

ANNUAL MEETING - JUNE 1965Canadian Research Report, 1964

A. SUBAREAS 2 and 3

by W. Templeman

The Biological Station of the Fisheries Research Board of Canada at St. John's, Newfoundland carried out researches on groundfish and related hydrography in Subareas 2 and 3 in 1964. The Arctic Biological Station located in Montreal conducted aerial surveys of harp seals in Subareas 2 and 3.

For location of most of the places mentioned in this report see the place name map, in ICNAF Redbook, 1962, Part 2, p. 4.

SUBAREA 2

A. Status of the FisheriesI. Cod, *Gadus morhua* L.

The Labrador inshore cod fishery was disappointing. Preliminary figures indicate that, in spite of some increase in effort, landings fell about 40%. Catch per man in the inshore fishery has declined since 1959 in Labrador with a considerable decline in 1964. This decline has coincided with increasing offshore cod fisheries in this area by European trawlers, especially in winter and spring.

Sampling of the inshore codfishery was carried out at Dumpling Harbour in southern Labrador and during a tagging cruise of the MARINUS to northern Labrador. Significant numbers of 5-year-old cod appeared in the southern Labrador trap fishery, but were not taken by jigger either in the north or south. Jigger catches consisted almost entirely of cod of age 7 and older, while a gillnet fishery in southern Labrador mainly took cod of age 9 and older.

B. Special Research StudiesI. Environmental Studies

1. Hydrography. The monitoring hydrographic section off Seal Islands (Fig. 1) was taken between July 31 and August 1. In this section there was a much greater volume of water below -1 and 0°C and bottom temperatures on Hamilton Inlet Bank and on the deep water slopes were lower than in 1963. Lowest temperatures in the section were -1.5°C compared with -1.3°C in 1963. Correspondingly in 1964 there was a greater volume of the lower salinity (below 34.0‰), colder inshore branch of the Labrador Current.

II. Biological Studies

1. Cod. On the same line of stations occupied in April and early May 1963 southeast of Hamilton Inlet Bank (Redbook, Pt. 2, 1964) half-hour otter trawl tows (No. 41 net at 3½ knots) were made by the A.T. CAMERON between March 31 and April 4 at depths from 238 to 732 m. The large quantities of spawning and post-spawning cod found in this area in April and early May 1963 were not found in 1964 nor were any trawlers seen fishing at cod depths in this area. Bottom temperatures at cod depths were higher and presumably the spawning schools were further northward than in 1963. The best catch of cod was 960 kg of small cod (mainly immature,

average weight 0.5 kg) in 238 m at 3.4°C where temperatures were almost a degree higher than in 1963. Below this depth cod were larger but scarcer at 278 m and 319 m with 290 kg (average weight 1.0 kg) in 278 m at 3.1°C and 165 kg (average weight 1.0 kg) in 319 m at 3.3°C. The catch was 120 kg of smaller cod (average weight 0.6 kg) in 362 m at 3.5°C, 7 kg (average weight 2.6 kg) in 459 m at 3.4°C and no cod in 551, 638 and 737 m at 3.4-3.5°C.

Strong westerly winds prevailed during this cruise and the area east of Hamilton Inlet Bank gradually became covered with ice. On attempting to reach cod grounds further northward east of Hamilton Inlet Bank on April 1 about 30 European trawlers were encountered retreating southward before the advancing ice.

By April 2-4, 62% of the 78 mature female cod examined were spent, 8% had some clear eggs and 31% only opaque eggs. By May 11-16 in this same area at 200-220 m, of 137 mature females 135 were spent and the 2 remaining were close to spawning, one possessing some clear eggs and the other over 50% of the bulk of eggs clear.

An attempt was made to tag cod southeast of Hamilton Inlet Bank on April 2. From a 10-minute otter-trawl set at 278 m 12 lively cod were placed in the tagging tank. These cod had come from bottom temperatures of 3.1°C and surface water temperatures of -1.5°C. Water temperatures in the tagging tank were -1.2°C or slightly lower. Some of the cod swam immediately to the bottom of the tank in a normal fashion but within a minute all were floating belly up and lifeless in the tank.

In May 1152 cod were tagged in Division 2J, southeast of Hamilton Inlet Bank and north of Hawke Channel, at a depth of 194-220 m and 768 were tagged in Division 2J, south of Hawke Channel, at a depth of 183-241 m.

From the tagging southeast of Hamilton Inlet Bank about half the recaptures were from the inshore fishery, about 75% in Labrador and 25% in Newfoundland. From the tagging in Division 2J south of Hawke Channel over half the recaptures were from the inshore fishery, and half of these were taken in the Labrador and half in the Newfoundland northeast coast inshore fishery.

Near Smokey in southern Labrador (54°15'N), 1152 cod were tagged in July in 18-37 m and 1152 cod were tagged at Saglek Bay in northern Labrador (58°20'N) in 6-18 m in August. Many cod tagged in previous years in the inshore shallow water of Labrador and Northeast Newfoundland have been taken in the offshore deep-water trawler fishery in winter and spring on the continental slope east and southeast of Hamilton Inlet Bank - Division 2J.

2. Redfish, *Sebastes mentella* Travin and *Sebastes marinus* (L.), The same line of stations, southeast of Hamilton Inlet Bank and just north of the seaward entrance to Hawke Channel, fished by the A.T. CAMERON in early April 1963, was again fished by this vessel, April 2-4, 1964, at depths from 238 to 737 m. Redfish of both species were more than 140 m for mentella and 180 m for marinus deeper than the summer-autumn levels. Catches per half-hour tow were less than 3 kg per tow at depths from 238 to 362 m at bottom temperatures of 3.1 to 3.5°C. Beyond these depths, at 459, 551, 638 and 737 m, catches were 3970, 930, 1050 and 70 kg for mentella and 140, 9, 0, 0 kg for marinus at bottom temperatures of 3.4 to 3.5°C.

Of 101 pregnant mentella females from this area, April 2-4, 6% were spent and 6% possessed unfertilized eggs. The remaining percentages were 1-4% hatched (1), 5-20% hatched (56), 30-60% hatched (22), 79-90% hatched (1) and partly spent (1). Of 58 pregnant marinus females only 1 was as far advanced as 30-60% hatched and 3 possessed unfertilized eggs.

3. American plaice, *Hippoglossoides platessoides* (Fabricius). In the A.T. CAMERON sets southeast of Hamilton Inlet Bank, April 2-4, as described for redfish, the largest catch of American plaice per half-hour tow was 1670 kg (average weight 1.1 kg) at 278 m. The only other significant catch was 205 kg (average weight 1.0 kg) at 551 m. At other depths from 278 to 459 m catches ranged from 5 to 40 kg and average weights from 0.3 to 0.4 kg. Only 1 plaice was caught at 638 m and none at 737 m.

These American plaice had opaque eggs and were at least a month and possibly 1½ months or more from the beginning of spawning.

4. Witch flounder, Glyptocephalus cynoglossus (L.). In the A.T. CAMERON half-hour tows, April 2-4, southeast of Hamilton Inlet Bank described above, a large catch of 3320 kg of witch flounder (1.4 kg average weight) was taken at 551 m. In April 1963 witch catches of 1180 and 670 kg were obtained at 549 and 640 m, but in 1964 the witch were much more concentrated, and only 11 and 3 kg were obtained in the sets immediately above and below 551 m - at 459 and 638 m. As in 1963 the female witch possessed small opaque eggs, usually less than 0.5 mm diameter, and were at least 1-1½ months from the beginning of spawning.

SUBAREA 3

A. Status of the Fisheries

I. Cod

Inshore fishery. Statistics are not yet available by Subarea but landings in the inshore codfishery were below those of 1963.

Catch per man in the inshore fishery has generally declined since 1956 on the northeast Newfoundland coast, coincident with the increasing offshore cod fisheries by European trawlers.

In the inshore sampling areas which have been examined most closely the trap fishery was poor on the east coast at Bonavista and only fair at St. John's. In the Trepassey area the trap fishery was fairly good whereas at Burin it was poor. The handline fishery at Bonavista was below the level of the 1963 fishery and can only be classed as fair. The longline and linetrawl fisheries at Bonavista, Trepassey and Burin were at about the same low level as in the 1963 season. The gillnet fishery at Trepassey and Burin was below the 1963 level.

II. Haddock, Melanogrammus aeglefinus (L.)

During the course of its short history, landings from the commercial haddock fishery on the Newfoundland banks, which began in 1945, fluctuated widely, with peak landings of 78,000 metric tons in 1949, 104,000 metric tons in 1955 and 80,000 metric tons in 1961. In the intervening years yields declined to lows of 43,000 metric tons in 1953 and 35,000 metric tons in 1959. Since 1961 the annual yield has declined rapidly from 80,000 metric tons to 35,000 metric tons in 1962 and 15,000 metric tons in 1963, of which Canadian trawlers landed 9000 metric tons. Preliminary estimates show Newfoundland haddock landings in 1964 to be 23% lower than those of 1963.

Although heavy exploitation has played its part in the present scarcity of haddock, the basic cause is the lack of successful survival of young. The last very successful year-class was that of 1955, which dominated in the catches during 1960-62. Since 1955, survival has been relatively poor and consequently the haddock fishery must inevitably continue to be at a low level until a good brood occurs and is recruited to the stock.

III. Redfish

Canadian landings and landings by Subarea are not yet available, but Newfoundland landings (including some for Subarea 4) of 18,000 metric tons were 16% lower than in 1963 apparently due more to a reduction in market demand than to scarcity of fish.

IV. American Plaice and Witch Flounder

Newfoundland landings of 33,000 metric tons of plaice and other flounders, mainly from Subarea 3, were 34% higher than in 1963 reflecting the increasing effort for plaice because of the scarcity of haddock and of

some diversion of effort from redfish.

In 1963 the catch of American plaice per hour's fishing by Newfoundland trawlers fishing the Grand Bank for a total effort of 22,000 hours was 760 kg. In 1962 the average catch from a smaller effort of about 18,000 hours' fishing was less - 620 kg per hour's fishing. Thus although the present catch per hour's fishing is not as great as it was in the middle 1950's it is encouraging that the downward trend of the past few years in catch per unit effort was reversed in 1963 in spite of a general increase in effort.

V. Sea Scallop, *Placopecten magellanicus* Gmelin

Canadian sea scallop landings from St. Pierre Bank (3P) amounted to 327 metric tons of shucked meats (2710 metric tons, whole weight) in 1964. Except for small landings in 1963, virtually no Canadian scallop dragging effort had been expended here since 1958. The 1964 catch was divided fairly evenly between the beds on the northern and southern parts of this Bank.

VI. Harp Seal, *Phoca groenlandica* Erxleben and Hood Seal, *Cystophora cristata* (Erxleben)

The Canadian fishery for harp seals in the spring of 1964 centred in Division 3K. Ships, landsmen, and a few aircraft together took 71,000 seals on the ice as compared with 55,000 in 1963. Seventy-six percent were young animals. Seven hundred hood seals were taken, about the same number as in 1963.

B. Special Research Studies

I. Environmental Studies

1. Hydrography. The 5 monitoring sections across the Labrador Current and continental shelf from Bonavista to the southern Grand Bank were occupied by the INVESTIGATOR II between July 23 and August 23.

In the triangular section extending eastwardly from Cape Bonavista, thence southwardly to the northern Grand Bank (Fig. 2) the volume of cold water below -1 and 0°C , both in the coastal and Grand Bank sections, was approximately similar to that in 1963, but the lowest temperatures were -1.6°C compared with -1.4°C in 1963. Bottom temperatures on the offshore part of the continental shelf off Bonavista were a little lower but temperatures of the water above 300 m beyond the continental shelf were a little higher than in 1963. The salinity pattern showed an unusual column of lower salinity water at the edge of the continental shelf off Bonavista, extending very deeply between 2 masses of higher salinity water.

In the section from St. John's across the northern part of the Grand Bank and Flemish Cap (Fig. 3) there was considerably more water in the Avalon Channel below -1°C than in 1963 with the lowest temperatures -1.5°C , and cold water of -1.4°C extended to the bottom at the deepest part of the Channel compared with a lowest temperature of -1.3°C and a deepest bottom temperature in the Avalon Channel of -0.7°C in 1963. On the other hand the volume of water below 0°C was less than in 1963 and temperatures over the surface of the Grand Bank along this line were greater, 0.1 to 0.6°C , compared with -0.2 to -0.4°C in 1963. On the eastern slope of the Grand Bank on the western side of Flemish Channel the volumes and temperatures of water below -1 and 0°C were approximately similar to those of 1963. On the deeper part of the slope, however, there was colder water, 3.3 to 3.6°C , in 1964 compared with 3.6 to 3.8°C in 1963. Temperatures on the western side and top of Flemish Cap were very similar to those of 1963 but the eastern slope of the upper part of the Cap showed the results of lower water temperatures, 3.4 to 3.6°C , in 1964 compared with 3.8 to 3.9°C in 1963. In general the salinity picture in this section from the upper eastern slope of the Grand Bank to the coast was similar to that of 1963 and did not reflect the differences in temperature, showing that the same type of water was present in both years although colder in some places and

warmer in others than in 1963. From the western side of Flemish Cap to the surface, along the western slope of the Cap and in the deeper parts of Flemish Channel salinities were slightly higher than in 1963 although temperatures were very similar in both years.

In the section from St. John's to the southeastern slope of the Grand Bank (Fig. 4), the volumes of water below -1°C and below 0°C were not greatly different from those of 1963 but the lowest temperatures were -1.5°C compared with -1.3°C in 1963. The cold branch of the Labrador Current on the eastern slope of the Grand Bank was colder and in greater volume than in 1963. Lowest temperatures in this branch were -1.4°C compared with -1.0°C in 1963. Temperatures over the surface of the Grand Bank showed little difference from those of 1963. Salinities over most of the Grand Bank and in the deeper water of the Avalon Channel were generally slightly higher than in 1963. In the deeper parts of the eastern slope of the Grand Bank below 270 m salinities were lower, 34.3-34.7‰, than in 1963, 34.5-34.9‰.

In the section at about 75 m extending along the southwestern slope of the Grand Bank (Fig. 5) the volume of water below 0°C in and near the Haddock Channel was approximately the same as in 1963 but the lowest temperatures were -1.2°C compared with -0.9°C in 1963. At the eastern edge of the Grand Bank the volume of water below 0°C was less and its lowest temperatures were higher than in 1963, -0.5°C compared with -1.1°C . Water temperatures over the surface of the Grand Bank were variable, slightly higher in some parts of the section and slightly lower in others than in 1963. Although as usual the upper water salinities were low in this section salinities over the top of the Grand Bank and its western approaches were usually 0.1-0.5‰ higher from bottom to surface than in 1963.

In the section at 275 m along the southwestern edge of the Grand Bank (Fig. 6) temperature conditions in the eastern half of the section were generally similar to those of 1963 although the lowest temperatures were slightly higher, -0.9°C , compared with -1.2°C in 1963. In the western half temperatures were generally lower than in 1963, with a lowest temperature of -1.2°C , compared with 2.3°C in 1963, and a highest temperature in water deeper than 125 m of 6.3°C , compared with 7.6°C in 1963. There appears to be an upwelling or residue of cold water at Station 17 to the west of the Southeast Shoal producing considerably lower temperatures than at neighbouring stations from 50 m to the surface. In 1963 a similar upwelling or occurrence of cold water occurred at Station 19, which is in line with the western edge of the Shoal. Salinities in this section were generally similar to those of 1963 and in both years at Station 15 water with higher salinities and temperatures than at neighbouring stations extended from the 150 m level to the surface.

Station 27, at 176 m, 2 nautical miles off Cape Spear near St. John's, has been maintained since 1950 and to a lesser degree since 1947 as a year-round hydrographic station and is occupied once to several times monthly throughout the year. Water temperatures from top to bottom at this station (Fig. 7) are usually lowest in March to early April. Bottom temperatures are lowest from March or April to October or November. Surface temperatures, highest between late July and early September, are above 12°C for only a brief period. The effect of surface warming during the warmer part of the year begins to affect the bottom waters by late November, and, with surface cooling in autumn and winter, water temperatures are approximately the same from top to bottom by January-February. The deeper water was colder in 1964 than in 1963 and the period with upper-layer temperatures above 10°C shorter.

II. Biological Studies

1. Cod. In the inshore Newfoundland area, routine sampling of the inshore cod fishery by various gears was carried out in the spring, summer and fall in regular sampling centres at St. Anthony, Twillingate, Bonavista, St. John's, Trepassey and Burin. At St. Anthony the trap fishery was supplied by fish of ages 5-8. Fish taken by handline were largely 7-year-olds. Nine- and 10-year-old fish were well represented in the gillnet

catches. Trap fish at Twillingate were small and young while fish caught by the other gears were larger with a greater range of ages. Although ages have not been determined for the 1964 samples the length frequencies indicate that the trap fishery in Bonavista and St. John's was probably supported by fish of ages 4, 5 and 6 but that 7-year-old fish were also important contributors. In the Burin trap fishery the fish were of extremely small size with 4-year-old fish probably being the most numerous. The handline fishery at Bonavista was probably supported by fish of ages 5, 6 and 7 but there is an indication of 4-year-old fish of the 1960 year-class entering the fishery for the first time. The longline fishery in Bonavista and Trepassey was supported by older fish, the length frequencies indicating that the 6-, 7- and 8-year-old fish were probably the most important contributors. The gillnet fishery in Burin and Trepassey was supported by old fish, also, but indications are that a narrower range of sizes and ages is represented here (fish greater than 7 years of age).

The annual survey designed to obtain information on the inshore distribution and relative annual abundance of small cod up to 2 years of age was carried out from September 5 to October 22. Beaches in areas selected in previous surveys were seined using a small-meshed Danish seine with the codend lined with fine-meshed nylon.

During the survey 157 successful sets were made on beaches from St. Mary's Bay to the northern part of Notre Dame Bay, with small cod, ranging in numbers from 1 to 576, being taken in 94% of the sets. Cod in their 1st year (zero cod) made up 22% of the total cod caught in all areas and 1+ cod 78%. The number of zero cod caught suggests only moderate survival and settlement of the 1964 year-class but the abundance of 1+ cod indicates a good survival of the 1963 year-class.

Offshore investigations have included surveys of distribution and abundance in relation to season, depth and temperature, and biological collections for various purposes. Cod catches during surveys of the Grand Bank and St. Pierre Bank by the A.T. CAMERON in June were usually small, with catches approaching commercial size only in shallow depths (about 75 m) at bottom temperatures of 0.4 to 1.4°C. Catches on Flemish Cap in September and on the eastern Grand Bank in October and off Labrador and northeast Newfoundland Shelf in October-November were generally small, seldom exceeding 450 kg per half-hour tow.

Cod were tagged in the following places, depths, dates and numbers: North Cape Grand Bank, 185-192 m, April 768; Woolfall Bank, 102-126 m, April, 1152; Eastern Grand Bank, 170-194 m, April, 768; Funk Island Bank, 216-236 m, May, 384; northern Grand Bank, 177-192 m, May, 768; Flemish Cap, 124-150 m, July, 768; Bonavista, 48-102 m, October-November, 1152, Baccalieu, 51-113 m, November 768.

At Funk Island Bank in 214-225 m on May 18, of 61 mature females, 60 were spent and 1 had more than 50% of the bulk of the eggs clear.

2. Haddock. An otter-trawling survey over the haddock region on the southern half of the Grand Bank was carried out in early June by the A.T. CAMERON. Of 82 drags in depths ranging between 45 and 275 m, only 3 haddock catches (310, 200 and 145 kg) were larger than 90 kg. At most of the fishing stations on the slope and adjacent bank areas water temperatures were favourable for haddock.

An otter-trawl survey in mid-June on St. Pierre Bank produced only 5 catches of any significance (160-660 kg) and these occurred at 5 stations along the western slope in 145 m, where there was an abrupt change in the temperature of the water mass near the bottom from near 0°C immediately shallower to 6°C or higher immediately deeper. Fishing for haddock has been insignificant on this bank since the fishery on the very abundant 1949 year-class came to an end in 1957.

From the length and age frequencies of samples taken during the June survey, about 70 and 15% of the catches were 2- and 3-year-old haddock of the 1962 and 1961 year-classes respectively and below commercial size. Haddock of the abundant 1955 and moderate 1956 year-classes, which were dominant in the surveys of 1959-1961, were insignificant in the 1964 survey. Considering, however, that the catches per unit effort since 1962 were considerably lower than those of previous years both in number and in weight,

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the apparent abundance of the 1962 and 1961 year-classes must not be over-emphasized. For example, the average number of haddock per drag in research vessel cruises on the southern half of the Grand Bank was 579 in 1960, 79 in 1962, 72 in 1963 and only 32 in 1964.

3. Redfish. The A.T. CAMERON continued the redfish survey of the Canadian area using half-hour tows. On a line on the seaward slope of Funk Island Bank at about latitude 51°45'N, fished on April 6-7, a large catch of 3220 kg of mentella redfish was obtained at 225 m at 3.2°C, 640 kg of mentella redfish at 550 m and 820 kg of mentella redfish at 640 m. These two catches at the greater depths were only about one-third the A.T. CAMERON catches at these depths in the same locality in April 1963 and may reflect a decrease in abundance due to commercial fishing for redfish by European trawlers at these considerable depths in this general area in 1963.

On Funk Island Bank and its seaward slope on April 6-7, of 80 mature mentella females only 1% was spent, but 11% were close to spawning with 95-100% of the larvae hatched and ready for extrusion. Five per cent had unfertilized eggs.

In September a survey on 2 lines of stations from 185 to 730 m at Flemish Cap showed the centre of abundance of redfish to be rather deep, with best catches occurring at 460-640 m. To the North of Flemish Cap a good catch of 2120 kg of mentella redfish was obtained in 550 m and on the eastern slope of the Cap catches greater than 1090 kg of mentella redfish were obtained at 460, 550 and 640 m.

During the period November 20-30 four survey lines were completed on the southeast slope of the Grand Bank. Best redfish catches were obtained on the most southerly line (eastern side at the tail of the bank). At 185 and 230 m on this line catches of about 910 kg of mentella redfish were obtained but these fish were very small, averaging only 0.14 and 0.3 kg respectively. However, at 365 m an excellent catch of 4770 kg of mentella redfish was obtained and these fish were of good commercial size (average weight 0.6 kg). On the three more northerly lines (to 47°00'N) catches were not large. Best catches were obtained at the 320 and 365 m levels and were usually between 450 and 900 kg of mentella redfish.

Growth equations have been produced for male and female mentella redfish from the following areas and for marinus redfish for the last two areas: Hermitage Bay, Gulf of St. Lawrence, southwest slope of the Grand Bank, Flemish Cap and Hamilton Inlet Bank.

4. Herring, Clupea harengus L. Small herring of the 1963 year-class, about 10 cm in length, were very abundant in the coastal waters of the east coast of Newfoundland, being reported from St. John's, Conception Bay, Trinity Bay and Bonavista.

5. Squid, Illex illecebrosus (Le Sueur). In 1964 the A.T. CAMERON took many squid by otter trawling on the southwestern slope of the Grand Bank between May 29 and June 14. Catches up to 590 kg per half-hour drag were made and this is exceptional since these squid are not usually caught in such quantities by a bottom otter trawl. Catches of squid were taken between 90 and 275 m but in most abundance at 185 m. On this basis a successful forecast was made in June (Trade News, July 1964) of the unusually great abundance of squid which appeared later in the year in the Newfoundland inshore area after 2 years of relative scarcity.

III. Gear Studies

1. Experimental gillnetting for cod. During May and early June the MARINUS fished nylon gillnets in St. Mary's Bay and Placentia Bay in areas and depths where commercial fishing is usually conducted. Gillnets of 165- and 178-mm mesh sizes were used and depths ranging from 20 to 140 m were fished. Generally, better catches were obtained in St. Mary's Bay than in Placentia Bay. In St. Mary's Bay slightly more cod were caught with the 178-mm mesh whereas in Placentia Bay slightly more were caught with the 165-mm mesh. The 178-mm mesh net caught fish of a slightly larger size and

greater age than the 165-mm mesh net. About 70% of the cod caught with both mesh sizes were males.

2. American plaice. In a comparison of day and night otter-trawl catches by the A.T. CAMERON on the eastern Grand Bank much smaller amounts of American plaice were caught in sets during the hours of darkness than in daylight. A comparison of the catches of American plaice using three different sizes of rollers on the footrope indicated that the 61-cm diameter steel bobbins and the 36-cm diameter rubber rollers toward the centre of the footrope gave similar results. The use of 15-cm diameter rubber disks on the footrope gave an average catch less than that of the other two arrangements.

B. SUBAREAS 4 and 5

by J. L. Hart

Canadian researches were carried out in Subareas 4 and 5 by the St. Andrews Biological Station and the Atlantic Oceanographic Group (Halifax) of the Fisheries Research Board of Canada. The Quebec Marine Laboratory at Grand River, the Department of Mines and Technical Surveys' Bedford Institute of Oceanography and the Arctic Station of the Fisheries Research Board also made important contributions. Many scientists at these laboratories contributed research results for compilation in this report. The names of those involved appear in the list of ICNAF scientists.

SUBAREA 4

A. Status of the Fisheries

I. Cod

Canadian landings of cod from Subarea 4 continued to be higher than those for any other groundfish species. Total cod landings for the Canadian mainland fleet were about 2% lower in 1964 than in 1963, with the greatest decrease in landings from the Gulf of St. Lawrence (4T). Sizes of cod taken from the southern Gulf of St. Lawrence showed little change from 1963. Most of the fish landed were between 40 to 70 cm, and in the third quarter of the year the peak in the size distribution was at 46 cm. Discards of cod in 4T were low, less than 2% by number and 1% by weight. Discards in offshore 4V-W were occasionally much higher, especially during summer fishing for other species. No major changes in size or age composition of cod landed from anywhere in Subarea 4 have been noted.

II. Haddock

Canadian mainland haddock landings in 1964 increased about 25% over those in 1963. Incomplete statistics suggest that part of this increase came from Subarea 4, particularly from Browns and LaHave Banks and other parts of Division 4X. Currently these banks have replaced the Sable Island-Emerald Bank region (4W) in importance for the Canadian haddock fishery. Sizes of haddock landed were similar to those in 1963, with most fish between 40 to 60 cm, with a mode around 48 cm in the February-April period. Estimates of discards of haddock varied from 1 to 9% by weight, depending on season and area.

III. Pollock, *Pollachius virens* (L.)

Pollock landings were similar in 1964 and 1963. Decreased landings from the Bay of Fundy region of 4X were replaced by increased landings from offshore banks in 4X and 4W. Pollock landings still seem partially limited by demand.

IV. Flatfishes

Since preliminary Canadian statistics on flatfish are not separated for species or area, precise information about flatfish landings is impossible to provide. The following three offshore species contribute most to these landings:

American plaice. This species is of particular importance in the southern Gulf of St. Lawrence and off Cape Breton (4T-V) and Sable Island region (4W). Landings and effort both appear to have increased in 1964. Discards of small American plaice remained high in 4T (70 to 80% by number).

Witch flounder (Greysole). This species has increased in importance over the past decade, with landings reaching about 10,000 metric tons by 1963. Landings in 1964 at about the same level came chiefly from off eastern Nova Scotia (4V), western Newfoundland (4R) and central Nova Scotia (4W). Danish seiners take about half the landings. Discards of small fish are negligible.

Yellowtail, Limanda ferruginea (Storer). Landings of this species from Subarea 4 have been increasing during the past 3 years and in 1964 about 5,000 metric tons were landed, mainly from Banquereau (4Vs) and Middle Bank (4W).

V. Halibut, Hippoglossus hippoglossus (L.)

Halibut maintained a high market value but landings were down somewhat from 1963, due mainly to decreased effort. No changes occurred in the areas exploited or in sizes of fish landed.

VI. Redfish

Total Canadian mainland landings increased about 7% over those of 1963. Most of the increase seems to have occurred in landings from the Gulf of St. Lawrence (4R-S-T). Apparently local trawlers made use of the abundant new 1956 year-class recorded earlier from research-vessel surveys.

VII. Herring

Preliminary tabulations indicate that total Canadian herring landings of 141,000 metric tons were 26,000 metric tons (23%) greater than in 1963. Increased landings occurred chiefly in the Bay of Fundy region of 4X where an all time record catch of 84,000 metric tons was made. Herring landings in 4W, 4V and 4T were essentially the same as in 1963.

VIII. Swordfish, Xiphias gladius L.

Total Canadian landings of swordfish in 1964 amounted to 7,994 metric tons round weight. This was 568 metric tons (7%) less than in 1963. The decrease was due mainly to smaller landings from the Nova Scotia Banks (4V and 4W). Fishing is now a year-round operation although efforts from January to May are, for the most part, outside the ICNAF area.

IX. Mackerel, Scomber scombus L.

Mackerel landings in 1964 amounted to 10,829 metric tons, an increase of 3,028 metric tons or 39% more than in 1963. Significant increases in landings occurred mainly in 4T and 4W. No effort statistics are available and there is no basis for predicting catches in 1965.

X. Bluefin tuna, Thunnus thynnus (L.)

Most of the Canadian fishery for bluefin tuna takes place in Subarea 5. Landings in 1964 in Subarea 4 amounted to 323 metric tons round weight, an increase of 92 metric tons over the 1963 landings.

XI. Sea scallops

Scallop landings by the offshore fleet in this subarea were entirely from 4X and included approximately 227 metric tons of shucked meats from Browns Bank and 100 metric tons of snucked meats from the lower Bay of Fundy (1,883 and 829 metric tons, whole weight, respectively). Compared to the previous year, this was a 53% reduction in landings by the offshore fleet in this subarea. An additional 5,295 metric tons (whole weight) were landed from this region (4X) by the inshore fleet, an increase of 17% over 1963 landings.

The inshore fishery in the southern Gulf of St. Lawrence (4T) landed 230 metric tons of shucked meats (1909 metric tons whole weight), the highest landings on record for this area. Experimental marketing of adductor muscles with attached roes was undertaken by this fishery in 1964.

XII. Harp Seal

The Canadian fishery for harp seals centred in Division 4T. Ships, aircraft and landsmen took 63,000 seals on the ice as compared with 87,000 in 1963. Eighty-three per cent were young of the year. Fifty hood seals were taken as compared with 100 in 1963.

B. Special Research Studies

I. Environmental Studies

1. Hydrography. Monitoring of oceanographic conditions was continued in 1964 at coastal stations and along established sections. The salient features of the water temperatures along the Canadian Atlantic coast, this past year, are the large negative anomalies mainly from the Scotian Shelf (4V-W) to the Bay of Fundy (4X) during summer and autumn. Surface temperatures in the Gulf of St. Lawrence (4T) also indicated below average temperature conditions but to a lesser degree than in the other divisions. Bottom temperatures in the Bay of Fundy (4X) and along the Halifax monitoring section (4W) indicated large negative anomalies. In general the 1964 means, at surface and along the bottom, were lower than those of 1963.

The monitoring section off Halifax (4W) was covered seven times in 1964. The temperature and salinity distributions of four crossings are given in Fig. 8, 9. In general, the conditions along this section were similar to those of 1959, another "cold year". However in late autumn 1964, at the times of observations, the conditions over some of the off-shore banks are the result of an intrusion of offshore waters.

Circulation studies were continued. The wind-driven circulation in the Gulf of St. Lawrence (4R-S-T) has been modelled by means of electrical analogs. Studies of non-tidal drift were continued in all areas and augmented in some of them. Compilation of drift bottle and seabed drifter data was emphasized in 1964. Folio 7 of Serial Atlas of the Marine Environment (American Geographical Society) on the surface circulation over the continental shelf pertains among other regions to Subarea 4.

Four hydrographic cruises were made in the Chaleur Bay area (4T) from May 27 to August 28. In May water temperatures ranged from 1.9°C at the bottom to 7.1°C at the surface. In July they ranged from -0.15°C at the bottom to 15.4°C at the surface. Finally, at the end of August, the corresponding figures were 4.9 and 15.6°C.

2. Bottom topography. Detailed charts of Chaleur Bay and Orphan Banks areas were published in 1964. These are intended for fishermen. The fishing grounds west and south of Anticosti Island (4S) were mapped for the same purpose.

3. Benthic studies. The bottom sampling program started in previous years was extended in 1964 to cover most of the Magdalen Shallows (4T) in the Gulf of St. Lawrence. Physical characteristics of the sediments in the same area are under study. Relationships between sediment parameters and abundance of some of the benthic organisms have been pointed out.

4. Plankton. Nine series of observations were made at 5 stations in Chaleur Bay from May 13 to October 26, 1964. Zooplankton volumes were generally smaller than those of 1963 and 1962. The peak of abundance occurred in July as in previous years.

The study of direct catches of 24 species of pelagic and hyperbenthic macro-invertebrates and fish revealed a well defined pattern of daily vertical migrations or daily changes in behaviour in all but one species. Almost all the migrations were nocturnal, underwent distinct seasonal changes, and ranged in extent from a night bottom phase of pelagic

forms to pelagic swarming of benthic forms in a restricted season and at a short distance from the bottom. Mysidacea with functional eyes were clearly the most pelagic of hyperbenthic groups. Variability of catches was greater in the late spring of 1962 than in the summer and fall of 1961.

5. Other environmental studies. An active study is under way to lay the proper foundations of a research program of biological oceanography.

Charts showing the sea surface temperatures in Subarea 4 are broadcast daily by radio-facsimile.

Analyses of time series of accumulated data are carried out.

II. Biological Studies

1. Cod. Surveys on the Gulf of St. Lawrence cod population were carried out in January and in September. The January survey in the Cape Breton area (4Vn) effectively combined echo-sounder records and trawling at selected stations. Using both methods, extensive coverage of the grounds was obtained and cod were found to be continuously distributed from the edge of ice off Sydney Bight to Scatari Bank. Concentrations were related to bottom contours with cod most abundant between 150-175 m. Nocturnal migration of cod off bottom as much as 30 m was again recorded. A continuing fall survey in the Magdalen Shallows region of 4T is designed to provide a long-term series of data on sizes and ages of cod to relate to changes in fishing effort and environment. In the September 1964 survey cod were spread quite evenly over the area, with no apparent relationship to bottom temperatures (0.2 to 11.2°C) or to feeding. Smaller fish predominated in the southern section. Length distributions of cod in small-mesh research-vessel nets had a peak at 34 cm. The numbers of 3-year-old fish (1961 year-class) were above average. This year-class is expected to influence scrod landings from 4T in the summer of 1965.

The regular cod survey was carried out at the end of June in the Orphan Bank-Chaleur Bay area. The average length of all cod caught with a covered codend was 42.6 cm in 1964 compared with 46.3 cm in 1963. The proportion of cod of commercial sizes (38 cm and larger) however was greater in 1964 than in 1963 (92.5% in 1964 compared with 86.1% in 1963).

Data on maturity stages for 25 cruises in the Gulf of St. Lawrence (4T) from 1959 to 1964 were summarized. Results indicate that cod spawning is spread over the period from May to October, with most activity early in this period. Egg and larval distribution cruises are planned for June and September 1965 to study the problem of recruitment to Gulf stocks.

Stomach contents of about 22,000 cod examined during 1959 to 1964 have been analysed, using IBM computer methods. Cod stomachs examined came from a wide area, but the principal data are for the 4V-T cod stock. Part of the analysis shows the relation of food type and volume to size of cod. Small cod (15 to 29 cm) fed mainly on small crustaceans (about 75% by volume), mysids, euphausiids, amphipods, and decapod shrimp. As cod grew, their diet became more varied and increasing numbers of molluscs and echinoderms were found. The crustacean diet gradually decreased with increase in size, and teleosts were taken more frequently. Cod over 70 cm in length contained about 70% fish by volume. The type of fish eaten varied with area.

Seasonal changes in stomach volumes of feeding cod and proportion of empty stomachs are shown in Fig. 10. For small cod there was little seasonal change in volume. Cod of 15 to 29 cm averaged about 4 cc per stomach; those of 30 to 49 cm, about 12 cc. Stomachs of larger cod contained most food in the January-April period. For 50 to 69 cm fish the amount was about double that for the remainder of the year (60 cc compared to 30 cc). Throughout the year the proportion of empty stomachs was never large. Highest percentage of empty stomachs for all sizes was recorded between January and April.

Analysis of the data on cod feeding, as related to their vertical migrations and those of hyperbenthic and pelagic prey, was continued. The study of stomach repletion indices ($R' = W/L^3$, where W is the wet weight of the whole stomach contents, and L is the fish length) showed, in the 3 years 1960 to 1962 and at the same locality (depth: 110 m), a significant and gradual decrease in stomach repletion from May to September, and a slight increase on October 12, 1961. Indices were significantly larger in trawled than in gillnetted cod, and those of cod longer than 50 cm were significantly more variable, and seldom as low in late summer and fall, than those of smaller cod. They did not differ significantly between the upper and lower trawl half, nor between day (05:-17: hours) and night (21: and 01:-03: hours).

2. Haddock. No survey cruises for haddock were carried out in 1964. Predictions in 1963 that for the Sable Island Bank region (4W) year-classes of 1957 and 1959 were relatively strong and those of 1958 and 1960 weak appear to be confirmed by results from the commercial fishery. Age composition of current commercial landings show the same general pattern of relative year-class strengths.

Analyses of earlier survey cruise data show larger trawl catches of haddock by day than by night. Comparison of size compositions shows that more small haddock (under 40 cm) are taken in daylight tows, while day and night catches of large haddock (over 40 cm) are similar.

Observations on haddock held at the surface after capture in 30-minute otter trawl hauls showed mortalities of about 30%. Haddock surviving did not regain full capacities as measured by blood lactic acid levels for about 4 hours. The results are important in considering tagging mortalities.

3. American plaice. An analysis in 1964 of cod stomach contents for the Magdalen Shallows (4T) provided an opportunity to estimate the effect of cod grazing on mortalities of small American plaice. For the period 1956 to 1961 estimated total instantaneous plaice mortality due to cod predation was reduced from about 0.8 in 1956 to 0.15 in 1961. The decrease in cod grazing on plaice is attributed to a decline in the abundance of large cod which are the main plaice predators.

4. Witch (Greysole). A review of records from commercial vessels fishing greysole shows that the most important areas for this species were Sydney Bight (4Vn), St. Georges Bay (4R), Scatari Bank (4Vn), Middle and Canso Banks (4W). Best catches were usually deeper than 200 m. There appears to have been little change in fishing grounds over at least the past decade.

Examination of greysole otoliths used in growth and age composition studies shows, from ring formation, that summer growth occurred from June to October. In the Scatari Bank region (4Vn) greysole reached a length of 30 cm (current minimum commercial size) in about 8 years. Up to 10 years of age there was little difference in growth for males and females. Beyond 10 years females grew somewhat faster. In research-vessel catches from 4Vn greysole of 10 to 15 years predominated in the catch, although some fish were estimated to be about 20 years old. Preliminary analyses suggest differences in growth rate and age composition between 4V and 4W greysole stocks.

5. Egg and larval studies.

Cod and plaice. Southern Gulf of St. Lawrence (4T). Plankton hauls during groundfish surveys from 1958 to 1962 showed that cod and plaice eggs were widespread in 4T, but particularly numerous over depths of 38 to 120 m. Cod eggs were more abundant than plaice eggs, and both were taken in greatest numbers in May. Both gadoid (mostly cod) and plaice eggs were more numerous in the Gulf (4T) than in the Nova Scotia Banks region (4V-W). Few larvae of either species were taken during these surveys.

Eastern Nova Scotia Banks (4W-4V). Plaice eggs were taken over a wide area, as early as the end of February, but peak catches occurred in April. A few plaice larvae were taken in late May. In late March gadoid eggs (mainly haddock) were most abundant across Emerald and Western Banks, towards the edge of the Scotian Shelf (4W). In early March scattered

gadoid eggs were taken south of Cape Breton Island (4V).

Other eggs and larvae. Mackerel, snake blenny (Lumpenus lumpretaeformis (Walbaum and sand launce))(Ammodytes americanus DeKay) larvae were taken in fair numbers in the Gulf of St. Lawrence (4T). Redfish, herring, sculpin (Myoxocephalus sp.) and four-bearded rockling (Enchelyopus cimbrius (L.)) larvae were encountered less frequently.

In the Nova Scotia Banks region (4W) sand launce larvae were commonly taken. Other larvae occurring were those of redfish, pollock, sculpin and mackerel.

6. Argentines. During 1964 exploratory fishing for argentines, Argentina silus Ascanius, was carried out on the Scotian Shelf (4V-W-X) and records from previous surveys were analysed. Argentines were caught in quantity along the edge of the continental shelf from Browns Bank to Banquereau. None were taken in the Bay of Fundy and only occasional specimens were taken along the Laurentian Channel and in the Gulf of St. Lawrence (4T). Largest catches were consistently taken between 175 and 375 m. Most argentines were between 20 and 30 cm in length. In general, size increased with depth of capture. Modal length of female fish (22 to 26 cm) was larger than for the males (19 to 23 cm) and females appear to grow slightly faster than males. During September-October 1964 fish of 2 to 5 years made up the greatest portion of the catch, with 3-year-olds predominating.

7. Silver hake, Merluccius bilinearis (Mitchill). Results from past surveys (1958 to 1963) show that silver hake were mainly found in the areas around Sable Island Bank (4W). They are scarce in the Gulf of St. Lawrence (4T) and eastward of Banquereau (4V). They occurred to the westward around Browns-LaHave Banks and in the Bay of Fundy (4X), but catches were generally small. The mean size of silver hake caught in the Sable Island region (4W) was around 30 cm in both winter and summer, with most fish between 25 and 35 cm.

During September-October 1964 both males and females had begun to mature at about the same length (24 cm) and all specimens over 35 cm were mature. By mid September about 45% and by mid October 90% of the females were spawning and spent. Indications are that silver hake spawning in 4W is virtually completed by November.

Age determination studies were begun and as recommended at last year's (1964) Annual ICNAF Meeting, exchange of otoliths with the USA and USSR was started.

8. Herring. Routine sampling of herring for size and age composition in the Passamaquoddy region of 4X showed mean lengths varying from 89 to 255 mm and mean ages from 1.0 to 3.4 years. Only 7% of the fish examined were spring spawned. Herring are recruited to the fishery at the end of their first year of life (average length 90 to 100 mm).

In the southwest Nova Scotia region of 4X, age IV herring which are reaching sexual maturity for the first time are the major contributors to the fishery. The 1960 year-class was especially strong -- 55% of the fish sampled in 1964 were of this year-class.

In May and June 1964, 6112 herring were tagged and released in Passamaquoddy to continue a study of the migrations of "sardine" herring and to evaluate tagging techniques. Recovery was mainly from the tagging area, but there was some movement eastward along the New Brunswick shore and across the Bay of Fundy to Digby. Recovery of spaghetti tags amounted to 10.6% as compared to 1.0% for opercular tags.

Experiments to discover length and weight loss due to storage showed length losses of 1.0 to 3.2% and weight losses of 11.7 to 59.3% for refrigerated storage. For herring preserved in formalin comparable values were 0.5 to 2.2% loss in length and 4.2 to 7.8% loss in weight.

9. Mackerel. Mackerel investigations were concerned mainly with the size and age composition of landings in 4X. Mean lengths decreased from 387 mm in May to 265 mm in July. As the season advances, the older and larger mackerel are replaced by younger and smaller fish.

10. Sea scallops. Studies of the development of sea scallop larvae were continued in 1964 and the major emphasis was placed on culturing larvae through to settlement. Larvae were obtained from eight separate spawnings and two cultures did particularly well. The larvae remained in the top third of the containers and were very abundant in the top centimetre. When they descended to the bottom they were usually moribund. Changing the cultures daily instead of every second day seemed to improve survival. The use of antibiotics to control bacterial growth was ineffective and one antibiotic apparently killed sea scallop larvae.

11. Species associations studies. Studies were begun on association between demersal fishes in order to assess fishes as factors which influence mortality, recruitment and growth of various groundfish species. Efforts during 1964 involved testing sampling methods, mainly trawling, that might be applicable. Rate of accumulation of species when several tows were made at a station was studied. Four to seven tows were required to achieve attenuation. Studies on feeding relationships among fishes living together were begun. Early results suggest that, although fishes have a large number of organisms in their stomachs, many species may concentrate their feeding on a few types of food without much overlap between species.

12. Tagging of groundfish. Taggings of cod, halibut and greysole were carried out in Subarea 4 during 1964 in a further effort to determine the interrelationships and migrations of stocks. All cod were tagged in the Gulf of St. Lawrence. In May, 1,887 cod were tagged in Divisions 4S and 4T; in September-October, 1,536 cod were tagged in Division 4S; and from September to November, 1,536 cod were tagged in Division 4R; 1,000 cod were tagged off Grand River (4T) in the autumn of 1964. It is yet too early for results to be significant.

About 1,600 greysole were tagged off Cape Breton in Division 4V and in the eastern part of 4W.

A total of 174 halibut were tagged in Subarea 4, 164 of these between Sable Island Bank and Banquereau (4W-4Vs), and 10 in Division 4X. Some recaptures have been recorded from those tagged in 4W-4Vs, mostly from the tagging region.

13. Discards of groundfish. Observations on 11 trips from June to September in Divisions 4T and 4R showed that, contrary to previous year, all cod, flounders and redfish caught were landed. No discards of these species were reported. Undersized flounders and redfish were landed for fish meal and all cod were processed as fillets or blocks.

14. Harp Seals. Research included an aerial photographic survey of the group of adult seals giving birth in Division 4T and a simultaneous capture-recapture tagging of young born in these same groups. In the latter experiment, some 2,800 young seals or 2.4% of estimated production were tagged from a helicopter and recovery obtained from the fishery which began a few days later. Returns from tagging gave an estimate of 120,000 young seals produced, while photographic survey indicated 95,000 adults in the same group; the real figures are believed to be intermediate but closer to the tagging estimate. Including other unsurveyed groups, the number of young seals produced in Subarea 4 was estimated at some 150,000 in 1964.

- 15 -

SUBAREA 5

A. Status of the FisheriesI. Haddock

The Canadian fleet continued to fish for haddock on Georges Bank (5Z). Statistics of landings are not yet available but landings are likely to be the equivalent of those in 1963 (8,000 metric tons). Samples of commercial landings for size and age have been forwarded to investigators of the U.S. Fish and Wildlife Service who have taken primary responsibility for analysis.

II. Cod

Substantial quantities of cod were taken along with haddock from 5Z, probably of the same order as in 1963.

III. Herring

There was no Canadian herring fishery in Subarea 5 in 1964. However, intentions to fish for herring on Georges Bank in 1965 have been announced.

IV. Swordfish

About 50% of the Canadian swordfish landings from the ICNAF area are made from Subarea 5. Landings from this subarea in 1964 (3,320 metric tons round weight) were essentially the same as in the previous year. The distribution of swordfish catches in 1964 is shown in Fig. 11.

V. Bluefin tuna and Skipjack

Canadian tuna and bonito landings in 1964 amounted to 1,315 metric tons round weight, about double the landings in 1963. Most of the increase was due to two purse-seiners that were in operation for their first full season. Landings from these vessels (992 metric tons) consisted of bluefin and skipjack in the ratio of approximately 3:2. The catches were made in 5Y, 5Z and the adjacent area southward to Cape Hatteras. The trap and sport fishery for bluefin in Subarea 4 accounted for the balance of the Canadian landings in 1964.

VI. Sea scallops

In 1964, Canadian sea scallop landings from Georges Bank (5Z) amounted to 5,941 metric tons of shucked meats (adductor muscles only), 49,310 metric tons of whole scallops. This was an increase of less than 1% over 1963 landings. The fleet size remained the same as in the previous year (40 boats compared to 39) but the catch per unit effort decreased and days spent fishing increased from 5,905 days in 1963 to 6,723 days in 1964. The Canadian fleet covered a larger portion of the bank than before and even fished in deep water (up to 137 m) off the northeast peak where no previous effort had been expended. Several boats continued to convert to other less arduous or more lucrative fisheries.

B. Special Research StudiesI. Environmental Studies

Studies of non-tidal drift (5Y-Z) as inferred from analysis of drift bottle and seabed drifter recoveries were continued. A study of the surface circulation in all of Subarea 5 is included in Folio 7 of Serial Atlas of the Marine Environment as part of a co-operative program.

II. Biological Studies

1. Herring. Samples of herring from Georges Bank taken in 1962, 1963 and 1964 were examined for size and age composition. It was observed that the 1956 and 1957 year-classes which were strong in 1962 were sharply

reduced in 1963, but dominated the samples again in 1964. The 1958 and 1959 year-classes were consistently weak in all the samples. The 1960 year-class dominated the samples in 1963 and was strongly represented in 1964.

2. Swordfish. Food studies indicated that swordfish feed chiefly on silver hake, redbfish, barracudinas and lanternfish. Cephalopods are also important in the diet. Twenty-eight swordfish were tagged and released during 1964, but so far there have been no recoveries. For longline catches the ratio of females to males is approximately 3:1. Apparently, the harpoon fishery took only females. Shore sampling of swordfish for length and weight studies showed a weight range of 7 to 486 pounds with an overall average for the season of 142 pounds. This is in sharp contrast to the 200-pound (average size) swordfish taken with harpoons prior to the 1963 season.

3. Tuna. Tuna studies were concerned chiefly with landings by two new purse-seiners. Bluefin varied from 55 to 170 cm (fork length) and skipjack from 46 to 60 cm. During the year 15 bluefin, 1 yellowfin, 1 bigeye, 4 common bonito and 82 skipjack were tagged and released.

4. Sea scallops. Investigations begun in 1963 to determine scallop distribution and the error involved in sampling were continued in 1964. The 2 years' data are now being analysed. Further work was undertaken with an underwater camera to study bottom characteristics and also to determine if scallop abundance can be better assessed with this camera than by standard dragging techniques.

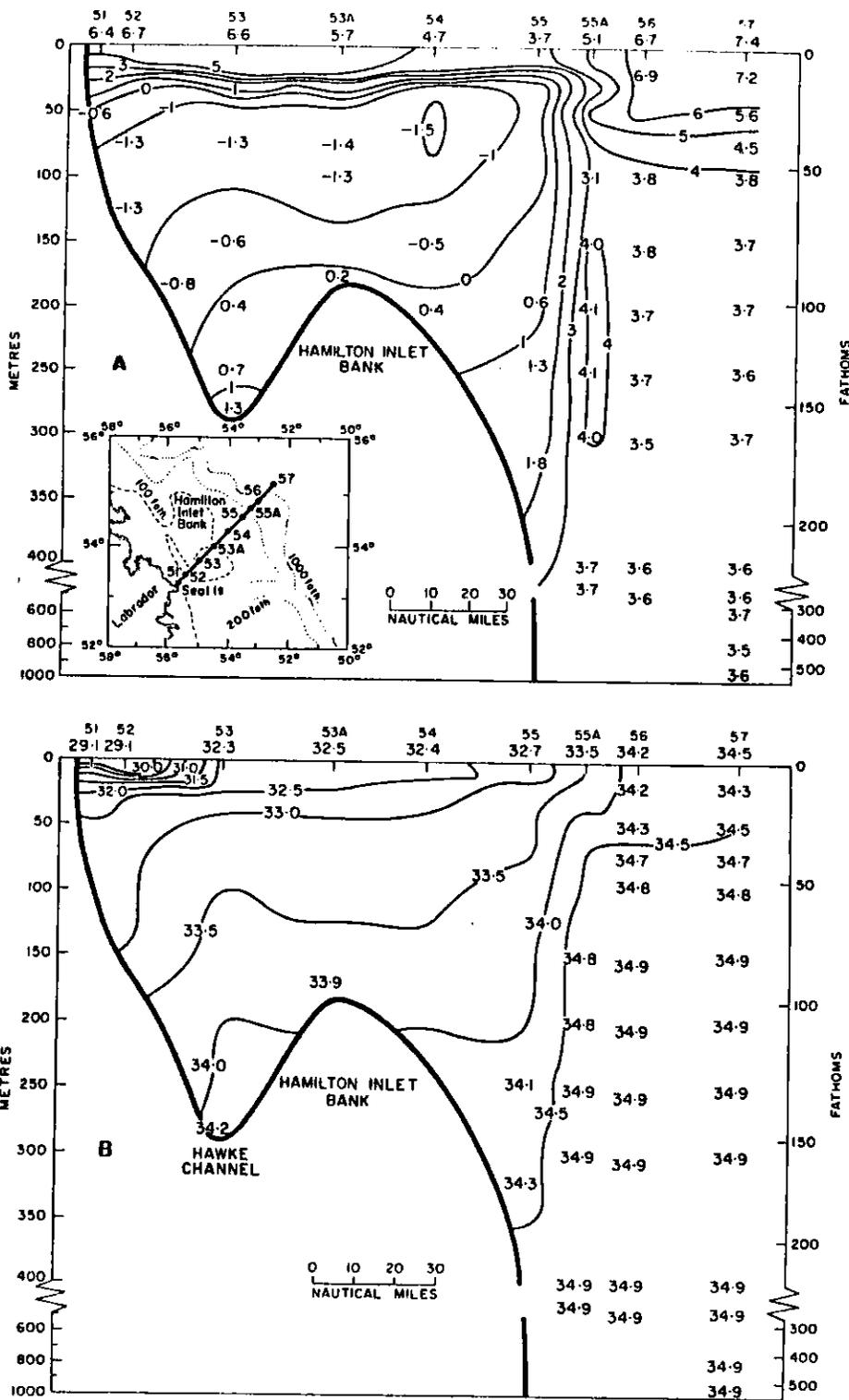


Fig. 1. A, temperature and B, salinity sections, °C and ‰, off Seal Islands across Hamilton Inlet Bank, July 31-August 1, 1964.

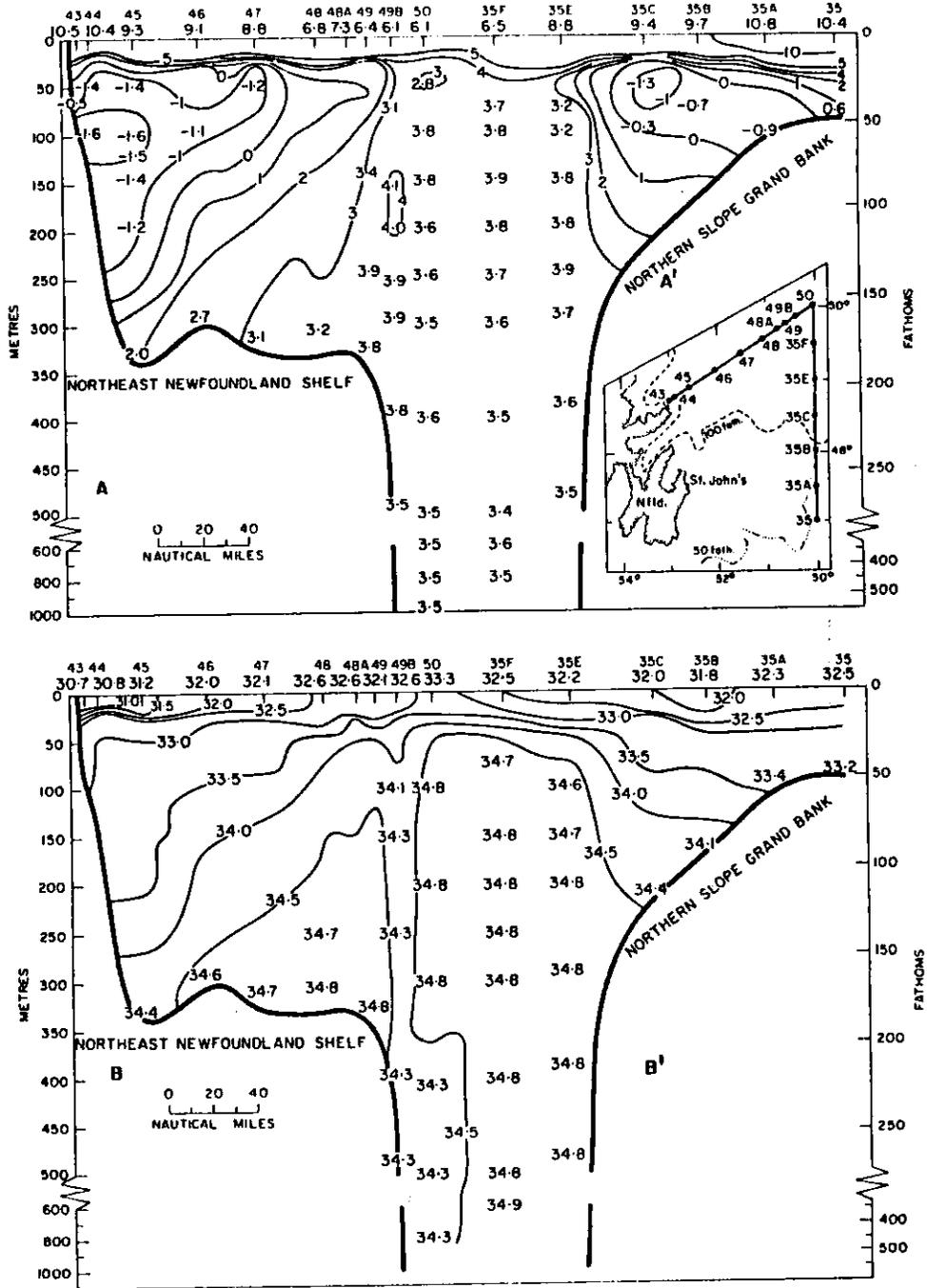


Fig. 2. A, A¹, temperature and B, B¹, salinity sections, °C and ‰, over the Northeast Newfoundland Shelf off Cape Bonavista and southward to northern Grand Bank, A, B, July 28-29, 1964 and A¹, B¹, July 24-28, 1964.

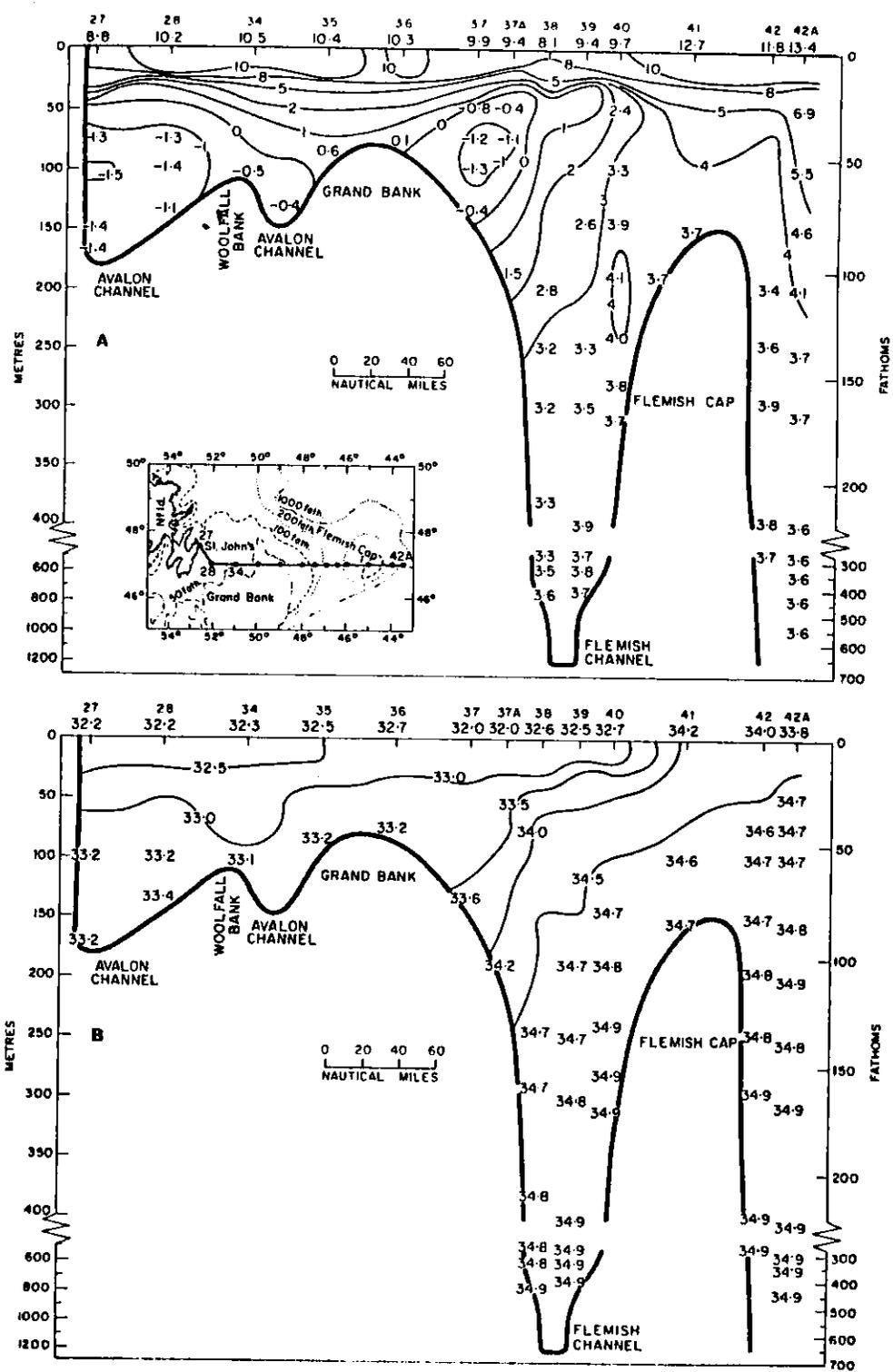


Fig. 3. A, temperature and B, salinity sections, °C and ‰, St. John's-Grand Bank-Flemish Cap, July 23-26, 1964.

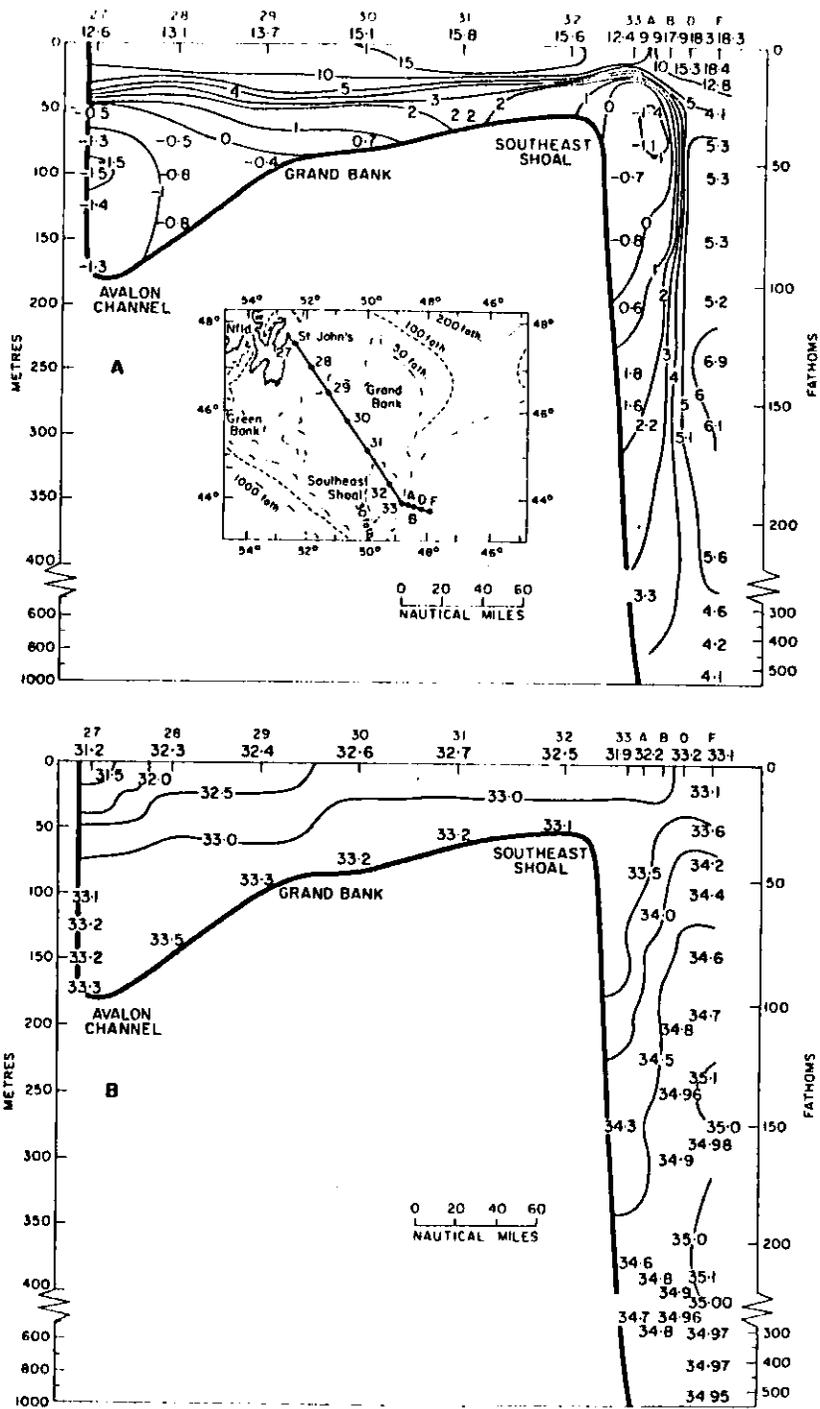


Fig. 4. A, temperature and B, salinity sections, °C and ‰, St. John's-SE slope Grand Bank, August 17-19, 1964.

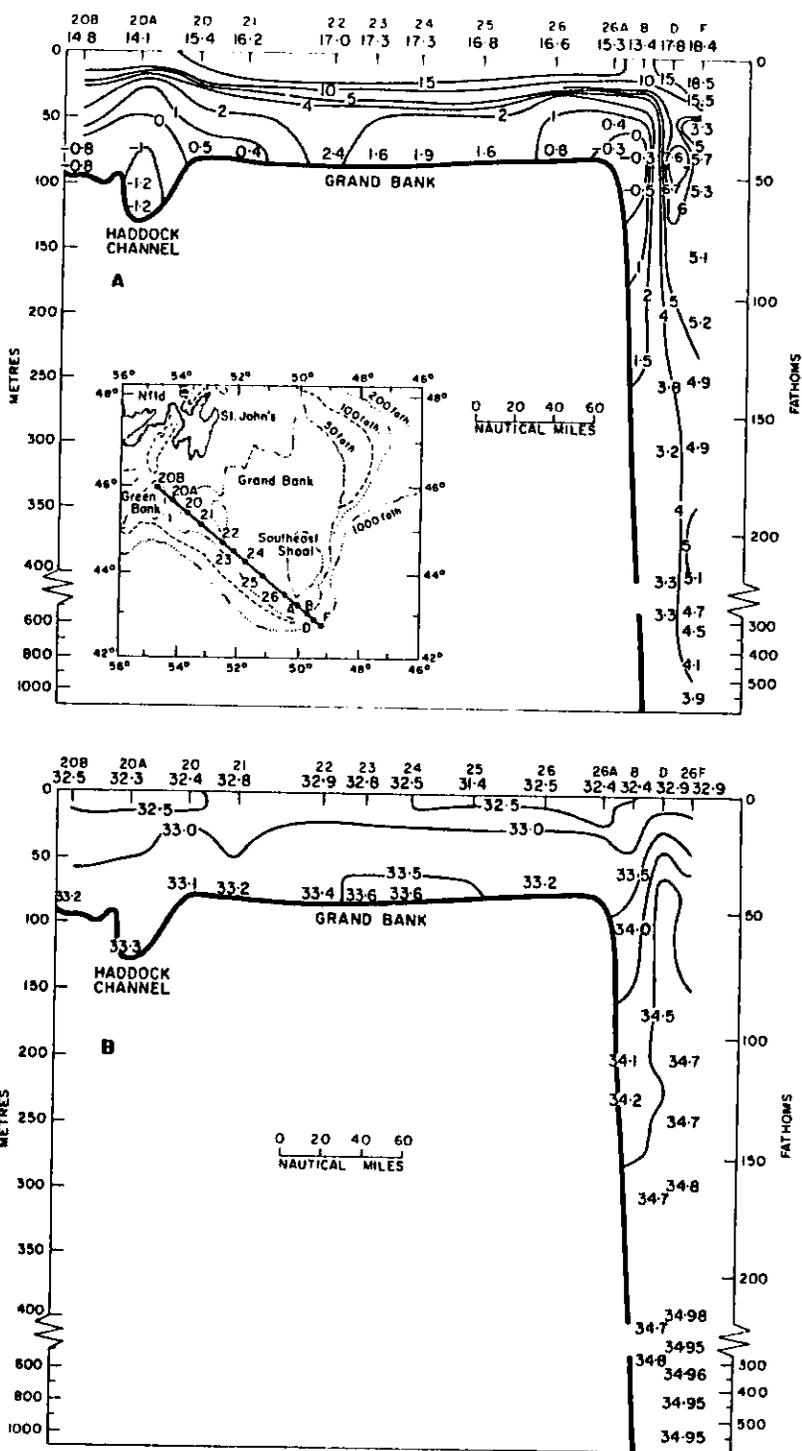


Fig. 5. A, temperature and B, salinity sections, °C and ‰, Green Bank-SE Grand Bank, August 20-23, 1964.

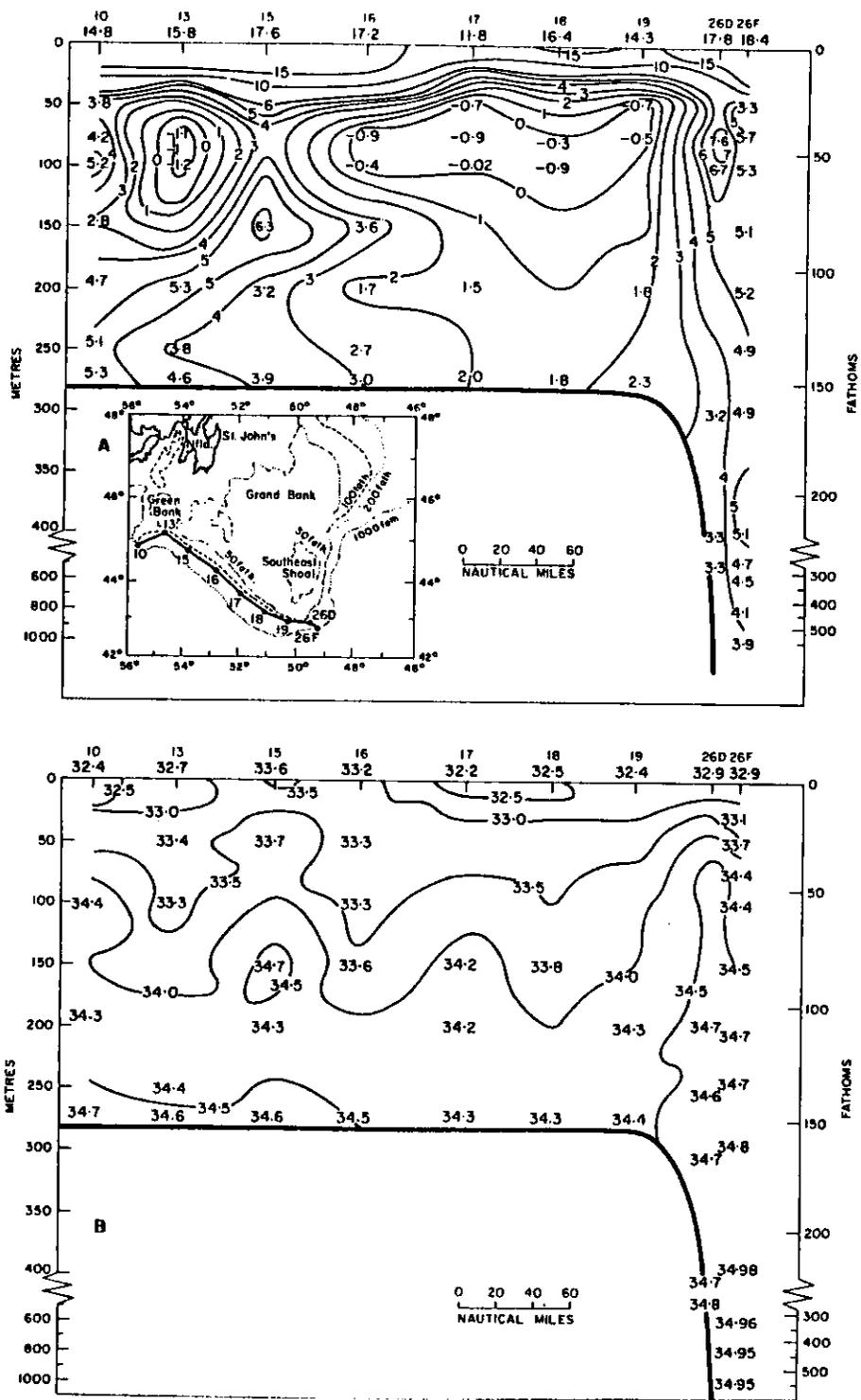


Fig. 6. A, temperature and B, salinity sections, °C and ‰, along the SW slope of the Grand Bank, August 20-23, 1964.

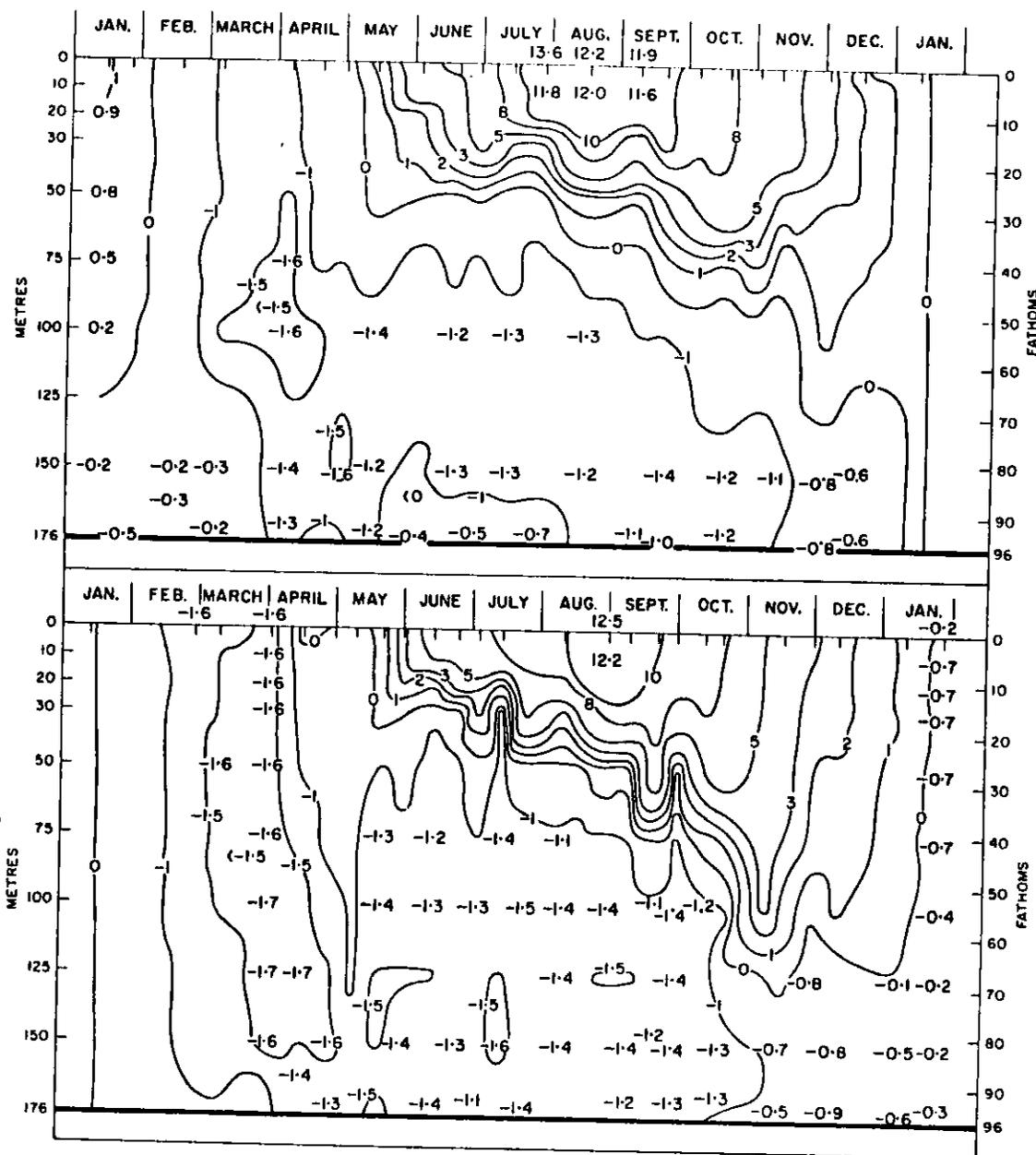


Fig. 7. Temperatures °C, above 1963 and below 1964 at Station 27, (see Fig. 3, 4, inset), 2 nautical miles off Cape Spear near St. John's

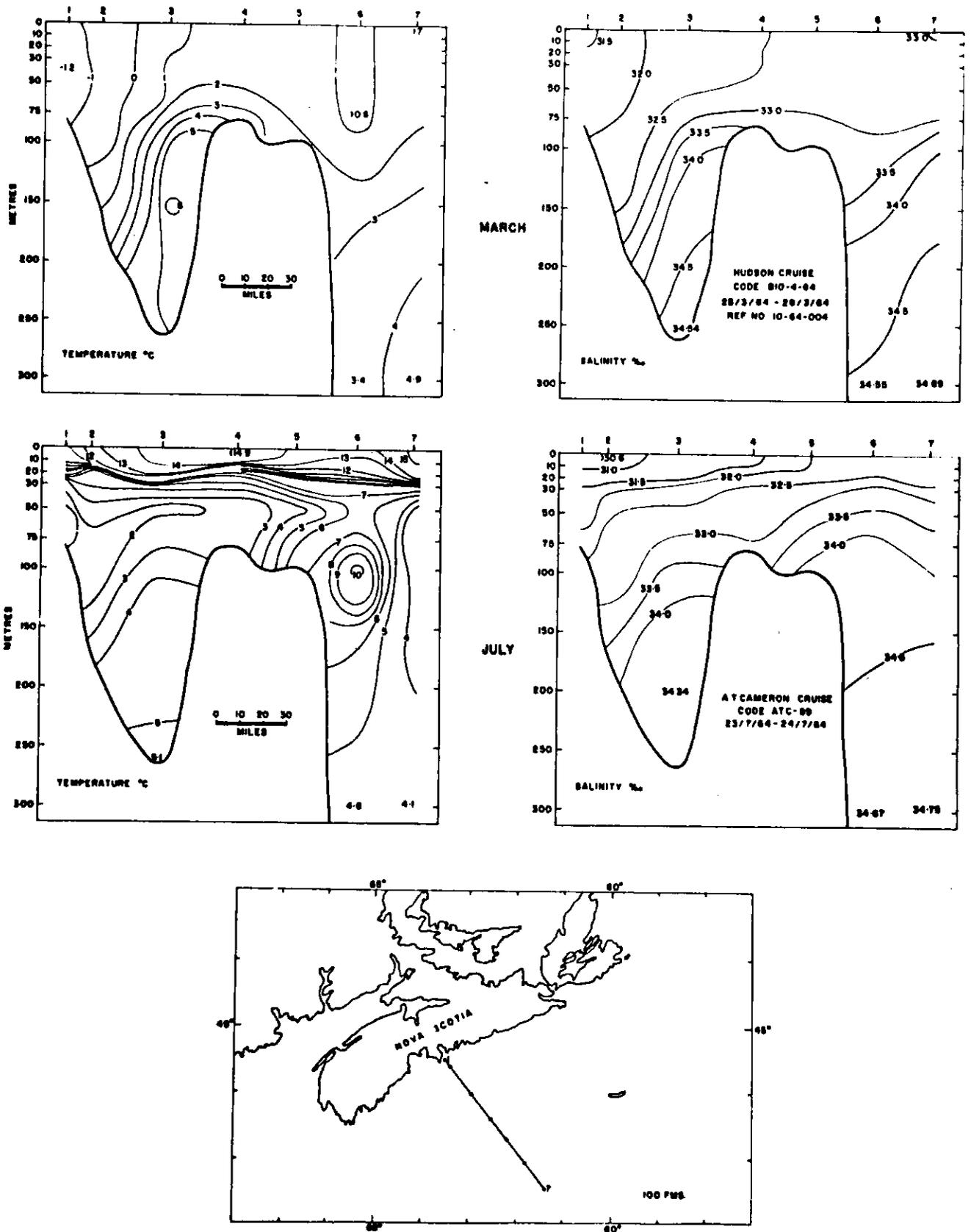


Fig. 8. Hydrographic section off Halifax, March and July 1964

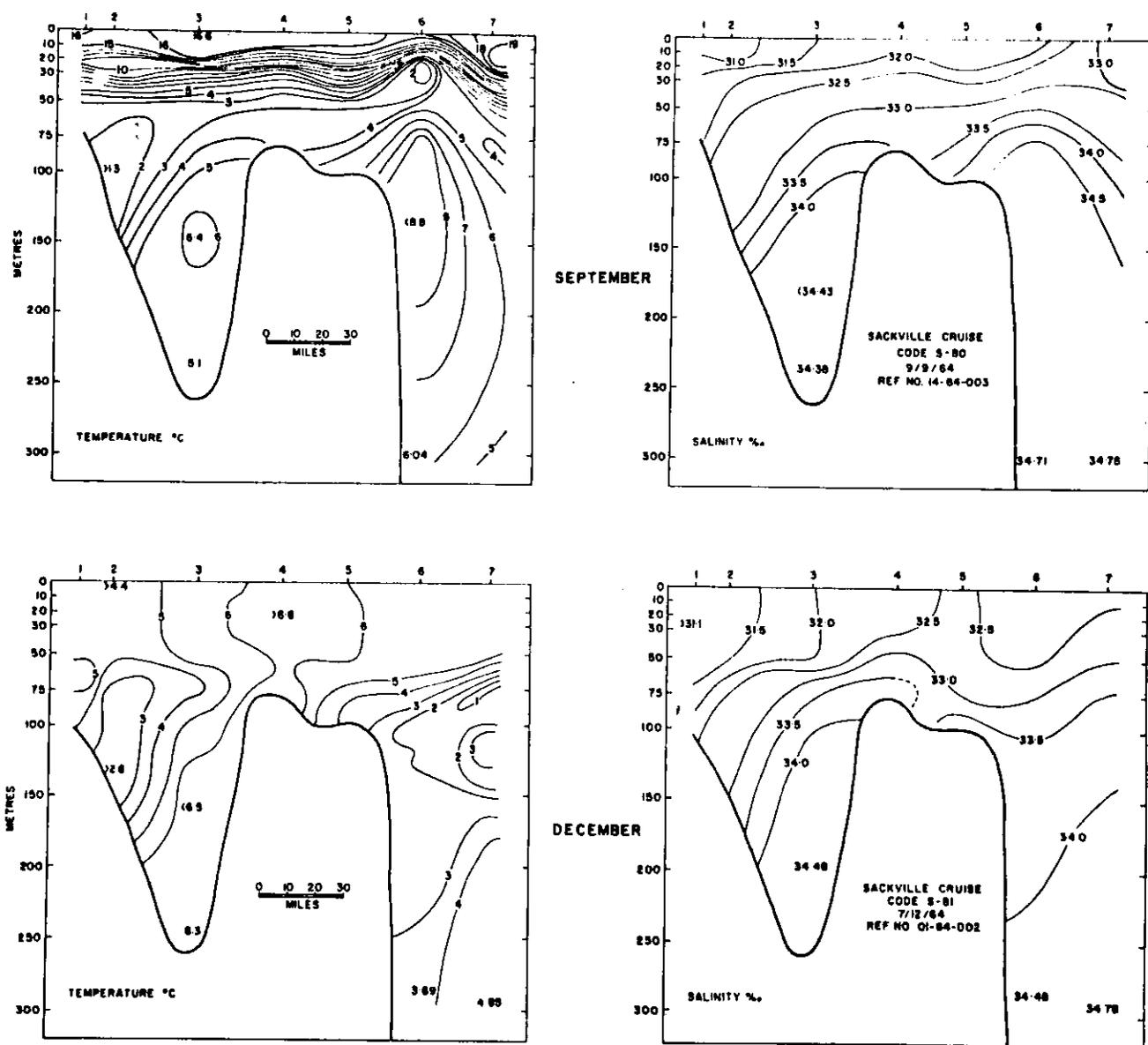


Fig. 9. Hydrographic section off Halifax, September and December, 1964

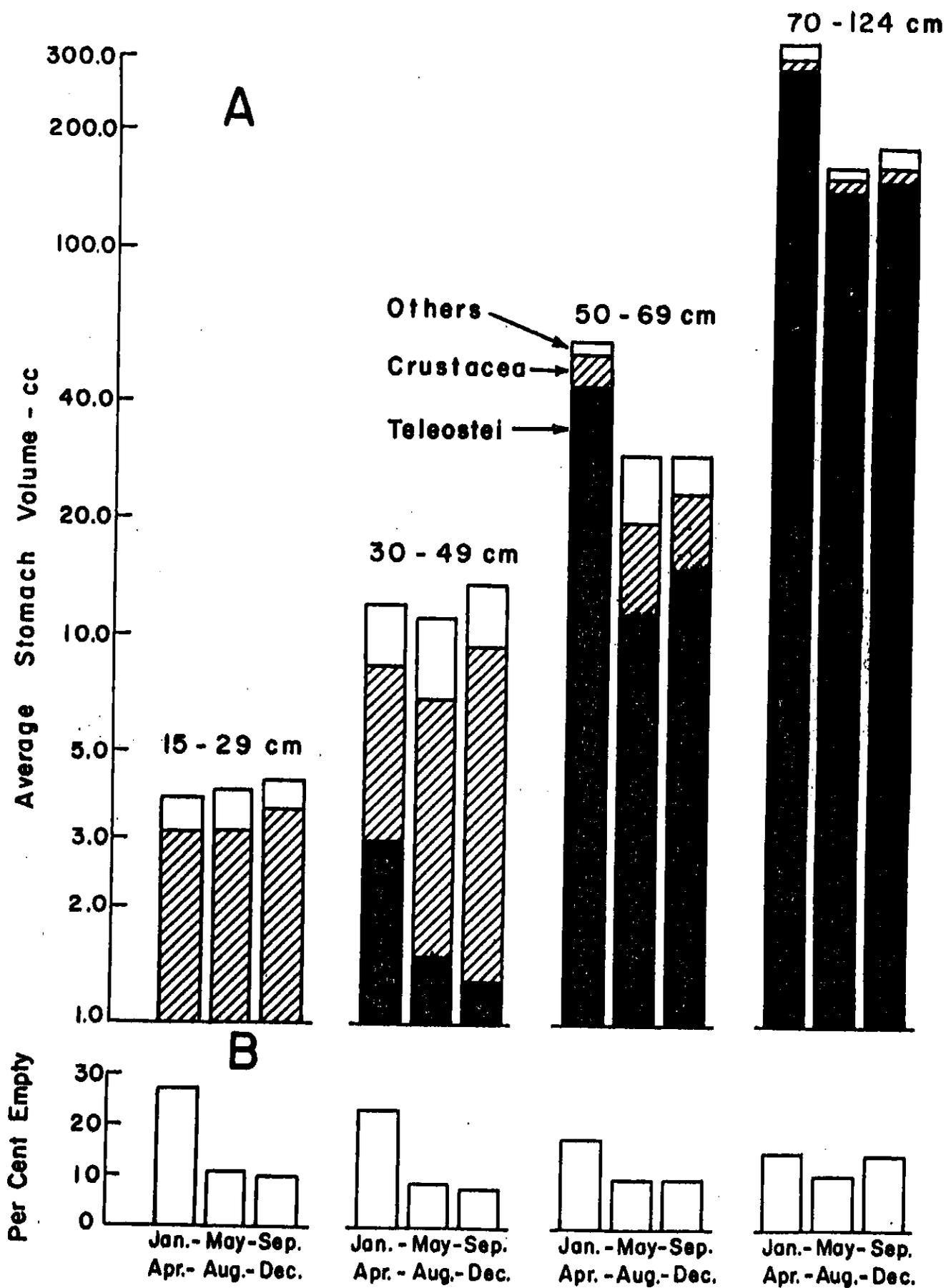


Fig. 10. Food volumes in cod and proportions of empty stomachs

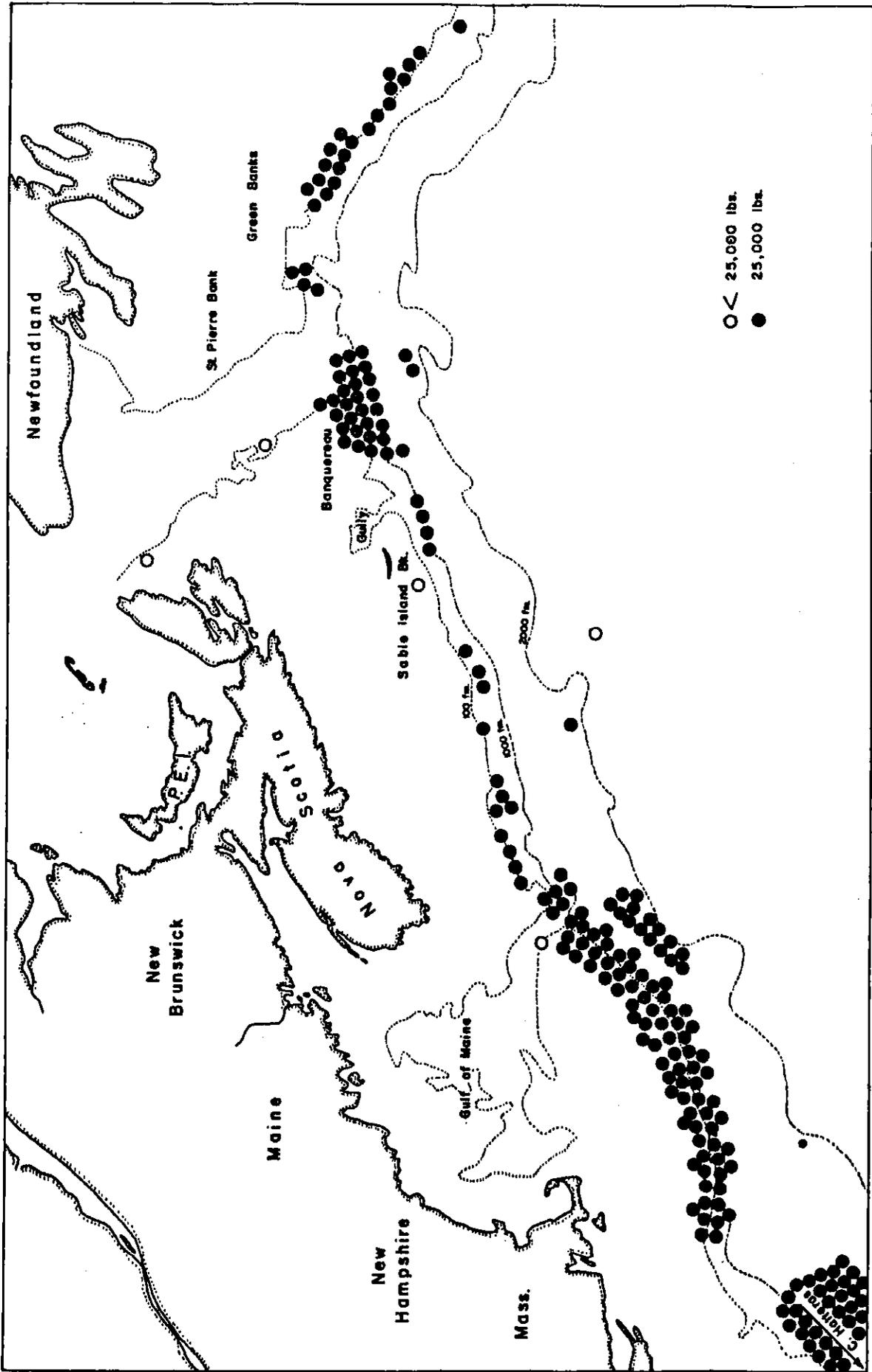


Fig. 11. Distribution of swordfish catches, 1964.