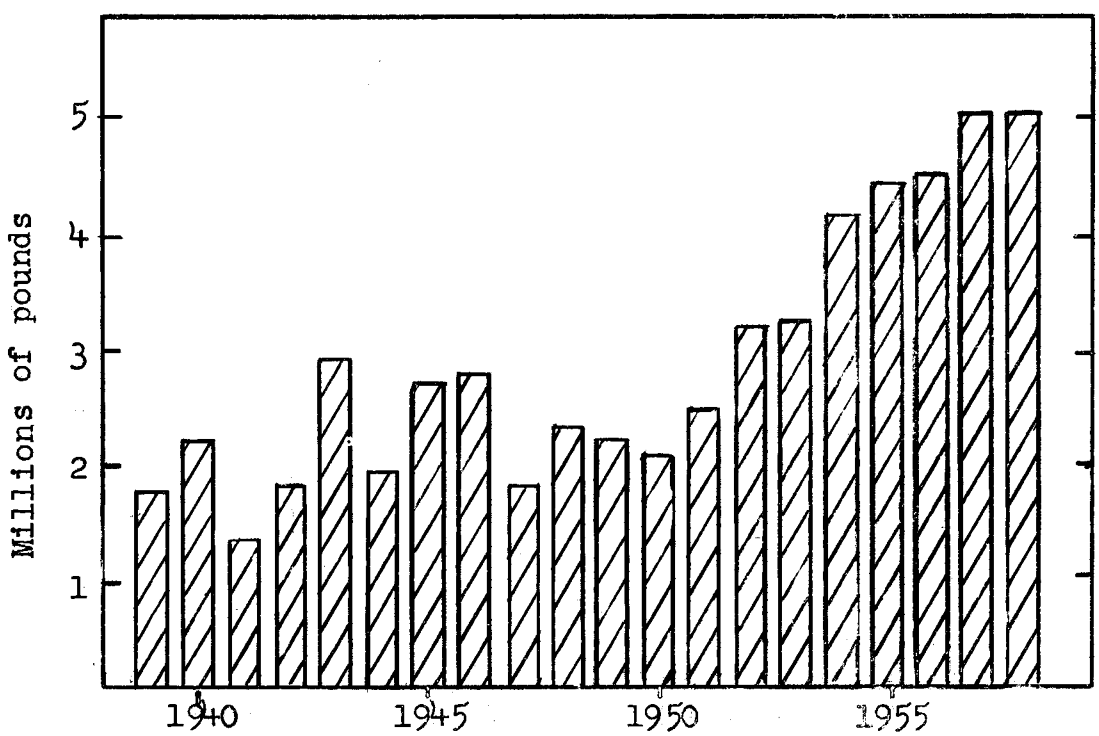
No. 42

THE CANADIAN SWORDFISH FISHERY

The fishery for swordfish off the Canadian Atlantic coast is becoming increasingly important, particularly in the Province of Nova Scotia. Catches in 1957 and 1958 exceeded 5 million pounds with landed values of more than 1 1/4 million dollars.

Swordfish are summer visitors to the Canadian Atlantic area and their distribution varies throughout a season and from one season to the next. Hence, the success of the fishery depends to a considerable extent on knowledge of the factors that affect the distribution. An investigation of the species was begun in 1958 to become more familiar with the fishery, the biology of the fish, and to provide a background for the more extensive investigations that will be initiated soon. Mr. G.M. Somerville was responsible for carrying out the field work and for the preliminary reporting.

During the 1957 season swordfish landings were made by 220 boats and vessels. Fifty-two of these were small boats operating close to their home ports. The other 168 were larger vessels (longliners, schooners and draggers) that may fish from Georges Bank to the Grand Banks. These offshore vessels account for more than 90% of the landings and the fleet has been increasing steadily since 1945. At the present time, longliners alone are being added to the fleet at the rate of 12-15 per year.



Canadian swordfish landings 1939-58.

There seems to be little reason for concern about the supply of swordfish in the Canadian area. The fish taken are nearly all large adults. There is no net fishing and small fish are seldom caught. There is no evidence of any substantial change in the abundance of swordfish in recent years. Each individual fish is the object of a special pursuit and the solitary habits of the species probably protect it from wholesale capture, as is the case of close-schooling fish.

The growth of the swordfish fishery is apparent from the accompanying figure. During the past 20 years, landings increased from 1,788,400 pounds in 1939 to 5,136,235 pounds in 1958. The reason for the increase is probably an increase in market demand but it has been made possible by the development of an offshore fleet that is capable of searching for swordfish over a very wide area. It is believed by fishermen that the stocks of swordfish are only lightly fished and the present investigations may provide the necessary background for greater use of this valuable resource.

S.N. Tibbo

No. 43

THE FOOD AND FEEDING HABITS OF SWORDFISH

During the course of the swordfish investigation in 1958, particular attention was given to food and feeding habits because of the influence these might have on the distribution of the fish and hence on the fishery.

Swordfish are caught while swimming lazily at or near the surface. About one third are seen actually "finning" and the remainder a few feet below the surface.

Earlier reports have suggested that the principal food items of the swordfish are mackerel, menhaden, bluefish, silver hake, butterfish, herring, rattails, and squid. Fishermen believe that, in general, swordfish strike into schools of these smaller fish from below, disabling them by slashing from side to side with the sword and then picking up the victims.

While on board the M.V. Fanny Faye, Mr. [illegible].M.Somerville found that the stomachs of most of the fish taken were from half full to filled with food. This food consisted chiefly of lancetfish with some lanternfish and rosefish. The majority of the food had been taken whole and showed no injury from being struck with the sword. In many cases, digestion was not far advanced and it is obvious that the swordfish had been feeding at considerable depth (lancetfish, lanternfish, and rosefish are deep-dwelling forms) and then returned quickly to the surface areas where they were caught.

The fact that swordfish lie at the surface in relatively warm water would appear to be an aid to digestion similar to the rest or sleep that most animals take after feeding.

R. A. McKenzie

No. 44

THE SOUTHWEST NOVA SCOTIA HERRING FISHERY

Investigations of herring stocks in southwest Nova Scotia were continued in 1958 to follow the course of an expanding fishery and to provide a better understanding of the biology of herring in that area.

Nova Scotia landings in 1958 amounted to 102 million pounds of which about 85% were taken in Digby, Yarmouth, and Shelburne Counties. Catches in this latter area were approximately 87 million pounds or more than double the 1957 figure (42 million pounds). The increase is attributed chiefly to successful purse seining for small herring (sardines) in St. Mary Bay and the eastern part of Yarmouth County. Samples of herring for biological studies were obtained from weirs, gill nets, and purse seines throughout Digby, Yarmouth, and Shelburne Counties. Emphasis was placed on the collection of larval herring and in obtaining information on the sizes of spawning areas and the densities of spawn on them. Fundamental information on movements, distribution, and abundance of both larval and adult herring was recorded from interviews with purse seiners. Some herring tagging was carried out in the Digby Neck area but only three recoveries were reported.

There was some indication of increased spawning activity near the Tusket Islands although the majority of the spawnings took place in the Lurcher Shoal-Trinity Ledge area. Most spawnings took place during the late summer or early autumn, but lobster fishermen at Port Maitland reported substantial amounts of herring spawn deposited on lobster traps during the latter part of May. Herring larvae were found most consistently in St. Mary Bay and 88% of the plankton tows taken there contained larvae varying in numbers from 1 to 1,236 per 15-minute tow with a standard 1-metre plankton net.

Routine sampling of commercial catches for length, age, and vertebral counts was continued throughout the year. Analyses of these data are incomplete but there is no indication of any decrease in the size and age composition of samples obtained from the gill-net fishery. Samples from purse seines in earlier years are not available for comparison. Otoliths show that the majority of the fish taken in the area are autumn-spawned types with ages varying from 2 to 9 years.

With the reduction in emphasis on Passamaquoddy investigations, it is proposed to intensify the study of herring stocks in southwest Nova Scotia.

E. C. Sollows

No. 45

ABUNDANCE OF HERRING LARVAE IN THE GULF OF ST. LAWRENCE

For eight consecutive seasons (1951-58) studies on the relative abundance of herring larvae in the Gulf of St. Lawrence have been based on plankton tows taken in the west entrance to Northumberland Strait for studies of the abundance of lobster larvae and provided by Dr. D.G. Wilder. The tows were taken with a rectangular 12'x3' plankton net, towed at the surface and were each of 30-minutes duration. In 1951 and again in 1958, all of the lobster tows were examined whereas in the other years samples were taken comprising all of the tows from four of the 21 stations. The examination of tows and the sorting and counting of larvae were carried out by Miss Phyllis J. Gibson. The number of tows examined and the number of larvae caught each year were as follows:

Period	No. of tows	Total no. of herring larvae	Average catch per tow
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	1,897.8
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
1958 June 15-July 15	186	1,692	9.1
July 16-Sept. 15	294	12	0.04

The abundance of larval herring both in total numbers caught and in the average catch per tow was at its lowest level in 1958. As pointed out in the Annual Report for 1957-58 (Appendix No. 50), the small catches in 1956 and 1957 may have been caused by a reduction in the spawning stock because of mass mortalities that resulted from a fungus disease. It is possible that this extended into the 1958 season as the commercial fishery, which is dependent on the spawning stocks, remained at a low ebb. However, this will not explain the observed differences in abundance of the larvae from 1951 to 1955 when only minor variations in landings occurred. It is doubtful whether predictions of commercial catches are possible from studies of larval abundance and it is proposed to study rather the relative abundance of the various year-classes in the fishery. It is planned that this project will get underway during the 1959 season.

S.N. Tibbo

No. 46

HERRING DRIFT-NET EXPERIMENTS

Herring landings on the south coast of Newfoundland declined from about 80 million pounds in 1946 to almost negligible quantities in 1957. Drift-net experiments were carried out in 1956, 1957, and 1958 with the support of the Industrial Development Service to discover the whereabouts of the herring stocks on which the fisheries have depended. In Fortune and Placentia Bays only small quantities of herring were taken during the summer months and were of no significance commercially. In Hermitage Bay, however, large catches were made throughout April, May, and June both in 1957 (Annual Report for 1957-58, Appendix No. 52) and in 1958. Mr. Bert Strickland of Hermitage was responsible for the operation of the gear and for providing preliminary reports.

The method of fishing was the same during the two seasons. 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. In 1958, the experiments were carried on from March 19 to July 1. A summary of the results is given in the accompanying table.

Month	No. of sets	Total no. nets used	Total catch lb.	Av. Catch per net lb.
March	3	14	12	1
April	8	38	7,480	197
May	14	62	20,620	333
June	9	45	12,090	268
July	1	5	150	30
Totals	35	164	40,352	246

Although no comparative figures are available, the catches of herring in drift nets were much greater than catches in anchored nets set in the same general area during the same period. On several occasions, when large catches were made with drift nets, the anchored nets caught no herring whatsoever. It is expected that the introduction of drift netting on a larger scale in other south-coast areas would increase present landings substantially.

S.N. Tibbo

No. 47

AN ELECTROFISHING EXPERIMENT

During November and December 1958, an electrofishing experiment was carried out in Port au Port Bay on the west coast of Newfoundland. The experiment was sponsored by the Industrial Development Service of the Department of Fisheries and conducted from the M.V. Linda May owned and operated by Crosbie and Company of St. John's, Newfoundland.

The electrofishing equipment was manufactured at the International Electronics Laboratory in Hamburg, Germany, and installed and used by Mr. Karl Heinz Ulrichs, co-inventor, and two assistants--Messrs. Hans Rump and Walter Riedliff.

The equipment consisted of a 100 KW, 440 volt, A.C. generator; two electrodes, one (anode) attached to the end of the suction hose and the other (cathode) tied to the hose 10-12 feet from the end; a powerful fish pump and a strong (approximately 1.5 KW) underwater light attached to the anode.

In theory, herring are brought to the immediate vicinity of the hose opening by a combination of positive reactions to light and an electric field.

Experiments were carried on by first locating schools of herring with an echo sounder. The electrodes, hose, and lights were then lowered to the approximate depth of the school and put in operation.

During the period November 24 to December 3, Mr. A.W. Holt of the St. Andrews Station was on board the M.V. Linda May observing the experiment. Schools of herring were readily located but attempts to capture them were unsuccessful. The operators made frequent adjustments to the equipment particularly in the relative position of the electrodes and the strength and nature of the current. On December 13 to 18, some success was achieved and a total of 200 barrels of herring were landed.

The usefulness of this equipment for commercial fishing has not yet been demonstrated but the results to date are encouraging.

S.N. Tibbo

No. 48

HERRING LANDINGS IN THE PASSAMAQUODDY REGION

The collection of daily records of herring catches by individual weirs and seines in Charlotte and Saint John Counties, New Brunswick, was continued and improved during 1958. Catches have been tabulated according to gear, sub-areas, and months. They have also been arranged by regions in relation to the proposed Passamaquoddy dam sites.

In 1958, 376 weir licences were issued, 5 more than in 1957. However, 107 weirs (81 in 1957) were not built. Of the 269 built, 66 were in the high-level pool, 9 in the low-level pool, 76 in the approaches to Passamaquoddy Bay, 37 in the eastern section of Charlotte County, 64 at Grand Manan, and 17 in Saint John County. There were 13 purse seiners and 31 drag seiners licensed in 1958 as compared to 17 and 22 respectively in 1957.

The total herring landings in Charlotte and Saint John Counties in 1958 amounted to about 36 million pounds or only slightly more than 40% of the 1957 catch. The 1958 landings inside Passamaquoddy Bay were approximately 9 million pounds or slightly more than 25% of the 1957 catch in this area. In comparison the average long-term (1937-57) landings were approximately 77 million pounds for the whole area and 11 million pounds for Passamaquoddy Bay.

A comparison of 1957 and 1958 landings according to gear shows that, whereas weir landings decreased considerably, drag-seine and purse-seine catches were only slightly below the 1957 figures.

Landings from weirs began in February and increased to a peak of 9.25 million pounds in September with 85% of the total weir catch (25.5 million pounds) being made in July, August, and September. Drag seining was confined to the period July to October and about 2.4 million pounds were landed by this method. Purse seining was carried on for 4 months beginning in January with a peak landing of 3 million pounds in March and a total of 3.8 million pounds for the period. The purse-seine fishery began again in July and continued to the end of the year. Landings reached a peak of about 3.5 million pounds in September with a total catch for the year of 7.9 million pounds.

In respect to the Passamaquoddy dam sites, the total landings in 1958 were approximately 9.0 million pounds in the high-level pool, 0.4 million pounds in the low-level pool, 3.7 million pounds immediately outside the Bay, 8.9 million pounds in the eastern section of Charlotte County, 6.9 million pounds at Grand Manan, and 6.9 million pounds in Saint John County.

The average landing per weir varied from 28,500 pounds in the low-level pool to 91,700 pounds in the high-level pool as compared to 90,000 and 511,000 pounds respectively in 1957. The average landings for all weirs inside the proposed dams was 84,400 pounds (457,000 pounds in 1957) and for those outside 100,000 pounds (207,000 pounds in 1957).

R.A. McKenzie

No. 49

THE ECONOMICS OF THE "SARDINE" FISHERY OF CHARLOTTE COUNTY

A survey of the primary fisheries of Charlotte County for the period 1946-57 was conducted in 1957 and 1958. The purpose of the study was to provide investment-income information for use in the assessment of the impact of proposed Passamaquoddy Power dams on the fisheries of the area. Mr. W.F. Doucet of the Economics Service, Department of Fisheries, had major responsibility for the survey. Special emphasis was placed on the herring weir and purse-seine fishery. Most of the data collected was of an inventory nature but for the years 1956 and 1957 considerable detail was obtained covering landings, receipts, fixed and operating expenses as well as capital assets such as boats, weirs, and other fishing equipment.

The sample of the herring weir fishery surveyed was slightly in excess of 50% of the weirs licensed in 1956 and 1957 and was stratified according to locality. One half of the purse seiners operating in 1956 and 1957 was surveyed but because of the smallness of this universe, the remainder of the fleet will be included.

Complete records were obtained for 82 herring weirs, partial records for 10, and inventories for 163. Of the 371 weirs licensed in 1957, 284 were operative but only 248 caught fish. Complete records were obtained for the 6 purse seiners that were surveyed.

The results of the study showed that the average replacement cost of a weir is $4,766. By far, the most valuable weir components are the stakes and the nets, which respectively are 21.5% and 40.2% of the entire weir cost. The average value of gear associated with the weir is $1,216. The average investment per weir with associated gear is therefore $5,982.

The average gross income in 1957 for 94 weir enterprises (about 116 individual weirs) was $2,615 and the average net cash return was $1,779. The main expenditures were for weir material, netting, and labour.

In contrast to weir fishing, the average replacement cost of purse seiners is $24,866. However, the average net return in 1957 was $27,263 per seiner--$22,273 accruing to labour and $4,990 to capital. Thus, from the standpoint of both labour and capital, purse seining is significantly more profitable than weir fishing.

S.N. Tibbo

No. 50

HERRING TAGGING EXPERIMENTS

From March 3 to September 24, 1958, 34 herring taggings were carried out. The United States Fish and Wildlife Service at Boothbay Harbor, Maine, assisted in many cases and a total of 79,794 herring were tagged (see table).

Herring taggings and recaptures, 1958

Area	Tagged	Recaptures no.	Recaptures %
Western Nova Scotia	3,531	3	.1
Point Lepreau	17,159	173	1.0
Entrance to Passamaquoddy	13,567	794	5.9
Passamaquoddy, Canada	24,692	1,243	5.0
Passamaquoddy, United States	8,569	340	4.0
Grand Manan	4,871	10	.2
Wolves Islands	2,966	143	4.9
Coast of Maine	4,439	33	.7
Totals	79,794	2,739	3.4

Returns from these taggings varied from 0 to 24%. Altogether, 2,739 (3.4%) were recaptured. Complete information on time and place of recovery of 100 tags was not provided, but of the other 2,639, 24% were recaught within a week of release, 36% during the next week, 19% in the third week, 7% in the fourth week, 4% in the fifth week, and the remainder (10%) spread chiefly over a period of 6 to 16 weeks following release. One tagged herring was at large 165 days. Over 80% of the recoveries were made in the packing plants and the remainder from fishing boats and carriers. No recoveries were made from United States reduction and pet food plants that purchased more than 30% of the Canadian catch in 1958.

About 61% of the recaptures were made within 5 miles of tagging site, 26% between 5 and 10 miles away, 10% between 10 and 15 miles away, and the remainder (3%) from 15 to 55 miles from the tagging site. The numbers of distant recoveries declined with increasing distance. Three were retaken on opposite sides of the Bay of Fundy--two went from Passamaquoddy to Digby Neck and one did the reverse.

In 1957, no tagged fish crossed the Bay of Fundy. The three recorded in 1958 probably did, but landings at the time of recovery were being made from both sides of the Bay and some confusion as to origin of the fish may have occurred.

No recaptures of fish tagged in Charlotte County were made westward along the coast of Maine, although one did go into Cobscook Bay and one from Cobscook Bay went southwestward along the coast of Maine. Many recoveries were made to the eastward in Charlotte County from herring tagged in Cobscook Bay and off the coast of Maine.

Recoveries from taggings in the Charlotte County area showed that herring move both in and out of Passamaquoddy Bay throughout the season. About midsummer, however, there was a fairly pronounced movement from the Passamaquoddy area to east

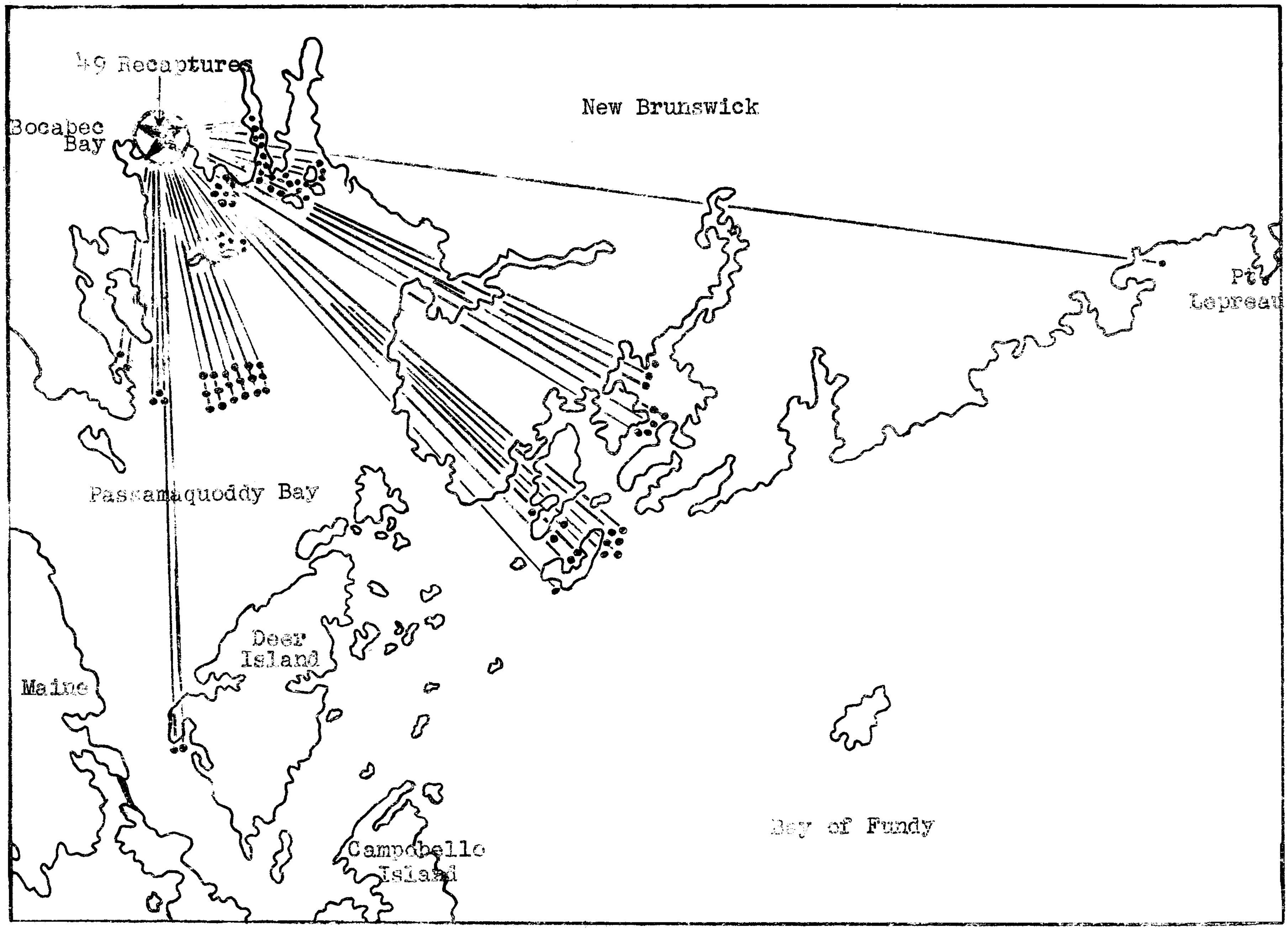


Figure 1. Recaptures from herring tagged at Birch Cove, May 16, 1959.

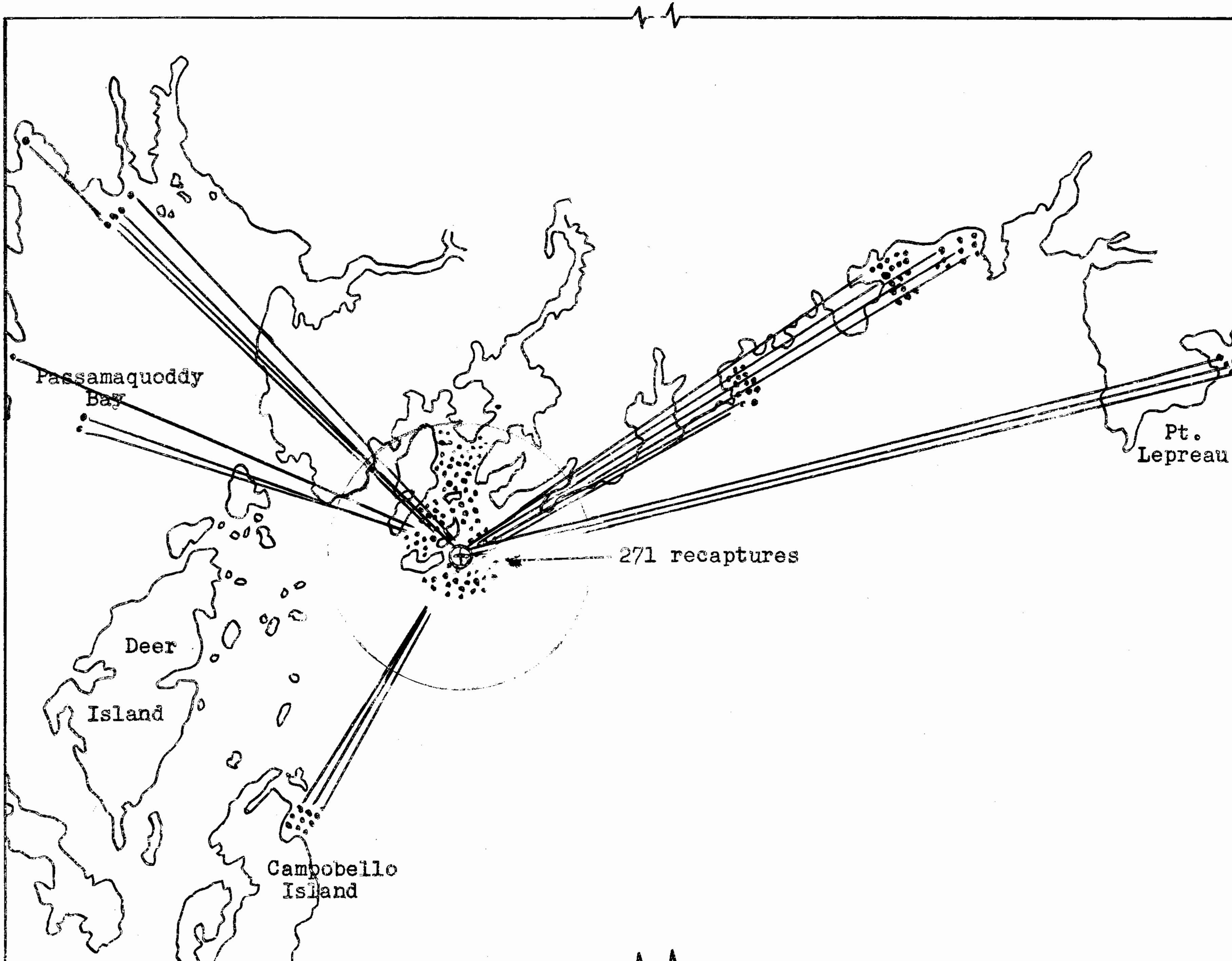


Figure 2. Recaptures from herring tagged at Spider Cove, July 2, 1958.

Charlotte and to Saint John County. This shift to the eastward coincided with substantial increases in landings in that region.

Recoveries from purse-seine operations in the middle of Passamaquoddy Bay in September-October showed that fish tagged earlier around the shores of the Bay had moved offshore to deeper water. Herring tagged in the central area of the Bay in September-October moved into the northeast part of the Bay a little later in the season.

As in 1957 more recaptures were made near the eastern than the western passages of Passamaquoddy Bay.

A test of the most suitable colour for tags conducted at Connor's Bros. plant in Blacks Harbour gave 75% returns for scarlet tags and 51% for maroon tags. A similar experiment in the field using about 1,000 each of scarlet, maroon and yellow tags resulted in recoveries of 12 scarlet, 5 yellow, and 0 maroon tags.

Tank experiments with opercular and dorsal tags showed 11% of the opercular tags and 36% of the dorsal tags in place after 3 months. Thirty-three per cent of the opercular tags fell off as the operculum under the tag wore away. The use of urethane as an anaesthetic made tagging easier but did not change the proportions surviving.

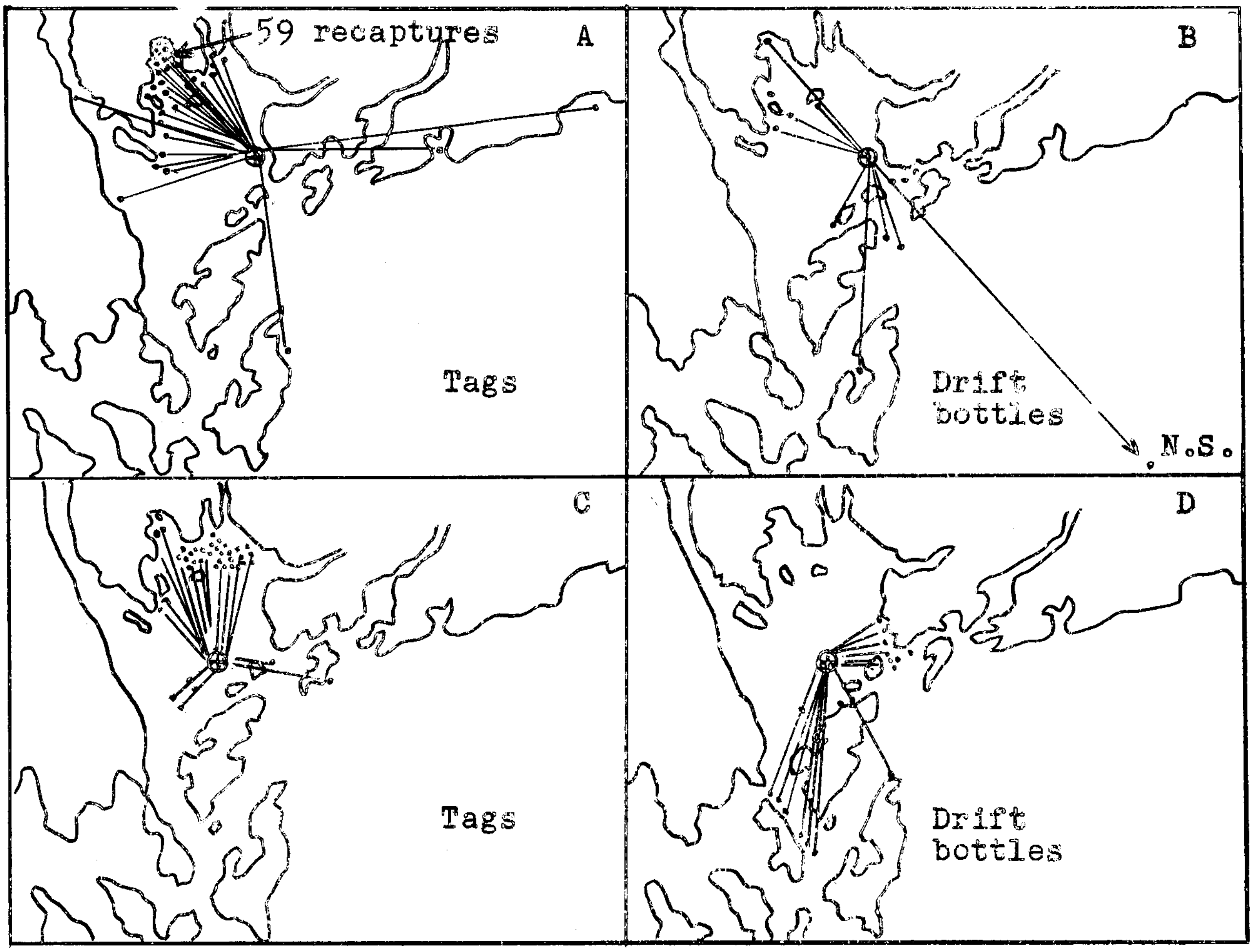
R.A. McKenzie

No. 51

HERRING MIGRATIONS AND SURFACE DRIFT

During 33 of the 34 herring tagging experiments in 1958 (Appendix No. 50), drift bottles were released at the same time as the tagged fish in an attempt to discover whether there was a relationship between herring migrations and the drift of surface waters. In each of 31 taggings, 48 bottles were released, in the other two, 44 and 49 bottles were released, making a total of 1,581 bottles altogether. For these experiments, the number of herring tagged and released was 77,843. There were 2,732 herring tags and 499 drift bottles recovered.

A comparison of the recoveries showed that for eight releases, the tagged herring and the drift bottles went in the same direction (Fig. A and B); for four releases, tag and bottle recoveries were made in opposite directions (Fig. C and D); for twelve releases, there was no uniformity in the direction of tag and bottle movements and in the remaining nine releases, there were insufficient recoveries of either tags or bottles for any conclusions.



Herring migrations and surface drift

These experiments have indicated that tagged fish do not always move in the same direction as the surface currents. Sometimes the surface layer may be very shallow and have no effect on the movements of fish. While there is insufficient evidence to establish a pattern of herring migration, there is a suggestion of random movement with some tendency to swim against the current. There are undoubtedly other factors affecting migration, such as enemies, reactions to light, vertical distribution, etc., and further investigations are necessary.

R. A. McKenzie
R. W. Trites

No. 52

STUDIES OF HERRING BEHAVIOUR

Herring groups confined in a cage orientated with a component upstream when the cage was towed. With increasing current speeds, the orientation upstream became more pronounced and finally the fish were displaced downstream tail first. Under these conditions the maximum swimming speed of herring was found to vary from 1.8 knots for fish of mean length 15.2 cm., to 2.8 knots for 26.7 cm. fish at about 12°C.

Underwater television cruises

Two cruises using underwater television equipment were made during 1958. The first, from May 16 to May 28, used equipment belonging to the United States Fish and Wildlife Service, Woods Hole, supervised by Mr. R. Livingstone. The second, from September 18 to October 1, used the National Research Council's unit developed by Mr. W.M. Cameron.

During the latter part of the first cruise and the whole of the second cruise, observations were made on groups of freshly-caught herring placed in a mesh-covered cage, 6 feet long, 4 feet wide, and 4 feet deep. The camera was attached to one end of the cage so that a clear view of most of the interior of the cage was obtained on the monitor screen. The cage, with its attached frame supporting the camera, was slung from above and in front from booms on the M.V. *Harengus* so that it could be lowered, held or towed at any depth. When towing the unit, the cage acted as a fin so that the camera end of the cage always moved first through the water. A current meter was attached inside the cage, half-way back, and in the upper part. Later calibration of this master meter with a second current meter supported in the position occupied by the fish during the experiment, allowed the velocity of water movement past the fish to be calculated. In the following account only results obtained from September 26 onwards are given as calibration for the earlier days has not been completed.

Behaviour of herring in water currents

The response of the herring to low natural currents was investigated by observing the behaviour of the fish in the cage while the boat was anchored in various tidal streams. The response observed in no way differed from their response to the apparent current set up in the cage when it was towed. This suggests that the response was not to water currents as such but based either on the displacement of fish relative to their visual field or perhaps to minor turbulence set up by the passage of water through the front mesh. This latter explanation seems unlikely as when fish were lowered to 100 feet, they maintained their orientation upstream while the cage was lit by artificial light, but drifted downstream when the light was turned off for

Underwater television camera and cage used to determine the maximum swimming speed of herring.

5 to 10 seconds. Failure of the television camera prevented the intended experiment of keeping the herring without light at this depth for a long enough period to allow light adaptation. In the absence of light adaptation, the loss of orientation mentioned above must not be taken as evidence that herring naturally occurring at 100 feet are at too low a light intensity for visual orientation in current to occur.

At current speeds below a certain minimum value, the herring circled the cage, their path determined by the walls and not related to the current. A minimum value for the orientation by current of 0.8 ft./sec. was indicated by the television experiments but this needs to be investigated further. As the speed of the cage through the water increased, the herring formed a group in the upstream end of the cage near the bottom and began to swim from side to side, always turning upstream when meeting the walls. The orientation of the herring into the current became more pronounced as the velocity increased and the side to side deviations decreased until they were slight and irregular. At higher current velocities the swimming speed of the herring increased until it reached a maximum when the fish, still heading upstream and swimming vigorously, slowly lost ground tail first until they were swept against the mesh of the cage.

Maximum swimming speed

To determine the maximum swimming speed a group of up to 50 herring selected by eye for uniform size were placed in the cage. The cage was then lowered to 20 feet and held there for 15 minutes. Tides or wind drift of the boat usually caused a minor current to pass through the cage under these conditions but the flow remained below 1.2 ft./sec. At 15 minutes the cage was towed at a gradually increasing speed. A record was kept of the behaviour of the herring and of the number of fish that had failed to keep pace and were on the back mesh, as seen on the television screen during each minute. A second observer recorded the current velocity on a minute by minute basis. The increase in speed continued until all the fish had failed, when the cage was raised, placed on deck, and the fish removed for measuring. A temperature reading at 20 feet was taken between each tow.

From graphs of percentage of fish failed and current speeds plotted against time the current speed at which 25%, 50%, and 75% of the fish failed has been determined and is shown in the accompanying table. The speed at which 50% of the herring failed to keep pace with the cage may be taken as the maximum swimming speed which may be maintained over one minute by fish of these sizes at these temperatures when swimming at an increasing rate. Such conditions might be found in nature where herring near the bottom were stemming an increasing tidal flow. All currents above the maximum swimming speed will be able to move the herring in the direction of flow.

Details and results of experiments to determine the maximum swimming speed of herring.

Mean length	Size range	No.	Hours after capture	Temperature	Average increase in speed	Time to 50% failure	Current speed at which fish failed ft./sec.			50% failure in knots	Date and experiment number
cm.	cm.			°C.	ft./sec./min.	min.	25%	50%	75%		
15.2	12.2-17.5	31	7¾	12.2	0.16 *	9	2.8	3.0	3.2	1.8	Sept.26 (4)
18.5	15.5-21.5	50	3¾	12.1	0.10	25	3.8	4.0	4.1	2.4	Sept.26 (2)
18.5	15.9-21.1	43	9	12.4	0.11	12	2.5	3.1	3.1	1.8	Sept.26 (5)
20.7	18.7-23.3	35	6	11.7	0.12	18	2.9	4.0	4.1	2.4	Sept.29 (3)
22.0	19.6-27.1	30	5¾	11.6	0.11	24	3.3	3.7	4.0	2.2	Sept.26 (3)
25.8	23.5-29.3	46	1¾	11.7	0.11 *	26	4.0	4.4	4.5	2.6	Sept.30 (1)
26.7	24.9-30.0	22	3¾	11.7	0.08	30	4.4	4.7	4.7	2.8	Sept.29 (2)

* to 75% failure only

In the second and third columns of the table, results have been given for two groups of herring of the same mean length and of the same stock which were tested at the beginning and the end of the day. Strong winds at the end of the day, making handling more difficult and necessitating an increase in speed before the tow and not just the increased holding time are likely to be the cause of the difference in swimming speed of the two groups.

The results have been given in the table in order of mean length. There is a statistically significant positive correlation between mean length and maximum swimming speed; the larger herring overcoming higher current velocities before 50% failed.

V.M. Brawn

No. 53

THE SURVIVAL OF HERRING UNDER ENVIRONMENTAL EXTREMES

Upper lethal temperature

The upper lethal temperature was determined for five groups of unacclimated herring during June, July, August, and October. Of these only the June and October determinations gave consistent increments of mortality with temperature and only the October determination is considered here. In October, herring were tested in an area 3 feet square by 18 inches deep separated by a galvanized wire screen from the aerator, thermometers, and water inflow. The fish were taken from a weir at 9.6°C., transported at 9.2°C., and within three hours all the fish were in the experimental tanks, never having been brought out of water.

The herring used in the October determination fell into two distinct size groups and 10 large and 30 small herring were selected to make up each test group. When the first 20 fish to die at 23° and 21°C. were considered, it was found that there was a significant difference in the mean length of the first 10 to die in each tank and the second 10. In a group of herring ranging from 9.5 to 30.4 cm., there is thus a differential mortality with temperature; the larger fish dying more quickly at high temperatures than the smaller ones.

Length-frequency distribution of the whole test group showed a discrete population having a mean length of 11.1 cm. with S.D. of 0.68. This corresponded to the 30 small fish initially assigned to each test temperature group. In the accompanying table, the percentage mortality of fish of this group and of the larger fish has been given separately. It can be seen that the upper lethal temperature of the small 9 to 12 cm. herring at 48 hours is close to 21°C. and for the 17 to 30 cm. herring is below this, falling between 19° and 21°C.

Determination of upper lethal temperature of herring taken from a weir at 9.6°C. in October 1958.

Temperature °C.	Temperature variation °C.		9-13 cm. herring No.	% mortality 6 hr.	12 hr.	24 hr.	36 hr.	48 hr.	17-30 cm. herring No.	% mortality at 48 hr.
23	+0.2	-0.5	29	76	90	100	100	100	10	100
21	+0.2	-0.9	31	13	23	39	45	45	10	100
19	+0.3	-0.3	30	0	0	0	10	17	6	33
17	+0.3	-0.3	29	0	0	0	7	31	9	33
15	0	0	28	0	0	0	0	11	9	22
10 (control)	+0.4	-0.7	28	0	0	0	0	0	10	0

The ability of herring to withstand sudden changes in depth

The herring to be tested were enclosed in the inner of two mesh-covered cages in about a cubic yard of water. The outer cage was closely covered to reduce water movement through the cage as it was rapidly lowered or hauled through the water. On the first run, 86 herring were placed in the cage, the lid was closed and the cage was allowed to drop as quickly as it could strip wire off the winch, until it reached 150 feet. The rate of descent was 1.7 ft./sec. The cage was left at 150 feet for five minutes and then hauled at a rate of 2.6 ft./sec. to the surface. At the surface, the behaviour of these fish was seen to be normal and there was no mortality in the following two hours. A second run with 58 herring descending at 1.9 ft./sec. to 145 feet, and after five minutes being hauled at 2.2 ft./sec. to the surface, gave the same results. These fish were caught on the same day that they were tested and ranged in size from 14 to 21 cm. It is concluded that suden changes in depth from the surface to 150 feet have no ill effects on these fish.

V.M. Brawn

No. 54

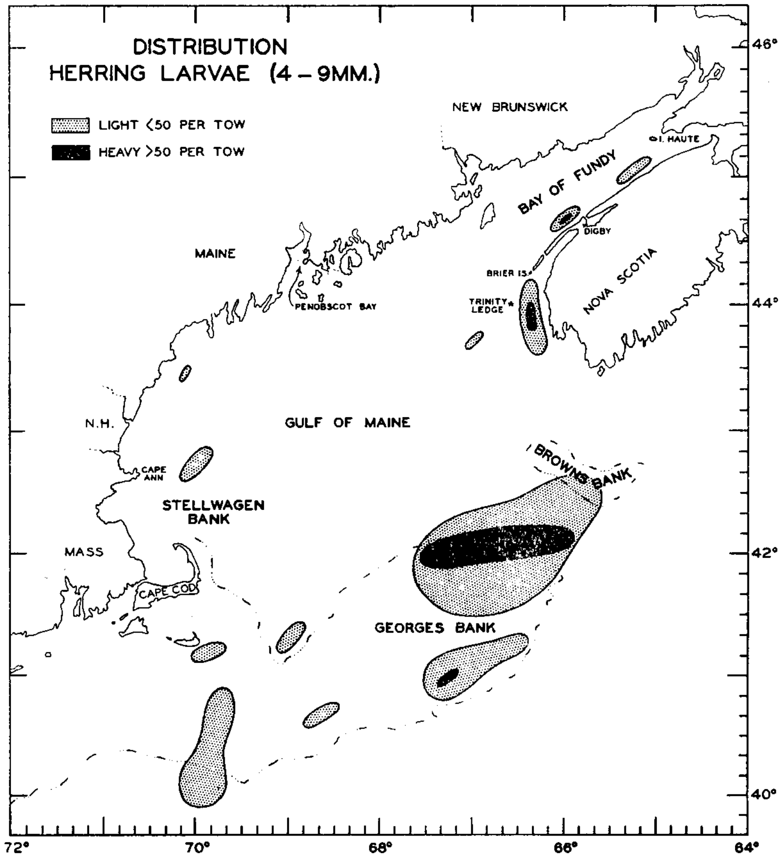
THE DISTRIBUTION OF HERRING LARVAE IN THE

BAY OF FUNDY AND THE GULF OF MAINE

The great concentration of young herring in the Passamaquoddy region presents a problem of explaining why such a fishery should be centered in this area. It is pertinent therefore to determine the source and methods of recruitment that are responsible for this fishery. Intensive sampling for larval herring provides information on these points.

As in 1957, plankton collections in 1958 were made on a co-operative basis by the Fisheries Research Board of Canada and the United States Fish and Wildlife Service. During the year, 14 stations were occupied on each of 22 cruises carried out in the Passamaquoddy area. In addition, collections made by the Fisheries Research Board at Prince stations 5 and 6 for the years 1941-46 inclusive have been examined. There were 3 special spring cruises from Grand Manan to St. Mary Bay, 3 offshore cruises in the Bay of Fundy and Gulf of Maine, 15 exploratory cruises at the entrances to Passamaquoddy and bi-weekly surface tows from early April to the end of December at the Lurcher Lightship.

The results indicate that herring larvae are not produced in Passamaquoddy Bay. A few larvae have been found in the area and the indications are that they move in on the flood tide, probably through Western Passage.



Herring spawning areas in the Bay of Fundy and the Gulf of Maine estimated from the distribution of newly-hatched (4-9 mm.) larvae.

Outside of Passamaquoddy in the Bay of Fundy and the Gulf of Maine, the major concentrations of herring larvae were found near Brier Island In September. In October, large concentrations of larvae were found on the northern edge of Georges Bank and in the vicinity of Trinity Ledges off southwestern Nova Scotia. While herring larvae were well dispersed in the Bay of Fundy during October, the heaviest concentrations were found off Digby. In November, larvae were still heavily concentrated on the northern edge of Georges Bank but some were found between there and Nova Scotia. The large October concentrations of larvae in the Bay of Fundy were followed by a more general distribution in the northern part of the Bay and along the west coast of Nova Scotia. Herring larvae were very sparsely distributed in the Bay of Fundy and Gulf of Maine in December. In January and February, the larvae were still more widely dispersed and fewer were taken.

Three special spring cruises around Grand Manan and in St. Mary Bay failed to produce any newly-hatched herring larvae, but the capture of one young larvae in June on the Lurcher Shoals supplied evidence of some spring spawning in this region.

The results indicate that major herring spawnings occur off the southwest coast of Nova Scotia and on the northern edge of Georges Bank. The drift of the larvae, as indicated by non-tidal surface currents and increasing size as the distance from the spawning areas increases, suggests that only Nova Scotia spawnings contribute substantially to the commercial stocks of herring in the inshore areas of southern New Brunswick.

J.E.H. Legare

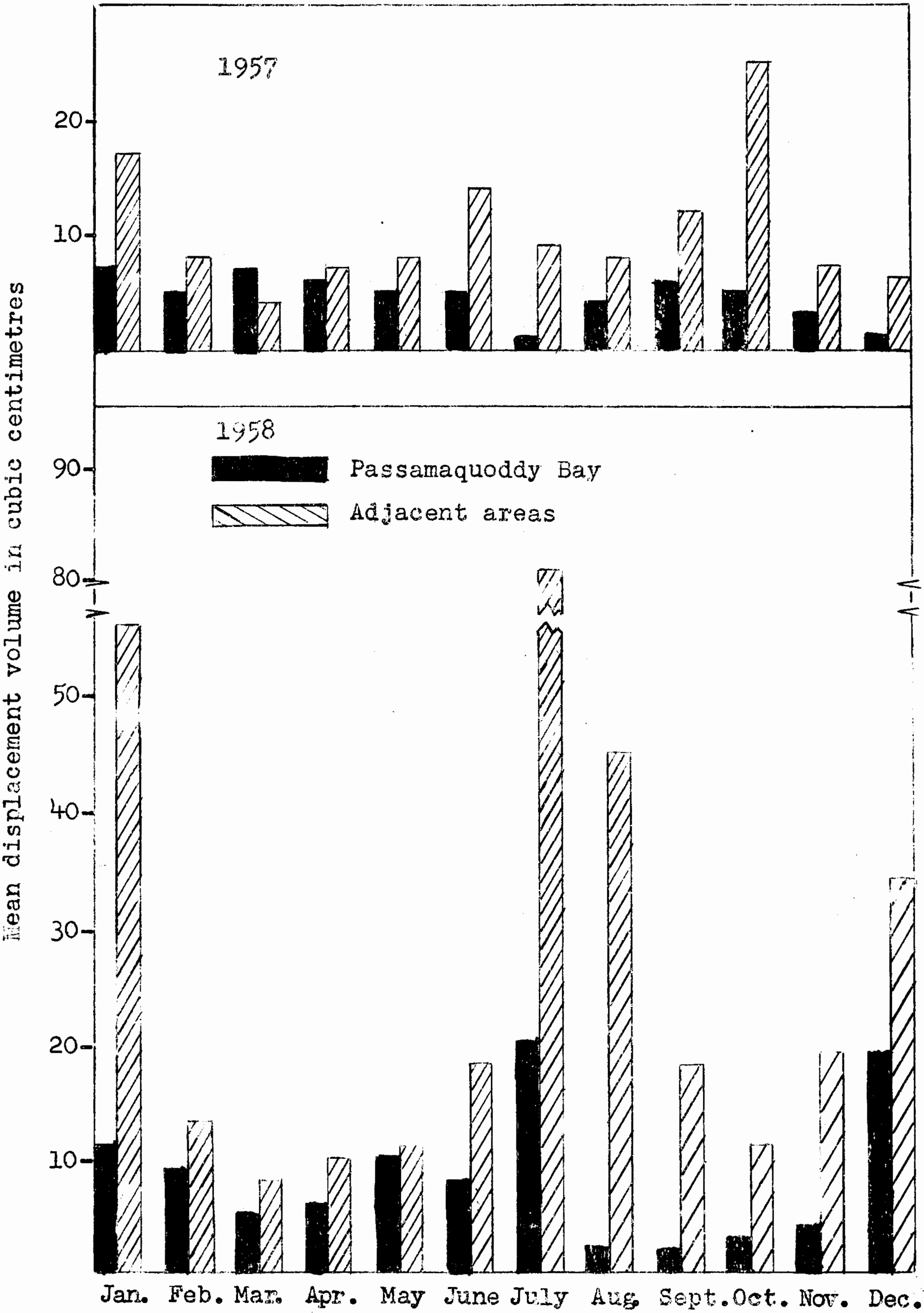
No. 55

THE DISTRIBUTION OF PLANKTON IN THE QUODDY REGION

The biology of plankton populations in Passamaquoddy Bay and its approaches is of special importance to the production and distribution of the young herring which support the large "sardine" fishery of the area.

Plankton collections have been made on a bi-monthly basis over a two-year period and a study of these collections indicates a very complex problem with a great many species involved and their distribution and abundance varying throughout a season and from one year to the next. The entire plankton population of the region consisting chiefly of littoral forms such as crustaceans, molluscs, etc. may be considered to belong to the neritic group. Only the more common and most abundant forms are discussed here.

In January, February, and March, the copepod Calanus finmarchicus was the most abundant form at most stations, although



Plankton concentrations in the Passamaquoddy Region, 1957 and 1958.

Tortanus discaudatus made up most of the collections at Station 8 in the St. Croix River. Plankton tows during this period were rich in adult chaetognaths, euphausiids, and annelids. In March, there were also large numbers of crab larvae. From March through July, larval forms of euphausiids, crabs, cladocerans, barnacles, fish, chaetognaths, and annelids made up most of the collections. Large numbers of diatoms, eggs, siphonophores, and medusae were also found. Pulses of Calanus finmarchicus, Metridia lucens, Tortanus discaudatus, Acartia clausi, and Temora longicornis were indicated at one or more stations on several occasions. The copepod taken most regularly in large numbers during this period was Pseudocalanus minutus. Copepods were abundant at a few stations in August with Calanus making up most of the catch. At the same time large numbers of Pleurobrachia were found throughout the Quoddy region. In September and October, the copepod Centropages typicus dominated the catch with smaller numbers of euphausiids, Sagitta, and amphipods particularly in October. The plankton collections in November and December were made up almost entirely of Calanus finmarchicus although Centropages and Tortanus were abundant at a few stations.

The average volume of plankton per tow is given by months for 1957 and 1958 in the accompanying figure. The values for Passamaquoddy Bay and for the adjacent areas are shown separately. The differences between the quantities taken in the two years are obvious, particularly for the collections in January, July, August, October, and December.

Special plankton collections to study the depth distribution of herring food organisms showed that in mid morning the majority of the plankton were in the deep-water layers while at night the largest quantities were taken near the surface.

Tides appear to play a major role in the horizontal distribution of plankton in the Quoddy region. Plankton concentrations were consistently larger in areas adjacent to the Bay and most of the forms found inside the Bay were also evident and in greater abundance immediately outside. Flood tides were generally associated with an influx of plankton to Passamaquoddy Bay. The most important endemic copepods in Passamaquoddy Bay in 1958 were Tortanus discaudatus, Acartia clausi, and Eurytemora herdmani in that order.

J.E.H. Legare

No. 56

THE FOOD OF HERRING IN PASSAMAQUODDY BAY

Various authors have discussed the rich feeding grounds of the Passamaquoddy area. As early as 1898 Moore wrote "The remarkable abundance of herring in the vicinity of Passamaquoddy Bay is doubtless a direct relation to the rich supply of nutritious food". There has, however, been very little evidence presented in support of this contention.

During the summer and autumn of 1958, an investigation was carried out in an attempt to relate the feeding habits of herring to the food available in the Quoddy region. Samples of freshly-caught herring were preserved in 5% formalin and brought to the laboratory for examination. A total of 1,696 herring from Passamaquoddy Bay and its approaches were examined. The number of herring with food was 1,098 or 64.7% of the total. Each stomach was examined separately for types of organisms. Average displacement volumes were calculated for each sample of about 100 fish.

The food of the herring was quite diversified and about 50 different organisms were identified and recorded. Copepods, eggs, cypris *Balanus* larvae, mussel larvae, cladocerans, and crab zoea occurred most frequently. Also appearing in large numbers was the parasitic trematode *Brachyphallus crenatus*. There was a direct relationship between the size of the herring and the size of the food in their stomachs.

The relative importance of plankton organisms in the diet of herring varied according to the availability of food in the different localities. Inside Passamaquoddy Bay herring were feeding more actively than outside the Bay and the dominant organisms found in the stomachs were species of copepods endemic to the Bay such as *Eurytemora herdmani*, *Acartia clausi*, and *Tortanus discaudatus*. Outside Passamaquoddy Bay neritic species of copepods such as *Pseudocalanus minutus* and *Calanus finmarchicus* and large numbers of harpacticid copepods and barnacle larvae were the main food items.

The pattern of feeding activity follows closely the relative abundance of plankton in the region. Heavy feeding in June was followed by a fairly regular decrease in July and August; a sharp increase in September followed by another decrease in October. In late November there was a slight renewal of feeding activity which corresponded with an increase in abundance of plankton at that time.

J.E.H. Legare

No. 57

EXPLORATORY FISHING FOR HERRING

Explorations for new areas and new methods of catching herring were continued in 1958. As for many of the Passamaquoddy projects, resources of equipment and personnel were pooled with the United States Fish and Wildlife Service for more extensive and efficient operation. The present fishery in both southern

New Brunswick and in Maine is carried on chiefly with weirs or bar seines close to the shore and little is known of the off-shore distribution and abundance of herring.

Bottom-trawl fishing was carried out on the northern edge of Georges Bank in January. For 13 tows with a standard No. 41 trawl with a small-mesh codend, the average catch amounted to approximately 150 pounds. Some herring were taken in every tow but the maximum was only 350 pounds. These herring were large, mature fish that had recovered from spawning, presumably during the previous autumn.

Dutch herring trawls and gill nets were used from the M.V. Harengus in Kennebecasis Bay. Small quantities of herring were taken in both. In the gill nets, which were approximately 50 feet deep, the herring catches were evenly distributed from top to bottom.

In an attempt to discover the entrance and exit of herring to and from Passamaquoddy Bay, gill nets, Isaacs-Kidd trawls, Dutch herring trawls, and Larsson trawls were used without success. There was no difficulty with the operation of the trawls but it was found to be impossible to anchor gill nets in the Passages. These experiments were combined with tagging operations and 10,000 marked herring were released in Letite Passage. None of the marked fish were recaptured.

On October 7, the M.V. Harengus fished with bottom trawls on the northern edge of Georges Bank. Moderate catches of herring were taken and sampled for biological studies. This is now the fourth consecutive season that successful bottom-trawl fishing has been carried out on Georges Bank.

Throughout the summer months, sonic-sounder cruises were carried out weekly in Passamaquoddy Bay. These showed that, in general, the largest concentrations of herring are in the open areas away from the small coves and inlets where the weirs are located. Large quantities (at least 2,250,000 pounds) of herring were taken by commercial purse seiners in the centre of the Bay in September.

S.N. Tibbo

No. 58

HERRING CATCHES IN RELATIONS TO ENVIRONMENT

Attempts to explain fluctuations in catches of herring in the Passamaquoddy region on the basis of variations in meteorological, hydrographic, and biological conditions were continued during 1958. Mr. H.D. Henderson, a summer student, was responsible for this assignment.

The project is of prime importance to the Passamaquoddy investigations. An understanding of the causes of present fluctuations in catch would assist materially in the prediction of changes in herring fisheries should power dams be installed at the entrances to Passamaquoddy and Cobscook Bays.

In 1957, efforts were directed chiefly towards comparisons of catches with temperatures and river discharge. In 1958, emphasis was placed on winds, sunshine, and plankton production although additional data on air and sea temperatures and river discharge were also examined.

The results of these studies were disappointing. Significant correlations have been demonstrated between catch in some years and in some districts with certain physical factors, but it has not been possible to establish any consistent correlation between catch and physical conditions over the period 1947 to 1956. For example, in only two of the ten years was there any significant relationship between catches and overall abundance of plankton in the area; comparisons of river discharge and catch per weir in the same year and for one and two years later proved fruitless; unusual catch years (high and low) compared with river discharge, salinities at various levels, plankton volumes, and cloud cover gave no significant results.

An overall appraisal of these studies suggests that while the abundance of herring in this area is probably related to the physical conditions of the environment, there is little or no relationship between abundance and catch. Perhaps this is not surprising in view of an extremely variable market demand and the fact that the weirs and bar seines are only efficacious on the fringes of the area of distribution.

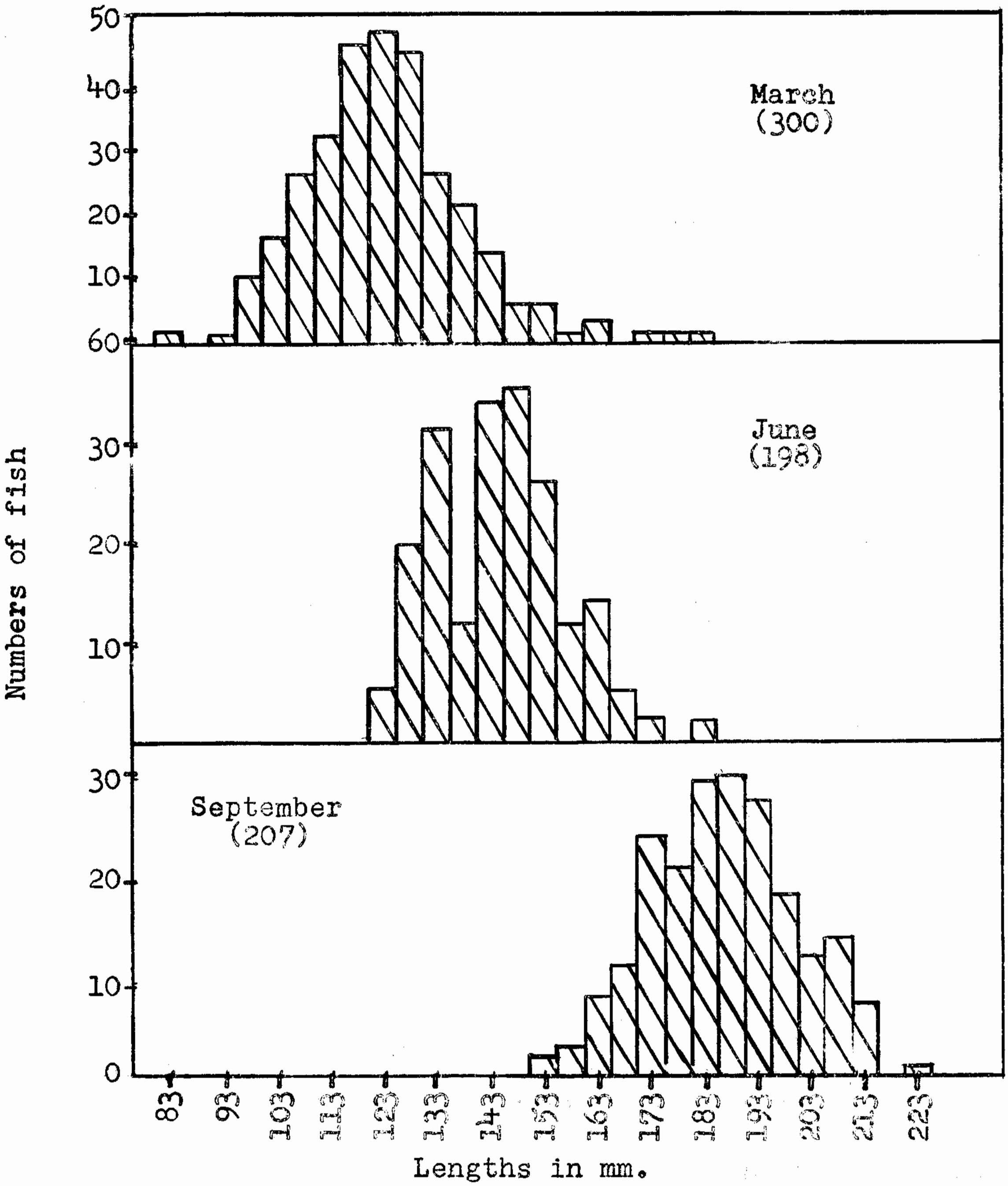
S.N. Tibbo

No. 59

THE LENGTH AND AGE COMPOSITION OF CHARLOTTE COUNTY "SARDINES"

The major responsibility in the International Passamaquoddy Fisheries Investigations for the age and growth analyses of the herring in the Passamaquoddy Region has been delegated to the Unites States Fish and Wildlife Service. Samples of herring were collected from all Quoddy areas except Quoddy Roads and eastern Campobello. In addition, there were two samples from Grand Manan and one from Georges Bank. Lengths and vertebral counts were recorded and forwarded to the Boothbay Harbor laboratory.

Fifty-two samples were obtained and 8,563 fish measured. Mean lengths varied from 96.7 to 188.4 mm. The accompanying figure gives an example of the length composition of the herring from catches in March, June, and September. During this period mean



Seasonal variation in length composition of "sardines" sizes increased from approximately 125 mm. in March to 145 mm. in June, and to 186 mm. in September.

Examination of scales from 18 samples showed that 49% of the scales were unreadable. Of the 968 fish, whose ages were determined 83% were 1+, 15% 2+ and 2% 3+ years old. A comparison of the average size of these age-classes month by month showed that most of the growth took place from May to August.

In contrast to the difficulty experienced in reading herring scales, Mr. Basil Parrish, Marine Laboratory, Aberdeen, aged some Passamaquoddy sardines by means of otoliths and experienced "no difficulty whatsoever with age readings. All otoliths easily read". He also indicated that "all otoliths (indicate) clear-cut autumn spawned. Centres (are) large and clear".

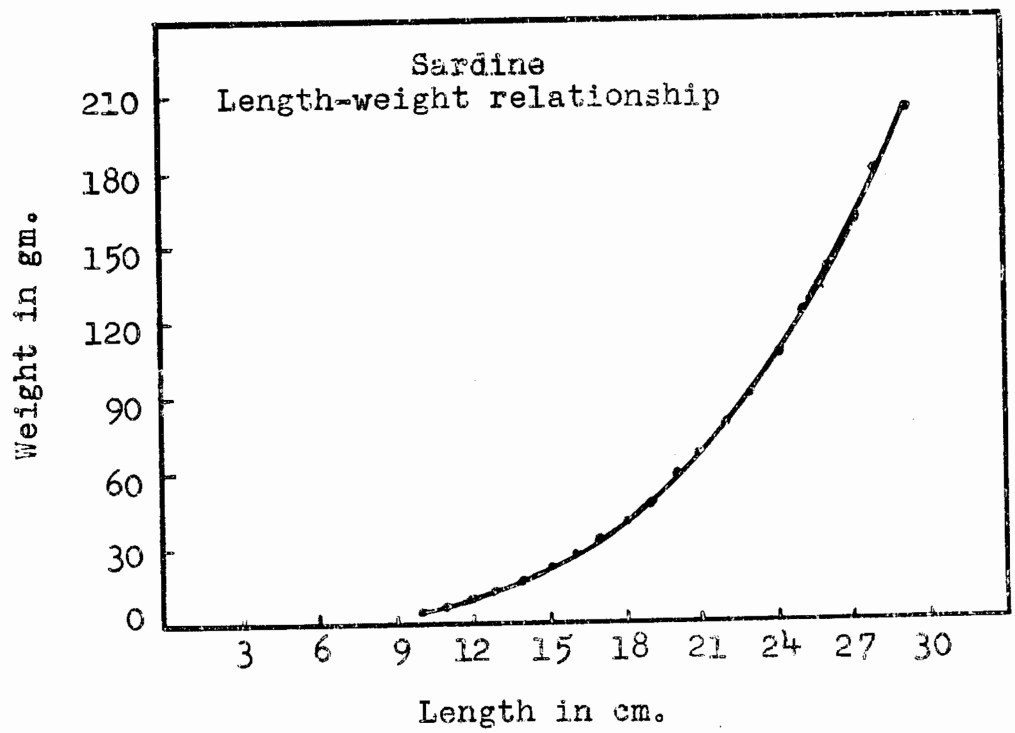
A change from scales to otoliths thus seems warranted, not only for age determinations but also for distinguishing between spring- and autumn-spawned fish.

R.A. McKenzie

No. 60

LENGTH-WEIGHT RELATIONSHIPS FOR "SARDINES"

In most of the samples of "sardines" that have been examined from the Passamaquoddy region, the only size measurement recorded has been the length from the end of the lower jaw to the tip of the longer lobe of the tail extended straight back



in line with the body. This is adequate for descriptions of comparative sizes of fish in an area but has little or no reference to the commercial fishery where the custom is to refer to landings in pounds or some other measure of weight. In order to provide a convenient means of converting the length of "sardines" in a sample to weights and hence to determine the actual numbers of fish caught, a length-weight relationship has been established. Samples were obtained during 1958 and the fish measured to the nearest millimetre and weighed to the nearest gram. All of the samples were examined fresh and in most cases individuals of the same length were weighed together and an average weight calculated.

Altogether, 2,052 "sardines" were examined. Lengths varied from 90 to 299 mm. and average weights from 4.3 to 215.0 gm. There were few individuals longer than 220 mm., but for the smaller sizes, average weights are based on 10 or more fish.

In the accompanying figure, average weights are plotted by centimetre length groups.

R.A. McKenzie

TROUT SUMMARIES

General summary of trout investigations

Alteration of a lake environment to improve trout angling

Control of the eel population of a lake

Pond formation on streams to improve angling

(a) With pond relatively large in relation to size of stream

(b) With pond relatively small in relation to size of stream

Annual variations in standing crops of trout in relation to environmental changes and other factors in a Prince Edward Island stream

Adequacy of natural seeding to utilize fully the trout-producing capacities of artificial ponds on Prince Edward Island streams

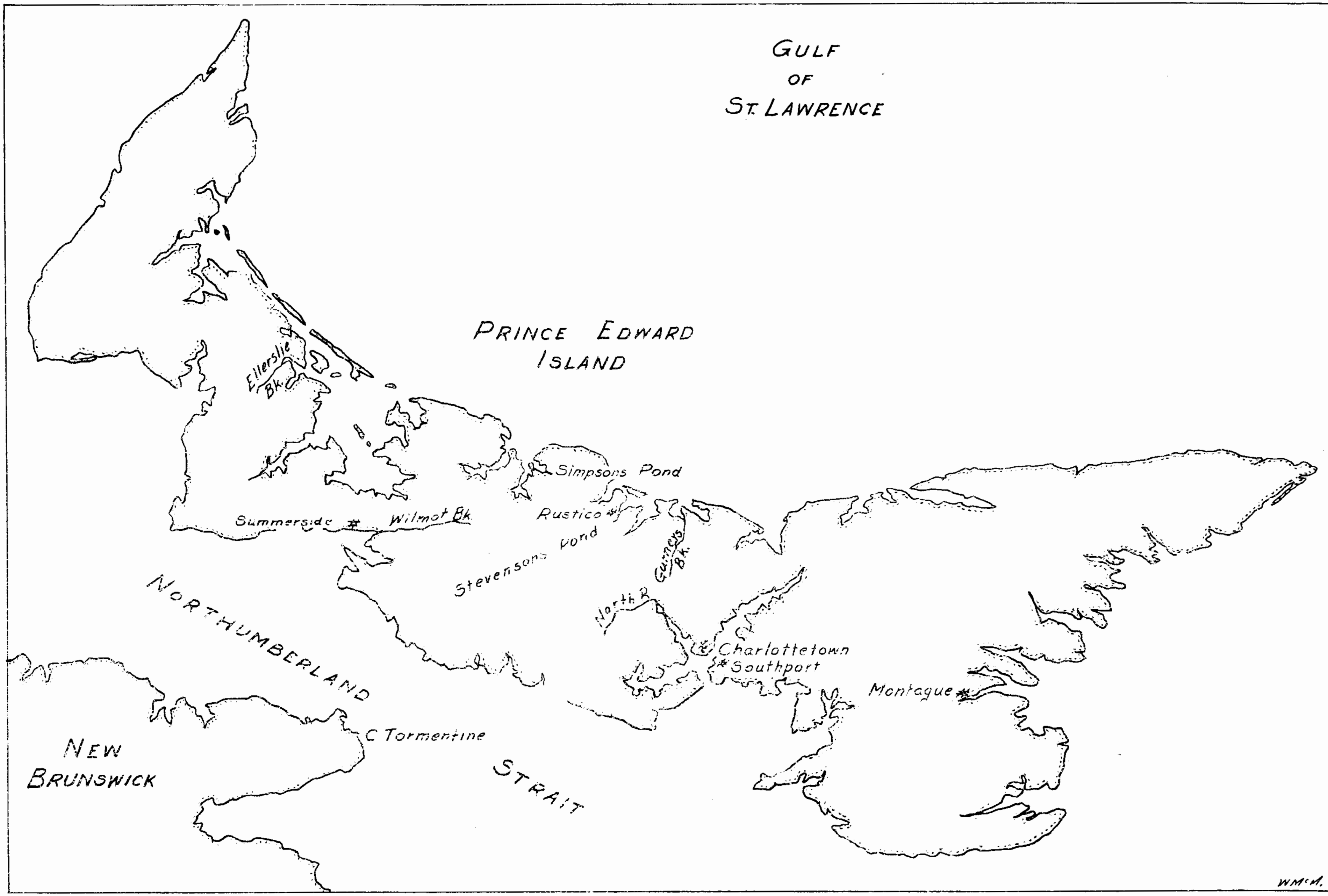
Rainbow trout in Prince Edward Island waters

Relative value of rainbow and brook trout in utilizing the productive capacity of New Brunswick lakes

Evaluation of conditions for trout production in a flooded estuary

Alkalization of a farm fish pond

Tolerance of immature trout and salmon to salt water


GULF OF ST. LAWRENCE
PRINCE EDWARD ISLAND
Ellerslie Bk.
Simpsons Pond
Rustico
Summerside
Wilmot Bk.
Stevensons Pond
Gurneys Bk.
North R.
Charlottetown
Southport
Montague
NORTHUMBERLAND STRAIT
C. Tormentine
NEW BRUNSWICK
WMcM.

No. 61

GENERAL SUMMARY OF TROUT INVESTIGATIONS

Fresh waters can be altered physically, chemically, and biologically to provide better environments for trout and other sport species. Industrial, agricultural, and forestry operations may also alter fresh waters, but often adversely for fish production. Research to maintain and improve the trout fishery must accordingly deal with both these opposing facets of habitat alteration. Concurrently, research must also be concerned with the development of procedures to make best use of the fish, and with providing information for regulation to achieve this end.

Fresh waters of the Maritime area can be usefully classified on a regional basis with respect to quality of water for trout production. This regional classification is primarily based on the character of the rock formations and the nature of the overlying soils. Research should be sufficiently diversified to overcome natural deficiencies in trout production and utilization peculiar to the several limnological regions.

Investigations have shown that stocking Maritime fresh waters of low to high production levels increased the 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 Maritime's mainland, resulted in a higher productive level and a marked increase in yield of brook trout to anglers. Stocking was necessary and effective. 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 on hard-water, spring-fed streams are highly productive of trout. The availability and yield of trout to anglers from a stream system is improved by pond formation, but introductions of trout are needed in some situations to realize the full productive capacity of the ponds. Where brook trout move to salt water, a pond formed on a 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.

Currently, and for the near future, emphasis is placed on the following projects:

1. Pond formation to increase stocks of trout, their availability and utilization by anglers, as a public endeavour, and by private enterprise for sale of angling privileges.

2. Comparison of rainbow and brook trout in their abilities to utilize the varied productive capacities of Maritime fresh waters.

3. Improvement of nursery streams to increase the supply and survival of young trout.

4. Assessment of the effects of forestry operations on trout (and salmon) streams.

M. W. Smith

No. 62

ALTERATION OF A LAKE ENVIRONMENT TO IMPROVE TROUT ANGLING

The infertility of the waters in the majority of lakes in New Brunswick and Nova Scotia conditions a low to mediocre fish production. Angling success in most lakes declines when they are subjected to a continued and increasing fishing effort.

Commercial fertilizers were added to Crecy Lake, New Brunswick, as a means to improve the growth and production of brook trout. Crecy is a 50-acre headwater lake similar to many others in the Maritime provinces. Trout were planted to supplement a low natural production of young in order to insure sufficient stock to demonstrate any improvements in production that might result from the fertilization.

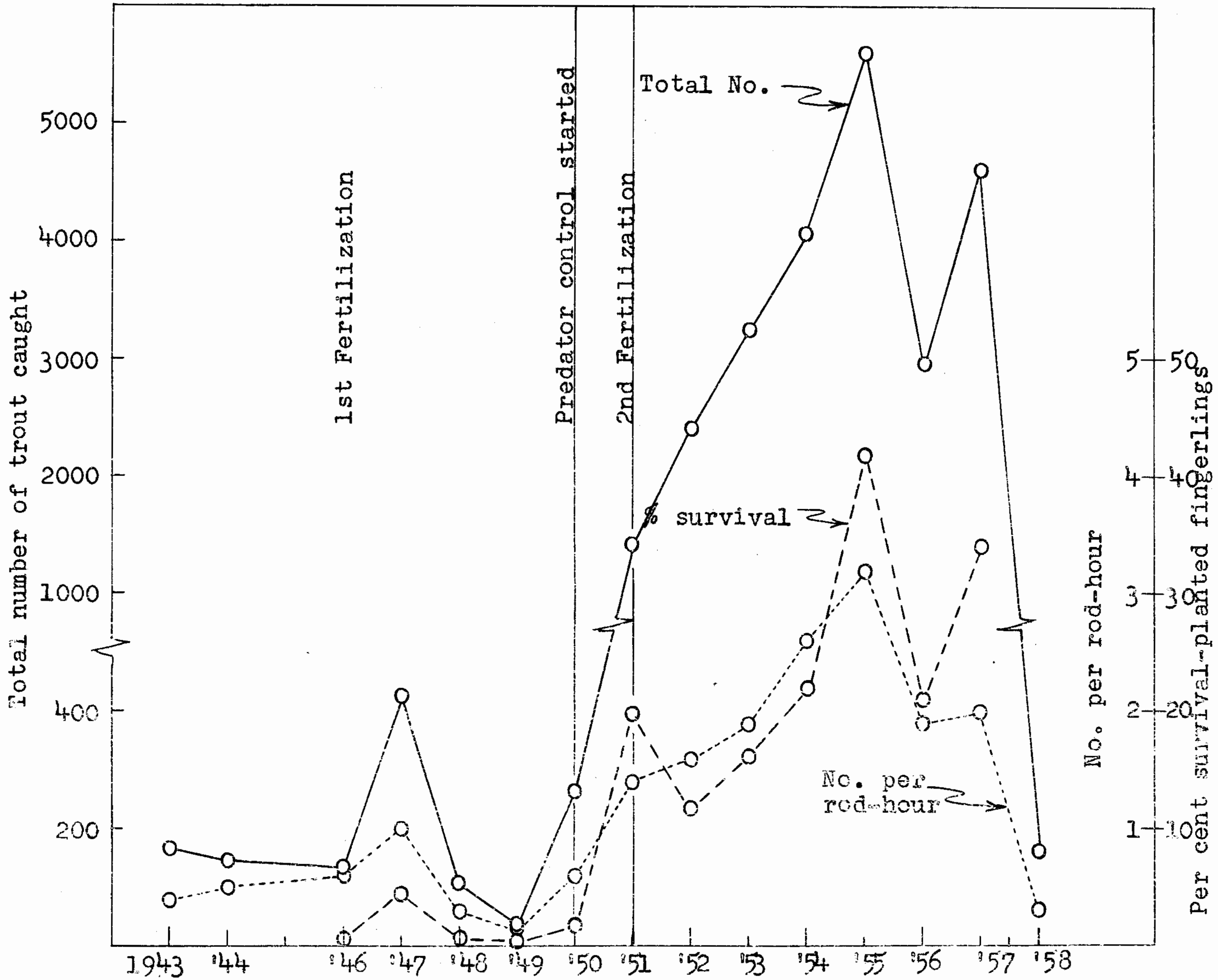
Fertilization improved the growth rate of trout in Crecy Lake. The favourable result was largely nullified, however, by increased predation by fish-eating birds and mammals, which were apparently attracted in great numbers to the lake by the consistent annual stocking. Control of these predators was undertaken, and attempts made to reduce the numbers of eels and older trout in the lake. Deferment of the opening date for angling was made in one year (1956) to learn if better summer angling could be realized. The results of these actions are in part illustrated by the accompanying figure and may be summarized as follows:

1. Fertilization resulted in a better growth rate of trout in Crecy Lake, to the point that fingerling trout (about 3 inches in length) planted in early September attained a suitable angling size (7 to 9 inches) by the next spring and early summer. A comparable rapid growth is not made by trout in other lakes of the area.

2. Fertilization, stocking, and predator control when applied together resulted in a marked increase in the survival of trout and in the yield to anglers. An increased survival of planted fingerling trout to the anglers' catches from less than one to a maximum of 42 per cent was realized.

3. The majority of the planted trout were taken by anglers during the first year after stocking. Almost none survived to be angled during the third year after their introduction into the lake.

4. Deferment of the opening of the angling season from April 1 to June 1, 1956, resulted in better catches to later dates in summer, but the total catch was smaller.



Results of fertilization and predator control upon survival of planted fingerling trout and the yield of trout to anglers. (There was no stocking of trout in 1957.)

5. The favourable effects of the fertilization on the quantity of trout foods were transitory, being maximum in the fourth year after fertilization, to fall rapidly to pre-fertilization levels in the fifth and sixth years.

6. From the inception of predator control in late 1950, the average cost of each trout taken by the anglers approximated 75 cents. The lowest cost, 45 cents, obtained when all management procedures were applied and the yield of trout was highest. The costs were for guardian services throughout the year and for stocks of trout.

M. W. Smith

No. 63

CONTROL OF THE EEL POPULATION OF A LAKE

The American eel is a common predator and competitor of trout in Maritime fresh waters. Control of its numbers in trout lakes is desirable. The eel is catadromous. Accordingly, long-term control would best be accomplished by preventing the entrance of the young eels (elvers) into lakes.

In 1951, a barrier was erected, and has since been maintained, in Crecy Lake outlet, New Brunswick, at a point within 25 yards of the lake. The barrier consists of a low dam and sluice over which all of the overflow from the lake is channelled to drop about two feet into the stream bed below. Crecy is a head-water lake of 50 acres; thus the outlet is a small stream.

Eels leave lakes at approaching maturity. Outward-moving eels have been captured in a trap maintained in Crecy Lake outlet throughout each year since 1950. The numbers of maturing eels taken in this trap serve as a gauge of the control measure. Eels have also been captured in Crecy Lake proper by baited traps and set-lines during the summer months. This effort gives information on the eel population persisting on the lake and on the effectiveness of such fishing methods.

The majority of eels leave Crecy Lake when six to eight years of age. The barrier was installed in 1951. If the barrier has been effective against the entrance of elvers, the numbers of large eels captured as they left the lake or by fishing in the lake should have declined in late years. The numbers of large eels taken in the outlet trap in 1957 and 1958 were 201 and 237 respectively. The average number per year from 1951 to 1956 inclusive was 320. In 1955 eels were taken in the lake at a daily rate of 1.1 per 10-hook set-line; in 1958 the rate was 0.5. The apparent reduction in the number of large eels in the lake may be ascribed to the effects of the barrier on the entrance of elvers. It is perhaps too soon to experience a desired collapse of the eel population in the lake.

M. W. Smith

No. 64

POND FORMATION ON STREAMS TO IMPROVE ANGLING

Ponds formed on spring-fed trout streams usually provide good angling areas. Pond formation on Prince Edward Island is viewed as a management procedure to improve availability and utilization of brook trout stocks. Where trout run to salt water, their movements are obviously curtailed by forming ponds.

(a) With pond relatively large in relation to size of stream.

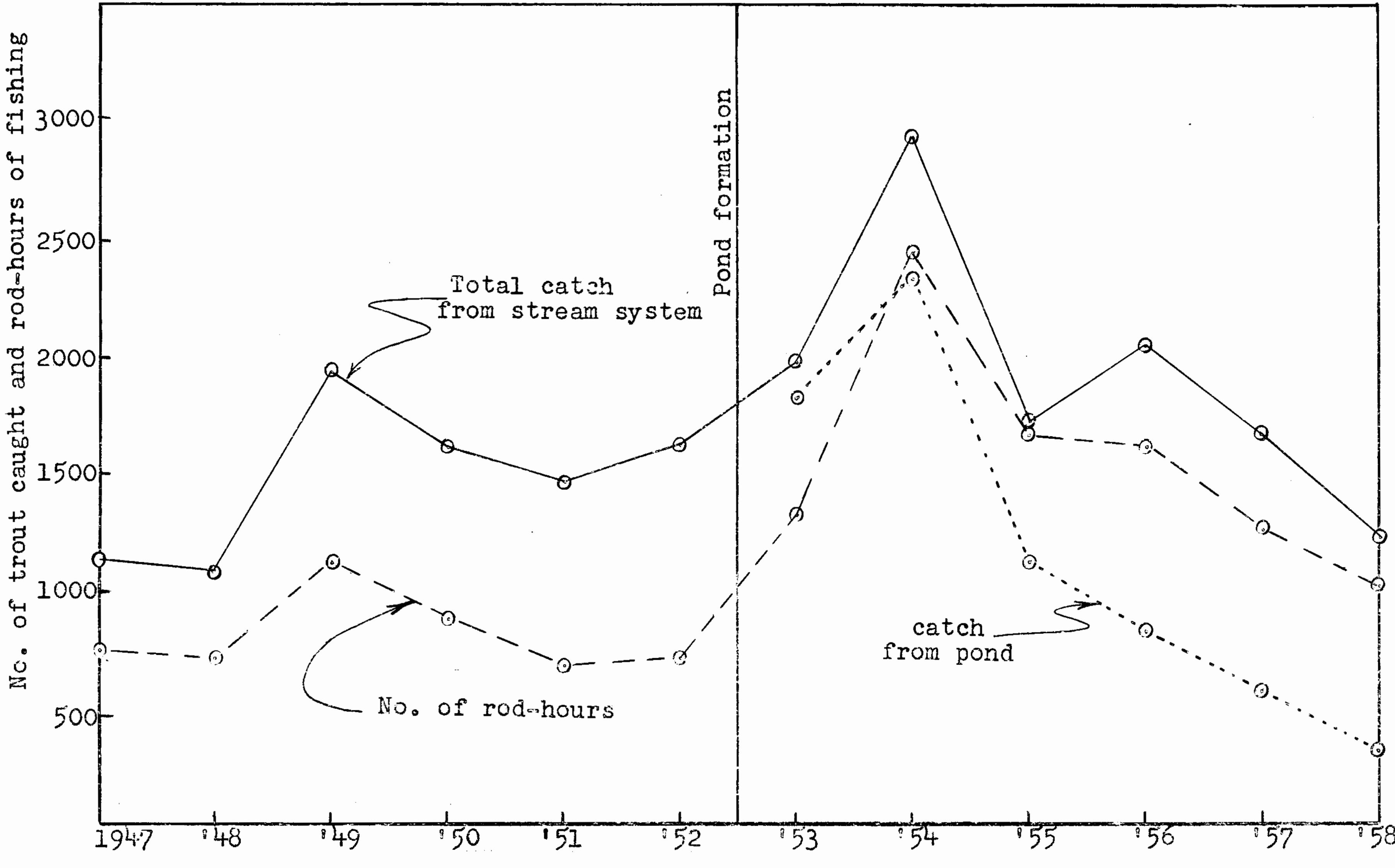
The effects of pond formation on the movements of brook trout between and within fresh and salt water, and on the yield to anglers from the entire stream system, have been studied at Ellerslie Brook, P.E.I. The brook has an effective length for trout production of about 4½ miles. Movements of trout have largely been followed by installing two-way fish traps (1) near head of tide at mouth of brook in 1946 and (2) 650 yards up-stream in 1950. A 7-acre pond was formed between the two sets of traps in 1952.

The traps have been operated throughout the year and tended daily. Trout taken in the traps have been measured and jaw-tagged. Trout moving from salt water were released into the pond until December 3, 1955; thereafter they have been excluded. A census of the trout taken by anglers has been kept annually.

Pond formation reduced the movements of trout between fresh and salt water markedly. In the years 1946-1951, the numbers of movements into and out of the stream were 10,273 and 10,472 respectively. After the pond was formed, 1952-1958, the inward and outward movements numbered 3,322 and 2,429. During the same period, 1952-1958, the number of movements by trout down-stream into the pond was 7,551, but only 2,429 out to salt water. For a majority of the trout moving down-stream the pond was apparently as suitable a habitat as the estuary had been previously, and held trout.

Angling records are illustrated in the accompanying figure. In the second year after pond formation, the total catch moved up sharply. The total effort increased commensurately so that the catch per rod-hour was 1.2 as compared to an average of 1.9 for the pre-pond years. In 1954, 79 per cent of the total catch came from the pond. Since 1954 the total catch for the stream system has declined but most particularly that for the pond. The pond was drained in September 1958 and only 73 trout were found.

A major objective of the investigations was to determine if pond formation resulted in a better harvesting of trout by anglers from a stream system. This occurred, largely as a result of the attraction of more anglers to the pond. The annual average pre-pond effort was 810 rod-hours on the stream system; with the



Angling records for Ellerslie Brook, P. E. I.

pond the average was 1,555 rod-hours. Apparently at the higher level of effort the trout-producing capacity of the stream system was not able to sustain appreciably higher catches as well.

The brook is a good nursery for trout. There is no evidence that pond formation has adversely affected the population of yearling trout in the stream (Summary 65). To satisfy the higher level of angling effort, with sustained higher catches, two actions are possible to meet the situation: (1) improve the stream for greater production of young fish, or (2) augment the stock by plantings. What may very well occur is that effort will decrease with poorer angling success, permitting natural production to recoup the angling losses, particularly in the pond.

(b) With pond relatively small in relation to size of stream.

The Government of Prince Edward Island has created a number of fishing ponds by damming streams at suitable sites with earthen embankments. Overflows from these ponds are directed into new channels around one end of the embankment. Trout can move freely up or down the overflows. Movements of trout into and out of one of these ponds on Wilmot stream have been studied over a three-year period. Trout captured in a two-way trap, installed at the head of the overflow stream, have been enumerated, measured and tagged. A thorough creel census has been maintained on the pond.

Wilmot pond is approximately 15 acres in area, but much of the area has a depth of water less than 5 feet. The tributary streams have a length of about 20 miles. The pond is relatively small in relation to the size of the tributary streams.

The traps were maintained from June through December in 1956, and from April through December in 1957 and 1958. A record of the movements through the traps follows:

	Up-stream	Down-stream
1956	2,497	442
1957	2,061	1,298
1958	1,787	1,338

Dominant up-stream movements were in June and July and outward in April and May. The low number of down-stream movements recorded in 1956 resulted from no trapping in April and May of that year.

The recorded numbers of trout taken by the anglers from the pond were 1,397 in 1956, 1,880 in 1957, and 1,948 in 1958. The proportion of tagged trout in these catches varied from 12 to 19 per cent. A thorough analysis of the movements of tagged trout at Wilmot has not been made. However, the low proportion of tagged trout in the catches from the pond in relation to untagged individuals taken, and in relation to the number of tagged trout that entered the pond, suggests that the Wilmot pond did not hold trout to the degree experienced at Ellerslie. There is supporting evidence for this view in the recorded capture of 66 tagged trout in the tributary streams in 1958 with an incomplete census, as against 231 taken in the pond with a thorough census. The movements of tagged trout suggest that to maintain a higher population of trout in Wilmot pond for greater angling success, screening against outward movements is required.

M. W. Smith

No. 65

ANNUAL VARIATIONS IN STANDING CROPS OF TROUT IN RELATION TO ENVIRONMENTAL CHANGES AND OTHER FACTORS IN A PRINCE EDWARD ISLAND STREAM

Investigations begun in 1947 have been continued to date to evaluate the stocks of trout and salmon in Ellerslie Brook and its tributaries and to determine ultimately the effect of pond formation upon them.

When making the annual summer population estimates the same sample sections of the stream were used in each year. With the exception of the 450-yard section in the tributary Hayes, each section was 50 yards in length.

Results

Marked annual fluctuations have been observed in the numbers of fingerlings (fish of the year) and older trout (yearlings and older) in Ellerslie and Hayes Brooks. Fluctuations between years in the numbers of trout in the sample sections have also occurred. The factors, acting to bring about the observed fluctuations, may be grouped under two main headings:

(A) - Climatic factors,
(B) - Environmental factors.

(A) - Climatic factors

The following observations illustrate some of the effects of climatic factors on the production of trout: 1. Annual variations in the numbers of fingerlings in Hayes and Ellerslie Brooks were of much the same order of magnitude. 2. In years when stocks were low in the Ellerslie system they were found to be low in many other streams of the region. 3. When frazil ice conditions were severe in the winter and spring, stocks of fingerlings were low the following summer.

(B) - Environmental factors

Shifts in the stream environment. Silting and scouring have, in some years, brought about marked changes in certain sections of the brook. When an area of the brook becomes covered by silt the trout population falls off. The effects of scouring are usually beneficial to older trout production. Pools are deepened and banks are under cut. This results in a greater number of hiding places or homes for older trout.

Brush in the stream also provides excellent hiding places for trout. On the other hand, after cover had been removed from areas of the stream a decrease in trout stocks was noted.

Population density. Older trout are limited in their distribution in the stream by the number of available hiding places in the habitat. What happens when a trout population is substantially increased in number is illustrated by the following observations. When the older trout population in a pool was doubled by stocking, about 50% of the stocked trout moved out of the pool within 48 hours. Few of the resident population moved from the pool.

Competition with other species. There was no evidence to show that there was competition between trout and salmon for living space. The two species occupy different types of habitats in the brook.

Impoundment. Trout older than yearlings move from the stream into the pond. There has been little movement from pond to stream. This has brought about a decrease in the average lengths of the older trout in the stream. The productivity of the stream has not been affected by pond formation. During the past summer stock of fingerlings and older trout were at pre-pond levels.

J. W. Saunders

No. 66

ADEQUACY OF NATURAL SEEDING TO UTILIZE FULLY THE TROUT-PRODUCING CAPACITIES OF ARTIFICIAL PONDS ON PRINCE EDWARD ISLAND STREAMS

An important question in the management of ponds formed on trout streams for increased production and availability of fish to the angler is whether the tributaries provide sufficient stock to utilize the full trout-producing capacities of the pond. Ponds on Prince Edward Island streams are highly productive of trout. Because they are spring-fed even small tributary streams effectively maintain pond levels and suitable temperatures for trout during the summer periods. Although these tributary streams are good nurseries, their size presents a physical limitation upon the quantity of young trout that can be produced.

Information on the above question is being sought at Stevenson's Pond, P.E.I. Initially the extent to which the native stock, produced in the tributary stream is populating the pond is being assessed.

Stevenson's Pond has an area of 6.2 acres. It is fed by a stream of approximately 3 miles in length. Yearling and older trout are prevented from moving down-stream from the pond by self-cleaning screens maintained throughout the year at the dam. Standing crops of trout in the pond are assessed by draining and the removal of the fish. The pond is closed to angling.

The pond was drained in June 1956 and all trout removed. The population was again assessed in September 1957 and the trout again removed. A second assessment was made in September 1958 at which time, however, the trout were returned to the pond after counting, measuring, and weighing.

Data on the number and lengths of trout in the standing crops are given in the accompanying table. In September 1957 the standing crop was 59 pounds per acre. In September 1958 it was less at 33 pounds per acre.

It has previously been determined for Stevenson's Pond that with initial densities of introduced yearling brook trout from 400 to 800 per acre, no significant differences were found in growth rate. The higher density was apparently below the carrying capacity of the pond. The density of trout in 1957 was of the order of the higher populations previously studied. The trout that were removed from the pond in 1957 and 1958 were in excellent condition. The results indicate that the contributions from the tributary stream, in this case small in relation to the size of the pond, were inadequate to utilize the full trout-producing capacity of the pond. Supplement from introduced stock appears needed. It is proposed to determine to what extent stocking is required to supplement native production to provide maximum yields from the pond.

Length frequencies of brook trout from Stevenson's Pond

Fork length in inches	Number 1957	Number 1958	Percentage of total number 1957	Percentage of total number 1958
Under 6	233	34	17	5
6 - 7	201	84	15	13
7 - 8	193	128	14	19
8 - 9	217	169	16	25
9 - 10	202	145	15	22
Over 10	298	103	22	16
	1,344	663		

M. W. Smith

No. 67

RAINBOW TROUT IN PRINCE EDWARD ISLAND WATERS

The rainbow trout is not native to Maritime waters. By introductions, the species has become locally established. In the Prince Edward Island area it is anadromous, and increasing numbers of steelheads are being taken. The rainbow trout must now be considered as an established sport fish in Island waters. There the rainbow trout has been superimposed on populations of native brook trout, either occupying ecological niches not utilized by the latter, or entering into direct competition with it, or both.

Preliminary studies have been made at Simpson's Pond (2.3 acres), P.E.I., to ascertain how well rainbow trout survive and grow in such situations. In October 1955, 1,172 underyearling rainbow trout were planted in Simpson's Pond. The pond was screened to prevent escapement down-stream. Each year since 1956 the survival and growth of these planted fish have been determined by draining the pond at approximately the same time in early fall. The pond has been closed to public angling. Data are presented in the accompanying table.

Survival and growth of rainbow trout in Simpson's Pond

	Number	Average fork length (in.)	Average weight (oz.)	Annual survival %
Planted 1955	1,172	5.2	1.1	--
Removed 1956	305	10.0	6.8	26
Returned 1956	300	10.0	6.8	--
Removed 1957	167	12.6	13.0	56
Returned 1957	130	12.6	13.0	--
Removed 1958	72	16.5	28.3	55

Survival of rainbow trout from underyearlings to yearlings was only moderate. Growth at all ages was good, and appreciably surpassed that for brook trout in the same pond. On September 22, 1955, yearling brook trout removed from Simpson's Pond averaged 8.5 inches in fork length and 4.3 ounces in weight. By comparison, rainbow trout attained an average length and weight of 10.0 inches and 6.8 ounces as yearlings.

During the years that rainbow trout were held in Simpson's Pond it was not found possible to exclude brook trout from the tributary stream. On draining the pond in 1956, 1957, and 1958, the following numbers of brook trout were removed respectively: 249, 671, and 750. Both brook and rainbow trout inhabited the pond without apparent effects upon each other. However, the total fish population in the pond was below that which could be supported, and there was no strong competition between the species for living space or food.

M. W. Smith

No. 68

RELATIVE VALUE OF RAINBOW AND BROOK TROUT IN UTILIZING THE PRODUCTIVE CAPACITY OF NEW BRUNSWICK LAKES

The rainbow trout grows faster, reputedly can withstand higher water temperatures, and utilizes zooplankton food more effectively than brook trout. One might judge that the rainbow trout could compete better and utilize more of the fish-producing capacity of soft-water lakes of low to mediocre productivity. The possible superiority of the non-indigenous rainbow trout is being tested in two soft-water lakes of Charlotte County, New Brunswick. These lakes are representative of many others in the Maritime area.

Underyearling rainbow trout were introduced into Kerr and Crecy Lakes in September 1958. The survival to anglers' catches and growth of planted brook trout in these lakes is known. In Crecy Lake the environment was altered by fertilization and predator control. The survival and catches of brook trout were markedly increased by these actions. There was no attempt to alter the natural conditions in Kerr Lake, and stocking with brook trout was unsuccessful in producing better angling. Under these two sets of conditions, (1) replication of fertilization and predator control at Crecy Lake and (2) with an unaltered natural environment in Kerr Lake, will more angling success be realized from stocking rainbow trout? A positive answer to this question would materially aid in the future management of many Maritime lakes for improved fishing.

M. W. Smith

No. 69

EVALUATION OF CONDITIONS FOR TROUT PRODUCTION IN A FLOODED ESTUARY

The causeway carrying the Trans-Canada Highway over the mouth of York River, Prince Edward Island, has formed a small (500 acres) artificial lake on what was formerly a tidal estuary. Salt water can enter the lake at high tide via a sluit through the causeway. The sluit 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, and to determine the suitability of the lake as a trout habitat. Further observations were made in 1957 and 1958.

Findings

In 1956 and 1957 it was found that the waters of the lake 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 water in the lake took place in the fall.

Trout moved into the lake through the sluice. In summer they were found only in the shallow layer between the lower oxygen-deficient strata and the warm surface waters.

Recommendations

As a remedial measure it was recommended that the inflow of salt water be stopped. The Provincial Government closed the sluice in October 1957.

Hydrographic surveys in 1958

Conditions in the lake in summer differed little from those observed in other years. Salinity determinations made in the lake through the tidal cycle showed that salt water was flowing in through the sluice at high tides.

There is little to be gained in making further surveys on the lake until such time as the salt water is prevented from entering the lake.

J. W. Saunders
M. W. Smith

No. 70

ALKALIZATION OF A FARM FISH POND

Alkaline waters are generally more productive than soft. Most lakes in New Brunswick and Nova Scotia have soft waters. Liming such areas is indicated as a possibility for raising their productive levels. Preliminary observations have been made on the effects of adding agricultural lime to a small farm fish pond (approximately one acre) at a sub-station of the Department of Agriculture, Tower Hill, Charlotte County, N.B.

Four hundred pounds of land lime were added to the pond at the mouth of the small inlet stream. Application of 100 pounds each were made at approximately two-week intervals from late July into September 1958. A minor increase, 6.5 to 6.8, in pH value of the water was noted. Conductivity rose from 25 to 39 reciprocal megohms. Colour from humic materials was moderately reduced.

The high buffering capacity of the water, plus run-off, apparently dictated that large quantities of lime, well above those used (130 lb. per acre - foot), were necessary to increase the hardness of the water appreciably.

The quantities of lime necessary to have an appreciable effect would apparently limit practical treatment of Maritime soft waters to those of only a few acres in area at the most.

M. W. Smith

No. 71

TOLERANCE OF IMMATURE TROUT AND SALMON TO SALT WATER

Fingerling and yearling trout have been observed in estuaries on Prince Edward Island. At Ellerslie Brook some salmon parr descend into the estuary in fall. To date little is known regarding the tolerance of immature trout and salmon to salt water. A series of preliminary observations, designed to provide information on the tolerance of young trout and salmon to salt water, was made at Ellerslie Brook, Prince Edward Island, during 1958.

Methods

Fish were held in battery jars (approx. 2 gal. capacity) and supplied with air from an aquarium pump. Observations were made on 155 fish in different salinities ranging from 10 to 28 parts per thousand. The range in size of the different groups of fish tested was as follows:

Salmon fry (underyearlings)	6.1 to 7.9 cm.
Salmon parr (yearlings & older)	8.0 to 14.0 cm.
Trout fingerlings (underyearlings)	4.6 to 7.9 cm.
Older trout (yearlings & older)	8.0 to 17.5 cm.

Observations

1. In general, the larger the fish the more resistant it was to high salinity (28‰).

2. Salmon fry and trout fingerlings did not appear to have been adversely affected by water of low salinity (10‰).

3. Salmon fry were more resistant to high salinity (28‰) than were trout fingerlings. Some trout fingerlings were observed to die after 9 hours in water of 28‰; salmon fry were able to withstand 13 hours exposure to the same salinity before any deaths occurred.

4. Fish showing signs of distress--rapid swimming followed by loss of equilibrium--in salt water, recovered when placed in fresh water.

5. There was a marked change in the outward appearance of both trout and salmon shortly before death. The fish became very thin, probably as a result of dehydration of the tissues. This change took place in a relatively short time.

6. Trout (fingerlings and older) and salmon (fry and parr) survived in simulated estuarial conditions--salt water (28‰) changed to fresh water and alternating these two at 6-hour intervals.

7. After a week in simulated estuarial conditions, salmon fry were able to live in high salinity (28‰) without any apparent adverse effect.

8. Trout fingerlings held for 24 hours in water of low salinity (10‰), survived better in water of high salinity (28‰) than did non-acclimated fingerlings.

9. Fish from which scales had been removed died before uninjured fish when both groups were held in salt water under similar conditions. Care should be taken when marking or handling trout or salmon near an estuary, not to injure the fish.

The above observations show that trout and salmon of all ages can adapt to life in estuaries where the water varies from near fresh up to salinities of 28 parts per thousand.

There is an obvious need for a better understanding of the present or potential value of the estuary in rearing young salmon and trout.

J. W. Saunders

SALMON SUMMARIES

Atlantic salmon research

Atlantic salmon statistics

Runs of adult salmon into the Miramichi River

Evidence for homing of Atlantic salmon

Tagging of adult Miramichi salmon 1957 and 1958

Use of hatchery and native salmon stocks for best production of smolts

Young salmon populations in the Margaree area

Effects of forest spraying with insecticides on aquatic insects, Miramichi area

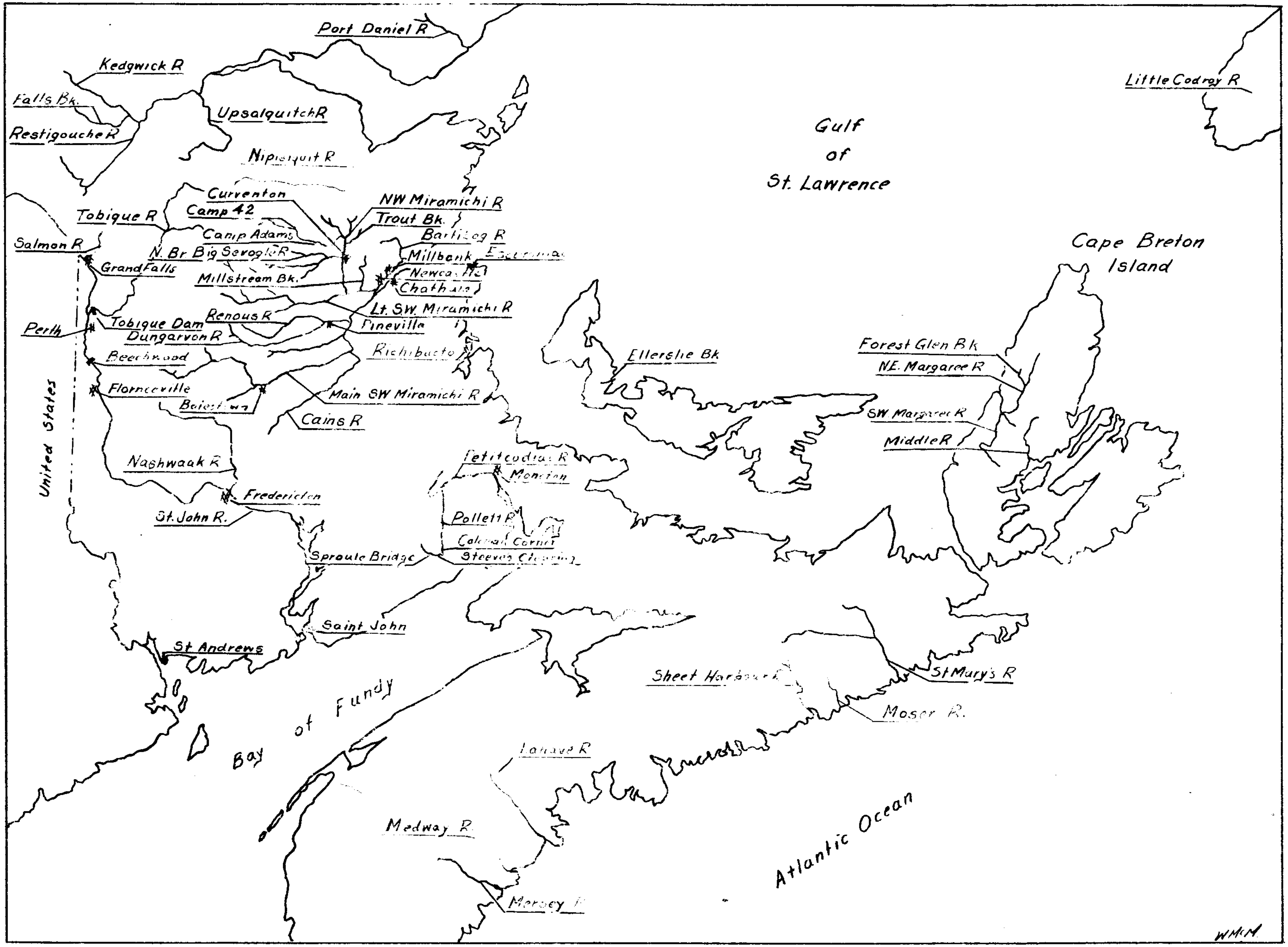
Growth of young salmon in Miramichi streams subjected to DDT

Effects of different insecticides on aquatic insects, salmon and other fishes, Richibucto area, 1958

Smolt production from the St. John River in relation to hydro-electric developments

The effects of impoundment on the production and movements of Atlantic salmon in a Prince Edward Island stream

Underwater observations of Atlantic salmon and brook trout



Port Daniel R
Kedgwick R
Falls Bk.
Restigouche R
Upsalquitch R
Nipisiquit R
Gulf of St. Lawrence
Little Codroy R
Curventon
Camp 42
Tobique R
NW Miramichi R
Trout Bk.
Camp Adams
Salmon R
N. Br Big Sevogle R
Millbank
Grand Falls
Millstream Bk.
Cape Breton Island
Lt. SW. Miramichi R
Renous R
Pineville
Tobique Dam
Perth
Dungarvon R
Richibucto
Beechwood
Ellerslie Bk
Forest Glen Bk
NE. Margaree R
Florenceville
Main SW Miramichi R
Cains R
SW Margaree R
Middle R
United States
Nashwaak R
Moncton
Fredericton
St. John R.
Pollett R
Sproule Bridge
Saint John
St Andrews
Sheet Harbour R
St Mary's R
Moser R.
Bay of Fundy
Medway R.
Atlantic Ocean
WMcM

No. 72

ATLANTIC SALMON RESEARCH

The research program for Atlantic salmon is aimed at obtaining information to allow the various commercial and sport fisheries to be maintained, through management, at the most profitable level for all concerned. Since 1949 it has been under a review by a Federal-Provincial Co-ordinating Committee. Through annual meetings of the Scientific Sub-committee of that group, and frequent liaison, the work of the St. Andrews Station is closely associated with the management program of the Department of Fisheries and research and management programs in Newfoundland and Quebec. In 1958 the research program included a variety of projects that may be considered under several broad headings.

1. Availability. Catch statistics obtained by Protection staff of the Department since 1949 indicate the availability of adult Atlantic salmon to commercial fishermen and anglers in the Maritime Provinces. They are reviewed at St. Andrews along with statistics from Quebec and Newfoundland and summarized annually in "Trade News".

In 1958 commercial landings were generally much higher than in 1957, although still below the average level of the past 30 years. Angling catches in 1958 in the Maritimes as a whole, and on many individual rivers, were the highest recorded since collection of statistics began nine years ago. Water conditions in the rivers were particularly favourable for early and sustained ascent of fish in 1958.

2. Distribution and migrations. The distribution in fresh water of young salmon from fry to large pre-smolt parr can be determined by electro-seining techniques developed mainly at the Pollett River, N.B., field station. In 1958 routine assessments were made at series of seining stations on the Pollett, Miramichi, and St. John Rivers, N.B., and the Margaree River, N.S., to learn the effects on smolt production of experimental plantings of hatchery stock, forest spraying with DDT, hydroelectric development, predatory bird control, and other factors.

As they descend to the sea on a few representative rivers smolts can be trapped, counted and marked by fin-clipping or tagged, for identification after they have reached the adult stage as grilse or older salmon. In 1958 a record high of 30,000 smolts were counted and marked at the Pollett trap; these were produced jointly by a natural spawning experiment that has been in progress for several years, a planting of hatchery stock in 1956 that was calculated to give maximum smolt production at the rate of five smolts per 100 square yards, and experimental plantings of "smolts" and "post-smolts". In the Miramichi area 18,000 smolts were marked at Curventon on the Northwest Miramichi, and 8,100 at a new trap on the Cains; neither of these traps were operated to capture all the smolts produced in the waters above, but only to provide a supply of fin-clipped fish of known origin.

In the Miramichi estuary Swedish type tags were applied to 1,000 smolts in June, 1958. It is hoped that these or other tags will be found suitable for identification of fish from smolts to adults, as an improvement over fin-clipping. In 1959 it is planned to tag 10,000 Miramichi smolts.

With facilities available at present it is impossible to learn the whereabouts of salmon between the smolt stage and the adult stage when they are catchable by commercial gear, angling, and adult research traps. In 1958 the usual data on catches of marked and unmarked adults were obtained by technicians at North Sydney, N.S., and Saint John, N.B., for Newfoundland commercial landings, at Escuminac for the local drift-net fishery, in the Miramichi trap-netting and angling areas, and by fishery officers throughout the Maritime Provinces. Analysis of the 650 recaptures of marked fish including scale readings is not yet completed.

An adult sampling trap was operated throughout the open-water season in the Miramichi estuary at Millbank for the fifth consecutive year; adult traps were maintained on the Northwest Miramichi for the ninth year at Curventon and for the second year 33 miles upriver at Camp Adams. These research traps give a useful record of the occurrence of salmon before, during, and after the public fishing seasons and help in evaluating present fishery regulations. In 1958 the runs of both grilse and large salmon into the estuary in the fall far exceeded the number entering during the public fishing season, and far more grilse entered than in any year since sampling started five years ago.

Special attention was given to the recapture data obtained up to 1955 on adult salmon that had been marked as smolts at Curventon on the Northwest Miramichi and Pineville on the Dungarvon, tributary to the Southwest Miramichi. Many fish of Miramichi origin were taken in Newfoundland waters and it is estimated that over 1/4 the total catch of Miramichi fish by rods and nets occurred in the Newfoundland and Labrador nets. A few Miramichi fish were taken in Maritime netting areas, but not in fresh water of rivers other than the Miramichi. In the Miramichi, mixing of fish from the two branches occurred in estuarial nets, but in fresh water there was marked segregation, with an average of 99.6% correct return to the Curventon trap and 98.4% correct return to the Pineville trap over a five-year period.

Adult salmon have been tagged at the Millbank estuarial trap and at the Curventon counting fence to learn the migration patterns, within the river, of individual fish. In 1957, 16% and in 1958, 23% of the fish tagged at Millbank were recaptured by commercial and sport fishermen and research gear. The rate of movement through the river and into the estuary was highly variable. Some were caught 70 miles upriver within two weeks; others were retaken near the tagging site after two months.

Production of young.

Since 1941 an experimental stretch of the Pollett River has been used for smolt production studies because it has been inaccessible to spawning adults, unless it was desired to introduce them. Experiments with introduction of hatchery-reared under-yearlings under various conditions were completed in 1957. Now an experiment to give the amount of natural spawning required for optimum smolt production is in progress, and field work on it should end in 1961. Data already available suggest that 250 eggs deposited in the river by wild adult salmon are equivalent to 35 planted hatchery underyearlings, per unit area of 100 square yards, in producing five smolts.

Recently the Pollett has been used also for an experimental planting of underyearlings calculated to supplement a below-normal native population. This situation would often exist in practice.

Since some available freshwater rearing areas are decreasing in size and suitability through hydroelectric developments and other environmental changes, experimental releases of large hatchery-reared fish that might migrate promptly as smolts have been made in 1957 and 1958 in the upper parts of the Pollett and Miramichi Rivers. Checking the downstream migrations at smolt traps below, showed that fish at least 5 1/2 inches long in May of the year of planting will migrate without delay if planted during the regular period of smolt descent. Their contribution as adults to local or other fisheries should be known soon, since a fraction of the planted fish were marked.

The Pollett and Miramichi smolt production studies are made in areas provided with experimental merganser control. Removal of mergansers was shown to greatly benefit smolt production from planted underyearlings on the Pollett, and later, to have similar effects in improving parr survival on the Northwest Miramichi. In 1950 it was hoped to demonstrate the effects of merganser control in improving the return of adults to the Miramichi system, but adverse effects of DDT spraying from 1951 to 1958 interfered with the experiment. A suitable experimental river is being sought elsewhere, and in 1957 and 1958 a preliminary census of young salmon was made on the Margaree River, N.S., accompanied by merganser census and banding operations by the Canadian Wildlife Service. Margaree merganser populations in the two years were of similar density to those of the Pollett before bird control.

Only a small fraction of the smolts produced on the Miramichi system can be trapped and counted on one or two tributaries. Estimates of total Miramichi smolt production are possible in years when adequate numbers of smolts can be marked at the upriver weirs, to mix with smolts from other branches, and be sampled at smolt traps operated in the estuary near Millbank. The 1958 estimate was 2.75 million, as compared to estimates of 1.7 million (1951), 0.8 million (1953), 1.5 million (1954), 1.3 million (1955), 2.0 million (1956), 1.3 million (1957).

Environmental changes.

Effort was continued in 1958 to assess the effects on salmon of environmental changes that are associated with industry and which are expected to have unfavourable results. Forest spraying with DDT insecticide to control an outbreak of spruce budworms has been investigated since 1954 in the Miramichi area. In 1958 previous findings were confirmed. Additional studies were made in 1958, co-operatively with the Department of Agriculture in the Richibucto area, in the hope of finding alternative insecticides that would have less harmful effects on young salmon and their food than the regular DDT-in-oil applied at a rate of 1/2 lb. DDT per acre. There were indications that 1/4 lb. of DDT per acre had little short-term effect on either young salmon or aquatic insects, yet gave substantial control of budworms. The budworm epidemic has collapsed in New Brunswick and no further sprayings are scheduled as part of the forestry program.

Hydroelectric development of the St. John River was increased recently by completion of a power dam at the mouth of the Tobique in 1953 and at Beechwood on the main stem in 1957. Both dams have fish passes, in contrast to the dam at Grand Falls which has barred the upper St. John to salmon spawning for many years. Concern of Tobique anglers over effects of the new dams lead to new fishery investigations in 1957 by Department and Board staff. These included in 1958: (1) assessment of young salmon populations above the Tobique dam which showed many more under-yearlings than last year, probably resulting largely from hatchery plantings; (2) study of smolt hold-up at Beechwood and of methods to by-pass smolts; (3) establishment of systematic creel census in the Tobique flowage to assess effects of the dam on abundance of other species, particularly predatory fish.

At Ellerslie Brook, P.E.I., pond formation has been studied by the St. Andrews Trout Investigation as a means of increasing trout stocks and their availability to anglers. Salmon also enter the stream and young salmon have been studied in relation to the changed environment. Adults and smolts have been held up by the pond. Such information should help analysis of effects of water impoundments elsewhere.

Control of predatory birds, discussed earlier, is also an environmental change but on the positive side as far as young salmon production is concerned.

Plans are being made to assess the long-term effects of lumbering operations on salmon and trout production, using the upper waters of the Miramichi as the experimental area.

Behaviour studies.

Since behaviour studies are now recognized to have fundamental importance in long-term salmon investigations, a comprehensive outline of desirable research projects has been prepared. These come under the headings: distribution of salmon, tolerance limits, movements and migrations, social behaviour, feeding, escape behaviour and spawning. To date the work has consisted mostly of observations and experiments in the field, but it is planned to begin laboratory research in 1959, using space and equipment in the new wing at the Station.

In 1958 progress was made in developing the use of skin-diving equipment for studying the distribution and behaviour of both young and adult salmon in shallow upriver areas of the Miramichi River. This would permit confirmation in the field, of laboratory behavioural studies.

Liaison.

Since the salmon research program enlarged in 1949 in conjunction with the organization of the Federal-Provincial Co-ordinating Committee, a major responsibility of the salmon staff has been to provide information to the public and maintain liaison with other agencies involved in Atlantic salmon research and management. In 1958-59 senior staff participated in one or more scheduled meetings of the following groups:

Co-ordinating Committee on Atlantic Salmon - Ottawa, (February, 1958), Quebec City, (March, 1958)

Scientific Sub-committee on Atlantic Salmon and Trout - St. Andrews, N.B., (February, 1959)

Regulations Sub-committee on Atlantic Salmon - Moncton, (March, August, 1958), Montreal, (December, 1958)

Interdepartmental Committee on Forest Spraying Operations - Ottawa, (January, 1958)

Investigational planning group of Department of Agriculture, Forest Protection Limited, Fisheries Research Board staffs - Fredericton, (February, March, 1958)

St. John River-Beechwood Study Committee - Fredericton, (March, April, May, June, October, 1958, January, 1959)

Anadromous Fish Committee, International Passamaquoddy Fisheries Board - Augusta, Me., (August, 1958), Orono, Me., (December, 1958)

In addition, many informal discussions were held with commercial fishermen and anglers, mostly during field trips, to discuss salmon fishing problems. Contact was maintained with officers of the Department's Protection Service and Fish Culture Development Branch as frequently as time permitted, particularly where investigations of mutual interest were in progress.

Valuable contacts with salmon investigators in Europe were made by Dr. Elson in September, 1958, when he attended the ICES meeting in Copenhagen and made side trips to Sweden and the British Isles.

C. J. Kerswill

No. 73

ATLANTIC SALMON STATISTICS

Catch statistics on the commercial salmon fishery in Quebec waters are obtained from published reports of the Provincial Bureau of Statistics. For our analysis they have been assembled under four areas. Data on commercial and angling catches in the Maritime Provinces are provided by the Federal Department of Fisheries. The latter are grouped under three areas of the "Maritime Region"--the Gulf, Fundy, and Atlantic Areas. The Gulf Area includes Quebec landings on the Gaspé coast as far north as Cape Gaspé and extends around the Gulf of St. Lawrence to the Richmond-Victoria County line of the east coast of Cape Breton Island. The Atlantic Area extends from there around the outer coast of Nova Scotia to Cape Sable, N.S. The Fundy Area extends from Cape Sable to Grand Manan Island, N.B.

Commercial catch, Quebec and Maritime Region.

Commercial landings in 1957 and 1958 are compared in Figure 1. Similar statistics for the 1949-1957 period were shown graphically in Appendix No. 62 of the Annual Report for 1957-58.

Table 1. Comparison of commercial catches of salmon in 1957 and 1958 in Quebec and Maritime Region.

	1957 Pounds	1958 Pounds	1958 compared to 1957 −	1958 compared to 1957 +
Quebec Total	338,200	502,700		49%
(a) Chaleur Bay	124,400	219,400		74
(b) South Shore St. Lawrence	24,400	36,100		48
(c) North Shore St. Lawrence	185,900	244,400		31
(d) Anticosti	3,500	2,800	20%	
Maritime Region Total	832,200	1,108,600		33%
(a) Gulf Area (incl. Que. (a))	654,700	834,500		27
(b) Atlantic Area	38,500	41,600		8
(c) Fundy Area	139,000	232,500		67

In 1958 the total commercial catch in Quebec was the highest since 1953, when it also just exceeded 500,000 pounds. In the Maritime Region the 1958 total landings of over 1,100,000 pounds continued a steady upward trend since 1955, when the catch fell below 700,000 pounds, the lowest level recorded there in the past 88 years. The last peak production in the Maritime Region occurred in 1930 when landings exceeded 5,000,000 pounds.

The Quebec landings in Chaleur Bay were influenced by the 1958 change in the opening of the season in the Gulf Area from June 5 to May 15. Many large salmon entered the area unusually early in 1958.

Table II. Comparison of angling catches of salmon in 1957 and 1958, Maritime Region.

	1957			1958			1958 catch-1957 catch, as % of 1957 catch	
	No. Fish	Effort Rod-days	C/E	No. Fish	Effort Rod-days	C/E	-	+
Maritime Region Total	39,106	104,831	0.38	65,048	157,848	0.41		66%
Gulf Area Total	35,207	51,926	0.68	56,764	74,383	0.76		61
Miramichi System	29,972	40,965	0.73	45,067	58,135	0.78		50
Restigouche System	3,437	1,552	2.2	9,268	2,412	3.8		170
Nipisiquit	725	3,130	0.23	1,048	3,540	0.30		45
Margaree	185	1,215	0.15	334	1,275	0.26		81
Atlantic Area Total	1,237	43,905	0.03	4,500	66,468	0.07		265%
St. Mary	143	1,440	0.10	735	4,392	0.17		415
Moser	81	4,690	0.02	207	6,475	0.03		156
Lahave	118	952	0.12	807	2,265	0.36		580
Medway	295	4,992	0.06	1,038	7,668	0.14		252
Sheet Harbour	283	10,585	0.03	368	14,945	0.02		30
Fundy Area Total	2,662	9,000	0.30	3,784	16,997	0.22		42%
St. John (main)	2,010	3,222	0.62	2,518	6,401	0.39		25
Tobique	65	260	0.25	186	539	0.35		186
Nashwaak	66	877	0.08	218	3,021	0.07		230
Petitcodiac	123	976	0.13	337	1,250	0.27		174

There was no appreciable change in fishing effort in 1958. The increased catches may be attributed to salmon being more plentiful in the vicinity of the nets during the fishing season than in recent years.

Angling catch, Maritime Region.

The total angling catch and the effort in rod-days for the three Areas (exclusive of the Quebec portion of the Gulf Area) in 1957 and 1958 are given in Table II. Also shown are the total angling catches on several of the principal rivers of each Area.

In 1958 the total angling catch was higher in all three Areas of the Maritime Region than in 1957, and was the highest recorded since 1949 when the present system of collecting statistics was instituted.

In Table II the angling effort on rod-days in the three Areas as a whole and on a few of the more productive rivers in each Area can be compared, as well as the catches per rod-day. Everywhere the angling effort was greater in 1958 than in 1957, and on most rivers the catch per rod-day was higher in 1958. Heavily fished rivers of moderate size in Nova Scotia like the Lahave and Medway provide about one fish or less per ten days of angling, whereas large rivers in New Brunswick like the Miramichi may give seven or eight fish per ten days. The Restigouche gave best returns for angling effort with two fish per rod-day in 1957 and almost four fish per rod-day in 1958.

Throughout the 1958 angling season water conditions on most rivers were favourable for the ascent of salmon and for angling. This may have been largely responsible for the improved catches rather than a significant increase in the abundance of fish.

C. J. Kerswill

No. 74

RUNS OF ADULT SALMON INTO THE MIRAMICHI RIVER

In 1958 an adult sampling trap was operated in the Miramichi Estuary at Millbank and two counting fences were maintained on the Northwest Miramichi River at Curventon and Camp Adams as in 1957. The estuarial trap, similar to regular commercial set-nets, has been operated through the open-water season each year since 1954. Annual operation of the Curventon fence began in 1950; the upriver Camp Adams fence was installed first in 1957. Past records were summarized in Trade News, June, 1958, page 6.

The following comments are offered on the data shown in the table:

Millbank trap. In 1958 over twice as many grilse were taken as in 1957, mainly because of a very large catch following the commercial fishing season. Only a small increase in large salmon occurred in 1958, also mainly during the late run. Neither the catches of grilse nor large salmon in the sampling trap during the 1958 mid-season

Numbers of grilse and large salmon recorded in 1957 and 1958 at three Miramichi locations (Millbank estuarial trap, Curventon, and Camp Adams counting fences).

	Grilse		Large Salmon	
	1957	1958	1957	1958
Millbank (Estuarial) sampling trap, 21 miles below head of tide)				
Totals	3855	8402	3867	4370
Before commercial season	0	0	3	17
During season	1335	1559	520	438
During mid-season closure	--	593	--	111
After season	2520	6250	3344	3821
Curventon (8 miles above head of tide Northwest Miramichi R.)				
Totals	875	2419	706	579
Before angling season	0	0	0	0
During season	400	1945	164	312
After season	475	474	542	267
Camp Adams (41 miles above head of tide, Northwest Miramichi R.)				
Totals	560	2033	151	102
Before angling season	0	0	0	0
During season	534	1987	145	96
After season	26	46	6	6

Periods of operation:	1957	1958
Millbank	May 8 - Nov. 8	May 12 - Nov. 6 except 4 days mid-June, 5 days early October
Curventon	June 4 - Nov. 5 except July 16-21	May 23 - Nov. 5
Camp Adams	May 29 - Nov. 5	May 24 - Nov. 5
Open fishing season for public:		
Millbank area (Commercial)	June 5-Aug. 31	May 15-July 6; July 22-Aug. 31
Curventon and Camp Adams (Angling)	June 5-Sept. 30	May 15 - Sept. 30.

closed period appear to have been affected significantly by the absence of other gear in the Estuary (as shown on chart of daily counts, not reproduced here).

<u>Curventon fence</u>. The grilse count was about three times higher in 1958 than in 1957, the increase occurring during the angling season. The increase was unexpected because the estimated population of large parr in the Northwest Miramichi in 1956 was smaller than in 1955 as a result of DDT spraying. Ordinarily these fish would have produced the grilse (age 3.1) returning in 1958 and 1957 respectively. Recent scale readings have indicated that many young salmon which were classified as small parr in 1956 and were very abundant, later grew rapidly enough to become two-year smolts in 1957. This, combined with excellent conditions for ascent of adults in 1958, could account for the abundance of grilse in 1958.

Fewer large salmon were counted in 1958 than in 1957, and the level was about 50% below the 1950-1955 average, an expected result of DDT spraying.

<u>Camp Adams fence</u>. As at Curventon, grilse in 1958 were over three times as plentiful as in 1957, the increase occurring mostly in the angling season. Large salmon were fewer in 1958, and again most ascended during the angling season. The 1958 increase in large salmon during the angling season at Curventon was due to a large late run in September; few of them ascended as far as Camp Adams. The low <u>total run</u> of large salmon at Camp Adams reflects the low <u>early run</u> past Curventon.

C. J. Kerswill
M. H. A. Keenleyside

No. 75

EVIDENCE FOR HOMING OF ATLANTIC SALMON

Several tagging projects by various agencies prior to 1950 in Canadian Atlantic waters showed that (1) many kelts move from Maritime estuaries to be caught one or two years later in the sea around Newfoundland as well as near the tagging site; (2) many virgin fish tagged in the sea off Newfoundland move westward and are subject to capture both in the sea and rivers of the Maritime Provinces. There is only one published record of a fish marked in 1938 at the smolt stage on the Northeast Margaree River, N.S., making a round trip to Newfoundland (tagged at Bonavista, June 1940) and back to the Northeast Margaree (recaptured by angler, September 1940). The early marking and tagging projects were not designed to provide information on the general pattern of migration and homing of salmon whose river of origin was known. Recent smolt marking projects on several rivers, combined with a widespread search for marked adults, have helped to clarify the picture.

Recapture data obtained in 1955 on salmon that were marked at the smolt stage on two Miramichi tributaries were given special study in 1958. In both 1953 and 1954 good numbers of smolts were fin-clipped at both marking sites--about 25,000 at the Northwest Miramichi (Curventon, N.B.) and about 20,000 at the Dungarvon (Pineville, N.B.). It was to be expected, therefore, that many one-sea-year adults (grilse) and two-sea-year adults (the most commonly caught large salmon) would appear in the 1955 catches. The recaptures of marked fish by the fishing public classified as grilse and older salmon are summarized in Table I. The examination of Newfoundland commercial catches were all made at North Sydney, N.S., and Saint John, N.B., where the fish are repacked before further shipment.

The following points are shown by these data:

(i) Salmon known to be of Miramichi origin are caught both as grilse and older salmon in the commercial sea fisheries over a wide area and many are taken around the coasts of Newfoundland and Labrador. To correct the proportion of the total Newfoundland catch examined at North Sydney, N.S., and Saint John, N.B., in 1955 the 55 marked salmon caught around Newfoundland would be multiplied by 3.35 giving 184. In the Miramichi drift netting area, all the landed fish were examined; in the Miramichi trap netting area most of the catch was examined carefully. It is estimated that about 1/4 of the total catch of Miramichi fish by rods and nets occurred in the Newfoundland and Labrador nets.

(ii) Miramichi fish from both tributaries were taken by shore nets in Chaleur Bay, but not in fresh water here or anywhere else outside the Maritime System.

(iii) The commercial fisheries near and in the Miramichi System took a mixture of salmon produced in the two tributaries.

(iv) In freshwater areas of the Miramichi watershed, recaptures of 69 angled marked fish showed pronounced segregation of the stocks in the two tributaries where they originated. Some straying occurred, as indicated by two Dungarvon marks taken in the Northwest Miramichi (4% of the 51 marks reported here), and two Northwest Miramichi marks taken in the Southwest Miramichi watershed (12% of the 18 reported here).

Information on the precision of homing to the natal stream is given by the returns of marked fish to adult counting traps operated at the Curventon and Pineville smolt marking sites from 1951 to 1956. These data are summarized in Table II.

From a total of 93,102 smolts marked at the N.W. Miramichi trap in the five years 1950 to 1954 inclusive, 895 (0.96%) have returned. Only three of these went to the wrong tributary, giving 99.6% correct return. From a total of 55,900 smolts marked at the Dungarvon trap, 362 (0.65%) returned. Only six of these went to the wrong tributary, giving 98.4% correct return.

These data show a very pronounced segregation of marked returning adults to the streams in which they were produced.

There is still no proof that the large number of salmon that are available to commercial gear far away from their rivers of origin in the Maritime Provinces can be expected to return to their home streams. To clarify the problem an intensive tagging

Table I. Miramichi marked salmon recaptured in 1955 by commercial fishermen and anglers.

Place of recapture	Marked on Northwest Miramichi (Ad + LV)		Marked on Dungarvon (Ad + RV)		Total
	Grilse	2-sea-year (+) Salmon	Grilse	2-sea-year (+) Salmon	
Commercial Nets					
Newfoundland	8	19	6	22	55
Quebec		1			1
New Brunswick					
Chaleur Bay	2	6	2	4	14
Drift Nets off Escuminac		67		61	128
Trap Nets, Miramichi					
Below Derby Junction	32	27	10	23	92
Northwest Miramichi	5	1			6
Southwest Miramichi	4	1	9	3	17
Nova Scotia		2			2
Total by Nets	51	124	27	113	315
Angling					
Miramichi River					
Northwest M., below Curventon	8	1	2		11
Northwest M., above Curventon	28	6			34
Sevogle (lower)	6				6
Southwest M., upper Renous			1		1
Southwest M., Dungarvon	1		7	7	15
Southwest M., main river	1		1		2
Total by Rods	44	7	11	7	69
Total Nets + Rods	95	131	38	120	384

Newfoundland total, corrected for fraction examined = 55 x 3.35=184

Estimated fraction of total catch of Miramichi fish taken by Newfoundland nets = $\frac{184}{384 + 129}$ = approx. 1/4

Table II. Returns of marked Atlantic salmon to two Miramichi traps where part of smolt run was marked annually, 1950-1956.

	No. smolts marked	No. of returns grilse & older salmon	Per cent returns	No. at other trap	Per cent correct return
Northwest Miramichi R. (Curventon)					
1950	7,969	65	0.8	0	100.0
1951	33,407	366	1.1	3	99.2
1952	848	29	3.0	0	100.0
1953	25,218	238	0.9	0	100.0
1954	25,660	197	0.8	0	100.0
Total	93,102	895	0.96	3	99.6
Dungarvon R. (Pineville)					
1950	253	0	0.0	0	100.0
1951	14,966	127	0.8	1	99.3
1952	461	1	0.2	0	100.0
1953	19,966	149	0.7	2	98.7
1954	20,254	85	0.4	3	96.5
Total	55,900	362	0.65	6	98.4

program is indicated, involving the release, at many distant points, of large numbers of tagged fish known, through marking, tagging or other criteria, to have originated in particular Maritime rivers.

C. J. Kerswill

Salmon

No. 76

TAGGING OF ADULT MIRAMICHI SALMON - 1957 AND 1958

A. Estuarial tagging. In 1957 and 1958 Peterson-type tags were attached to large salmon caught in the estuarial trap at Millbank, N.B., as they entered the Miramichi River. Some of these fish were later recaptured by commercial and sport fishermen and at the Curventon counting fence on the Northwest Miramichi River. In 1957 tagging was done from May to August; in 1958 from May to November. Data are presented in Table I.

The major point of interest is the increased total per cent recapture in 1958, due mainly to a five-fold increase in per cent recapture by commercial fishermen. This may be due to: a) lower tagging mortality and/or tag loss in 1958; b) better co-operation by fishermen in reporting tag recoveries in 1958; or c) a higher rate of exploitation of salmon in 1958. a) and b) are unlikely because the tagging and search for recovered tags has been done by the same experienced personnel for several years. Also, these factors should lead to greater recoveries from anglers as well as set-net fishermen, which was not the case in 1958. Greater exploitation seems the most likely explanation. Salmon were more readily taken in set-nets during the 1958 season, due probably to a combination of environmental factors (frequent increases in river discharge, moderate summer temperatures, etc.).

In both years a few tagged salmon were retaken downstream from the tagging site. This may reflect: a) fish moving in and out of the river mouth before entering fresh water; b) fish moving into the Miramichi Estuary and then out again on their way to other rivers to spawn; or c) disturbance of upstream migration by the tagging procedure.

The length of time between tagging and recapture shows that the rate of movement of salmon through the estuary and into the river is highly variable. Some tagged fish were recaptured 70 miles upriver within two weeks; others were retaken a few miles from Millbank two months after tagging. Three salmon tagged on September 18, 1958, were retaken 30 miles upriver at Curventon 2, 12, and 43 days later.

Table I. Recaptures during year of tagging of large salmon tagged at Millbank, N.B. Per cent recaptures by commercial and sport fishermen based on numbers tagged in respective open seasons.

Year of tagging	Total		Commercial		Sport		Research gear	
	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)
1957	146	15.7 (23)	146	7.5 (11)	146	6.8 (10)	146	1.4 (2)
1958	221	23.1 (51)	89	37.1 (33)	200	5.0 (10)	221	3.6 (8)

B. <u>Freshwater tagging - Northwest Miramichi River</u>. Upstream migrating grilse and large salmon were tagged from May to November, 1958 at the Curventon counting fence. A small vinylite tag was attached with stainless steel wire below the fish's dorsal fin. Some tagged fish later passed through the Camp Adams counting fence, 33 miles upstream; other tags were recovered by anglers. Data are shown in Table II.

A higher proportion of grilse than of large salmon was recaptured, but few large salmon were tagged. The per cent recapture of tagged grilse by anglers (8.4%) should approximate the proportion of the entire grilse run taken by angling, if the following assumptions hold: a) an adequate proportion of the migrating grilse was tagged (about 10% in 1958), b) tagged fish mix with untagged, continue their migration and react to angling similarly to untagged fish, c) all recovered tags were turned in, d) all grilse passing Curventon were trapped (unlikely in early spring before fence installed). The validity of b), c), and d) is questionable, due to lack of information. The proportion of grilse taken by anglers is therefore probably higher than 8.4%

The average rate of travel of grilse between the two fences is about 20 days. Except for a very few fish this rate varies little from June to September. No grilse tagged after September reached the upper fence.

Table II. Recaptures during 1958 of salmon tagged at Curventon, N.B., in 1958. Per cent recaptures by anglers based on numbers tagged during open season.

Type of fish	Total		Anglers		Camp Adams		Other	
	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)	No. tagged	% rec. (no.)
Grilse	259	30.1 (78)	203	8.4 (17)	259	22.8 (59)	259	0.8 (2)
Large salmon	24	12.5 (3)	12	8.3 (1)	24	8.3 (2)	---	---

M. H. A. Keenleyside

No. 77

USE OF HATCHERY AND NATIVE SALMON STOCKS FOR BEST PRODUCTION OF SMOLTS

<u>Comparative smolt production from stocks of hatchery and native origin</u>. A particular section of the Pollett River has been used for the past 17 years for studying smolt production under various conditions of predator control and seeding. Control of mergansers and kingfishers has formed an integral part of the studies of seeding requirements reported below.

Field work for a study of the amount of hatchery under-yearling stock (about 4 cm. long) needed to give the best smolt production was completed in 1957. The results are shown graphically in Figure 1.

The most reasonable rate of smolt production to aim for proved to be about five smolts per 100 square yards of river bottom. This required planting underyearlings at a rate of about 35 per 100 square yards.

Field work for a study of the amount of spawning required to give similar production will be completed in 1961. However, in 1958, the final year-class of native underyearlings to be involved in this study was assessed. It seems reasonable therefore, to make a tentative prediction as to the final result from this study. The data required for such a prediction are shown in Figures 2, 3, and 4.

The unknown quantity which it is desired to establish is the "potential egg deposition" required. To estimate this, it is necessary to work back from the figure for best smolt production established by the studies of planted stocks. Rates of production below are given as numbers per 100 square yards of stream bed.

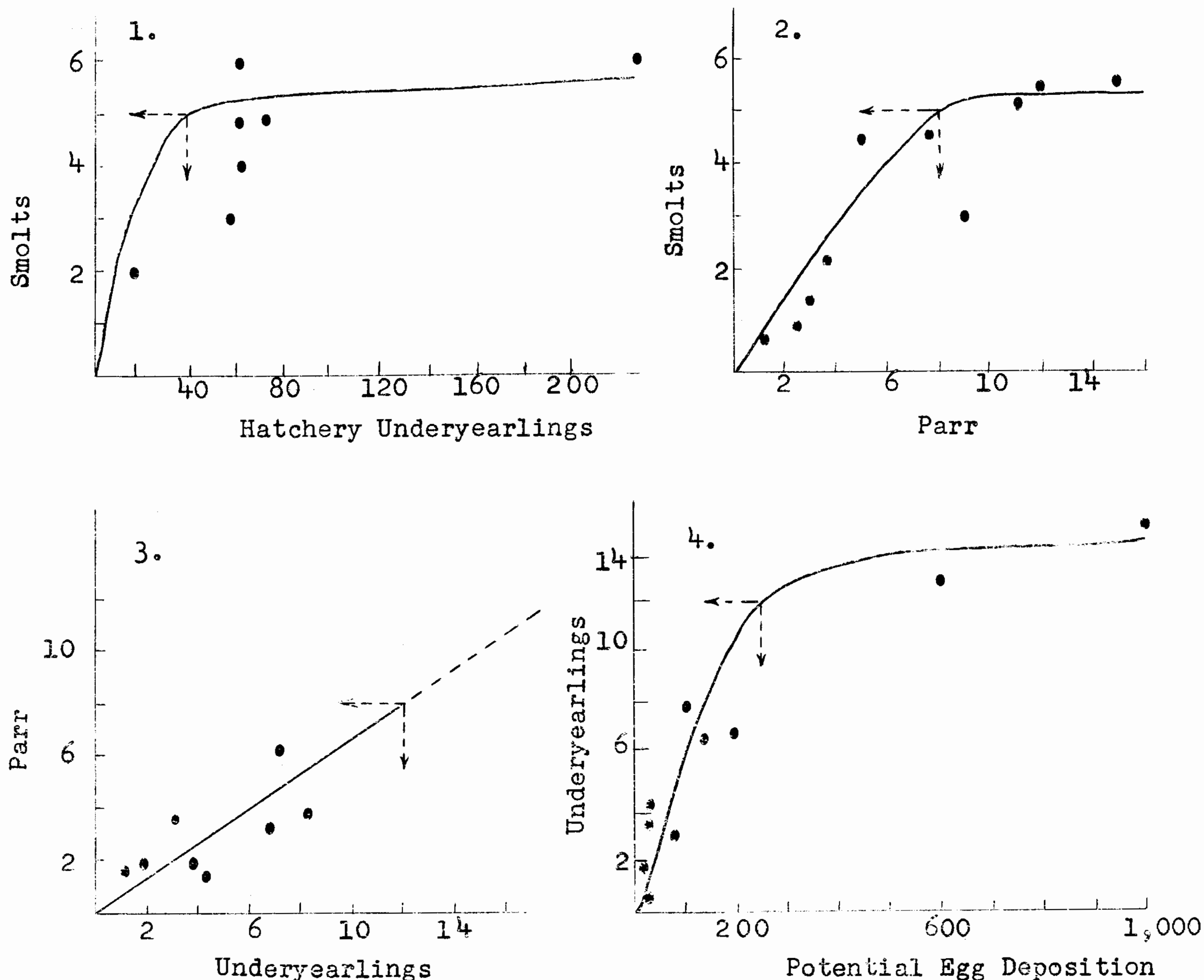
The number of parr required to get five smolts is indicated by the data plotted in Figure 2. About eight parr are needed.

In Figure 3 are plotted the numbers of parr resulting from various populations of native fry (underyearlings). A survival rate of about 65% is indicated. This is the best figure available until the 1959 parr census is completed. The eight parr required would necessitate a preceding population of 12 underyear-lings.

In terms of potential egg deposition, 12 underyearlings would arise from something like 250 eggs per 100 square yards being brought into the river, as shown by the egg-underyearling relation-ship pictured in Figure 4.

The comparison between the hatchery stock requirements and natural spawning requirements is thus that about 35 hatchery underyearlings have equivalent value to 250 eggs brought to the river by wild adult salmon.

Effectiveness of a supplemental planting. In 1956, the native fingerling population in the Pollett was estimated to have a density of 6.8 fish per 100 square yards. This was expected to produce, at previously observed survival levels, just under three smolts per 100 square yards. With the maximum capacity of the stream set at six smolts per 100 square yards, this meant that a supplemental planting to produce three to four smolts per 100 square yards was needed. With the optimum hatchery underyearling-to-smolt survival rate calculated as about 15 per cent, a planting of about 25 fry per 100 square yards, or 109,000 in the experimental area was indicated. In practice, 99,000 (23 per 100 square yards) were planted in late September of which 9,000 were marked before planting by removal of the adipose fin. The fish received from the hatchery were larger than stocks used in earlier experiments (mean lengths 7.2 ± 0.9 cm. as against 3.6 ± 0.5 cm.) and even slightly exceeded the indigenous underyearlings (6.9 ± 0.7 cm.).



Figures 1 to 4. Relations between successive stages of young Atlantic salmon in the Pollett River. Data plotted as average numbers of fish per 100 sq. yds. of stream bottom.

Table I. Seaward migrants from spring plantings of hatchery reared "smolts" and fall plantings of "post-smolts". (About 5,000 fish per planting.)

Date of planting	Place	Mean length & std. dev. at planting (cm.)	per cent migrating: same spring	per cent migrating: same fall	per cent migrating: next spring	per cent migrating: next fall	length at migration 12 miles downstream: same spring	length at migration 12 miles downstream: same fall	length at migration 12 miles downstream: next spring	length at migration 12 miles downstream: next fall
A. Spring plantings										
May 22/57	Pollett	13 ± 1	41	0	14	<1	14 ± 1	--	17 ± 2	--
May 29/57	Miramichi	13 ± 1	24	0	6	--	14 ± 1	--	13 ± 1	--
May 29/58	Pollett	15 ± 1	98	<1	(in 1959)		16 ± 1	--	(in 1959)	
May 28/58	Miramichi	15 ± 1	92	<1	"		16 ± 1	--	"	
B. Autumn plantings										
Sept. 11/57	Pollett	16 ± 2	--	0	38	<1	--	--	18 ± 2	--
Sept. 5/57	Miramichi	16 ± 2	--	0	22	<1	--	--	17 ± 2	--
Aug. 29/58	Pollett	22 ± 2	--	<1	(in 1959)		--	--	(in 1959)	
Sept. 2/58	Miramichi	22 ± 2	--	6	"		--	23 ± 2	"	
Sept. 11/58	Pollett	23 ± 2	--	1	"		--	--	"	

Survival rate of the planted stock through the parr year was excellent, apparently exceeding that of the native. In 1958 the bulk of this mixed population migrated as smolts. Judging by the number of adipose-marked smolts the 1958 smolt run was composed of 19,008 planted fish (survival rate from planted underyearlings, 19 per cent) and 4,139 native fish (survival rate from July underyearlings, 14 per cent). The rates of production per 100 square yards amount to 4.4 and 1.0.

Production from this hatchery planting was greater than anticipated. The extra production appears to have been made at the expense of native stock already present--not a desirable feature. This may be accountable, at least in part, to two factors: (1) the planted stock was extra large in size as compared to that used in experiments from which survival rates were derived; (2) the late fall planting, with low temperature contributing to less urgent need for adjustment to a new environment, may have affected survival. It would appear also that the design involved an over-estimate of smolt rearing capacity, thus necessitating loss of some stock, either native or introduced.

Planting smolts. Under certain conditions, it may be desirable to liberate larger hatchery-reared fish which will migrate to sea promptly and on return supplement expected deficiencies of adult stocks. A series of experiments in which selected fish were liberated about 12 miles above counting weirs was carried out on the Pollett and Northwest Miramichi Rivers in 1957 and 1958. Results are summarized in Table I. The following conclusions have been drawn.

(1) Fish should be selected for size, preferably a minimum 4-inch total length in the previous fall, but perhaps equally well at 5 1/2-inch minimum length in May of the year of planting.

(2) Those planted during the current local smolt season will migrate seaward almost immediately.

(3) Smolts, or more properly "post-smolts", held in hatcheries until late summer will not migrate in large numbers until the following spring, with interim mortality approximating that for pre-smolt parr planted in the autumn.

Ultimate values of planted stock. Useful information has accumulated on the means of using hatchery stock for increasing smolt runs. Large scale, practical confirmation that such enhanced smolt runs will have commensurate value to the desired fisheries has still to be obtained. Some 125,000 marked smolts were liberated from the Pollett River between 1949 and 1956. Of these about 110,000 were of hatchery origin, mostly planted as underyearlings. Under 15,000 were from native spawned fish. The approximate observed values of these smolts have been as follows: for hatchery-reared stock originating in other rivers 0.02% returned to the planted river, none being recorded in other rivers, and 0.5% were taken in distant commercial fisheries; for native stock in the same stream, 4% have returned to the river of egg origin, none being recorded in other streams and no commercial returns being available as yet.

P. F. Elson

No. 78

YOUNG SALMON POPULATIONS IN THE MARGAREE AREA

The Margaree Area of Cape Breton, N.S., is being considered as the site for a co-operative test of the practical value of controlling mergansers for improving salmon fisheries.

As part of the groundwork the second annual assessment of young salmon and other fish in selected sample areas of the Margaree and Middle Rivers was completed in 1958. Comparison of the numbers found in the two years can be made from Table I.

Table I. Young salmon and other fish found in selected sample areas of Cape Breton streams, given as average numbers per 100 square yards of stream bottom.

Year & Stream	Salmon under-yearlings	Salmon parr	Trout	Eels
1957				
Forest Glen Brook	20	39	7	2
N.E. Margaree	22	36	3	2
Middle River	40	34	1	2
1958				
Forest Glen Brook	12	31	21	3
N.E. Margaree	16	17	5	11
Middle River	7	26	2	1

In 1958 the populations of underyearlings found were relatively low in both the Margaree, where the experimental procedure is to be applied, and in the Middle River, which is to serve as a control stream for the study.

The Margaree has apparently had an improved run of adults in 1958, which may well lead to improved populations of young, quite aside from any experimental procedure. In 1957 the mouth of the Middle River was partly blocked to spawners by highway construction. Young salmon there should increase as this is alleviated, which would obscure its immediate value as a control stream.

From the point of view of sound experimental procedure, delay in the application of merganser control until at least one more census of fish can be made seems to be indicated.

P. F. Elson

No. 79

EFFECTS OF FOREST SPRAYING WITH INSECTICIDES ON AQUATIC INSECTS, MIRAMICHI AREA

In 1955, the year after DDT spraying began in the Miramichi area, systematic collecting of emerging aquatic insects was started on tributaries within the spray zone, and on a control stream just

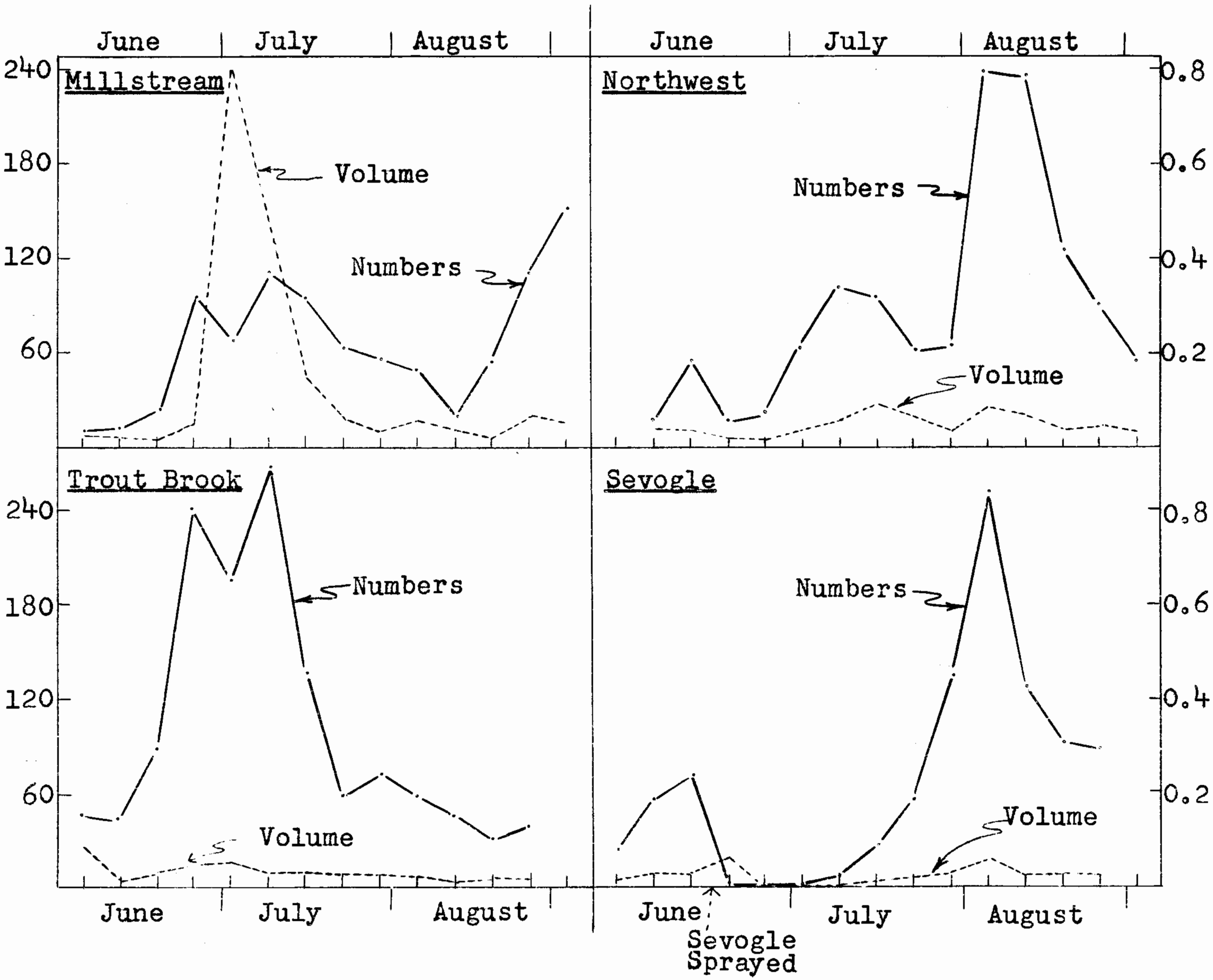


Figure 1. Aquatic insect emergence at four stations in the Miramichi area 1958.

outside. The work has continued annually, with the assistance of Dr. F. P. Ide, University of Toronto, whose techniques of collecting and qualitative and quantitative analyses have been used. The data provide a useful means of assessing the extent and duration of effects of insecticide spraying on the food of young salmonid fishes. Aquatic insects appear to be more sensitive as indicators of the effects of spraying than do fishes. The techniques will likely play an important role in future studies of effects of chemical insect control on fisheries.

In 1958 collections were continued at the same four sites as in 1957, using 3 yard-square emergence traps in similar rapid sections at each site. Twenty-four hour collections were obtained through daily servicing of the traps, 5 days per week, from late May through August. Figure 1 shows the weekly changes in emergence of all insects at the four sites through the 1958 season.

The main points shown by the 1958 collections are:
(1) Spraying of the Sevogle for the third time in June, 1958 was followed by typical reduction in emergence of all aquatic insects for several weeks. Then a large emergence of chironomids (midges) occurred in August. (2) The Northwest Miramichi, sprayed only once, 4 years ago, still shows a low volume, with chironomids predominating, but caddisflies show a comeback in one cage-trap. Mayflies were numerous in 1958 at this station, a trend which was noticed on a smaller scale in 1957, the first year of sampling here. (3) Trout Brook, sprayed in 1956, showed signs of recovery in 1958, with more caddisflies than in 1957. Post-spray recovery of caddisflies appears to have been much more rapid at Trout Brook than in the Northwest Miramichi.

Studies of the food of young salmon have shown that fry normally consume the immature stages of smaller kinds of insects like chironomids, and smaller forms of mayflies and stoneflies. The larger forms, like caddisflies and large stoneflies, are more commonly taken by parr. Lack of these species could have serious effects on the growth of the later stages of pre-smolt parr.

C. J. Kerswill
from report by
F. P. Ide

No. 80

GROWTH OF YOUNG SALMON IN MIRAMICHI STREAMS SUBJECTED TO DDT

The heavy mortality of young salmon in Miramichi streams subjected to DDT spraying has been reported before. This amounted to roughly 90 per cent for underyearlings, 80 per cent for small parr (mostly yearlings) and 60 per cent for large parr (mostly 2-year-olds).

Aside from these primary effects on survival, DDT spraying has secondary effects on smolt production from such areas, because of altered growth rates which probably result from (1) change in the composition of aquatic insect fauna used as food, and (2) change in competitive conditions resulting from primary mortalities.

Studies of growth have been made by examining scales of young fish taken in the same areas before, during, and after spraying. The assumption has been made that a direct proportionality exists between the total length of a fish and the length of the anterior radius of a scale, but allowing for the fact that young salmon are about 2 1/2 cm. long at the time of scale formation. Information thus derived is summarized in the table.

Average lengths of young salmon taken in the Northwest Miramichi River from 1953 to 1957, as calculated from scale reading.

Time relative to DDT spraying	Calculated length 1st year (cm.)	Calculated length 2nd year (cm.)	Measured length 3rd year (cm.)
Before	5.5	8.5	11.2
Same year	5.2	7.7	10.3
After	5.8	9.5	11.4

Two tentative conclusions emerge: (1) growth is noticeably curtailed in the year of spraying; (2) growth is increased above normal, i.e., there is "compensatory growth", in the year after spraying. There was some indication, not appearing in the table, that by 2 and 3 years after spraying, with young salmon populations back to normal numbers but insect fauna not fully recovered, growth may again be curtailed below normal. These considerations suggest the following generalizations about smolt production for sprayed streams where, as in the Northwest Miramichi, most smolts normally run as 3-year-olds.

(1) Survivors of fish sprayed as underyearlings will be below normal size at the end of their first year. Compensatory growth in the next year may give a higher than normal proportion of 2-year smolts.

(2) Survivors of fish sprayed as yearlings will be below normal size at the end of their second year, so the proportion of 2-year smolts from such year-classes will be reduced. Compensatory growth in the third year should result in a greater than normal proportion of 3-year smolts.

(3) Survivors of fish sprayed as 2-year-olds will be below normal size at the end of their third year, reducing the proportion of 3-year smolts, but should nearly all make relatively large 4-year smolts.

(4) Survivors of fish sprayed in more than one year would be subject to corresponding effects on growth.

P. F. Elson

No. 81

EFFECTS OF DIFFERENT INSECTICIDES ON AQUATIC INSECTS, SALMON AND OTHER FISHES, RICHIBUCTO AREA, 1958

In 1958 a field experiment was undertaken in the vicinity of Richibucto, N.B., in the hope of finding an insecticide that would be less harmful than regular DDT-in-oil to young Atlantic salmon, but still give adequate control of spruce budworms. It was a co-operative effort by the Forest Biology Division of the Department of Agriculture and the Fisheries Research Board.

The fisheries part of the project included: (1) observing the survival of caged hatchery-reared yearling salmon, 2 to 3 inches long, held at the lower ends of 5 streams flowing through woodland sprayed with different insecticides, and in an unsprayed control stream; (2) observing the survival of similar fish planted above barrier fences erected at the lower ends of the 6 streams, and the survival of native brook trout and other fishes; (3) qualitative and quantitative analyses of adult aquatic insects collected 5 days per week throughout the season in square-yard cage traps installed on the 5 sprayed streams plus an unsprayed control. Unfortunately an experimental area was not available anywhere in New Brunswick to provide adequate supplies of native salmon fry, budworm-infested woodland and no previous DDT spraying.

The insecticides were DDT-in-oil applied at concentrations of 1, 1/2 and 1/4 lb. per acre and DDD-in-oil at 1/2 and 1/4 lb. per acre. Spraying of the insecticides by a pair of Stearman planes occurred from June 12 to 21. Observations on fishes and aquatic insects extended from early June to mid-August, followed by occasional checks on wild fish in the streams until freeze-up.

The data on fish survival show: (1) sprayings with DDT insecticide at rates of 1 lb./acre and 1/2 lb./acre were followed by the death, within three weeks, of many hatchery-reared young salmon both cage-held and free-living. With the highest concentration of DDT (1 lb./acre) 35% of the caged salmon died; with 1/2 lb./acre DDT, 20% died. (2) with these two insecticides many native brook trout, sticklebacks, and sculpins died within a few days of spraying. (3) spraying with DDT at 1/4 lb./acre and with DDD at 1/2 lb./acre and 1/4 lb./acre had no observable effects on either introduced or native fish within a short post-spray period of three weeks. Observations on the caged specimens were more reliable than on free-living fish. After three weeks deaths began to occur in the cage in the unsprayed control stream, presumably from starvation.

The data for the period June 5 to August 6 on aquatic insect emergence in the 5 sprayed streams plus control, indicate that (1) DDT at 1/2 lb./acre was more toxic than 1/2 lb./acre DDD, but both insecticides had observable effects, particularly in reducing the number of larger forms, e.g., caddisflies, and causing great increases in production of chironomids; (2) DDT at 1/4 lb./acre was much less damaging to the insect fauna than were the heavier concentrations of DDT.

DDD was ineffective in controlling budworms, as were two other products, Korlan and Sevin, checked at Richibucto on budworms but not on fish. It appears that in future tests of this kind, emphasis should be placed on improving the DDT formulation, for example by trying still lower concentrations. Although the recent budworm epidemic has collapsed, further experiments should be undertaken soon to improve control techniques in preparation for future outbreaks.

C. J. Kerswill

No. 82

SMOLT PRODUCTION FROM THE ST. JOHN RIVER IN RELATION TO HYDRO-ELECTRIC DEVELOPMENTS

The problems raised by hydroelectric development of the St. John River are important because of the value of St. John salmon and also because of the implications that future developments may have for salmon stocks elsewhere. The Department of Fisheries and the Research Board have set up a co-operative program of study, with the New Brunswick Electric Power Commission maintaining a close liaison and co-operating in some fields.

(1) Assessment of young stocks. In 1957 the Board established a continuing program of censusing young salmon stocks in the rearing areas of the Tobique system.

Native underyearlings were virtually absent in 1957, probably the result of extensive spraying of the watershed with DDT in that year. Yearlings and older parr were present in 1/2 or less of the numbers usually found in similar areas.

In 1958 underyearlings were present in about 1/3 of normal density. These represent the progeny of 569 adults ascending the Tobique Narrows fishway in 1957. That a relatively small number of adults (average run, 1953-1956 was 4,285) should produce such a good showing of underyearlings is encouraging. An increase by one-half in the larger parr found in 1958 probably represents primarily the contribution of hatchery plantings, but also any inaccuracies inherent in the sampling method.

In 1958 Departmental biologists established that the lower main stem of the river supports young salmon of all stages. The potential importance of such areas is suggested by the production of a Swedish river which was comparable in size and general physical characteristics before power development, to the St. John. The main stem of that river produced all the salmon for fisheries taking about 100,000 lb. a year in fresh water and an equal amount in associated tide water.

(2) Effects on smolts. Smolt delay either in upper impounded waters or at dam faces could be a serious factor if up-river rearing areas supply much of the young stocks. In 1958 the Department was unable to establish, with a counting weir across a tributary, the existence of a downward migration either at normal smolt season or later in the year. A few smolts were taken by nets in the head pond. A systematic creel census on the head pond failed to reveal more than a few young salmon being caught by anglers in late May and early June. The Tobique smolt run of 1958 was probably less than half of normal because of earlier spraying of rearing areas with DDT.

At Beechwood there was an accumulation of smolts in the head gate slots of the dam, which at least established the existence of a normal smolt run from some parts of the St. John system above.

Table I. Size and condition factor (k) of young salmon collected in Beechwood head gate slots, summer 1958.

Date of collection	Number collected	Per cent in sample smolts	Per cent in sample parr	Average length (cm.) smolts	Average length (cm.) parr	Average condition (k) smolts	Average condition (k) parr
June 4	6	100	0	15.7	--	0.67	--
21	50	100	0	15.2	--	0.71	--
July 5	100	80	20	16.8	10.4	0.58	0.84
12	104	100	0	16.0	--	0.57	--
21	31	--	--	--	--	--	--
Aug. 2	16	44	56	16.3	10.4	0.67	0.89
10	31	33	67	16.8	12.4	0.85	0.87
16	7	0	100	--	10.2	--	0.95

Changes in the size of these fish indicate that there was some shift in populations, one group passing out of the collections as another entered. The normal condition factor for smolts is about 0.7 to 0.9 and of parr about 1.0 to 1.2. Seasonal changes in condition factor of the Beechwood specimens indicate gradual starvation, either in the slots or as new groups entered. The last "smolts" to enter (Aug. 10) had apparently delayed long enough above the dam to revert towards the parr state, were in improved condition and might better be described as "post-smolts".

About 1/4 of the smolts collected appeared to have passed through a smolt stage in 1957. About 1/3 also showed slow growth associated with DDT spraying in 1 or 2 parr years.

The Beechwood head gate slots induce circulations in the surge towers which tend to catch and hold some smolts there. Similar qualitative observations have been noted for similar installations in Europe. An unmeasured amount of predation by large eels occurs in the Beechwood gate slots.

It has been found that most smolts prevented from making an early summer migration will not move seaward in late summer or in autumn. Thus, there is increasing evidence of an important hold-up in impoundments.

Studies to solve this problem were initiated in 1958. The N.B.E.P.C., and the Board co-operated in an exploratory study of means to provide more rapid passage of smolts over dams. An experimental system of water jets and DC electric fence was set up at the dam on the Pollett River, where smolts were delayed in 1958. The scheme was successful in transporting into a small opening about 1/4 of the smolts placed manually within the influence of the experimental "fish path". In 3 hours of night-time operation this opening accepted only 8 free-swimming smolts. However, without the fish path in operation no smolts entered.

(3) Upward migration of adult salmon. The Conservation and Development Service of the Department has accepted primary responsibility for studying the upward movement of adults--required both for maintenance of stocks and for angling. The Board has

participated in an advisory capacity in respect to studies concerning fishway entrances. Salmon entered gallery ports over operating turbines more readily than other ports. No important difference could be established between the value of entrance orifices at the surface and those submerged several feet deep.

P. F. Elson

No. 83

THE EFFECTS OF IMPOUNDMENT ON THE PRODUCTION AND MOVEMENTS OF ATLANTIC SALMON IN A PRINCE EDWARD ISLAND STREAM

In connection with a study of the effects of impoundment on the trout populations of Ellerslie Brook, Prince Edward Island, data concerning the movements and production of salmon have been gathered.

A two-way counting fence (estuarial fence) has been in operation at the mouth of Ellerslie Brook since the spring of 1947. A second fence (stream fence) was located 650 yards upstream from the estuarial fence in the fall of 1950. In the fall of 1952 a pond was formed in the area between the two fences. In 1953 and 1954 adult salmon captured in the estuarial trap were placed in the pond.

Movements of adult salmon.

From 1947 through 1954, 102 spawners entered Ellerslie Brook. Females outnumbered males in all years. Some of the observed effects of the pond on the movements of adults were:

1. The pond tended to restrict upstream movements of spawners. In 1953, 19 adults were placed in the pond, five moved through the stream fence into the stream spawning areas. Again in 1954, 5 of 17 spawners moved into the stream.

2. Some females shed their eggs in the pond but there was no evidence of successful spawning there.

3. There was a marked tendency for salmon to remain in the pond following spawning. Salmon netted in the pond in late summer following spawning were in extremely poor condition.

Movements of salmon parr.

In some years salmon parr moved in numbers through the stream fence in the fall. Some features of these movements are presented below:

1. Parr in the fall movements appeared to be all males.

2. Before impoundment parr moved in both directions through the stream fence. Following impoundment practically all movements were down into the pond.

3. Few parr that moved down through the stream fence continued on into the estuary. In 1950, 210 went down through the stream fence. During the same period only 13 moved into the estuary. The end result of the fall movements was a concentration of male parr in the lower part of the system.

4. Following impoundment there was an increase in the number of parr moving into the estuary in fall.

Movements and production of salmon smolts.

Following pond formation smolts descending into the estuary were, on the average, larger than those descending into the pond from the stream. Angling records obtained on the pond showed that smolts were being retained in the pond. All smolts that descended through the stream fence in 1957 and in 1958 were marked. The results obtained from these marking programs were as follows:

1. Of the 95 smolts marked at the stream fence in 1957 only 28 were recaptured at the estuarial fence in the same spring.

2. Smolts retained in the pond were, for the most part, the smallest fish in the run.

3. In 1958 there was no evidence of smolts being retained in the pond. The run in 1958 consisted of large smolts.

4. Marking showed that smolts, produced from parr in the pond, made significant contributions to smolt runs into the estuary.

5. Smolts produced in the pond were predominately males.

Survival of parr and smolts in the pond.

Smolts. The 67 smolts held in the pond in 1957, suffered heavy mortalities. Five were angled there the following summer and two moved into the estuary in 1958. The pond was drained in summer 1958. No marked smolts were found.

Examination of scales from two of the angled smolts showed that there was an abrupt check in growth after the fish had entered the pond. This was followed by a period of relatively slow growth.

Parr. In the fall of 1956, 192 parr moved into the pond. Data on their subsequent movements are presented below:

Into estuary as parr, fall 1956....................32
Into estuary as smolts, spring 1957................69
Angled in pond, summer 1957........................12
Into estuary as parr, fall 1957....................39
Into estuary as smolts, spring 1958................13
Captured when pond was drained 1958................ 1

Survival of parr in the pond was good. Of the 192 parr in the pond, 80% descended into the estuary, 46% of the salmon that left the pond did so as parr.

To date there is no explanation for the near total mortality of the smolts held in the pond.

J. W. Saunders

No. 84

UNDERWATER OBSERVATIONS OF ATLANTIC SALMON AND BROOK TROUT

During August, 1958, a series of observations was made of salmon and brook trout in the Northwest Miramichi River, N.B. Using flippers, face mask, snorkel breathing tube and a rubber skin-diver's suit fish were studied in water from a few inches to about six feet deep. When approached slowly and quietly the young fish could be observed from as short a distance as two-three feet. Adult salmon resting in pools during their upriver spawning migration could be approached with care to within three feet. Observation periods lasted 30-40 minutes during which time student assistant D. G. Maddison recorded observations made by the swimmer and kept records of water temperature, light intensity, water flow, etc. A total of about 12 1/2 hours was spent in swimming.

Several types of observations are possible with this technique:

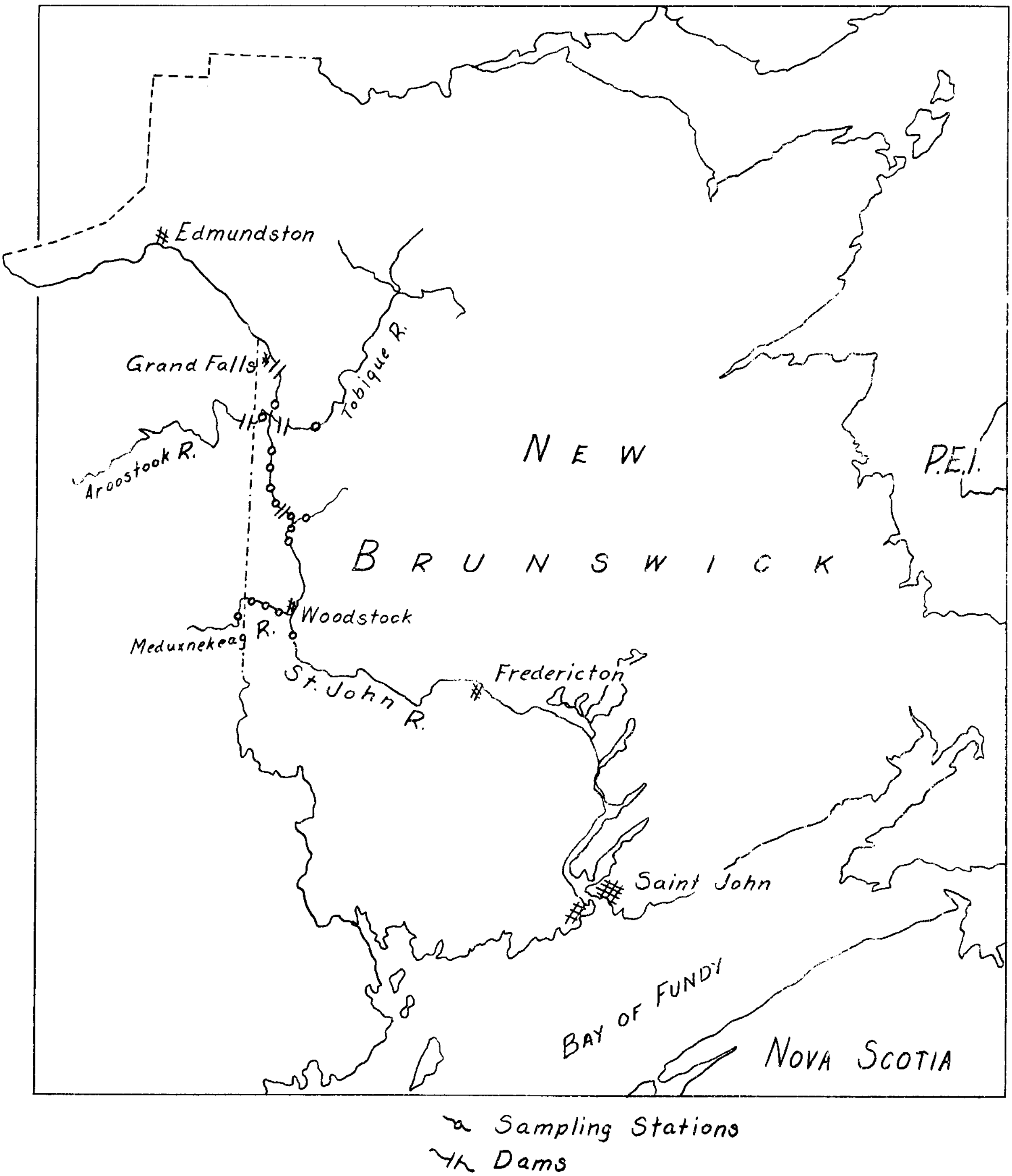
1) The species and general abundance of fish in an area can be determined quickly. This is especially useful in rapids and pools, where fish are difficult to observe from above the water's surface. The numbers and kinds of fish can then be correlated with environmental factors.

2) Several features of the behaviour of salmon and trout can be observed: a) the means by which fish hold position, b) intra- and interspecific reactions, e.g., aggressive encounters during defence of territories, c) feeding.

Observing fish directly in their natural surroundings has its limitations (uncontrolled environment, occasional turbidity of water, difficulty of rapid recording of observations), but it can be an extremely valuable addition to the study of a species' behaviour. Confirmation of laboratory findings in the field is vital to a behavioural investigation and swimming underwater in their natural habitat is one of the most efficient ways of studying the behaviour of fish in the field.

M. H. A. Keenleyside

POLLUTION


Edmundston
Grand Falls
Tobique R.
Aroostook R.
NEW
BRUNSWICK
P.E.I.
Woodstock
Meduxnekeag R.
St. John R.
Fredericton
Saint John
BAY OF FUNDY
NOVA SCOTIA
Sampling Stations
Dams

No. 85

POLLUTION

The program of research on pollution is new in 1958. Its primary aim is to investigate pollution which affects fisheries in the Maritimes area. Also within its scope are other man-made changes in the physical habitat of fishes.

During 1958, main emphasis was placed on a "base-line" survey of part of the Saint John River system. This is designed to serve as a reference point for assessing future changes. Increased use of this river for disposal of wastes and other purposes seems likely. Some of the largest municipalities in New Brunswick are located on its banks, and both population and industry are expanding at present. It is the largest river in the Maritimes, and plans are under way to develop more of its hydroelectric potential than the present 40% utilization.

During the survey, some cases of pollution were encountered, and a report is given below. Beechwood dam was within the study area, and two effects of this new construction on fisheries were investigated.

Sampling stations are indicated on the accompanying map. Investigation at these points was limited to the physical nature of the river, and the bottom-living invertebrates. Study of the latter provides a rapid and meaningful method of estimating the seriousness of pollution and other environmental change.

Base-line survey of the Saint John River

This section deals only with unimpounded parts of the main river. Only high lights of the findings are presented here.

Sampling stations spanned 60 miles, and were chosen to represent typical portions of the river. Findings were similar at all points. The profiles of the bottom in Figure 1 show that the river bed is fairly flat for a great proportion of its total width. Other conditions were also fairly uniform across the river. The bottom was almost wholly of rocks. Rates of flow were mostly 3 to 5 feet per second, and depths were 6 to 18 feet, excluding the immediate edges of the river. Because of high water during sampling, these rates and depths are greater than is normal during summer.

The bottom fauna was also uniform, and dominant forms were caddisflies (Hydropsychidae) and midge larvae (Tendipedidae). The former were mostly of the *Hydropsyche bifida* group, and the latter mostly a species of *Calopsectra*. Both of these animals obtain their food by spinning nets, and are indicators of continually flowing water. Numbers of individuals are given in the following table. The biovolume of the caddisflies was much greater than that of the midges. Other organisms present were leeches, oligochaete worms, limpets, and blackflies. Total biovolume averaged 2.2 ml. per square meter. Gravel banks were occasionally encountered during sampling, and were barren of invertebrates or nearly so.

Total volumes of invertebrates, and numbers of dominant organisms, for various habitats in the Saint John River system. (All figures are averages for one square meter of bottom. A dash indicates absence, or small numbers, of the organism.)

Habitat	Biovolume ml.	Number of individuals: Hydropsychidae	Oligochaeta	Tendipedidae	Asellus
Free-flowing Saint John River	2.2 ± 0.5	380 ± 99	-	560 ± 150	-
Beechwood impoundment	10.5 ± 1.9	-	1,400 ± 480	1,000 ± 360	650 ± 330
Tobique impoundment	3.5 ± 0.9	-	550 ± 230	280 ± 130	-

These results are not of great practical importance at present. However, the uniformity of findings makes them a useful yardstick for investigating future changes in the river from pollution and other causes.

Occurrence of pollution

Routine sampling disclosed slight pollution by food-packing wastes at East Florenceville. Sludge deposits were heavy on the bank near the outfall, but were light in the river, and restricted to a mile-long strip on one side. The bottom fauna indicated that reduction of dissolved oxygen was negligible.

The Meduxnekeag River, which joins the Saint John River at Woodstock, was reported locally to be polluted. Investigation showed that organic matter from sources in Maine rendered the portion of stream near the border unsuitable for fish. Seven miles downstream from the border, the biota indicated heavy enrichment, but only mild deoxygenation. Seining showed that good populations of normal stream fishes were present.

Sampling in the Aroostook River, one mile upstream from its mouth, indicated mild organic pollution. At that place, conditions could not be considered deleterious to fish life.

Woodstock was the largest municipality in the area studied. Sewage from Woodstock did not have an appreciable effect on water quality of the Saint John River as it affects fisheries.

The impoundment at Beechwood

The Beechwood headpond is about 18 miles long. An important question at present is whether this body of water will be useful as a habitat for young salmon or other species of fish. Accordingly, some work was centred on this section of the river.

Permanent closure of the dam occurred less than a year before this survey, but considerable change had occurred in that time. From the fisheries standpoint, silt had become the most important feature of the bottom along the whole impounded section. The layer of silt will undoubtedly become thick over several years. This has happened in the adjacent impoundment on the Tobique River, which is now five years old. No oxygen deficit is to be expected in the deeper water above Beechwood. This is because the dam is essentially of the "run-of-the-river" type, and because outlets are near the bottom of the dam.

An estimate was made of production of invertebrates suitable for fish food in the Beechwood and Tobique headponds. Over the length of the Beechwood impoundment, the biovolume of bottom organisms averaged 10.5 ml. per square meter. This figure is about five times greater than the biovolume for free-flowing parts of the river. A large portion of the volume was contributed by the crustacean *Asellus intermedius*, which enjoyed an explosive increase in numbers following damming of the river. An additional large contribution to the total volume was made by midge larvae, mainly *Tendipes decorus*. Numbers of these organisms are given in the accompanying table. Both are readily used as food by small fish. A smaller proportion of the biovolume consisted of oligochaete worms, which are generally not important as fish food.

Such heavy fertility is common immediately following impoundment of a section of river, and may be expected to decline in a few years. An estimate of future production of fish food is given by the Tobique headpond. Here the biovolume of bottom fauna was only 3.5 ml. per square meter. Almost 90% of this volume consisted of oligochaete worms, not desirable as fish food. Thus the impoundments do not seem to hold great promise for the future production of fish.

Drying of river bottom by operation of Beechwood Dam

There has been some concern about the effects of "peaking" operations at Beechwood dam during times of low flow in the river. At such times, more water flows past the dam at periods of peak demand for electricity. Overnight and on week-ends, when demand is low, water is conserved behind the dam. Such operation affects long stretches of the river. For instance, week-end periods of low flow past the dam at Grand Falls have caused sharp weekly fluctuations in water levels at a point 95 miles downstream. This periodic lowering of water level below the dam may damage salmon populations, which use the river as a rearing area and as a migration route. It is possible that areas of bottom containing eggs may be dried, and that fish may be stranded in shallow water, exposing them to predators.

A first step in assessing the seriousness of such damage is to estimate the amount of river bottom likely to be exposed by peaking at Beechwood Dam. Such an estimate can be made at East Florenceville. A gauging station is located there, and the relation of water level to rate of discharge is known. (Data kindly supplied by the Department of Northern Affairs and National Resources.) This relation can be applied to the profile of the river bed obtained at East Florenceville, shown in Figure 1G. This profile seems to be representative of the free-flowing sections of the river, although the water is a little shallower.

It has been suggested that flow through Beechwood should not fall below 1,000 c.f.s. The amount of bottom exposed at this flow may be compared with that for unregulated river flow. Inspection of flow charts reveals that once or twice a year, flows at East Florenceville may be expected to drop to levels of 3,000 to 5,000 c.f.s. for periods of several weeks. In the five years for which records are available, the lowest average monthly flow was 3,100 c.f.s. The actual minimum daily flow was itself a result of manipulations at dams. However, a 10-day average of flows at this time yields an estimate of 2,500 c.f.s. as the 5-year minimum if no regulation had occurred. From this, it seems that a reasonable estimate of expected minimum flows is about 3,000 c.f.s.

Exposure of bottom at this "normal" minimum flow is compared with exposure at 1,000 c.f.s. in Figure 2. Considering the vertical exaggeration of 7.5, it is seen that lowering the flow to 1,000 c.f.s. exposes only a small additional portion of the bottom. The amount is a strip of approximately 10 or 20 feet at either side, less than 5% of the total bottom area at normal low flows. Thus, if a minimum of 1,000 c.f.s. were maintained through Beechwood, the extra exposure of bottom in typical parts of the river is insignificant.

This conclusion must not be construed to mean that the effect on salmon would be insignificant. However, it serves to direct attention to other considerations which are probably

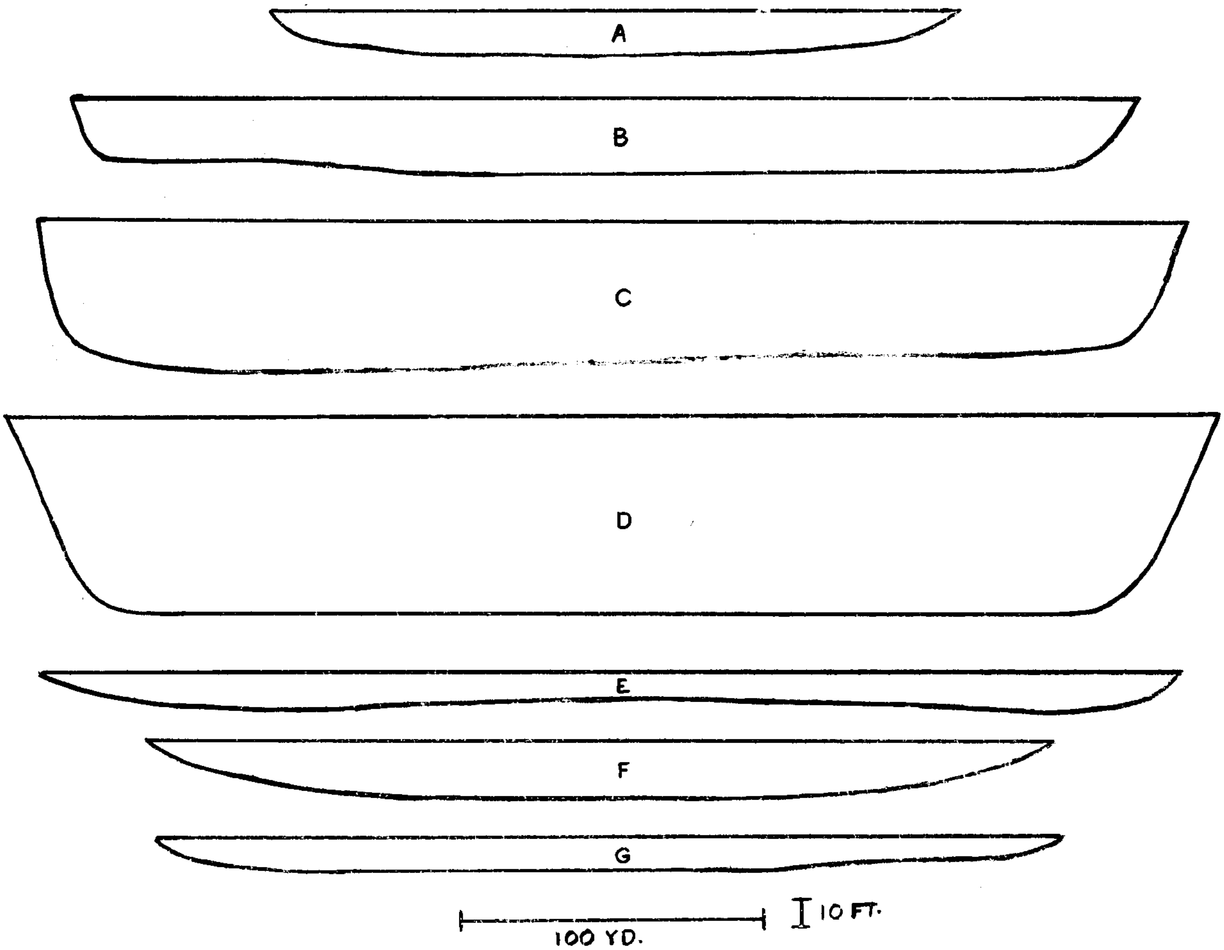


Figure 1. Cross-sectional profiles of the Saint John River. Section A is above the entrance of the Aroostook River. Sections B, C, and D are above Beechwood dam at distances of 17.3, 5.6, and 0.6 miles. Sections E, F, and G are 3.1, 6.9, and 10.2 miles below the dam, G being at East Florenceville. Vertical exaggeration: 3 times.

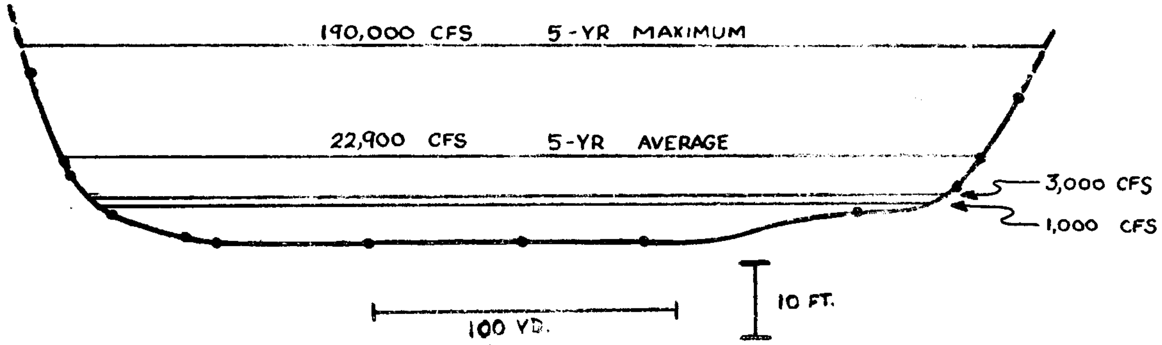


Figure 2. Water levels at East Florenceville for various rates of discharge in the Saint John River. Vertical exaggeration: 7.5 times.

more important. For instance, the areas utilized by salmon for spawning and rearing may be atypic portions of the river, such as shallow gravel bars around islands, or riffle areas. The actual velocity of flow in the river may be an important factor in survival of salmon eggs and food organisms of young salmon. To assess the effects of flow manipulation in the Saint John River on salmon, research is clearly indicated along the following lines:

(1) path of migration of large salmon, with regard to likelihood of stranding;
(2) extent of spawning and rearing in the main river;
(3) the specific portions of the river used for spawning and rearing.

J. B. Sprague

SEAWEED SUMMARIES

Seaweed investigations

Rate of growth of Irish Moss

Constitution and productivity of a population of Irish Moss

ALEWIFE

Preliminary alewife investigations, 1958

FAUNAL RECORDS

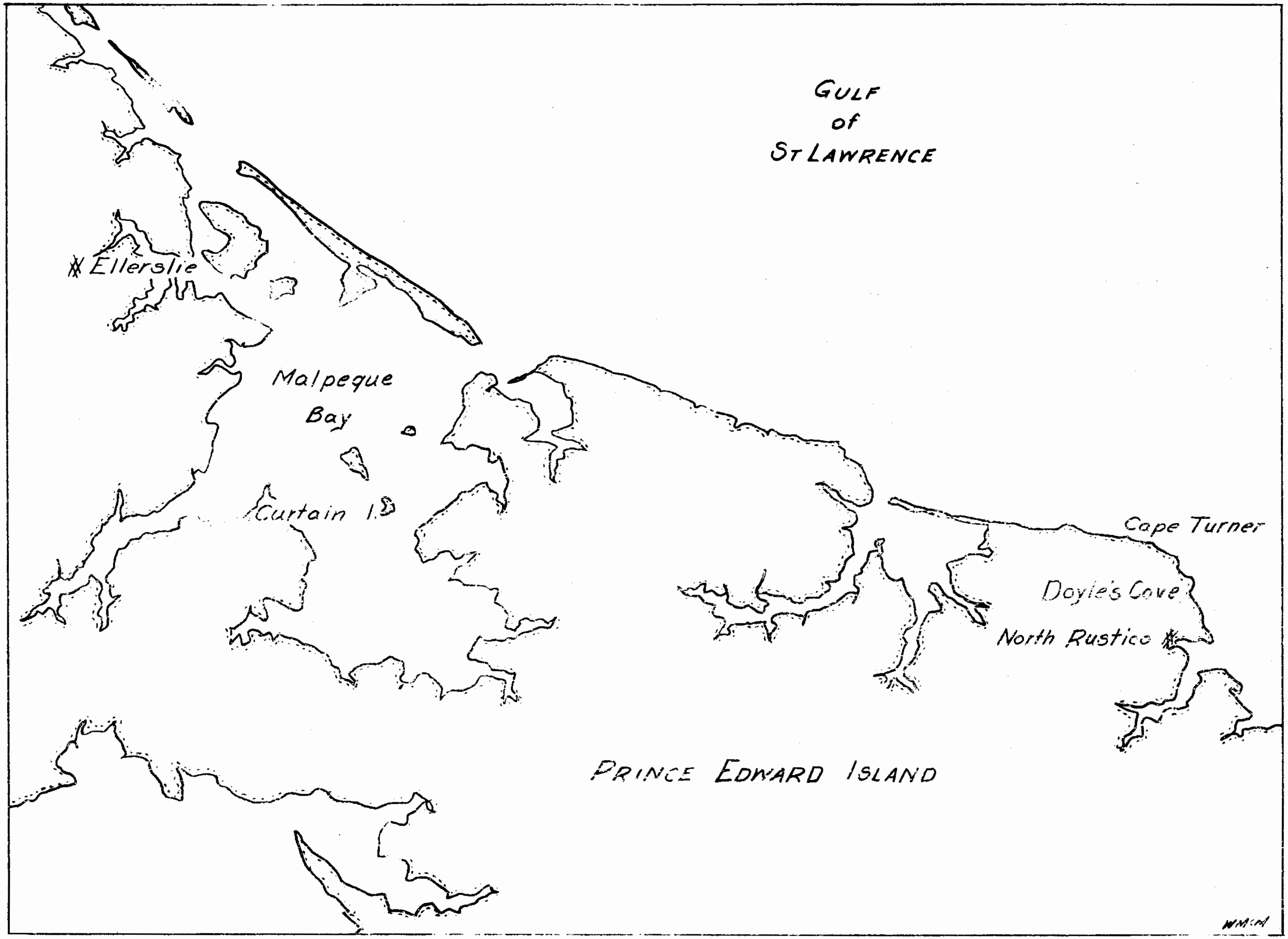
Records of unusual species from the Atlantic coast, 1958

Bulletin of Canadian Atlantic fishes

MATHEMATICAL STATISTICS

Mathematical statistician--A summary of activities

Does it pay to control the lobster fishery at Tignish?


GULF
of
ST LAWRENCE
Ellerslie
Malpeque
Bay
Curtain I.
Cape Turner
Doyle's Cove
North Rustico
PRINCE EDWARD ISLAND
WM'H

No. 86

SEAWEED INVESTIGATIONS

The main object has been a study of the nature and continuity of the crop of *Chondrus crispus*, Irish Moss. This has been done by measuring the rate of growth in area for individual specimens, by examining the population off the north shore of Prince Edward Island in terms of developmental classes, and by estimating the productivity of the bottom. In addition, collections of marine algae have been made at numerous localities in order to increase our knowledge of the marine flora of the Maritimes.

A. R. A. Taylor

No. 87

RATE OF GROWTH OF IRISH MOSS

The rate of growth of individual Irish Moss plants was studied again this year by photoprinting individual plants with Ozalid paper. The individual plants were on rocks partly embedded in large concrete blocks. At intervals the blocks were hauled to the surface and the areas and lengths of plants were measured. The methods have been described in the 1955 and 1956 Annual Reports. The main series of measurements was made at Curtain Island in Malpeque Bay and a second series at Doyle's Cove on the Gulf of St. Lawrence shore of Prince Edward Island. Hydrographic conditions at both places are similar but the Curtain Island position is less exposed, slightly warmer in summer and often covered by ice and snow in winter; the plants were about ten feet deep at M.L.T. on flat rock ledges. A third group of plants was measured in the Bay of Fundy at Alma, New Brunswick, where the hydrographic conditions are very different; the tidal amplitude is large, the water remains cold all year and is more turbid.

The growth rates of Irish Moss in 1958 averaged somewhat less but were generally of the same magnitude as in previous years. Growth rates at Curtain Island are summarized and compared for different periods of the year and for different size-development classes in the accompanying table. This has been done for Curtain Island plants only. These results show that growth is most rapid in the period from May to July and falls off through the remainder of the summer. Also, there is little consistent difference between the growth rate of smaller, little-branched and of larger, much-branched plants. Although the number of observations is small, one might infer that unbranched specimens of classes 1 and 2 grow most rapidly.

Seasonal growth rates of Irish Moss at
Curtain Island, P.E.I.

Year-Class	Mean growth in area per plant during seasonal period: Winter	May-June	June-July	July-August
1958 All	0.0021 cm^2/cm^2/day ±0.004 (s.d.) n=22, 251 days	0.0062 ±0.0035 62, 36	0.0074 ±0.0039 51, 30	0.0050 ±0.0037 57, 33
1957 All	0.0025 ±0.0013 n=75, 240 days	0.0118 ±0.0065 55, 26-31	0.0108 ±0.0047 59, 38-45	0.0056 ±0.0028 49, 40-42
1956 All			0.0118 ±0.0058 16, 30	0.0066 ±0.0035 7, 39
1958 1-2		0.0085 5, 36	0.0148 5, 30	0.0110 3, 33
3-4	0.00018 n=6, 251 days	0.0061 22, 36	0.0073 13, 30	0.0060 13, 33
5-6	0.00019 n=4, 251 days	0.0054 11, 36	0.0068 25, 30	0.0038 32, 33
7	0.00274 n=3, 251 days	0.0053 5, 36	0.0081 5, 30	0.0047 3, 33
1957 1-2		0.0087 1, 26	0.0121 7, 38-45	0.0126 1, 40-42
3-4		0.0139 11, 26-31	0.0116 23, 38-45	0.0052 17, 40-42
5-6		0.0116 18, 26-31	0.0110 27, 38-45	0.0059 26, 40-42
7		0.0112 25, 26-31	0.0096 23, 38-45	0.0051 9, 40-42

Classes: 1 and 2, small, unbranched specimens;
3 and 4, small, slightly branched (1-3X);
5 and 6, medium large (<10 cm.), more branched (>3X);
7 large (>10 cm. tall), much branched (>4X).

A. R. A. Taylor

No. 88

CONSTITUTION AND PRODUCTIVITY OF A POPULATION OF IRISH MOSS

Quadrats, marked by one-metre squares of pipe, were established in 1956 at Doyle's Cove, on the north shore of Prince Edward Island near North Rustico, in water about 10 feet deep at M.L.T. Selected quadrats, at first of 1.0 m.^{2} area (1956) and latterly of 0.25 m.^{2} (1957-1958), were cropped of the algae growing on them by diving and plucking all specimens greater than about 2 cm. long (some were missed and some lost). This treatment was meant to simulate raking. Other species of algae were separated from the Chondrus, fresh weights were determined, and the Chondrus specimens were sorted into size-development classes. The Chondrus and other algae were dried in an oven at 105°C. and weighed. Several of the quadrats were harvested two and three years in succession. The yield of Irish Moss and other algae from the quadrats is recorded in Table I.

Table I. Yield of Irish Moss -- Doyle's Cove quadrats, north shore, P. E. I.

Year	Prior treatment	Quadrat size	Yield per square metre: Chondrus No. Individs. (x) (s.d.)	(n)	Chondrus Dry wt.-gm.	(n)	Other algae Dry wt.-gm.	(n)
1958	none	0.25 m.^{2}	5200±1400	6	540±295	6	150±30	6
1957	"	0.25	3800±1630	12	370±190	12	80 ±35	3
1956	"	1.00	2550± 720	3	400±115	4	107±70	4
1958	cropped in 1957	0.25	2100±1140	4	108± 76	4	196±88	4
1957	cropped in 1956	0.25	2700±1770	9	180±130	9	121±78	8
1958	cropped 1956 and 1957	0.25	1670	1	74	1	397	1

The density of Irish Moss on the bottom is variable, and this is reflected in the variation in yield recorded in Table I. A yield of 400-500 gm. of Irish Moss (oven-dried) per square metre was usual; there were about 2500-5000 individual specimens per square metre. Cropping the area may reduce the number of individuals present next year only slightly, but there is a pronounced reduction in the weight of the crop obtained in this next year (to about one-half to one-fifth). This confirms the result reported last year. Another result of cropping is a consistent increase in the number and weight of other algae.

The size-development classes set up in 1956 are based on length of the individual specimen and the degree of its branching.

Class (1) unbranched, shorter than 6 cm.,
(2) unbranched, longer than 6 cm.,
(3) branched 1-3X, shorter than 6 cm.,
(4) branched 1-3X, longer than 6 cm.,
(5) branched more than 3X, shorter than 6 cm.,
(6) branched more than 3X, longer than 6 cm.,
(7) much branched, more than 4X, longer than 10 cm.

These classes were set up to make possible an analysis of the distribution of smaller (younger) and larger (older) specimens in the population, and a comparison of the constitution of crops after different treatments. Three years' results are reported in Table II. The majority of individuals are always distributed in classes 1, small unbranched young specimens, 3, small slightly branched, and in 5 and 6, more-branched, medium-large plants. The main mass of the crop is in classes 5, 6, and 7. Specimens in classes 5-7 are the ones most likely to be removed by raking. About 85% of the total weight in all samples is accounted for in these three classes, whereas they represent about 50-57% of the individuals removed. As pointed out last year, even fewer of the smaller plants would be taken in actual raking than in these tests, and those that were would come off as parts of the large clumps.

Many specimens are left behind in plucking the samples from the quadrats. Attempts were made to clip off all the specimens with scissors this year from 6 quadrats in order to test the possible effect of a mechanical clipping harvester on the ability of the population to regenerate. The yield of Irish Moss as oven-dry weight, 404.8 ± 203.7 gm./m.^{2} (n=6) was of the same order as that obtained by plucking the specimens. The weight of specimens left behind after plucking is not great.

To determine the distribution of size-development classes in the actual population on the sea-bottom, whole clumps or clones were removed from the rocks, separated into the size classes, counted, and oven-dried. The result of a determination based on 20 clumps taken in June 1958 is recorded in Table III. Only 37% of the individuals in the natural population were of "rakeable" size (classes 5-7), but this percentage accounts for 85% of the weight of the natural population. Collecting storm-tossed moss does not deplete the crop in any way. Raking will not do so permanently either, unless an excessive removal of clumps occurred, or unless the same area were raked intensively every season so as to remove all larger specimens.

Table II. Composition of Irish Moss crop from Doyle's Cove quadrats, north shore, P.E.I.

Year obsd.	Quadrat size m.^{2}	No. qds. (n)	A. -- Mean % number of individuals per size-development class: 1 (% ±s.d.%)	2	3	4	5	6	7
(a) natural population -- no prior harvesting									
1958	0.25	6	20.8±7.6	0.4±0.1	25.1±17.3	5.3±2.8	21.1±10.5	23.7±2.9	3.7±3.2
1957	0.25	12	22.1±10.3	0.6±0.6	21.5±11.6	8.8±4.1	10.9±7.5	32.0±8.3	4.1±2.5
1956	1.00	3	17.2±1.9	0.1±0.1	13.5±6.9	3.1±0.4	23.5±3.2	37.3±5.9	5.3±6.7
(b) harvested also during previous year									
1958	0.25	5	26.2±17.0	0.05	37.2±4.3	1.7±1.0	23.0±10.8	11.5±4.9	0.4±0.2
			B. -- Mean % weight of Irish Moss per size-development class						
(a) natural population -- no prior harvesting									
1958	0.25	6	2.4±0.1	0.2±0.3	8.6±5.0	2.8±1.7	18.0±10.7	44.1±16.0	23.8±21.9
1958*	0.25	6	3.2	0.2	8.3	3.9	15.7	48.4	20.3
1957*	0.25	12	2.8	0.1	6.3	5.8	7.2	57.8	20.0
1956	1.00	3	1.0±0.6	0.04±0.02	3.3±2.1	1.4±0.3	13.1±5.9	62.2±8.6	17.9±9.2
(b) harvested also during previous year									
1958	0.25	5	5.7±5.5	0.03±0.07	21.9±12.9	2.1±1.6	27.8±10.2	37.6±9.9	4.9±6.1

* Each of these series was derived by multiplying the mean % number of individuals for the corresponding series in A (a) above by the mean weight per individual for the class (p.189 of the 1957-58 Annual Report) and then expressing each class value (weight) as a percentage of the total.

Table III. Composition of the natural population by size-development classes, Doyle's Cove, P.E.I., June 1958. (Determination from 20 clonal clumps)

Mean % of total	Size-development classes						
	1	2	3	4	5	6	7
A. By number of individuals	38.0	0.4	18.4	5.9	3.9	25.2	8.2%
B. By weight	4.2	0.1	6.1	3.4	4.0	60.9	21.3%

A. R. A. Taylor

No. 89

PRELIMINARY ALEWIFE INVESTIGATIONS, 1958

The Fish

The alewife, gaspereau, mulhaden or kyak (Pomolobus pseudoharengus) is anadromous along the coast of the Maritime Provinces and Quebec and has become established in fresh water in Lake Ontario. Bearing a great resemblance to it, but considered by some authorities to be a different species, (Pomolobus aestivalis) is the blueback.

The Fishery

Adults have long been fished commercially by gill nets, traps and other methods including dip nets during their ascent in brackish and fresh water to spawning areas. They have been used as food fish in the fresh, smoked, or salted state and as bait for the lobster fishery. However, since 1949 with the opening of a market in New Brunswick for alewives as raw material for the pet food industry, they have been in great demand. This demand is reflected in the course of the fishery in two large alewife-producing river systems in New Brunswick between 1943 and 1958.

Alewife landings ('000 cwt.)

	Saint John River		Miramichi River	New Brunswick
	Harbour Area	Head-of-Tide Area (Grand Lake)		
1943-46	25	0.4	5	74
1951-54	25	56	180	290
1955	9	90	80	200
1958	7	31	-	-

Excellent catches were made in the period 1951-54 stimulated by the pet food market. But this was followed by a steady decline from 1953 and 1954 to the present.

Results of a more detailed examination of the fishery from 1947-1958 in the head-of-tide area of the Saint John River system showed the following:

Alewife fishery - head-of-tide area in Saint John River

	Landings '000 cwt.	Trap nets licensed no.	Value to fishermen $'000
1947-48	3	(gill nets only)	5
1949	3	7	5
1951-54	58	50	69
1955	88	75	152
1958	31	107	91

The decrease in landings suggests increased effort may be using up the accumulated spawning stocks and causing a decrease in abundance in the Saint John River system.

Investigation

The Department of Fisheries and Fisheries Research Board, recognizing the need for biological information upon which to base sound management policy, planned early in 1958 a limited co-operative program of observation and sampling of alewives in the Saint John River system at (1) harbour area, (2) head-of-tide (Grand Lake) area, and (3) upriver (Beechwood) area; and in the Miramichi River system at Newcastle. Circumstances prevented carrying out the program at Beechwood and Newcastle. From each of the other areas, weekly samples of fish were taken for biological study, weekly catches were recorded, daily catches were recorded from selected nets along with water temperatures, wind direction and force, amount of rainfall and water heights.

Analysis of catch records in the Saint John River system

Best catches were made in the harbour area in May when water temperatures were 44° to 46°F. After May 31 there was a diversion of fishing effort to taking the higher priced salmon. In the head-of-tide area, first good catches were made when water temperatures reached 46°F. Catches increased steadily to a maximum in the last week of legal fishing (June 23 to 26), suggesting the run was not yet over. Fishery officers estimated from observations that only half the run was fished. Experiments by Maine biologists show that only 5% escapement for spawning is adequate to perpetuate the run.

Analysis of samples from the Saint John River system for biological study

Results of examination of fish from the early, middle, and late part of the runs into Newcastle Creek in the head-of-tide (Grand Lake) area showed the following:

Alewife characteristics

	April 29	May 27	June 24
Mean vertebral number	49.01	48.64	48.56
Mean fork length (mm.)	268.78	259.88	260.00
Eye/head (%)	29.85	27.58	27.48
♀/♂ (%)	48/52	56/44	68/32
Maturity (%) (a/b/c/d)	8/86/4/2	4/12/68/16	2/30/60/8
Age composition (years) (4/5/6/7/?)	28/50/8/0/14	-	18/46/10/4/22
Mean age (years)	4.76	-	5.0

Mean vertebral numbers, fork lengths, and eye to head proportions of early-run fish differ significantly from those for middle- and late-run fish. These characteristics in middle- and late-run fish do not differ significantly. This suggests that the early run may be _P. pseudoharengus_ and the middle and late runs be _P. aestivalis_ or that early-run fish begot early-run fish. Further analyses are necessary. Females increase in proportion as the run progresses (50% to 70%). This contradicts beliefs of United States biologists. Five per cent of the early-run fish had ripe gonads with water temperatures below 40°F., while 70% of the middle- and late-run fish were ripe with water temperatures 55° to 65°F. Early- and late-run fish range in age from 3 to 7 years with 5-year-olds dominant. Scales suggest a good proportion of the fish mature at 3 and 4 years of age and spawn each year. With 5-year-old fish dominant, these have presumably spawned at least once previously.

Considerations

There is opportunity to keep a watching brief on the course of the commercial fisheries in the Saint John and Miramichi River systems through the Department of Fisheries personnel. However, field studies by a biologist are needed to determine whether there is adequate recruitment. This involves a detailed study of the biology of the alewife from first adult appearance to the descent of its progeny.

L. R. Day

No. 90

RECORDS OF UNUSUAL SPECIES FROM THE ATLANTIC COAST, 1958

The following species of unusual invertebrates, fishes and mammals have been reported or identified in 1958.

Crustacea

Neolithodes grimaldi (A. Milne-Edwards and Bouvier).

A specimen of this spider crab was caught by a long-liner while fishing in deep water between Banquereau and Sable Island Bank, in September 1957. The carapace length is 12 cm. (rostrum broken). The specimen was procured by Mr. G. J. W. Sullivan. Identification was confirmed at the United States National Museum.

Mollusca

Chrysodomus (Beringius) ossiani (Friele).

Egg cases of this gastropod were found near Harrington Harbour, P.Q., in 1957, by Mr. G. M. Somerville. Identified by Dr. Gunnar Thorson, Copenhagen, Denmark.

Pisces

Cetorhinus maximus (Gunnerus). Basking shark.

A 40-foot shark, that was caught in a weir at the southern end of Grand Manan and reported in the "St. Croix Courier", July 17, 1958, was doubtless this species.

Hydrolagus affinis (Brito Capello). Chimaera.

A 109 cm. specimen was caught in early June, 1958, by the vessel Harry B. Nickerson III, Captain Warren S. Levy, off the southwest corner of St. Pierre Bank at Lat. 44° 47' N., Long. 55° 56' W. in 750 fathoms. The specimen was sent in by Fisheries Inspector J. Lockman and is now in the collection of the Royal Ontario Museum.

Acipenser brevirostrum Le Sueur. Short-nosed sturgeon.

A small sturgeon, 69 cm. long, was caught by the M. V. *Harengus* in the Long Reach, Saint John River, N.B., on May 30, 1957. It was placed in the Museum of the Biological Station by Miss Sheila Duff, who identified it as a short-nosed sturgeon. This determination was subsequently confirmed by Dr. V. D. Vladykov; it appears to be the first authentic record of this species for Canada.

Etrumeus sadina (Mitchill). Round herring.

About 3 hogsheads of this fish were caught in a weir at Maces Bay, N.B., on September 3, 1958. A few specimens were brought to the Biological Station by Mrs. Esther Lord.

Coregonus clupeaformis (Mitchill). Common whitefish.

Two specimens were sent to the Biological Station in 1958. The first, 29 cm. long, was caught in a herring weir at Halls Harbour, N.S., on May 31, 1958. A larger one, 44 cm. long, was caught in a weir near Blacks Harbour, N.B., in June or July 1958. Both identifications were confirmed by Dr. W. B. Scott, Royal Ontario Museum.

Salmo gairdneri Richardson. Steelhead trout.

This species, known as rainbow trout, is established in Prince Edward Island. In September 1958 two sea-run specimens were caught in a trap at Wilmot Brook, P.E.I. Dr. M. W. Smith states that these are the first sea-run specimens reported in eastern Canada. One, 44 cm. long and caught September 17, 1958, is in the Biological Station collections.

Omochelys cruentifer (Goode and Bean). Snake eel.

A specimen, 56 cm. long, was found in a swordfish stomach in late July 1958. The swordfish was caught at Lat. 45° 30' N., Long. 57° 10' W.; where it ate the snake eel is open to doubt. The specimen was sent in by Fisheries Inspector W. N. Duggan and it was identified by Dr. W. B. Scott and Mr. Wm. C. Schroeder. It is a first Canadian record; the specimen was also of record size.

Notacanthus nasus Bloch. Spiny eel.

One specimen, 99 cm. long, was caught by the trawler Acadia Snowbird on the Grand Banks in 70 fathoms in April 1958. It was sent in by Fisheries Inspector J. M. Meagher. Another spiny eel was reported by Mr. M. F. Fraser as having been caught by the trawler Cape Alert on the southern edge of the Grand Banks in 100 fathoms, also in April 1958. It was approximately 75 cm. long.

Paralichthys oblongus (Mitchill). Four-spotted flounder.

This species has not been reported from Canadian waters previously. Two specimens were received in 1958. The first, 37 cm. long, was trawled in Passamaquoddy Bay, N.B., on June 7, 1958, by the boat Campobello, Captain J. Fitzgerald. A second specimen, 43 cm. long, was sent in by Fundy Cold Storage Company Ltd., Beaver Harbour, N.B. It was reported as having been trawled in the nearby Bay of Fundy in early July.

Zenopsis ocellata (Storer). John Dory.

A young specimen, 11 cm. long, was caught on August 19, 1958, by the M. V. *Harengus* off the western end of Sable Island Bank at Lat. 42° 58' N., Long. 61° 56' W. in about 100 fathoms depth.

Palinurichthys perciformis (Mitchill). Barrelfish.

A specimen, 30 cm. long, was taken by dipnet about August 25, 1958, near Ryder's Ledge Buoy, between Cape Sable and Bon Portage Island, N.S. The fish was sent in by Fisheries Inspector J. E. Daley through Mr. M. Fraser.

Roccus saxatilis (Walbaum). Striped bass.

Three unusually large specimens have been reported in the press. (1) A 20-pound specimen was caught in Grand Lake, N.S. It was reported in the "Halifax Mail-Star" October 28, 1957: there was a supporting photograph. (2) A 75-pound specimen was caught near the junction of the Belleisle and Saint John Rivers. It was reported in the Saint John "Telegraph Journal" February 5, 1958. (3) A 29 1/2-pound specimen, 104 cm. long, was taken at the Reversing Falls, Saint John Harbour. It was reported, with a supporting photograph, in the "Telegraph Journal" on July 15, 1958.

Sebastes marinus (Linnaeus). Redfish.

An unusually large redfish, that was exhibited at the Lunenburg Fisheries Exhibition, has been sent to the Biological Station by Mr. M. F. Fraser. It is 80 cm. long and weighs 23 1/2 pounds: it is believed to be a record. It was caught by Captain Russell Decker at Lat. 42° 38' N., Long. 62° 56' W. (offshore from Emerald Bank) in 275 fathoms on August 13, 1958.

Careproctus longipinnis Burke. (?) Sea snail.

A specimen, 23 cm. long, taken by Captain Orlando Lace in 90 fathoms at the western end of Banquereau, in late April 1958, probably belonged to this species. Only a drawing and description were submitted through Mr. R. M. MacPherson and positive identification is not possible.

Tautoga onitis (Linnaeus). Tautog.

It is worthy of note that a sport fishery for this species developed in 1957 in Eel Brook Lake, Yarmouth County, N.S. (salt water). About 2,000 fish were caught in 1957 and 450 in 1958. This information, with specimens, was supplied by Mr. E. G. Sollows.

Remora remora (Linnaeus). Remora.

A specimen, 23 cm. long, was caught by the trawler Cape Bonnie southwest of Sable Island in August 1958. It was forwarded by Dr. W. J. Dyer.

Mola mola (Linnaeus). Sunfish.

A specimen, weighing about 300 pounds, was caught off Eastport, Maine, in mid July 1958. Information from Mr. P. Wentworth, U.S. Fish and Wildlife Service. It is uncertain on which side of the international boundary the fish was caught.

Ceratias hölbolli Krøyer. Deep sea angler.

A specimen, 24 cm. long, was caught by the trawler Cape Spry on July 7, 1958, in 150 fathoms at Lat. 49° 10' N., Long. 60° 20' W. (east of Anticosti in the Gulf of St. Lawrence). It was forwarded by Mr. R. M. MacPherson.

Mammalia

Delphinapterus leucas (Pallas). Beluga or white whale.

A specimen, 8 1/2 feet long, was captured on the shore of Bedford Basin at the north end of Halifax, N.S., in late May 1958. It was reported, with photograph, in the "Halifax Mail-Star" of June 2, 1958. Dr. V. D. Vladykov concurs in the identification.

A. H. Leim

No. 91

BULLETIN ON CANADIAN ATLANTIC FISHES

A general account of the Atlantic Coast Fishes is sought by administrators, educators and the general public. The preparation of the text of such a Bulletin has reached an advanced stage. The area being 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, and a statement of its range, with the Canadian distribution in more detail. When information is available, the life history is dealt with under headings of migrations, breeding, growth rate, food, enemies, abundance, and, if commercially valuable, its importance is stated.

As of February 6, 1959, drafts have been prepared for 180 species. All of the commercially important ones have been covered, with the exception of the wolffishes, that are of minor importance. About a dozen moderately common species remain to be treated; however, there are several times as many northern and deep water forms still to be dealt with; it is anticipated that the total number will reach about 250 species. Following completion of this portion of the Bulletin a key to the species will be developed.

Illustrations, on a trial basis, have been prepared on 12 species; other sources are being explored.

A. H. Leim

No. 92

MATHEMATICAL STATISTICIAN--A SUMMARY OF ACTIVITIES

A variety of work was done in 1958. Part of the year, from September on, was spent on educational leave.

The long connection with groundfish research has led to two new methods of estimating natural and fishing mortalities. Explanations of these methods were prepared and accepted for publication.

In 1957 the work with lobster statistics was started. The statistical assessment of the data is not yet finished but important results can be reported. Thus in Summary No. 93 the information pertinent to the management of the lobster fishery at Tignish is summarized.

The lobster work has also given new impetus to additional theoretical work. The concepts of catchability and resulting fishing mortality are being studied with a probabilistic model. This work when completed will help to solve the problem as to how to estimate population size from catch, effort, and catchability data.

A program for an electronic computer to calculate fishing and natural mortality rates has been prepared. This will be used to assess the accuracy of the available fisheries statistics in mortality studies.

A large share of the time was spent with smaller problems arising from consulting service or with less scientific projects. The latter include studies of card systems to record fisheries data.

J. E. Palcheimo

No. 93

DOES IT PAY TO CONTROL THE LOBSTER FISHERY AT TIGNISH?

The lobster fishery at Tignish, P.E.I., has been intensely studied by the lobster investigation since 1945. Some of the accumulation of statistics and information has now been analyzed, and we can make a preliminary report of those results which are pertinent to the management of the fishery.

Mortalities. In Table I the fishing mortalities are listed for the years 1947-1956. The figures are based on the estimated removal of legal-size lobsters by fishing during the lobster season (May-June), and on the population size estimates at the start of the season as determined from tagging-recapture data. The variations encountered, while not completely under-stood, are correlated both with seasonal water temperatures and with the amount of fishing effort expended. It should be noted that the catchability and thus the fishing mortality also depend on the size of the lobster.

Table I. The mortality estimates. The minus sign in front of the natural mortality rate indicates that the survival rate was over 100% by the amount shown.

Year	Mortality estimates fishing %	natural % ♂	natural % ♀	Year	Mortality estimates fishing %	natural % ♂	natural % ♀
1947	73			1952	68	15	-70
1948	77			1953	63	28	17
1949	59	-52	-119	1954	58	[illegible]	31
1950	73	24	- 13	1955	69	[illegible]	53
1951	73	14	23	1956	[illegible]	27	-30

There have been no direct experiments to determine the natural (between seasons) mortality. One growth-marking experiment put it at about 20%. We have also attempted to calculate this mortality indirectly by comparing the calculated population at the start of the season with estimated population left in the water at the end of the previous season. Figure 1 illustrates the situation. The solid line represents the estimated size composition of the legal-size male stock at the start of the 1953 season. This has been obtained by employing the population size estimate, the length frequency samples of landings, and the known relative catchabilities of different-sized lobsters. The broken line represents the estimated length composition at the start of the 1953 season of that male population which was left in the water and was of legal size at the end of the previous (1952) season. This length composition has been estimated by applying the growth data to the estimated length composition of legal-size male lobsters at the end of the 1952 season; no allowance is made for natural mortality.

For each length group we have now two abundance estimates; one at the start of the season (solid line), and the other one representing the abundance at the end of the previous season of those lobsters which would grow into the size group considered. To estimate the natural mortality we consider only those groups which are unaffected by recruitment and which fall within the range of reliable growth data; in this case the 22-24 cm. group has been selected. The ratio of the abundance of the lobsters in this group at the start of the season (solid line) to the estimated abundance of the same lobsters at the end of the previous season (broken line) gives the survival rate (%) and hence the natural mortality rate. This way the natural mortalities as listed in Table I are obtained. The minus sign indicates the estimated survival rate was over 100%.

Figure 1 - Comparison of the length composition of the 1953 population (♂) with that of the 1952 population (♂) as estimated at the start of the 1953 season.

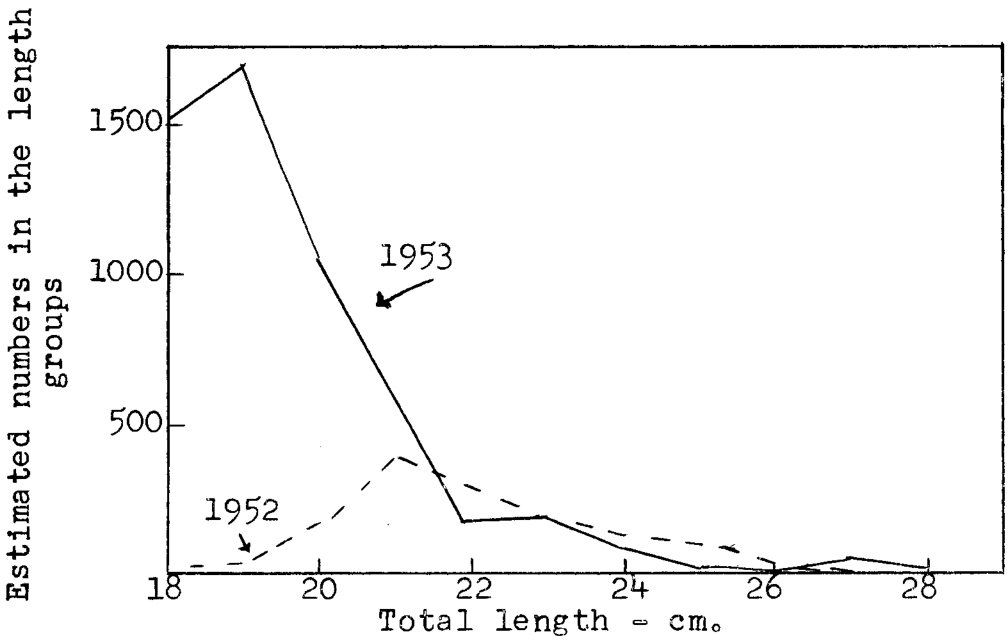
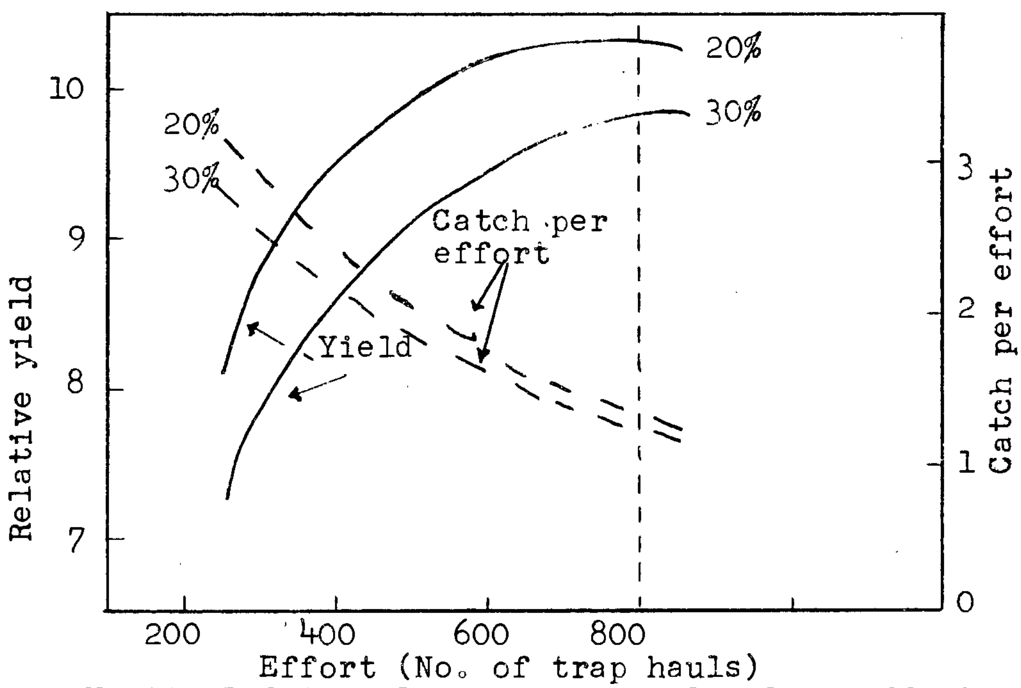


Figure 2 - Relative yield and catch per effort by weight from a group of legal-size lobsters for varying fishing mortality and for two alternative natural mortalities.



Vertical dotted line - Present level of effort

The natural mortality figures in Table I are affected by out of season fishing. Since this illegal fishing may be quite extensive in some years the figures in Table I appear, even as variable as they are, quite low. Thus we suspect that there is recruitment to the area or that part of the stock is unaccessible but becomes accessible through its movements; some bias may also be present in the estimates.

Growth. Growth studies of Tignish lobsters were completed in 1957. We have employed these data to determine the growth by weight of the legal-size lobster stock. In Table II the estimated total weight of legal-size lobsters at the end of the season is tabulated for the years 1948-1953 along with the estimated weight of the same population at the start of the next season, should there be no mortality between the seasons. The growth as calculated from these figures varies between 39% and 41%.

Table II. Total estimated weight of the population of legal-size lobsters at the end of the season and the total weight of the same population after one year's growth has been applied to it.

Year	Total weight '000 lb.		Total weight after one year's growth '000 lb.		Growth
	♂	♀	♂	♀	%
1948	165	145	232	203	40
1949	397	279	559	393	41
1950	300	187	424	262	41
1951	297	167	423	235	42
1952	376	387	524	539	39
1953	274	493	385	690	40

Can we construct a model of the fishery? The information on growth, recruitment, movements, and especially on natural mortality is still too sketchy to construct a statistically sound model of the Tignish lobster fishery. Thus, for instance, the natural mortality estimates are quite variable and apply only to a small section of the legal-size population. Nevertheless, some conclusions which are of practical importance can be drawn. Indeed, many fisheries are being regulated on the basis of weaker statistics.

Does it pay to control the total effort? To calculate the yield for different total fishing efforts at Tignish, we have considered a group of legal-size lobsters and assumed that it remains in the fishery at the maximum for 3 years. The first year these lobsters have the same length frequency as the average length frequency of legal-size (over 2½ in. carapace length) lobsters at Tignish at the start of the season. For a given number of trap hauls the fishing mortality and the yield by different size groups can be calculated. The growth by weight between the first and second year (season) is given in Table II. The fishing mortality during the second season per given effort is obtained by estimating first the length frequency at the start of the second season. The growth between the second and third season is assumed, quite arbitrarily, to be the same as between the first and the second. Similarly the fishing mortality per given effort during the third season is assumed to be the same as during the second. Two alternative natural mortality rates are considered, namely, 20% and 30%.

The above assumptions provide a basis for calculating the relative yields at different levels of fishing. The calculations are presented graphically in Figure 2. The solid lines exhibit the relative yields per given number of trap hauls for assumed 20% and 30% natural mortalities respectively. The broken lines represent the relative catch per effort figures. The present level of fishing mortality (on an average close to 70%) is brought about by a very high fishing effort. It appears, e.g., that if the total effort were reduced by 50% from the present level of fishing, the yield would be reduced by only about 15% while the catch per trap haul (effort) would almost double.

Does it pay to increase the size limit? To evaluate the effect of increasing the minimum legal size for lobsters, calculations similar to the above can be made. We have evaluated the effect of an increase from 2 1/2 to 2 5/8 inches carapace length. No appreciable benefits are noted except when the lower 20% natural mortality rate and the very high level of effort corresponding to 70% fishing mortality are assumed.

This may seem surprising since growth is about 40% by weight per year. However, with the assumptions made, those lobsters which are between 2 1/2 and 2 5/8 inches carapace length the first year are, in our calculations, being fished only for 2 seasons with the higher size limit. If we knew that the life expectancy of lobsters at Tignish is higher than assumed, worthwhile benefits would be realized. However, with the present high level of fishing effort there are very few lobsters in the samples which could be considered having been legal size more than 3 years. Thus the data are missing to draw any more definite conclusions.

We note that the assumed short life expectancy was not critical when we considered the effect of restricting the total effort expended on the fishery. In the case of a higher true life expectancy, the expected yield would be relatively still higher at lower levels of effort.

J. E. Paloheimo