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Canadian Research Report, 1970

A. Subareas 1, 2 and 3

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B. Subareas 4 and 5

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A. SUBAREAS 1, 2 AND 3

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

Data on Canadian landings from the ICNAF area were not available when this document was prepared and any landings data used are preliminary, usually for Newfoundland only, and are only approximately similar to the data which will be reported to ICNAF in May-June.

Subarea 1

A. Status of the Fisheries

As far as I know at the present time, there was no Canadian fishery in this subarea.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies. Combined hydrographic and geophysical surveys were carried out in Baffin Bay with the *Hudson*.

II. Biological Studies

1. Atlantic salmon, *Salmo salar* L. Work at Greenland and on the high seas was continued during two *A. T. Cameron* cruises. From 6 to 23 April drift nets and longlines were fished in the Labrador Sea, resulting in a catch of 52 salmon of which 27 were tagged. A further 322 salmon were taken and 147 tagged in the Davis Strait and Labrador Sea in September and early October. On both cruises, material was collected for morphometric and meristic studies, blood chemistry, parasite investigations and food studies. At West Greenland, comparative fishing was undertaken with the Danish RV *Adolf Jensen*.

Of 385 salmon tagged from drift nets by the *A. T. Cameron* in the West Greenland and Labrador Sea areas (mostly from Disko Bay) in September to early October 1969, 15 fish were recaptured in 1969, 14 in West Greenland and 1 in Newfoundland. In 1970, 12 recaptures were reported from this tagging, 2 from West Greenland, 5 from Canada, 2 from England, 1 from Scotland and 2 from Ireland. Overall returns from this experiment amount to 7.0% of the fish tagged. However, if returns are grouped by condition of the fish when tagged, they are as follows: fair condition - 0, good condition - 5.0%, excellent condition - 12.7%.

Fishing was carried out with drift nets and longlines by the *A. T. Cameron* in the Labrador Sea in April and in the Labrador Sea and Davis Strait in September-October 1970. The results of fishing on these and previous cruises allow some generalizations concerning seasonal distribution of salmon in the sea between Canada and Greenland. In spring, salmon are present outside the pack ice off Labrador, at least as far north as Cape Chidley (about 60°N), as far south as the southern tip of the Grand Bank (about 43°N), and in the Labrador Sea extending more than halfway between the coasts of Labrador and West Greenland. Almost all the fish taken in these areas in spring exhibit 2 sea winters on the scales. In late summer and autumn, salmon are present along the West Greenland coast between Cape Farewell (about 60°N) and Umanak (about 70°N), and are also found in small numbers in the Davis Strait as far west as 80 nautical miles from the coast of Baffin Island and also in the Labrador Sea about halfway between southwest Greenland and Labrador. These fish are almost all of age 1+ sea years. Since salmon have been taken by research vessel in the mid-Labrador Sea in spring, summer and autumn, it is possible

that a number of salmon remain in this area during their seagoing phase, without migrating to or from the Greenland coast.

Preliminary analysis of scale characters, specifically measurements of annuli and counts of circuli of scales of Atlantic salmon smolts, indicate that it may be feasible to distinguish some stocks of Atlantic salmon by this method using a discriminant function analysis. By applying the method to samples of smolt scales from Sand Hill River, Labrador and River Almond (Tay System), Scotland, it was possible, using the width of each of the first two river zones and the number of circuli in each zone, to separate 85% of the smolts from these areas ($P > 0.50$). Seventy-eight percent of the Almond River smolts and 74% of the Sand Hill River smolts were identified with a probability greater than 0.80. However, when the method was applied to 220 scale samples of Atlantic salmon caught in West Greenland during *A. T. Cameron* cruise 164, 1969 and separated initially on the basis of electrophoretic studies, only 63% of the American and 76% of the European salmon were identified.

Preliminary analysis of stomach contents of Atlantic salmon suggests that salmon were feeding heavily and almost continuously during August-October in the Labrador Sea, Davis Strait and coastal areas of West Greenland and during May-July in Newfoundland and Labrador coastal areas. Salmon examined from Chaleur Bay, the Miramichi estuary and Saint John estuary, New Brunswick, during 1970 had all ceased feeding except for about 5% of the fish which had taken such items as smelt, herring, alewives, three-spined sticklebacks and had some partly-digested fish material in their stomachs. The main items of diet (in terms of volume) in the coastal areas of West Greenland, Newfoundland and Labrador were capelin, launce, amphipods and euphausiids. Other items of incidental importance were redfish fry, Greenland halibut fry, herring, Arctic cod, Atlantic cod, polar sculpin, Arctic squid and alligatorfish. In the Labrador Sea and Davis Strait the main items of diet were Arctic squid and paralepids, plus some unidentified fish remains.

Studies to determine whether parasites are useful in separating stocks of salmon caught on the high seas continued in 1970. Emphasis was placed on a comparison of the abundance of the larval nematode *Anisakis* sp. and the adult tapeworm *Eubothrium crassum* in 2-sea-winter salmon caught in

home waters in 1970 with 1-sea-winter salmon caught in Greenland in 1969. In 1969, biochemically-identified North American salmon caught in West Greenland contained an average of 4.5 *Anisakis* larvae per host while European salmon in the same area contained 7.1 larvae. Thus, parasitological evidence supported the biochemical separations. In 1970 the mean number of *Anisakis* in 665 2-sea-winter salmon (tentative age assignments) from eight sampling stations in Canada was 4.5; that of 40 Irish salmon was 6.3. These data lend further support to biochemical identifications of North American and European salmon in Greenland. However, available evidence indicates that the difference in abundance of *Anisakis* in salmon from both sides of the Atlantic may be too small to be of value as a primary means of stock separation.

The variation in abundance of *Anisakis* in different Canadian samples in 1970 was much less than in 1969. Practically all samples (except Bay of Fundy) in 1970 had means (range 4.2-4.9) very similar to the mean observed in North American salmon in Greenland the previous autumn. The Bay of Fundy (Saint John area) had only 2.9 larvae per host.

When the abundance of *Anisakis* in Canadian salmon (caught in 1969) was compared with the hosts' sea ages, the mean number of *Anisakis* present was found to increase during the salmon's first three years at sea (1st = 2.5, 2nd = 3.8, 3rd = 6.9). Also the similarity of means for salmon caught in home waters (in 1970) to those for salmon caught in Greenland the previous autumn suggests that few if any *Anisakis* larvae are acquired by the salmon during the winter and spring feeding activities. Means for samples of 1-sea-winter salmon showed most variability; they ranged from 1.4 (East Shore, Bay of Fundy) to 8.2 (Labrador) and were sometimes higher than those of older fish in the same samples. This variation may be related to more restricted movements and different feeding habits of the grilse. The mean total length of *Anisakis* specimens also increased with the sea age of the salmon. This is related to the permanent nature of these worms and indicates that they continue to grow over an extended period in the salmon.

Previous studies indicated that *E. crassum* is found in a higher proportion of North American salmon in Greenland than in European salmon in the same area. In 1970 50% of more than 550 Canadian salmon were

infested. This is considerably higher than the proportion estimated for North American salmon in Greenland in 1969 (24%). Observed infestations are apparently not permanent as are those of *Anisakis*. The absence of *E. crassum* in 40 Irish salmon (caught in fresh water) is not comparable with the high proportion observed in Canadian salmon (caught at sea). There was no relationship between the sea age of the salmon and the rate of infestation with *E. crassum*. Also there is no apparent relationship between the proportion of salmon infested in Greenland and the proportion infested in home waters.

Subarea 2

A. Status of the Fisheries

I. Cod, *Gadus morhua* L.

Tagging experiments have shown that large numbers of cod found offshore in winter and spring move inshore in summer. Since the inshore and offshore fisheries are exploiting the same stock of fish, changes in the abundance of the stock or stocks offshore will be reflected in changes inshore. Since 1960, the European otter-trawl fleet has fished extensively the pre-spawning, spawning and post-spawning concentrations of cod in winter and spring. The offshore catch increased from 1960 to 1969. The inshore catch has fallen off sharply since 1967, having remained relatively stable until then only because the number of inshore fishermen had increased. The inshore population, however, has been steadily declining since 1954 as shown by a decreasing catch per man per year. It might be expected that a reduction in the abundance of the stock would be reflected more in the inshore than the offshore fishery because the inshore gears are restricted in area fished whereas the offshore fleet is mobile and has efficient fish-finding capabilities. May (ICNAF Research Bulletin No. 4: 67-75, 1967) attributes an increase in the growth rate of cod caught by inshore fishermen in Labrador in the period 1955-66 to the reduction of the stock by the intense offshore fishery of recent years. In addition the average sizes of cod taken by trap have decreased in recent years.

Because of lack of research vessel time the usual sampling of the Labrador coastal fishery for lengths and ages was not carried out.

An unusually large catch of 3-year-old cod was taken by the *A. T. Cameron* on the southern part of Hamilton Inlet Bank in May; this is a good indication that the 1967 year-class is strong. These cod averaged about 25-30 cm in length (1,630 kg, 12,500 fish in a 30-minute set with a No. 41 Yankee net with a 24.1 m headline) and will not be of commercial size for several years. No large catches of commercial-sized cod were taken.

II. Harp and hood seals, *Pagophilus groenlandicus* (Erxleben) and *Cystophora cristata* (Erxleben)

The fishery started on 22 March. The Canadian catch of young harp seals in Subareas 2 and 3 consisted of 37,000 whitecoats and ragged jackets and 21,000 beaters, or 58,000 young seals in all. Nine thousand older harp seals were also taken and 2,000 hood seals.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies. The standard section off Seal Island was occupied in early August. See the research document on hydrography of the Newfoundland area for details (Res. Doc. 71/22).

II. Biological Studies

1. Cod. In 1970 the inshore cod fishery was reported to be particularly poor. Biological observers from the Station accompanied the M.V. *Lady Anna* which was sent to the Labrador area by the Industrial Development Branch to obtain information on the fishery. Bottom water temperatures at the usual hydrographic stations were low and in addition capelin were not abundant in the inshore areas. Rapid fouling of nets by "slub" was also a factor which tended to produce low catches. The "slub" was identified by the Biology Department of Memorial University as being composed mostly of the diatom *Chaetoceros socialis*.

The low catch in the inshore cod fishery off Labrador in 1970 is attributed to the reduction of the stock by the intense fishery of

recent years, but may have been made even lower by unfavourable biological and hydrographic conditions inshore.

"Virtual population" analyses on Division 2J cod indicated that fishing mortality values (F) for ages 4-13 increased from 0.06 in 1959 to 0.35 in 1961 and 0.40 in 1962 and then decreased to a level of 0.28-0.34 during 1963-66 except in 1965 when F increased to 0.52 for one year only because of a high proportion of older fish in the catches. Cod are first recruited to the otter-trawl fishery in this area in significant numbers (5%) at age 4, are 50% recruited at age 6 and are fully recruited at age 8.

2. Atlantic salmon. In April 1970, 5 drift net sets and 2 longline sets were made in the Labrador Sea. Twenty-seven salmon were tagged, 22 from drift nets and 5 from longlines. All 3 returns were from the Canadian mainland.

3. Atlantic mackerel, *Scomber scombrus* L. Mackerel were reported to be abundant in the Strait of Belle Isle during August-September 1970 and were plentiful as far north as Domino and Cape Harrison during late August. This is the second year in succession that mackerel have occurred in relative abundance in southern Labrador coastal waters compared with previous years. During 1969 mackerel were taken at Black Island, Labrador (53°46'N), considerably north of Triangle Harbour, the previously authenticated northern range limit. The occurrence of mackerel at Cape Harrison during August 1970 represents an even farther northward extension of their range.

4. Harp seal. Aerial survey showed about 120,000 harp seals whelping on the Front. Estimates made by aerial photographic survey are usually too low. Comparison of the strength of the one-year-old age-class with the catch of young of the same year-class suggests a production of 180,000 young on the Front in recent years. The analysis is reported in Serial No. 2476, Canada's contribution to the mid-term seal assessment meeting at Charlottenlund, 25 January 1971.

Subarea 3

A. Status of the Fisheries

I. Cod

Canadian landings from Subarea 3 were not available when this

report was written and only general accounts of the status of the fisheries can be given from Newfoundland landings only. Total cod landings in Newfoundland were about fifteen percent less than in 1969. This was principally due to a poor inshore cod fishery especially in Labrador and on the northeast coast of Newfoundland.

Cod landings from the inshore fishery at Twillingate (Division 3K) in the summer of 1970 were substantially lower than in 1969 for the corresponding period, 27 May-10 July. Handline fishing was almost non-existent whereas about 35 part-time fishermen were handlining in 1969. Also, many of the larger boats capable of fishing in water up to 360 m were concentrating on Greenland halibut, American plaice and witch flounder whereas formerly the main fishery was for cod.

In Division 3L, observations were carried out during the summer periods of maximum fishing intensity at Bonavista and St. John's on the east coast and Admirals Beach in St. Mary's Bay. Boats which had been engaged in the deepwater fishery with longlines off Bonavista since 1952 have changed to gillnets almost completely this year because of greater success with this gear in catching the variety of species which the processing plants now accept. Cod, American plaice, Greenland halibut and wolffish are being landed, with species other than cod amounting often to 50% of the catch. In the 1950's only cod were landed. The change in fishing and landing practice is a combined result of the decrease in the abundance of large cod and of the processing plants now being able to accept a greater number of species. Landings at Bonavista and St. John's in the peak June-July period were 15-20% lower than in 1969 and continued at a low level throughout the remainder of the year. However, trap landings in Admirals Beach were much higher in June than in 1969.

Rough weather was a severe hindrance in late summer and autumn, reducing the number of fishing days considerably. Squid for bait was again lacking as only very small quantities appeared in the coastal waters.

II. Haddock, *Melanogrammus aeglefinus* L.

Newfoundland haddock landings at about 2,070 tons, and probably mainly from 3Ps, were slightly lower than 1969 landings of 2,435 tons.

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

Newfoundland landings from Subareas 4 and 3, mainly from 4R, increased to about 41,600 tons from 31,900 tons in 1969.

IV. American plaice, *Hippoglossoides platessoides* (Fabricius); Witch flounder, *Glyptocephalus cynoglossus* (L.); Yellowtail flounder, *Limanda ferruginea* (Storer); and Greenland halibut, *Reinhardtius hippoglossoides* (Walbaum)

Newfoundland landings of American plaice fell slightly to 63,000 tons from 67,000 tons in 1969. Landings of witch flounder rose to 8,800 tons from 6,100 tons in 1969. Landings of yellowtail flounder increased greatly to 20,000 tons from 6,000 tons in 1969.

Newfoundland landings of Greenland halibut decreased to about 11,200 metric tons from 11,900 tons in 1969.

V. Herring, *Clupea harengus* L.

Herring landings in Newfoundland, mainly from the inshore area of the western part of Division 3P, fell slightly to 158,000 tons from 163,000 tons in 1969.

VI. Atlantic salmon

Newfoundland landings of Atlantic salmon from the commercial fishery rose to 1,740 tons from 1,440 tons in 1969.

VII. Capelin, *Mallotus villosus* (Müller)

Capelin landings in Newfoundland almost entirely from the coastal area of Subarea 3 at 3,440 tons were slightly greater than those of 1969, 3,340 tons.

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

Squid were very scarce and only 75 tons were landed.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic Studies. The five standard sections across the

continental shelf and Labrador Current were occupied at the usual times in July-August using the Fisheries Protection vessel, *Cape Freels*. The year-round monitoring Station 27 off Cape Spear was occupied monthly or oftener throughout the year. The results of these hydrographic observations are presented in a separate document (Res. Doc. 71/22).

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, sexual maturity, spawning, food, location of catch and catch per unit effort.

For the east coast of Newfoundland, including ICNAF Divisions 3K and 3L, the bulk of the work for an analysis of the stock by the virtual population method has been completed. Estimates have been made or are being made of numbers of cod of each year-class present in the fishery by each of the inshore gears and for otter trawl. This work will be completed in 1971, and will cover the period 1955-68 in Division 3L and 1961-68 in Division 3K.

In the trap fishery in 3L, samples indicate that the 1965 and 1966 year-classes are the heavy contributors. In the gillnet catches, the 1962-64 year-classes contributed most heavily (over 50% of the numbers) at St. John's and Admirals Beach, whereas in Bonavista these year-classes were not as important as the dominant 1960 and 1961 year-classes.

Age determinations have been completed for 7,600 cod from representative samples taken in research vessel cruises in the northern Grand Bank area (ICNAF Subarea 3L), 1960-70, covering depths from less than 90 to over 550 m and various seasons of the year. A preliminary analysis shows that most of the cod caught were from 2 to 8 years of age in any one year, with 1- and 16-year-olds being the extremes. Year-class dominance was in evidence but the strongest did not exceed 30% of the total in samples of any year, and strength of an individual year-class was evident in samples for 4 to 5 consecutive years. Relatively strong year-classes in the samples were those of 1955, 1957, 1958, 1959, 1962, 1964, 1966 and 1968.

During an otter-trawl survey of ICNAF Division 3N in the spring of 1970, catches were composed almost solely of fish of the 1966-68 year-classes. Results indicate that the 1966 and 1968 year-classes were probably fairly good ones but the 1967 year-class seems to have been less abundant. Catches during a fall cruise were generally small and were composed almost solely of 1968 year-class cod.

Although no regular groundfish survey was conducted in Division 30 during 1970, bottom sets made during squid survey cruises in spring and early summer failed to produce significant catches of cod of any size.

The very strong 1964 year-class, which contributed to a three-fold increase in landings from 3N and 30 in 1967, seems to have all but disappeared from the fishery. The landings decreased in 1968 from the high 1967 level and in 1969 were only slightly above the 1966 level before the entrance of the 1964 year-class.

Indices of abundance of pre-recruit cod caught during research vessel cruises to St. Pierre Bank in the 1957-70 period were compared with those of new recruits to the Newfoundland commercial otter-trawl fishery in this area. Correlation coefficients of 0.88 indicated that the indices from research surveys could be used to predict relative abundance indices of year-classes entering the commercial otter-trawl fishery.

Analyses of length frequencies by depth zone in connection with this study indicated that young cod of 2-3 years of age (< 37 cm) remained in most years in the 90-180 m depth zone throughout the entire March-June period, although peculiar hydrographic conditions could alter this picture. Older cod, on the other hand, were confined to the 90-180 m depth zone during the winter-early spring period but moved onto the top of the bank in the 0-90 m depth zone during late spring-early summer, and some migrated to the Newfoundland coast in summer.

Relative strengths of year-classes determined from these abundance indices indicated that survival of the 1954-65 year-classes varied only moderately, with the weakest year-classes being only 75% less than the long-term 1954-68 average and the strongest year-classes being about equal to the average. The 1966 and 1968 year-classes appear to be considerably stronger than the average, and the 1967 year-class is slightly below average.

2. Haddock. Although no regular haddock surveys were conducted in the haddock areas of the southern Grand Bank (3N-O) in 1970, bottom sets made during squid survey cruises in spring and early summer failed to produce significant catches of haddock of any size. Indications are that the adult stock of haddock in this area is at a very low level and only small quantities of commercial-sized haddock can be taken. Catches of pre-recruits in recent years indicate that the most recent year-classes up to 1968 have been poor.

During a cruise to St. Pierre Bank (3Ps), fish of the 1966 year-class were still important contributors to the catches but catches of pre-recruit fish indicated that the 1969 year-class was probably a fairly good one. However, year-classes 1967 and 1968 seemed to be very poor.

Reports of quantities of haddock were received from several areas of the south and east coasts of Newfoundland, and early in the season contributed significantly to catches by codtrap.

3. Redfish. Echo-sounder surveys accompanied by baited handline fishing in 1969 have confirmed existence of large numbers of pelagic redfish almost continuously distributed from the northern part of the Grand Bank and southern Labrador to Greenland. These redfish (*Sebastes mentella*) were usually at the 140-270 m depth and were found over water from 370 m to over 2700 m. An echo-sounder survey by the *E. E. Prince* in July 1970 from Hamilton Inlet Bank to Flemish Cap showed almost continuous records from the edges of the slopes and over the intervening oceanic depths similar to those confirmed as redfish on previous cruises by the *A. T. Cameron*. Unfortunately during the *E. E. Prince* cruise attempts at identifying the source of the echoes as redfish were not successful and only on two occasions were fish taken from the depths at which the echo targets were most plentiful. Both of these were, however, *Sebastes mentella*.

4. American plaice and yellowtail flounder. Total mortality rates (Z) and natural mortality (M) were calculated for male and female American plaice from the northeastern and the southeastern Grand Bank. Calculations of total instantaneous mortality rates were made using two-year combinations of commercial catch curves. A comparison for the earliest and latest available data is as follows, with annual mortality rates in parentheses.

Northeast Grand Bank (north of 46°N)

	Males	Females
1955-56	0.35 (30%)	0.19 (17%)
1967-68	0.60 (45%)	0.45 (36%)

Southeast Grand Bank (south of 45°N)

	Males	Females
1957-58	0.36 (30%)	0.21 (19%)
1965-66	0.67 (49%)	0.44 (35%)

Estimates of natural mortality (M) by the Silliman method for the northeast Grand Bank were 0.24 for males and 0.14 for females and for the southeast Grand Bank 0.30 for males and 0.18 for females. The increase in total mortality reflects the increase in the rate of exploitation of this species since the fishery began in the early 1950's. A detailed assessment of this fishery is nearing completion.

A research cruise in June surveyed a series of lines on the southeast, east and northeast slopes of the Grand Bank and also the shallow central areas (3N and 3L). No large concentrations of juvenile flatfish were located. The best catches of commercial-size plaice were located on the eastern slope near 45°N where 800 kg were caught at 230 m in a ½-hour tow. The largest concentrations of yellowtail flounder were located just south of the Virgin Rocks (230-270 kg in ½-hour tow). Nearly every shallow water set (< 90 m) on the northern half of the Grand Bank produced at least 70 kg of this species.

A cruise in October to the Grand Bank north of 45°N (mainly 3L) indicated that the yellowtail had migrated from the northern half of the bank since the same stations that produced up to 230 kg in June all yielded less than 45 kg in October. Plaice catches were fairly similar for both cruises.

5. Greenland halibut. Of the 238 Greenland halibut tagged during October 1969 near the entrance to White Bay, Newfoundland, 5 were recovered during the early spring of 1970 by European trawlers northeast of Funk Island, roughly 145 nautical miles from the tagging site, and 2 were taken by inshore boats on the eastern side of Notre Dame Bay, 75-85 nautical miles from the tagging locality. The remaining 13 of the recoveries occurred within a 50-mile radius of the tagging site, all by longliners using gillnets.

All 5 offshore recoveries occurred during April and May and the inshore recoveries occurred during the July-December period. This suggests a winter migration to the continental slope for spawning.

6. Herring. In the autumn of 1969, studies were initiated to test the hypothesis that herring which over-winter in southwest Newfoundland migrate from the southern Gulf of St. Lawrence. Herring samples taken from seiner catches at Magdalen Islands (Bird Rocks) in early November just prior to the start of the fishery off southwestern Newfoundland were compared with samples taken a few weeks later off southwestern Newfoundland. Statistical analyses of eight biological characteristics (length, age, maturity condition, vertebral numbers, dorsal, pectoral and anal fin ray numbers and nematode incidence) indicate that the herring fished in both areas belong to the same stock complex. The samples from both areas consisted of similar proportions of two spawning stocks - about one-third spring spawners and two-thirds autumn spawners.

The 1969-70 samples for age determination, and those for the earlier seasons, were complicated by the presence of two basic spawning groups with autumn spawners constituting 69% of the seasonally weighted samples. The determination of ages from otoliths for fish with more than 9 growth zones is so unreliable that a 10+ grouping is used for the older fish. More than half of the autumn spawners had 10 or more growth zones and thus belong to year-classes spawned in the late 1950's, whereas fewer than one-third of the spring spawners belong to pre-1960 year-classes.

Preliminary analysis of age determinations for samples taken in the 1965-66 to 1968-69 seasons indicate that the purse-seine fishery since its beginning in 1965 has been based largely on herring of pre-1960 year-classes. During 1954-56 the herring populations in the Gulf of St. Lawrence were severely stricken with a fungus disease (*Ichthyosporidium hoferi*) and it is reported that probably more than 50% of the herring were destroyed. The resulting reduction in predation and competition for food may have been favourable to the production of good year-classes of herring in the late 1950's. Unless recruitment to the currently-exploited stocks soon increases considerably more than is apparent from the present data, the winter herring fishery along southwest Newfoundland must inevitably decline to a lower level than at present.

In an attempt to identify the various herring stocks contributing to the large fall-winter herring fishery in March 1970, 25,000 herring were tagged with internal stainless steel tags on the southwest coast of Newfoundland. Tag recoveries were reported from the meal-line magnets at the Isle aux Morts plant within a week of the commencement of tagging and, up to mid-December 1970, 559 tags were recovered from plants in southern Newfoundland and southern Gulf of St. Lawrence, representing a recovery rate of 2.2%. Seeding experiments at the Isle aux Morts plant indicated a recovery efficiency of 30%. The distribution of tag returns was as follows:

Area of recapture	Dates of recapture 1970	No. tags recovered
Southwest Nfld.	6 March-15 April	391
St. Pauls-Magdalens	16-30 April	51
Bird Rocks	1-15 May	13
Gaspé-Chaleur Bay-Bradelle Bank	26 June-20 October	90
Burgeo Area, Nfld.	3-19 December	4
Doubtful	-	10
		559

The significant feature of this recapture data is that the herring stocks which support the fall-winter fishery on the south coast of Newfoundland represent the over-wintering phase of a stock complex of herring derived from spring and fall spawnings in the southern Gulf of St. Lawrence.

Studies of the incidence and intensity of infestation of herring with larval *Anisakis* continued during 1970. Preliminary analyses of the occurrence of larval *Anisakis* in adult herring ($\geq$ 30 cm) indicate that this parasite is valuable as a biological indicator of stock heterogeneity. Incidence of infestation was higher in herring from southwestern and northeastern Nova Scotia (74% and 64%) and the Banquereau-Sable Island area (66%) than in herring from southwestern Newfoundland and the southern Gulf of St. Lawrence (25-29%). *Anisakis* incidence increased northwards along western Newfoundland to 61% in the Strait of Belle Isle. There was

a southward decrease in eastern Newfoundland to 8% in spring-spawning herring from Notre Dame Bay and thence an increase to 48% in herring along the eastern Avalon Peninsula. Both the incidence and intensity of infestation increased with fish age (size).

The intensity of infestation in herring from southwestern Newfoundland and the southern Gulf of St. Lawrence (about 0.50 nematodes per fish) is very low in comparison with eastern North Atlantic herring, particularly those from the North Sea. Even the highest intensities in the Canadian area (2.01 to 2.96 nematodes per fish) are comparable to the intensities in herring from Scotland and Ireland, which have been termed low by European investigators.

The remarkable similarity in *Anisakis* incidence in herring from the Magdalen Islands in the autumn and spring, from southwest Newfoundland in winter, and from the Gaspé area in summer supports the view that the fisheries in these areas at different times of the year occur on the same stock complex. Although only a few samples from Nova Scotian areas have been examined, the higher but similar incidence values for southwestern and northeastern Nova Scotia and the Banquereau-Sable Island area suggest a possible inshore-offshore migratory pattern on the Scotian Shelf and that these herring do not intermingle to any great extent with the more northerly Gulf of St. Lawrence-southwest Newfoundland stocks. From nematode abundance it appears that herring along the northwest coast of Newfoundland are also relatively distinct from southern Gulf-southwestern Newfoundland herring.

Studies on herring which over-winter along southwestern Newfoundland have revealed significant meristic differences between spring- and autumn-spawning herring. Mean numbers of gillrakers and of pectoral, anal and dorsal fin rays are all higher for autumn-spawning than for spring-spawning herring ($P < 0.01$), with gillraker and pectoral fin ray numbers exhibiting the greatest degree of difference between spawning groups. However, there is no significant difference between mean vertebral numbers of spring and autumn spawners of this population.

7. Atlantic mackerel. During 1970, approximately 900 mackerel were collected from Newfoundland coastal areas for studies of length, weight, sex, maturity, age and growth and feeding.

A sample of adult mackerel obtained from Placentia Bay during early July 1970 contained a high proportion of pre-spawning and spawning fish. This is the first documented capture of pre-spawning and spawning mackerel in southern or eastern Newfoundland waters and confirm the occurrence of at least sporadic mackerel spawning in southeastern Newfoundland as suggested by the presence of 0-group mackerel in Conception Bay during November 1968. Juvenile mackerel captured in Conception Bay during November 1968 were much smaller than those reported in late fall in the coastal waters of northeastern United States.

8. Capelin. Certain irregular zones that have been noted in the otolith structure of Newfoundland capelin resemble the descriptions of spawning zones or checks in other species of fish. These irregular zones are characterized by an accentuated translucent (winter) band followed by a narrow opaque (summer) band which in the younger fish is sometimes divided by a check. A comparison of the marginal zone of the otoliths of recovering-spent capelin at the end of their growing period in October and November with the marginal zone of the otoliths of pre-spawning, spawning and recently-spent capelin has demonstrated that these irregular zones represent spawning zones and that the well-defined winter band and narrow summer band are the result of the pronounced inhibition of growth due to spawning. A preliminary study has indicated that a few individuals survive to spawn three times; that on a percentage basis repeat-spawning is more common among females (average 30%) than amongst males (10%) and that on the average, repeat-spawners are smaller than first-time spawners of the same age.

9. Launce, *Ammodytes dubius* Reinhardt and *A. hexapterus* Pallas. Analyses of meristic and morphometric data of launce have revealed that the Grand Bank and St. Pierre Bank specimens are slender with relatively short heads and high meristic counts, whereas those from Trinity Bay and St. Mary's Bay are deep-bodied with relatively longer heads and low meristic counts. Consequently the offshore launce have been provisionally assigned to *Ammodytes dubius* and the inshore specimens to *Ammodytes hexapterus*. Differences in body form and meristics are also evident within these two groups, particularly in meristic characters of the inshore specimens.

10. Atlantic salmon. Additional returns were recorded from the 1969 tagging of 247 salmon out of 270 caught by drift nets of synthetic twine at Port aux Basques. Returns to 31 December 1970 amounted to 42.5% of the fish tagged. A previous experiment in 1937 with similar methods of obtaining the fish for tagging but with hemp instead of synthetic twine in the drift nets and a tag attached to the dorsal instead of immediately in front of the dorsal gave a return of 13.3% of the fish tagged. Distribution of returns from the 1970 tagging was as follows:

	Returns in 1969	Returns in 1970	Total	%
West Greenland	-	1	1	1
Labrador	-	1	1	1
W and SW Nfld.	22	3	25	24
Miramichi River & drift nets	34	2	36	34
Chaleur Bay	17	-	17	16
Gaspé & Anticosti	4	-	4	4
Quebec North Shore	15	3	18	17
Nova Scotia	3	-	3	3
Total	95	10	105	100

Twenty-one percent of the returns were from anglers. Fish were rated as fair, good or excellent condition when released, and percentage returns from each group were 26%, 45% and 43% respectively. Of the salmon tagged from monofilament nets, 49.1% were returned; the corresponding return of fish tagged from multifilament nets was 40.6%.

Two qualitative differences in the non-specific serum protein patterns of salmon were employed to differentiate between North American and European salmon.

Of twenty-five salmon in six samples taken by the *A. T. Cameron* in April 1970 just off the continental shelf of northeastern Newfoundland and southern Labrador, 52% were of European and 48% of North American origin. In 1969 for northern Greenland waters 43% were of North American origin. The European content of the Labrador-Newfoundland sample is unexpectedly high.

To find out just how close to shore European salmon might migrate, samples were gathered from Bonavista and St. Anthony, Newfoundland during the early summer. These fish were caught in shallow water just off the shore. Of the approximately 150 fish analysed, only one had protein patterns identical to the European control samples. This fish had five river years.

In August salmon sera were collected in Iceland. Thirty-four fish were sampled, 15 of which were from the State Experimental Fish Farm at Kollafjördur, north of Reykjavik; the remainder were from two rivers of Faxa Bay. All fish showed the European type of protein pattern.

11. Pink salmon, *Oncorhynchus gorbuscha* (Walbaum). Field work at North Harbour River associated with the pink salmon transplant was continued in 1970.

The estimated fry run in 1970 was 670,000, from spawning of 1,116 adults in 1969. Estimates of fry survival from the 1969 spawning were obtained from egg samples buried in plastic containers in the gravel of the main river (77%), by enumeration of fry at the mouth of the spawning channel from egg deposition by 7 females in 1969 (75%), and by a mark and recapture experiment during the fry run in the main river (72%). In each case, the estimate is slightly below that for 1969 (80, 78 and 76%).

To determine the extent of predation on pink salmon fry during their migration to sea, gillnets were fished near the head of tide at various times during the run. Stomachs of 135 brook trout, 28 brown trout and 310 smelt were examined. One smelt contained 2 fry in its stomach while 4 brook trout contained a total of 209 fry.

Returns in 1970 were an estimated 1,490 to the river plus 600 reported from other areas, mainly in the commercial fishery. These were the progeny of the natural spawning of 1,353 adults in 1968 (no eggs planted since 1966). The first recorded return at the fence was on 15 July, and the last on 14 September. The fence was extensively damaged by flood conditions on 8 August and again on 11 August and was inoperative during most of the period between 8 and 14 August. The total count of adults through the fence was 316; the estimated number of 1,490 was calculated on the basis of redd counts after spawning was complete, the ratio between number of redds and number of females counted in 1969, and the sex ratio of the 316 fish

actually counted in 1970. With the exception of a few late-running fish, spawning occurred from 8 to 25 September, mainly 15-20 September, and was distributed over the lower 5½ km of North Harbour River and 1 km of a tributary (Cataract Brook). At the beginning of the spawning period, 100 male and 101 female salmon were transported to the spawning channel (most spawning takes place in the main river below the mouth of the channel). Reports from other areas were as follows: 568 fish from the commercial fishery, of which 80% were from St. Mary's and Placentia bays on the Newfoundland south coast (North Harbour River empties into St. Mary's Bay), and the remainder almost entirely from the Newfoundland northeast coast. Twenty-five fish were sighted in other rivers in St. Mary's and Placentia bays, 6 fish angled from scattered Newfoundland areas, and 1 fish taken at a counting fence at Indian River on the northeast coast.

Twelve egg samples were placed in plastic containers in the gravel of the main river. Development was more rapid than in the previous few years (with hatching on 13-19 November, compared with 5-9 December in 1969 and 9-20 December in 1968).

12. Short-finned squid. Previous research has indicated that the populations of squid which are commercially exploited in Newfoundland inshore waters during the summer and fall months migrate from the south and appear on the continental shelf off southern Newfoundland and Nova Scotia in spring, prior to their arrival inshore. Two cruises were conducted in these areas to study the distribution, abundance and biology of the northward migrant squid, with special reference to characterizing populations from size distributions, maturities, parasite burden and polymorphic proteins.

During the first cruise (*A. T. Cameron*), fifty 30-minute otter-trawl sets were run from 22 May to 2 June on 12 lines of stations running from 100 to 370 m. Squid were taken in 11 sets in numbers ranging from 1 to 390. The only squid taken south of Newfoundland were 390 specimens at the mouth of the Haddock Channel; most specimens were taken on the southern part of the Scotian Shelf and were smaller than those on the Newfoundland banks.

During the second cruise (*E. E. Prince*), 56 otter-trawl sets were run 23 July-4 August in the same areas fished on the previous cruise. Squid were taken in all areas except the southern tip of the Grand Bank. Most catches ranged from 1 to 50 specimens with larger catches being taken in the Haddock Channel (350 and 204 specimens) and the southwestern part of the Sable Island Bank (146 and 207 specimens). Squid were generally smaller on the Scotian Shelf but maturities were further advanced in the larger males.

B. SUBAREAS 4 and 5

Canadian researches in Subareas 4 and 5 on oceanography and fish stocks were carried out by the Fisheries Research Board from the following establishments: the St. Andrews Biological Station, the Marine Ecology Laboratory (Dartmouth), the St. John's Biological Station, and the Arctic Biological Station (Ste. Anne de Bellevue). The Bedford Institute of Oceanography of the Department of Energy, Mines and Resources also contributed to these research efforts.

Reports on studies by many scientists whose names appear in the list of Canadian scientists engaged in work concerned with ICNAF problems were used in preparing this report. Raw data for preliminary summaries of 1970 landings were obtained from the Canadian Department of Fisheries and Forestry.

Subarea 4

A. Status of the Fisheries

I. Groundfish general

A strike by fish handlers at various Canadian mainland ports in March and April and a strike by fishermen at three ports in eastern Nova Scotia from May to December markedly affected Canadian mainland groundfish landings. We estimate that the former strike reduced landings by about 12,000 metric tons and the latter by 20,000 metric tons. Total reduction is about 12% of total Canadian mainland landings. Pro-rated over actual landings for 1970, the species breakdown for "lost" landings is approximately (in metric tons):

Cod	-	12,800
Haddock	-	2,900
Redfish	-	7,800
Flatfish	-	5,000
Others	-	3,500

II. Cod

Mainland landings declined by 4% from 1969 but made up about 40% of total weight of groundfish landed. Cod landings from Div. 4R-S-T and 4Vn continued their trend upward from 1967. Cod landings from Div. 4Vs, 4W, and 4X decreased by 23% from 1969 and 44% from 1968 levels. This decrease is partially attributed to strikes and closure of an area in Div. 4X in March and April. In addition, larger units of our mobile fleet are spending less time in these areas due to poor availability of haddock and possibly cod.

III. Haddock

Haddock landings, declining since 1967, dropped sharply by 40% from the 1969 level and were only half that of 1968. Slight gains were registered from Div. 4R-S-T and 4Vn. However, these are not really significant since haddock landings from all these areas account for less than 4% of the total. Divisions 4W and 4X show large declines of about 43% in each. Some of this decline resulted from diversion of effort from haddock to other species, mainly cod, flounder, and redfish in Div. 4V and 4T, and some resulted from the strikes.

IV. Flatfish

Total landings of flatfish (plaice, witch, yellowtail, winter flounder) were about 8% below those of 1969. This decline seems definitely a result of the strike at ports in eastern Nova Scotia. At these ports in 1969 flatfish comprised over a third of their landings and contributed about 25% of the total mainland flatfish landings.

Generally, increases were registered in Div. 4R-S-T, 4Vn, and 4X, while the remainder of the area showed decreases.

Atlantic halibut landings were down by 23% from 1969, but this may reflect a reduction in effort rather than a change in abundance.

V. Redfish

The rising trend in landings begun in 1963 has continued, and the increase of 4% would have been much higher except for the strikes. Landings from Div. 4R-S-T were down slightly, but landings from 4Vs, 4W, and 4X increased. This suggests that, due to poor availability of haddock in the latter Division, some trawlers fished deep water for redfish more often than in previous years.

VI. Pollock

Pollock landings were down by 20% from 1969. Since most of these are caught in Div. 4X and 4W, the decline may result from decrease in effort in these areas.

VII. Other groundfish

Other groundfish include hake, cusk, wolffish, unspecified or mixed groundfish. Together, they comprise about 5% of the total landings. Hake and cusk are important to several localized inshore fisheries, the former in Div. 4T and the latter in Div. 4X. Landings of these two species showed increases in 1970.

VIII. Sea scallop, *Placopecten magellanicus* Gmelin

Total landings remained around the 1969 level at 14,200 metric tons whole weight (1,702,000 kg meats). A decline in landings to 3,860 metric tons in Div. 4X was offset by an increase in landings from Div. 4T to 9,400 metric tons. A new event was the landing of some Iceland scallops (*Chlamys islandicus*) from Div. 4T, 4V, and 4W. Since most scallops are shucked at sea, it will be difficult to distinguish landings of this species from those of *Placopecten*.

IX. Herring

Landings in Subarea 4 (excluding Div. 4R) amounted to 317,000 metric tons, about the same quantity as landed in 1969. Landings increased from 143,000 to 169,000 tons in Div. 4T, and from 6,000 to 17,000 tons in Div. 4W. These

increases were offset by smaller landings in Div. 4X: 132,000 tons in 1970 compared with 170,000 tons in 1969 (and 280,000 tons in 1968). The increases and decreases can be related in part to changes in fishing effort although in Div. 4X it is evident that abundance has declined. Landings from all regions are expected to be lower in 1971.

X. Swordfish

Canadian swordfish catches which are all landed in Subarea 4 amounted to nearly 5,000 tons in 1970, an increase of about 700 tons over 1969. The catch by Subarea was (approximately): Subarea 3, 1,900 tons; Subarea 4, 1,200 tons; Subarea 5, 1,300 tons; Subarea 6, 600 tons. Fishing records indicate that both availability and effort were somewhat greater in the eastern part of the range (Subareas 3 and 4) in 1970. Mean size of swordfish landed continued to decline, but this chiefly reflects the large numbers of small (<20 kg) swordfish taken in Subareas 5 and 6. Because of high levels of mercury in swordfish flesh, there is unlikely to be a fishery in 1971.

XI. Mackerel

Landings in Subarea 4 (excluding Div. 4R) were nearly 15,000 metric tons, an increase of 2,000 tons (15%) over 1969. Landings from Div. 4W and 4X were about 10% less than in 1969, but this decrease was more than offset by increases in the southern Gulf of St. Lawrence and its approaches (Div. 4T and 4V). Evidence from all Subarea 4 regions indicates a substantial increase in the abundance of mackerel in the northern part of its range.

XII. Tuna

Total Canadian landings of tuna in 1970 amounted to slightly more than 3,900 metric tons, about 40% of which (1,560 tons) came from a reactivated fishery for small bluefin and skipjack off the coast of New Jersey (Subarea 6). Incidental landings of bluefin, bigeye, yellowfin, and albacore from swordfish vessels were approximately 300 tons.

The remainder (2,100 tons) was a mixture of yellowfin and skipjack from the eastern Pacific and the Gulf of Guinea. Except for the virtual certainty that incidental landings by swordfish fishermen will disappear in 1971, no reliable forecasts for the tuna fishery can be made.

XIII. Sharks

Landings of several species amounted to 7.6 metric tons, about the same as in 1969.

XIV. Atlantic salmon

Total catch, commercial and angling, for Subarea 4 (exclusive of Div. 4R) declined to 575 tons from 670 in 1969 and 804 in 1968. Commercial catch in Div. 4S-T-V-W decreased by 10% from 1969 but rose in Div. 4X by 20% (catch 44 tons). The angling catch (79 tons) was about half that in 1969. Grilse again comprised 60% by numbers of angled fish.

XV. Harp and hood seals

The fishery started on March 20. The Canadian (also the entire) catch in the Gulf of St. Lawrence (Div. 4R-S-T) was 45,000 whitecoats and ragged jackets, and 11,000 beaters or 56,000 young seals in all. In addition, less than 1,000 older harp seals were taken. Hood seals are protected in the Gulf of St. Lawrence.

B. Special Research Studies

I. Environmental Studies

1. Hydrographic studies. A numerical study of the M_2 tide and tidal streams in the Gulf of St. Lawrence (Div. 4R-S-T) was completed. Circulation pattern there, deduced from salinity and temperature observations, were also correlated with the pressure systems in and around the Gulf area. The detailed observations in the Gaspé–Bradelle Bank (Div. 4T) area reported previously were analysed, and the drogue movements

agreed with the geostrophic calculations, although no gyres were observed. The observations program in that area was repeated in November 1970 for a tighter network of stations and with a computer on board so that preliminary analysis could be done in ship time. The observations were partly repeated after 2 weeks, and the oceanographic conditions were completely changed, pointing to the danger of combining observations so far apart in time. Current observations during that period are being analysed.

A study of the response of the Scotian Shelf water to hurricane "Gladys" was done, taking into consideration the partition of energy among different scales of motion and the apparent concentration of energy near the Shelf edge. A general study of the response of the Shelf to meteorological conditions is continuing.

Studies of different inlets around Nova Scotia (Div. 4V and W) continued, including Chedabucto Bay, Canso Strait, Petpeswick Inlet, Halifax Harbour, Bedford Basin, and St. Margaret's Bay.

2. Plankton studies. A four-year study of the relative abundance and seasonal distribution of herring larvae in the Bay of Fundy (Div. 4X) and Gulf of Maine (Subarea 5) was completed in 1970. The program consisted of four seasonal cruises each year, extending over a 1200-mile cruise track, with plankton hauls, temperature and salinity observations, releases of drift bottles and seabed drifters at about 90 locations for each cruise.

Preliminary analyses suggest that, although there were differences between years, especially in total numbers of larvae caught, the general pattern was similar each year. Herring larvae were abundant in autumn, considerably less in winter and spring, and virtually absent in summer. Distribution of newly hatched larvae indicated two important spawning areas:

the northern edge of Georges Bank (Div. 5Z), and the southwest coast of Nova Scotia (Div. 4X). For both areas the significant spawning is in autumn. These autumn-hatched larvae grow slowly, reaching a length of 30–45 mm by spring.

The main features of surface circulation in the region are variations in the southwest drift along the coast of Maine and in exchange of surface waters between the Bay of Fundy and the Gulf of Maine. Both are associated with the northerly drift along the west coast of Nova Scotia and with formation and disappearance of the Gulf of Maine eddy.

Surface circulation undoubtedly influences distribution of herring larvae and it appears that larvae from southwest Nova Scotia spawnings are held within the Bay of Fundy and its approaches. There were no recoveries of drift bottles released in the southern part of the study area and hence nothing can be said about the effect of surface circulation on the eventual fate of larvae produced on Georges Bank.

In 1970, analyses of a herring larval survey were completed for the Scotian Shelf (Div. 4V-W). Field studies of recruitment of cod and other species in Div. 4T by means of egg and larval surveys continued but at a reduced level.

3. Other environmental studies. A program of environmental survey and monitoring was begun for the Gulf of St. Lawrence (Div. 4R and T) by a special cruise to assess pollution levels by sampling the water column, biological organisms and sediments through the Gulf, Estuary, and River.

Charts of sea surface temperature, layer depth, and selected bathythermograms for Subareas 3, 4, 5, and 6 were prepared and broadcast daily by the Maritime Command Weather Office of the Canada Forces.

II. Biological Studies

1. Groundfish general. Research-vessel survey methods were reexamined and revised during 1970 and a new stratified random method developed for groundfish populations extending from Div. 4X to Div. 4T. Annual quantitative groundfish otter-trawl surveys were extended to encompass the entire Bay of Fundy (4X), the Scotian Shelf (4V-W-X), and the southern Gulf of St. Lawrence (4T). These surveys were coordinated with comparable surveys by the USA and USSR, forming part of a survey program extending from Cape Hatteras (Subarea 6) to Banquereau (Div. 4V).

2. Cod. Continuing population studies in Div. 4T showed 4- and 5-year-old fish predominating in landings. Numbers of prerecruit cod and other commercial species in the autumn trawl survey (Div. 4T) indicated adequate recruitment to the 1971 fishery.

Analysis of the Div. 4X cod fishery indicated that the rapid increase in landings in the 1960's resulted mainly from development of an offshore, predominantly Canadian, otter-trawl fishery on Browns and LaHave Banks. Abundance (by weight) of the exploited stock declined 30% between 1965 and 1969. The level of fishing mortality from 1965 to 1969 ($F = 0.70$) was considerably above that giving maximum sustainable yield-per-recruit.

3. Haddock. Assessment of the eastern Scotian Shelf (Div. 4V-W) haddock stock indicated that the traditional, mainly Canadian, fishery on adults has been exploiting this population close to its maximum yield-per-recruit under present mesh regulations. Impoverishment of the 1961-64 year-classes by the greatly increased fishery in 1965-66, combined with recruitment of several naturally poor year-classes, resulted in the present low adult stock abundance.

The average abundance in 4V-W of 1954-59 year-classes at ages 1–3, from research-vessel surveys, is significantly correlated to their abundance estimated from Canadian commercial fishery statistics at age 4. From tentative predictions of year-class strengths, and assuming that fishing mortality remains at about F = 0.50, the total population available to the fishery will decline further from 25 million fish in 1969 to 20 million in 1972 and yield from 9,000 to 12,000 tons. Prerecruit surveys in 1970 gave no indications of improved recruitment prior to 1974.

Most recent studies of the Div. 4X haddock fishery indicate that the ICNAF annual quota of 18,000 tons annually for 1970–72 is much too high to prevent serious stock decline. Recruitment to this fishery has been poor since 1963, and prerecruit surveys in 1970 gave no indication of significant improvement.

Studies of spawning period and fecundity of haddock showed that peak spawning in Div. 4X-W stocks occurred about the last week in April in 1970.

4. Silver hake. Studies of gill parasites in this species were concluded and are being reported; there was no evidence that the parasites were useful as biological indicators.

5. Northern sand launce. Meristic and morphometric studies of launce continued in an effort to characterize populations and relate characteristics to environment. Experimental fishing indicated that catches may vary with tidal flow, probably as a result of the behaviour of the fish in relation to tidal currents.

6. Food resource and digestion rates. Studies on seasonal changes in gross energy content of major natural fish foods have been virtually completed. While many species showed no regular seasonal fluctuation in calorific value, some crustaceans changed seasonally by as much as 48% of their annual minimum value. The euphausiid, *Meganyctiphanes norvegica*, showed significant annual differences in energy content as well as regular seasonal change.

For young cod acclimated at 5, 10, and 15°C and fed 0.4 g (dry weight) of euphausiid and shrimp, the time taken to empty their stomachs was: for euphausiids 29, 15, and 13 hours; for shrimp 58, 25, and 20 hours.

7. Herring. Studies of herring stocks show that the 1968 "sardine" year-class on the New Brunswick side of Div. 4X was apparently poor and that of 1969 seems poor also. Stocks in the Nova Scotia region of Div. 4X are being maintained by the 1966 year-class. In the Gulf of St. Lawrence (Div. 4T) the exploited herring stock was made up of a high proportion of older fish. The scarcity of younger recruits indicates that a period of lower catches will likely follow.

In Div. 4T, 56,000 herring were marked with internal metal tags, from commercial traps at the Magdalen Islands and from purse seines off Gaspé. Recaptures in 1970 numbered 497. Seeding experiments with tags introduced directly into the fish plants gave average recovery rates of 28%. Thus, the 497 recaptures are probably less than half the number actually taken.

The pattern of tag recaptures shows a migration of herring into and out of the Gulf of St. Lawrence. The returns suggest that, whatever the spawning type, the herring at times occur together in the same general area and the same populations of fish contribute to three major fisheries: off the Magdalens and off Gaspé in Div. 4T, and off Newfoundland in Subarea 3.

Meristic analysis of Bay of Fundy herring (Div. 4X), especially the "sardine" component, suggests that the New Brunswick and Nova Scotia stocks might be distinct. The conclusion that Nova Scotia (Div. 4X) herring and those of Georges Bank (Div. 5Z) are discrete is reinforced by these results.

8. Swordfish. Preliminary tagging results suggest that swordfish may return to the same area of the continental shelf each year and tend to remain there all summer. The

results also show a tenfold increase in the return rate of harpoon-tagged, free-swimming fish compared to that of fish released from longlines.

9. Tuna. Size data for bluefin tuna show that the 1969 year-class was strong in the New Jersey Subarea 6 fishery during August, with the 1967 year-class dominating September landings. The 1966 year-class apparently did not contribute to the fishery, although some older fish were caught.

Large bluefin have been increasingly abundant in the more northern parts of their range, including Div. 4T. This may be associated with warmer than average surface water (0.5–1.5°C above the mean), particularly during the summer warming period. Such early warming may be important in determining the distribution of bluefin forage species, and hence the subsequent occurrence of this predator species.

Continuation of a sonic tagging program in cooperation with the Woods Hole Oceanographic Institution resulted in temperature-telemetering sonic transmitters being attached to 8 large bluefin. Seven of these fish were followed for up to 56 hours and 130 miles, all but one leaving St. Margaret's Bay, N. S., where they were tagged. Data demonstrating regulation of body temperature by these fish were obtained.

10. Atlantic salmon. About 137,000 hatchery reared and 37,000 wild smolts were tagged and liberated in stock evaluation and utilization studies. Over 3,000 adult salmon and grilse were tagged and liberated in fishery areas or as they entered and ascended rivers.

Drift-net tagging of Atlantic salmon was carried out in the Miramichi drift-net fishing area (Div. 4T) in June and July; 384 fish were caught and 304 of these tagged. Returns of tagged grilse (20.9%) were lower than returns of tagged larger fish (47.3%). Slightly higher returns were

obtained from salmon tagged after capture in monofilament, as opposed to multifilament, nets.

Tag returns for wild Miramichi smolts tagged from 1964 through 1968 show: 52% as grilse in Canada (15% to commercial fisheries, 19% to angling, 18% escapement), 10% from Greenland, 38% as large salmon in Canada (33% to commercial fisheries, 3% to angling, 2% escapement).

Returns as large salmon only (1965-68 liberations) show: 24% off Greenland area, 9% in Newfoundland, 52% in Miramichi area commercial fisheries, 4% in other mainland fisheries, 7% by inland angling.

Returns as grilse from a group of wild smolts given a subacute dosage of DDT were only half as great as from a group given similar handling but without DDT.

Recruitment in mainland rivers to the 1970 under-yearling class was low in most sample areas. This reflects decreased numbers of adults, especially 2-sea-year and older females. Available data indicate still lower adult runs in 1970.

Pollution in rearing areas from forest operations and mines was associated with lowered production of young. Industrial pollution from pulp mills and wood-treatment plants was accompanied by slower upstream passage of ascending salmon, as shown by tracking individual fish, and by simultaneous water quality studies.

Using biochemical techniques, genetic polymorphism was shown to exist for blood transferrins of Atlantic salmon. Different gene pools appear to be characteristic of different areas, large river systems, and possibly even parts of some river systems.

Returns from five lots of hatchery reared smolts of selected 2-sea-year parents included 63% as 2-sea-year fish and 37% as 1-sea-year fish. Returns from four lots of hatchery reared smolts from 1-sea-year parents gave 61% as 1-sea-year and 39% as 2-sea-year fish.

11. Harp seals. Aerial survey showed about 65,000 harp seals whelping in the Gulf. Estimates made by aerial photographic survey are usually too low. Capture-recapture tagging corrected for distribution of tagging and sealing suggested about 80,000 young seals born in the Gulf in 1970. Comparison of the strength of the 1-year-old age-class with the catch of young of the same year-class suggests a total production of 265,000 young for the whole population and 180,000 young for the Front in recent years, leaving 85,000 for production in the Gulf. The analysis is reported in Serial No. 2476, Canada's contribution to the mid-term seal assessment meeting at Charlottenlund, 25 January 1971.

Orientation of young harp seals was studied in the Gulf by experimental release and short-term tracking of 25 1-month-old animals in various parts of the Gulf in April 1970. The animals consistently moved into the wind, showed no clear pattern of activity under windless conditions, and moved towards an icefield at 20 m distance only. Although wind patterns in April 1970 would have allowed the animals to migrate correctly by moving into the wind, the same is not true for other years. Two distant tag recoveries from the released experimental animals, up to 1 year of age, showed that their subsequent migratory behaviour was normal.

III. Gear and Selectivity Studies

Continued development and trials of acoustic echo-counting equipment have been carried on. This has proved to be successful for demersal surveys, and studies are in progress to determine usefulness in guiding commercial operations.

The acquisition of quantitative data on the behaviour of commercial types of groundfish otter trawl and the development of verified engineering principles for the rational design of new trawls remain the current aim of fishing gear engineering research. A procedure, based on recognized engineering

principles, was developed for extending the information available from data already obtained. Experimental information, after primary reduction, provides simultaneous quantitative data on: wing spread, headline height, hydrodynamic (stagnation) pressure in the mouth of the trawl, four bridle tensions at the wing tips, warp tensions, and warp angles at the towing block, vessel speed through the water, towing velocity over the sea floor, ocean currents, and structural details of each trawl.

The above engineering procedure will also provide from these experimental data: detailed shape of the headline and footrope involving estimated load distributions, resolution of each of the four wing-bridle tensions into three force components (drag, transverse, and vertical), detailed shape of the wing bridles and ground warps, three components of ground-warp tension at the doors, detailed shape of the towing warps, three components of towing-warp tension at the doors, door spread, transverse or spreading force produced by the doors, and the vertical force exerted by the doors on the sea floor. These synoptic statements of simultaneous data taken for fifteen different trawl constructions at speeds ranging from 2.5–5 knots should provide enough factual information to check most hypotheses concerning the distribution of stresses in and the shape of the "working gear" of otter trawls.

Subarea 5

A. Status of the Fisheries

I. Cod

Canadian mainland landings of cod, at an estimated 2,500 tons, declined by 57% from 1969.

II. Haddock

Landings of haddock for the area were down by 53% from 1969. Over 19,000 metric tons of haddock were landed by mainland Canada from this area in 1966. In 1970, the landings were estimated at 1,900 tons.

III. Sea scallop

Landings from Div. 5Z continued to decline and the 33,400 tons whole weight (4,024,000 kg meats) landed were 8% lower than for 1969. The decline resulted despite addition of four vessels to the Canadian offshore fleet. A small recruitment to the fishery, within a limited area on the Northern Edge of Georges Bank, was fished intensively. The remaining effort was distributed over the rest of the Northern Edge, and in deeper water off the Northeast Peak. A survey at three principal Canadian ports in May–August 1970 showed a significant difference between ports in meat size landed. Analysis of log records suggested that this reflected an underlying difference in area fished by boats from these ports. Vessels from two of the ports concentrated on the area of recent recruits and landed meat sizes were around 101 and 95 meats/kg. Boats from the third port (landings averaging 57 meats/kg) fished pockets of larger scallops to the exclusion of the area of recent recruits.

IV. Herring

The Canadian fishery continued at a relatively low level at about 3,800 tons. Most of the catch was made in the southern part of Div. 5Y.

V. Swordfish

Landings for the whole ICNAF area are included in the section on Subarea 4. However, catches in Subareas 5 and 6 were approximately 1,900 tons, about 38% of the total.

B. Special Research Studies

I. Biological Studies

1. Scallop. A research cruise to the Northern Edge of Georges Bank (Div. 5Z) in June used a modified scallop drag with attached underwater camera to estimate a standing stock of approximately 1.4 million kg of scallop meats within the 80 square nautical mile (274 km^2) area of the recruitment concentration. Population densities within the area averaged

more than $1/m^2$ and were considerably higher than those observed elsewhere.

Experiments on size selection for scallops were carried out within the area of high density small scallops.

2. Herring. A successful international project to survey Georges Bank (Div. 5Z) spawning beds by submersible, involving the USA, Canada, and the USSR, was carried out in late September and early October. The Canadian contribution was the use of the 8-ton submersible *PISCES* which traversed herring egg beds, resulting in the collection of valuable information on the physical structure of the beds, their faunal characteristics, and on the herring populations using them.