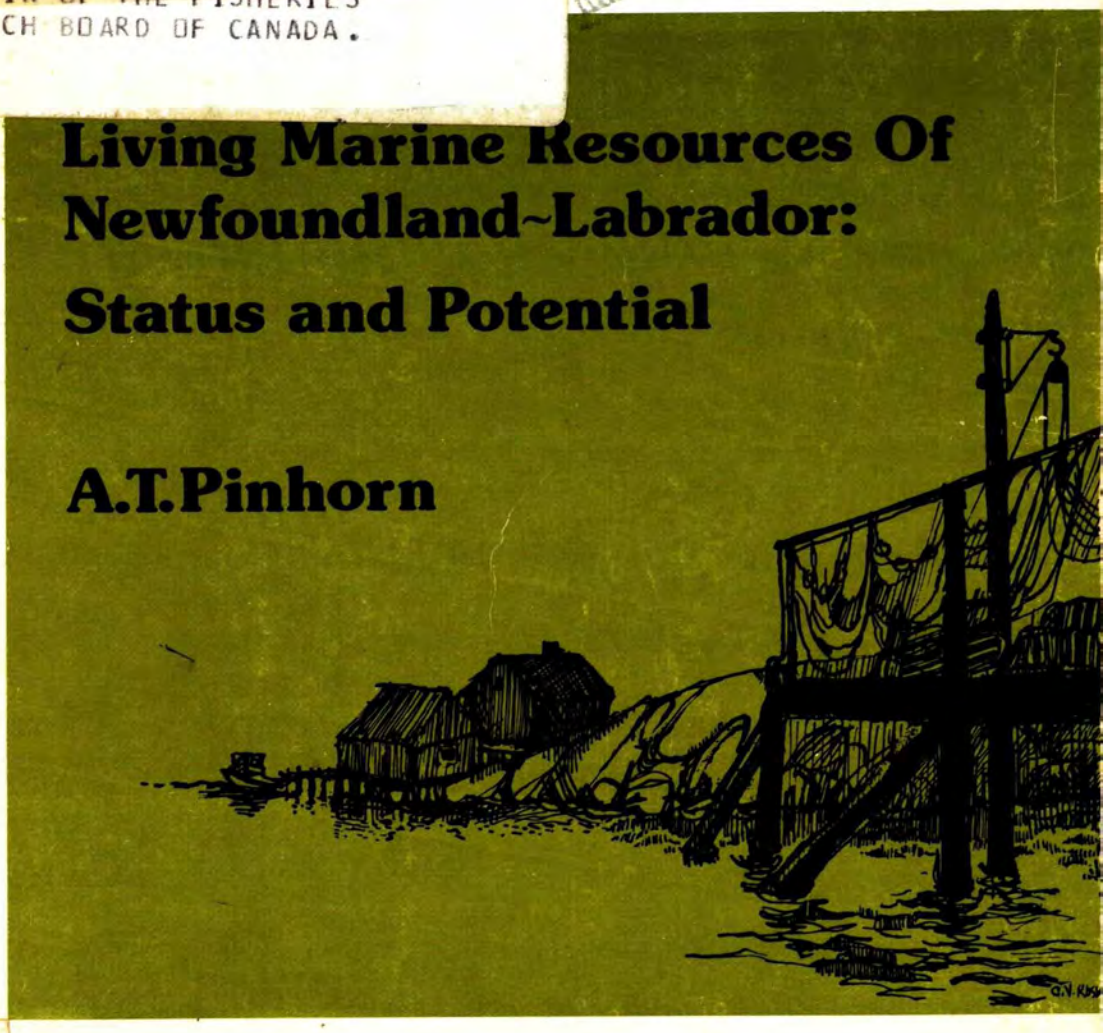
Bulletin of the Fisheries Research Board of Canada

Living Marine Resources Of Newfoundland~Labrador: Status and Potential

A.T.Pinhorn



BULLETIN 194
Ottawa 1976

Environment Canada
Fisheries and Marine Service

Environnement Canada
Service des pêches et des sciences de la mer

Living Marine Resources of Newfoundland~Labrador:

Status and Potential

Bulletins are designed to interpret current knowledge in scientific fields pertinent to Canadian fisheries and aquatic environments. Recent numbers in this series are listed at the back of this Bulletin.

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Catch of flatfish and deck of a modern stern trawler fishing on the Grand Bank.
(Reproduced courtesy of W. D. Brakel)

BULLETIN 194

(*La version française est en préparation*)

Living Marine Resources of Newfoundland-Labrador:

Status and Potential

Edited by
A. T. Pinhorn

Department of the Environment
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Abstract

PINHORN, A. T. [ed.] 1976. Living marine resources of Newfoundland–Labrador: status and potential. Bull. Fish. Res. Board Can. 194: 64 p.

Knowledge on the marine fisheries resources of Newfoundland and Labrador to 1964 was summarized in Bulletin 154 of the Fisheries Research Board of Canada. Additional information, which has become available since that time, is summarized here. Scientific basis for regulating and managing the international fisheries in the Newfoundland and Labrador area through the International Commission for the Northwest Atlantic Fisheries (ICNAF) is also discussed.

Current information is presented for all species that presently support or have potential for supporting commercial fisheries in the area. Detail given varies depending on the present extent of knowledge and previous coverage of the species. It is presented on a species-by-species basis and, when possible, on a stock-by-stock basis within species. Pertinent information is given on the distribution, abundance, general biology, and fishery of each species, especially where this was not previously covered. Also, since in the late 1960s and early 1970s regulations of one form or another have been introduced for many species, an extensive treatment of the management regime for such species is presented. Potential for increased catches from all these resources is summarized.

Résumé

PINHORN, A. T. [ed.] 1976. Living marine resources of Newfoundland–Labrador: status and potential. Bull. Fish. Res. Board Can. 194: 64 p.

Le Bulletin 154 de l'Office des recherches sur les pêcheries du Canada réunissait sous une forme condensée l'état de nos connaissances sur les ressources de la pêche, à Terre-Neuve et au Labrador, en 1964. Le présent Bulletin résume les connaissances additionnelles que nous avons acquises depuis. Il traite de plus des fondements scientifiques de la réglementation et de la gestion de la pêche, dans la zone internationale de la région de Terre-Neuve et du Labrador, par la commission internationale des pêcheries de l'Atlantique nord-ouest (ICNAF).

Le bulletin donne les renseignements les plus nouveaux sur chaque espèce ou quand c'est possible, chaque population de poissons pêchés commercialement dans la région, ou qui pourrait l'être, et la nature des données varie, selon l'état de nos connaissances, actuel et antérieur. Les renseignements portent sur la distribution, le nombre et la biologie générale des poissons de chaque espèce, de même que sur le rendement de la pêche de ces poissons. Ces renseignements sont plus étoffés si l'espèce était antérieurement peu connue. De plus, comme depuis la fin des années 60 et le début des années 70, plusieurs espèces sont protégées par réglementation on trouvera des détails sur les formes de gestion qui s'appliquent à elles. Pour chacune des espèce on donne un aperçu des possibilités d'augmenter le rendement de la pêche.

Introduction

A. T. Pinhorn

Available knowledge on the marine fisheries resources of Newfoundland to 1964 was summarized previously by Templeman (258). Since then, additional information has become available on several species. For a number of then unexploited or underexploited species (e.g. queen crab, shrimp, herring, etc.), more knowledge is available as a result of considerable research in recent years. For other species (e.g. groundfish), for which considerable knowledge was available, detailed assessments of the level of the maximum sustainable yield (MSY) and current stock status were recently completed in relation to quotas established at annual meetings of the International Commission for the Northwest Atlantic Fisheries (ICNAF). For some other species, little or no additional research has been conducted and the information presented here is summarized from Templeman's Bulletin with only recent statistics updated. Since repetition of the previous Bulletin has been kept to a minimum, the reader is referred to it for further details on some species.

Much of the research conducted on marine fishes off Newfoundland and Labrador is aimed at providing estimates of the MSY for various stocks. This simply means the maximum average annual catch of fish that can be sustained by a given stock over a long period with a given recruitment pattern. A stock is a group of fish of a given species that occupies the same geographical area, has the same migratory pattern, and mixes within itself to a far greater extent than it intermixes with other groups. For management purposes, stocks must be so defined that the effects of a fishery on one stock are confined to that stock and are not significantly reflected in any other stock. In regulating a fishery on a given stock, provided it has not already been severely depleted by fishing, the actual catch in any year can be greater than the MSY in years when larger than average year-classes (survival from spawning stock) recruit to the fishery, and less when smaller than average year-classes recruit. However, over the long term, average of the catches will approximate the MSY. If the stock has been depleted, then obviously some catch less than the MSY will be taken when regulation is initiated to allow for rebuilding of the stock, but the catch will approach the MSY as it rebuilds.

Catch quota limitation is the primary regulatory tool of ICNAF in attempting to obtain the MSY from Northwest Atlantic fish stocks. For species under catch quota regulation by ICNAF, the total allowable catch (TAC) is, for the purposes of this Bulletin, defined as the maximum catch recommended by ICNAF scientists, which can be taken from a stock in a given year, whereas the catch quota is defined as the actual catch allocated by the International Commission and may sometimes be different from the TAC for other than biological reasons.

Three meetings of ICNAF have been of particular importance to Newfoundland: Annual Meeting — June 1972, Annual Meeting — June 1973, and Special Commission Meeting — January 1974. From these three meetings, almost all stocks of fish that support directed fisheries in the Labrador–Newfoundland area were put under catch quota regulation for the first time. Most quotas established at these meetings were based on the yield-per-recruit curves and set in each year as closely as possible to the level necessary to generate maximum yield-per-recruit from the curves. In other words, the catch quotas set for these species should regulate the fishing mortality at the level at which the long-term MSY is obtained.

All the yield-per-recruit curves have the characteristic shape of increasing rapidly from zero as the fishing mortality (hence fishing effort) increases, then levelling off at some higher level of fishing mortality. Increases in fishing effort beyond this levelling-off point produce little or no increases in yield-per-recruit and may even produce a decrease. Most curves have a recognizable maximum level of yield-per-recruit at some level of fishing mortality and it is at this level that the catch quota regulation aims to fix the fishing mortality (F_{max}). However, some curves (e.g. flatfish) have no recognizable maximum but

continue to increase slowly to high levels of fishing mortality. In these cases, the catch quotas are aimed at regulating fishing mortality at a level ($F_{0.1}$) defined as the level at which the increase in yield obtained by adding a unit of effort is one-tenth that obtained in a lightly fished stock. This level generally occurs at about 90% of the maximum yield-per-recruit for species that have recognizable maximum yield-per-recruit levels. Yield-per-recruit management schemes do not allow for effects of fishing on spawning stock size and, hence, stock recruitment relationships. Maintenance of adequate spawning stock, if such were known, would be a different management objective and might imply different catch quotas.

At the Annual Meeting, June 1974, except for two new quotas on squid and mackerel, revised quotas were recommended for 1975 on all stocks under quota regulation in 1974.

However, the method of allocating quotas among countries differed in subsequent years from that used in 1972. At the 1972 Annual Meeting quotas were set for the 1973 fishing season by the now commonly known 40:40:10:10 formula. Also, the quotas applied only to the ICNAF Convention Area, defined as the area outside territorial waters. For the purpose of the ICNAF Convention Area, territorial waters refers to the area inside the 3-mile limit as it existed in 1949 when the Convention was signed. The procedure of allocation was as follows: from the total quota to be allocated among nations, the estimated catch outside the Convention Area (inside 3-mile territorial limit) was subtracted. The remaining catch was shared among all countries fishing the stock on the basis of 40% for the average catch of each country during the most recent 10 years, 40% for the average catch of each country during the most recent 3 years, 10% for the coastal state, and 10% reserved for new entrants, special needs, and nonmembers.

At the 1973 Annual Meeting quotas were set for the 1974 fishing season by a different approach. The coastal state estimated the catch required for 1974 and this was subtracted from the total quota to be allocated. This coastal state required catch included both inshore and offshore catches and thus was different from the Convention Area distinction at the 1972 meeting. The remaining portion of the total quota was then divided among other countries (excluding coastal state) according to the basic formula 45:45:10 with some adjustments necessary for special needs of members. This formula operated in a manner similar to the previous formula with 45% based on the 1962–71 average catch of each country, 45% based on the 1969–71 average catch of each country, and 10% allowed for new entrants, nonmembers, and others.

Since the reliability of the MSY estimates varies from species to species, a system of coding with digits 1 to 5 has been used to indicate the degree of reliability. The digit 5 is used when the estimate of MSY is reliable and further research will not likely significantly change the estimate, 1 is used when it is little more than an educated guess, and digits 2 to 4 indicate increasing reliability. No code is used when no estimate of MSY is available. Figure 1 indicates the statistical divisions of the ICNAF Convention Area referred to in the text as ICNAF Subareas and Divisions. Figure 2 shows main areas and localities mentioned in the text. All references to tons in the text, tables, and figures are metric tons (1 metric ton(t) = 2204.6 lb). All weights are round, i.e. guts in, unless otherwise stated. For illustrations, descriptions, and general biological background of the various species, the reader is referred to (94) for various fish species, and to (24) and (142) for invertebrate species.

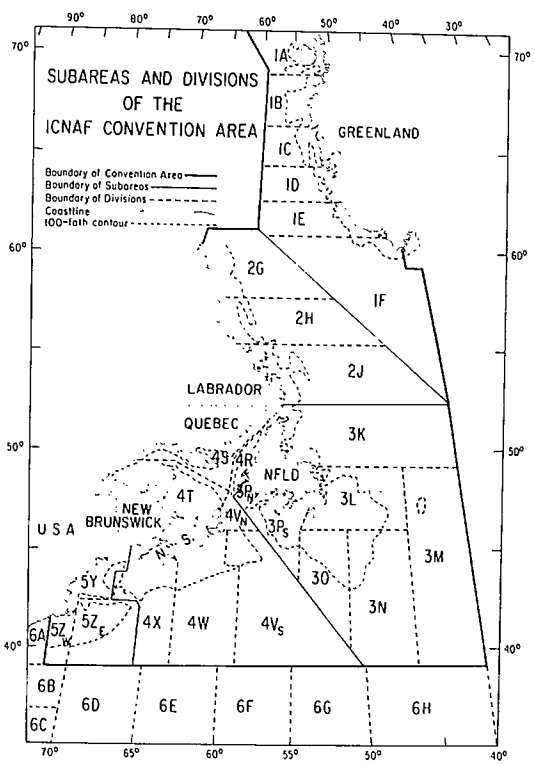

FIG. 1. Statistical divisions of the ICNAF Convention Area.

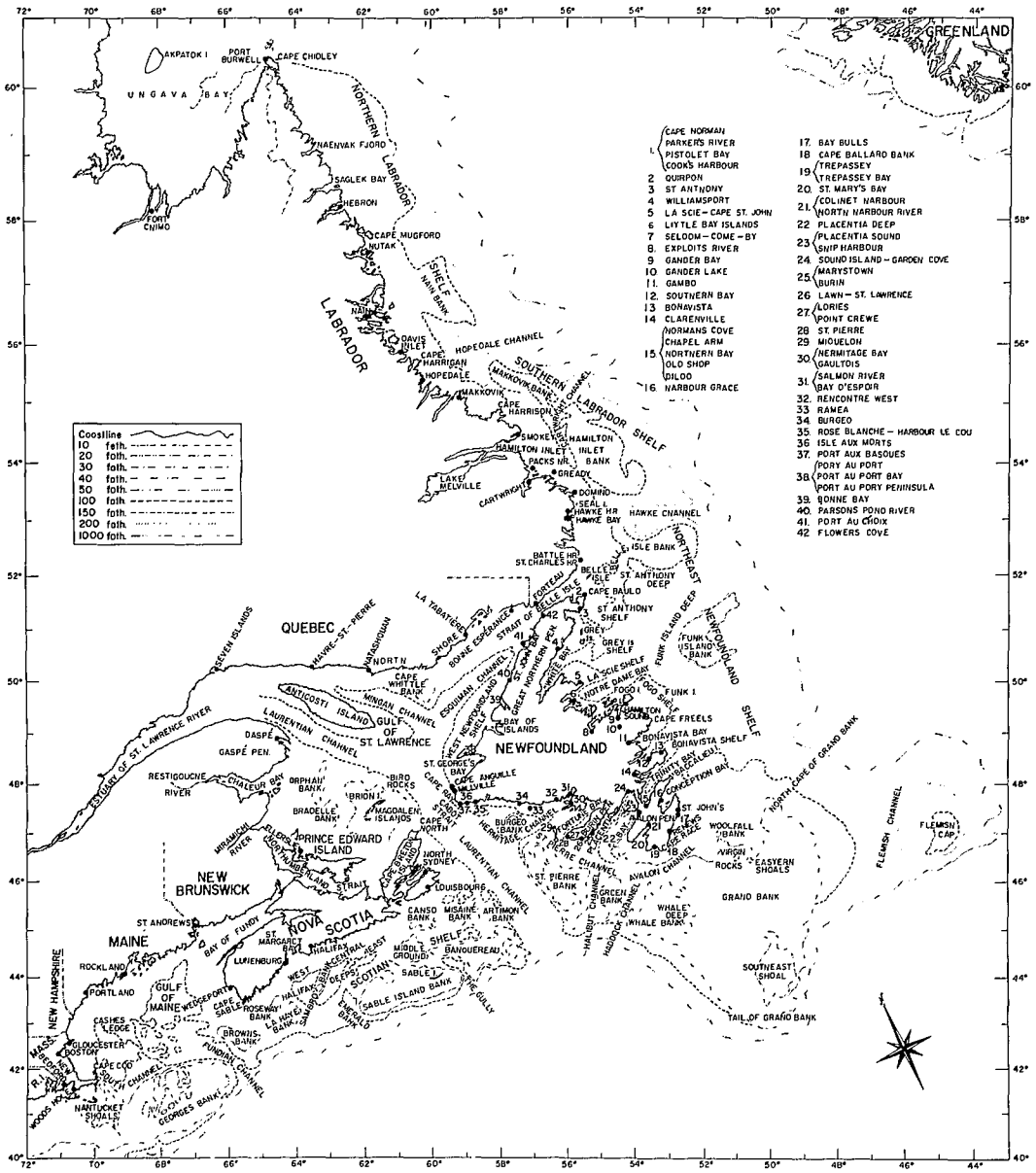

FIG. 2. Main areas and localities along the coast and continental shelf from Labrador to Rhode Island, mentioned in this Bulletin or important to fishery.

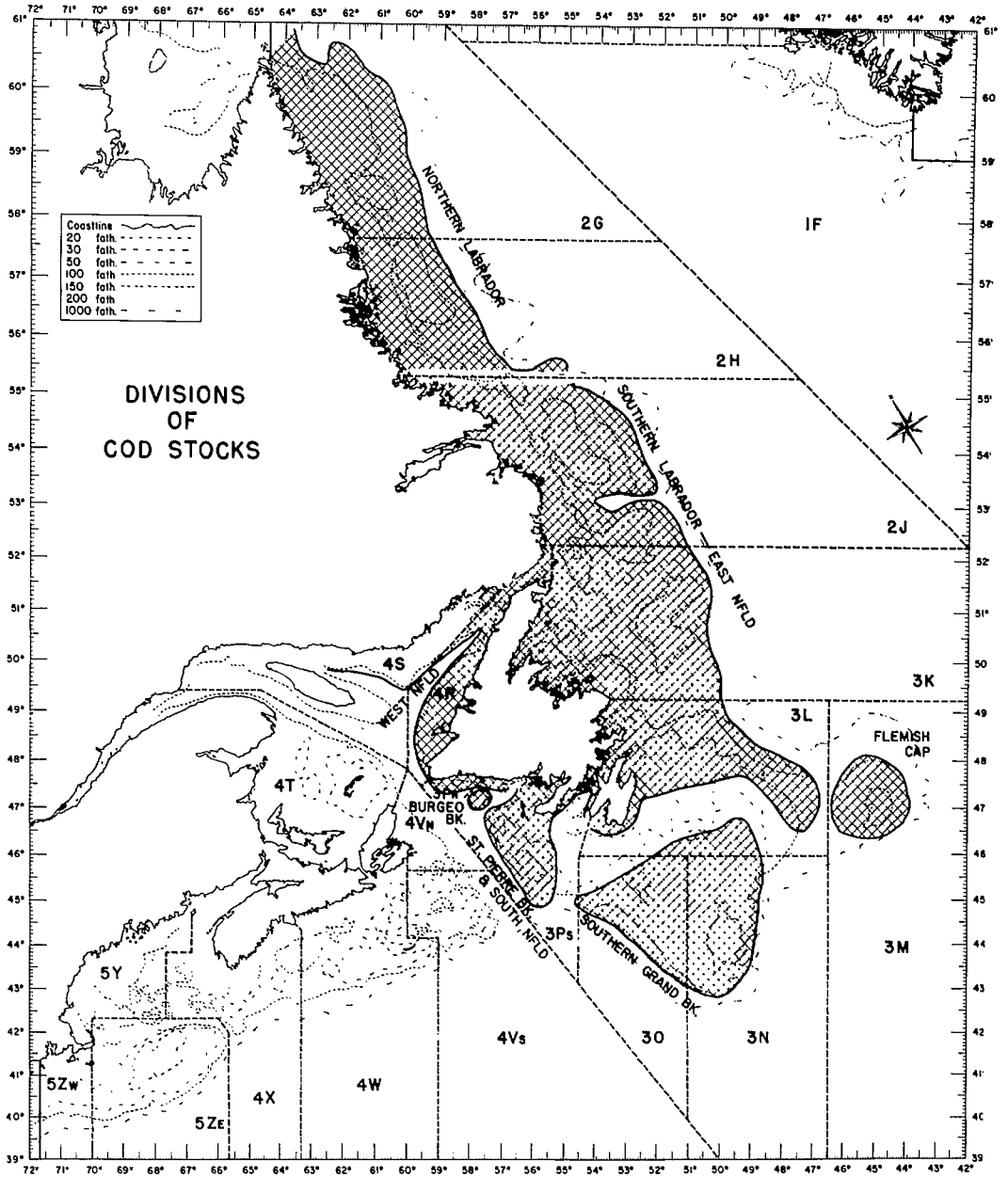

FIG. 3. Cod stocks in the Labrador–Newfoundland area.

Groundfish

Cod *Gadus morhua*

A. T. Pinhorn/R. Wells

Cod is the single most important species in the Labrador–Newfoundland area in terms of both landed weight and landed value; in 1974 the landed weight in Labrador–Newfoundland was about 70,000 tons(t) and the landed value $15 million. This was only slightly less than the landed weight of American plaice, yellowtail, and witch combined and 30% more than their combined landed value. In terms of employment, the inshore groundfish fishery, which relies heavily on cod as its most important species, employs approximately 10,000 persons.

There are basically six stocks of cod in the Labrador–Newfoundland area (Fig. 3). The largest is the Labrador–East Newfoundland stock complex extending from northern Labrador to northern Grand Bank. This is referred to as a complex because (although subdivision along biological lines is difficult due to the cline from north to south in such biological parameters as growth, vertebral numbers, age, and size at maturity, etc.) tagging in this whole area reveals that a large number of tagged fish are recaptured near the locality of tagging, with some movement throughout the area but, by no means constituting free mixing. The Flemish Cap stock is completely separate from the other cod stocks and is relatively smaller. The southern Grand Bank stock mixes somewhat with the southern part of the Labrador–East Newfoundland stock complex but contributes little to the inshore fishery. The St. Pierre Bank stock mixes somewhat with the southern Grand Bank stock to the east especially in winter, and the west Newfoundland stock to the west in winter, and supports the major portion of the south coast inshore fishery. The small Burgeo Bank stock is managed with this stock. The west Newfoundland stock overwinters on the western part of the southern coast area and mixes with Burgeo Bank and St. Pierre Bank cod at this time but moves into the Gulf of St. Lawrence in summer.

Total landings of cod from the entire ICNAF Convention Area (Fig. 4) increased from about 1,000,000 t in 1955–59 to a high of almost 2,000,000 t in 1968. Landings subsequently declined to slightly more than 1,000,000 t in 1970–72. Total Canadian landings and Newfoundland landings declined over this period, especially since 1968.

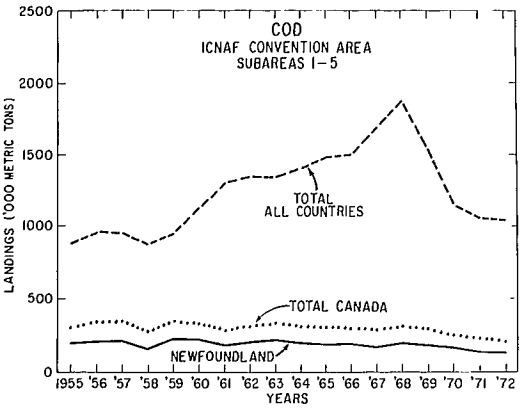

FIG. 4. Cod landings from the ICNAF Convention Area, 1955–72.

Labrador–East Newfoundland Stock Complex (ICNAF Subarea 2, Divisions 3K and 3L) — Although it is not possible at present to subdivide this large stock complex into smaller units on biological grounds, two separate management portions have been identified as follows:

Northern Labrador Portion (ICNAF Divisions 2G and 2H) — Cod of northern Labrador are considered separately for management purposes from the rest of the Labrador–East Newfoundland stock complex because the effect of the fishery on this part of the complex has been more severe than in the south. In 1958–64, the average catch in this area was 5000 t, of which the Canadian catch, averaging 1100 t, was taken entirely by inshore gears (Fig. 5). The abundance of cod was severely reduced during 1965–69 when the average annual catch was 68,000 t. In addition, the numbers of newly recruited cod in this area in 1967, 1968, and 1969 appeared to be lower than average and consequently would yield a smaller than average catch when they were exploited by the fishery. Catch predictions incorporating these factors indicated that fishing at F_{max} in the early 1970s would produce about 20,000 t. Thus, the member countries of ICNAF agreed in 1973 that the catch quota for this area in 1974 be set at 20,000 t, even though the MSY was estimated to be 30,000 t (reliability code 4). In fact the catches in 1970–73 were less than 20,000 t and it was felt that the reduced catches with the quota of 20,000 t in 1974 would permit the supply of cod in this area to recover to the MSY level.

Southern Labrador–East Newfoundland Portion (ICNAF Divisions 2J, 3K, and 3L) — Cod in the

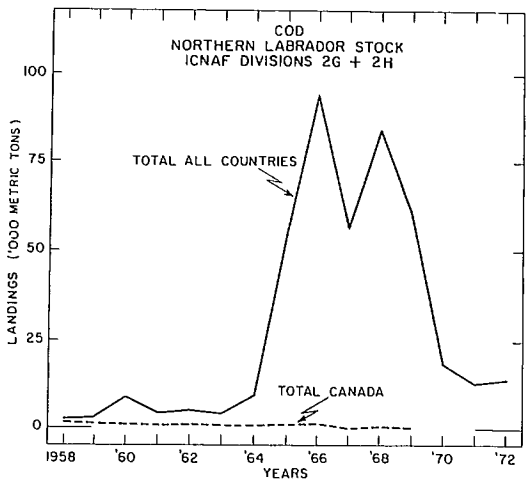

FIG. 5. Cod landings from the northern Labrador stock portion (ICNAF Divisions 2GH), 1958–72.

area from southern Labrador to the northern part of the Grand Bank are considered as forming one stock complex. A major characteristic of this complex is a shoreward feeding migration in early summer and an offshore movement in late summer and fall in response to cooling water temperatures. Spawning occurs as early as February–March in the northern part of the area and progressively later in the south. In some areas (e.g. Hamilton Inlet Bank) large numbers of prespawning, spawning, and postspawning cod are concentrated during this period.

The fishery on this stock has been carried out for many years. Since 1959 there has been a sharp increase in landings due largely to the development of a winter–spring offshore fishery in the Labrador area by European trawlers on prespawning, spawning, and postspawning concentrations (Fig. 6). The Canadian (mostly Newfoundland) catch showed some decline in 1958–72. The average yearly catch by all countries including Canada in 1960–72 was 560,000 t. Fluctuations in landings occurred because of changes in stock abundance, and in amounts of fishing effort strongly influenced by ice conditions. There was a steady decline from slightly more than 800,000 t in 1968 to 420,000 t in 1971, and 458,000 t in 1972, reflecting decreased abundance as well as severe ice conditions that prevented the fleets from operating in the area for the full fishing season.

At the 1972 ICNAF Meeting, a quota of 575,500 t in the ICNAF Convention Area was agreed to from this stock for 1973. This, with an estimated catch of 90,000 t within the Canadian 3-mile territorial limit, allowed for a total catch in 1973 of 665,000 t.

At the 1973 ICNAF Meeting, a quota of 606,700 t in the Convention Area was agreed to for 1974. This, with an estimated catch of 50,000 t within the Canadian 3-mile territorial limit, allowed for a total catch of 656,700 t in 1974. Canada's catch in the Convention Area was about 11,000 t in 1971 and 12,000 t in 1972. Levels of quota in the future will probably fluctuate around 550,000 t, although they will probably be less than that initially because of poor recruitment now entering the fishery.

The MSY for this stock is estimated to be 550,000 t (reliability code 4). Fishing mortality in 1967–70 was more than necessary to obtain this maximum yield (187). Since 1970, catches have been smaller because fishing was restricted by ice conditions and because of reduced stock abundance. In a heavily exploited fishery, an increase in fishing effort does not necessarily result in an increase in catch because fish are taken when they are younger and smaller. In the case of this cod stock, a reduction in effort of 15% below that necessary to take the MSY in 1975 (as measured by a proportional decrease

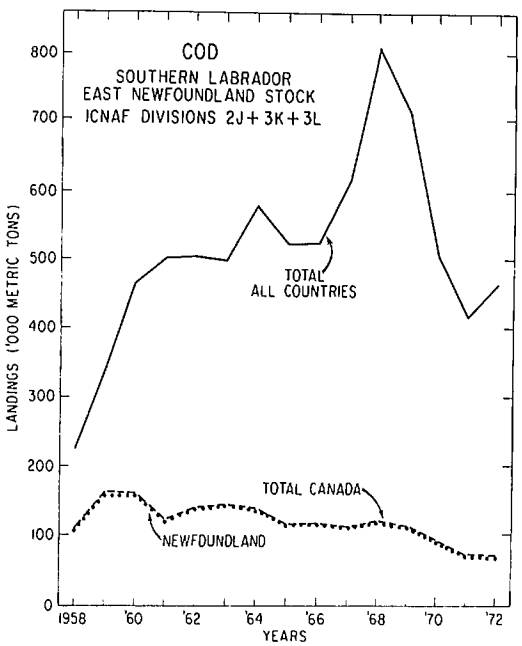

FIG. 6. Cod landings from the southern Labrador–east Newfoundland stock portion (ICNAF Divisions 2J, 3K, and 3L), 1958–72.

in fishing mortalities) would not, in the long run, appreciably affect the amount caught, but would make the fishery more efficient by increasing the catch per unit of effort.

Fleming Cap Stock (ICNAF Division 3M) — Cod of the Flemish Cap comprise a distinct stock characterized by large variations in the strengths of year-classes. Catches were variable in 1963–72; the average catch was 41,000 t (Fig. 7). Canadian catches in this area were small, almost always less than 100 t.

At the 1973 Annual Meeting of ICNAF a quota of 40,000 t was established for 1974, the MSY for the stock in this area (reliability code 4).

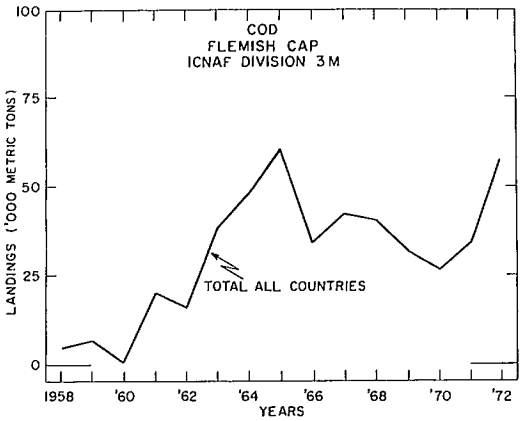

FIG. 7. Cod landings from the Flemish Cap stock (ICNAF Division 3M), 1958–72. Canadian landings were insignificant.

Southern Grand Bank Stock (ICNAF Divisions 3N and 3O) — The cod inhabiting the southern slopes of the Grand Bank in winter and dispersing northward across the surface of the bank in spring are considered one stock. Generally, the cod of this stock remain on the bank throughout the year. There is so little movement to the inshore areas that the stock cannot be considered as contributing significantly to the Newfoundland inshore cod fishery.

During 1958–64 the total cod catch from this stock by all countries averaged 60,000 t (Fig. 8). The catch increased to 110,000 t in 1966, and to 227,000 t in 1967. This sharp increase in 1967 reflected heavy fishing effort on good 1963 and 1964 year-classes (188), but by 1968, the catch decreased to 166,000 t and during 1969–71 remained at a level of 110,000–125,000 t. The 1972 catch was 103,000 t. The Canadian catch in 1971 was 2311 t and in 1972 was 1736 t.

The MSY for this stock is estimated at 130,000 t (reliability code 3). At the 1972 Annual Meeting of ICNAF, a quota of 103,500 t was agreed to be allocated among nations for 1973. There was evidence that the abundance of the spawning portion of the stock had been decreased by heavy fishing in recent years, and the fishery was heavily dependent on single year-classes entering the stock. Therefore, some protection was afforded this year-class to allow for rebuilding of the stock.

At the 1973 ICNAF Meeting the quota was set at 100,100 t for 1974.

Scientific advice in the near future will likely be to set a quota that will reduce the fishing effort to a level necessary to produce maximum yield-per-recruit (hence lower quotas), as the 1970–72 level of exploitation produced catches less than the long-term yield, at fishing mortalities beyond the level of maximum yield-per-recruit.

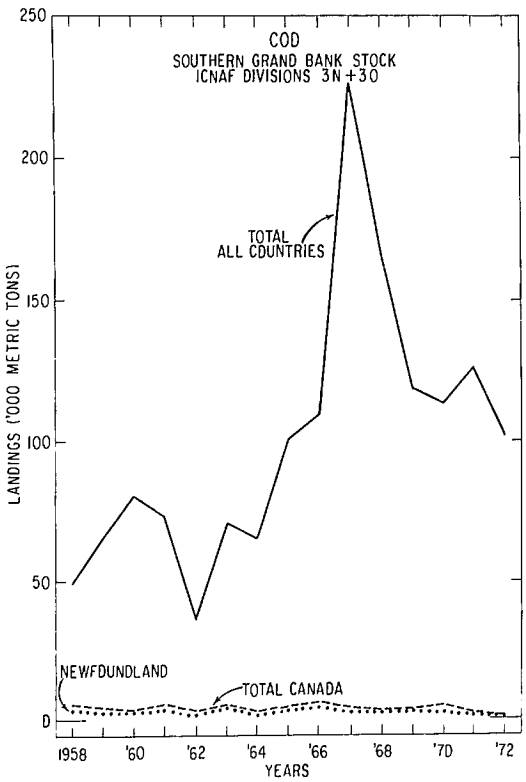

FIG. 8. Cod landings from the southern Grand Bank stock (ICNAF Divisions 3N and 3O), 1958–72.

St. Pierre Bank and South Newfoundland Stock (ICNAF Subdivision 3Ps) — Cod inhabiting the outer slopes of St. Pierre Bank in winter and migrating across the top of the bank and to the Newfoundland south coast in summer form another distinct stock. This stock mainly supports the inshore fishery along the eastern half of the Newfoundland south coast, and is important to offshore and inshore sectors of the fishery.

Landings from this stock increased from 45,000 t in 1958 to 86,000 t in 1961, decreased to about 50,000 t in 1962–65, and then increased again to a level of 62,000–77,000 t in 1966–71 (Fig. 9). The 1972 catch was 44,300 t.

The MSY for this stock is estimated at 60,000 t (reliability code 5). Although the level of fishing effort in recent years has been somewhat beyond that necessary to generate the MSY (184), the quota for 1973 was set at 50,500 t in the Convention Area at the 1972 ICNAF Annual Meeting. This, with an expected catch in the inshore fishery inside the 3-mile limit of 20,000 t, allowed for a total catch of 70,500 t in 1973, slightly above the long-term sustainable yield because of a good year-class (1968) expected to enter the fishery in 1973.

At the 1973 ICNAF Annual Meeting, the quota in the Convention Area was set at 50,000 t with 20,000 t estimated outside the Convention Area in 1974.

The level of quota in the near future can be expected to drop to or below 60,000 t.

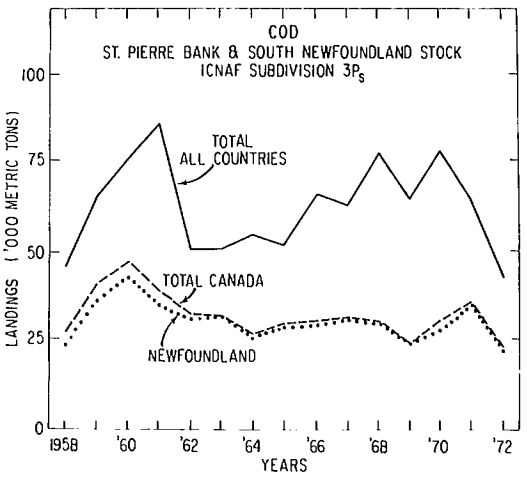

FIG. 9. Cod landings from the St. Pierre Bank–south Newfoundland stock (ICNAF Subdivision 3Ps), 1958–72.

West Newfoundland Stock (ICNAF Divisions 3Pn, 4R, and 4S) — Cod in the northern and eastern Gulf of St. Lawrence, including the southwest coast of Newfoundland immediately outside Cabot Strait, are considered as one stock. The stock is concentrated in the southwest Newfoundland coast area in winter and disperses into the Gulf in spring.

Landings for 1959–72 are shown in Fig. 10. Average annual landings over this period were 82,000 t; Canada's average landings were 50% of this. France, Portugal, and Spain took most of the remainder. The landings decreased steadily from more than 100,000 t in 1970 to about 58,200 t in 1972, the lowest level in the period.

No international fishing quotas have been allocated for the Gulf of St. Lawrence as Canada claims exclusive fishing rights there. The MSY is estimated to be about 77,000 t (reliability code 2). There will, however, be room for increased Canadian catches as the foreign fishery phases out.

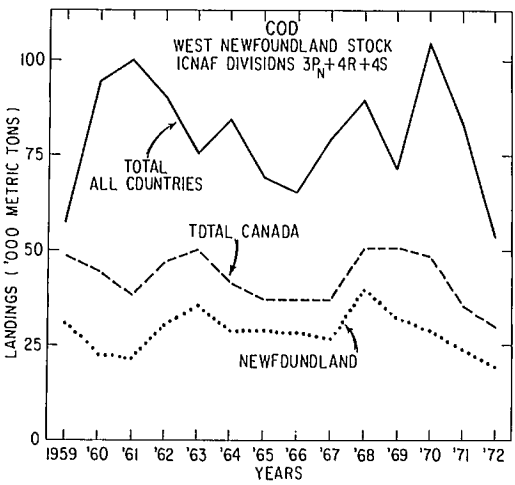

FIG. 10. Cod landings from the west Newfoundland stock (ICNAF Divisions 3Pn, 4R, and 4S), 1959–72.

Haddock (*Melanogrammus aeglefinus*)

A. T. Pinhorn

Total haddock landings in ICNAF Subarea 3 reached a peak of 104,000 t in 1955, decreased to a low of 35,000 t in 1959, followed by a peak of 79,000 t in 1961 and thereafter decreased rapidly. By 1969 the fishery had all but disappeared, and landings continued to be negligible in 1970–72 (Fig. 11). Total Canadian catch in this

period was about half the total catch by all countries with about three-quarters caught by Newfoundland boats.

Although small catches of haddock are taken farther north (e.g. West Greenland), the Grand Bank is the most northerly area of concentration of this species in the Northwest Atlantic so they are susceptible to various kinds of environmental changes. Consequently, successful survival from spawning is the exception rather than the rule. The 1949 and 1955 year-classes of haddock, contributing to the peaks in landings in 1955 and 1961, respectively, were the only two significant year-classes in the past 25 years. Most year-classes since 1955 have been almost complete failures. This, as well as heavy fishing pressure in recent years, has caused a reduction in the haddock stocks to an extremely low level, and a virtual extinction of any directed fishing for haddock. Almost all haddock landings, at present, from Subarea 3 occur as a result of by-catches from other fisheries and there are no prospects for improvement in the immediate future (reliability code 5).

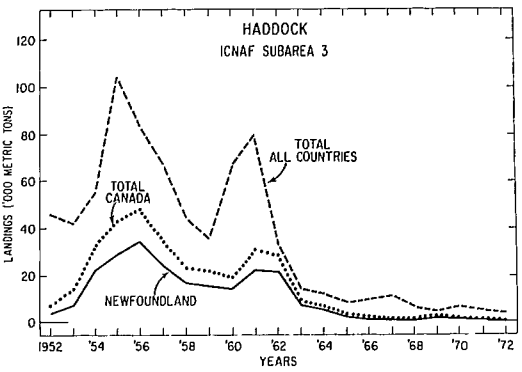

FIG. 11. Haddock landings from ICNAF Subarea 3, 1952–72.

Redfish *Sebastes mentella, S. marinus*

L. S. Parsons

Two types of redfish occur in the Northwest Atlantic but only one is important commercially. *Sebastes mentella*, or *mentella*-type redfish as it is commonly known, is the dominant commercial form. *Sebastes mentella* has a sharp, projecting beak on the lower jaw and a large eye, whereas in *Sebastes marinus* the beak is absent or reduced and the eye is relatively small.

Although it is only in deep water, approximately 110–350 fath (200–640 m), on and at the edges of the continental shelves that the resource is presently being exploited, a pelagic oceanic stock of redfish extends in large numbers throughout the Labrador Sea from the banks of Labrador and northern Newfoundland to West Greenland.

Exploitation of redfish historically has been by bottom otter trawling; however, in recent years midwater trawling has been successful in the Gulf of St. Lawrence. Initial attempts at midwater trawling in other redfish fishing areas have met with only limited success.

In the area of the continental shelves no further virgin stocks of redfish remain and, due to heavy exploitation, the fishery is now dependent in most areas on catching relatively small redfish that have recently grown large enough to enter the fishery. The strength of incoming year-classes is of major importance in determining the amount of fishing a given stock can sustain in a given year, and forecasts of yields from different stocks must rely to a large extent on surveys for the abundance of prerecruit fish. Redfish are slow growing and generally do not recruit to the commercial fishery until they are 7–10 years old.

The stocks of redfish in the Newfoundland–Labrador area have been subdivided for fisheries management purposes as follows:

Labrador–Northeast Newfoundland (ICNAF Subarea 2 and Division 3K) — There was no fishery for redfish in this area prior to 1958, when a directed fishery commenced with catches reaching 150,000 t. Catches were 187,000 t in 1959, but decreased to 130,000 t in 1960 and 55,000 t in 1961, around 20,000 t in 1962 and 1963, but increased to 56,000 t in 1964. There was a steady decline to 20,000 t by 1968, and catches remained remarkably stable at about this level to 1972 (Fig. 12).

The fishery during its early years exploited an accumulated stock of old fish and the high catches of 1958–60 were far above the estimated MSY level of 40,000–50,000 t (reliability code 3; 186). The heavy fishing intensity in the early years of the fishery apparently reduced this stock to such a level that, although fishing effort has been low in recent years, stock abundance is still below that at which catches at the MSY level can be maintained. Because this stock is considered to be in a depressed state, the catch quota for 1974 was established at 30,000 t, below the MSY level, to enable the stock to recover. With the exception of 1958, Canadian landings of redfish from this area have been negligible.

Northern and Eastern Grand Bank (ICNAF Divisions 3L and 3N) — The mean annual catch of redfish in Divisions 3L and 3N during 1955–71 was 20,400 t with annual catches fluctuating between 4000 and 45,000 t (Fig. 12). The nominal catch was approximately 34,000 t in 1971 and 28,900 t in 1972. The MSY of this stock is estimated at about 20,000 t (reliability code 3; 179). The catch quota for 1974 was established at the 1972 catch level of 28,000 t.

Canada's historical participation in this fishery has been minimal.

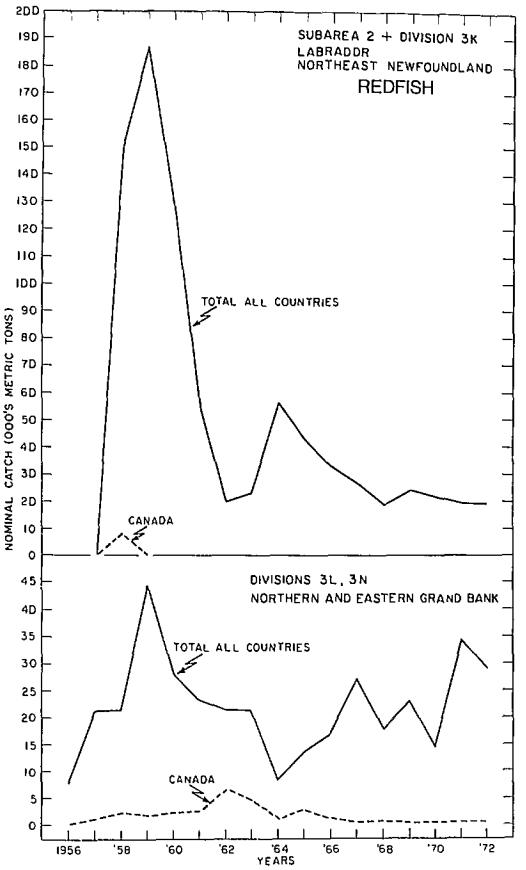

FIG. 12. Landings of redfish from Subarea 2, Divisions 3K and 3LN, 1956–72.

Southwest Grand Bank (ICNAF Division 3O) — Redfish catches from this area fluctuated between 2000 and 20,000 t during 1955–71 (Fig. 13). The 1972 catch of about 16,000 t was less than the 1971 catch of 19,800 t but above the 1955–71 mean annual catch of 11,000 t. The MSY of this stock is uncertain but an upper limit of 19,000 t has been derived (reliability code 3; 179). The total allowable catch for 1974 was 16,000 t.

Flemish Cap (ICNAF Division 3M) — The redfish fishery in this area commenced in 1956; during 1957–59 the average catch was 46,000 t and the fishery exploited an accumulated stock of old fish (Fig. 13). The catch dropped to about 8000 t in 1960 and remained at a low level during the 1960s (with the exception of 33,000 t in 1965), averaging 9700 t from 1960–71. The catch increased dramatically from 8000 t in 1971 to approximately 42,000 t in 1972, due to a substantial upswing in fishing effort on this stock. To prevent further diversion of fishing effort, a preemptive catch quota of 40,000 t was established for 1974. More recent analyses indicate that the MSY of this stock is in the vicinity of 15,000–20,000 t (reliability code 3; 178). Therefore, the long-term prospects are for sustainable catches considerably less than the 1974 total allowable catch.

Historically, Canada's participation in this fishery has been virtually nonexistent.

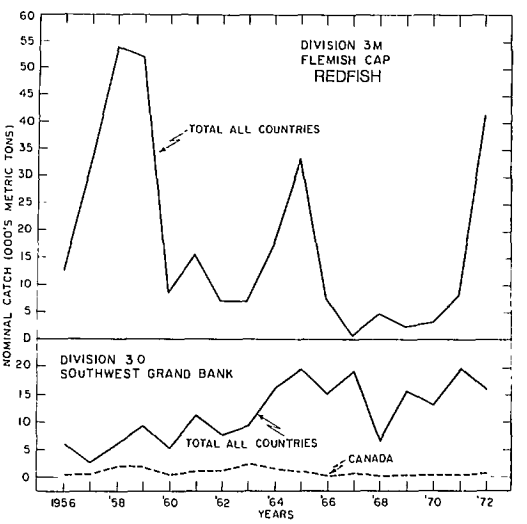

FIG. 13. Landings of redfish from Divisions 3M and 3O, 1956–72.

South Coast of Newfoundland (ICNAF Divisions 3Ps and 3Pn) — A small fleet of smaller-sized Newfoundland trawlers has fished this area on a regular basis. The redfish catch from this area increased gradually from less than 5000 t in 1955 to about 15,000 t in 1964

(Fig. 14), the increase almost entirely due to the catch of the Newfoundland fleet. A rather dramatic increase in landings has occurred in recent years, mostly due to substantially increased fishing effort for redfish by the USSR. The catch peaked at 37,000 t in 1970 and subsequently decreased to about 28,000 t in 1971, and 26,000 t in 1972. The increased catches have apparently been supported by recruitment of several stronger-than-average year-classes.

The MSY of this stock is estimated to be 23,000 t (reliability code 3; 179). However, sustained annual catches of this magnitude will be possible only if recruitment is maintained at the level of recent years. Until recent years Newfoundland's share of the redfish catch from this area amounted to 70–90% of the total landings, though this dropped as low as 19% in 1971. The catch quota for 1974 was established at the 1972 catch level of 25,000 t.

Gulf of St. Lawrence (ICNAF Divisions 4R, 4S, and 4T) — The redfish fishery in this area is almost completely Canadian with the USA the only other country catching significant amounts of redfish in recent years. This area has been characterized by enormous variations in year-class survival. The recent development of a large Canadian midwater trawl fishery for redfish resulted in tremendous expansion of catching capability in the Gulf of St. Lawrence and has precipitated concern about overfishing. Preliminary analyses revealed that the tremendous upswing in the fishery from 1963 to the present (Fig. 14) (80,000–90,000 t during 1969–72), has been largely due to the advent of large 1956 and 1958 year-classes (209). Recent research surveys indicate that recruitment prospects are poor for the next several years, and the redfish fishery is expected to decline. In the long term, landings from this area are likely to average less than 40,000 t/yr (reliability code 2).

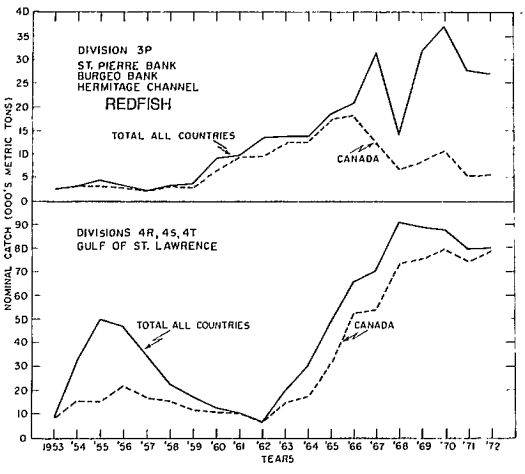

FIG. 14. Landings of redfish from Divisions 3P and 4RST, 1953–72.

Flatfish

T. K. Pitt

Since the beginning of the fresh frozen fish industry in Newfoundland in the late 1940s, the importance of flatfish to the local fishery has been increasing, especially since the early to mid-1960s. At first, the fishery was confined almost entirely to otter trawlers in offshore areas, but in recent years flatfish have become of prime importance also to the inshore longline and gillnet fishery.

At the 1972 Annual Meeting of ICNAF, catch quotas were established for 1973 on Grand Bank (ICNAF Divisions 3L, 3N, 3O) for American plaice and yellowtail. Quotas for 1974 were established for practically all flatfish stocks at the 1973 Annual Meeting and January 1974 Special Meeting of ICNAF. Generally in this Bulletin, in dealing with the various species, the division of stocks as presently established for international quotas will be used.

Flatfish accounts for American plaice, yellowtail, Greenland halibut, witch, Atlantic halibut, and winter flounder are as follows:

American plaice (*Hippoglossoides platessoides*)

T. K. Pitt

On the basis of actual quantities landed, American plaice is the most important flatfish to the Newfoundland fishery. Located on the Grand Bank (ICNAF Divisions 3L, 3N, and 3O) the primary concentration of American plaice in the Northwest Atlantic produced over 90,000 t in 1967 (Fig. 15D) and has been of major importance to the Canadian and international fishery since the mid-1960s.

American plaice is principally a cold-water species, occupying primarily depths from 40 to 150 fath (73–275 m), but its overall distribution in the Northwest Atlantic extends throughout the ICNAF Convention Area from Division 1B off West Greenland to Division 5Zw in the Gulf of Maine. In the Newfoundland area, in addition to the Grand Bank stock, fishable quantities of plaice are present on Hamilton

Inlet Bank (Division 2J), in Notre Dame Bay and the northeast Newfoundland Shelf (Division 3K), and on St. Pierre Bank and adjacent coastal waters (Division 3Ps). Additionally, plaice are present in most other coastal bays although usually in very limited quantities. A relatively small stock is present on Flemish Cap (Division 3M). However, the Grand Bank, primarily Divisions 3L and 3N, has the only stock capable of maintaining a major directed fishery.

The earliest fishery for American plaice in the Newfoundland area of the Northwest Atlantic was in the late 1940s by Canadian trawlers on the southern slope of the Grand Bank. Catches of plaice at this time were mainly by trawlers, primarily fishing for haddock. Total amounts of American plaice from the Grand Bank, almost entirely by Canadian-based trawlers (Fig. 15), increased from an average of 10,000 t in 1950–54 to 20,000 t in 1960–61. During the next 6 or 7 years there was a rapid increase in plaice landings by the Canadian and European (mainly USSR) fleets to about 90,000 t in 1967. This period corresponds to the drastic decline in haddock stocks. In recent years total landings have declined and are now in the 60,000–70,000 t range. Most catch was taken from Divisions 3L and 3N with the latter Division producing less of the total catch in the past few years. Landings from Division 3O by Canadian boats have never exceeded 5000 t; however, the USSR apparently caught about 20,000 t in 1967 and 5000–10,000 t in other years.

Stocks of plaice on Hamilton Inlet Bank, the northeast Newfoundland Shelf, and Notre Dame Bay (ICNAF Subarea 2 and Division 3K), on St. Pierre Bank (Subdivision 3Ps), and on Flemish Cap (Division 3M), are small compared to Grand Bank stocks. Canadian (Newfoundland) landings from the northern stock (Fig. 15A) were almost entirely from boats less than 50 ft in length using gillnets and generally fishing less than 25–30 miles from the coast. The greatest proportion of total landings from the stock was taken by European otter trawlers. On St. Pierre Bank (Fig. 15B), except for substantial landings by the USSR in 1968 and 1969, the fishery has been primarily by Canadian trawlers operating from Newfoundland ports. The fishery on Flemish Cap (Division 3M; Fig. 15C) has never been of more than minor importance and landings were almost entirely by the USSR who caught about 5000 and 4000 t in 1965 and 1966 respectively, probably in conjunction with their cod fishery. Canadian landings from this stock have been negligible.

American plaice has a relatively slow rate of growth and reaches minimum commercial size between 6 and 10 years of age (191). Spawning occurs both offshore and in coastal waters, with the time of spawning varying from early to mid-April on St. Pierre Bank and on the southwest portion of the Grand Bank, to the end of June in the deeper water, 110 fath (200 m), off Labrador (190). Whereas there probably is considerable transfer of larvae from northern areas southward, once the fish have settled on the bottom it appears that movement is minimal (192). There is practically no intermingling of stocks at least during the adult stage. At present there is no evidence of strong year-class fluctuations and generally a large number of age groups from about 6 to 20 contribute to the fishery.

Because of slow rate of growth, replacement of biomass of fish removed would be comparatively slow. The heavy exploitation of American plaice on the Grand Bank has resulted in a sharp reduction in the catch per hour on the

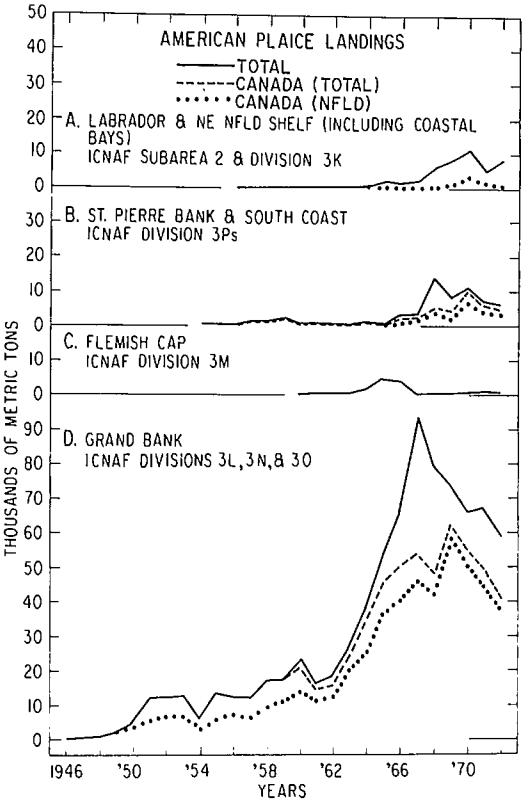

FIG. 15. Landings of American plaice from the various stocks in the Labrador–Newfoundland area.

northern half of the Grand Bank (Division 3L) from around 1.17 t/h in 1958 to about 0.45 t/h in 1971 and 1972, and from 0.90 t/h to about 0.23 t/h during the same period for the southern area (Divisions 3N and 3O).

Based on fairly substantial scientific evidence the TAC recommended for plaice for all the Grand Bank and the quota allocated for 1973 and 1974 was 60,000 t (reliability code 4). The history of landings for stocks in the other localities resulted in the following TACs recommended for 1974: Subarea 2 and Division 3K (Fig. 15A), 8000 t; Subdivision 3Ps (Fig. 15B), 8000–9000 t; and Division 3M (Fig. 15C), 2000 t (reliability code 2). Quotas of 9000 t for Subarea 2 and Division 3K, 2000 t for Division 3M, and 11,000 t for Subdivision 3Ps were allocated by the Commission at the 1974 Special Meeting. These are probably maximum values and total landings should not increase beyond these levels.

Yellowtail *Limanda ferruginea*

T. K. Pitt

Catch records from research and commercial vessels indicate that abundance of yellowtail increased on the Grand Bank from the early 1960s at least to 1970 (193). The Grand Bank is the northern limit of commercial concentration of this species although there are scattered records from as far north as the Strait of Belle Isle. It is a shallow-water species occurring primarily in 20–50 fath (37–91 m).

Landings increased from 3000 t in 1965 to 15,000 t in 1969 and rose rapidly to 39,000 t in 1972 (Fig. 16A). Based on the possibility that stock abundance was increasing, a precautionary catch quota of 50,000 t was set for 1973 at the 1972 ICNAF Annual Meeting, which later proved to be optimistic. Based on improved assessment data, this was reduced to 40,000 t (reliability code 3) for 1974 at the 1973 Annual ICNAF Meeting.

Compared to other flatfish in this area, yellowtail have a fairly fast rate of growth. They reach minimum commercial size of about 28 cm between age 4 and 5. About 90% of fish caught are age 6, 7, and 8. Recent research vessel surveys indicate a general decline in abundance both in the recruiting and fully recruited year-classes. This general decline in abundance is also evident in commercial catch per hour so there is every indication that total removal levels will decline drastically in the immediate future.

Greenland halibut
(*Reinhardtius hippoglossoides*)

T. K. Pitt

Although the general distribution of Greenland halibut in the Northwest Atlantic ranges from the Arctic region to Georges Bank, the greatest fishable concentrations (except for off West Greenland) are off Labrador, the northeast Newfoundland Shelf, and in White, Notre Dame, Bonavista, and Trinity bays (ICNAF Subarea 2, Division 3K, and part of Division 3L). The greatest concentrations are at 150–325 fath (275–595 m) (89). Tagging returns (Pitt unpublished data) suggest that ICNAF Subarea 2 and Divisions 3K and 3L probably support a single Greenland halibut stock.

During the 1950s and early 1960s the only significant fishery for this species in ICNAF Subareas 2 and 3 was by Newfoundland fishermen in the coastal areas, principally White, Notre Dame, and Trinity bays. The product was pickled or salted and sold on the Canadian market. With the development of a fresh fish market for Greenland halibut in 1965, there was a marked increase in effort for this species. Longlines, later replaced almost entirely by gillnets, were used by the Canadian fishermen, fishing from boats usually not larger than 50 t. Because of the apparent depletion of stocks, the local fleet now fishes up to 45 miles from the coast and fishable concentrations in Trinity and Notre Dame bays have been greatly reduced. Canadian (Newfoundland) landings increased sharply from nearly 2000 t in 1964 to 16,000 t in 1966–67, but since that time there has been a gradual decline to about 9000 t in 1972 (Fig. 16B). Since 1967 the European fleet, mainly USSR and Poland, landed increasingly large quantities and total landings reached 36,000 t in 1969 and 1970. Since then total removals have declined to the 25,000–30,000-t range in 1971 and 1972 (Fig. 16B).

As with most species, effect of heavy exploitation of the spawning stock on subsequent recruitment is not known. Greenland halibut do not grow fast, entering the fishery normally at age 6 or 7 with a life span of approximately 20 years and, in common with other flatfish stocks in the Northwest Atlantic, do not appear to be subject to large fluctuations in year-class strength (88). Preliminary assessments suggest a removal level of not more than 40,000 t annually from this stock (reliability code 2) and of this amount probably not more than 5000–7000 t can be removed from the coastal areas, including deepwater bays. In addition to the northeast

coast, limited quantities are available in Fortune Bay but it appears doubtful if much expansion can be expected there. A quota of 40,000 t was agreed to at the Special Meeting of ICNAF in January 1974 for the 1974 fishing season in Subarea 2 and Divisions 3K and 3L.

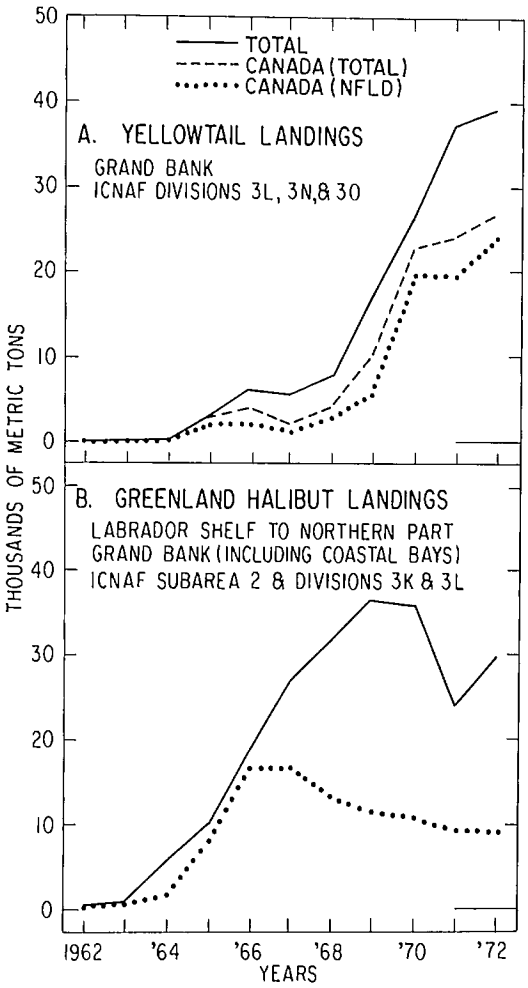

FIG. 16. (A) Landings of yellowtail from the Grand Bank. (B) Landings of Greenland halibut from Subarea 2 and Divisions 3K and 3L.

Witch *Glyptocephalus cynoglossus*

T. K. Pitt

Witch in the Northwest Atlantic are distributed from the southern part of Labrador (ICNAF Division 2J) to the area off Chesapeake Bay. In recent years Subarea 3 produced the largest landings. In the Newfoundland area the main fishery for witch is in Divisions 3K, 3L, 3O, and 3Ps.

The earliest landings of witch were from Division 3O (southwest part of the Grand Bank) primarily by Canadian trawlers fishing for haddock (Fig. 17B). The fishery on the Grand Bank was almost entirely Canadian up to 1965, but since then the European fleet, principally the USSR, have taken far more than Canada. In Divisions 2J, 3K, and 3L (Hamilton Inlet Bank to the Grand Bank, including coastal bays) most reported landings to 1968–69 were by the Polish and USSR fleets (Fig. 17A). At this time the Newfoundland inshore fishermen began using gillnets to fish Greenland halibut in Trinity, Bonavista, and Notre Dame bays. As witch occupy approximately the same niche as the latter species, landings of witch increased fairly rapidly. Since 1970 total landings from these areas were in the 16,000–18,000-t range, with Canada usually taking less than 50%. In Division 3Ps landings in what is primarily a Canadian fishery have remained at a relatively low level (Fig. 17C) rarely exceeding 3000 t.

Witch are slow-growing fish attaining commercial size between ages 8 and 10 years. Spawning fish are caught in many localities; however, except along the southwest coast of Newfoundland, few small (<20 cm) witch are taken. There is no strong evidence of wide fluctuations in year-classes. Witch are usually taken at depths greater than 150 fath (275 m) and are usually associated with muddy bottom conditions.

In Divisions 2J, 3K, and 3L there was practically no fishery for witch before the 1960s so the early catches were from accumulated virgin stock. However, with the reduction of the previously unexploited stock biomass, catch per hour by Canadian boats has been greatly reduced. In Notre Dame, Bonavista, and Trinity bays the inshore boats were forced to move progressively farther offshore as closer stocks were depleted. Poland and the USSR in particular have taken substantial quantities mainly from the area just south of Hamilton Inlet Bank to Funk Island, probably to a large extent as by-catches of other fisheries. If Canada's deep-sea fleet decides to exploit the northern cod stock, witch may be a valuable by-catch. More witch could probably be taken along the southwest slope of the Grand Bank (Division 3O) and on St. Pierre Bank and in Fortune Bay (Division 3Ps) by using gear such as a Danish seine that fishes soft muddy

bottom better than the conventional otter trawl using large rollers.

At the Annual Meeting of ICNAF in June 1973, total quotas of 22,000 t in Divisions 2J–3KL, 10,000 t in Divisions 3NO, and 3000 t in Division 3Ps were agreed to for 1974 (reliability code 2).

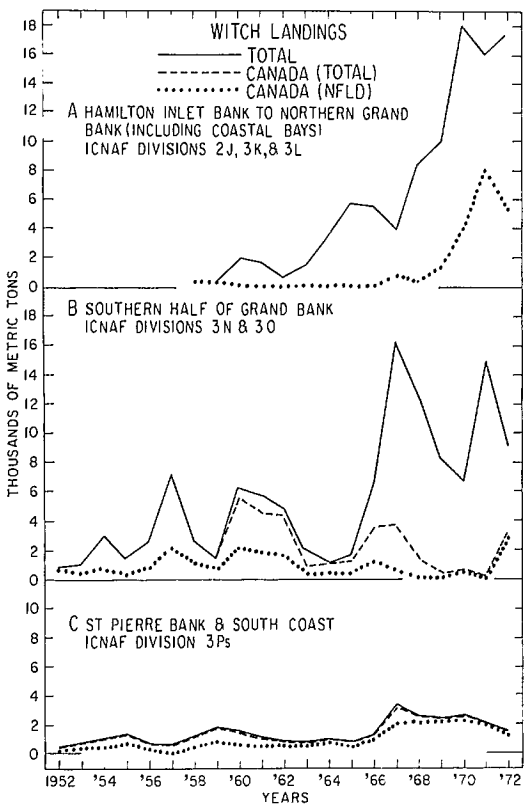

FIG. 17. Landings of witch from various stocks in the Labrador–Newfoundland area.

Atlantic halibut (*Hippoglossus hippoglossus*)

T. K. Pitt

The best Atlantic halibut grounds extend from the southern tip of the Grand Bank along the southwest slope of the Grand Bank to the southern part of St. Pierre Bank. Newfoundland vessels have never landed more than 900 t and total landings in Subareas 2 and 3 have rarely exceeded 1500 t. Since it was a by-product of the haddock fishery, catches have declined in recent years. The only way the fishery could be expanded would be by the use of large longliners or other multipurpose boats on the southwest slope of the Grand Bank and adjacent areas. It is doubtful if more than 1400–1800 t could be taken annually even with a large increase in effort (reliability code 1).

Winter flounder (*Pseudopleuronectes americanus*)

T. K. Pitt

These common inshore flatfish, although they may be present in considerable quantities in certain areas, nevertheless do not constitute a large stock and reported landings in Subareas 2 and 3 have been practically negligible. They are confined to a relatively narrow shallow coastal zone, which limits the size of the habitat. It is doubtful if they have a large commercial fishing potential and little is known of the size of the biomass.

White hake (*Urophycis tenuis*)

A. T. Pinhorn

White hake, though a member of the cod family, does not live as close to the bottom as haddock or cod (258). This fact is confirmed by feeding studies (183) that were characterized by the insignificant contribution of benthic organisms to the food of hake. The species occurs on the south coast (although they are numerous only on the western half), on St. Pierre Bank, and on the southern part of the Grand Bank (258). Best catches are obtained in 55–135 fath (100–247 m) between 2.8 and 8.4 C (183). Although little is known of the stock relationships in the Newfoundland area, it has been suggested that there is probably one stock of hake in ICNAF Subarea 3. Hake spawn during May–June (183).

Newfoundland landings of white hake, almost all from Subarea 3, were 567 t in 1970, 1174 t in 1971, and 990 t in 1972. Total landings of white hake by all countries in Subarea 3 were 1031 t in 1970, 9046 t in 1971, and 6429 t in 1972. Most of the increased catch in 1971–72 was accounted for by USSR although the Canadian catch also increased. A significant portion of the Newfoundland landings is usually from the inshore area along the western half of the south coast. The offshore catch is mainly from Divisions 3Ps and 3O.

There are not enough white hake in the Newfoundland area to supply a large fishery. Catches are incidental to fishing for other species

on the southern part of the Grand Bank and on St. Pierre Bank. Some are also caught in the inshore fishery for cod on the south coast of Newfoundland.

For information on the distribution and abundance of white hake in the southern Gulf of St. Lawrence and on the Nova Scotia banks see (82; 218).

Pollock (*Pollachius virens*)

A. T. Pinhorn

Pollock, like white hake, do not live as close to the bottom as cod or haddock (258). They occur on the south coast, on St. Pierre Bank, and on the southern part of the Grand Bank (258).

Pollock landings are low in Newfoundland, almost all from the southern part of Subarea 3. Newfoundland landings from the ICNAF area were 82 t in 1970, 106 t in 1971, and 92 t in 1972. Total pollock landings by all countries from Subarea 3 were 726 t in 1970, 859 t in 1971, and 683 t in 1972. Most of the catch came from Divisions 3Ps and 3O. Landings have decreased as the Grand Bank haddock fishery, in which this fish was a by-catch, declined.

There are no indications at present that there are enough pollock in the Newfoundland area to supply a large fishery. The supply of pollock will fluctuate with periods of temperature change in the area (258). They are caught incidentally to fishing for other species on the southern part of the Grand Bank and on St. Pierre Bank or in the inshore fishery for cod on the south coast of Newfoundland.

For information on the distribution and abundance of pollock in the southern Gulf of St. Lawrence and on the Nova Scotia banks see (62; 82; 218).

Wolffish *Anarhichas lupus*, *A. denticulatus*, *A. minor*

A. T. Pinhorn

Three species of wolffish inhabit the Newfoundland area: the Atlantic (striped) (*Anarhichas lupus*), northern (broadheaded) (*A. denticulatus*), and spotted (*A. minor*). Only the Atlantic and spotted species are used for food at present, the northern wolffish is always jellied.

By far the most common species in the southern part of the area is the Atlantic wolffish, found as far north as southern Baffin Island (258). The spotted and northern wolffishes are plentiful in deep waters from the northern Grand Bank to Baffin Island and occur in small numbers on the eastern and southern parts of the Grand Bank and St. Pierre Bank (258).

Wolffish do not form dense schools and there is, therefore, no directed fishery for the species; catches reported are incidental to fishing for other species (258). Newfoundland landings increased from 123 t in 1954 to 1898 t in 1970, 2862 t in 1971, and 2138 t in 1972. Total landings by all countries from the ICNAF Area were 6519 t in 1970, 11,785 t in 1971, and 12,314 t in 1972; with about 50% caught in Subareas 2 and 3.

For information on the distribution and abundance of wolffish in the Gulf of St. Lawrence and Nova Scotia banks see (82; 218).

Porbeagle (*Lamna nasus*)

A. T. Pinhorn

The porbeagle or mackerel shark is a migrant from southern waters, moving northward during the summer and southward in autumn (263). It is common in the southern part of the Newfoundland area from July to at least early September (258).

In 1961 Norwegian vessels using surface longlines landed about 1800 t of porbeagle from the ICNAF Area as a whole (258). By 1964 landings amounted to over 8000 t. Since then other countries, notably the USSR, have engaged in the fishery and landings reached a peak of 12,750 t in 1966, most from Subarea 5 and Statistical Area 6. Landings were 6052 t in 1970, 11,639 t in 1971, and 23,821 t in 1972. These landings were mostly porbeagle but included other species of shark.

No estimate of MSY is available but research vessels found these sharks numerous on the southeast shoal of the Grand Bank in July and Newfoundland trawlers have caught large, mature specimens even in winter on the southwestern Grand Bank. On the Newfoundland coast they are most plentiful in the southeastern and southern parts. The earliest coastal record is May and the latest November, but most have been between July and early September (258).

Spiny dogfish (*Squalus acanthias*)

R. Wells

The spiny dogfish is found on both sides of the North Atlantic. This dogfish occurs in large

numbers during the warmer part of the year around all the coasts of Newfoundland and northward to southern Labrador (Fig. 18). Many winter off New England and farther south. They arrive off Nova Scotia and in the Bay of Fundy in June and in the Gulf of St. Lawrence in July. In Newfoundland, they arrive on the south coast in June, on the east coast in July, and in Labrador in August. Spiny dogfish have been scarce or absent on the Labrador coast and east coast of Newfoundland since about the early 1950s but were plentiful at least as far north as Smokey prior to that time. In the Newfoundland and Labrador area (but not off southwest Nova Scotia) they are usually in the warmwater layers off bottom and are, therefore, not often taken by otter trawl. The best catches of spiny dogfish have been taken on St. Pierre Bank in the spring. The five best half-hour catches in this area by research vessels ranged from about 3600 to 9800 kg (180). One 15-minute tow by the *Investigator II* in 1960 yielded about 4500 kg. All catches were taken in 110–150 fath (201–274 m), mostly on the northwest part of the bank, but one on the southwest edge. On the average in the northwest area of the bank 450 kg/h fished were taken by research vessels during the spring period and 135 kg/h on the southwest slope. Catches offshore on the Grand Bank, Flemish Cap, off the east coast of Newfoundland, and off Labrador have invariably been small.

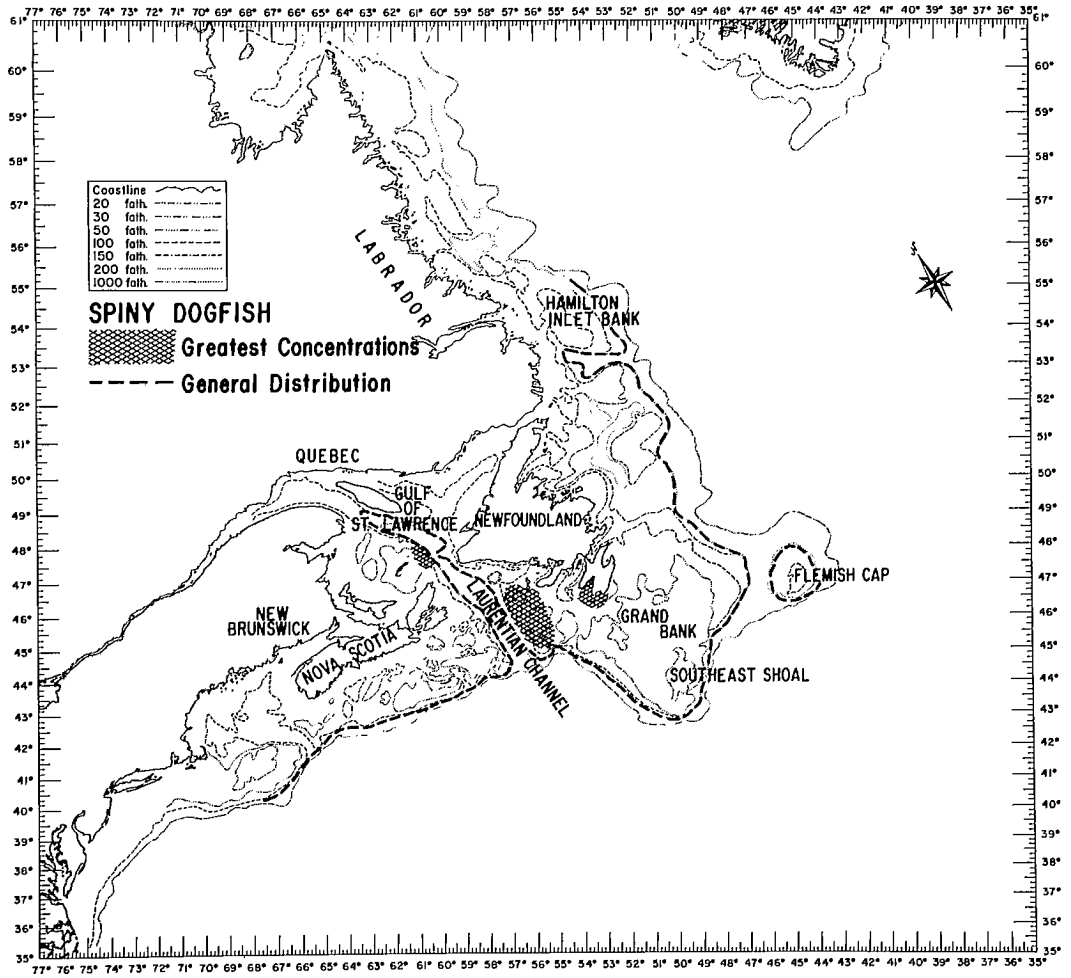

FIG. 18. General distribution and areas of concentration of spiny dogfish off the Canadian Atlantic coast, as determined from research vessel catches.

Black dogfish (*Centroscyllium fabricii*)

R. Wells

This dogfish is found in the eastern North Atlantic and in the western North Atlantic from about 65°N latitude southward to Georges Bank (Fig. 19). Research vessel catches ranged to about 200 kg (275 specimens) per half hour fished but are generally much lower (180). Research catches were made in depths from about 140 to 620 fath (256–1135 m) and were reported in 185–730 fath (338–1335 m) off the southern Scotian Shelf. Good catches were made on the bottom (plains) of the Laurentian Channel in summer.

Off Labrador and the east coast of Newfoundland practically all catches were taken in 250–400 fath (458–732 m). The average weight of a dogfish in this area was nearly 1.8 kg. On the Flemish Cap and Grand Bank, where the average weight of a dogfish was 1.4 kg, as well as on the Scotian Shelf, practically all catches were taken in depths greater than 250 fath (458 m). On the Scotian Shelf, the average weight was only 0.3 kg.

On St. Pierre Bank, about one-third the catches by weight were taken in depths shallower than 200 fath (366 m) and practically all the remainder in 200–250 fath (366–458 m). The

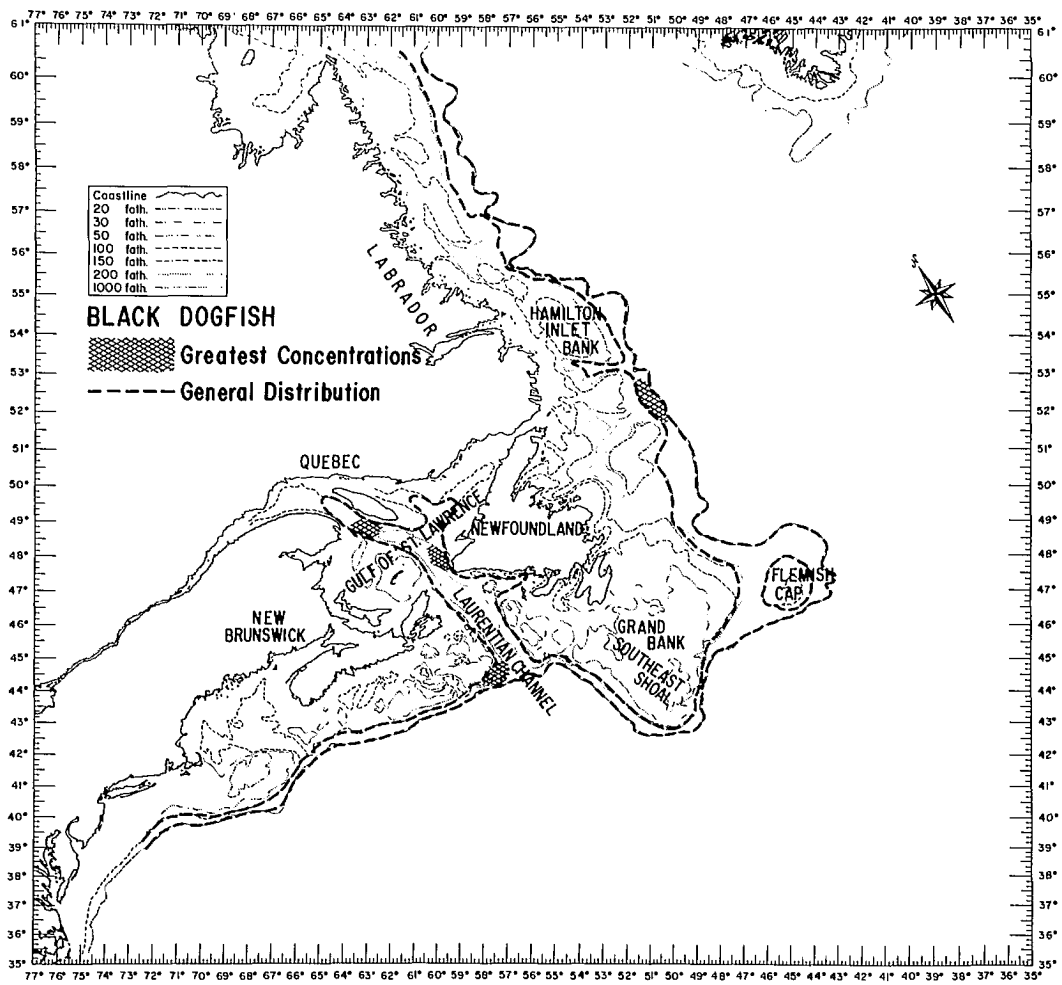

FIG. 19. General distribution and areas of concentration of black dogfish off the Canadian Atlantic coast, as determined from research vessel catches.

dogfish had an average weight of 0.45 kg. Inside the Gulf of St. Lawrence the average weight was 0.7 kg.

Although catches were generally small, the dogfish may on occasion school in large numbers. One catch of about 1360 kg was taken in shoal water on St. Pierre Bank in April 1950, by a commercial trawler in a 90-minute tow. This species is probably not abundant enough in the Canadian area to support a commercial fishery.

Skates

L. S. Parsons

Skates, fishes of the family Rajidae, are strongly flattened dorsoventrally with the body forming a thin flat disc, usually subcircular.

Skate "wings" (pectoral fins) are excellent food with a flavor somewhat like scallops (258). Although skates occur in abundance over a wide area, reported landings from the ICNAF Area have been small, ranging from 3000 t in 1965 to a peak of 25,000 t in 1971 (not including discards). More than 80% have been taken in ICNAF Divisions 4W, 5Ze, and 5Zw mainly as by-catch in the large USSR hake fisheries; hence the reported catches do not reflect the relative abundance of skates. In the Northeast Atlantic directed fishing for skates and rays has been carried on for several decades (average landings were approximately 53,000 t during 1951–60 and 43,000 t during 1961–70). France, the United Kingdom, and Spain have taken the bulk of the catch.

Although several species of skates commonly occur off the Canadian Atlantic coast (including thorny, barndoor, smooth, winter, and spinytail), the thorny skate is by far the most numerous. Because it is the prime constituent of the Canadian Atlantic skate resource, only the thorny skate will be discussed in detail. For general information on some other skates of the Newfoundland area see (258).

Thorny skate (*Raja radiata*)

L. S. Parsons

This species extends from West Greenland and Hudson Bay to South Carolina in the western Atlantic. It generally occurs at depths from 20 to 300 fath (37–549 m) and deeper, inhabiting a wide variety of bottom habitats, including sand, gravel, and mud, at water temperatures from 0 to 10 C (17).

Research surveys show that thorny skates are widely distributed from northern Labrador to southern Nova Scotia including the Gulf of St. Lawrence (Fig. 20). The center of abundance off the Canadian Atlantic coast appears to be in the Grand Bank and St. Pierre Bank areas where long-term average catches per hour fished of 70–180 kg have been obtained near and on the edge of the banks, with average catches as much as 410 kg/h in some localities (180). The skates range in length from 14 to 100 cm, with an average length of 64–71 cm and an average weight of 1.8–3.2 kg in various localities. Occasionally, individual catches of 900–4500 kg/h fished have been obtained, with the largest single catch about 11,350 kg/h. Densest concentrations have been found along the eastern edge of the Grand Bank with the largest catches taken from 165 to 220-fath (302–402-m) zone (180).

North of the Grand Bank along eastern Newfoundland and Labrador and the Gulf of St. Lawrence average catches of thorny skate by the *A. T. Cameron* have been less than 45 kg and generally less than 23 kg/h fished.

Preliminary estimates of abundance for the Grand Bank and St. Pierre Bank areas indicate a minimum trawlable biomass (weight of fish catchable by the survey gear) of approximately 130,000 t of thorny skate in ICNAF Divisions 3L, 3N, 3O, and 3Ps combined (200 fath (365 m) and shallower), with a MSY of about 40,000 t (180; reliability code 2).

Available knowledge of skate behavior based on observations from research submersibles and underwater television indicates thorny skates have a low vulnerability to capture by standard otter trawls with rollers because they tend to stay close to the bottom and avoid capture (47; 417). It has been suggested that the standard otter trawl only catches about one-tenth the thorny skates initially present in the area swept by the trawl (47). Hence, the standing stock and sustainable yield may be considerably higher than these estimates but this resource would be difficult to harvest efficiently.

Grenadiers

L. S. Parsons

Grenadiers, fishes of the family Macrouridae, are deepwater species, most dwell on the continental slopes. They are commonly called "rat-tails" because they possess long, whiplike tails. At least seven species have been reported off the Canadian Atlantic coast. Only three of these — roundnose, roughhead, and common

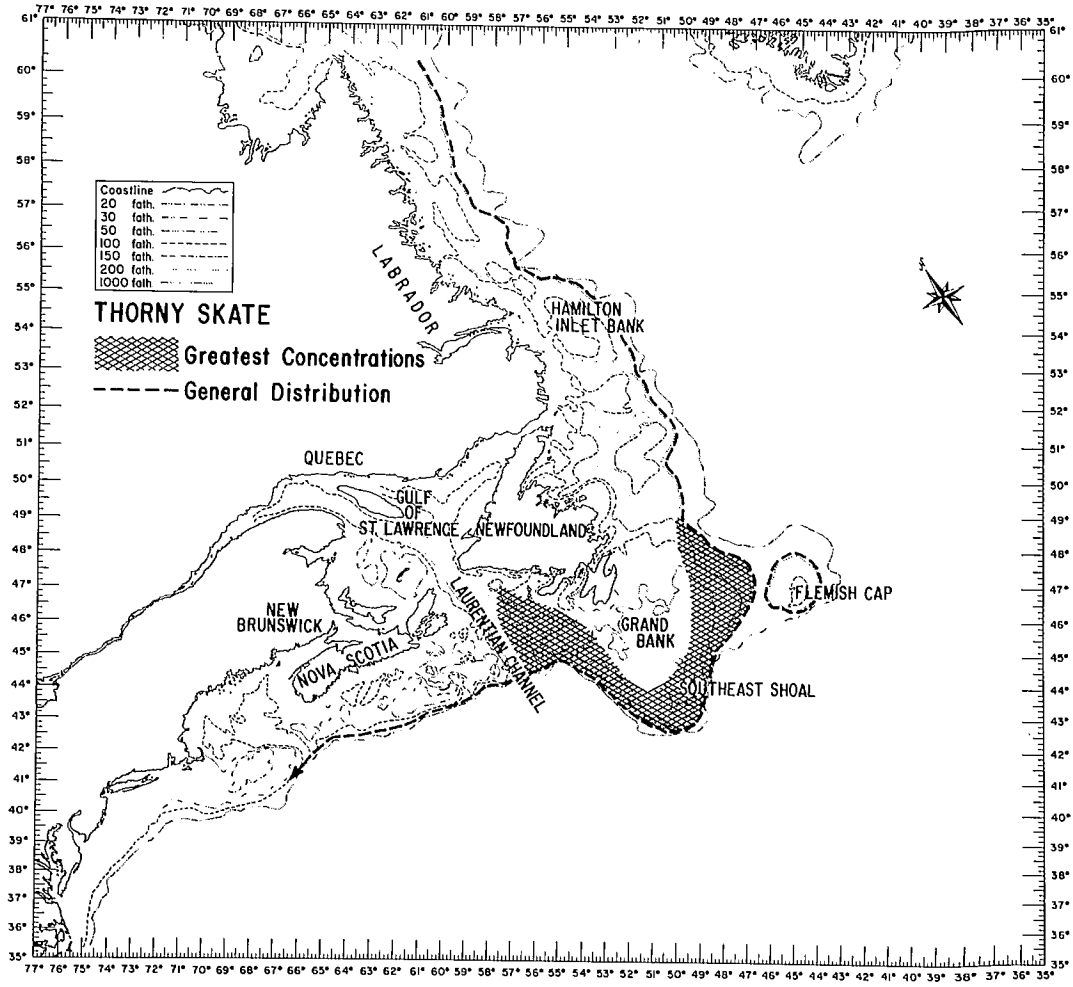

FIG. 20. General distribution and areas of concentration of thorny skate off the Canadian Atlantic coast, as determined from research vessel catches.

grenadiers — are plentiful and only one species, the roundnose, is presently being exploited, chiefly by the USSR.

Roundnose grenadier
(*Coryphaenoides rupestris*)

L. S. Parsons

The roundnose grenadier occurs on both sides of the North Atlantic at depths from 100 to 1200 fath (183–2195 m). It is distributed from Cape Hatteras to northern Labrador and is also found off Greenland, Iceland, and the Murmansk coast south to the Skagerrak and Irish Sea.

Research catches indicate the center of abundance of roundnose grenadiers in the Northwest Atlantic occurs off northeast Newfoundland and Labrador (Fig. 21). This species is restricted to deep water at the edge of the continental shelf. Data from USSR show the roundnose occurs in commercial concentrations on the edge of the northeast Newfoundland Shelf at depths from 250 to 550 fath (457–1006 m) and deeper. During experimental otter trawling by the St. John's Biological Station, catches of 1360–1800 kg/h fished have been obtained consistently in some portions of this area. In areas where high catch rates were obtained, catches of 1800–2300 kg/h fished were common at depths from 250 to 450 fath (457–823 m), with catches as large as

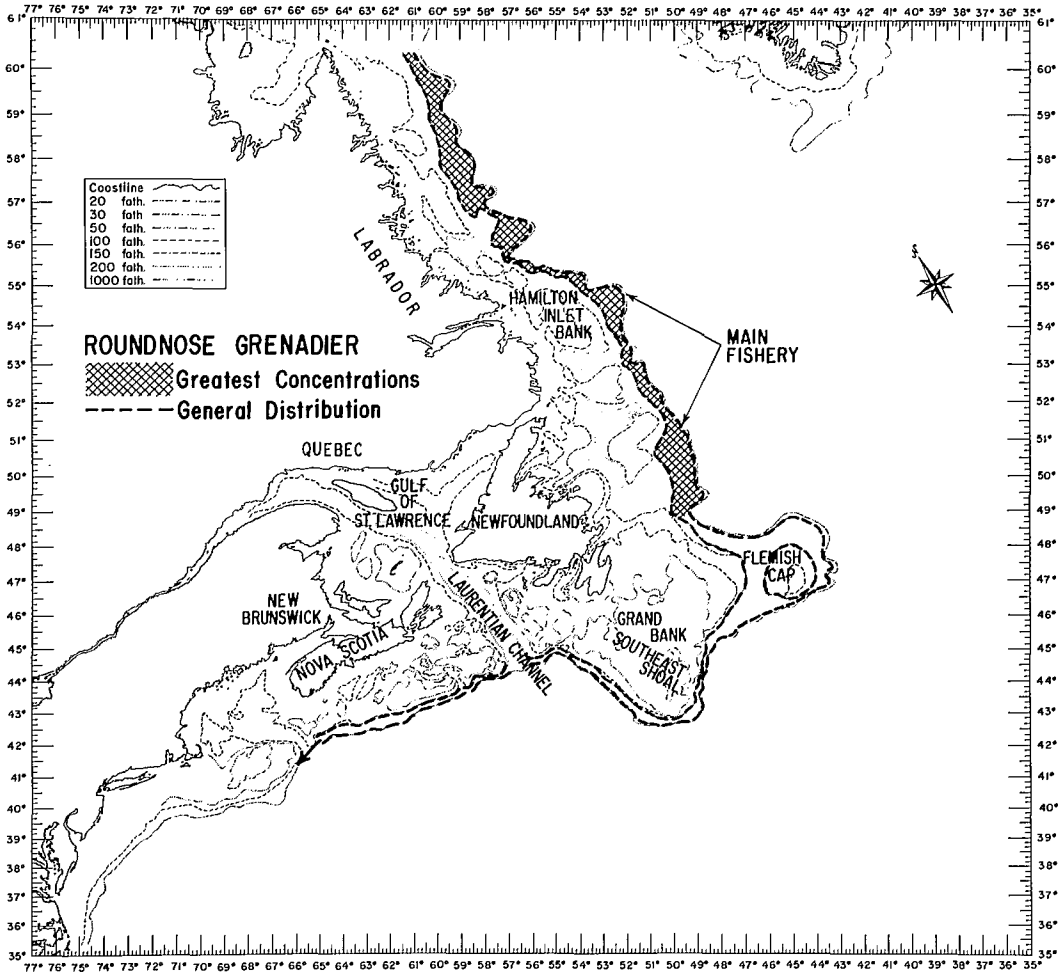

FIG. 21. General distribution and areas of concentration of roundnose grenadiers off the Canadian Atlantic coast, as determined from research vessel catches.

4100 kg/h at relatively shallow depths of 200–250 fath (366–457 m) and 5450 kg/h at 250–300 fath (457–549 m). The fish averaged 0.64 kg. Catch records suggest that the greatest concentrations of roundnose grenadier occur during the second half of the year, but this area has not been fished to any great extent by Canadian research cruises during January–March.

Data from USSR indicate that on the edge of the northeast Newfoundland Shelf the commercial fishery for roundnose grenadiers is based on 9–14-year-old fish, 60–70 cm in length and 0.4–0.8 kg in weight (210). Females grow more rapidly than males. There are indications that current age determinations may be underestimating the ages of grenadiers. The fishery in the Northwest Atlantic is based on feeding concentrations of sexually immature fish. Euphausiids, copepods, squid, and such fish species as lanternfish and redfish play a prominent role in their diet (194).

Knowledge of stock relationships and migrations of roundnose grenadiers is scanty. Concentrations of sexually mature roundnose grenadiers in the Northwest Atlantic are found at depths greater than those presently fished commercially. This has been confirmed by capture during exploratory fishing of large sexually mature fish at about 820 fath (1500 m) off central Labrador and of spawning and postspawning fish at 465–700 fath (850–1280 m) off Nova Scotia (58). Percentage of mature fish apparently increases with depth. Information about time of

spawning is sparse. It has been suggested that spawning occurs year-round (58).

Catches of roundnose grenadiers were first recorded in ICNAF statistics for 1967 (although quantities were probably taken before that time in conjunction with the cod and redfish fisheries in ICNAF Subarea 2 and the northern part of Subarea 3, and included under unspecified groundfish). Also, reported catches since 1967 could contain small amounts of roughhead grenadiers. Catches fluctuated between 13,000 and 31,000 t from 1967 to 1972 except for 1971 when 75,000 t were caught (Fig. 22), mostly by the USSR. The roundnose grenadier is reported to be the dominant species in commercial grenadier catches (248). Catches of this species off Newfoundland comprise more than 90% of the entire grenadier catch from the Northwest Atlantic. The proportion of roundnose grenadiers in the catches increases with depth; apparently beyond 450 fath (823 m) it is the only grenadier caught in quantity by otter trawl (248).

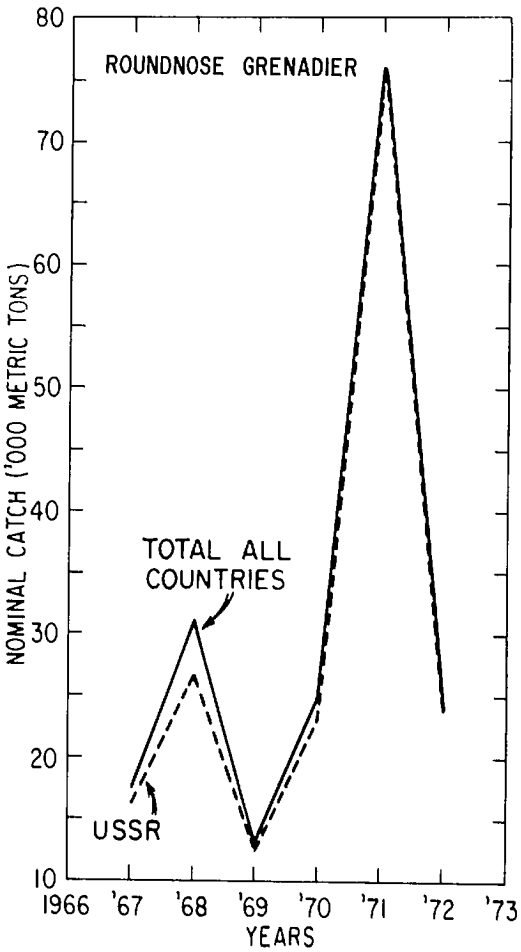

FIG. 22. Nominal catches of roundnose grenadiers from Subareas 2 and 3, 1967–72. (Roundnose grenadiers did not appear in the ICNAF Statistical Bulletin's list of species until 1967 although amounts were probably caught before then and included with other groundfish.)

A recent preliminary assessment (185) indicates that the immature concentrations off Labrador and northeast Newfoundland may be already fully exploited. However, the estimates of MSY (24,000–37,000 t) (reliability code 3) probably represent the potential of only the immature portion of the stock. The potential of the total stock may be substantially higher if the fishery were extended to mature fish at greater depths. Canada's participation in this fishery has been nil. Agreement was obtained at the January 1974 meeting of ICNAF to limit 1974 catches of roundnose grenadier from ICNAF Subareas 2 and 3 to 32,000 t.

Roughhead grenadier (*Macrourus berglax*)

L. S. Parsons

The roughhead grenadier also occurs in deep water on both sides of the North Atlantic, along the continental slope of North America south to Georges Bank, in Davis Strait, off southern Greenland, Iceland, Spitsbergen, and northern Norway.

Research surveys indicate that the roughhead is more widely distributed than the roundnose grenadier and, although also a deepwater species, occurs in greatest numbers at somewhat shallower depths of 100–400 fath (183–732 m) than the roundnose. The largest research catches of roughheads have been taken from July to September along the eastern and northern edges of the Grand Bank and in some localities off northern Labrador (Fig. 23). Research catches of this species have seldom exceeded 450 kg/h fished, much less than catches of the roundnose (180).

The roughhead grenadier is reported to be 3–12 years old at lengths of 33–82 cm (248). It attains a maximum length of 90 cm but fish larger than 75 cm are rarely caught. Average weights in research catches generally range from 0.6 to 1.4 kg.

Relatively little is known of the biology and life history of the roughhead grenadier. It probably occurs in limited numbers in commercial

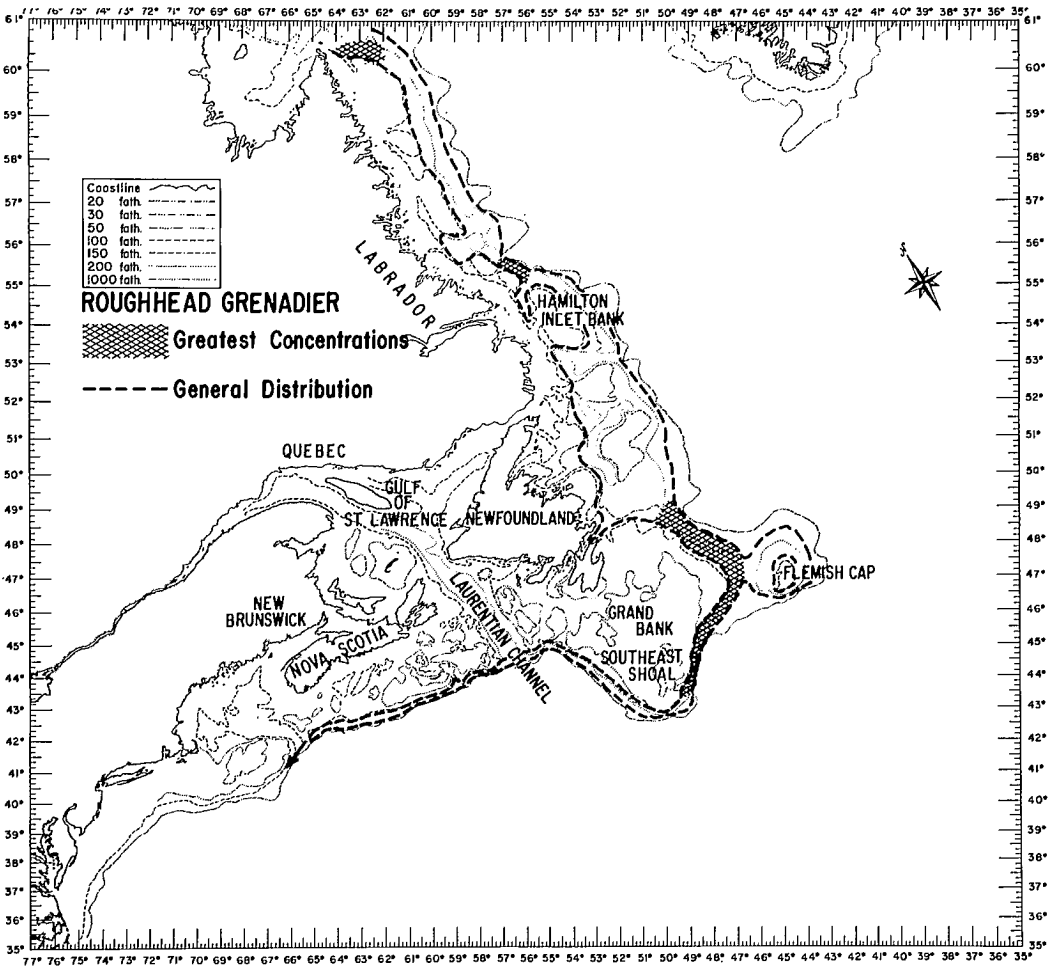

FIG. 23. General distribution and areas of concentration of roughhead grenadiers off the Canadian Atlantic coast, as determined from research vessel catches.

catches off northeast Newfoundland and Labrador but the exact proportion of roughheads in these grenadier catches is unknown. Roughheads are more dispersed than roundnose grenadiers.

Common grenadier (*Nezumia bairdi*)

L. S. Parsons

The common grenadier is a much smaller fish than the roundnose or roughhead; it attains a length of no more than 40 cm and average weights in research catches were less than 230 g. This species is most abundant in 100–400 fath (183–732 m). Research catches indicate they are widely and fairly evenly distributed from northern Labrador to southern Nova Scotia, including the Gulf of St. Lawrence. They have never been taken in commercial quantities and are not sufficiently abundant to support a commercial fishery.

Blue hake (*Antimora rostrata*)

L. S. Parsons

The blue hake, a deepwater species closely related to the cods, is widely distributed in the North Atlantic ranging from Denmark Strait to Gibraltar in the east and from southern Baffin Island to Cape Hatteras in the west. It attains a maximum length of about 55 cm (94).

During 1959–73 the research vessel *A. T. Cameron* caught moderate numbers of this species along the continental slope from Baffin Island to southern Nova Scotia (Fig. 24) at depths from 240 fath (439 m) (otter trawl) to 1250–1300 fath (2286–2377 m) (deep-sea longline), except on the southwest slope of the Grand Bank where the shallowest capture was at 125 fath (229 m). Otter trawl catches per hour fished at 250–450 fath (457–823 m), for sets in which this species occurred, averaged from 5–10 fish on the eastern slope of the Scotian Shelf to 80–91 fish on the eastern slope of the Grand Bank with average catches as high as 157 fish at 350–400 fath (640–732 m) in the latter area. These fish were generally small with average weights from 0.14 kg

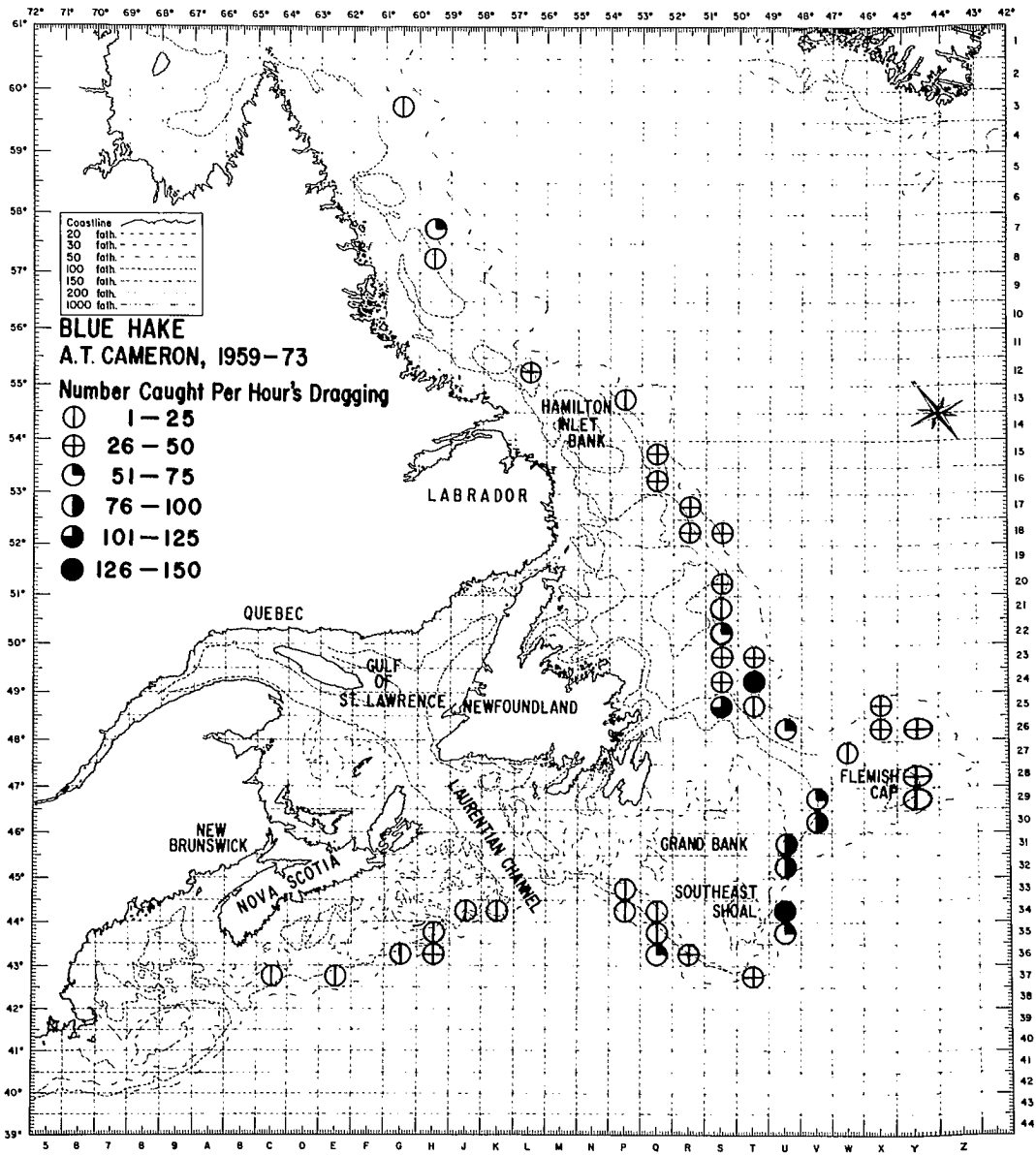

FIG. 24. General distribution of blue hake off the Canadian Atlantic coast, as determined from otter-trawl catches by the *A. T. Cameron*, 1959–73.

at 250–300 fath (457–549 m) to 0.36 kg at 400–450 fath (732–823 m).

The *A. T. Cameron* caught blue hake over depths of 700–1300 fath (1280–2377 m) during experimental deep-sea longlining in various localities throughout this area. The largest longline catches in single sets were 96 specimens north of Flemish Cap (1250–1300 fath; 2286–2377 m), 78 and 95 specimens off the southwest slope of the Grand Bank (950–1100 fath; 1737–2012 m) and 75 specimens off the southeastern edge of the Scotian Shelf (1150–1200 fath; 2103–2194 m). Specimens caught by longline were considerably larger (average weights 0.6–1.6 kg) than those taken at shallower depths by otter trawl.

It has been suggested that blue hake may be one of the more plentiful fishes in water over 350 fath (640 m) off the middle Atlantic states (17). However, exploratory deep-sea trawling in 1952 and 1953 by the research vessel *Caryn* from the Nova Scotia banks southward averaged only 14–29 specimens per haul in 300–700 fath (549–1280 m) (215). Unpublished Newfoundland Biological Station data indicate this species does not occur in commercial concentrations in Canadian waters, at least not at depths shallower than 500 fath (914 m).

Lumpfish (*Cyclopterus lumpus*)

R. Wells

Little information concerning the abundance of lumpfish inshore is available, but a few specimens are commonly seen in catches of cod by trap in most areas around the Newfoundland coast in spring and early summer. In the offshore areas, small quantities of lumpfish are often present in the catches when fishing for other species. On occasion, large concentrations of lumpfish may be present on the offshore banks, presumably because of unsuitably low temperatures in the shallower water inshore. In 1973, for example, three catches of about 2300 kg each per 30-minute tow were taken in February and March by the *A. T. Cameron.*

In recent years, an inshore fishery for lumpfish has developed in Newfoundland. The eggs are extracted and preserved in brine for export. In 1972 about 200 t of eggs representing approximately 500 t of fish were processed, and in 1973 about 150 t representing approximately 375 t of fish, the decrease was due to interference with the fishery by severe ice conditions. Little is known of the potential of this resource.

Arctic cod (*Boreogadus saida*)

R. Wells

This gadoid fish resembles the Atlantic cod but may be distinguished by its slender body and forked tail. It is rarely over 23 cm long, or much heavier than about 30 g. In Canadian waters it occurs in the far north, in Hudson Bay, and along the Labrador and eastern Newfoundland coasts (Fig. 25). Its occurrence has been noted in the St. Lawrence estuary, in Miramichi Bay, and Gulf of St. Lawrence.

Catches by small-meshed otter trawls used in research on the eastern Canadian shelf have generally been small, and until 1974 never over 200 specimens per half-hour tow. During a survey for capelin by midwater trawl in November 1973 off Labrador, several catches contained an estimated 115 kg of Arctic cod among about 10 t of capelin. In October 1974, a catch of over 5 t was taken by the *A. T. Cameron* in a 1-hour tow off White Bay.

As this species is small and apparently not abundant, it may be considered at present to have no commercial value.

Silver hake (*Merluccius bilinearis*)

A. T. Pinhorn

Silver hake is distributed along the continental shelf from South Carolina north to the Gulf of St. Lawrence and Newfoundland, although main concentrations are off the New England coast on the slope of Georges Bank and Nantucket shoals and on the Nova Scotia banks (219). The fish have been recorded from shallowest water to over 500 fath (914 m) but main concentrations are found from 30 to 150 fath (55–274 m). They are seldom found in temperatures less than about 4 C with a preferred temperature of about 6 C. They are found in small numbers along the southwestern slope of the Grand Bank and St. Pierre Bank (258).

No significant catches of silver hake have been reported in the Newfoundland–Labrador area although large quantities are taken in Subareas 4 and 5. The catch from Subarea 4 was 114,000 t in 1972 and from Subarea 5 was 107,000 t. The stocks in the Newfoundland–Labrador area are not extensive enough to support a commercial fishery.

For more information on silver hake in the southern areas, see (63; 219).

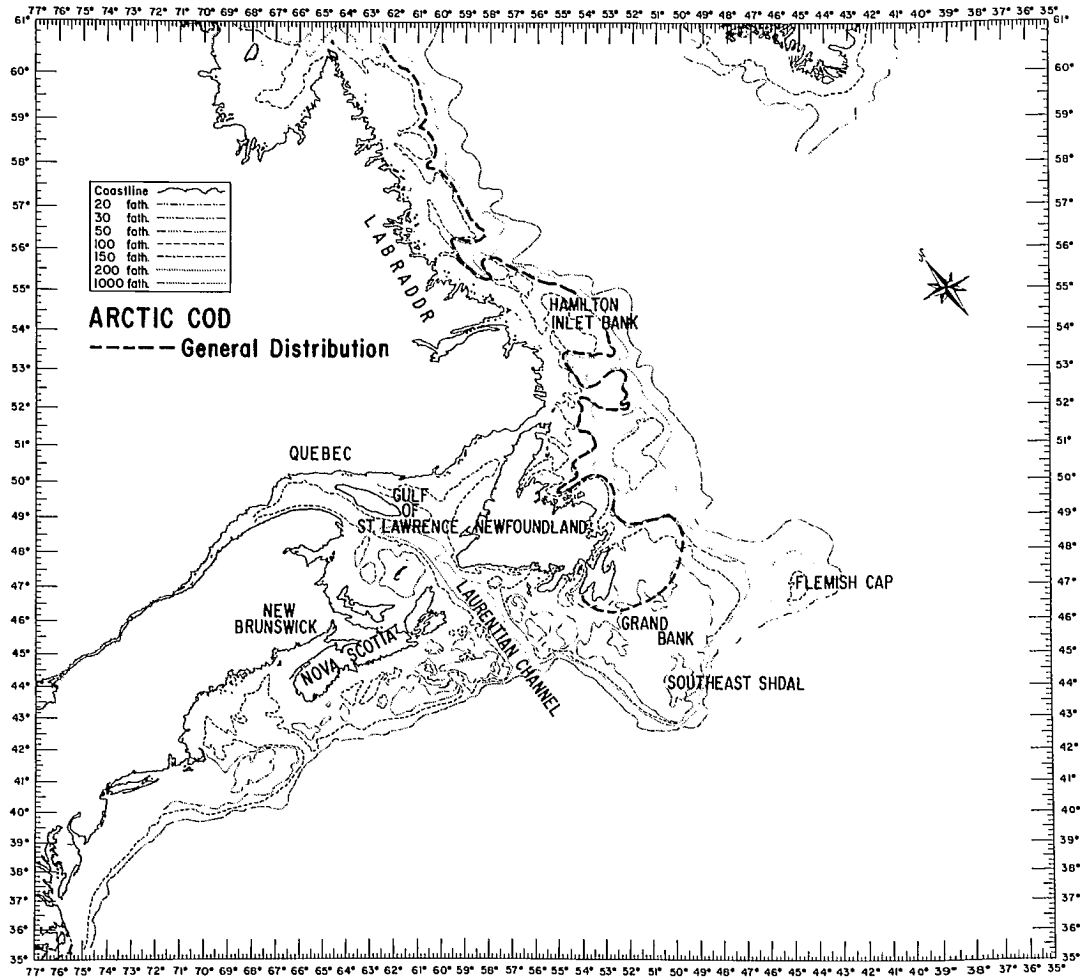

FIG. 25. General distribution of Arctic cod off the Canadian Atlantic coast, as determined from otter-trawl catches by the *A. T. Cameron*, 1959–73.

Atlantic argentine (*Argentina silus*)

A. T. Pinhorn

Argentine is distributed on both sides of the Atlantic from Porcupine Bank (approx. 49°N) to northern Norway, Iceland, and Greenland on the eastern side and along the edge of the continental shelf from Labrador to about Georges Bank, as well as deepwater basins such as Georges Basin and Emerald Basin on the western side (219). The species extends from 70 to 200 fath (128–366 m) with main concentrations at about 150 fath (274 m).

No significant catches have been reported in the Newfoundland–Labrador area but catches in Subarea 4 were 5868 t in 1972 and 32,700 t in Subarea 5. It is doubtful whether stocks in the Newfoundland area are sufficient to support a significant fishery.

For more information on argentines in the southern area, see (64; 219; 236).

Monkfish (angler) (*Lophius americanus*)

A. T. Pinhorn

Monkfish are widely distributed from the tropics to the northern Gulf of St. Lawrence and Newfoundland in shallow and deep water although main concentrations appear to be

off Canada on the Scotian Shelf. It is found on all types of bottom (219).

No significant landings have been reported from the Newfoundland area but landings from Subarea 4 in 1972 were 2879 t and from Subarea 5, 4332 t. Concentrations in the Newfoundland area are probably not sufficient to support a significant fishery.

Pelagic Fish

Atlantic herring (*Clupea harengus harengus*)

G. H. Winters

Prior to 1965 the Newfoundland herring fishery was associated largely with the demand for herring as bait for the cod fishery and with the periodic demand for pickled herring products as food, especially during and just after World War I and II (73). Landings during this period, therefore, do not necessarily reflect fluctuations in resource abundance. For example, landings increased to nearly 46,000 t in 1916, decreased to about 10,000 t during the mid-1930s and peaked again at 75,000 t in 1946 (73). During 1945–50 large orders for pickled herring were placed by the United Nations Relief and Rehabilitation Administration to supply the food demands of war-torn Europe, consequently landings averaged nearly 56,000 t for this period, most taken by beach seines, gillnets, and traps. At this time the large fisheries were concentrated in Placentia Bay, Fortune Bay, and the Bay of Islands area. Production of food herring fell substantially in the 1950s and by the early 1960s annual landings had decreased to less than 10,000 t, mostly used as bait. Landings remained at this level until 1965 when herring surveys along southwest Newfoundland by the Industrial Development Service of the former Department of Fisheries revealed large concentrations. As a result, an intensive purse seine fishery developed in that area and annual herring landings by all vessels in Newfoundland ports increased rapidly to a peak of 160,000 t in 1969. Landings have since decreased; in 1972 and 1973 about 64,000 and 55,000 t were landed respectively.

Southwest Newfoundland–Southern Gulf— The discovery of large concentrations of herring in the fjords along southwest Newfoundland in the winter of 1965 occurred coincidentally with the decline and collapse of the British Columbia herring fishery. This provided a ready surplus of purse seiners and experienced fishermen that enabled the resource to be exploited almost immediately upon its discovery. From a single vessel in the winter of 1965 the seiner fleet increased rapidly to more than 50 vessels by 1969 (69). Investigations carried out by the St. John's Biological Station soon revealed that this fishery was based almost entirely on mature adult herring consisting of a mixture of both spring- and autumn-spawning types (70) that migrated to the area in November and remained until early April. Tagging studies (15; 283; 284) and biological characteristics (71; 72) have shown that the southwest Newfoundland herring populations represent the overwintering phase of part of a stock complex of herring largely derived from spring and autumn spawnings in the southern Gulf of St. Lawrence. Thus, purse seine fisheries that developed around the Magdalen Islands and along the Gaspé coast in the spring, summer, and fall period in the mid-1960s were not based so much on completely different stocks, but mainly on parts of the same stock complex at different times and places along its seasonal migration route. Since 1971 a spring fishery has developed in the St. George's Bay area, where tagging studies have shown the fishery to be based at least partially on the same southern Gulf stock complex of herring.

Landings from the southern Gulf of St. Lawrence stock complex, as a whole, increased from 50,000 t in 1965 to a peak of 296,000 t in 1970 and declined to 90,000 t in 1972 and to less than 60,000 t in 1973 (287; Fig. 26). Landings from the southwest Newfoundland component increased from just under 15,000 t in the 1965–66 season to a peak of 140,000 t in the 1968–69 and 1969–70 seasons. By 1971–72 landings declined to 43,000 t. As a result of declining catches and high exploitation rates (285) the Atlantic Herring Management Committee recently imposed conservation measures on the southern Gulf herring stock, including catch quotas. A mobile fleet quota of 30,000 t was imposed on the 1972–73 winter fishery along southwest

Newfoundland (including St. George's Bay) of which only 18,000 t were caught. Mobile fleet catches from the 1973 spring and summer fisheries in the southern Gulf were restricted to 23,000 t (full amount taken) and a further quota of 15,000 t was imposed on the 1973–74 winter fishery along southwest Newfoundland but only 3000 t were caught, due mainly to severe ice conditions.

The great abundance of herring in the southern Gulf of St. Lawrence and southwest Newfoundland during the 1960s was due largely to the accumulation of biomass produced by two large year-classes spawned in the autumn of 1958 and in the spring of 1959. Total stock size declined from about 2,000,000 t in the mid-1960s to about 500,000 t in 1971, a reduction of 75% (287). Over the same period the portion of this stock complex available to the southwest Newfoundland fishery declined from about 800,000 to 130,000 t. The 1958 and 1959 year-classes accounted for nearly 60% of the exploitable stock size of the entire complex in 1965 and remained dominant until 1970. Recruitment to the southern Gulf stock complex has been relatively poor since the late 1950s with the result that by 1973 adult stock size was reduced to 12% of its original level in 1965. Adult stock size increased slightly in 1973 due mainly to a fairly good 1968 year-class of spring spawners and 1967 year-class of fall spawners but will remain at a low level, at least for the next several years.

The abundance of herring in the southern Gulf and southwest Newfoundland area during the 1960s and the associated high yields, should not be considered representative of the sustained yield from this stock complex mainly because of the anomalous recruitment pattern. The large 1958 and 1959 year-classes, which supported this fishery, appear to have been produced under exceptional circumstances, occurring in succession shortly after a fungus disease (*Ichthyosporidium hoferi*) had caused widespread mortalities of herring and mackerel in the southern Gulf of St. Lawrence during 1953–57 (262). The effects of such a reduction in standing stock levels of both herring and mackerel on inter- and intra-specific competition were undoubtedly conducive to high larval survival. The fact that, in the decade following the production of these large year-classes, not a single comparable year-class has been produced (287) suggests that the occurrence of large year-classes, particularly in successive years, is not a regular feature of the biology of this stock complex; more likely, the much smaller year-classes that prevailed after 1959 represent the normal situation when pelagic fish biomass is at high levels. In the future, therefore, average yields will probably be substantially less than those of the late 1960s and it has been suggested that under optimum fishing rates and with large year-classes occurring only infrequently a sustained yield of 100,000 t for the stock as a whole might be considered reasonable (287). As the southern Gulf herring are fairly old before they migrate to southwest Newfoundland in significant proportions (287) a large fishery in the southern Gulf of St. Lawrence will substantially reduce potential yields in southwest Newfoundland, perhaps to the 20,000-t level (reliability code 4).

Fortune Bay — The Fortune Bay herring are predominantly spring spawners (176) and tagging studies together with biological characteristics (176) suggest they do not mix with either the southwest Newfoundland stock to the west or the Placentia Bay stock to the east.

Traditionally, up to the early 1950s, Fortune Bay was a main center of the Newfoundland herring fishery with catches averaging 16,000 t during 1945–50 (258). Annual catches from Fortune Bay declined to less than 700 t during 1954–66 when the demand for herring as food was low. With the advent of the purse-seine fishery in the mid-1960s, however, catches increased rapidly to nearly 5700 t in 1967 and fluctuated between 6900 and 15,000 t from 1968 to 1972 (Fig. 26).

A preemptive quota of 12,000 t was imposed on mobile fleet catches in 1973 of which only 2000 t were caught due to a combination of reduced abundance and extremely severe environmental conditions. Since the early 1960s good year-classes have been recruiting every 2 or 3 years, the most recent being the 1968 year-class. Stock size estimates indicate that total stock size in 1973 was less than half the 1969 level due mainly to high fishing mortality rates in 1971 and 1972 and to the poor recruitment from the 1969 and 1970 year-classes. On this basis a mobile fleet quota of 4000 t was imposed for 1974.

The pattern of year-class survival in this stock implies that a strong year-class must sustain the adult stock size for several years. Maintenance of adequate spawning escapement will, therefore, be at the expense of loss in yield-per-recruit. In view of this a sustainable yield of 8000 t might be considered appropriate for this stock (reliability code 5).

St. Mary's–Placentia Bay — The herring from these bays partially intermingle during the overwintering period in Placentia Bay but maintain separate spawning areas. For management purposes, they have been treated as a single stock complex. This stock complex of herring is similar to the Fortune Bay herring in growth, stock size, and spawning group composition and has exhibited parallelism in the occurrence of strong year-classes.

An average of 14,000 t was removed from this stock complex during the high demand period 1945–50, most from Placentia Bay. Landings dropped to a low level in the 1950s and remained so until the mid-1960s when a reduction plant was built at Riverhead, St. Mary's Bay. Landings increased substantially in 1968 when over 6500 t were caught by purse seiners, mainly in St. Mary's Bay. Landings dropped considerably in 1969 at the time of the Electric Reduction Company of Canada (ERCO) phosphorus spill and remained at the 1000-t level until 1972 when purse seiners landed nearly 4500 t (Fig. 26) and the total catch was 6000 t. A mobile fleet quota of 8000 t was imposed on this stock complex in 1973, 5000 t in Placentia Bay (full quota taken) and 3000 t in St. Mary's Bay (only 850 t caught, mainly due to unusual ice conditions) apportioned generally on historical catches.

The 1969 ERCO phosphorus spill caused severe mortality (about 55%) to this stock and eliminated between 35,000 and 40,000 t of biomass. Mortality was especially heavy in the older fish with pre-1964 year-classes virtually wiped out. Fortunately the strong 1968 year-class was not affected by the spill and this allowed the stock to recover to about 70% of its original biomass level in 1968.

The pattern of annual recruitment in the St. Mary's Bay–Placentia Bay stock is similar to that of the Fortune Bay stock and consequently maximum yield-per-recruit will be reduced by the provision for adequate spawning stock size. A long-term yield of 8000 t may be considered representative of the production of this stock (reliability code 5).

Newfoundland East Coast — East coast herring are predominantly spring spawners that are normally concentrated in large schools during the overwintering period (174). Their availability during this period is considerably reduced by winter ice and flow ice, and this has restricted the fishery mainly to the spawning season in May and June.

Information on stock relationships is scanty but preliminary analyses of tagging data indicate each bay has its own local stocks that do not mix with stocks from adjacent bays. An exception would appear to be the Notre Dame Bay stock of spring spawners that apparently moves northwards to the Strait of Belle Isle area to feed during summer and returns again in late fall. The recruitment pattern is similar to the southeastern Newfoundland herring stocks with good year-classes occurring every 2 or 3 years.

The east coast of Newfoundland has never possessed a large herring fishery. Even during 1945–50 when demand was high, total landings averaged less than 7500 t, the bulk came from Trinity and Notre Dame bays. By the early 1960s landings dropped to less than 1000 t and remained at that level until 1971 when about 5000 t were landed, mostly caught by inshore gear (Fig. 26). These low landings have tended to reflect low effort levels due to adverse environmental conditions rather than to resource constraints.

Estimates of stock size are not available for the herring populations on Newfoundland's east coast, although it is not unreasonable to assume they are perhaps equivalent in size to the Fortune Bay or Placentia Bay stocks. Altogether an annual yield of 20,000–25,000 t could be harvested from these stocks (reliability code 3).

West Coast Herring — Stock interrelationships of the populations of herring on the west coast of Newfoundland are unclear. Fish tagged during the fall fishery in the Hawke's Bay area have been recaptured from landings of fish caught along southwest Newfoundland during the winter fishery, and subsequently from summer fisheries in the southern Gulf of St. Lawrence. This indicates that at least some of the southern Gulf of St. Lawrence stock complex pass through the northern Gulf enroute to their overwintering area along southwest Newfoundland. The St. George's Bay fishery is based mainly on fish that move westward across Cabot Strait to feeding and spawning grounds in the southern Gulf and also probably northward into the northern Gulf of St. Lawrence.

The Bay of Islands area on the west coast of Newfoundland has traditionally yielded large catches of herring with landings averaging 15,000 t during 1945–50 (258). Landings dropped considerably during the 1950s and have remained at a low level up to the present time. The Bonne Bay–Hawke's Bay area has yielded between 2000–6000 t per year during the last decade or so,

the bulk of the catches made by purse seiners in late fall (Fig. 26). In recent years a large mobile fleet fishery has developed during April–May in the St. George's Bay–Port au Port area and catches increased from about 100 t in 1970 to about 15,500 t in 1973.

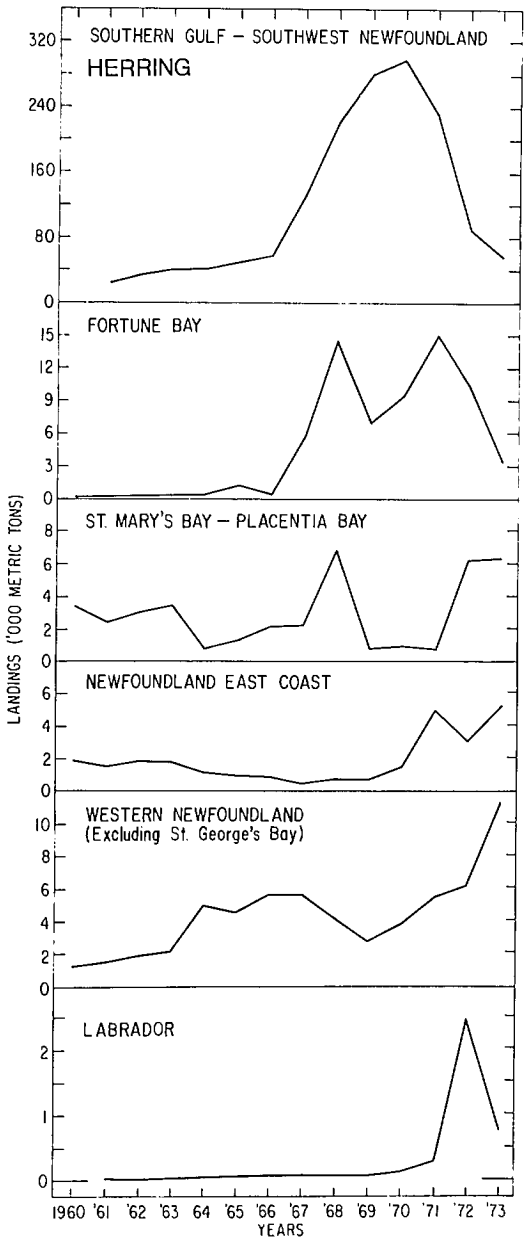

FIG. 26. Landings of herring at Newfoundland ports, 1958–73, from various stocks.

Herring stocks along the west coast are predominantly spring spawners, although in the northern areas summer spawners may form a significant proportion. Considering only the resident populations, the west coast herring could perhaps support annual yields of 10,000–15,000 t (reliability code 3) although it would be difficult to fish the resident population separately from the 4T and 4R migrants.

Labrador Herring — Little information is available on the Labrador herring except that they are predominantly late summer spawners and consist mainly of large, old, slow-growing fish (174). Large catches were taken in the Labrador area in the late 1800s. In 1885, for example, 20,000 t were landed in Labrador to August 23 (73). This fishery, however, has been characterized by a great abundance of herring or by complete failure of the fish to appear on the coastal fishing grounds (214). As a result, an extensive fishery has never developed in this area. During the 1960s, landings dropped to less than 100 t but increased substantially to over 2400 t in 1972 in response to strong demands for high quality food herring (Fig. 26). Sustainable yields from this area are probably less than 5000 t (reliability code 3).

Atlantic mackerel (*Scomber scombrus*)

L. S. Parsons/G. H. Winters

Mackerel are moderately warmwater fish and occur in abundance along the Atlantic coast of North America from Virginia north to the Strait of Belle Isle, sometimes migrating farther north along Labrador. They are seasonal migrants to Newfoundland waters, appearing in numbers in July and disappearing again in late autumn; catch records indicate they are most plentiful from August to October. There are regular southward migrations in the fall, perhaps to overwintering areas at the edge of the continental shelf from Sable Island to Georges Bank, confirmed recently by the recapture, during December–March south of Cape Cod, of mackerel tagged in eastern Newfoundland waters during August–September (156; 177). In spring and early summer mackerel move northward into the coastal waters of Nova Scotia, the Gulf of St. Lawrence, and Newfoundland. There are two major spawning areas, one in the bight between Long Island and New Jersey and the other in the southern Gulf of St. Lawrence where spawning occurs in June and July.

Mackerel that appear along the northeast coast of Newfoundland in midsummer apparently come from the Gulf of St. Lawrence through the Strait of Belle Isle. Recent research by St. John's Biological Station demonstrated the occurrence of mackerel spawning in southeastern Newfoundland coastal waters (175). Mackerel schools that first appear in southeastern Newfoundland waters in late June and early July probably represent an offshoot from the northward migration over the Scotian Shelf into the Gulf of St. Lawrence, which spawn after entering Newfoundland waters.

The largest Newfoundland landings in recent years have been from the northeast coast (Strait of Belle Isle to Trinity Bay). This region has traditionally yielded the bulk of the Newfoundland catch with relatively smaller catches along the south and west coasts. Since 1969 mackerel have been present in unusually large numbers along southern Labrador; in 1971 approximately 220 t were caught in that region.

During the late 1800s there was a small fishery for mackerel with two short periods, 1870–72 and 1879–80, of minor abundance (Fig. 27). The greatest landings in this period, 391 and 330 t in 1879 and 1880, occurred when mackerel were abundant along the Atlantic coast of the United States.

From 1880 to the 1930s mackerel virtually disappeared from Newfoundland waters. The catch increased sharply in the late 1940s and early 1950s during a period of climatic warming, with peak catches about 2300 t in 1952 and 2570 t in 1953, but declined to near zero by 1959 probably due to parasitic infection. Mackerel catches during 1960–64 were 250 to 1000 t. Catches decreased again in the mid-1960s but began to increase again in 1968 and by 1973 had reached 2900 t, 14% of the total Canadian Atlantic catch. It is not known how much the catch fluctuation was related to fluctuation in effort.

Historically the main method of capture by U.S. fishermen has been purse seining that presently accounts for about one-third the total Canadian catch. In Newfoundland, mackerel are usually caught by bar seines and gillnets. The Industrial Development Branch of the Fisheries and Marine Service recently introduced mackerel traps and Scottish-type ringnets to the Newfoundland area; ringnet catches in Trinity Bay have been particularly promising.

Fluctuations in the abundance of mackerel in Newfoundland waters have been attributed to long-term changes in water temperatures and changes in the abundance of mackerel in the southern Gulf of St. Lawrence and along the Atlantic coast of Nova Scotia. Recent increase in the Newfoundland–Labrador catch, from 196 t in 1968 to 2900 t in 1973, has apparently been due to the occurrence of strong year-classes, in recent years, in the northern spawning population of mackerel (156). The Newfoundland mackerel catch could be increased substantially during periods of abundance if enough suitable gear were available and market conditions were favorable. Natural fluctuations in supply need not prevent further development of this fishery, provided mackerel were fished as part of a multispecies operation that could utilize herring or some other species during periods of low mackerel abundance.

Since the late 1960s an intensive international fishery for mackerel has developed during the November–April period off the southern New England coast and landings reached a peak of nearly 390,000 t in 1972. This fishery is now under ICNAF quota regulations, as well as the mackerel fisheries along the Atlantic coast of Nova Scotia and New Brunswick. Analyses of available data led to the conclusion that the southern fishery for mackerel is based, at least partially and probably substantially, on the northern population of mackerel that spawns in the Gulf of St. Lawrence (156). If this is so, future yields in the Canadian mackerel fishery will depend not only on the occurrence of good year-classes of mackerel but also on the fishing mortality generated by the international fishery off the New England coast. Reliable information on the population size of the northern mackerel stock, and on the proportion of that stock migrating to the Newfoundland area, is not yet available and so potential yields in the Newfoundland area cannot be accurately determined. It is probable with increased fishing effort the catch could be increased to 20,000 t (reliability code 3).

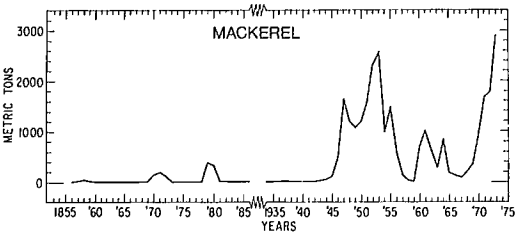

FIG. 27. Newfoundland landings of mackerel, 1856–1973.

Bluefin tuna (*Thunnus thynnus*)

G. H. Winters

The bluefin tuna of the Newfoundland area, migrating from spawning in the Bahamas, arrive in Newfoundland waters around mid-July. These fish remain around the coasts until October when they retreat southward again. Tuna feed heavily on squid, mackerel, herring, and billfish while in this area, and are usually found in the warm surface layer above the intermediate layer of cold water. As tuna do not feed readily at temperatures below 10 C, quite often, especially on arrival here, cold temperatures restrict their feeding activities and consequently troll fishing is poor.

Tuna are not fished commercially in Newfoundland, but have, in the past, supported considerable sport fisheries in Conception and Notre Dame bays. Only a small amount of landings is used for food and the rest is discarded. Tuna have been reported in large schools in the east coast area but recent catch data suggest that recruitment to the adult stock has been declining, perhaps in response to intensive juvenile fisheries off the New England area. In addition, the bluefin possesses dark meat and traditionally has not commanded a high market price. In Nova Scotia they are caught by traps and floating longlines, but the low temperatures prevalent around Newfoundland would restrict the duration of the fishing season for the latter method. Commercial fishing for tuna in the Gulf of St. Lawrence has now been banned because of high mercury content in the flesh. In 1973 recreational and commercial tuna boats using sports gear began an export trade of fresh-frozen tuna carcasses to Japan at lucrative prices. Federal regulations limiting the expansion of this fishery have recently been imposed.

Sand lance *Ammodytes hexapterus, A. dubius*

G. H. Winters

Two species of sand lance (sand eel) are present in the Newfoundland area; an inshore species that is abundant in most bays and inshore shallow areas, and an offshore species that is common on the Labrador Shelf, Grand Bank, St. Pierre Bank, and Gulf of St. Lawrence. Research vessel surveys indicate that large quantities of sand lance exist on the Grand Bank and stomach content analyses of predator fish suggest widespread abundance of sand lance elsewhere. Other sand lance species are caught in Europe in large enough quantities to be used for fish meal so local species probably could support a reduction fishery in the Newfoundland area. The Industrial Development Branch of the Fisheries and Marine Service conducted extensive surveys for this species in the Grand Bank area without apparent success, but this was probably due to lack of familiarity with the behavioral habits of the fish. They commonly burrow in the sand and are difficult to detect by conventional acoustic equipment except when they migrate upward to the pelagic zone to feed. There are no historical catch statistics for sand lance and they are only occasionally used for bait. A sustained yield of 100,000 t for the whole Newfoundland–Labrador area might be a reasonable estimate of their annual potential yield (reliability code 1).

Capelin (*Mallotus villosus*)

G. H. Winters/J. S. Campbell

Capelin are distributed along the Labrador coast from the northernmost area southward to the Gulf of St. Lawrence and southern Grand Bank, wherever suitable spawning areas exist. Feeding concentrations of capelin have been located on Hamilton Inlet Bank and in Notre Dame Bay in autumn. Capelin are abundant around the coast of Newfoundland on St. Pierre Bank, and on the Grand Bank where, especially on the Southeast Shoal, they concentrate during the spawning season (189; 256).

At least some capelin stocks along the east coast of Newfoundland remain near the coast or in the deep bays during the winter and spring months. Large inactive schools of capelin were located in Trinity Bay at an approximate depth of 100 fath (183 m) (282). In April these capelin move into the warming surface waters where they disperse to feed. Feeding continues into early June when the ripening fish migrate to the beaches for spawning.

Capelin concentrations have been located during winter and spring by Canadian research vessels (257) and Soviet fishing vessels (86) on the northern areas of the Grand Bank. In May and June, Soviet vessels reported a southerly migration of capelin from the area toward the southern part of the Bank where spawning concentrations have been located in June and July (189). In addition to this southerly migration from the northern areas of the Grand Bank, evidence collected on the movement of cod (260), a major predator of capelin, suggests that capelin from the west and northwest slopes migrate inshore to spawn on the east coast of

Newfoundland. Survivors of spawning on the Southeast Shoal appear to migrate to the northern and central areas of the Bank (85). At the same time, immature capelin have been located on the northern area of the Bank (44) suggesting this is a major feeding area of overwintering capelin destined to spawn either on the east coast of Newfoundland or on the Southeast Shoal the following year.

Substantial concentrations of adult and immature capelin have been located in Notre Dame Bay and on Hamilton Inlet Bank during August–November (36; 86). The feeding schools appear to be survivors of previous inshore spawning in Notre Dame Bay and along the Labrador coast, and young capelin maturing to spawn the following season. These capelin have a fat content of 15–21%, whereas the fat content of capelin captured during the spawning period may decline to less than 1%.

During the early part of this century, capelin were used extensively for raw fertilizer, as bait in the line cod fishery, and as dogfood. Landings were as high as 25,000 t from the inshore Newfoundland area (259). Since 1950, landings of capelin have declined continuously to about 5000 t between 1960 and 1970. This decline has been due to changes in fishing methods for cod and a decrease in domestic use of capelin as fertilizer and dogfood. An international offshore fishery for capelin commenced in 1972 with landings of 70,800 t and landings increased to 268,500 t in 1973.

Capelin have been taken by castnets and beach seines from inshore areas during the spawning period for many years. Recently the introduction of the Scottish ringnet technique, pair trawling, and single vessel midwater trawling for capelin in inshore areas has proven quite successful. During July 1973, one pair of longliners fitted with a ringnet was able to land in excess of 200 t of capelin. Recent development of new fishing techniques and gear has increased the inshore catch of capelin in Newfoundland from less than 1000 t in 1972 to over 4000 t in 1973. Although much of this total was processed into fish meal, a market developed in Japan for female capelin with roe. Also, an increasing number of fish plants have equipment suited for the processing of capelin into canned, frozen, smoked, and dried products for human consumption.

Offshore exploitation of capelin by Canadian vessels occurred for the first time in 1972 and 1973, but has been mainly exploratory. Vessels fitted with midwater trawling gear have been most successful, although purse seining has been attempted. Midwater trawlers proved to be more versatile, as the gear is more suited to the vertical movements and behavior of capelin, and the vessels have the ability to fish under more adverse weather conditions (143). Soviet vessels have been using midwater trawling methods and Norwegian vessels purse seining since 1972 with considerable success.

In May and June 1972 the Norwegian research vessel *Johan Hjort* conducted exploratory fishing and echo sounding for estimation of capelin abundance on the Grand Bank (44). Total abundance of capelin in the area surveyed was estimated at 0.8 million t. The estimated production of capelin in excess of the major predators food requirements, at the current predator population levels in the Newfoundland area, has been obtained from estimates of the biomass of major predators and their annual consumption of capelin (30). Annual consumption of capelin by such predators as cod, seals, seabirds, and whales at virgin population levels are in the order of 5 million t (286). The decline in abundance of such major predators as cod, haddock, and harp seals indicates that there is a substantial excess production of capelin available to commercial fisheries, perhaps in excess of 1 million t. A total quota of 258,000 t (exclusive of Canadian catch inside 3-mile limit) was allocated at the Special Meeting of ICNAF in January 1974, 110,000 t in ICNAF Subarea 2 and Division 3K and 148,000 t in ICNAF Divisions 3L, 3N, 3O, and 3Ps to control development of this fishery. It was also recommended that future increases in the TAC be related to the rate at which new information allowed the true potential of the resource to be evaluated.

Barracudina *Paralepis coregonoides borealis, Notolepis rissoi kroyeri*

A. T. Pinhorn

Two species of barracudina are known off the Newfoundland coast and over oceanic depths outside the continental shelf. They are quite numerous in deep, open water of temperate and tropical seas but occasionally are found in the Labrador Sea and over the Newfoundland Shelf during periods of hydrographic warming. They are important in the food of salmon in the Labrador Sea and Davis Strait (90). Pilot-scale commercial reduction for meal and oil, and fish protein preparations indicate that meal from barracudina is as satisfactory as regular

commercial meal and fish protein concentrate is comparable in all respects to that from approved species (219). Virtually nothing is known of the commercial potential of this species.

Atlantic saury (*Scombersox saurus*)

A. T. Pinhorn

Atlantic saury are found in temperate parts of the Atlantic, on the coast and in open seas. In the western Atlantic it occurs from eastern Newfoundland southward to North Carolina and the West Indies. They are abundant mainly south of Cape Cod and occasionally on the Nova Scotian coast (219). As Atlantic saury are only found in Canadian waters in summer and early autumn, it is apparently a migratory species that visits the northern areas when water is warmest. They are common in Newfoundland only in occasional years and, although are suitable for human consumption, have only been used in Newfoundland as bait (258). No landings have been recorded from the Newfoundland area and no commercial potential exists for development of a fishery for this species.

Anadromous–Catadromous Fish

Atlantic salmon (*Salmo salar*)

W. H. Lear

Atlantic salmon landings from Newfoundland and Labrador averaged 1769 t during 1910–54 with high peaks of production of 3129, 2993, and 2630 t in 1930, 1931, and 1938, respectively. In 1955–72, landings increased from 727 t in 1956 to 1814 t in 1967 but decreased to 1406 t in 1972 (Fig. 28B). Figures for 1973 indicated a total catch of 2019 t, the highest since 1940. The fishery is conducted mainly by surface gillnets set out from shore that accounts for about 97% of the Atlantic salmon landings, the remaining 3% is taken by salmon traps and miscellaneous gears. There is no driftnet fishery operating at present around the coast of Newfoundland–Labrador.

Landings during 1969–72 were highest in southern Labrador (Area O, Fig. 28A), high along the northeast coast (Areas A, B) and the southwest coast (Area J), particularly near Port aux Basques (where a large driftnet fishery operated until banned by regulations in 1972), followed by areas on the southeast coast (Areas C–F, H). Landings were lowest on the eastern part of the south coast and on the west coast (Areas G, K–N). Estimates of grilse (3–6-lb fish that return to spawn after one complete year at sea) and larger salmon (over 6 lb and 2 or more sea-years) taken in Newfoundland–Labrador during 1969, 1970, and 1971 suggest that grilse proportions were 29, 40, and 25% respectively (93).

In addition to the commercial catch in 1955–72, the angling catch accounted for about 12,000–46,000 salmon (89% grilse 6 lb and under during 1955–72), or about 25–86 t/yr. Angling catches peaked at 42,500 fish in 1964 and averaged 34,000 fish during 1965–72. The angling catch during 1973 was 46,000 fish.

Results of tagging experiments by Blair (19; 20) and Lear (unpublished data), as well as the high smolt ages (approximately 4.5 years) (91; 93) of grilse and large salmon caught in southern Labrador (Area O), suggest that practically all fish exploited by this fishery originate from rivers in Labrador and northern Newfoundland, although a few salmon marked as smolts in the Pollett River, Bay of Fundy, were taken in southern Labrador (80). Recoveries of salmon tagged as smolts suggest that fish from Maine, USA, contribute somewhat to the fishery of northern Labrador from Hopedale to Nain (A. L. Meister personal communication).

The high average smolt ages (3.4–4.1 years) of salmon and grilse caught in Area A and the results of recent tagging experiments (Lear unpublished data) suggest that fish caught in this fishery originate mainly from rivers in Newfoundland and Labrador although a small proportion from Miramichi area are also taken.

On the east coast of Newfoundland there is a varied mixture of stocks from rivers in Labrador (182), Newfoundland, the Maritimes (18), Quebec (18), and Maine (Meister personal communication).

Results of tagging experiments of grilse and salmon near headland areas suggest varying proportions of fish other than those of Newfoundland–Labrador origin occur in the different fisheries. Tagging recapture data indicate that proportions of large salmon originating outside Newfoundland–Labrador rivers account for 0%

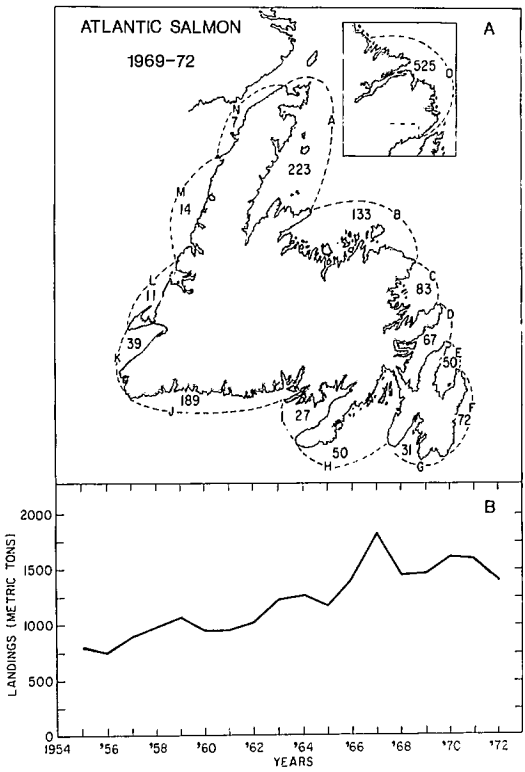

FIG. 28. (A) Average annual landings of Atlantic salmon in the statistical districts of Newfoundland, 1969–72. (B) Newfoundland commercial landings of round fresh salmon, 1955–72.

in southern Labrador, approximately 15% along the northeast Newfoundland coast (Areas A–E), 50% along the southeast Newfoundland coast from Renews to St. Lawrence (Areas F–H), and 75% near Port aux Basques (Area J). Corresponding figures for grilse indicate that the mainland proportions of grilse are considerably lower for those areas mentioned than the salmon proportions. It must be emphasized that taggings were conducted at headland locations and do not necessarily reflect the mainland proportions of salmon and grilse exploited by fisheries inside headland areas, especially near river estuaries where the proportions of non-Newfoundland salmon would naturally be expected to be closer to zero.

Apart from a few incidental catches taken by trawlers (167), the first recorded commercial exploitation of salmon at West Greenland was a catch of 14 t by native Greenlanders in 1959, using set gillnets attached to the shore. This fishery reached a peak of 1542 t in 1964. Since that time it has fluctuated around 1100 t including catches by driftnets as well as shorenets since 1969. Fishing takes place along the west coast from 60 to 70°N during August–November. A small shorenet fishery also operates at Angmagssalik (about 66°N) on the east coast. Driftnet fishing, by vessels based in Europe, began in 1965 and combined catches by setnet and driftnet reached a peak of 2676 t in 1971. Driftnet fishing occurs close to shore as well as 30–40 miles offshore, and has gradually developed to cover the same north–south distribution as the inshore fishery.

Distribution of river ages in the Greenland catch includes fish of river age 1–7; about half age 2 and 90% age 2–4. Over 90% of salmon taken are 1+ sea-years in age and, if surviving, would return to home waters as 2+ sea-years (8–14 lb) or more. The remainder are fish that have previously spawned and 2+ sea-year fish that, if surviving, should return as 3+ sea-years (15–30 lb) or more.

Smolt tagging experiments show that salmon originating from rivers in Canada, eastern United States, United Kingdom, Ireland, France, Norway, Sweden, and Iceland are caught in West Greenland.

Atlantic salmon have been tagged at West Greenland, in Davis Strait, and Labrador Sea, but mainly near shore along the Greenland coast by scientists from Denmark, Canada, the United Kingdom, and the United States. Of 2042 fish tagged between 1965 and 1970, only 88 recaptures had been made to the end of 1971; 61 at Greenland and 27 in home waters (108). Home-waters recaptures were as follows: Canada 12, Scotland 6, England and Wales 3, Ireland 5, and Spain 1 for a total of 27 (45% to North America and 55% to Europe).

However, there are marked annual fluctuations in the proportion of North American salmon off West Greenland as determined from serum transferrin polymorphisms. North American proportions at Greenland are as follows: 43% in 1969 (168), 23% in 1970, 53% in 1971, and 20% in 1972 (181).

Based on an average increase in weight of 50%, and lower and upper values of natural mortality of 15 and 40% between West Greenland and home waters, the reduction in weight of salmon returning to home waters, for a Greenland catch of 2000 t, ranged from 1800 to 2550 t. Reduction in home-water catches combined ranges from 1080 to 1530 t, assuming an overall exploitation rate of 0.6 for home-water fisheries exploiting 2-sea-year salmon (12).

Denmark has agreed to phase out its Greenland driftnet fishery for salmon by 1976. The phase-out will be by decreasing quotas of 600, 550, and 500 t for 1973, 1974, and 1975 with no fishery in 1976. Norway will similarly phase out its smaller West Greenland salmon fishery by 1976.

The Greenland inshore salmon fishery (within 12 miles of the Greenland coast) will limit its annual catch to 1100 t and will involve only native Greenlanders.

With civilization and industry expanding into many important salmon-producing regions in Newfoundland and the mainland, it is unlikely natural production of young salmon in the rivers will be greater in years to come than it is now. There is no reason to expect changing environmental conditions in the sea to favor survival and thereby offset any losses from adverse conditions in the rivers. One means of compensating for losses in the rivers is to produce young salmon in specially designed rearing facilities. This approach is being actively pursued in several mainland and Newfoundland rivers. The efficacy of these facilities has not been fully evaluated but they undoubtedly contribute some measure of improvement to commercial salmon fisheries. The phase-out of the West Greenland driftnet fishery will mean more large salmon for commercial fishermen, anglers, and spawning escapement.

For more information on Atlantic salmon in the Newfoundland area see (158). For a more detailed account of the West Greenland salmon fishery and the distribution and origins of salmon at West Greenland see (108; 173; 182; 261; 268). For a detailed account of food of salmon in high seas and coastal area see (90). For more detailed data on landings see (109).

Pink salmon (*Oncorhynchus gorbuscha*)

W. H. Lear

Pink salmon were first introduced into Newfoundland in 1959 by a transplantation of one-quarter million eggs (fertilized and hatched to the eyed stage) from Indian River, B.C., to North Harbour River, St. Mary's Bay, Newfoundland (21). Subsequent plantings of 2.5, 3.4, 3.3, and 5.9 million eggs were made in 1962, 1964, 1965, and 1966. Eggs transplanted during 1962 were from Glendale River, B.C., and in 1964–66 from Lakelse River, B.C.

Returns from the plantings have been highly variable; from a planting of 3.4 million eggs in 1964 there was a total of 638 returns in 1966 and from a planting of 3.3 million eggs in 1965 a total of 8440 returns in 1967 (Fig. 29, 30). Returns to North Harbour River have ranged from 42 to 75% of total annual returns whereas returns to the immediate area of St. Mary's Bay have ranged from 56 to 100% and have generally been above 90%, indicating a low degree of straying. Returns since 1967 have declined generally except in 1970 when there was a return of 2090 adults, the natural progeny of 1353 adults that spawned in North Harbour River in 1968. The 1971 and 1972 returns of 117 and 142 fish, respectively, low compared to the parental stocks, indicated the transplant has been unsuccessful in terms of commercial or sport fishery potential.

For more information on pink salmon in Newfoundland see (21; 198; 91A).

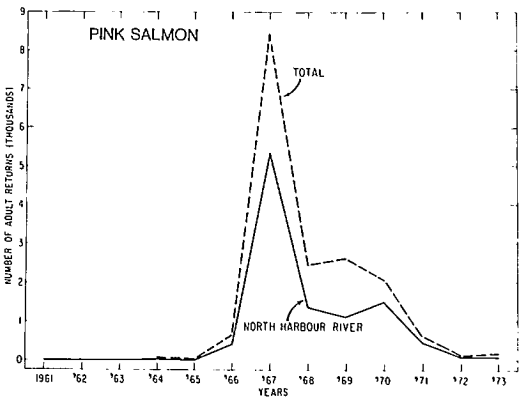

FIG. 29. Annual returns of pink salmon adults to North Harbour River (solid line) and total returns for all areas combined (broken line), 1961–73.

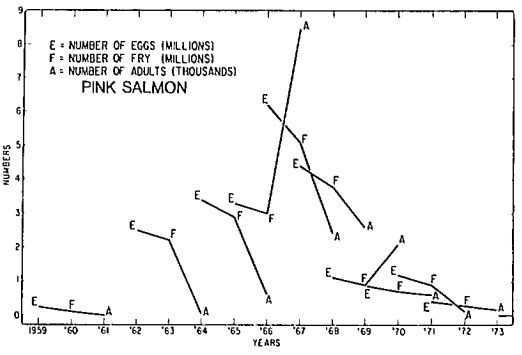

FIG. 30. Numbers of eggs, fry, and subsequent total adult returns of pink salmon, 1959–73.

Trout *Salvelinus fontinalis, S. alpinus, Salmo trutta, S. gairdneri*

W. H. Lear

No new information on brook, brown, and rainbow trouts is available than reported in Bulletin 154 (258).

Arctic char are abundant in Labrador waters especially north of Cape Harrison (8) and are particularly important in the economy of Labrador. There is a commercial gillnet fishery for char between Makkovik and Nachvak Fjord (Fig. 2). Annual catches of Arctic char from this area (including some sea trout) indicated a 6-year cyclical pattern during 1954–72 and varied between 74 and 219 t (Fig. 31), with an average catch of 139 t. This fishery is limited to July and August, during the short period Arctic char remain at sea and relatively close to home rivers. Such a fishery, if exploited too intensively, can cause serious depletions in stocks of native rivers. Recovery from stock depletion would be slow because of slow growth rates associated with low river temperatures and short periods of sea growth. In view of these factors the commercial fishery for char in northern Labrador has been restricted to permanent residents of the coast who depend on the fishery for an important part of their livelihood.

Arctic char are present in some Newfoundland streams where they exist in the landlocked form. Two small sea runs are known, at Parsons Pond River and in Parker's river, Pistolet Bay.

For more information on Arctic char and other anadromous fishes of the Newfoundland area see (8; 33; 216).

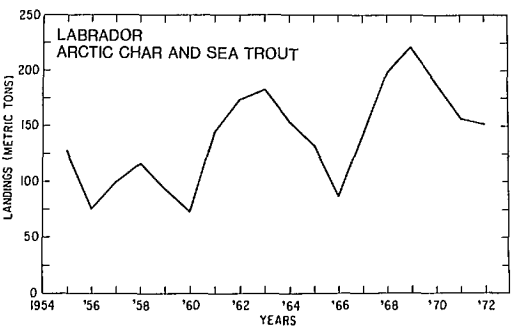

FIG. 31. Labrador commercial landings of Arctic char and sea trout, 1955–72.

American eel (*Anguilla rostrata*)

A. T. Pinhorn

Eels probably occur in most Newfoundland streams that have an uninterrupted flow to the sea. They are particularly abundant in various rivers and streams along the Avalon Peninsula, in Trinity Bay, Bonavista Bay, Hamilton Sound, Notre Dame Bay, White Bay, and Labrador (46).

Eel exports from Newfoundland, mostly to the United States, are reported from at least the early 1900s, first as a salted product and later exports were frozen (258). From 1930 to 1961, 3 t were exported in 1930, 13 t in 1931, 4 t in 1940, and smaller quantities in some other years but in 1962, 21 t were landed, and the eels mainly shipped alive to Europe (258). In 1963, 25 t were landed, in 1964, 12 t, and in 1965, 3 t. After that no landings of eels were recorded for Newfoundland until 1971 when 19 t were landed. In 1972, 36 t were reported. Landings of eels in the Maritime Provinces totalled 862 t in 1970, 1103 t in 1971, and 848 t in 1972.

The limited eel fishery in Newfoundland has been conducted mainly with baited eelpots and fykenets in areas relatively close to shipping routes. To take full advantage of the high catch per unit of effort possible in the fishery, eeltraps such as those used in Nova Scotia will need to be used mainly for silver eels migrating to sea for spawning (258).

American smelt (*Osmerus eperlanus mordax*)

A. T. Pinhorn

Smelt extend from southern Labrador to as far south as Virginia. They are also found in landlocked form in some lakes, including the Great Lakes and inland lakes of Ontario, where they have been established through introduction.

Smelt live in coastal waters entering estuaries in autumn where they are caught during the winter. They spawn in brooks and streams during April–June and eggs become attached to rocks, gravel, or vegetation. Young fry are carried downstream to brackish water soon after hatching. Subsequent growth is rapid so 2-year-old smelt are large enough for commercial use (94).

Newfoundland landings have declined in recent years after reaching peaks of 186, 208, and 196 t in 1931, 1937, and 1939. In 1964–71 landings ranged from 8 to 18 t. The 1972 landing was 14 t.

In different years areas of importance for the fishery are the northeast coast from Cape Norman to Cape Freels, Bonavista Bay, Placentia Bay, Fortune Bay, and St. George's Bay.

No new information on the status of the resource is available. For information on the life history of the species in the Miramichi River and Lake Erie see (66).

Invertebrates

CRUSTACEANS

Lobster *Homarus americanus*

E. J. Sandeman

In terms of landed value the lobster fishery is the most important fishery of Atlantic Canada and in 1972 has a landed value of $37.0 million (cf. cod in this same year, $26.2 million).

Newfoundland is situated at the extreme northern part of the lobster range in the Northwest Atlantic and landings of lobsters are only about one-tenth those of the Maritime Provinces and Quebec. Although the lobster fishery is of less importance in Newfoundland, it ranked third in 1972 with a landed value of $3.2 million after cod ($13 million) and flatfish ($9.5 million).

Landings of lobsters in Newfoundland have shown a decreasing trend over the last few years (Fig. 32), but 1952–72 average landings were 1800 t. The fishery, one of the most regulated of all world fisheries, is very intensive and in most areas is dependent on lobsters that molt to legal size between the end of the one year's fishing season and the beginning of the next. More intensive fishing is unlikely to increase landings by any appreciable amount. Unless there is a marked change in the temperature regime and if the minimum legal size of lobsters landed remains unchanged, the sustainable annual yield can be considered as 1800 t (±450 t, reliability code 5). This total yield could be taken by considerably fewer fishermen.

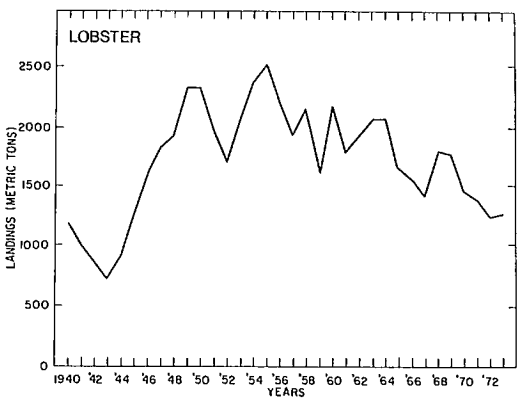

FIG. 32. Lobster landings in Newfoundland, 1940–73.

Lobsters are rather scarce on the north shore of the Gulf of St. Lawrence and only occasional specimens are found on the Labrador coast. Although lobsters are found in deep water at the edge of the continental shelf off Nova Scotia and south to beyond Cape Cod, they do not normally occur offshore north and east of Cabot Strait.

Shrimp *Pandalus borealis*

E. J. Sandeman

Newfoundland's shrimp fishery is of recent origin. In the peak year 1971, 675 t were landed. At present the fishery is confined to a small, productive area close to Point Riche off the northwest coast of Newfoundland, but the potential area for shrimps extends over many square miles in the northern part of the Gulf of St. Lawrence from north of Anticosti Island to Newfoundland. Estimated potential of the Esquiman Channel area is 2250 t/yr (reliability code 2), but longer trips and possibly larger vessels that can range farther afield will be required to attain this potential. Less productive shrimp grounds in several areas of the south coast of Newfoundland are unlikely to be important though a few small, isolated fisheries might be possible if prices increase. An area that appears to have potential for shrimps, but of which little is known, is Hawke Channel off Labrador.

Shrimp *Pandalus montagui*

E. J. Sandeman

Stocks of this species of shrimp, which is slightly smaller than the usual commercial shrimp of the Gulf of St. Lawrence, are likely found in some of the shallower and cold deepwater bays and fjords of Labrador. There is limited knowledge of the distribution and abundance of this species (244; 246), and no estimate of annual sustainable yields can be given.

Further information on the distribution and biology of shrimp in the area can be found in (49; 51; 207; 208; 244; 246).

Rock crab (*Cancer irroratus*)

R. J. Miller

This species occurs around insular Newfoundland but does not extend into Labrador (246). It is found from 0 to 10 fath (18 m) (246), predominantly on rock bottom, although it may be found on sand near rocky areas, or on mud within eelgrass beds (213; D. Redden personal communication). Although crabs are prey for lobsters, crabs apparently do not eat lobsters and are probably not serious competitors with lobsters for food or space (213).

There is no Newfoundland fishery for rock crabs although there has been a small intermittent fishery in the southern Gulf of St. Lawrence (213). This fishery has been based on males greater than 9 cm carapace width. Females seldom reach this size. A 9 cm crab is only $\frac{1}{4}$ lb, so processing costs are high; however, given high prices for crab meat and improvement in automatic meat extracting machines, development of a rock crab fishery would deserve consideration. It could be prosecuted by lobster fishermen as a by-catch during the lobster season and with only a small modification of lobster traps out of lobster season (37). There is no estimate of standing stock or MSY for Newfoundland.

Toad crab (*Hyas araneus* and *H. coarctatus*)

R. J. Miller

Both species are common on Newfoundland and Labrador coasts (246). Depth distribution ranges from a few fathoms to over 275 fath (503 m) on the continental slope (246), although abundance decreases considerably below 80 fath (146 m) (personal observation).

A fishery would have to be content with crabs averaging no larger than $\frac{1}{4}$ lb and the meat would have to be extracted by mechanical means. Although no estimate of MSY is available, toad crabs would be sufficiently abundant to support a fishery.

Snow crab (*Chionoecetes opilio*)

R. J. Miller

Males and females copulate in summer. The female attaches approximately 40,000 eggs to her abdomen soon after copulation and carries them for nearly a year. Crab larvae hatch from the eggs and swim in plankton for about 4 months before settling on the bottom and assuming the shape of the adults. They grow from 2 to 55 mm shell width, the approximate size at sexual maturity, in about 4 years. Until this size, crabs are found predominantly on rock bottom. Larger male crabs are most commonly found on mud or sandy-mud bottoms although females remain most abundant in rocky areas. Females do not grow after sexual maturity so are not included in the fishery due to their small size. Males continue to molt, reaching 100 mm shell width at about 7 years. Maximum size in Newfoundland is 140 mm (272; Miller unpublished data).

Exploratory fishing has shown the species to be located around most Newfoundland and Labrador coasts with the possible exception of Newfoundland's southwest coast (Miller unpublished data). Fishable concentrations of commercial-sized males (over 100 mm shell width) are most common between 90 and 180 fath (165–329 m) within 20 miles of shore. Depths of maximum concentrations occur about 20 fath (37 m) deeper off the northeast coast of Newfoundland than around the coast of the Avalon Peninsula.

The Newfoundland stocks are not shared with any other province or country. Tagging studies demonstrated that commercial-sized animals do not move more than a few miles (273, 276; Sandeman unpublished data).

Areas now yielding commercial catches and areas suspected of having commercial concentrations are mostly on the east and southeast coasts of Newfoundland (Fig. 33). Possible exceptions are within a 30-mile radius of Port au Choix. Areas identified in Fig. 33 as having suspected but unproven potential are only approximations based on unintensive exploratory fishing (joint project of Environment Canada, Fisheries and Marine Service and Government of

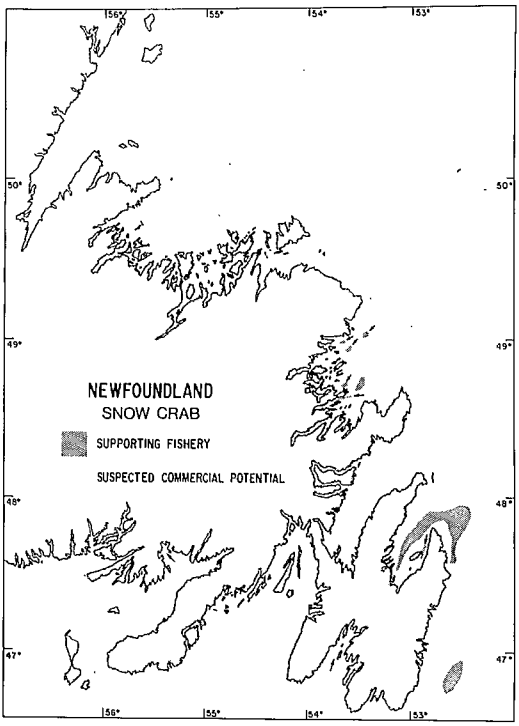

FIG. 33. Areas supporting a snow crab fishery and areas suspected of having commercial potential. Arrows point to small areas.

Newfoundland and Labrador), and reports from groundfish fishermen of large crab catches in gillnets (140). Widely dispersed exploratory fishing off Labrador ranging from 52°00′N to 56°30′N showed potential within a 20-mile radius of position 54°00′N, 55°30′W.

This is a young, expanding fishery in Newfoundland. Landings have increased from 93 t in 1968 to 3400 t in 1974 (see following table). The fishery is prosecuted from wooden boats between 40 and 60 ft long, hauling an average of 150 Japanese crab traps per day. Although the number of boats and processing plants tripled over 1973 and 1974, the areas north of Bonavista Bay (Fig. 33) have seen negligible exploitation.

Yr	Metric t	Lb
1968	93	205,000
1969	425	937,000
1970	894	1,971,000
1971	1380	3,043,000
1972	1488	3,281,000
1973	2045	4,509,000
1974	3400	7,480,000

The annual MSY for Newfoundland is predicted at 5000 t (reliability code 3).

Crab stocks will probably not be hurt by heavy fishing if the present minimum size of about 100 mm is maintained. There is a large breeding population of smaller crabs (274) and growth rates start to decrease above this size (272). There are three potential sources of resource waste: landing soft-shelled (recently molted) crabs not suitable for processing because of high water content of the meat (275), inadequate transport or storage allowing crabs to die before processing, and crab mortality resulting from the groundfish gillnet fishery (140).

The greatest management need is controlled entry to prevent further overcapitalization in fishing and processing sectors.

Krill *Meganyctiphanes* sp., *Thysanoessa* sp.

E. J. Sandeman

Euphausiids (krill) are extremely abundant in the Gulf of St. Lawrence and along the south coast of Newfoundland. Exploitation of krill in the Antarctic by the USSR could point the way to the development of an important new resource in Newfoundland.

ECHINODERMS

Sea urchin *Strongylocentrotus droebachiensis*

R. J. Miller

This species is most common from 0 to 10 fath (18 m) and on rocky bottom. It is widely distributed around the Newfoundland and Labrador coasts. The only obvious migration is downward movement from the shallowest areas to avoid ice scouring and storm surges. Although both sexes are found as large as 7.5 cm shell diameter (not including the spines), in most areas the standing stock consists predominantly of animals less than 5 cm diameter (139). A 5 cm diameter sea urchin is 7 years old on average (48; 141). Sea urchin size, abundance, and degree of gonad development commonly decrease with depth, thus the best fishing areas would be in shallow water, e.g. less than 2 fath (3.7 m) near Grand Manan, New Brunswick (163), and less than 5 fath (9 m) in Logy Bay, Newfoundland (48).

There is interest in all A lantic provinces in supplying Japanese and French sea urchin markets. A fishery for Japanese export began

in Charlotte County, New Brunswick, in 1974, but was aborted in 1975 due to problems in product quality. As the fishery is for roe, the fishing season would be limited to December–March when roes are large but not in soft spawning condition. In Newfoundland MSY of large urchins (over 4.5 cm diameter) in ice-free areas may be 5000 t, but the sustainable yield from areas where sea urchins are dense enough to fish commercially would be no more than 1000 t (reliability code 1). Because of highly variable recruitment (personal observation), it would be difficult to predict an MSY for small areas. Roe yield would be 10–15% of live weight.

Molluscs

Short-finned squid (*Illex illecebrosus*)

M. C. Mercer

Three species of short-finned squid (genus *Illex*) are known to occur in the Northwest Atlantic (205). The species considered here has the northernmost distribution and supports a commercial fishery. In the western Atlantic it is reported northward to northern Labrador (242), possibly to Baffin Island and Greenland (59), although records from there require confirmation (124), and southward at least to Florida (205).

Squid fished at Newfoundland approach from the south and are taken on the southwestern part of the Grand Bank and on the southern part of St. Pierre Bank in spring prior to reaching the inshore area (122; 129; 134; 242; 243). Part of the population migrates inshore and supports a commercial fishery from about mid-July to late October or early November. On arrival inshore all squid are juveniles but by the time they depart in the fall most are fully grown and the males are mature (121; 125; 130; 242). Mating and spawning have been suggested to occur in the winter at an age of 1 year with the squid dying after spawning (247). Heterogeneity is indicated in offshore and inshore populations by separate modes in mantle length compositions and by between area variations in length compositions (125; 129; 133), and by size at maturity (130). It has been suggested that mixed age groups within a single year-class are present, related to spawning over a protracted season and extensive area (125). Stock relationships are presently unknown.

The short life span and the single year-class entering the fishery each year, combined with variability in environmental parameters, should effect fluctuations in the amount of squid available to the inshore fishery (127). The Newfoundland fishery is passive as it is based entirely on availability of squid to jigging devices in inshore waters of less than 10 fath (18 m). Annual landings have ranged from nil to a peak of 10,500 t in recent years (128; Fig. 34). In years of abundance the resource inshore is capable of supporting a much larger fishery; in 1956 for instance, pilot whales taken by whalers on the east coast would have consumed 4–5 times as much squid as ever taken in the inshore fishery (127).

Estimates of MSY cannot be viewed in the context of the inshore fishery alone as the species is fished by many nations on the continental shelf throughout the ICNAF Area from the Grand Bank southward. Although ICNAF statistics do not break down the squid catch by species, the 7284, 1842, and 9224 t taken on the shelf off Newfoundland and Nova Scotia in 1971, 1972, and 1973, respectively, were short-finned squid. An estimated 23,000 t/yr are taken on the shelf off the eastern United States. Recent estimates of the standing stock ranged to hundreds of thousands of tons (60; 271); these figures are guesses but the order of magnitude may be correct. If pilot whale stocks formerly fished at Newfoundland feed almost exclusively on short-finned squid throughout the year as they are reported to do when inshore at Newfoundland (221); if they feed at a rate of 4–6% of body weight per day (226); if the average weight of a whale is 830 kg as it is in herds examined at Newfoundland (221); and if the preexploitation population size was 50,000 (132; 151); then consumption of squid would be in the order of 600,000–900,000 t/yr. Pilot whale stocks have

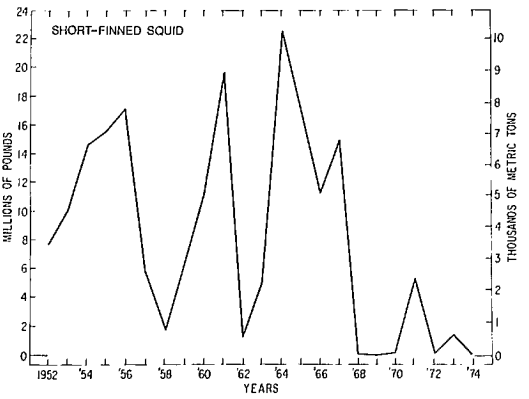

FIG. 34. Landings of the short-finned squid at Newfoundland, 1952–73.

been depleted (132; 151), releasing further squid production to other predators including fisheries. The errors inherent in the above estimate are obvious but it does indicate the resource has remained largely untapped by the traditional fishery. In the absence of detailed stock assessments, management is by preemptive quota under ICNAF. The recommended quota for 1976 is 15,000 t in Subareas 2–4 and 30,000 t in Subarea 5 and Statistical Area 6.

Substantial increases in Newfoundland landings will require diversification of gear and active searching for squid. The Japanese employ echo sounders to locate squid and powerful surface illumination and lighted lures to attract them to the surface where they are taken by mechanized jiggers (11). The technique is established for other squid in the family and proved effective for the short-finned squid at the edge of the continental shelf off New York, where most catches are presently made with pelagic trawls and high-opening bottom trawls.

Giant scallop (*Placopecten magellanicus*)

M. C. Mercer

The giant scallop is a large species reaching shell heights to about 22.5 cm (42). It ranges from Pistolet Bay, Newfoundland, to Cape Hatteras (196; 245), and occurs in shallower depths in northern than in southern populations. The area of greatest abundance is between the 20 and 50 fath (37–91 m) contours of Georges Bank (196) and beds there support the largest offshore fishery (22; 28).

Breeding times vary geographically, the population in Port au Port Bay spawning in spring and fall with the main spawning occurring in fall (159). After a planktonic phase, larvae have been found settled on the inside of stabilizer tubes of navigation buoys (135) and on bryozoans (13). Specimens collected on bryozoans and held in laboratory tanks, detached when they reached a height of 4–5 mm and then attached to larger scallops; field observations indicate they remain attached until a height of about 10 mm (42). Little is known of the early life history of the species. It is evident that year-class strength on inshore beds is strongly correlated with temperature conditions prevailing during larval development and the pattern of water circulation that may retain or disperse the larvae (38). In Port au Port Bay it appears that moderately calm weather and strong west and north-to-east winds in relatively warm years give strong year-classes, whereas southwesterly winds during the breeding period give poor year-classes (160). Wide variations in landings occur where the species is fished commercially on Georges Bank (28), in the Bay of Fundy (38), in Port au Port Bay (258), and on St. Pierre Bank (40; 240). The variation relates to sporadic overfishing but also to wide fluctuations in recruitment.

The age of scallops can be determined from annual rings on the shell (253) which are quite distinct in northern populations (160); when these are less distinct, observations on growth changes in the hinge ligament, changes in shell curvature and color, and variation in activity by borers have been used as aids in identifying the rings (136). Wide geographic variation in growth rate occurs (136; 160; 252; 253). In addition, rates may vary between adjacent beds, possibly related to differences in substrate and in silt content of the water (160). On the Boswarlos bed in Port au Port Bay, scallops attain heights of 120 mm in 6 years and 140 mm in 8 years. The rate then slows and at 10–12 years a height of 150–160 mm is reached (160).

The principal Newfoundland beds are in Port au Port Bay and on St. Pierre Bank. Although scallops occur elsewhere, particularly on the south and west coasts of the island (245), populations in these areas will not sustain large commercial fisheries.

The Newfoundland scallop fishery began as a canning industry in Port au Port Bay in the 1930s and shifted to marketing of frozen meats in the early 1940s; by 1953 landings had reached almost 82 t of meats, 95% from Port au Port Bay (258). This fishery was prosecuted by small local boats employing Digby dredges (101) in 1951. In 1954 and 1955 large vessels from Nova Scotia entered the fishery and in these years landings were 209 and 178 t, taken primarily by Nova Scotian vessels. In 1956 the fishery collapsed, yielding only 9 t (258). The collapse was undoubtedly related to overexploitation rather than to temperature-related mass mortalities, which sometimes occur in warmwater areas (39; 41; 117). Recruitment has been irregular (160) and landings since that time have varied from 0.5 t in 1967 to 106 t in 1969. At present, fishing in Port au Port Bay, St. George's Bay, St. John Bay, and Placentia Bay is restricted to local vessels operating under permit.

Over 450 t of scallop meat was landed from St. Pierre Bank in 1953–56 (240), almost all by vessels from the Maritimes. Landings then decreased as mainland vessels diverted their effort to Georges Bank (258). In 1964 landings

increased again to 327 t, 78 t by Newfoundland, and since that time Newfoundland landings on St. Pierre Bank have ranged from nil in 1966 to 19.5 t in 1973.

Because of wide fluctuations in recruitment, sustainable yields will continue to be highly variable; pulse fishing related to stock abundance and economic factors will be the pattern of exploitation.

Iceland scallop (*Chlamys islandicus*)

M. C. Mercer

The Iceland scallop is a subarctic species and occurs in more northerly colder waters than the larger giant scallop. It is easily distinguished from the giant scallop because its wings are asymmetrical whereas those of the giant scallop are symmetrical, and it has pronounced radial ribbing whereas the giant scallop is smooth and shows pronounced concentric growth rings (24).

In the eastern Atlantic populations occur southwards to the area of Bergen, Norway (57), and in the west range to Buzzards Bay, Mass. (1). It is abundant in northern Norway, the Barents Sea (278; 279; 280), and the northeastern Gulf of St. Lawrence. Survey data from the Canadian Atlantic have recently been summarized (180).

The Iceland scallop attains a height of 60 mm in 7 years and 80 mm by about 10 years in northern Norway (278). In the Barents Sea it matures at a height of 40–50 mm at 3–5 years (278); spawning there occurs in June and July (238).

A fishery for the Iceland scallop rapidly developed on the northwest coast of Newfoundland recently. The fishery began in 1969 when 23 t of meats were landed, but landings receded slightly to 18 t and 15 t in the succeeding 2 years. In 1972 and 1973, however, 239 and 201 t, respectively, were taken.

The fishery is prosecuted by multipurpose vessels under 60 ft long, in the Port au Choix to Flowers Cove area; the scallopers are equipped with gangs of Digby-type dredges (101) fitted with $2\frac{1}{2}$- or 3-inch rings. The vessels can switch from dragging scallops to trawling shrimp (and the groundfish by-catch), longlining cod, or gillnetting herring. Effort expended on scallops depends on interaction between availability and prices of these species. In 1972, for instance, a sharp increase in scallop prices resulted in the conversion of nearly all the fleet to this fishery. In 1973 prices fell sharply, herring and cod were abundant, and a new year-class recruited to make shrimping more lucrative so the percentage of vessels fishing scallops fell considerably.

Studies on the population dynamics of Iceland scallop in the Gulf of St. Lawrence have just commenced and estimates of MSY are not available. However, accumulated old scallops are still being "fished-up." When these have been taken the fishery will depend on expanding to more distant grounds and on new recruitment, a parameter which may be expected to show wide annual variation.

Soft-shell clam (*Mya arenaria*)

M. C. Mercer

In the western Atlantic the soft-shell clam ranges from Labrador to Cape Hatteras (65). It is generally found in the intertidal zone although subtidal populations occur in Chesapeake Bay (104).

There is a single annual reproductive cycle north of Cape Cod and two in southern areas (204). After spending about 2 weeks in plankton, the larvae attach by means of a byssus thread. They can move about until they attain a length of about 25 mm; then they remain settled (43). They generally burrow to a depth of about twice their length, deeper in looser soils and where they are not crowded (111).

The growth rate varies regionally (165; 166), and with conditions of feeding, submergence, salinity, sulfide content, silt (164), and type of substrate (255). A commercial size of 50 mm is reached in $1\frac{1}{2}$–2 years in Chesapeake Bay but requires 5–6 years in Maine (65) and the Bay of Fundy (164).

The species has a long history of exploitation in New England and the Maritime Provinces, for use as cod bait in the last century and for human food (65). Clam digging with traditional four-tined clam hacks takes only about 60% of market-size clams and kills, by smothering, 50% of the remainder (119). However, a small hydraulic rake takes 95% of marketable clams, damages less than 5% of the catch and destroys less than 5% of the small clams left behind (103; 120). Efficient hydraulic escalator harvesters developed in the Chesapeake Bay area (65) have been adapted for use in the Maritimes (102; 115).

In addition to the effects of fishing, clams are subject to predation by winter flounders (118), herring gulls (110), ravens (personal observation), and other predators. Storms and ice-scouring can result in mass mortalities of clams (43).

The St. John's Biological Station has initiated studies to determine the extent of the local resource and its potential for commercial exploitation. Surveys in the summers of 1971–74 covered most beaches except those on the southwest coast and part of the northeast coast. First estimates indicate standing stocks of marketable clams of about 38,000 and 27,000 kg (steamed meat weight) at Hawke Bay and Millville, respectively. In most areas surveyed the flats are not extensive and, even where densities are high, the total standing stocks range from a few hundred to a few thousand pounds and will not support large-scale commercial exploitation.

Blue mussel (*Mytilus edulis*)

M. C. Mercer

The blue mussel lives from high in the intertidal zone to depths of a few fathoms attached to the substrate by byssus threads. Growth and meat condition of intertidal mussels are inversely related to the degree of exposure to air, and they have thick, bluish, eroded shells in contrast to the thin, clean, brown, sharp-edged shells typical of the faster-growing sublittoral mussels, which are more attractive to the consumer (14; 105).

At Newfoundland, mussels are collected by dipnet mainly on the northeast coast, particularly in Bonavista Bay and are canned or pickled. In a survey of the northeast coast conducted in 1968 densities of about 2000 bu (27 t)/acre of marketable mussels on approximately 75 acres of bottom were reported (211). An estimate of 600,000 bu (8165 t) was made as a total for the island. From a follow-up survey in 1969 the harvestable yield for Bonavista Bay was estimated at 900–1000 t of unshucked mussels (212); assuming a meat yield at peak fatness of 15% the meat yield would be 135–150 t. Meat condition is reported to be best from mid-May to early August (211). By mid-September most mussels have been partly or completely spawned, resulting in a loss of approximately half the meat weight.

The blue mussel is cultured extensively in Europe (106), particularly in Spain and Holland, to serve a predominantly French market for fresh mussels. Lower sea temperature, with the consequent slower growth, higher labor costs in a labor-intensive industry, and isolation from established markets, mitigate against development of mussel culture at Newfoundland. However, R. P. Scaplen (personal communication) obtained good growth and meat condition in mussels grown by suspended culture at Garden Cove, Placentia Bay; a modal class of $1\frac{3}{4}$ inch and a meat yield twice that of bottom grown mussels at the same length was obtained in 2 years. Markets in North America are poor and, in spite of the large United States resource, annual landings are only about 450 t with an average value of about 10¢/lb (138). Large mariculture developments would require effective marketing.

American oyster (*Crassostrea virginica*)

M. C. Mercer

The American oyster ranges from the northern Gulf of St. Lawrence to the Gulf of Mexico. It is cultured and fished commercially in the Gulf of St. Lawrence and south of Cape Cod. Low temperatures apparently restrict its abundance between Nova Scotia and Cape Cod and limit its northern distribution. Considerable data are available on its biology (54) and culture in Canada (113).

Minimum temperatures required for feeding are 5–7 C (54; 95) and, although there are interpopulation differences, spawning requires temperatures of approximately 20 C (96; 97; 98; 250).

An experimental introduction indicated poor prospects for commercial mariculture of the species at Newfoundland (126).

European oyster (*Ostrea edulis*)

M. C. Mercer

The European oyster has lower thermal requirements for growth and reproduction than the American oyster. It has been reported to tolerate temperatures below 0 C and it has been suggested there are races that show different degrees of cold-hardiness (84). Spawning can occur at 15–16 C (83) and larvae grow at lower temperatures than American oyster larvae (34; 35). Since the species broods its larvae, it is more suited to situations where currents tend to disperse the larvae than is the American oyster.

An introduction of Conway (Wales) oysters to St. Andrews, N.B., and Ellerslie, P.E.I., in the late 1950s showed heavy mortalities associated with low winter water temperatures (114). The species has been successfully introduced from Holland to Maine (277) and a few animals from this stock were imported and bred under quarantine at Ellerslie in 1970. A transplant from this source was made to two Newfoundland

localities in 1972 and these are being monitored to determine growth, mortality, maturation, meat condition, and environmental parameters. This is the first step in the assessment of the feasibility of mariculture of the species at Newfoundland. Although demonstration of biological feasibility of oyster culture at Newfoundland is a necessary first step, it is not sufficient in itself to ensure economic feasibility on a commercial scale. The Maritime oyster industry is poorly organized in production and marketing, and produces at a level far lower than the physical and economic capacity of the grounds (157). The Canadian market presently consumes about four times domestic production; imports are from the United States (fresh and frozen) and Japan (canned). Technology exists to expand production immediately and an eightfold increase has been suggested as a national production goal over the next 10 years (254). Mariculture in Newfoundland would in future have to compete with larger and more specialized enterprises than have been traditional in the Maritimes.

Rough whelk (*Buccinum undatum*)

M. C. Mercer

The rough whelk lives from the intertidal zone to deep water mostly on bottoms of mud with sand and shells. It feeds on shellfish, dead fish, and crabs. In Britain spawning occurs in November; the young reach a length of 2.5 cm at age 1 and mature and spawn at a length of 5 cm when they are 2–3 years old (10).

The species is abundant in the cool-water areas of the Canadian Atlantic coast (116) and is a popular seafood in parts of Quebec and northern New Brunswick. Exploratory whelk surveys were initiated in 1972 and continued in 1973 to investigate the feasibility of commercial exploitation at Newfoundland. Grounds examined in the White Bay area were small and widely separated and could not support a large number of fishermen (53).

Two closely related species of whelks (*Buccinum scalariforme* and *B. polare*) are abundant on the snow crab fishing grounds. A standing stock of about 1 t of large whelks per square mile was estimated for Conception Bay and off St. John's in depths 100–150 fath (183–274 m) (R. J. Miller personal communication). Extrapolation for all Newfoundland–Labrador would give 18,000 t as a total standing stock; at a turnover rate of 0.5/yr, this would give 9000 t as a potential annual yield (reliability code 1). The large potential error in this estimate must be realized and, even if the figure is approximately correct, it is also necessary to demonstrate the economic feasibility of harvesting the resource.

Common periwinkle (*Littorina littorea*)

M. C. Mercer

Periwinkles are mobile herbivores that graze on algae from the splash zone (155) to the subtidal (67). They tend to aggregate in damp or sheltered places at low tide and are most common on sheltered rocky shores. In North America there is a seasonal movement with greater congregation in the low-tide zone in the colder months (237). Densities of the species vary considerably with up to 950 per m^2 recorded at Plymouth, England (52).

Periwinkles grow more rapidly where immersion time is greater (154; 281). Near Plymouth a length of 25.4 mm is attained by the fourth winter (154) and this is approximately the same near Halifax (87).

During the 1950s the periwinkle was the only snail regularly fished and marketed in the Maritimes (112). For the 1960s the only landings specified in the Fisheries Statistics of Canada were from New Brunswick where landings (in shell) were 6.7–29 t in 1962–68. The species is not yet exploited at Newfoundland, but populations are widely distributed around the coasts. No estimates of standing stock or potential yield are available.

Mammals

M. C. Mercer

WHALES

The early history of whaling in Newfoundland is one of wide fluctuations in effort and catches related to economic factors, war, and changes in whale abundance (137; 197; 220; 265).

The most recent continuous whaling operation was a small-whale fishery, primarily for pilot whales, which began at Dildo in 1947. The recent small-whale fishery which started at Blandford, N.S., in 1962 was quickly replaced (in 1964) by a fin whale fishery, and shortly thereafter Newfoundland whaling stations at Dildo and Williamsport began to hunt fin whales (in 1965 and 1967, respectively). Other species of large whales were taken but were of lesser importance in terms of numbers, weights, and values. The fishery was of short duration as commercial whaling on the Canadian Atlantic coast was banned by the Government of Canada on December 22, 1972.

Pelagic whaling continues in the Northwest Atlantic as Norwegian combination catcher–factory ships pursue the "small whale quartet" of bottlenose, minke, pilot, and killer whale during the summer (266). In addition, the recent rapid expansion of the capelin fishery off Newfoundland–Labrador makes man an increasing competitor with the fin and minke whales for their primary food item.

Fin whale (*Balaenoptera physalus*)

The fin whale is second only to the blue whale in size and may attain a length of 80 ft (24 m). While the species is cosmopolitan, it occurs primarily in latitudes higher than 30° (107). The fin is easily distinguished from other rorquals by its unusual color pattern. The baleen plates are gray-blue except those on the right front which are yellowish-white. The right side of the lower jaw is white and the left side is pigmented (107).

Fin whales occur in summer feeding concentrations in the Northwest Atlantic between the shoreline and the 1000-fath (1828-m) contour from 41°20′ to 57°00′N. Populations may be stratified latitudinally so that grounds occupied by a southern population in summer are occupied by a northern population in winter (78; 144). Precise relationships between stocks fished off Blandford and northeastern Newfoundland are not completely resolved; significant differences in various biological parameters exist but tag returns indicate mixing to about 10% between stocks (144).

Using estimates of whale catches by Newfoundland shore stations for 1906 and 1907 (99) and taking 50% of the total catch as fin whales, 1695 fins were taken in 1903–07 for an average of 339 per year (144). In 1945–51, the northeast Newfoundland stations took an average of 464 fin whales per year and there are indications of overexploitation in this period. From these figures it appears that the MSY could be about 400 whales or less for all whaling grounds around Newfoundland (144). Off Nova Scotia the catch averaged 193 per year in 1964–70 which appears to have been higher than the MSY (144). For all Northwest Atlantic populations the 1967 estimate from tag–recapture experiments was 11,984 and from strip census data[1] 3162, a mean of about 7200 whales with a MSY of about 560 (144). As the data base relating to fin whales improved through research, the yield estimates were revised downward and Canadian quotas were reduced from 800 in 1967 to 360 in 1972. The latest estimate of MSY from catch–effort data is 193 whales and the yield that could be taken in 1972 was estimated at only 143 without further reducing the stocks (6).

Sei whale (*Balaenoptera borealis*)

The sei whale is smaller than the blue and the fin, attaining a length of about 60 ft (18 m). It is distinguished by the soft, fine texture, and gray-white color of the inner edges of the baleen plates and by the ventral throat grooves which are quite short, terminating in front of the navel (107).

The geographic limits and migration patterns of sei whales fished on the Canadian Atlantic coast have not been determined precisely. The whales appear to migrate northward in spring and retreat southward in autumn. Two runs of sei whales pass through the grounds hunted by the Blandford whalers, these being in the periods June–July and September–October. Sei whales occur on the southern coast of Newfoundland

[1] This is based on detailed logs of sightings made along the cruise track on a tagging cruise.

in August and September. They have been fished off the Labrador coast in late season, August–November.

Population estimates for Nova Scotia waters from tag–recapture experiments and strip census data show great discrepancy; the mean of eight separate calculations indicate a stock size of 1570 individuals (147). Total catch off Nova Scotia in 1966–71 was 642 whales.

A strip census off Labrador resulted in only four sightings and a population estimate of 828. Historical catch records indicate a catch of 20 animals was never maintained for more than 5 years from the Williamsport and Hawke's Harbour whaling stations (147). In 1965–71 only 14 sei whales were taken at Dildo and 3 at Williamsport (147).

Availability of the species to Canadian shore stations may be episodic and this, and the relative desirability of the species (compared with the fin whales) are reflected in the variable landings (145). Because of the sporadic effort on sei whales and lack of evidence on depletion of stock the species was not managed under a national quota. A minimum legal-size limit was set at 35 ft (11 m).

Blue whale (*Balaenoptera musculus*)

The blue whale is probably the largest animal that ever existed. The young are 25–26 ft (7.5–8 m) long at birth and about 52 ft (16 m) at weaning 7 months later. Maturity is reached at an age of about 5 years and a length of about 80 ft (24 m) in the female (26), and 75 ft (23 m) in the male (206). Adult specimens have been measured up to 110 ft (33 m) long (203).

Blue whales have been intensively hunted on nearly all whaling grounds and numbers were drastically reduced (239) prior to institution of almost complete worldwide protection in 1966. The northward migrating whales in the western North Atlantic were fished in the 20th century within the Gulf of St. Lawrence, along the Newfoundland and Labrador coasts, and over oceanic waters in Davis Strait (75). Excessive pelagic whaling in 1922–34 precipitated a decline in catches by Canadian shore stations; the catch at Newfoundland was 153 whales in 1924–30. Subsequent episodes of fishing slowed the recovery of the stock (75). The species has been fully protected in the Canadian Atlantic since 1966 but three were taken illegally by error in the Canadian fishery 1966–69 (148).

An estimate of the initial standing stock based on a cumulative catch estimate for 1898–1915 indicated a preexploitation population of about 1500 in the Northwest Atlantic (225). Another calculation, assuming the abundance of fin whales to be constant 1903–51 and using the blue:fin ratio as an index of the size of the blue whale stock, indicated an initial stock of slightly over 1100 blue whales with a MSY of approximately 100 animals (5). From sightings by catchers and an analysis of strip census data the most recent estimate of stock size is in the low hundreds (148).

Minke whale (*Balaenoptera acutorostrata*)

This smallest of the rorquals grows to only about 30 ft (9 m) in length. It can be distinguished by the yellowish-white color of the baleen and the white patch on the outer surface of the flippers.

Data obtained in the Norwegian small-whale fishery indicate that the minke occurs across the North Atlantic and animals are segregated in different areas by size and sex (74). The general pattern is that during the northward summer migration the adult males keep to the open sea while the females and young are in coastal waters (107). This renders the distinguishing of populations more difficult and stock relationships and detailed migration patterns have not been determined.

Puberty occurs at an earlier age than with fin whales, there is no resting year between pregnancies, and a high proportion of sampled females are lactating and pregnant simultaneously; thus there would appear to be less room for density dependent factors to operate in compensating for decreased population size related to exploitation (151).

A shore-based fishery for the species began at eastern Newfoundland in 1947. Catches were mostly May–July when the species moved inshore to feed primarily on capelin (222). Comparison with length–frequency data obtained in other areas (74; 169; 251) indicated that catches off eastern Newfoundland consisted largely of mature animals with immatures and calves underrepresented and probably staying farther south (222). Newfoundland landings averaged 35 per year in 1955–69 and catches had no discernible effect on the stock (152). In 1970–72 the catch increased to 73–97 per year.

The small-whale fishery that began in Nova Scotia in 1962 was quickly supplanted in 1964 by the fin whale fishery. The principal effort directed towards the minke is by the Norwegian small-whale fishery which took 2330 and 2650 animals in 1971 and 1972, respectively; only 11

and 120 respectively of these were taken in the Newfoundland–Labrador area.

As minke whales in the North Atlantic approach ships, the data obtained through shipboard census cannot be used to estimate population size (148). No tags have yet been returned from those tagged in 1965–72 and catch–effort data are incomplete (148). Thus there are no estimates of stock sizes or of the proportion of the North Atlantic stocks available to a shore-based fishery at Newfoundland.

Humpback whale (*Megaptera novaeangliae*)

The humpback attains a length of about 50 ft (15 m) and differs greatly in appearance from the rorquals. The body is quite plump and the partly white flippers are narrow and extremely long, up to nearly one-third the length of the animal (107). The species is easy to catch and populations in all the world oceans have been depleted.

The migration routes of humpbacks have been mapped in general terms (78; 100; 264) as extending north–south on each side of the Atlantic. A tagging program was carried out in the western and central North Atlantic in an attempt to obtain more detailed data on migration patterns and stock relationships; however, only one tag of 160 was returned in the fishery expecially licensed for the experimen (149).

An early estimate of humpback stock size in the Northwest Atlantic based on cumulative catch data is 1500 whales (225). A more recent strip census estimate of 1259 whales in the summer population is suspected of being high because of biases in the methodology of the census (149). However, a population estimate made in the West Indies using visual and acoustic techniques indicated the presence in winter of 785–1157 whales (average 1018) and this may be a conservative estimate (281A).

Successive whaling periods at Newfoundland apparently depleted the humpback resource as evidenced by declines in peak landings from 161–287 per year in 1903–05 to 88 and 29 whales in 1927 and 1951 respectively (225). Although it appears that Northwest Atlantic stocks, protected from exploitation since 1960, may have recovered enough to allow an annual harvest of 10–30 whales (146), the minimum population size that can survive exploitation is not known. Humpbacks congregate in pods of 20–30 to perhaps 100–200 and it is suspected that these are family groupings or isolated stocks, each subject to extinction unless killing is spread over many stocks (146).

Black right whale (*Balaena glacialis*)

This species is unusual in appearance having very long baleen plates and a characteristic irregular horny prominence on top of the snout. Although it occurs in higher latitudes in summer than in winter, it is generally restricted to temperate waters.

This species was the first large whale to be hunted and the fishery in the Bay of Biscay dates back to about the 10th century. The first long distance voyages made in pursuit of whales were made by the Basques to Newfoundland in the 16th century to hunt right whales. The stock off the United States coast had virtually collapsed by 1750 (4), and while the species was still recorded in small numbers off the United States coast (3), effort shifted to Newfoundland (249).

The black right whale has been protected, or at least not intensively hunted, since about 1920 in the North Atlantic (146). Sightings (161; 162), strandings (235), and an illegal capture (225) in Canadian waters indicate a moderate recovery at the northern end of its range. The species was regularly seen by whalers out of Blandford. Estimates based on sightings and strip census data indicate a population in tens of individuals off the eastern Canadian coast in summer (148).

Gray whale (*Eschrichtius robustus*)

The California gray whale was nearly exterminated in the North Pacific but recovered and now numbers approximately 11,000 (201). The species suffered a less fortunate fate in the North Atlantic, where it has become extinct. It has been shown that the gray whale survived in the North Atlantic to historic times (269) and was known to Icelandic naturalists (50). The "scrag" whale from the Northwest Atlantic (45) may have been this species.

Sperm whale (*Physeter catodon*)

The cosmopolitan sperm whale is the largest toothed whale and feeds primarily on squid and fish. It is easily recognized by its huge truncate head and lack of a dorsal fin.

Large polygamous bulls migrate along the slope and are within catcher range of all three Canadian shore stations; pods have been seen feeding as far north as Cape Chidley (148). The smaller females are confined to latitudes lower than about 40°N and S.

Sperm whales were fished to uneconomic levels in the North Atlantic by the early 19th

century and whalers from the United States then sailed to more distant grounds (146). Relatively few sperms were taken by the United States whalers on the Grand Bank in the 19th century (267) and since the mid-19th century North Atlantic stocks have been lightly exploited (146).

Recent Canadian catches have been small because of fluctuations in the price of sperm oil and difficulties in keeping sperm and mysticete oil separate in a small plant. Of the 39 sperms landed in the 1964–70 period 25 were captured by Blandford whalers in 1970 after the fin quota was taken (148); numbers taken in 1971 and 1972 increased to 37 and 41, respectively (153).

Strip census data obtained in 1966–69 resulted in a population estimate of 22,000 sperm whales for the entire North Atlantic (10–70°N, 20–80°W) (150). It is not known how this compares with the initial population size in the region prior to heavy exploitation in the 19th century and, as relevant parameters are not known for these populations, no estimates of sustainable yields are possible. Neither are there data on the proportion of the total estimated population available in the Newfoundland area.

Northern pilot whale (*Globicephala melaena*)

This toothed whale is easily recognized by the prominent bulbous head which is the source of the local vernacular appellation "pothead" and by its broad-based dorsal fin.

Males grow to about 20 ft (6 m) and the females to 16 ft (5 m). Females mature at 6–7 years, and males at about 12 years. Pelagic herds average about 20 individuals, rarely more than 100, but herds stranded naturally or driven ashore by whalers average about 85 and often exceed 200 (221). The species is widely distributed in the northern North Atlantic.

Pilot whales feed almost exclusively on squid in the Newfoundland area (221). They follow the squid inshore in July and depart with the squid in October or November and are rarely seen in winter (123). Availability of pilot whales is closely related to that of squid and, in years of squid scarcity inshore, fewer whales were taken in the fishery (132; 221; 258).

Although there has been small-scale exploitation of the species at Newfoundland for the past few centuries the modern fishery began in 1947 at Dildo, Trinity Bay. Small numbers were harpooned in 1947–50 and the first large landings (3100 in 1951) began when the practice of driving the animals ashore was initiated (258). Landings then increased rapidly to a peak of 9794 and 7831 in 1956 and 1957, thereafter decreasing sharply; landings were 47,109 for the period 1951–61 and of these 30,119 were taken in 1953–57. It is considered that the fishery severely depleted the stocks and initial population size has been estimated at 50,000–60,000 for stocks exploited by this fishery (132; 151). The catching method had the unfortunate aspect of killing all age and sex groups within a herd; thus two usual criteria of the degree of exploitation — increase in total mortality and reduction in mean size of animals killed — were not observed from animals taken in the fishery (221).

Bottlenose whale (*Hyperoodon ampullatus*)

This toothed whale is about 10 ft (3 m) long at birth in spring; males attaining about 32 ft (9.8 m) and females about 28 ft (8.5 m) when fully grown (16). Females mature at about 9 years and males at 13, and the life span is at least 37 years (31). The bottlenose is found in the temperate and cold waters of the North Atlantic; it migrates northward in spring and early summer and southward in winter (77), living in deep water. It reportedly feeds on fish and Arctic squid (*Gonatus fabricii*) (68) at least in the eastern Atlantic. As it surfaces within a few hundred meters of the diving slick it is easily hunted. The bottlenose readily approaches a nonmoving vessel and does not leave a wounded companion and, as the species congregates in pods of four to ten animals, it is possible to kill several in the same pod (151).

Concentrations in the Northwest Atlantic occur mainly in early summer months near Sable Island and on the edge of the shelf around Newfoundland and Labrador. Bottlenose hunting in the North Atlantic was begun by the Scots in 1877 followed by the Norwegians in about 1880 (23). In 1896, 65 Norwegian vessels landed a peak of 2864 whales but by the late 1920s this whaling period ended (16). Thereafter bottlenose were taken in a small-whale fishery directed mainly towards minke whales. In 1960–63 the take was an average of 216 animals per year (23). In 1964–70 the Norwegian catch was about 400 per annum, and landings in 1971 were 213, dropping off to only 17 in 1972 (32). Norwegian whaling off Labrador began in 1969 (16) and a large proportion of 1969–71 catch was taken there (32). The species was fished by Canadian vessels from the whaling station at Blandford in 1962–67 when the total catch was 87, taken mainly in the area of Sable Island and the edge of the Grand Bank (148).

More data are required on migration habits and stock size and relationships to determine whether the species has been overexploited on a regional basis (151). It appears that numbers are sufficient to support small localized fisheries (148).

Killer whale (*Orcinus orca*)

The characteristic high, spiked, dorsal fin distinguishes the species and accounts for its local vernacular name of "swordfish."

Killers follow the rorquals northward in spring, passing the east coast of Newfoundland and the Strait of Belle Isle in June and July. It has been suggested that the majority move along the Labrador coast to true Arctic waters and some remain farther south (234).

The species has not been fished commercially off eastern Canada other than small catches taken ancillary to the fishery for minke and bottlenose whales. Only seven killer whales were taken off Newfoundland and Nova Scotia in 1947–68 (234; International Whaling Statistics). The Norwegian small-whale fishery takes some killer whales (76) and Norway took an average of 107 killer whales per year in the North Atlantic during the 4-year period ending 1963 (23). The species appears to be abundant but no estimates of stock size or population structure are available.

Harbor porpoise (*Phocoena phocoena*)

In the western Atlantic this small fish-eating whale occurs from West Greenland (27) and Baffin Island (241) south to about Cape Hatteras (25; 29) although it is not common south of northern Maine (55). The species is common inshore in summer, deserting coastal waters during winter (131; 234). Population dynamics and stock relationships have not been documented.

Several thousand animals were reported taken yearly in the Bay of Fundy by Indians during the 19th century (56) and a fishery was carried out sporadically in New England. In recent years, small fisheries for the species have been pursued in Greenland, Japan (56), the Baltic (288) and Black seas (264). It was estimated that 1500 specimens were taken in the non-Greenlandic salmon driftnet fishery off West Greenland in 1972 (92). Although porpoises have not been subjected to directed fishing at Newfoundland, the species is common and is often captured in gillnets and cod traps (131; 234), which may contribute significantly to porpoise mortality.

Other small whales

Several other species of small, toothed whales occur with varying regularity in the Newfoundland area (131; 234; 235) where they sometimes strand or become entangled in stationary fishing gear.

There is a population of the beluga (*Delphinapterus leucas*) in the Gulf of St. Lawrence which is now virtually unexploited (233). The earlier fishery took up to 1800 animals per year (270) but the population in 1973 was estimated between 500 and 1000 animals (233A). Strays occasionally occur around Newfoundland (131; 234; 235).

The white-sided dolphin (*Lagenorhynchus acutus*) and white-beaked dolphin (*L. albirostris*) appear to be common and are sometimes taken at Newfoundland (131; 234; 235). No estimates of population size are available.

Seals

Harp seal (*Pagophilus groenlandicus*)

There are three stocks of harp seals that breed on pack ice in the White Sea, Norwegian Sea around Jan Mayen, and in the Canadian Atlantic. Morphological differences (81; 289) and tag returns (195; 200; 223; 230) indicate little mixing between the western or Canadian stock and the other two. The western stock is divided into substocks; one breeds east of Belle Isle on southward drifting pack ice at the "Front," and the other (the "Gulf" herd) in the southern Gulf of St. Lawrence on locally formed winter ice. Recent evidence indicates variable and sometimes extensive mixing between the subpopulations related to the variable ice conditions (227; 228; 231) so that completely independent management of the subpopulations is not possible.

Seals of the western population summer on the coast of West Greenland and in the eastern Canadian Arctic. They migrate southward in autumn reaching eastern Newfoundland and the Gulf of St. Lawrence by late December and early January. Nearly all whelping occurs in the first 2 weeks of March, slightly earlier in the Gulf than on the Front. The newborn "whitecoats" remain on the ice until molting is completed about 3 or 4 weeks after birth. Suckling then ceases and the females leave the molted "beaters" and mate with the males. Adults and "bedlamers" (immature harps more than 1-year-old) mount the ice to molt in late March to May. Bedlamers have a spotted coat in contrast to the harp-shaped markings that develop when the animal matures at 3–7 years (224).

Determination of catch quotas and other regulatory measures are dependent of course on defining the objective of management; achievement of consensus in this regard is more difficult for harp seals than for most species. There are those who feel, for humanitarian reasons, that seals should not be killed. Such a policy would eventually result in a very large population. Seals eat a considerable volume of fish (about 1.2 million t/yr in the late 1960s for the western population (231)) of present or potential commercial value and several seal species carry nematode parasites, the larvae of which spoil the value of fish. An argument can be advanced from the fishing industry to reduce the population to a low level. For the sealing industry itself it would be in the long-term interest to seek an intermediate population level at a point MSY could be attained.

Removal of an adult from the population is perhaps as harmful as removing three pups and a juvenile would be equivalent perhaps to two pups (61). This is because the older animals are more likely to survive long enough to give birth. It is fortunate that the pups, in terms of the value of the skins, are more valuable than adults or juveniles, and this lessens potential conflict between short-term and long-term interest over which to exploit. In addition to the main fishing for pups, catches of other ages both mature and immature are taken. The 1973 provisional figures indicate that 20.7% of the catch at the Front comprised immatures and adults. During summer some seals are taken along the Greenland coast by the local population (4000–7000/yr in 1967–71) and a few are taken in the Canadian Arctic.

The extensive data available on the history of the fishery have recently been reviewed (258). Landings reached a maximum of 687,000 in 1831 (including a small percentage of hood seals) and, although annual variations have occurred since that time, the overall trend has been downward. Three main methods of estimating stock size are used: tag–recapture experiments, aerial photographic surveys, and changes in year-class strength. Overall production was estimated at 285,000–320,000 animals in 1967 decreasing to 235,000–270,000 by 1969 (229). Landings were only slightly below these production estimates, although MSY when young only are taken is now estimated at about 66% of production (7). A lesser portion would have to be taken if killing were spread over other age-groups.

First quotas under the ICNAF Harp Seal and Hood Seal Protocol were instituted for the 1971 fishery when vessels were limited to 200,000 and landsmen to 45,000. The reported total landings were 236,000. In 1972 the quota was reduced to 120,000 for vessels and 30,000 for landsmen; landings were 124,000 in each of 1972 and 1973, increasing to 131,000 in 1974.

Hood seal (*Cystophora cristata*)

The hood seal lives to 25 years and females mature at 3–5 years (170; 171). The species breeds on the ice in early spring and requires heavier ice than the harp; it molts on pack ice about 3 months after the reproductive season. Hood seals occur in family groups, are much more scattered than harps, and require more individual hunting. Parents often defend the young ("bluebacks") and frequently one or both are killed with the pup; mature hoods comprised 28, 33, and 35% of the total killed in the Newfoundland fishery in the periods 1895–1913, 1914–31, and 1932–61, respectively (258).

The greatest concentration of whelping hood seals is on the Jan Mayen pack ice. Smaller numbers breed northeast of Newfoundland and a small fraction in the Gulf of St. Lawrence (199). Recently a large whelping concentration was rediscovered in Davis Strait (232). There is evidence from marking, and an exact correspondence in breeding dates, that the hood seals breeding near Newfoundland are an offshoot from the main northern herds, both groups molting in the Denmark Strait in summer (172; 199). The numbers at Newfoundland are considered to vary with the climatic cycle, being greater during cold cycles. In 1960 it was estimated that 10% of hood seals were whelping on the Front (199).

The apparent interchange between hood populations indicates the need for coordinated management. Numbers in the Gulf of St. Lawrence are low and the species is fully protected there by the Government of Canada. Elsewhere in the Northwest Atlantic management is under the aegis of ICNAF which instituted a quota of 15,000 for the 1974 season on the Front; of this about 10,000 were taken (232) compared with 1965–73 landings ranging from a low of 3782 in 1965 to a peak of 25,163 in 1966. There is no quota on the recently rediscovered whelping population in Davis Strait. In the eastern Atlantic the current quota, as set by the Sealing Commission for the Northeast Atlantic (9), is 30,000 animals (232). Norwegian catches in the Denmark Strait averaged 16,000 per year during 1951–60 but this fishery was phased out in 1961 (224).

Plants

E. J. Sandeman

Irish moss (*Chondrus crispus*)

At present Irish moss is the only seaweed exploited in the Newfoundland area. Almost all has been harvested from Port au Port Bay and considered to be of high quality (as judged by the high ratio of kappa/lambda carrageenin produced from it) (202). Estimates of the standing stock are available from Port au Port Bay (2) and from Bay of Islands (79), but additional work is required to assess the best time of harvesting and yields that might be obtained on a sustained basis. Several likely areas of Irish moss abundance have been cited by different workers and detailed surveys are required to assess the standing stock and productivity of these areas. Surveys for Irish moss and other seaweeds around Newfoundland are summarized in (79).

Other seaweeds *Ascophyllum nodosum*, *Laminaria* sp., *Alaria esculenta*, *Ptilota serrata*

Extensive beds of *Ascophyllum nodosum* exist at several localities in Newfoundland but there has been no exploitation. *Laminaria* sp. and *Alaria esculenta* are also present as are large quantities of the red alga *Ptilota serrata*. Although the latter species has been used extensively as fertilizer for vegetable gardens, no suitable commercial use has really been found for this seaweed.

Summary and Conclusion

A. T. Pinhorn

The foregoing sections summarized the known status of the various living marine resources of Newfoundland–Labrador. This status ranges from decimated (haddock) to unexploited (sand lance). In concluding this Bulletin it seems relevant to draw attention to the resources in relation to their potential for expansion. In discussing this potential the various resources have been treated under the headings of Groundfish, Pelagic Fish, Anadromous–Catadromous Fish, Invertebrates, and Plants. Since commercial whaling has been banned on the Canadian Atlantic coast no discussion of the whale fishery is included.

Groundfish

Most groundfish species have been fished for many years and are either fully exploited, or in some cases, overexploited. These include cod, haddock, redfish, American plaice, yellowtail, Greenland halibut, witch, Atlantic halibut, pollock, white hake, and wolffish. Short-term overruns or shortfalls of sustainable yields will occur because of fluctuations in recruitment, but with proper management the average long-term catch should approximate the MSY level except for haddock which has been reduced to a level of stock size far below that necessary to produce MSY.

The species that may have greatest potential for expansion of the total groundfish catch are skates (especially thorny skates), dogfish (especially spiny dogfish), and roundnose grenadier. The MSY figure of 40,000 t quoted for thorny skate is considered a minimum figure although skates have a low vulnerability to capture by standard otter trawls and may be difficult to harvest in a directed fishery. Dogfish are available during the spring and summer season in Newfoundland–Labrador area and large catches have on occasion been obtained by research vessels in the Grand Bank–St. Pierre Bank area. Roundnose grenadiers are probably fully exploited in the depth range in which fishing presently occurs but substantial catches of mature fish can probably be obtained at greater depths when new technology allows fishing at these depths.

Other species that may have some smaller potential for increase are blue hake, lumpfish, and Arctic cod. Blue hake, however, do not exist in commercial quantities in Canadian waters in depths less than 500 fath (914 m) and are not readily accessible with present fishing techniques, although USSR catches of roundnose grenadiers are made as deep as 330–650 fath (603–1188 m). An inshore fishery for lumpfish roe recently commenced in Newfoundland but little is known of their abundance. Arctic cod are small and apparently not very abundant and at present

have no commercial value. Silver hake, Atlantic argentine, and monkfish are not present in sufficient quantity to allow for a significant commercial fishery, the major concentrations occurring farther south.

Pelagic Fish

Of the pelagic fish species in the Newfoundland–Labrador area, herring has traditionally supported the largest fisheries. Of the six stocks discussed in this Bulletin, the southwest Newfoundland stock has been the most heavily fished in recent years and this, with recent year-class failures, resulted in a badly depressed stock, producing low catches. Future yields from this stock will be determined largely by success of recruitment and this is influenced quite strongly by the interaction between herring and mackerel biomass. Thus, it is impossible to predict catch levels in future years. Heavy fishing on the Fortune Bay stock and the Placentia Bay–St. Mary's Bay stock also resulted in a somewhat reduced stock abundance. However, with proper management some increase in catch may be possible. A potential for increased catch exists in the Newfoundland east coast stock, although adverse environmental conditions will affect the fishery in this area. Little increase can be expected in the fishery from the Labrador stock or the west coast stocks.

Capelin has been the object of an intensive fishery only in the past couple of years. Catches increased from a negligible level in 1970 to 268,500 t in 1973. The MSY is still uncertain in this resource but could be as high as 700,000–800,000 t. A major consideration must be the role of capelin in the marine ecosystem as a whole, since capelin is an important food item in the diet of several species. Of particular concern in this respect is the cod–capelin relationship and, although the capelin resource itself may support a large fishery, there could be a reduction in abundance and effects on the migration patterns of species such as cod. It seems probable, however, that some increase in the catch of capelin is possible but it should be carefully controlled, and the effects on other species dependent on capelin for food should be carefully monitored.

Increased catches of mackerel to about 20,000 t may be possible in the warmer months but would be difficult to maintain each year because of the wide fluctuations in abundance. Catches would be relatively high in years of high mackerel abundance but would be low in years of low abundance. Although the interrelationships of the northern and southern populations of mackerel are not clearly understood, it is probable that the intense fishery in the southern part of the area (ICNAF Subareas 5 and 6) will have some effect on the abundance of mackerel migrating to the Newfoundland–Labrador area.

Sand lance represents a resource that is completely unfished at present. With the proper technology a yield of 100,000 t could probably be sustained in the Newfoundland–Labrador area.

No substantial increase in catches of bluefin tuna can be expected as these are heavily exploited as juveniles. Also, they possess dark meat and do not bring a high market price at present, and the season is short because of low temperatures. Large numbers of barracudina exist over oceanic depths and pilot scale experiments show they are suitable for reduction, but little is known of their potential. Atlantic saury are common in Newfoundland only in occasional years and as summer migrants and probably cannot support an extensive fishery.

Anadromous–Catadromous Fish

The most familiar of this group of fish is the Atlantic salmon. It is unlikely that any great increase in the catch of Atlantic salmon is possible but the phase out of the West Greenland driftnet fishery will mean more large salmon for commercial fishermen, anglers, and spawning escapement. The transplant of pink salmon has been unsuccessful in terms of commercial or sport fishery potential. The present commercial fishing for Arctic char is limited to July and August when the char are at sea. Such a fishery if exploited too intensively could cause serious depletion of river stocks with subsequent slow recovery. The eel fishery in Newfoundland where baited eelpots and fykenets are used has been limited to areas relatively close to shipping routes. Higher catch per unit of effort and increased catches would be possible using eeltraps mainly for silver eel migrating to sea for spawning. It was earlier suggested that the smelt fishery could probably be expanded in some areas now fished and extended into new areas (258), although low landings in recent years indicate this has not taken place.

Invertebrates

In terms of landed value the lobster fishery is the most important fishery of Atlantic Canada. There is unlikely to be any appreciable increase

in lobster landings even with increased effort since the resource is at present fully exploited. Increased landings of shrimp in the Gulf of St. Lawrence are possible but vessels will have to undertake longer trips and range farther afield. Other areas also appear to have potential for shrimp but little is known of their abundance and distribution in these areas. The snow crab fishery is young and expanding in Newfoundland. Areas now yielding commercial catches and areas suspected of having commercial concentrations are mostly on the east and northeast coasts of Newfoundland. The 1973 total catch was 2045 t but the MSY for Newfoundland is predicted at 5000 t. There is room for increased catches in certain areas, but controlled entry is needed to prevent overcapitalization in both fishing and processing sectors especially in areas where stocks are fully exploited. Neither rock crab nor toad crab at present support a fishery although both species are in sufficient abundance to be fished commercially if they could be processed and marketed profitably. Euphausiids (krill) are extremely abundant in the Gulf of St. Lawrence and along the north coast of Newfoundland and could be the object of a fishery similar to that in the Antarctic by the USSR, if technology for harvesting and processing were developed and suitable markets existed.

A fishery for sea urchins is possible with a sustainable yield of perhaps 1000 t (live weight) yielding 100–150 t of roe. The fishery would be limited to December through March when roes are large and would have to concentrate in ice-free areas.

Estimates of sustainable yield for short-finned squid are not available but estimates of standing stock indicate it to be several hundred thousand tons. Abundance inshore fluctuates widely but in years of high abundance the inshore fishery can be much larger than previously. However, substantial increases in Newfoundland landings will require diversification of gear and active searching for squid.

Landings of giant scallop in the Port au Port Bay area reached a peak in 1954 of 209 t of meat but collapsed in 1956 because of overexploitation. Similarly, landings from St. Pierre Bank have fluctuated widely and yields in the Newfoundland area will continue to be highly variable because of wide fluctuations in recruitment and because of economic factors. A fishery for Iceland scallops developed recently on the northwest coast of Newfoundland and is prosecuted by multipurpose vessels that can switch from scallops to shrimp, cod, or herring. Estimates of sustainable yield are not available but the fishery is still in the "fishing-up" stage of harvesting a virgin stock of accumulated old scallops. Landings in the future mature fishery will fluctuate widely depending on new recruitment and the availability and price of alternate species.

Surveys have indicated that with development of suitable methods of harvesting, increased exploitation of blue mussel and rough whelk may be possible. The soft-shell clam resource can support only a low level of landings. An experimental introduction of American oyster to Newfoundland indicated poor prospects for commercial mariculture, while a transplant of European oyster is at present being monitored to determine growth, mortality, maturation, and meat condition and effect of environmental parameters.

Plants

Irish moss is the only seaweed being exploited in the Newfoundland area, but additional work is necessary to assess best harvesting time and sustainable yields. Several other species may also have potential.

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