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Canadian Research Report, 1968

A. Subareas 1, 2 and 3

by W. Templeman

The St. John's Biological Station of the Fisheries Research Board of Canada carried out fisheries and oceanographic researches in Subareas 1, 2 and 3. The Atlantic Oceanographic Laboratory of the Bedford Institute engaged in oceanographical researches in Subareas 1, 2 and 3 and the Marine Ecology Laboratory of the Fisheries Research Board of Canada at Dartmouth carried out studies of the deep scattering layer in Subarea 3. The Arctic Biological Station of the Fisheries Research Board of Canada in Ste. Anne de Bellevue studied the harp and hood seals in Subareas 2 and 3.

The 1968 landings data reported in this document are preliminary data for Newfoundland only and are only approximately similar to the data which will be reported to ICNAF in May-June. The totals for the Canadian landings are not yet available.

Subarea 1

A. Status of the Fisheries

A Canadian trawler fished in West Greenland, Div. 1E, but took only about 8 tons of cod.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies. As part of the study of the North Atlantic Deep Water by the Atlantic Oceanographic Laboratory, an atlas has been prepared of Oceanographic Sections occupied in 1965-67. This includes temperature, salinity, dissolved oxygen and silica for Davis Strait, Labrador Basin, Denmark Strait and Newfoundland Basin.

II. Biological Studies

1. Atlantic salmon, *Salmo salar* L. During 1968, emphasis on Atlantic salmon research at the St. John's Station was directed toward the marine aspects of salmon ecology, particularly high seas distribution and effects of high seas fisheries on salmon stocks. The overall objective of several projects begun during the year is to determine ways of identifying fish of Canadian origin during the marine phase of salmon life history. Preliminary field work consisted of a field trip of about 6 weeks in Greenland to observe fishing techniques, collect length and age data from the commercial fishery and make collections for morphometric, meristic, parasitological and serological studies.

Subarea 2

A. Status of the Fisheries

I. Cod, *Gadus morhua* L.

The inshore cod fishery in Labrador was very poor, more than 40% lower than in 1967. This was due to less fish rather than less effort. For the first time a significant catch of cod and associated fishes was taken offshore in Subarea 2 by Canadian (Newfoundland) trawlers. Preliminary estimates of the amounts taken offshore, all in Div. 2J, were 4,600 tons of cod and small amounts of American plaice, redfish, Greenland halibut and wolffish.

II. Harp seal, *Pagophilus groenlandicus* (Erxleben) and Hood seal, *Cystophora cristata* Erxleben

Canadian catches of harp seals (preliminary figures) in 1968 in Subareas 2 and 3 were 33,000 young and 5,600 older seals, as compared with 31,000 and 11,000 respectively in 1967. Thus the catch of young harp seals by Canadian ships and landsmen was not reduced following an opening date for the fishery which changed from 12 March to 22 March, but the catch of older seals was halved following a closing date which changed from 30 April to 25 April. The Canadian catch of hood seals was 22 young and 13 old seals or 35 in all, compared with 1,240 in 1967. A lower availability of hood seals in 1968 is suggested.

An age sample of 600 moulting harp seals showed relative absence of 4-, 5- and 6-year-old animals following heavy catches of young in 1962, 1963 and 1964 (see Research Document 68/70). Since nearly all female harp seals are giving birth by 7 years of age, recruitment is expected to fall rapidly in this population beginning in 1969.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies

See Subarea 1 - I.

II. Biological Studies

1. Cod. The inshore Labrador cod catch was sampled mainly in August in 8 localities between Saglek in Div. 2G to Pack's Harbour in Div. 2J for length, age, sex, sexual maturity, and food. Catch statistics were collected at selected locations. The following numbers of cod were measured and otolithed in Div. 2G, 623 and 257; in 2H, 2,347 and 953; and in 2J, 3,524 and 1,141.

2. Atlantic salmon. On an *A.T. Cameron* cruise to the northern Labrador Shelf, 21 salmon were taken in 5 overnight drift net sets between 29 March and 5 April. About 1,800 m of nets were used for each set, with the gear fished at the surface over depths of 2,400-3,500 m, outside the seaward edge of the ice.

3. Harp and hood seals. Charter of a sealing vessel for two weeks in late April-early May allowed collection of a sample of 300 moulting harp seals after the end of the regular fishery. Comparison of an age sample of similar numbers taken during the fishery showed that the latter source is adequate for studying age composition, although full mixing of moulting animals does not occur until after 25 April. Thirty animals taken on deck were fully measured, weighed and examined. The relative absence of 4- to 6-year-olds did not allow precise determination of the mean age at maturation of female harp seals of this population, which age, however, lay between 4 and 6 years.

Moulting animals were fat and feeding intermittently, perhaps below the core of the Labrador Current, because Isaacs-Kidd hauls in shallow water between the ice floes caught very little macroplankton.

Subarea 3

A. Status of the Fisheries

I. Cod

Total Newfoundland cod landings from Subareas 2-4 (but mainly from the inshore fishery of Subarea 3) increased by over 20,000 tons to 199,000 tons. In this total the landings from the inshore fishery of Div. 2J decreased sharply from 1967, landings from the inshore fishery in Subarea 3 were slightly greater than in 1967 and landings from offshore vessels doubled to about 47,000 tons.

On the east coast in Div. 3L, inshore landings were generally higher than in 1967 because of better catches in spring and summer of 1968. For the remainder of the year, inshore catch levels were below those of 1967 because of bad weather and absence of squid bait. In this division there was evidence of a strong 1964 year-class.

II. Haddock, *Melanogrammus aeglefinus* L.

Newfoundland haddock landings, mainly from Subarea 3, fell from 1,960 tons in 1967 to about 1,100 tons, the lowest since 1945 the year before the Newfoundland haddock landings began to increase by the use of otter trawlers.

III. Redfish, *Sebastes mentella* Travin and *Sebastes marinus* L.

Newfoundland redfish landings, almost all *S. mentella*, increased slightly from 28,000 to 29,000 tons. Landings from Subarea 3 fell about 50% from 14,000 tons in 1967 and landings from Subarea 4 increased about 50% from 14,000 tons in 1967.

IV. Flounders, American plaice, *Hippoglossoides platessoides* (Fabricius); Witch flounder, *Glyptocephalus cynoglossus* (L.); and Yellowtail flounder, *Limanda ferruginea* (Storer)

Newfoundland landings of American plaice from Subarea 3 declined

by over 4,000 tons from the 49,000 tons landed in 1967. Witch flounders declined by about 1,600 tons from 5,968 tons in 1967 and yellowtail flounders increased by 2,800 tons from the 1,519 tons landed in 1967. Although there was a decrease in American plaice, the Newfoundland fishing effort for this species probably increased during the year.

V. Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum)

Newfoundland landings of Greenland halibut, almost all from the deep east coast bays of Newfoundland in Subarea 3, decreased by about 3,000 tons from the 16,595 tons (16,548 from Subarea 3) landed in 1967.

The mean length of the Trinity Bay commercial samples was 58.8 cm, a decrease from 62.7 cm and 61.4 cm in 1966 and 1967 respectively. The mean length of the Bonavista Bay commercial samples was 62.4 cm. The Bonavista Bay samples included a greater proportion of older fish than those from Trinity Bay.

From catch and effort data collected at 3 Trinity Bay localities, there has been a decrease in the catch per 90 m gillnet set from 157 kg in 1966 to 68 kg in 1967 and to 41 kg in 1968. Coinciding with the decrease in the Greenland halibut catch per net has been an increase in the flounder (mainly witch flounder with some American plaice) catch per net set in these Greenland halibut nets from 2 kg in 1966 to 18 kg in 1968.

VI. Herring, *Clupea harengus* L.

Newfoundland herring landings increased by about 80% to about 146,000 tons. As in 1967, the landings were mainly from Div. 3P in a winter-spring purse seine fishery for herring to be reduced to meal and oil. The increased landings resulted from increased effort and reduction capacity.

VII. Atlantic salmon

Newfoundland landings of Atlantic salmon in the commercial fishery (total from Subareas 2, 3 and 4) decreased by about 300 tons from the 1,800 tons taken in 1967.

VIII. Capelin, *Mallotus villosus* (Müller)

Newfoundland landings of capelin, mainly from Subarea 3, were about 3,500 tons, approximately the same as in 1967.

IX. Short-finned squid, *Illex illecebrosus* LeSueur

Squid were extremely scarce in the Newfoundland coastal area, with recorded commercial landings of only one ton compared with 6,900 tons in 1967.

B. Special Research Studies

I. Environmental Studies

1. Hydrography. The standard section, St. John's-Flemish Cap, was taken between 29 February and 6 March and again from 25-27 July. Station 27, 3.2 km off Cape Spear near St. John's was occupied once or twice a month throughout the year. These observations are reported in another Research Document.

For work by the Atlantic Oceanographic Laboratory, Bedford Institute, see Subarea 1, B.I.

2. 3. Plankton and Benthic Studies. A study of the distribution of planktonic foraminifera, both in the water column and in the sediments, for much of the Canadian Atlantic Seaboard, has been continued by the Atlantic Oceanographic Laboratory.

4. Other Environmental Studies. The Sir Charles Hamilton Sound-Funk Island Survey has continued since 1964 and is part of the overall charting program by the Atlantic Oceanographic Laboratory to provide modern charts along the east coast of Newfoundland.

The deep sound-scattering layers in the sea have been found to occur with surprising uniformity over large areas of the North Atlantic. If, as suspected, bathypelagic fish are largely responsible for the scattering layers, these fish must be among the most abundant of the higher animal forms in the oceans. Even conservative estimates, based upon hydroacoustic surveys, make it seem likely that they represent an important stage in the biological production processes taking place in the open oceans.

In July a series of eight stations was sampled by the Marine Ecology Laboratory along the 2,000 m depth contour east and south of Newfoundland, using a large mid-water trawl fishing at 900-1,100 m. Simultaneously the depth and strength of the scattering layer was monitored from another vessel. Catch counts were high but the weight of the catches was generally low, averaging about 23 kg per hour's tow. The data are being analyzed with regard to abundance, size composition and distribution characteristics. Taxonomic studies are being undertaken at the Royal Ontario Museum.

II. Biological Studies

1. Cod. The commercial fishery for cod, both inshore and offshore, was sampled in important Newfoundland fishing ports. Information was gathered on size, age, growth, maturity, spawning, food, location of catch, and catch per unit effort.

In early March, cod catches by the *A.T. Cameron* on Flemish Cap (using a No. 41-Yankee otter-trawl with a 24.1 m head line) were poor, the largest being 204 kg for a 30-minute tow. About 35% of the mature females were spent. Also in early March good catches were taken on the eastern Grand Bank in depths of 120-320 m. The largest catch for a 30-minute tow was about 1,800 kg. About 95% of the cod were immature and small, averaging 0.9-1.4 kg. On the southwestern slope of the Grand Bank in May, cod catches were usually below 230 kg for a 30-minute tow.

In studies of the cod population of Div. 3L, inshore cod catches were monitored for length, age, sex, etc. at Bonavista, St. John's, and St. Mary's Bay.

A *Martinus* cruise in April-May in Trinity and Bonavista Bays showed that the large gillnet cod would soon spawn. These cod apparently spawn mainly in the coastal areas, in contrast to the younger trap and handline fish which spawn before arriving in the coastal areas in late spring and early summer.

In a cruise of the *A.T. Cameron* to the northwestern slope of the Grand Bank and in the Avalon Channel from 27 May to 5 June, otter-trawl sets were taken on lines from 80 to 230 m. Cod and American plaice

taken in 30-minute sets were usually from less than 90 to 320 kg. In the western part of the area there was a much higher proportion of cod over 60 cm in length than in the eastern part of the area where the 4-year-old cod with a strong mode at 45-47 cm dominated the catches. (This same age group was dominant in the coastal cod-trap catches.) Many of the cod were feeding heavily on capelin which were present in large schools in many locations, being caught in the otter trawl and visible as heavy echo-sounder traces.

During May, a cruise of the *A.T. Cameron* was made to St. Pierre Bank to investigate the biology and distribution of cod in relation to temperature and depth and to determine the abundance of young cod in an attempt to predict contributions of various year-classes to the commercial fishery. Very small catches of commercial-sized cod were obtained but significant quantities of small cod (up to 250 per 30-minute tow) were taken with peaks at 19 cm on the northern part of St. Pierre Bank and 22 cm on the southern part. These were mainly of the 1966 year-class although 1965 and 1964 were also well represented. Cruises in 1967 also produced significant quantities of the 1964-66 year-classes.

During 1968, analyses of data on the biology and fishery of cod in the southwest Newfoundland coast area (Div. 3Pn) during 1952-65 were completed and the results prepared for publication. Total effort and landings by all gears in 3Pn increased 2 to 3 times in 1960 over 1959 and remained at a higher level thereafter. As a result of this increase in effort, the proportion of larger and older cod in the longline catches decreased after 1959-60 and the total mortality rate increased. Growth of the younger age-groups decreased during 1952-65 because of a decline in bottom temperatures in the Gulf of St. Lawrence. Growth of older age-groups increased in the mid 1950's because of increased food supply due to mass mortality of herring in the Gulf but decreased thereafter as a result of decline in bottom temperatures.

As a result of a suggestion at the 1968 ICNAF Annual Meeting that in view of the more recent data on mortality and growth for 3N-0 cod new assessments should be provided, assessments based on 1959-62 data were made and a preliminary report presented to the mid-year meeting of the ICNAF Subcommittee on Assessments. Results indicated that greater

benefits were predicted from the 1959-62 data than from the earlier assessments on 1955-58 data. Depending on the particular value of E chosen, maximum benefits to the otter-trawl landings occurred at mesh sizes of 140-152 mm (5½-6 inches). Immediate losses to the otter-trawl landings were 11% or less for increases from 102 to 140 mm (4-5½ inches).

2. Haddock. In a survey in May by the *A.T. Cameron*, the greatest haddock catch per 30-minute tow was 140 kg on the southern Grand Bank and 40 kg on St. Pierre Bank. The very low level of the stock is indicated by the low catches from 90 to 275 m where the haddock were most plentiful. In these most favourable depths there were averages of only 6.4 kg (11 fish) per tow in 24 tows on the southwestern Grand Bank and 8.6 kg (64 fish) per tow in 15 tows on the southern and western slopes of St. Pierre Bank. On the Grand Bank there was no evidence of a new year-class. On St. Pierre Bank a small 1966 year-class is present.

3. Redfish. An *A.T. Cameron* cruise to Flemish Cap in July-August 1968 yielded best catches of 2,220 kg (av. wt. 0.4 kg), 620 kg (av. wt. 0.25 kg), and 1,140 kg (av. wt. 0.7 kg) of *Sebastes mentella* redfish in 30-minute tows at depths of 275, 365, and 550 m respectively. These catches were all obtained on a line extending northward from the Cap. Catches on a line on the eastern slope of the bank were considerably smaller than those obtained on the northern line. No large catches of *S. marinus* redfish were obtained but in most sets at 275 m some of these redfish were taken (the best catch being 141 specimens weighing 123 kg). Studies on the diurnal availability of redfish indicated that catches were more variable at 275 m than they were at 550 m.

4. American plaice. A survey of a small section of the eastern slope of the Grand Bank in early October produced catches of 540, 680, 1,450, 350, 1,320, and 1,360 kg at 110, 130, 145, 165, 185, and 365 m respectively. Catches at comparable depths just 4 nautical miles away produced 115, 255, 180, 80, and 45 kg (to 185 m only).

In order to carry out a study of the population dynamics of this species, the major emphasis during the year was on age determination from otoliths collected from commercial trawlers in 1953-68.

5. Yellowtail flounder. Compilation of data on various aspects of the biology of this species is nearing completion. It was decided to include age and length data collected during 1968 in order to give a better estimate of mortality since better separation of this species in the Newfoundland statistics and apparently increased fishing for it began in 1965.

6. Greenland halibut. Samples were obtained from Trinity Bay, Bonavista Bay, Notre Dame Bay, Gulf of St. Lawrence, and the Grand Bank for studies of age, sex and maturity.

Stomachs were collected from Greenland halibut sampled on the gillnet trips in Trinity, Bonavista, and Notre Dame bays. Capelin comprised about 85% of the diet of Greenland halibut above 25 cm. Below 25 cm the food items were mainly euphausiids, small shrimp and amphipods. Other food items of larger Greenland halibut were shrimp of various species, Greenland halibut, cod and euphausiids.

Gillnet mesh selection experiments were carried out in Trinity, Notre Dame and Bonavista bays using 152-, 178-, and 203-mm (6-, 7-, and 8-inch) mesh monofilament gillnets. These experiments suggest that at present for these three particular mesh sizes, an increase in mesh size yields a decrease in numbers but an increase in weight per unit of fishing effort.

7. Herring. Most of the Newfoundland herring catch is taken in winter and spring on the western half of the south coast of the island. In this population between Hermitage Bay and Cape Ray, no consistent differences in migration, time, maturity, age composition, or size were found. This population migrated inshore to the various bays along the southwest coast in late November and early December and were abundant until about the middle of March. The decline in abundance during the next few weeks progressed westward across the area. Herring from the

southwest coast during this winter-spring period show a wide range in maturity with most stages present. Near ripe and freshly spent fish were most abundant in December and January. Inshore spawnings were observed in late April and early May in Hermitage Bay.

In preliminary assessments of abundance, the natural mortality index was estimated at 0.30 and it was also estimated that during the 1967-68 season the seine catch of 143,000 tons was between 0.35 and 0.51 of the estimated population.

Based on the number and nature of spawning reports received, the level of spring spawning near the beaches around Newfoundland in 1968 appeared to be about the same as in 1967 and less than in 1966. In Notre Dame Bay, spawning took place in deeper water than usual, continuing the trend observed in 1967. Although no spawnings have been observed at other times than in May and June, maturity stages of herring samples of the Newfoundland catch indicate that a large number of herring spawn later in the year.

8. Capelin. The *Investigator II* carried out cruises in Trinity Bay using midwater and Isaacs Kidd trawls and plankton nets.

From 30 January-2 February capelin schools were dispersed but mainly outside the 180 m contour and at a depth of 9-220 m at temperatures of 0°C or less. They were feeding very little.

From 27 February-7 March the capelin were concentrated in large schools at depths between 155 and 220 m at temperatures from -0.5 to 0.0°C at the bottom of the cold layer and almost all in the outer part of the bay. The largest concentration found was a school about 1¾ nautical miles long and 25-55 m deep near the mouth of the bay. Stomachs were empty and the fat content of the larger fish ranged from 12.5 to 14.5%.

From 28 March-4 April there was considerable vertical migration of large schools from usually less than 75 m at night to 90-185 m in the daytime. Temperatures down to 185 m were less than -0.5°C. The capelin were beginning to feed and fat contents of maturing fish ranged from 8.4-11.4%.

From 13-17 May the only large schools of capelin located were outside the 180 m contour in the upper 25 m and were immature capelin. Many small comet-shaped traces located at generally less than 25 m below the surface were probably small schools of maturing capelin on their way to the spawning beaches. Temperatures at the depths where these small schools were seen were 0.5 to 1.5°C. Eight maturing capelin taken on 31 May were still feeding and their fat content ranged from 5.6 to 6.6%.

On 10-14 September, 23-30 October and 11-18 December the bay was surveyed by echo-sounder and no large schools or concentrations of capelin found. Small comet-shaped schools similar to those found in May were dispersed all over the bay at depths from 55 m to the surface. Often these small schools would form a loose concentration.

At Middle Cove near St. John's, beach spawning began on 19 June at beach water temperatures of 5.4 to 5.9°C. Beach spawning ended on 12 July when the water temperature near the beach was 9.8 to 10.4°C. The first larvae in this area were taken on 19 July and the last on 28 August. Fat content declined from 1.9-3.2% on 19 June to 1.0 to 1.7% on 10 July. In this period the average total length of the male capelin declined from 194 to 177 mm and females from 177 to 155 mm.

In an *A.T. Cameron* cruise to the Southeast Shoal of the Grand Bank on 8-18 July it was indicated that spawning had ended about a week earlier. Catches consisted mainly of dead mature males. Only one set produced live capelin and these were 98% females, all spent. Many recently hatched larvae were taken on 12 July. The fat content of recently dead male capelin ranged from 0.2 to 0.5% and of spent females from 0.6 to 1.1%.

9. Atlantic salmon. Investigations of morphometric and meristic characters of North American smolts were begun to determine whether these might be of use in determining area of origin of fish taken at sea. Data collected during 1968 will allow preliminary evaluation of variation in these characters between major river systems. Much of the initial effort in this study was directed to development of criteria and techniques

for measuring and counting. Plans for 1969 include extension of this study to European rivers.

Material for parasitological and biochemical studies was also collected in Greenland to evaluate the usefulness of these techniques in separating groups of salmon by area of origin. Studies of salmon parasites will continue from the work begun at the St. Andrews Station several years ago. Biochemical studies will begin early in 1969.

During the past year, analysis was completed on the size, age, and sex composition of 5,049 salmon sampled at Bonavista, Port Union, and St. Anthony during the period 1960-63. The sea-age composition of the sample was: grilse, 48%; 2 sea-year salmon, 43%; 3 sea-year and older salmon, 3%; and previously spawned salmon, 6%. The average fork lengths of the maiden salmon were: grilse, 54.1 cm; 2 sea-year salmon, 72.9 cm; 3 sea-year salmon, 88.4 cm; and 4 sea-year salmon, 96.5 cm. The average round weights of the maiden salmon were: grilse, 1.9 kg; 2 sea-year salmon, 4.5 kg; 3 sea-year salmon, 8.7 kg; and 4 sea-year salmon, 13.2 kg.

At Bonavista in a sample of 3,830 salmon from the commercial fishery females outnumbered males in all sea-age groups: grilse, 58% female; 2 sea-year salmon, 73% female; 3 sea-year and older salmon, 90% female; and previously spawned salmon, 65% female.

10. Pink salmon, *Oncorhynchus gorbuscha* (Walbaum). The 5,334 pink salmon that returned to North Harbour River in 1967 were allowed to spawn naturally in the river. Egg deposition was estimated to be 4,400,000. The fry were not counted but fry survival from eggs in plastic cases in the river gravel was 87%. The hatching period was 10-28 November, the earliest in these experiments by about 7 weeks. (Atlantic salmon eggs in the same location hatched from 15 January to 11 April.) Fry were seen in the river from 2 April to 23 May. Fry began running to sea earlier than usual the usual run from the river being in May. Juveniles remained in St. Mary's Bay as late as September when 5,000 were sighted and October when 7,000 were seen. Specimens taken in October averaged 190 mm in fork length.

In studies of predation of fry in the sea near the mouth of the river from 9 May to 4 June, 6% of the Atlantic salmon smolts, 5% of the seaward migrating brook trout and 2% of the seaward migrating brown trout had 2, 2 and 1 fry per fish respectively. In 1,673 herring, capelin, cod, sculpins, cunners, brook trout, and mackerel taken from 21 May to 26 July no pink salmon fry were found.

From 5.9 million pink salmon eggs from British Columbia planted in North Harbour River in November 1966, 1,353 fish returned to the river in 1968 between 6 August and 4 October with a peak on 22 August. Spawning occurred in the river between 8 and 22 September with the peak about 15 September.

From the commercial fishery an additional 933 fish were recorded, 724 of these been taken in St. Mary's Bay. A total of 35 pinks was recorded from 5 other rivers.

B. Subareas 4 and 5

by F.D. McCracken

Research on oceanography and fish stocks in Subareas 4 and 5 was carried out by the following Canadian establishments: the St. Andrews Biological Station, the Marine Ecology Laboratory (Dartmouth), the St. John's Biological Station, the Arctic Biological Station (Ste Anne de Bellevue) of the Fisheries Research Board of Canada; the Bedford Institute of Oceanography of the Department of Energy, Mines and Resources; and la Station de Biologie marine (Grande-Rivière) du Ministère de l'Industrie et du Commerce of the Province of Quebec. Reports on researches by many scientists, whose names appear in the list of Canadian scientists engaged in work concerned with ICNAF problems, were used in preparing this submission. Preliminary statistics of landings used in reporting on the status of the fisheries were in part obtained and compiled by the Canadian Department of Fisheries. The status of fisheries and special research studies on harp and hood seals are reported separately in Appendix 7.

Subarea 4

A. Status of the Fisheries

I. Cod

Cod landings on the mainland were up about 10 percent over 1967, nearly to 1966 levels, and made up about 35 percent of the total weight of groundfish landed. The increase was for Nova Scotia ports and presumably mainly from Div. 4V, W, X, and 5Z. Landings from Div. 4T appeared to be about 9 percent lower, probably due to effort shifts to queen crab and redfish by the otter-trawl fleet. Sizes and ages of cod taken from Div 4T were similar to 1967, with a modal size at 46 cm and 4-year-old fish (1964 year-class) dominant. The 1963 year-class also remained important. Discards of cod were negligible, about 1 percent.

II. Haddock

Total haddock landings declined about 10 percent from 1967 levels, but quantities landed from Subarea 4 were probably about the same as in 1967. Haddock taken in Div. 4W in spring were about the same size as in 1967, with most being from 38-60 cm. The dominant year-class was 1963, with 1962 also prominent.

III. Flatfish

Total landings of flatfish (plaice, witch, yellowtail, and winter flounder) were lower by 10 percent. Decreased landings were general from Div. 4V, W, and S. Diversion of small otter trawlers to queen crab fishing caused a drop in Div. 4T winter flounder landings from 1,563 to 158 metric tons, which accounts for about 35 percent of the total decrease in landings.

Atlantic halibut landings declined 12 percent from 1967 levels.

IV. Pollock

Pollock landings have remained fairly steady over the past 3 years. A small increase (about 3 percent) followed the small decline (5 percent) in 1967. Markets influenced these landings.

V. Redfish

Landings of redfish have continued the rising trend begun in 1963. Most of the increase has been from the Gulf of St. Lawrence (Div. 4R-S-T) and has resulted from successful survival of a series of new year-classes. The successful year-classes followed a period of about 8 years of extremely poor recruitment.

Preliminary estimates based on age-distribution analysis of redfish stocks suggest that yield from the fishery will be significantly lower in 1969 than in 1967-68. However, further year-classes of small redfish have succeeded in settling to bottom in some areas of the Gulf of St. Lawrence, and it is not anticipated that any decrease in catches should be too dramatic or of long duration.

VI. Sea scallop, *Placopecten magellanicus* Gmelin

Total landings of scallops increased about 68 percent to 12,400 tons whole weight (1,483,800 kg meats). Offshore landings at about the same level as 1967 were mainly from the Lurcher region of Div. 4X. A small fishery (187 tons) developed in Div. 4V. Most increases came from the inshore fishery in the Bay of Fundy region (3,400 tons) and from the southern part of Div. 4T (7,500 tons) where landings reached an all time high.

VII. Herring

Herring landings in Subarea 4 (excluding Div. 4R) were 377,000 tons, up 114,000 tons (43 percent) over 1967, as a result of a rapidly expanding industrial fishery. Greatest increases occurred in Div. 4X (80,000 tons) and

Div. 4T (33,000 tons). There were small increases in Div. 4W (400 tons) and Div. 4V (50 tons), but fisheries there are so far not important.

VIII. Swordfish

Landings of swordfish for all ICNAF areas amounted to 4,500 tons, a slight decrease (7 percent) from 1967. There were no significant changes in area of capture and about 50 percent of the total catch was from Subarea 4. The decrease in landed weight resulted partly from the smaller size composition of fish caught. With increasing fishing pressure on the stocks, this trend is likely to continue.

IX. Mackerel, *Scomber scombrus* L.

Mackerel landings (excluding Div. 4R) amounted to 10,790 tons, a decrease of 3 percent from 1967. Landings from Div. 4V-W-X decreased from 8,000 tons in 1967 to 5,700 tons. Landings from Div. 4T-S increased from 3,200 tons in 1967 to more than 5,000 tons, probably as a result of higher water temperatures there during the early part of the season.

X. Tuna

Tuna landings at 260 tons declined 13 percent, and most fish were taken while swordfishing. Several species are included in the landings but are not separated. The bluefin fishery in St. Margaret's Bay (Div. 4X) was almost a complete failure.

XI. Sharks

Incidental landings of porbeagles (*Lamna nasus*), mako (*Isurus oxyrinchus*), and hammerheads (*Sphyrna* sp.) were only 11 tons (50 tons in 1967).

XII. Atlantic salmon

The catch of Atlantic salmon (commercial plus angling) declined to about 830 tons, compared to landings of

about 1,350 tons in each of the previous 2 years. Most decrease in catches occurred in Div. 4R-T. The angling catch at 133 tons declined by about 47 percent, with low river discharge contributing to the decrease. Grilse comprised about 70 percent of the angling catch.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies. In June, plankton, fish eggs and larvae sampling in Div. 4T was carried out along with occupancy of over 200 physical oceanographic stations at 98 sites. Earlier surveys suggested that gyres, 10-20 km in diameter, were present and moving through the system. Current meters and parachute drogues were employed to study the nature and persistence of these gyres.

The ice forecast survey for Div. 4R-S-T, consisting of standard oceanographic stations, was undertaken in November and the Halifax Section (Div. 4W) was monitored 6 times.

The moored buoy program in Div. 4X and W, initiated in 1967, was continued. Analysis of the current meter records has shown the existence of inertial motions, and that tidal ellipses associated with tidal motions are of different shapes at different sites on the Scotian Shelf.

In September, current meters were placed along the 1000-m depth contour at the edge of the Shelf, and a series of oceanographic stations occupied to study the complex mixing of water from the Labrador Current and Gulf Stream which occurs there.

The detailed study of St. Margaret's Bay, initiated in 1966 as part of a system production study, was continued. Emphasis in the field program was placed on measuring the exchange of water between the bay and off-lying areas, and

monitoring the general T-S distribution at weekly intervals from June to November and fortnightly during other months.

Environmental studies related to fisheries problems were continued with special emphasis on circulation and on long- and short-term variations of water properties. The two main areas studied were: Bay of Fundy-Gulf of Maine and adjacent continental shelf, and the southwestern Gulf of St. Lawrence. However, circulation studies are also being carried out over the continental shelf to the east, including the Newfoundland area.

Surface and bottom circulations in the eastern Gulf of Maine are best described, for the moment, as those of an upwelling area with bottom convergence towards the south-western Nova Scotia coast. This convergence appeared stronger in spring and summer and weaker in autumn and winter.

Average surface drift in the Gulf of St. Lawrence showed a counter-clockwise circulation with no evidence of a return circulation along the North Shore. The drift and recovery of drift bottles in the Gulf of St. Lawrence were used to make a preliminary estimate of surface water escapement through Cabot and Belle Isle Straits.

The long-term cooling trend along the Canadian Atlantic coast was still evident during 1968 with a smaller decrement of temperature than previously. Short-term changes in water properties were followed from quarterly observations offshore and daily observations at coastal stations. Data indicate that an intrusion of relatively high temperature and high salinity waters occurred in the deeper layers of the Gulf of Maine between January and April. The effect of this intrusion was felt during the next 6 months from surface to bottom in the Bay of Fundy-

Gulf of Maine area. In the southwestern Gulf of St. Lawrence, spring and summer surface temperatures were generally 1°C higher than normal.

2. Plankton Studies. Combined plankton-physical oceanography investigations have been carried on in St. Margaret's Bay and out to LaHave Basin. In spring, a clockwise eddy containing the largest plankton population densities lay adjacent to the mouth of the bay and inshore from the 50-fath line. Further offshore was a strong westerly flow of cold water with low plankton densities. This may have been acting as a barrier, holding neritic populations against the coast. In summer, there is a regular pattern of increasing salinity with isohalines sloping from the bottom towards the surface as one moves away from the shore. Neritic plankton populations develop in the fresher, less dense waters close to shore. These patterns are disrupted by strong offshore winds, and are thought to cause major exchanges of bay water with offshore water.

3. Miscellaneous. Charts of sea surface temperature, layer depth,selected bathythermograms and wave data for Subareas 3, 4, and 5 were prepared and broadcast daily by the Maritime Command Weather Office of the Canadian Forces. The annual input of data for these charts exceeds 100,000 sea surface temperature observations and approximately 17,000 bathythermograms.

II. Biological Studies

1. Cod. Intensive study of the southern Gulf of St. Lawrence cod as a model for investigation of changing fish population parameters was continued. The September, small-mesh, otter-trawl survey indicated that the usually dominant 3-year-olds were not as abundant as in 1967. Also, the 1964 year-class (3-year-olds in 1967) was not as abundant in 1968 as had been expected, but was still above average.

Egg and larvae surveys were continued to investigate recruitment mechanisms and compare the effect on survival of annual variations in environmental conditions. Time of disappearance of ice cover, water temperature, relative surface drift, damage or deformity of young eggs, relative number of eggs spawned, and availability of food for larval fish have all been found to be important factors.

Accumulated data on stomach contents of cod from Div. 4T have been analysed and are being published in a comparison with data from other areas. Continued use of the trawl camera during surveys provides data on populations of benthic organisms that may be related to food selection of cod and other groundfish species.

2. Haddock. Three research-vessel cruises from Browns Bank to Sable Island Bank confirmed that the 1964-67 haddock year-classes are small throughout the area. First indications are that the 1968 year-class may be considerably better than those of the previous 4 years.

3. Silver Hake. Observations on gill disease in silver hake showed that the incidence was slightly lower than in 1967 and there was a marked decline in intensity. This may be associated with increased abundance of juveniles as shown in research-vessel catches, indicating increasingly good year-classes in 1967 and 1968; these should be of commercial size in 1970-72. The occurrence and distribution of a trematode parasite (*Anthocotyle merlucaii*) on the gills are being studied.

4. Sand Launce. An analysis of stomach contents shows that the sand launce feeds mainly on copepods on Nova Scotia Banks. Marked differences have been found in the lengths-at-age, otolith sizes, and otolith structures of launce from different parts of the banks. These

indicate the existence of a number of separate populations whose characteristics are being determined.

5. Argentine. Studies of the taxonomy, population dynamics, and species composition of the intestinal trematode parasites were completed. Initially, differences in the latter suggested separate populations of the fish, but later results showed a gradual change in the characteristics from south to north, indicative of a single stock with fairly continuous distribution. Work on fecundity of argentines on Nova Scotia Banks was continued. Ripening argentines were found in abundance between 170 and 200 fath along the edge of the continental shelf in February. The spawning concentration in Emerald Basin was sampled at the beginning of May and was found to be almost identical in size composition to the 1967 concentration there, but was at a more advanced stage.

6. Mesopelagic Fishes. Further collections of mesopelagic fishes were obtained in waters adjacent to the continental shelf. Seven species collected are previously unrecorded from Canadian waters. The most common species in these collections is the myctophid, *Benthosema glaciale*, and its age, growth, and distribution are being studied.

7. Food Resource and Digestion Rate Studies. Studies of food resource division among fishes in Passamaquoddy Bay indicated that species there overlap little in their major food-energy sources. Most have at least one major food source unshared with any other species or with only one other species. Because of the partial overlap in prey lists, the fishes form an ordered predation series wherein only adjacent fish species are well associated by prey species. However, the strength of the food-environment partitioning is partially facultative. In summer, when krill, *Meganyctiphanes*, is abundant, several species of

fish feed heavily on it, while in the winter, when it is not so abundant, it is a major food source for only a few species.

Replicate experiments with young cod acclimated to various temperatures from 2 to 15°C reconfirmed that meal size is a limiting factor to digestion rate. Arithmetic increases in meal size gave logarithmic increases in digestion rate. A study of seasonal variation in gross energy content of major food sources for Passamaquoddy Bay fishes was continued, using an oxygen bomb calorimeter for caloric value determinations.

8. Herring. Research was concentrated chiefly in the Bay of Fundy (Div. 4X) and Gulf of St. Lawrence (Div. 4T). Artificially fertilized ova from spring-spawning herring in Div. 4T developed normally in the laboratory and hatched in 17 days at 7.2°C. Ova of autumn-spawning herring from Div. 4T hatched in 14 days at 7.3 to 8.0°C. Studies of larval abundance and distribution from quarterly cruises in Div. 4X, 5Y, and 5Z show variations in vertical distribution and size of larvae. Data are being examined for dominant faunal associates and for extent of mixing of Georges Bank and Bay of Fundy populations.

About 200 samples (34,000 fish and 7,500 pairs of otoliths) of juvenile and adult fish were collected from commercial fisheries in Div. 4X and 4T. Size ranges and age compositions were essentially the same as in previous years except for the Nova Scotia side of the Bay of Fundy where mean lengths and ages were somewhat lower. However, the indicated change is probably a result of differences in season of sampling. The 1966 year-class was dominant (80-90 percent) in Div. 4X. In Div. 4T, the 1959 and 1960 year-classes, which were most abundant in 1967 samples (39.6 and 23.0 percent respectively), continued dominant.

Echo-sounder and sonar surveys in Div. 4X and 5Y were carried out in March, April, and November. Large numbers (300-500) of schools were located on each cruise, but most probably contained less than 5 tons. A few large schools (3,000-12,000 tons) were observed in Div. 4X in March and in Div. 5Y in November.

Continuing studies of the optical appearance of otolith nuclei from herring in Div. 4T show that this method of separating spring- and autumn-spawning components of the stock is unreliable.

Condition (fatness) studies showed no consistent relationship between mean length and percent fat for any area. Seasonally, there is a rapid increase during May and June but little change thereafter. The lowest values were obtained in April (3.2 percent). From July to November, mean fat content ranged from 11.8 to 13.8 percent. The seasonal variation in fat content is somewhat greater for spring spawners than for autumn spawners.

9. Mackerel. Sampling for size and age composition from commercial landings in Subarea 4 continued. Mean lengths of 26.2 cm in Div. 4X, 33.3 cm in Div. 4W, and 35.7 cm in Div. 4T, support the hypothesis that there are three distinct size groups of mackerel in Subarea 4 during the summer months.

10. Swordfish. Research on this species is reported under Subarea 5.

11. Atlantic Salmon. Recently increased smolt taggings have been extended to additional rivers and stocks to better determine salmon utilization. Hence, total recapture data should be treated cautiously in making year-to-year comparisons. However, total figures presented here include all recent smolt tagging in Canada.

From 63,000 tagged smolts liberated in 1965 (1,090 adult recoveries) and 87,000 liberated in 1966 (795 adult recoveries), approximately 12 percent of the recoveries were made in West Greenland, about 40 percent as large salmon in Canada and 45-50 percent as grilse in Canada.

From 128,000 tagged smolts liberated in 1967 there have been 457 recoveries, for which the ratio of recaptures in West Greenland:grilse in Canada is 1:10.

Nearly 165,000 tagged smolts were liberated in 1968.

12. Scallop. A research submarine was used for *in situ* studies of scallop populations in the Northumberland Strait (Div. 4T). Densities of scallops and other species were measured. Scallops are aggregated into discrete beds with densities in excess of 3/sq m.

Studies on the survival of scallop discards, returned to bottom in cages, revealed that 2-4 hours exposure on deck resulted in 50-100 percent mortality.

III. Gear and Selectivity Studies

Acoustic echo-counting equipment was used along with experimental fishing to obtain information on distribution of fish aggregations. The equipment counts the echoes from each transmission in a vertical column from the seabed to approximately 20 m above bottom. This column can be subdivided to give vertical as well as horizontal fish population distributions. Data from tests carried out on the Scotian Shelf and in the Gulf of St. Lawrence are being analysed by mathematical consultants at the University of Toronto. Their findings are being used to modify the equipment and develop survey techniques.

IV. Miscellaneous Studies

Studies on an unfished population of American plaice in St. Margaret's Bay have confirmed that the stock is almost completely isolated from stocks on the Scotian Shelf, for, of 8,000 tagged, only 3 were returned from outside the bay; 200 from inside. The stock size is of the order of 2 million fish or 1/16 m^2. The greater part of the biomass and production occurs between 30 and 40 fath. In shallower water they compete with winter flounders.

Subarea 5

A. Status of the Fisheries

I. Cod

Canadian mainland landings of cod were 15,127 tons in 1966 and 8,523 tons in 1967. Landings in 1968 were probably about the same as in 1967.

II. Haddock

Landings of haddock on the Canadian mainland were probably slightly lower than the 13,625 tons landed in 1967. Landings in both years are considerably lower than the 18,960 tons landed in 1966.

III. Scallop

Landings of scallops from Georges Bank of about 40,000 tons (4,810,000 kg meats) decreased slightly from the 1967 catch of 42,000 tons. As in 1967, effort was concentrated on the northeastern edges of the bank; number of days fished were similar in both years. The number of vessels in the offshore fleet was 49 compared to 48 in 1967. Landings from Subarea 6 were about 3,500 tons.

IV. Herring

Canadian landings were almost certainly more than double the 6,500 tons reported in 1967. Increased catches consisted mainly of adult herring from Div. 5Z and the southern part of Div. 5Y.

V. Swordfish

About 40-45 percent of the total Canadian swordfish landings (4,500 tons) probably came from Subareas 5 and 6 and appear to have shown little change from 1967.

VI. Tuna

Incidental catches of several species by swordfish fishermen are included in the report for Subarea 4.

B. Special Research Studies

I. Biological Studies

1. Scallop. Scallop catch statistics continued to be collected from offshore fleet log records and catches were assigned to 10-min squares for Georges Bank. Collaboration and exchange of Georges Bank and Subarea 6 scallop data with the U.S. Bureau of Commercial Fisheries continues.

2. Herring. Research was restricted to studies of larval abundance and distribution reported under Subarea 4.

3. Swordfish. Research was concerned chiefly with life history and ecology with emphasis on distribution and abundance, food and feeding habits, and recruitment. Commercial landings have been relatively stable for the past 3 years, but swordfish less than 50 pounds, dressed weight, now constitute a much larger proportion of the catch. These small fish may belong to a previously unexploited size class but there are indications of a general reduction in the size composition of the stock. Larval swordfish were collected for the first time near the Windward Islands in the Caribbean Sea, suggesting that spawning occurs in the Guinea Current system.

4. Miscellaneous. The migrations of large pelagic fishes continue to be of interest: 265 sharks, 74 tunas, and 25 swordfish were tagged and released during the year. Six tags were recovered, three of them from yellowfin tuna in the tropics -- two released in 1967 in the Gulf of

Guinea and the other in 1968 in the Bay of Guayaquil. Two blue sharks and a swordfish were also recaptured, the latter of special interest since it was the first return of a new type of harpoon tag.

Subarea 5

B. Special Research Studies

I. Biological Studies

5. Short-tailed Squid. An otter-trawl survey was made on the continental shelf from Georges Bank to North Carolina in August and September. *Illex* squid were taken in all sets except for four in 25-100 fath in Raleigh Bay, N.C. Largest catches were obtained off Cape May and Chesapeake Bay, the greatest number in a half-hour set being 740. Total catch for the cruise was slightly over 4,000 specimens, most of which were of the same size groups normally fished at this time of year in Newfoundland.

A study of the systematics and biology of the sepiolid squids of the genus *Rossia* in the Canadian area was completed.

Subarea 4

A. Status of the Fisheries

Harp and Hood Seals

Canadian catches of harp seals (preliminary figures) were 56,600 young and 4,600 older animals, a decrease from 91,000 young and 5,000 older animals in 1967. The decrease in catch of young followed a change in the opening date for the fishery to March 18 from March 7, with no change in the quota of 50,000 young animals permitted to be taken by ships and aircraft south of 50°N Lat. Hood seals remained totally protected.

Study of age samples of migrating entrant harp seals showed adequate to strong survival of recent age classes following a mean kill of young animals of 88,000 in 1965-1967 inclusive, three years when the quota has been in force with the same opening date. Only following a kill of 110,000 young seals in 1963 has survival of the corresponding year-class been markedly depressed.

B. Special Biological Studies

II. Harp and Hood Seals

(1) Sampling of southward migrant harp seals continued from two shore stations in January. As well as age frequencies, the mean age at first reproduction of females was computed, and it fell from near 5 years in previous years to 4.3 years, suggesting that recent kills averaging 88,000 young annually are near sustainable yield for the population of harp seals in Subarea 4. (The catch of older seals in Subarea 4 has always been low and is here disregarded.)

(2) From March 7 to 17, prior to the start of the fishery, 2,200 young harp seals were tagged from helicopters around the Magdalen Islands and early post-natal natural mortality was studied. Small numbers of adult female harp seals were tagged or branded, and small numbers of young branded. A visiting Norwegian scientist collected blood samples from adult females and young for serological studies. Under permit, visiting Canadian investigators collected

(over)

twenty live young for studies in aquaria, and made anatomical and biochemical studies of seals on the ice. Also under permit, personnel of the Canadian National Museum collected animals for habitat groups of harp and hood seals.