INTERNATIONAL COMMISSION FOR THE NORTHWEST ATLANTIC FISHERIES

Serial No. 806
(D. a. 60)

Document No. 10

ANNUAL MEETING - JUNE 1961

Canadian Research Report, 1960

A. Subareas 2 and 3 - by W. Templeman

In 1960 researches have been carried out by the Fisheries Research Board of Canada in Subareas 2 and 3 on cod, haddock, redfish and American plaice. Between July 23 and August 25 six hydrographic sections were taken. These ranged from southern Labrador to the southern Grand Bank, and from the coast to the edge of the continental shelf, usually to 1000 metres.

Cod, Gadus morhua L. Sampling of cod in the Labrador area was intensified during 1960 and cod catches were sampled in 13 inshore areas between Fishing Ship Hr. and Nachvak Fjord. These inshore collections were mainly from the commercial trap and jigger fishery. Offshore sampling of cod stocks was carried out by the A.T. Cameron, mainly in the Hamilton Inlet Bank area. Age readings from otoliths collected inshore indicate that the most abundant year-classes are those of 1948 and 1950. Older fish were more numerous in the 1960 samples than in those of 1959. Growth curves from the inshore material show the usual picture of slow growth for the area, and slower growth in the north than in the south.

Catch and effort data were collected for the Bonavista cod fishery during the 1960 season and sampling was carried out in July and September. In most of the Newfoundland shore areas the 1960 fishery for cod was quite successful but in Bonavista catches declined below the 1959 level. Landings at Bonavista decreased to 7,100,000 pounds of cod during 1960 compared with 9,600,000 pounds in 1959, 8,700,000 pounds in 1958 and 15,300,000 pounds in 1957. Of the 1960 total 39% was from handlines (both jiggers and baited hooks), 39% from traps, 4% from linetrawls and 18% from longlines.

Because of higher water temperatures in the inshore areas following a warm 1959-1960 winter, the inshore fishery at Bonavista began somewhat earlier than in 1959 and by the end of June landings from all gears amounted to 700,000 pounds higher than at the same period in 1959. Following June, however, monthly landings generally fell below those of similar periods in 1959 and the season ended with the total cod landings about 25% less than in 1959. Particularly in the handline and longline fisheries was the decrease noted, with the totals from each of these gears about 30% less than in 1959.

Since 1952, trends in the fishery at Bonavista by different gears have been studied. In 1953 the average catch per haul in the trap fishery was low. During the entire period the best average catch for cod traps was 5,300 pounds per haul during the 1954 season. Since that time there has been a steady decline to a low of 2,600 pounds per haul in 1960, less than half of what it was in 1954. In 1958 there were low average catches for all gears. This was widespread outside the Bonavista area as well, and was due in large measure to unusually stormy weather and, for the line gears, to a shortage of suitable squid bait.

In the handline fishery during the observed years there was more irregularity in the catch per unit of effort than for the traps, dropping to a low in 1953 following which there was an increase up to 1956 and then another decline to 1958 after which some improvement is shown. Poor fishing conditions in 1958 reduced the average in that year, so that, discounting this, there probably has been a relatively small decline in the average catch since 1957.

In the longline fishery, for the offshore deep-water grounds the average catch of cod per line of gear was reasonably stable from 1952-1955 but there has been a steady decline

in the average in subsequent years. For the inshore grounds fished by longline, although some irregularity is evident in the earlier years, the same decline is apparent in the catch from 1956 onward.

From yearly observations made on the length-frequency distribution of the cod catch by various inshore gears at Bonavista it is apparent that, to a very large degree, the success of the fishery by these gears is closely associated with the relative abundance of young fish supplying the fishery each year.

In the trap fishery the high average catch of 1954 can be attributed to the abundance of cod with a modal group at 58-59 cm in the distribution. From 1955-1958 relatively few young fish entered the trap fishery and the larger and older fish supporting it were reduced in numbers to such an extent that the catch per unit of effort declined. Not till 1959 and 1960 did a large new group appear with a modal group at 47-48 cm. These fish were relatively small and their greatest contribution by weight should be in future landings by the trap fishery.

Cod traps catch fish at a smaller size than handlines. Thus, when a large group of young fish first appears in the trap fishery its influence is not so great in the handline fishery until a year or two later. For this reason, although there were high average catches in the trap fishery of 1954, the best catches for the handlines came in 1955 and 1956.

In the longline deep-water fishery cod caught in the early years were largely part of old, virgin stocks. When these older fish became reduced in numbers the continued success of the fishery depended largely upon cod with a modal group at about 62-65 cm. However, during the past few years the fishery in and near the Bonavista area has been more intense due to heavy exploitation by large European trawlers and longliners in addition to the local longline fleet. As a result the cod making up the 62-65 cm modal group have been greatly reduced in abundance and this reduction is reflected in the decline in the catch per unit of effort from 1955 onward. This continuing decline may be attributed to the intense fishery and the scarcity of new cod entering to replenish the stocks.

The longline shoal water fishery usually occurs in the autumn. The cod catches from this fishery are from the same stock which supplies the inshore handline fishery and thus the trend in the catch per unit of effort resembles that for the handline fishery.

For the inshore cod-trap fishery about 4 to 5 years elapse between a spawning and the subsequent entrance of fish of that year-class to the fishery. For the deep-water longline fishery an additional 3 to 4 years must elapse before sufficient numbers of the fish remain in deep water throughout the summer and become available to the longlines. Thus, the 1955 year-class caught in abundance by cod traps in 1959 will probably not add appreciably to the longline catches in deep water before 1962 or 1963, at the earliest.

From 1957-1960 data on catches have been gathered from the cod-trap fishery in the St.John's area. The fishery by cod trap depends for success on the availability of cod which have moved to the coast pelagically in the shallow warm surface water layers. Prospects for a successful cod fishery are generally much better following a cold winter and when the cold intermediate water layer extends so close to the surface that the cod are heavily concentrated in the shallow warm surface layer. After a cold winter the trap fishery is usually later in starting than after a warm winter, but will generally continue much later in the season unless summer storms produce severe mixing of the surface waters.

An examination of mean air temperatures at St.John's Airport from 1956-1960 showed that the winters of 1956-1957 and 1958-1959 were quite cold while the other two winters were warm. In 1957 the trap fishery at St.John's began in late June, in 1959 not till the first part of July. In both these years because of the large volume of the cold intermediate water layer, cod were concentrated within range of the traps up until the first part of August and catches remained at a fairly high level. In 1958, after a relatively warm winter, the trap fishery began early in June with good catches being obtained. By the middle of July, however, the warm water of the surface layer extended deeply enough to permit cod to move out of the range of the traps and

catches declined to a non-profitable level. In 1960 the trap fishery began in early June with good catches occurring early in the fishery and increasing in July following which there was a gradual decline. However, good catches occurred even in the first part of August, much later than would usually be expected following a warm winter. Although temperatures near the surface were high the summer was unusually calm and very little mixing occurred between the warm surface layer and the colder water below. With favourable weather continuing through the summer many fishermen kept operating their traps even though catches were considerably below those obtained in July.

Ages of cod from the St.John's inshore fishing area were determined from otoliths of trap-caught fish obtained from 1958-1960. In 1958 the 1953 year-class made up 40% of the catch by number, the 1952 year-class 27%. The strength of these year-classes was reflected in a strong modal group at 49-55 cm in the length distribution of the catch. In 1959 the abundant 1955 year-class accounted for 31% and together with the somewhat less abundant 1954 and 1953 year-classes for 70% of the catch by number. The 1955 year-class had a modal length of 48-50 cm in the 1959 length distribution. In 1960 the 1955 year-class accounted for over 60% of the trap catch by number and had a modal length of 51-53 cm.

It is apparent from this preliminary examination of ages that a particular year-class, even a strong one, only contributes appreciably to the cod-trap fishery for a short period. The 1953 year-class which comprised about 40% of the catch by number in 1958 made up less than 20% of the catch in 1959 and only about 5% in 1960. It is highly probable that this reduction was not due entirely to mortality for apparently, as the cod grow older, large numbers remain in deeper water out of the range of the traps.

Age readings from otoliths of cod collected from the Burin inshore area during 1959 and 1960 indicated best survival of the 1955 year-class, followed by moderate survival of the 1952, 1953, 1954 and 1956 year-classes. The linetrawl catches contained older fish than those from the trap or jigger. The data suggest that 4-year-old fish are not fully recruited to the trap gear. Preliminary growth curves showed a moderate rate of growth with very little difference between the growth rates of the 1959 and 1960 samples.

During Cruise No.26 of the A.T.Cameron to the Labrador Shelf (Fig.1) significant catches of cod were made at 100-125 fathoms on the northeastern slope of Hamilton Inlet Bank (Group IV) especially at 125 fathoms (Station 22) where 3,000 pounds of cod were taken in a 1/2-hour drag at a bottom temperature of -0.17°C.

The series of surveys begun in the fall of 1959 to gather information on the inshore distribution and abundance of small cod of the 0+, 1+ and 2+ age-groups was continued in September and October 1960. The gear used in both years was a small Danish seine with a small-meshed, lined codend. The seine was used to explore beaches in the eastern Newfoundland area. Beaches found to be suitable for operating the gear in 1959 were visited again in 1960 and, in addition, explorations were extended to St. Mary's Bay and Notre Dame Bay and more beaches were explored in Trinity Bay and Bonavista Bay.

In all, 97 successful sets were made. The average number of cod of the 0+ group was 16 per set and older cod (mainly 1 year olds) 64 per set. In 1959 the 0+ cod averaged 50 per set and the older cod only 7 per set. On the basis of these surveys it appears likely that the 1960 year-class of inshore cod is less abundant than that of 1959.

Cod of the 0+ group had a modal length of 7 cm in Notre Dame Bay and Trinity Bay and 9 cm on the southern shore of the Avalon Peninsula. In the Trinity Harbour length distributions the mode of the 1960 year-class (0+ age), at 7 cm in October 1960, was 2 cm lower than that of the 0+ cod in October 1959. Cod of the 1+ age-group had a modal length as follows: Notre Dame Bay and Bonavista Bay, 15 cm; Trinity Bay and Conception Bay, 16 cm; southern shore of the Avalon Peninsula, 14 cm; St. Mary's Bay, 13 cm.

In Bonavista Bay, in the Chandler Reach catches, the modal length of the 1959 year-class shifted from 6 cm in October 1959 to 15 cm in October 1960, an increase of 9 cm for the

year. In Conception Bay the mode of the length frequency of the 1959 year-class changed from 8 cm in early October 1959 to 16 cm in late September 1960, a growth of 8 cm for the year.

Haddock, Melanogrammus aeglefinus (L.). The annual groundfish otter-trawling survey over the haddock area of the southern half of the Grand Bank was made by the A.T.Cameron on April 23-30 and May 11-12, 1960. During these surveys each drag of the otter trawl is of 1/2-hour duration. In 1959, after a very cold winter, during the spring survey there were on the southwestern slope of the Grand Bank quantities of haddock at 100-125 fathoms and deeper, below an intermediate layer of below 0°C water, as well as in the shallower water above this cold layer. In 1960 after a warmer winter, there were very few haddock at 65 fathoms and deeper, but the best catches per 1/2-hour drag in the warmer water were 5 catches of 1,300-2,400 pounds at depths of 39-50 fathoms and bottom temperatures of 1.0 to 4.6°C and one of 9,500 pounds at 48 fathoms and 2.1°C.

As in the surveys of 1957-1959 the catches of haddock obtained during the St.Pierre Bank survey, June 3-10, were low. A total of only 1,060 pounds of haddock was caught in 37 sets at the regular survey positions extending over the shallow and deep-water areas of the bank where haddock are to be expected. Small and usually non-commercial concentrations of haddock, however, do exist, as indicated by catches of 1200 and 730 pounds in 43-minute and 60-minute drags, respectively, from sampling sets (after the regular survey had been completed) in 90-120 fathoms on the southern part of the southwestern slope of the bank. These 2 small catches were obtained at bottom temperatures of 6.9°C, just below the cold intermediate layer. There has been no haddock fishery on this bank since 1956 and, because of the relative failure of year-classes since the very abundant one of 1949, it is unlikely that there will be a significant haddock fishery on St. Pierre Bank in the near future.

In July the A.T.Cameron carried out a savings gear cruise in the shallow 26-fathom depths of the central part of the Southeast Shoal of the Grand Bank. A total of 60 successful 40-minute sets were made resulting in catches of haddock mainly belonging to the 1955 and 1956 year-classes and almost all between 31 and 45 cm in fork length with peak catch sizes between 35 and 38 cm.

Four 40-minute drags produced catches over 20,000 pounds, the largest being 39,600 pounds; 16 catches ranged from 19,000-10,000 pounds; 25 catches were in the 10,000-5,000 pound range; the remaining 15 ranged between 5,000 and 850 pounds. The bottom temperatures throughout the experiment were between 3.1 and 4.2°C.

On the Grand Bank in recent years, year-classes of 1949 and 1955 have been the most successful and those of 1952, 1953 and 1956 survived only moderately well.

The once very abundant 1949 year-class had by 1960 been reduced in numbers to less than 2% of the research vessel catches. The 1952 and 1953 year-classes which, initially, were together probably not more than one-quarter as abundant as the 1949 brood, accounted for only 6%. None of these year-classes are now distinguishable as individual modes on the right limb of the length-frequency curve for 1960.

The success of the 1955 year-class was clearly evident by the large number of 1-year-old fish in 1956 followed by an even greater number of 2-year-old fish in the 1957 catches. By the spring of 1960 the mode of this group had progressed to 34-35 cm and in numbers accounted for 67% of the research vessel catches. The much less abundant year-classes of 1956 comprised about 16% of the survey catches as 4-year-old fish. This year-class in 1959 appeared to be about one-quarter as abundant as the 1955 brood and this evaluation still holds for the 1960 age-frequency data.

It takes 4 or 5 years for young Grand Bank haddock to grow large enough to enter the commercial fishery. The most recently successful year-classes, those of 1955 and 1956, were exploited in 1960 not only by the traditional Canadian and Spanish fleets but by a fleet of USSR factory vessels as well. The total haddock landings by all fleets from the Newfoundland banks (ICNAF Subarea 3) have decreased from a peak of 230 million pounds in 1955 to 77 million pounds

in 1959, while Canadian landings are down from 107 million pounds in 1956 to 49 million pounds in 1959. Year-classes of 1957, 1958 and 1960 appear to be almost complete failures and survival of the 1959 year-class seems to be very low. As a result a crisis in the haddock fishery is evident with a rapidly declining population of haddock of commercial size in view at least for the period 1962-1964 and no significantly surviving year-classes of haddock later than those of 1955 and 1956 to provide a future commercial fishery.

Redfish, Sebastes marinus mentella Travin and Sebastes marinus marinus (L.). The comprehensive survey of the redfish of Subareas 2 and 3 by the A.T.Cameron (using a 41-5 otter trawl and 1/2-hour's dragging per set) has been continued during 1960 on the Northeast Newfoundland Shelf and on the southern part of the Labrador Shelf.

In the cruise to the Northeast Newfoundland Shelf (Aug.20-Sept.1) no catches which could be considered indicative of good commercial fishing were obtained. Rather surprisingly the best catches of redfish occurred on the shallow bank area between Funk Island Deep and the edge of the continental shelf. The best catch, 2,380 pounds of redfish per 1/2-hour's dragging, was obtained at a depth of 150 fathoms in this area. Sets in the deeper parts of the Funk Island Deep (225-275 fath) showed redfish to be scarce though catches did improve on the seaward edge of the depression. Two lines of sets at standard depths across the edge of the continental shelf also yielded poor catches of redfish though on the more northern line in a set at 300 fathoms a catch of 1,400 pounds of large mentella-type redfish was obtained.

Thirteen marinus-type fish were caught during sets in the Funk Island Deep and, rather strangely, none were taken in the 4 sets at depths of 120-180 fathoms across the shallower bank area. On the more northern of the 2 lines at the edge of the continental shelf the more usual distribution of marinus-type fish was found, specimens occurring in the sets at 150, 160, 180 and 200 fathoms with greatest numbers in the set at 180 fathoms, where 31 marinus-type redfish averaging 5 pounds in weight were obtained with 115 mentella-type fish averaging 1 1/2 pounds.

Between July 28 and August 13, 1960 the A.T.Cameron explored the offshore waters of the Labrador Shelf along 5 lines or groups of stations (approximately between Lat. 57°N and 53°40'N) mainly between 100 and 400 fathoms (Fig.1).

Noteworthy catches of redfish per 1/2-hour's dragging were 2,400 pounds mentella-type at 175 fathoms, Group IV, Station 25, NE of Hamilton Inlet Bank; 4,400 pounds, almost all large marinus-type, at 150 fathoms, Group V, Station 33, southeast of Hamilton Inlet Bank; 3,300 pounds mainly mentella type at 200 fathoms, Group V, Station 36; and 3,900 pounds almost all mentella type, at 250 fathoms, Group V, Station 37.

Except for one marinus-type redfish in Group II all redfish in Groups I-III, north of Hamilton Inlet Bank were of the mentella type.

In Group IV marinus-type redfish occurred at 125-150 fathoms but were not abundant. Mentella-type redfish occurred at 150-400 fathoms and were numerous from 175-250 fathoms. Almost all the redfish at 150 fathoms however were of the marinus type.

On the southern line (Group V) where mentella-type redfish were more abundant and marinus-type redfish much more abundant, marinus-type redfish ranged from 125-250 fathoms but were abundant only at 150-160 fathoms while mentella-type redfish ranged between 125 and 400 fathoms and were abundant from 175-300 fathoms.

All large catches of marinus-type redfish were at temperatures over 3°C and all large catches of the mentella-type were at temperatures of 4°C and over. The marinus-type redfish, lying shallower, were living in lower temperatures than the mentella type.

The marinus-type redfish from this area were considerably larger and usually weighed from 2 to 3 times as much on the average as the mentella-type redfish from the same set. In Group IV, the mentella-type redfish increased in size with depth. In Group V the definitely mentella-type redfish, from the beginning of the large catches of redfish in 175

fathoms and proceeding deeper, increased in size with depth. There was also in this group a corresponding increase in size of mentella-type redfish proceeding shallower from 175-150 fathoms. At 150 fathoms mentella-type redfish were intermingled with far greater quantities of the large marinus-type fish and although they could be recognized as mentella, they had many characteristics more closely approaching the marinus type than did the deep-water mentella-type redfish. It is very likely that some of these mentella types of the intermingling area of both types may have some marinus-type inheritance. However, the marinus-type redfish of Group V also showed the same characteristic of increasing in size from 160-250 fathoms and also increasing in size from 160-125 fathoms. Numbers were small in both cases at each of the depth extremes and further investigations are needed to rule out the possible differential effects of time of day on movements of smaller and of larger redfish.

Information gathered during the A.T.Cameron surveys for haddock in April and May gave some information on redfish catches in relation to bottom temperatures. In 1959 the water at 80-100 fathoms on the southwestern slope of the Grand Bank was generally cold and redfish were scarce at these depths with an average catch (in four 1/2-hour sets at each depth) of 210 pounds at 80 fathoms (average bottom temperature -0.05°C) and of 1,170 pounds at 100 fathoms (1.2°C). In 1960 temperatures at these depths were considerably higher and the redfish catch was correspondingly greater - averaging (in four 1/2-hour sets at each depth at the same stations) 2,800 pounds in 80 fathoms (5.2°C) and 3,260 pounds at 100 fathoms (5.0°C). The redfish in this area are small and of the mentella type.

A study of the food and feeding of redfish is in progress. Unlike the other commercially important trawl-caught species in this area, the redfish is almost exclusively a pelagic feeder. The most important types of food are euphausiids, hyperiid amphipods, copepods and small fish. Smaller amounts of shrimps, mysids, squid, chaetognaths and ctenophores are eaten. Diet varies with the size of the redfish, the smaller food organisms being eaten by smaller redfish. There seem to be two major feeding periods during the day, during the ascent and descent phases of the nocturnal vertical migration. The intensity of feeding seems to be affected by the sexual cycle.

American plaice, Hippoglossoides platessoides (Fabr.). Growth curves from several localities indicate distinctly different growth patterns and it would appear highly likely that these can be used to identify populations.

During a survey by the A.T.Cameron along the eastern, northeastern and northern slopes of the Grand Bank from September 10-18 the best catches of plaice were taken in depths of between 60 and 150 fathoms on the eastern slope of the bank. The best catch, 4,800 pounds per 1/2-hour's dragging, was taken at a temperature usually considered high for plaice, 1.96°C, and at a greater depth than usual, 150 fathoms. The second largest catch, 2,700 pounds, was obtained in 60 fathoms at -1.06°C.

There was evidence from this survey that on the plateau and the 40-60 fathom slope of the northeastern and northern Grand Bank where the bottom slopes vary gradually and temperatures are uniformly low there are fairly large numbers of small plaice of pre-commercial sizes.

A comparison of the incidence of jellied plaice from the 1960 survey on the northern and eastern Grand Bank with that recorded in 1950-1952 indicates a considerable reduction in this condition. Along the eastern and northeastern slope of the bank scarcely any jellied plaice were encountered. To the north the incidence was higher, but still lower than in 1950-1952. It would appear that in the areas where plaice were feeding well, the incidence of jellied fillets was lower than in areas where food was scarce or of inferior nutritive quality. Another factor that probably has changed the overall picture is the removal of many very old, slow-growing fish.

Some American plaice were found in the A.T.Cameron Cruise 26 to the Labrador Shelf (Fig.1). The largest catch of plaice on this cruise was 520 pounds at 100 fathoms (Group IV, Station 20) on Hamilton Inlet Bank, but plaice were generally present from Group I southwards mainly in depths of 80-125 fathoms and at bottom temperatures from 0.3 to -0.8°C.

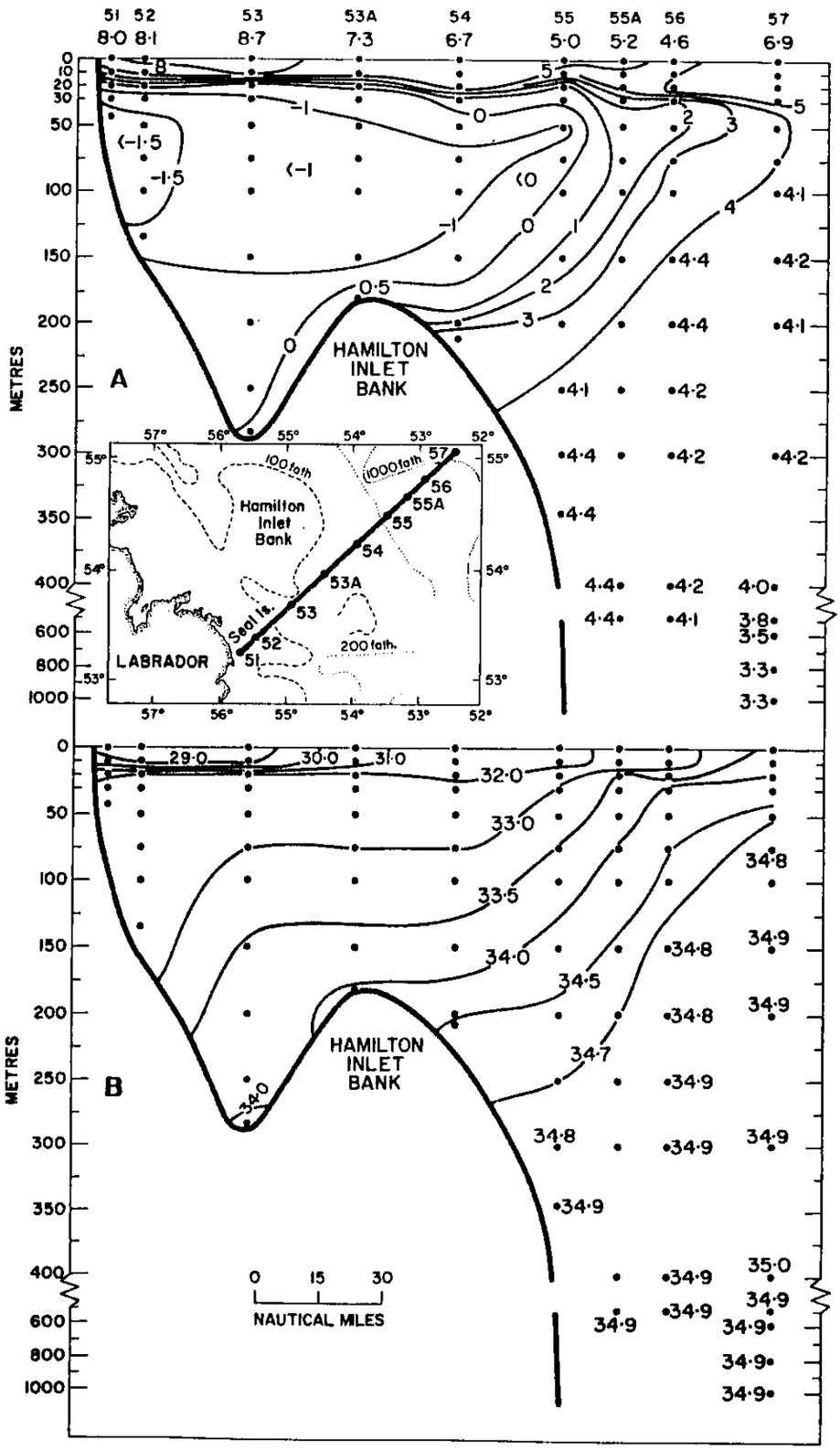

Fig. 2. Hydrographic section from Seal Islands, Labrador, across Hamilton Inlet Bank, August 2-5, 1960.
A - Temperature °C; B - Salinity ‰.

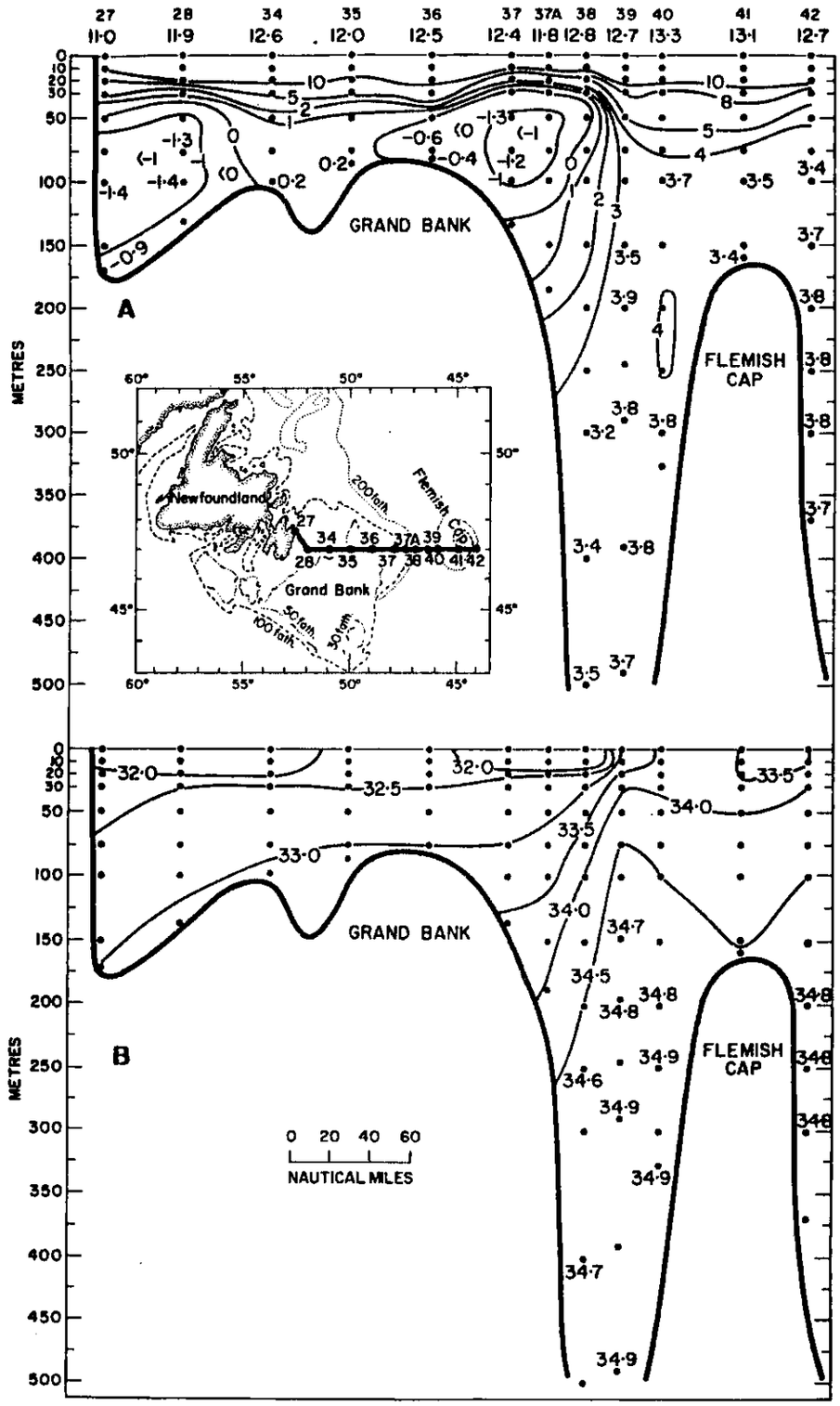

Fig. 3. Hydrographic section St. John's - Grand Bank - Flemish Cap, July 23-27, 1960. A - Temperature °C; B - Salinity ‰.

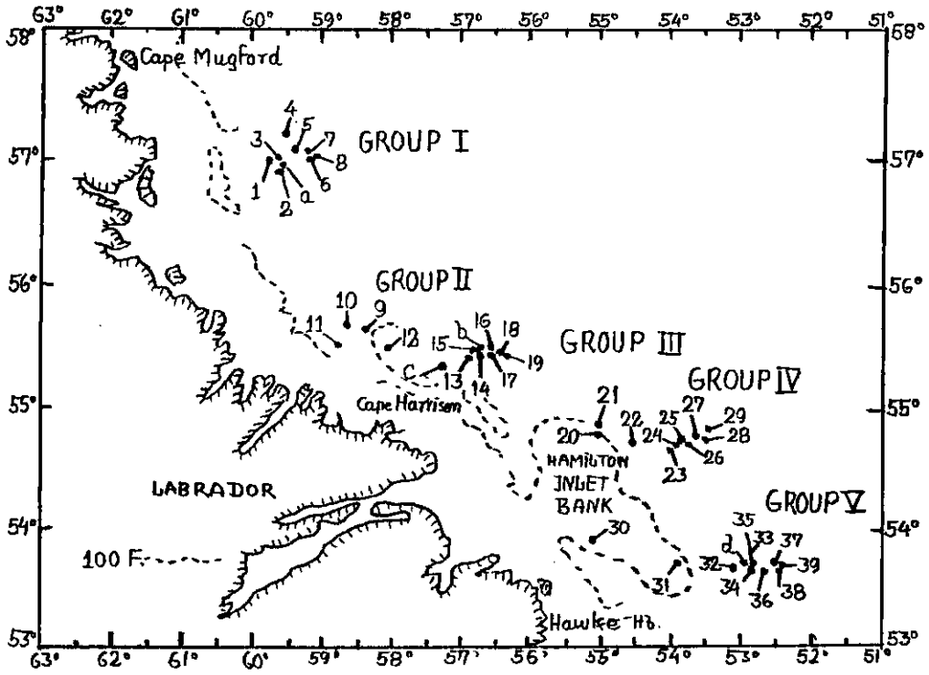

Figure 1 - Locations of 1/2-hour otter-trawl drags by the A.T.Cameron, Cruise 26 to the offshore Labrador Shelf, July 28-August 13, 1960.

Hydrography. Between July 23 and August 25 the annual 6 hydrographic sections from southern Labrador to the southern Grand Bank were taken by the Investigator II.

In the section off Seal Islands, Labrador (Fig.2) water temperatures close to the coast were slightly lower than in 1959. In the offshore area the volume of below 0°C water was less than in 1959. For the second time since 1950 (the other occasion was on Aug.6-7, 1957) temperatures higher than 4°C were present in the offshore deep water of this section.

In the Cape Bonavista section the temperature picture was essentially similar to that of 1959. The temperatures of the offshore deep water, however, were higher but not as high as in 1957 when temperatures between 4.1 and 4.3°C were to be found in the offshore deep water in this section.

In the St.John's - Grand Bank - Flemish Cap section (Fig.3) temperatures of the inshore deep water and those over the surface of the Grand Bank and Flemish Cap were a little higher than in 1959. The offshore deep-water temperatures were as usual generally below 4°C.

In the section from St.John's to the southeastern slope of the Grand Bank surface temperatures were generally higher and the bottom temperatures over the northern part of the Southeast Shoal of the bank lower than in 1959.

In the section over the Grand Bank, mainly at about 40 fathoms (75m) fringing the southwestern slope of the bank, surface and bottom temperatures over the western bank area were generally higher than in 1959.

In the section at 275 metres (150 fath) fringing the southwestern slope of the bank, surface temperatures were higher but there was much more cold water from the eastern branch of the Labrador Current than in 1959. To the west bottom temperatures were higher and more like the usual conditions than in 1959.

The unusually fine summer produced higher surface temperatures than usual in the southern sections. To the north in the deep slope water of the continental shelf there were higher temperatures than usual from the warmer West Greenland Current part of the Labrador Current but this change was highly evident only in the Labrador section. Otherwise

temperature conditions on the average in 1960 were not much different from those of 1959 apart from the changes evident in the very variable temperature conditions which are commonly encountered on the southwestern fringe of the Grand Bank.

The Atlantic Oceanographic Group surveyed the continental shelf along the Labrador coast during August and September, and the offshore portion of the western North Atlantic south to Bermuda in autumn. Chemical oceanography was given much attention, and plankton studies were carried out.

B. Subareas 4 and 5 - by W.R.Martin

Canadian researches in Subareas 4 and 5 during 1960 were carried out by the Biological Station, St. Andrews, N.B., and the Atlantic Oceanographic Group of the Fisheries Research Board of Canada, Halifax, N.S., and by the Marine Biological Stations of the Quebec Department of Fisheries at Grande-Rivière and LaTabatière, P.Q. This report is limited to the major groundfish species of Subarea 4, cod and haddock, and Subarea 5 scallops. A summary of oceanographic studies, pertinent to ICNAF, is included.

Cod, Gadus morhua L. Summer tagging of cod off northern New Brunswick has shown that western Gulf of St. Lawrence (4T) cod migrate to the Laurentian Channel off Cape Breton for winter months. Most winter recaptures have been taken by European trawlers which fish concentrations of cod at depths of about 100 fathoms from Scatari to St. Paul during the months of February to May. During summer months almost all recaptures have been taken by Canadian fishermen in the shoaler waters of the western Gulf of St. Lawrence.

In order to learn whether or not the winter concentrations of cod off Cape Breton are all from the western Gulf, cod were tagged at 80 fathoms off Sydney Bight in early February 1960. Use of the new offshore research vessel A.T.Cameron made this possible.

Most recaptures from February to May 1960 were taken along the western side of the Laurentian Channel between Scatari and Cape Smoky. European fishermen returned 25 tags as compared with 15 from Canadians.

During June to December 1960, 50 of the 52 recoveries were taken from the western Gulf of St. Lawrence, mainly off northern New Brunswick and Gaspé. All but one of the returns were from Canadian fishermen.

None of these tagged cod was recaptured across the Laurentian Channel. Only one was returned from Nova Scotia banks, Banquereau, in July. Western Gulf of St. Lawrence cod appear to be a well-defined population, living in the western Gulf (4T) in summer, and along the western side of the Laurentian Channel off Cape Breton Island (eastern 4T and 4V North) in winter.

The cod surveys made in the Gulf of St.Lawrence since 1957 were extended to winter months for the first time in 1960. Two January cruises with the A.T.Cameron surveyed the western slope of the Laurentian Channel from Gaspé to Sydney Bight and the shallow waters southeast of Shippegan Island. The Harengus made one spring (May) survey cruise in the Cape Breton area and two cruises in the southwestern Gulf of St. Lawrence in June and September. The A.T.Cameron used a 41-5 and the Harengus a 36 otter trawl. All tows were 30 minutes in duration. Comparative fishing with these two research vessels indicated that fishing efficiency of the Cameron for cod is 1 1/2 times that of the Harengus, and Cameron catches were adjusted accordingly.

Except for one tow east of Orphan Bank which caught 1,200 cod in 55 fathoms, winter catches were concentrated between 100 and 125 fathoms at bottom temperatures of 2° to 4°C. The largest numbers of medium-size cod per tow were found along the Laurentian Channel north of St. Paul Island and off Sydney Bight. Winter fishing in the Gulf confirmed the results of recent taggings in showing that commercial-size cod migrate to deep water and south in late fall. It also showed that very small cod (0 and 1 age-groups) were still present in shallow water off Shippegan Island in January.

In late spring (May) cod in the Cape Breton area were scattered over a wider depth range than in winter. Medium-size fish (39-68 cm) were caught in approximately equal numbers at all depths from 15 to 125 fathoms and at temperatures of 0° to 4°C. Small-size cod (up to 38 cm) were more numerous in shoal water.

Later in the spring (early June) small cod were found in still larger numbers in shallow water in the Gulf. Medium-size cod appeared to be present in larger numbers in both shallow (15 fathoms) and deep (60 fathoms) water at temperatures ranging from -1° to 3°C.

In the fall small cod were found mainly in shallow water at bottom temperatures of 6° to 8°C. The medium-size cod had moved to deeper water and were found mainly at depths of 50 to 70 fathoms, at bottom temperatures of 0° to 1°C.

These observations show that market-size Gulf cod are concentrated in narrower depth and temperature ranges in winter than in late spring or early fall. They also show that small cod are found in shallow water at all seasons, at bottom temperatures of -1° and below in winter and at 7°C in early fall.

Diurnal variations in cod feeding and cod catches by otter trawl were observed off Grande-Rivière, Quebec (4T) in the summer of 1960. Fewer and larger cod were caught at night in the second half of the season, indicating vertical migrations of smaller cod (less than 51 cm) at night. The number of fish caught was related to the occurrence of euphausiids and possibly herring in the stomachs. Vertical migrations of food appear to affect movements of cod off bottom.

Quantities and sizes of cod discarded at sea by small otter trawlers were assessed by making five sea trips on commercial draggers during the period June to August 1960. The draggers used nylon codends of 4 3/8 to 4 1/2 inch mesh size, and no chafing gear on top of the codends.

Discards were 6 to 16% by number and 2 to 8% by weight. This was comparable with 1959 when discards for nine trips amounted to 1 to 22% by number and 1 to 11% by weight. There were differences between the two years. In 1960, fishermen used nylon codends rather than manila, and thereby raised the 50% retention length by about 3 cm. In 1960 smaller fish were retained for landing; the 50% cull point was reduced from 44 to 42 cm. These changes would normally reduce discards to almost nothing. However, 4-year-old cod, the age-group most affected by discards, were about half again as abundant in 1960 survey catches as in 1959, and as a result, discards did not decrease appreciably in 1960.

The summer otter-trawl fishery for cod in the southwestern Gulf of St. Lawrence (4T) has been sampled for more than a decade. Data on age composition of the landings are plotted in Figure 1. It is obvious that a major change in the ages of landed fish has occurred between 1949 and 1960. In the earlier years, up to 1952, the ages of the fish were well spread out between ages 3 and 14. However, since 1955 there have been few individuals over 10 years of age, and in 1960 there were few over 7. These changes are believed to have resulted from greatly increased fishing effort by Canadian and European fleets on this population. The only dominant year-class that can be followed in these landings for more than two years is the one spawned in 1950. Recent results show that the increased intensity of the fishery rapidly reduces the size of each year-class, and even the stronger year-classes contribute to the commercial fishery for very few years.

Cross-sections of otoliths from 10-year-old cod, taken in 1957 and 1959 from the Gulf of St. Lawrence (4T), were examined for growth increments. The results conformed with, and supplemented, age-length data in showing faster growth in the period 1954 to 1955 than in the years immediately before and after. This period of fast growth corresponded with years of greater availability of moribund herring as food for cod.

Mortality estimates for 4T cod are being examined by several methods. Fishing effort is being related to catch per unit effort in numbers, to changes in abundance of year-

classes, and to tag returns. For the latter study, the results of a tagging experiment in 1955 and 1956 are available, and additional taggings by St. Andrews and Grande-Rivière Stations are continuing to supplement these results. The 1959 tagging in Chaleur Bay was repeated in August to October 1960 when 1,500 'otter-trawl' cod and 200 'line' cod were released.

The results of most of these studies and analyses of statistics and sampling of commercial landings are being used for an assessment of the effects of various mesh sizes and different fishing intensities on stocks and landings.

Increased otter trawling by Canadian and European vessels has resulted in higher total landings from the 4T cod population. However, the more intensive fishing has reduced the abundance of large, old cod. This is seriously affecting salt-fish operations which depend on the larger sizes of cod. Landings per unit effort by fresh-fishing draggers have also decreased significantly over the past 10 years.

Commercial catches of cod from 4T were unusually low in 1960. This appeared to be due to the thicker cold-water layer which enabled cod to spread out to a greater extent than in 1959. The reduced concentration of cod resulted in lower catches. With reduced abundance and availability of 4T cod, draggers shifted part of their operations to Division 4S cod in 1960.

Studies of survey and commercial catches of 4T cod permit forecasts of the 1961 fishery. Three-year-old cod will escape if 4 1/2-inch nylon codends are used by Canadian draggers. Four-year-old cod (1957 year-class) will be relatively abundant. A large proportion will be caught by the nets and about half of these are likely to be retained for markets, to contribute about 20% of all cod landed by draggers. The remainder will be discarded, raising percentage discards to about 15 to 20 by number and about 10 by weight. Five-year-old cod (1956 year-class) are expected to be dominant, contributing about 40% of those landed by draggers. Fish 8-years-old and older will constitute less than 10% of total landings. The average size of all cod landed is expected to be about one centimetre shorter in 1961 than in 1960.

Haddock, Melanogrammus aeglefinus (L.). Winter tagging of Nova Scotia bank haddock was repeated in 1960 in an attempt to define populations and their movements; 601 tagged haddock were released on Western Bank in March. Recaptures have been very low, with all from offshore banks near the region of tagging, mainly in the month following tagging.

Survey cruises in 1959 and 1960 from the Gulf of St. Lawrence (4T) to Emerald Bank (4W) have provided information on abundance and distribution of various sizes of haddock.

In winter, catches of haddock in the eastern areas were small and confined to deeper water along the Laurentian Channel and the Gully between Sable Island and Banquereau. Throughout the region east of Western Bank haddock were virtually absent from the cold waters on top of the banks, where they are found in summer. Largest catches were obtained from depths of about 45 to 70 fathoms, in the vicinity of Western and Emerald Banks. In 1959 the cold-water layer extended deeper than in 1960, and as a result, haddock were generally deeper and more concentrated in 1959 than in 1960.

Otter-trawl landings of 4W haddock have been sampled for lengths and ages during the February-April quarter since 1948. Mean length at age has shown a marked decrease over the past 12 years. For example, mean size for 7-year-old haddock was 60 to 64 cm in 1948-50 and 53 to 55 cm in 1958-59. Similar decreases have been apparent for all ages from 5 to 8. Examination of size-frequency ranges for the various age-groups indicates that the change has been a result of decreased growth.

Low availability of pre-recruit sizes and lack of strong year-classes show that total haddock landings from Divisions 4T, 4V and 4W are likely to be below average in the immediate future. The strong 1952 year-class is no longer of much importance to the fishery. The 1955 year-class which is now dominant does not appear to be of more than average strength. The 1956 and 1957 year-classes, now entering the fishery, are of about average

strength. Survey results indicate that the 1958 and 1959 year-classes, which will enter the fishery in 1962-63, are small.

Other groundfish. Less intensive studies were carried out on American plaice, Hippoglossoides platessoides (Fabr.) (4T), halibut, Hippoglossus hippoglossus (L.) (4V-W) and pollock, Pollachius virens (L.) (4X).

Gear selection. A comparative fishing experiment was carried out in June to determine the effects of gear selectivity on length and age composition and growth of cod. The M.V. Harengus fished as an otter trawler alongside a 55-foot commercial longliner close to the coast of northern New Brunswick (4T). There was a marked difference in length compositions of fish. The longlines took a much larger proportion of large cod (over 70 cm) than the otter trawl. The longline catch contained a larger number of fish aged 8 years and over, but comparable numbers of younger fish, with the 1954 year-class dominant for both gears. The growth curves showed no consistent differences.

The mesh selection of a cod trap was examined at LaTabatière, Quebec (4S). Cod released by a 4 1/2-inch nylon back were caught by a secondary 3-inch back. The selection factor was 4.3, with 50% released at 49 cm. As in previous trap experiments, the selection factor was higher than that observed for otter trawls with comparable codend mesh size.

The selective properties of a large-mesh (average 4 7/8) double-strand, synthetic, Courlene codend were studied by catching released fish in a small-mesh cover during half-hour survey tows. Selection factors of 3.7 to 3.9 for cod, 3.3 for haddock, and 2.0 to 2.1 for plaice were slightly higher than for manila. On this basis, the mesh size equivalent to 4 1/2-inch manila would be 4 1/8 to 4 3/8 inch Courlene for roundfish. This is close to the 4 3/8-inch equivalent prescribed by Canadian cod and haddock regulations for double-strand, synthetic twines.

Sea scallop, Placopecten magellanicus (Gmelin). Three sea trips were made to Georges Bank (5Z) in 1960 - two on commercial scallop draggers to observe industrial practices and one on the U.S. Bureau of Commercial Fisheries' M.V. Delaware to observe methods of investigation. One commercial boat used drags with 4-inch rings, the rest, 3-inch, and all found scallops abundant. Some boats regularly took enough scallops by dragging for 2 to 3 hours in the morning and for 3 to 4 hours in the evening to keep their shucking crews busy 24 hours a day. This practice, called "deck loading" resulted in discards suffering longer air exposure and more mechanical damage (10 to 20% killed) than in normal fishing operations. The 50% cull point stayed at 95 to 100 mm shell height, and the proportion, by count, of discards in the catch remained high, but not as high as in 1959. The fishery depended almost exclusively on one year-class (either 1954 or 1955). The year-classes of 1956 and 1957 seem much less abundant and a drop in landings has been predicted for 1961. Studies of spawning and early life-history were initiated in 1960, which should help explain year-to-year differences in the success of reproduction.

There was evidence of mass mortality on one part of the Bank.

Experiments have shown that the lifetime of "cluckers" (attached empty shells of scallops) is longer than formerly supposed. This decreases our estimate of the normal natural mortality rate which is so important in population studies and in forecasts of conservation values of various fishing practices. Other experiments, still under way, are exploring the effects of air exposure in contributing to deck damage and the mortality of discards after they are returned to bottom. They can withstand freezing if not jarred, but jarring when frozen kills them. Many hours of air exposure at temperatures just above freezing is not harmful but desiccation is very damaging.

Hydrography. The monitoring sections off Halifax and across Cabot Strait were covered three times in 1960. The temperature and salinity distributions of the section off Halifax are given in Figure 2. The bottom waters of the Scotian Gulf and over Emerald Bank were colder in February 1960 than at the same time in 1959, but warmer in May and

November 1960 than during the previous year. Along the edge of the continental shelf the waters were warmer in 1960. At all times in 1960 the observed temperatures on the bottom on the continental shelf were below normal.

In Cabot Strait, the deep, warm layer had regressed during the first half of the year but increased in volume during the last 6 months while its maximum temperature had increased. The zone on the slopes covered by water between 1.0 and 4.0°C seemed to be slightly deeper than in the last few years.

Over the Magdalen Shallows the distribution of the cold-water layer was equally extensive during the spring seasons of 1959 and 1960. In the late summer the cold-water layer did not dissipate as rapidly in 1960 as in previous years.

Study of the seasonal and long-term variations of temperatures was continued at monitoring stations along the southern Canadian mainland. In 1960 the surface coastal waters were warmer than in 1959. The increase in temperature was generally greater during the first 6 months as compared to the remainder of the year. However, in the Bay of Fundy area and along the outer coast of Nova Scotia at Sambro Lightship, the 1960 temperatures were below the 1950-1959 average. The surface waters in the Gulf of St. Lawrence were featured by unusually high summer temperatures and rapid cooling in late autumn. Considering long-term series of temperature observations it is estimated that the cooling trend experienced during the last few years is continuing in most areas for the surface and the bottom waters.

The results of drift-bottle experiments over large areas such as the Gulf of St. Lawrence, the Gulf of Maine, the Bay of Fundy and the western sector of the Scotian Shelf made possible an assessment of the seasonal and in some cases year-to-year variations in the surface circulation. During one survey the drift-bottle experiment was augmented by the release of drift poles and markers and by geomagnetic electrokinetograph measurements.

A heat budget study of the waters of the Gulf of St. Lawrence was carried out to elucidate our concepts of advection in the area and of the formation and dissipation of the cold-water layer which may be at times an environmental barrier for certain groundfishes.

The submarine geology program initiated in 1959 was continued during 1960 with emphasis on the Laurentian Channel and the Bay of Fundy.

An oceanographic and seismic survey was undertaken during August and September, covering sectors of the Scotian Shelf and of the Gulf of St. Lawrence.

Plankton. From June to November 1960, 98 plankton tows were made off Grande-Rivière, Quebec (4T) with a Clarke-Bumpus sampler. Mean volumes of total plankton were about 0.3 ml/m^3, two to three times less than in 1959. This was possibly due to slower warming and generally colder mid-water temperatures in 1960.

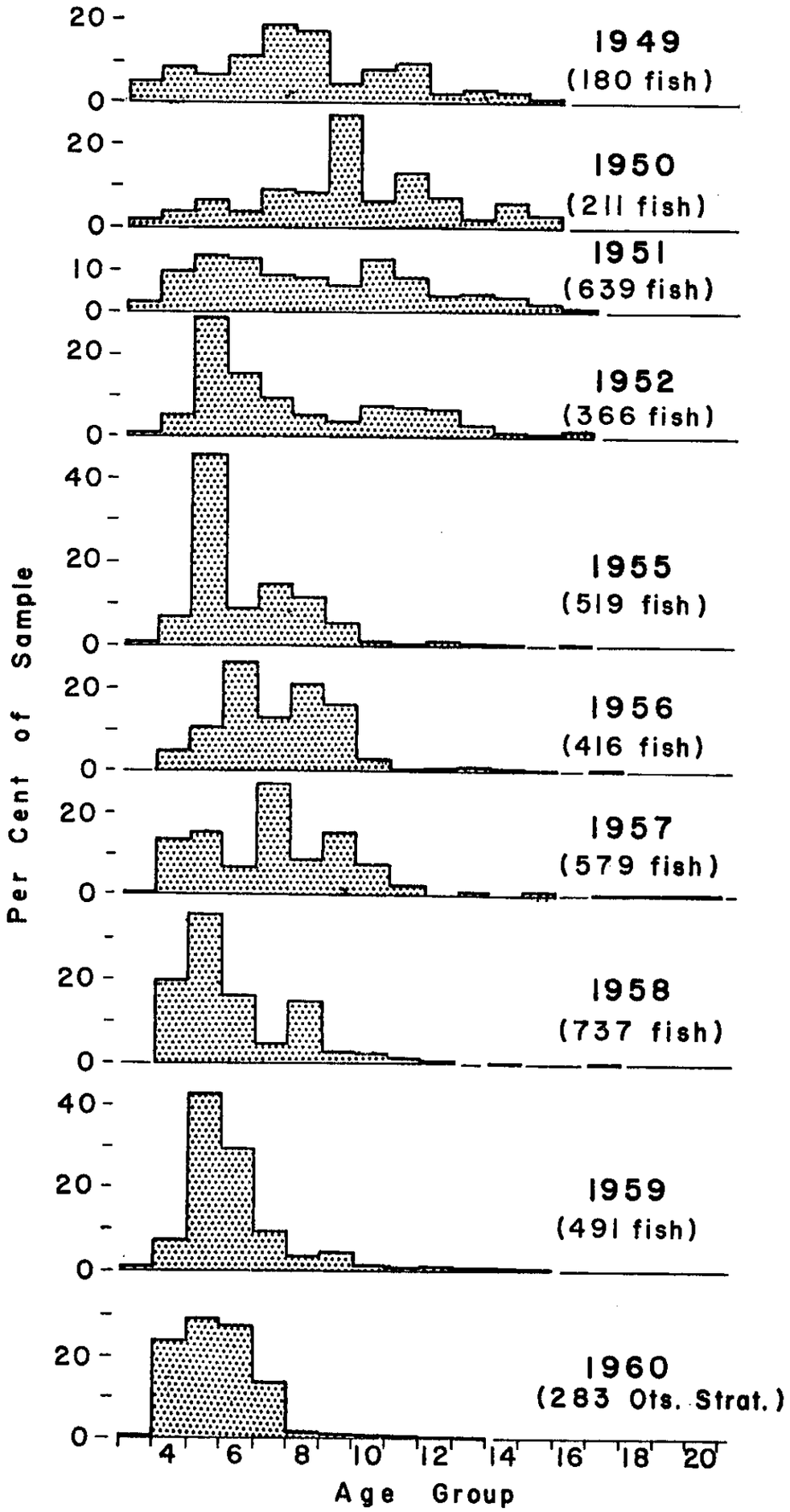

Fig. 1. For 'Canadian Research Report, 1960.
B. Subareas 4 and 5'' by W. R. Martin.

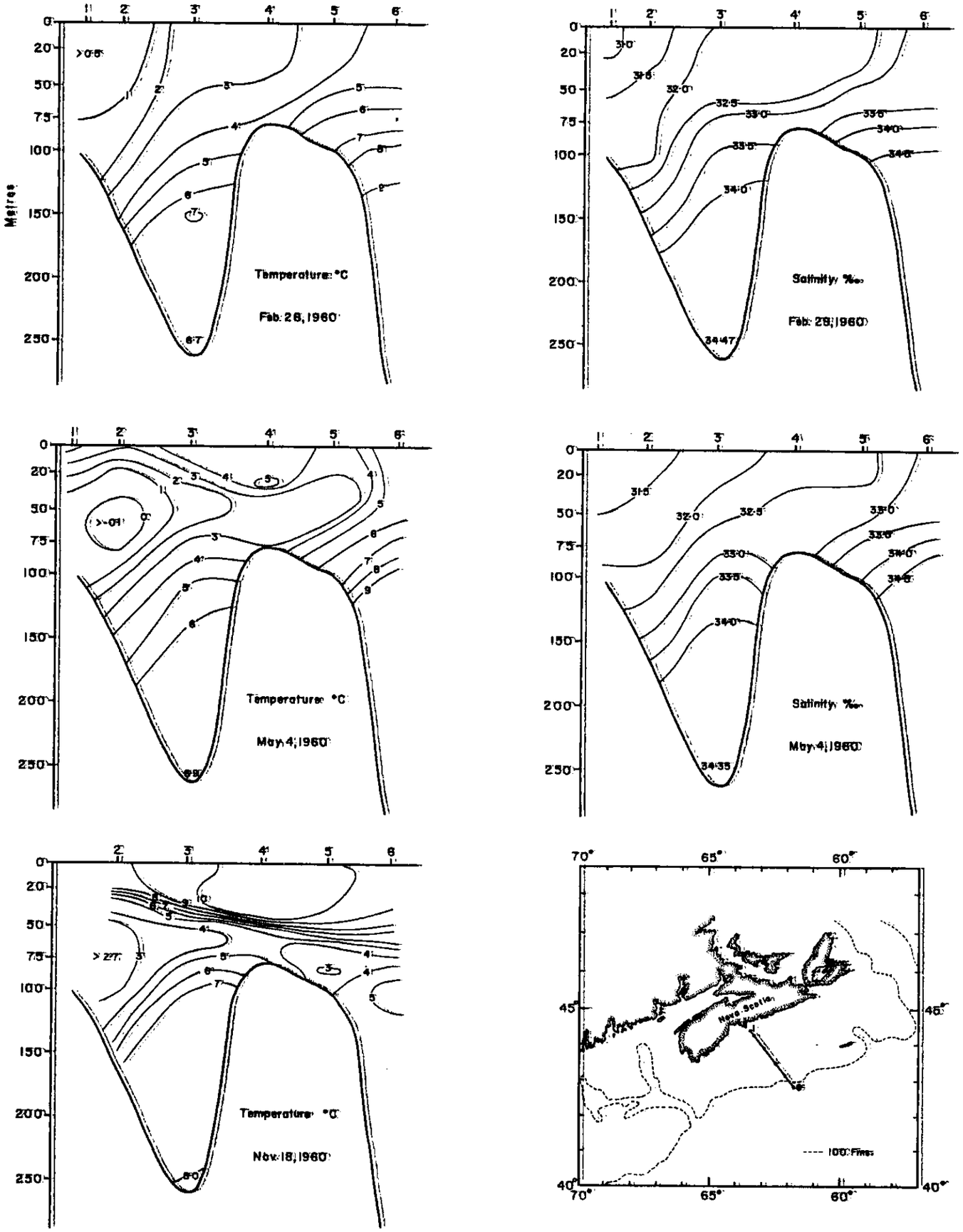

Figure 2. Hydrographic sections off Halifax, 1960. Temperature °C; Salinity °/oo.

CORRECTION to P.10, last paragraph, first sentence should read: "Low availability of pre-recruit sizes and lack of abnormally strong year-classes currently in the fishery show that total haddock landings from Divisions 4T, 4V and 4W are likely to drop below average during the years immediately following 1962."