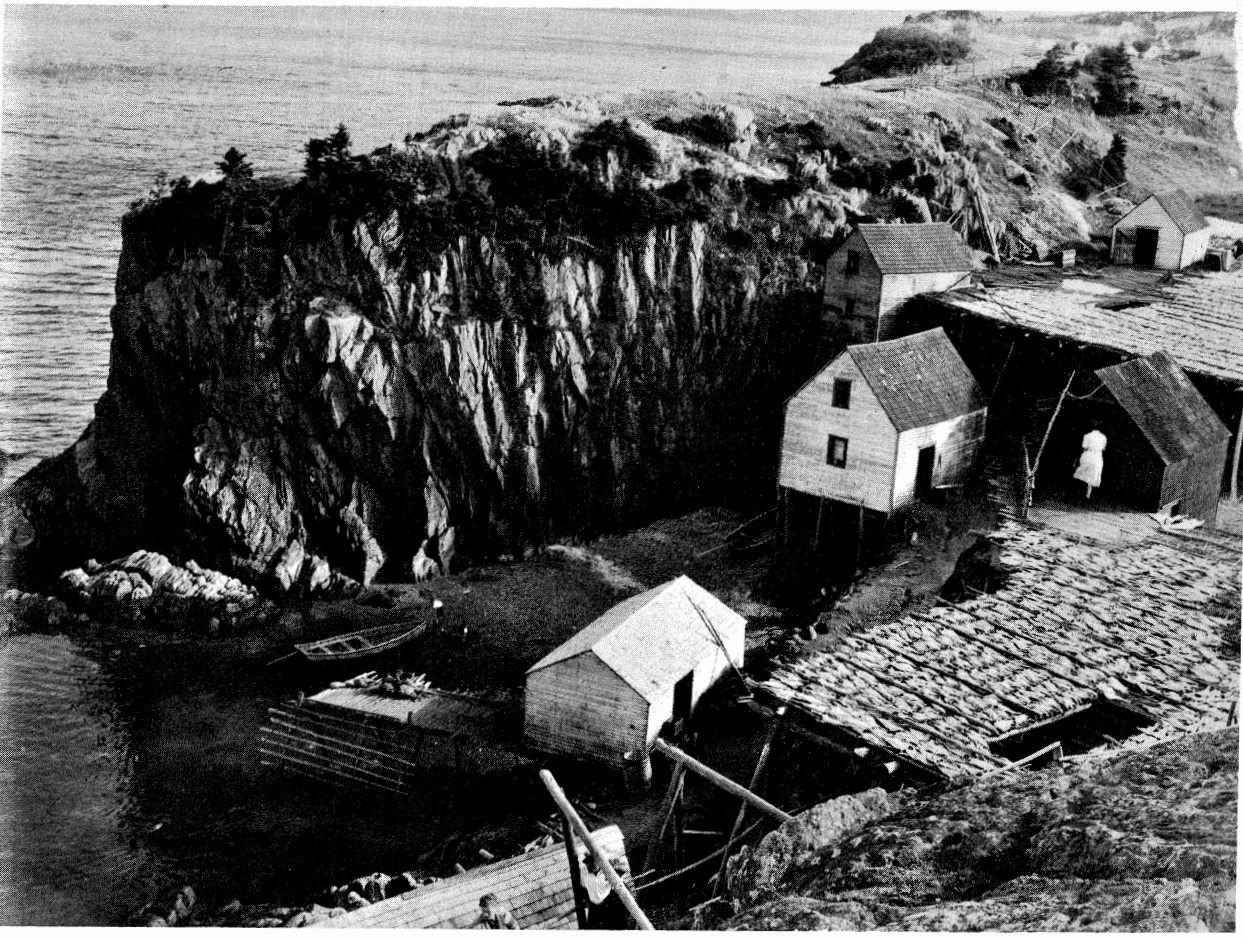
BULLETIN NO. 154

marine resources of Newfoundland

Wilfred Templeman

Fisheries Research Board of Canada, Ottawa, 1966

MARINE RESOURCES OF NEWFOUNDLAND



Frontispiece. Norman's Cove near Chapel Arm, Trinity Bay, August 26, 1952. A small fishing premises showing fish stage and fish sheds, and salt cod drying on the flakes.

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Marine Resources of Newfoundland

By Wilfred Templeman
Fisheries Research Board of Canada
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FISHERIES RESEARCH BOARD OF CANADA
Ottawa 1966

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1966

Contents

Summary

The following are the main scientific and statistical aspects of the marine fishery resources of the Newfoundland area, especially in relation to the fishery by Newfoundland. To meet the ever-increasing fishing pressure and the long-term activities of our competitors in the fisheries of the Northwest Atlantic, the federal and provincial governments, the fishing industry, fishermen, and scientists will need to cooperate effectively.

Quantity and Value of Newfoundland Fisheries

In 1964 total landings by Newfoundland fishermen were 638 million lb, landed values $22.9 million, and marketed values $46.6 million. Cod landings were 70% and all groundfish landings 90% of total landings. Landed values for cod were 61% and for all groundfish 78% of the total landed values. Marketed values for cod were 55% and for all groundfish 79% of the total. Cod used for salting declined from 72% of the cod landings in 1954 to 54% in 1964, the remainder being used for fresh and frozen fish. Marketed values per landed pound of round cod increased from 3.4 cents for salt and 4.3 cents for fresh and frozen cod in 1954 to 5.3 and 6.4 cents in 1964. Lobsters and salmon accounted for only 0.7 and 0.4% of total landings but 9.3 and 4.4% of landed and 7.2 and 4.3% of marketed values. The marketed value of fisheries products in 1964 was 204% of the landed value. In 1963 Newfoundland landings of marine fish were 26% of total Canadian landings and 17% of the landed value. Newfoundland fishermen were 32% of the total Canadian sea fishermen.

Atlantic Cod

Cod provide by far the greatest commercial fishery in the area. Though the fishery is ancient, even in recent years new winter and spring concentrations have been discovered and exploited off southern Labrador and northern Newfoundland.

In recent years up to 1963, 95% of the Newfoundland landings were taken in the inshore fishery: in 1964, 90%. In this fishery cod are most abundant on the east coast, especially in headland and offshore island areas which continue seaward as extensive underwater shelves and shoals. The annual landings were highest, at 640–680 million lb, in 1917–19, 1934–36, and 1945–47. In recent years they have declined to 470 million.

In the Labrador subarea (Subarea 2 of ICNAF, Fig. 6) the total landings increased greatly in recent years to 580 million lb in 1961 but declined to 469 million in 1964. The Newfoundland landings from this subarea decreased only

from 62 million to 54 million lb in the period 1951–63, but declined from 100% of the total for many years up to 1950 to 32% in 1955–58 and to 9% in 1961–64.

In the Newfoundland subarea (Subarea 3 of ICNAF) in 1961–64 the landings averaged 1046 million lb a year, Canadian landings being 35% of the total. Newfoundland landings from the inshore fishery were 32% of the total; from the offshore fishery, 2%. The total Canadian and the Newfoundland shares of the landings from this subarea have been gradually decreasing in recent years. In 1964 total landings from the subarea rose to a new high of 1282 million lb, of which total Canadian landings were 28.3% and the Newfoundland landings 27.5%.

In the Newfoundland and Labrador inshore fishery, between 1956 and 1964, the number of men increased by 53% and inshore fishing boats by 57%. The amounts of fishing gear used increased considerably (traps by 69%, lines of trawl by 68%, and cod gill nets by 1819%), but the total landings remained about the same. Yearly landings per fisherman decreased from 32 thousand lb in 1956–60 to 25 thousand in 1961–64. In the same period the total inshore landings increased in Division 2J (Fig. 6) and decreased in Division 3K and in 3L but showed little change in 3P and 4R. Landings per fisherman decreased in Divisions 2J, 3K, 3L, and 4R but showed little change in 3P. As a result of normal price increases and of the considerable increases in fishermen, boats, and gear without corresponding increases in catch, the costs of obtaining the same amount of cod increased considerably.

The cod of the northeast coast of Newfoundland spend the winter in deep, warm water below the cold layer, often 100 miles or more from the coast. In June, after spawning, large numbers move in the warming surface layer to the coast, feeding on capelin. They are taken in shallow water by trap, gill net, and handline, but their availability is affected greatly by variations in temperature and thickness of the surface layer, by onshore and offshore winds, and by other factors such as intensity of light and spawning places of the capelin.

Longlining experiments in 1950–55 showed that commercial quantities of large cod were present throughout the summer off the east coast of Newfoundland in deep water, mainly between 120 and 160 fath. Many of these populations have now been much reduced, mainly by European fishing.

Cod differ considerably in size and growth rate in various parts of the area. Off Labrador a 12-year-old cod weighs only 3 lb, whereas cod of this age from the east coast of Newfoundland weigh 5 lb, from the west coast 8 lb, and from the southern Grand Bank, the fastest-growing area, 13 lb.

The size of the year-classes varies considerably. Fish 4–6 years old usually make up 80–90% of trap catches. In Subareas 2 and 3, the total mortality of the fishable stocks is about 50–60% per year. As the fishing pressures are continually increasing, cod are bound to be smaller in the future and the catch per unit of effort less.

Haddock

Haddock are found in commercial numbers chiefly on the southern part of the Grand Bank and on the southern and western slopes and on the plateaus of St. Pierre Bank. Except in 1954–56, when there was a good fishery on St. Pierre Bank due to unusually high survival of the haddock hatched in 1949, the fishery of the Newfoundland area has been almost entirely on the Grand Bank.

The modern fishery began in 1945–46, and Spain caught most of the fish until 1953. Since 1954, Canada has taken the largest share except in 1955, when Spanish landings were again highest, and in 1960 and 1961, when the Russian landings were the highest.

There have been three peaks in the landings from Subarea 3: 173 million lb in 1949, 230 million in 1955, and 176 million in 1961. In 1964 the landings from this subarea were only 27 million lb, 41% by Newfoundland.

Survival of the newly hatched young varies greatly. In recent years, survival has been high only in 1942, 1946, 1949, 1952, and 1955. In 1947, 1953, and 1956 it was commercially significant, in 1961 and 1962 of small commercial significance, and in other years insignificant. Hence, the trend of the fishery since 1961 has been markedly downward and no great improvement is expected in the next few years.

Redfish

Two species of redfish are found in the area: *Sebastes mentella* and *S. marinus*. *Sebastes mentella* is found mainly in deeper water than *S. marinus,* is much more plentiful, and is the main object of the redfish fishery. Redfish are common on the continental slope and in deep-channel parts of the area, mainly between 100 and 400 fath.

In the ICNAF area the fishery began in 1935 in the Gulf of Maine and is now widespread. Landings rose slowly at first but very rapidly in recent years, with the entrance of European nations into the fishery, to a high of 858 million lb in 1959. They decreased to 412 million lb by ICNAF member countries in 1962 and 397 million in 1964. Including nonmember countries landings were 469 million lb in 1964. Canadian landings reached their highest level, 83 million lb, in 1963, the Newfoundland landings being 59% of this total.

Redfish are very slow growing. In some areas, recruitment of young fish is high only in occasional years. In the southern part of the area, successful new year-classes have appeared, and large, old fish are no longer plentiful. The future of the fishery depends on utilizing small redfish from the southern populations and developing efficient means of harvesting the larger redfish in deeper water in the northern part of the area.

Halibut and Other Flatfishes

The Newfoundland landings of Atlantic halibut, commonly between 400 and 800 thousand lb per year (but 1.7, 1.0, and 1.2 million lb, respectively, in 1962–64), were 16% in 1963 and 20% in 1964 of the total Canadian landings from Subareas 2, 3, and 4. They are restricted, in part, by lower landed prices in Newfoundland than in Nova Scotia.

Newfoundland landings of turbot, or Greenland halibut, usually 1–2 million lb a year, increased to 3.9 million in 1964.

The American plaice is by far the commonest flatfish in the area. The main Newfoundland fishing grounds for this species are on the eastern, northern, and northwestern parts of the Grand Bank, in Subarea 3. The total landings from Subarea 3 rose gradually after the fishery began in 1948 and reached 66 million lb in 1963 and about 100 million lb in 1964, when Canadian landings were 82 million lb. In 1963 and 1964 the Newfoundland fishing effort for this fish increased greatly because haddock were scarce, and 46 and 60 million lb were landed in the province.

Jellying of the flesh of the older plaice was commercially troublesome in the early fishery, but has been much reduced with a reduction in relative numbers of old fish.

This flatfish grows slowly, apparently varies little in size of year-classes, is available over long periods on the same fishing grounds, and hence is in danger of over-exploitation.

The Newfoundland landings of witch flounder, or greysole, from Subarea 3 usually come mainly as a by-product of haddock fishing on the southwestern Grand Bank. They reached their highest of over 9 million lb in 1960, but decreased to 2.7 million in 1963 and 3.6 million in 1964 with the decline in effort for haddock. In 1963 and 1964 the Newfoundland landings from Subarea 4 increased to 4 million and 3 million lb from 0.3 million in 1962.

Pelagic Fish

Herring landings declined greatly from 160 million lb in 1946 to 12–19 million in 1956–64, but only a small percentage of the population is caught.

Mackerel are occasionally plentiful. The landings were highest, at 5.7 million lb, in 1953.

The bluefin tuna, a large species, is found in the area. The only fishery for it at present is a sport fishery by troll line with bait. The fishery is entirely in Conception Bay usually from late July to September. The landings were greatest in 1963 and 1964, at 270 tuna (116 thousand lb) and 316 tuna, respectively.

Swordfish occur in small numbers from late July to October off the western part of the south coast of Newfoundland, but in abundance in summer and early autumn near the southwestern edge of the Grand Bank. The highest Newfoundland landings and the only significant landings in recent years, 123 thousand lb, were made in 1963.

Porbeagles have been fished by surface longline in the Newfoundland area, especially by Norwegians, since 1961. They may be seasonally numerous enough in the southern part of the area to support a fishery. The market at present is in Italy.

Salmon and Trout

The commercial landings of Atlantic salmon reached a high of about 7 million lb in 1930 and since then have gradually fallen to slightly over 2 million a year. Landings have risen since 1956 to 2.8 million in 1964. Yearly landings by anglers have doubled since 1958–61 and were 42,500 salmon in 1964.

The introduction of sockeye and pink salmon from the Pacific coast may be feasible. Eggs of the pink salmon were recently planted in a Newfoundland river, but the returns of adults to the river so far have been far too few to replace the original supply of eggs.

The two native species of trout, the brook trout and the Arctic char, have sea-running forms, and Arctic char are numerous off northern Labrador. Rainbow and brown trout have been introduced and the latter has established sea runs of large fish.

Other Fish

Capelin are excellent food for humans but are used little for this purpose at present. They are very abundant, and about 10 million lb per year are now taken, but probably at least several hundred million pounds a year could be caught. With the decrease in size and in the standing stock of commercial fishes such as cod and haddock, which feed on them, the capelin will probably become even more numerous.

The smelt fishery is small but might well repay research and development efforts.

Pollock and white hake are landed both by trawlers and by inshore line fishermen in small but increasing amounts from the southern part of the area. In 1964 the Newfoundland landings were 1.0 million lb of pollock and 0.4 million lb of white hake.

Three species of wolffish, the Atlantic or striped, the spotted, and the northern or broadhead, occur in the area. The latter two are common only north of the Grand Bank. Newfoundland landings of striped and spotted wolffish, the broadhead being unsuitable, are gradually increasing and were 1.1 million lb in 1964.

Eels are common in Newfoundland and landings were close to 50 thousand lb a year in 1962 and 1963. The fishery can be developed considerably beyond this level.

Spiny dogfish are often numerous in the area, and in times of abundance could support a large fishery. The market is in England and other European countries.

Several species of large skates are landed in the area in numbers great enough for skates' wings to be a by-product of groundfish fishing.

Many other fishes occur in the area in numbers, though usually modest, that could be used or very likely will be. Among these are the Atlantic argentine, silver hake, monkfish or angler, lumpfish, Atlantic saury or billfish, winter flounder, launces, and ocean pout or eelpout.

Crustaceans

Lobster landings were at their peak of 17½ million lb in 1889, and have become stabilized at about 4–5 million lb in recent years. This is probably close to optimum utilization, except for increases in periods of years with high surface-water temperatures and decreases in periods with low temperatures. Between 1956 and 1964 the numbers of lobster fishermen and traps increased considerably, and the yearly landings decreased to 557 from 1129 lb per fisherman and to 8.2 from 15.8 lb per trap.

The pink shrimp is relatively numerous in deep water in the Gulf of St. Lawrence and in neighbouring areas. It will probably be used commercially in the near future.

The most important crabs are a spider crab, called *Chionoecetes opilio* and the common rock crab, *Cancer irroratus*.

Molluscs

The supply of squid varies greatly, and in recent years the landings have ranged from 23 million to 1 million lb. In years of abundance a much greater quantity could be caught.

The sea or giant scallop is found in many shallow-water areas near the coast of Newfoundland. There are many small beds, especially on the south and west coast, and larger ones in Port au Port Bay and on St. Pierre Bank. The landings from the inshore area were highest at 460 thousand lb of scallop meats in 1954, but only a little over half of this total was landed in Newfoundland. The average yearly landings in Newfoundland for 1958–63 were only 27 thousand lb, but in 1964 landings rose to 194 thousand lb. Of these, 173 thousand were from St. Pierre Bank and 20 thousand from the Port au Port area.

At present other molluscan resources, Iceland scallops, soft-shell clams, and mussels are exploited either little or not at all.

Mammals

The principal seal is the harp and the main fishery is for its young, the whitecoat, in the first few weeks after birth. In 4 years of the 19th century this fishery produced over 600 thousand seals per year, but in 1954–64 the kill ranged from 32 to 78 thousand yearly, over 40% being taken by landsmen. Norway and Nova Scotia now dominate this fishery. The herd is being gradually destroyed and sealing practices will have to be changed to kill fewer young and especially fewer female adults. Regulations to this end for the Gulf herd were applied in 1965.

The fishery for large whales, which may be able to sustain a yearly kill of about 400 whales, has now ceased because it has become unprofitable. There is a continuing but highly fluctuating fishery for a small whale, the pilot or pothead. This fishery landed as many as 9799 potheads in 1956. Pothead landings are usually high when squid, on which they feed almost entirely, are plentiful inshore and are always low when squid are scarce. The minke whale is captured in small numbers, averaging about 30 per year between 1947 and 1964. Its meat is excellent for human food.

Seaweeds

No commercial use is now being made of the seaweed resources, though formerly there was a small export of Irish moss. Irish moss occurs in many areas, but the seaweeds present in great quantity are the rockweeds, kelps, and red seaweed, *Plumaria* sp.

Large Vessel Fishing Effort in the ICNAF Area

In the period 1952–62, the total tonnage doubled for fishing vessels of 51 or more gross tons, fishing the ICNAF area. The Canadian Maritimes and Quebec percentage of this total held level at about 4.4. The Newfoundland percentage of the total declined to 1.3 from 2.1 and that of crew members to 1.5 from 2.2. By far the greatest increases in tonnage and fishing effort have been made by the USSR. Further increases have occurred and are in prospect.

Offshore and Inshore Fishing

The Newfoundland inshore cod fishery depends on stocks of cod that are also heavily fished offshore, especially in winter and spring. As the international offshore effort for cod increases, the inshore fishery must increase its efficiency and fishing effort even to maintain landings at their present level.

In 1965, about a third of the Newfoundland fish landings were made by the offshore otter-trawling fleet, using only about 700 men. To improve the Newfoundland landings significantly it is necessary to expand greatly the offshore trawler fishery, especially for cod and redfish. Newfoundland's greatest unused

resource is the offshore fishery for cod. In 1964 Newfoundland took only 2.5% of the 930 million lb of cod caught offshore in Subarea 3 and only 0.007% of the 440 million lb of cod taken offshore in Subarea 2.

Introduction

In Newfoundland the marine fisheries in 1935 used 45% of the labour force (36,886 persons); in 1945, 31% (31,634 persons), and in 1961, 15% (about 18,800 persons), or over 18% of the employed part of the labour force. In 1961 the fishing industry produced 8.8% of the value of all commodity production, primary fishing accounting for 5.7% and fish processing for 3.1% (Copes, MS, 1964). Though up to the early part of the 20th century the fishery was by far the greatest factor in the economy, other industries such as mining and forestry have now superseded it in economic value.

In 1963 the landed value from the fisheries was $20 million and the marketed value $44 million. In 1964 the landed value was $23 million, the marketed value $47 million, and there were over 21 thousand men either fully or partly employed in fishing. All except 700 of these were engaged in the inshore fishery. There were also about 3 thousand workers in fish plants and many more thousands in the service industries which were made possible by income from the fisheries. In a great part of the coastal area, fishing is still the major occupation. Although the incomes of inshore fishermen are low, the total value of the fisheries, including export values, is of great importance to the economy.

Although some species, especially cod, haddock, redfish, American plaice, and the harp seal, are being heavily exploited, much less than the maximum sustainable yield is being harvested from various others, including herring, capelin, squid, and swordfish. Also, species not being utilized now, such as launce and shrimp, may well be worth fishing at once or in a few years. The present Newfoundland offshore fishery, especially for cod, is only a minor one. A great expansion of this fishery, with special emphasis on cod and redfish, offers prospects for a large increase in the landings and income.

In this Bulletin I give information and opinions on all the important marine fishery resources of Newfoundland. Also, as only a small part of the background of the fisheries can be given, I include references to other pertinent sources of information so that the interested reader may pursue the subject further. Some of the more important of these not discussed in detail here are: Newfoundland Fisheries Commission (1890–1898) (containing Adolph Nielsen's reports on his work as Superintendent of Fisheries); Newfoundland Fishery Research Laboratory (1932–37); Kent Commission (1937); Walsh Committee (1953); and International Commission for the Northwest Atlantic Fisheries (ICNAF): Proceedings (since 1951), Statistical Bulletin (since 1952), Redbook (since 1958), and Sampling Yearbook (since 1958).

For a recent assessment of the prospects of the Canadian fishery for most of the commercial fishes and marine invertebrates discussed in this bulletin, see

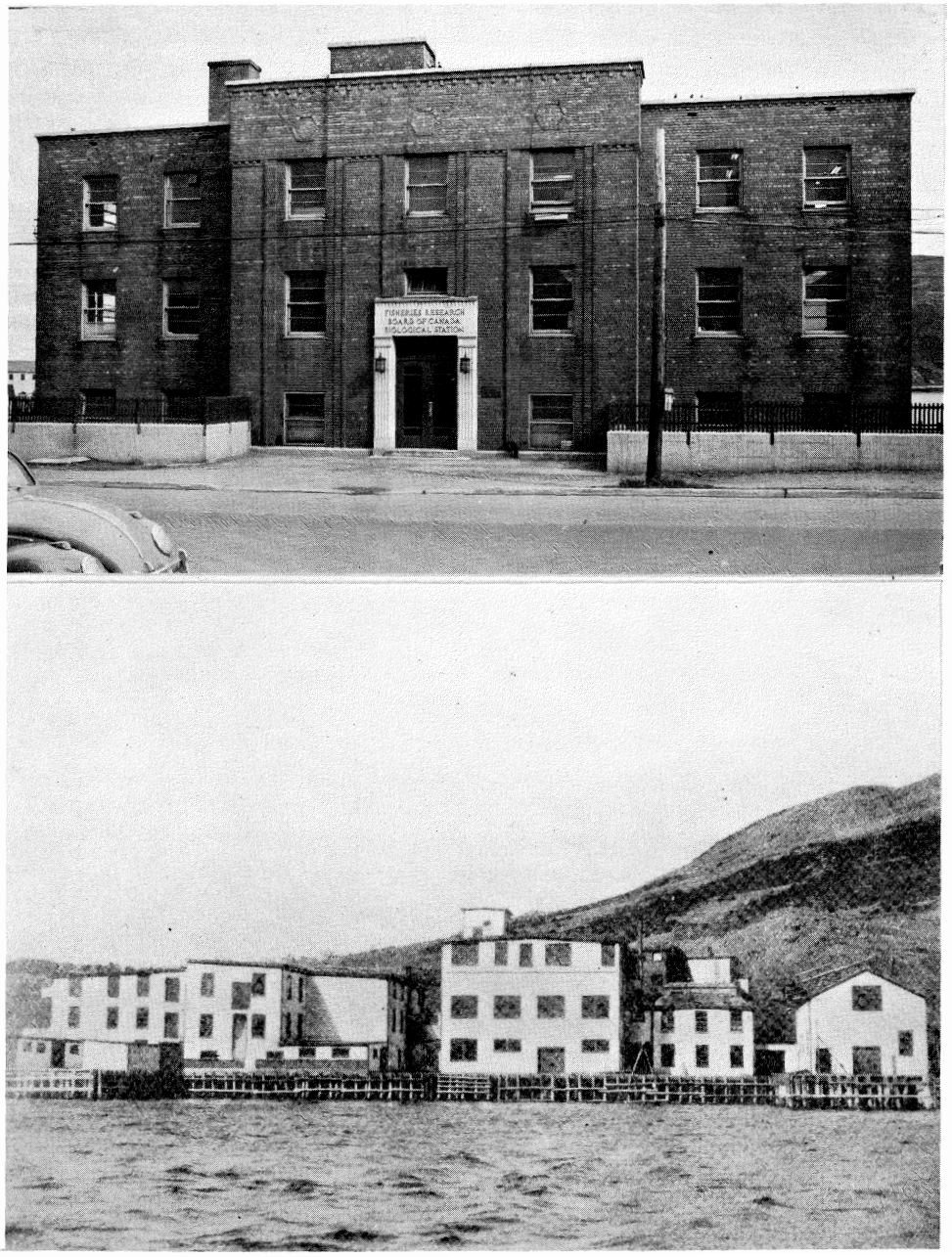


FIG. 1. *Above*. The Biological Station, now of the Fisheries Research Board of Canada, opened in 1940 and situated on the waterfront, on Water Street East, St. John's. *Below*. In the upper story of the central building, the Newfoundland Fishery Research Laboratory at Bay Bulls, in operation from 1931 to 1936 under Dr Harold Thompson. (The building was part of Harvey and Co. Fish Plant. For a plan and description of the laboratory and a list of its staff, see Anon., 1932.)

Ricker (1962). For information on the specific characteristics, drawings of typical specimens, distribution, and biology of fish species found in the Canadian and northern New England sections of the Northwest Atlantic, see Leim and Scott (1966) and Bigelow and Schroeder (1953).

FIG. 2. The *Cape Agulhas* off Cape Harrigan, Labrador, June 1932 (from Ann. Rep. for 1932, Newfoundland Fishery Research Laboratory, 1933).

The scientific names of the fishes and other marine animals, usually referred to by their common names in the Bulletin, are listed in the appendix. For lists of fish species from the Newfoundland area generally, see Newfoundland Fishery Research Laboratory (1932–35); and for an annotated list of the fishes of Labrador, see Backus (1957).

Brief History of Marine Fisheries Research in Newfoundland

After a preliminary survey of the need and opportunities by Dr Harold Thompson in 1930 (Thompson, 1931), the Newfoundland Fishery Research Laboratory (Fig. 1) was established in Bay Bulls near St. John's in 1931 with Dr Thompson as Director. Considerable research was carried out with part-time use of the trawler *Cape Agulhas* (Fig. 2) for surveys in the years 1931–35. Yearly summaries of the research were published in the Laboratory's annual reports for 1931 to 1936–37 (1932–37). A good beginning was made in research on the main commercial fishes: by Lindsay and Thompson (1932) on Atlantic salmon, by Frost (1938) on fish egg and larval distribution, by Thompson (1939) on haddock, and by Thompson (1943) on cod.

Dr. Thompson resigned in the autumn of 1936. The Bay Bulls laboratory was destroyed by fire in April 1937. Many records and much material were lost with the laboratory.

After the fire, the staff moved to part of the Court House Building, St. John's, where they remained until the present laboratory at St. John's (Fig. 1) was completed in 1940. Dr. W. F. Hampton became Acting Director in 1937 and remained in charge until 1943. The author became Director in June 1944.

During the Second World War (1939–45) it was not possible to conduct extensive field studies but biological researches were carried out on lobsters, capelin, dogfish, salmon, and herring. At this time the laboratory, called the Newfoundland Government Laboratory, was responsible for all government chemical analyses, except those relating to public health, and also carried out some technological research on fisheries. For additional details on fisheries research in Newfoundland up to that time, see Templeman (1945).

Groundfish research was resumed in the spring of 1946 with the launching of the 82-ft *Investigator II* (Fig. 3).

After confederation of Newfoundland with Canada in 1949, the laboratory became a Biological Station of the Fisheries Research Board of Canada. Researches on groundfish were expanded on the major species: cod, haddock, redfish, and American plaice. Explorations of new deep-water cod grounds by longline were carried out with chartered longliners from 1950 to 1955, and explorations for flounders in 1953–54 with the Danish seiner *Matthew II,* loaned by the Newfoundland Government. Other vessels were chartered for exploration of shrimp

and scallop resources. Smaller research vessels of the Station, the 62-ft *Marinus* since 1953 and the 50-ft *Parr,* have been mainly used in studies in the inshore area.

Offshore researches were greatly facilitated and expanded by the acquisition of the 177-ft *A. T. Cameron* (Fig. 3) in October 1958. Those on lobster, which

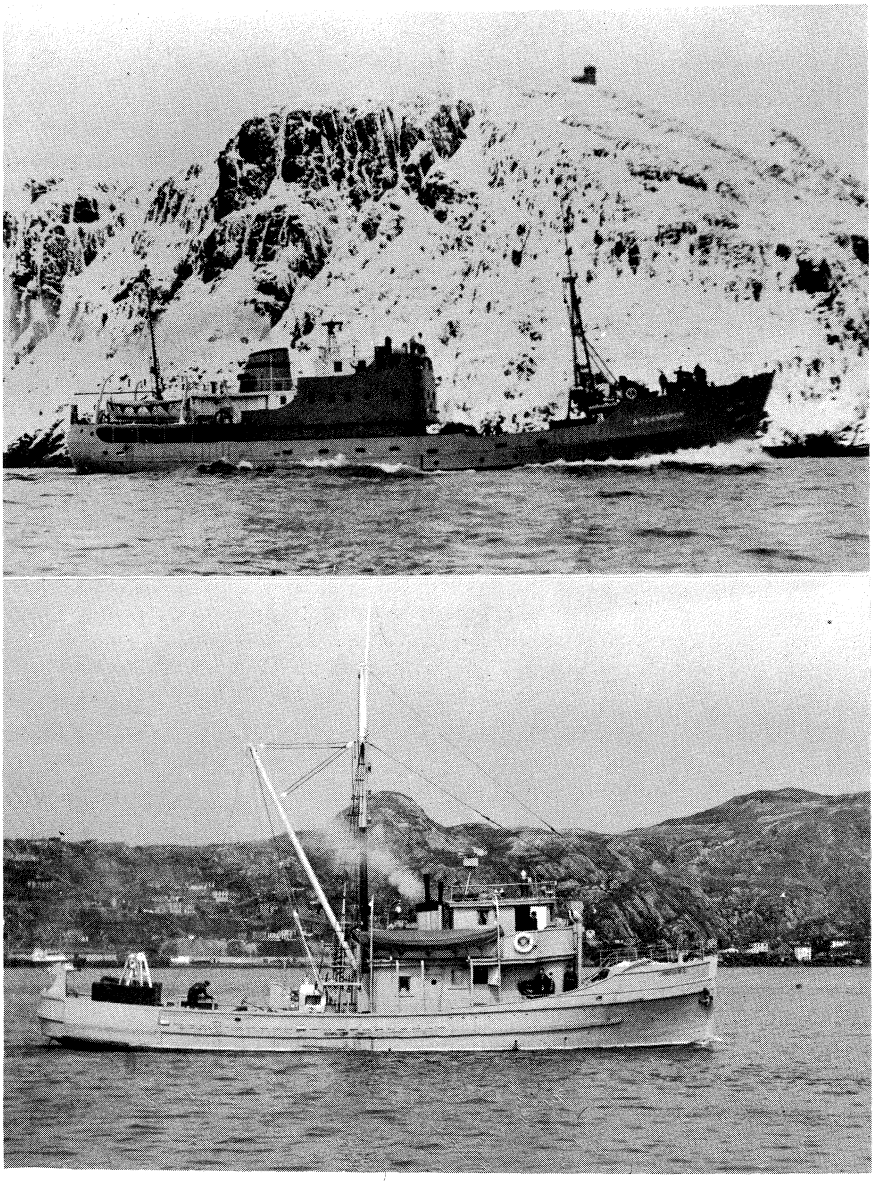


FIG. 3. The larger research vessels of the Biological Station, St. John's. *Above.* The *A. T. Cameron* leaving St. John's Harbour, January 9, 1959. *Below.* The *Investigator II* leaving St. John's Harbour, May 24, 1962.

had ceased in 1940, were begun again in 1961, and those on herring, capelin, and squid in 1965.

In recent years, fisheries and related oceanographic researches in areas adjacent to Newfoundland and Labrador have been rapidly increasing, and many countries are carrying out these researches in addition to Canada. These include the USSR, Portugal, Spain, France, Poland, West Germany, East Germany, Iceland, Norway, Great Britain, and the USA. Most of them either have or are building large research vessels, which now visit or will visit this region. The USSR, especially, is conducting much biological fisheries research in this region.

General Trends and Aims in Fisheries Research

Much of the work of the St. John's station between 1946 and 1959 concerned explorations for new stocks of fish and new fishing grounds. Many of the results of the explorations are discussed later. When the fish stocks over the whole area become heavily exploited by large numbers of fishing vessels, the exploratory phase comes to a natural end.

Much of the research that follows the exploratory phase concerns the fish in relation to its environment: how, where, and when temperature, light, food, spawning, and other factors concentrate the fish of various sizes in appreciable numbers and make them available to the fishery. Also, a kind of census taking, continued indefinitely, is necessary to find out how nature and fishing are affecting the numbers and sizes of fish. To obtain this information the fish are studied in many ways, especially in relation to their ability to maintain their numbers and size sufficiently for a profitable fishery in spite of heavy tolls by fishermen. It is also important to know what mesh sizes in otter trawls and traps will liberate small fish without detriment to the long-term landings.

Fish growth is studied to know how rapidly the weight of fish captured is replaced by growth of the fish remaining. It is also necessary to study migration and the amount of intermingling between various stocks of fish. Other important subjects for research are: survival of young and the amount of recruitment of young fish to pre-commercial sizes, rates of fishing mortality and of natural mortality, and how all of these are affected by the fishery.

From this information it is sometimes possible to predict what the fishery for a particular species will be like, or at least what amounts and sizes of fish will be available, a number of years in advance. We have had considerable success in recent years in making such predictions for haddock. Prediction is more difficult for cod since young cod of pre-commercial sizes do not live as close to the bottom as haddock and hence are not so readily caught and their numbers assessed by otter-trawl surveys; also, the great inshore cod-fishery depends on availability of cod in a limited area.

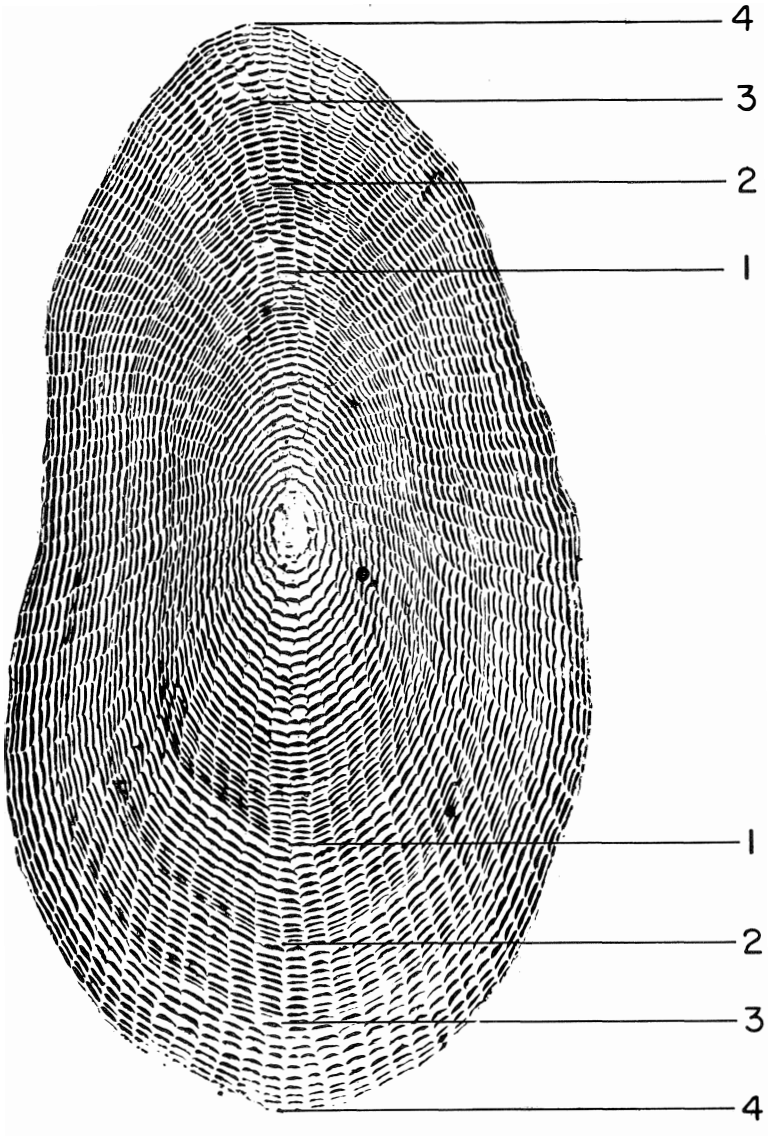


FIG. 4. Impression on plastic of a scale of a 4-year-old haddock. The small, bony blocks in the scale are called sclerites. Wide sclerites are formed in summer, when growth is fast, and narrow ones in winter, when growth is slow. The solid lines are drawn at the end of the winter growth at each of the 4 years.

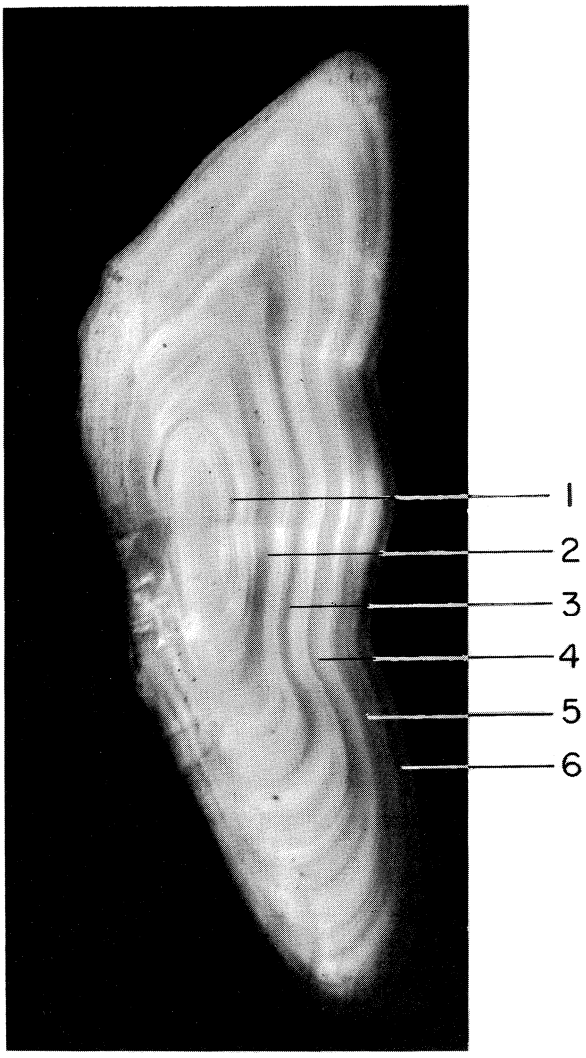


FIG. 5. Cross-section of the ear-stone, or otolith, of a 6-year-old cod under reflected light. The dark bands are translucent material formed in winter; the white ones are opaque material formed in summer, the faster-growing period. Lines were drawn to show the winter bands of years 1–6. A faint white line outside the 6th winter band shows new summer growth; hence the fish is 6+ years old.

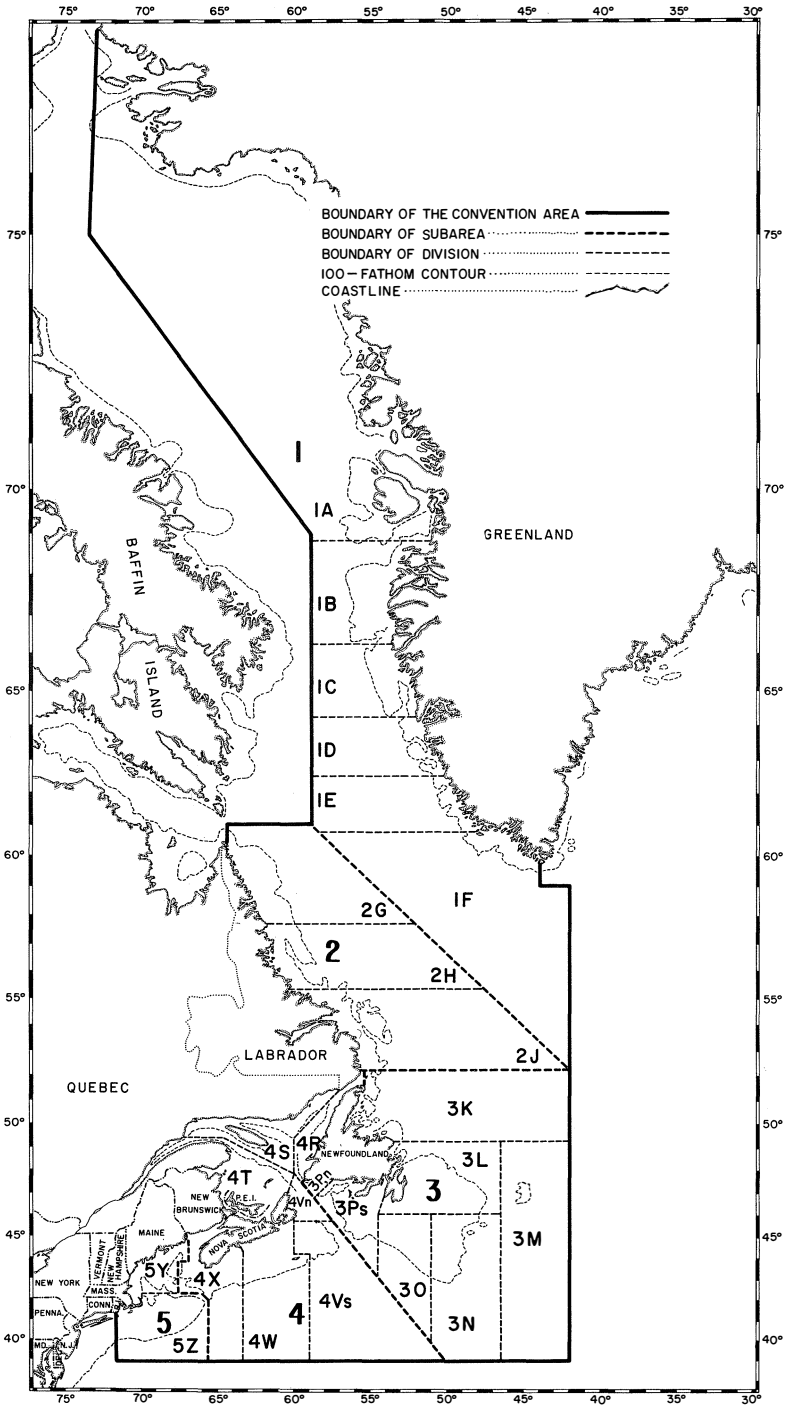


FIG. 6. The ICNAF (International Commission for the Northwest Atlantic Fisheries) area, Subareas 1–5 and Divisions 1A–5Z.

Age and Growth of Fish

To follow the structure of a fish population it is necessary to study its age and growth. Ages in young fish may be determined from summer and winter rings in scales (Fig. 4), but more usually for groundfish at the present time sections of otoliths, or ear-stones (Fig. 5), are used for age-reading. Growth in individual fish may be calculated by measuring the growth in scales or otoliths and applying appropriate formulas to these measurements.

Statistical and Fishing Areas and Catch Statistics

Statistics of landings of groundfish (cod, haddock, American plaice, redfish, etc.) and of other marine forms contributing to international fisheries are made generally available by the International Commission for the Northwest Atlantic Fisheries (ICNAF) from records collected by the member nations. For statistical purposes and for convenience in handling problems which are not the same in all areas, ICNAF has divided the Northwest Atlantic into five main subareas (Fig. 6): Subarea 1. West Greenland; Subarea 2, Labrador; Subarea 3, the eastern and southern Newfoundland area from the Strait of Belle Isle to Cabot Strait and including the continental shelf in this area and the Newfoundland banks; Subarea 4, the Nova Scotian area and the Gulf of St. Lawrence; and Subarea 5, Georges Bank and the New England area of the Gulf of Maine. Each of these subareas is in turn subdivided for convenience in research on and regulation of fish populations.

This paper is mainly concerned with Subareas 3 and 2 and Division 4R from which almost all Newfoundland's present landings originate. However, for trawlers whose home ports are on the south coast of Newfoundland, the northern half of the Scotian Shelf of Subarea 4 is as close, and for the western ports closer, than the Grand Bank fishing grounds. Newfoundland trawlers in winter–spring are beginning to fish more in the Nova Scotian area particularly on the cod stock in winter and spring in Division 4Vn. Subarea 1, the West Greenland area, is also within reach of Newfoundland freezer-trawlers.

Statistics used in this paper are taken mainly from statistical publications of ICNAF, the Newfoundland departments of Fisheries and Customs, the Department of Fisheries of Canada, and the Dominion Bureau of Statistics. The 1964 statistics are as yet unpublished and hence are provisional. Statistics for 1961–63 are incomplete since the increasing landings by East Germany are not included. These landings were about 90 million lb in 1962 and 130 million in 1963 (mainly from the West Greenland area, Subarea 1, and the Northeastern Newfoundland area, Division 3K), and were almost entirely of redfish and cod. Statistics are of landings, usually in terms of whole (round) weight.

Figure 7 shows the main areas and localities along the coast and on the continental shelf from Labrador to Rhode Island that are either mentioned in this Bulletin or important to fishing.

Quantity and Value of Newfoundland Fisheries

In the period 1958–62 cod represented 75% of the quantity (584 million lb per year) and 65% of the landed value ($15 million per year) of Newfoundland fisheries (Fig. 8). Lobster was 0.7% in quantity but 9% in value and salmon 0.4% in quantity and 4.6% in value, the angling quantities and values being omitted. Other valuable fisheries (3% or more) were, in descending order of

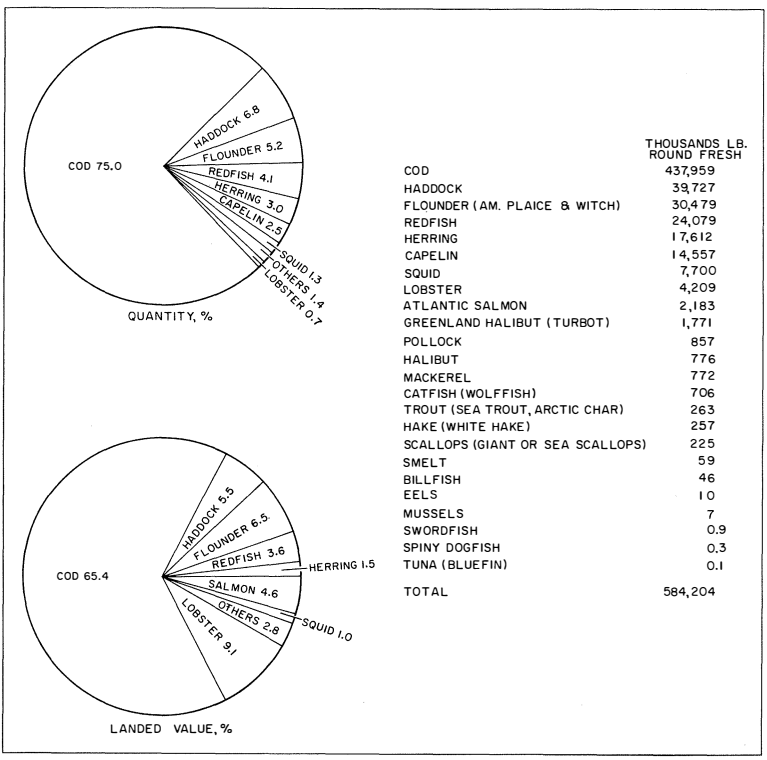
FIG. 7. Main areas and localities along the coast and the continental shelf from Labrador to Rhode Island that are mentioned in this bulletin or are important to fishing.

quantity: haddock, flounder (plaice and witch), redfish, and herring; and in order of value: flounder, haddock, and redfish.

In 1963, for the landings, landed values, and number of fishermen the percentages of the Canadian totals for all fish and shellfish and for marine fish only were:

	Landings	Landed value	Fishermen
All fish and shellfish	25	15	25
Marine fish only	26	17	32

In recent years (1954–64, Fig. 8A) herring landings fell and haddock landings fell greatly; cod and total landings fluctuated and declined slightly. The variations in overall total landings and values followed closely the variations in those of cod. Landings of plaice and greysole and redfish increased greatly, but the increase in plaice and greysole was entirely due to plaice, the greysole landings having declined. Landings of other groundfish: Greenland halibut (turbot), halibut, pollock, wolffish (catfish), and hake increased but were still small. Landings of lobsters fell slightly and those of salmon increased slightly.



	THOUSANDS LB. ROUND FRESH
COD	437,959
HADDOCK	39,727
FLOUNDER (AM. PLAICE & WITCH)	30,479
REDFISH	24,079
HERRING	17,612
CAPELIN	14,557
SQUID	7,700
LOBSTER	4,209
ATLANTIC SALMON	2,183
GREENLAND HALIBUT (TURBOT)	1,771
POLLOCK	857
HALIBUT	776
MACKEREL	772
CATFISH (WOLFFISH)	706
TROUT (SEA TROUT, ARCTIC CHAR)	263
HAKE (WHITE HAKE)	257
SCALLOPS (GIANT OR SEA SCALLOPS)	225
SMELT	59
BILLFISH	46
EELS	10
MUSSELS	7
SWORDFISH	0.9
SPINY DOGFISH	0.3
TUNA (BLUEFIN)	0.1
TOTAL	584,204

FIG. 8. Relative importance of the many fish and invertebrate species in the Newfoundland fisheries for the 5 years 1958–62. The total quantity was rounded before the individual totals.

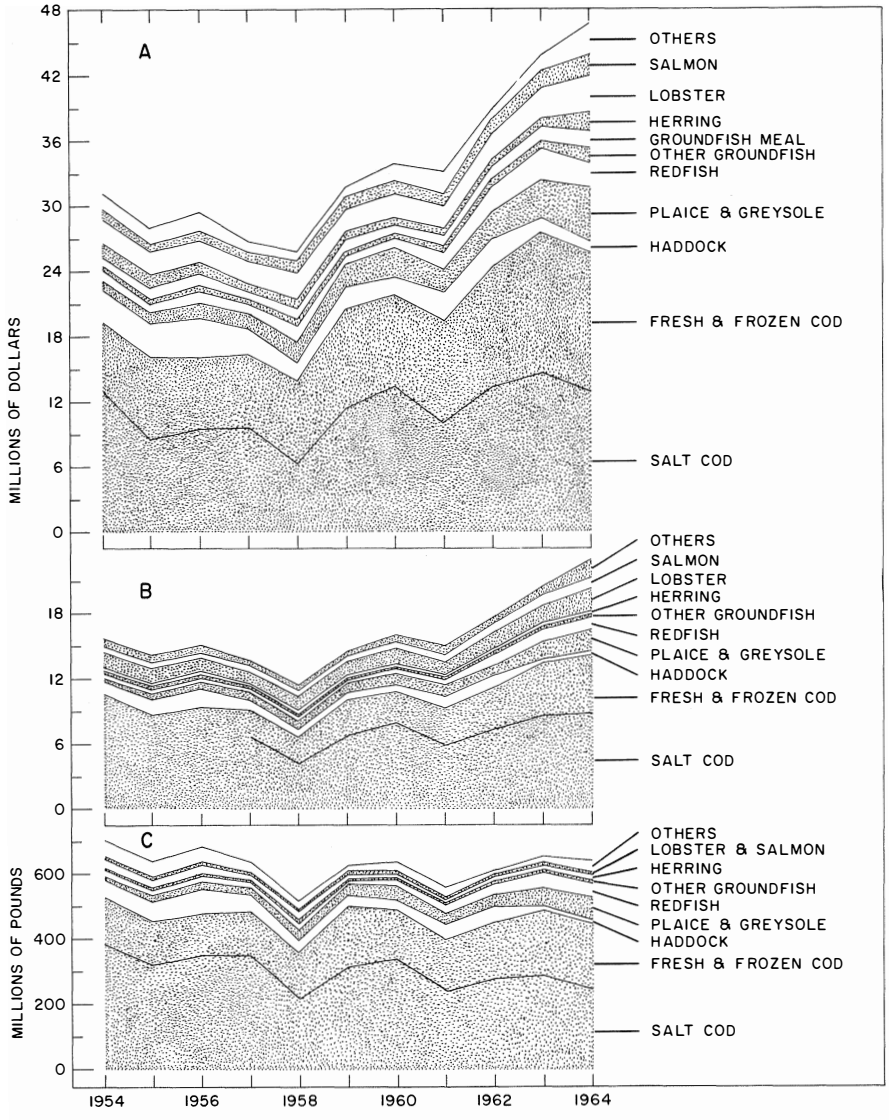


FIG. 8A. A, marketed values; B, landed values; and C, landed quantities from the Newfoundland fisheries for the years 1954—64. (Cod, haddock, pollock, catfish, hake, and halibut were converted to round, others as in Canadian fisheries statistics. Seals and whales were not included in the landings because no weights were available, but were included in values. Cod liver values and values of cod by-products except meal were included with cod. Marketed values of groundfish, especially cod, plaice and greysole, haddock, and redfish were greater than shown since groundfish meal values should have been attributed to them. The landed values for salt cod are somewhat unreal since they were calculated from the average price by statistical district paid to the fishermen for salt cod either saltbulk or dried or for fresh cod used by fish plants for salting. The former includes some costs for salt and some of the labour values, expenses and increases in value normally included in the marketed value. The results therefore are not true landed values but values paid to fishermen.)

Landed values fell from $15.7 million in 1954 to $11.3 million in 1958 and rose to $22.9 million in 1964. Marketed values fell from $31.2 million in 1954 to $25.7 million in 1958 and rose to $46.6 million in 1964.

In 1964, total groundfish landings of 574 million lb were 90% (cod 70%) of total landings of 638 million; groundfish landed values of $17.9 (cod $13.7) million were 78% (cod 61%) of total landed values of $22.9 million; and groundfish marketed values of $36.8 million were 79% (cod 55%) of total marketed values of $46.6 million. This shows little overall change since 1954 when groundfish were 87% of the landings and 81% of both landed and marketed values, but cod has declined slightly and haddock greatly in importance relative to the other groundfishes from the earlier to the later part of the 11-year period.

In 1964, lobsters and salmon were only 0.7 and 0.4% of total landings, but in percentages of landed values were 9.3 and 4.4, and of marketed values 7.2 and 4.3.

The real value is the marketed value since it includes all the values added to the landed value. Marketed values in 1964 expressed as percentages of landed values were: all fisheries products, 204; cod, 184 (salt cod, 149; fresh and frozen, 239); haddock, 256; plaice and greysole, 242; redfish, 237; herring, 708; lobster, 158; and salmon, 195. The lower marketed value increase for cod compared with the other groundfish is due to such a large proportion of the cod being sold as salt fish rather than in a fresh or frozen state, and to landed values being calculated artificially high for salt cod (see later discussion). The relatively high marketed value for herring in 1964 was produced by the large proportion of the catch used for skinless fillets. The relatively small increases in marketed over landed values for salmon and especially for lobsters are due to their relative scarcity, with resultant high landed prices, and to their being marketed with little change from their landed state.

Cod used for salting declined from 72% of the landings or 380 million lb in 1954 to 54% or 241 million lb in 1964. Cod used in the fresh and frozen fish industry increased from 28% (149 million lb) in 1954 to 46% (203 million lb) in 1964.

Nominal landed values for salted cod include all increases in value to the fishermen due to salting and drying. Thus, neglecting the salt, labour, and other costs and the considerable fishing time lost in salting and drying fish, landed values per landed pound were greater for cod used for salting than for those used for the fresh and frozen product, and the difference between them has been increasing. Landed values in cents per pound of fresh round cod used for salting (values for cod used for the fresh and frozen product in parentheses) were: 1957, 1.9 (1.8); 1960, 2.3 (1.9); 1963, 2.9 (2.5); and 1964, 3.6 (2.7). Corresponding marketed values were: 1954, 3.4 (4.3); 1957, 2.8 (5.8); 1960, 3.9 (5.7); 1963, 5.1 (6.6); and 1964, 5.3 (6.4). Thus, marketed values per landed pound were greater for cod used for the fresh and frozen product. Additional marketed

values for the fresh and frozen fish industry come from values of meal. These are lost when the fisherman salts his own fish.

Effects of Intensive Fishing

When the Newfoundland Government Laboratory resumed its groundfish researches in 1946 the haddock, plaice, and redfish fisheries were barely beginning. The populations of these fish were virgin stocks. In any large virgin stock of fish native to an area, the fish are as numerous as their environment and their food will allow. The fish are big and grow slowly and, as the natural mortality balances the growth, the overall size of the population is practically stable. The first effect of the fishery is to reduce the numbers of the large, old fish; in their place, larger numbers of much faster-growing, smaller fish are produced. A sustained fishery can then take only the surplus produced from these fish by recruitment and growth, less their natural mortality. As the numbers of large old fish are greatly reduced by intensive fishing and as the fishery comes to depend increasingly on small fish, all hook-and-line fisheries are discriminated against. With hook-and-line gear it is not possible with the same effort to catch as great quantities of small as of large fish, but, if the small fish are plentiful enough, traps and otter trawls may continue to fish them effectively.

Outline of hydrographic conditions

The great fisheries of the Northwest Atlantic are made possible by the extensive underwater shelves and banks (Fig. 7) and by the hydrographic conditions. As a result the area has waters rich in fish food, of various but rather low temperatures, and hence suitable for the various groundfish species.

Currents

A current of very cold water flowing southward along the east coast of Baffin Island is joined by another very cold current emerging from Hudson Bay and Foxe Basin by way of Hudson Strait to form the inshore, cold part of the Labrador Current (Fig. 9). Since the rotation of the earth causes the current to turn to the right, this very cold part of the Labrador Current is deflected shoreward along the coast of Labrador and the east coast of Newfoundland and provides inshore conditions favourable to cod and American plaice. To the north of the Grand Bank the Labrador Current divides, one branch passing mainly through the Avalon Channel and along the coast southward toward Cape Race and more weakly over the Grand Bank, and the second flowing along the eastern slope of the Grand Bank.

North of Labrador the westward, colder part of the Labrador Current is joined seaward by warmer water from the West Greenland Current. This warmer water flows deep along the outer slopes of the continental shelf and the banks, and supplies the warmer, deep water necessary for large quantities of redfish and smaller numbers of Atlantic halibut and Greenland halibut.

The Gulf Stream flows eastward just south of the Grand Bank, and the mixture of northern cold and southern warm water gives water of intermediate temperature. This warm water affects the southwestern Grand Bank, covering parts of the southwestern slope in winter and flooding somewhat over the bank in summer. This provides the slightly higher temperatures which make the southwestern Grand Bank generally more suitable for haddock than for cod.

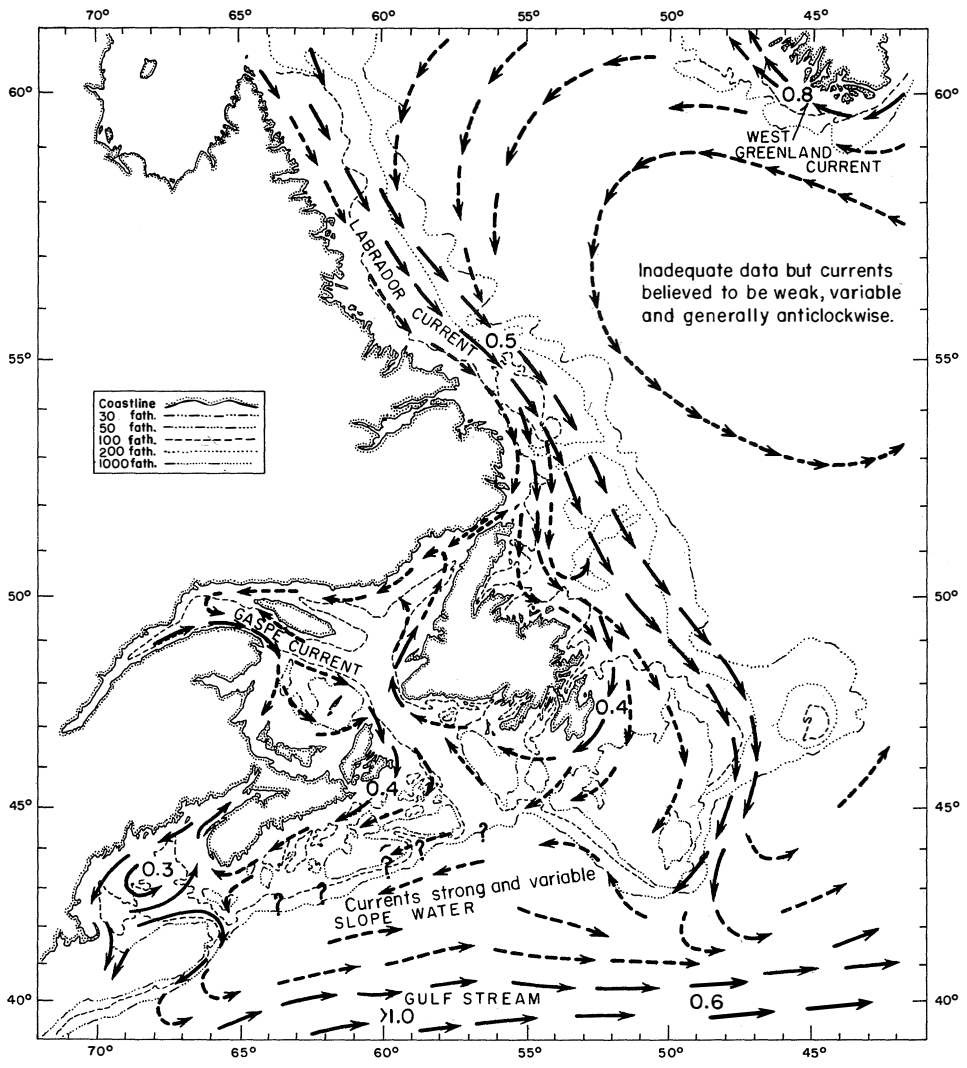


FIG. 9. Typical circulation of surface waters in the southern part of the ICNAF area during spring and summer. *Solid arrows:* current direction relatively persistent; *broken arrows:* current direction less persistent. *Numbers*: approximate speed of current in knots.

Sea Temperatures off the East Coast of Newfoundland and Labrador

The water of the Labrador Current (Fig. 9) flowing along the east coast of Newfoundland becomes so cold in winter that the temperature may be as low as −1 C (30 F) from the surface to 100 fath or deeper. The temperature of some of this water usually falls to −1.5 C (29 F) and occasionally lower. It may be as

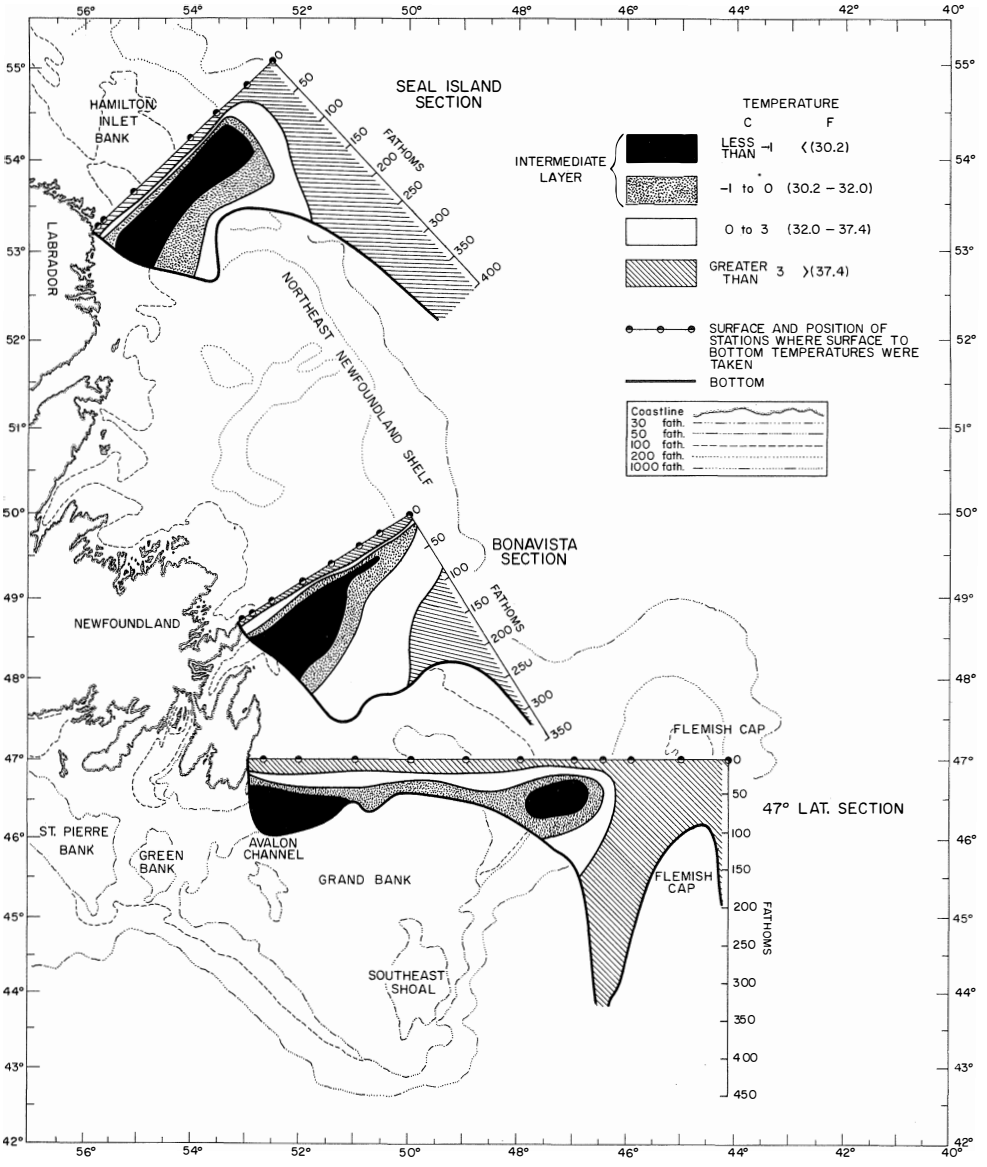


Fig. 10. Generalized temperature sections, surface to bottom, in summer off the east coast of Newfoundland and southern Labrador (from Templeman and Fleming, 1963b).

low as 0 C (32 F) at a depth of 120–150 fath or even deeper in some inshore areas. Below this cold layer lies the warmer and more highly saline layer of the offshore part of the Labrador Current with temperatures higher than 0 C (32 F).

When the sun begins to warm the water in spring it heats the surface water and makes it lighter. Hence, throughout the summer there are three layers of water along the Newfoundland coast: an upper warm, an intermediate cold, and a deep warm layer (Fig. 10). The two upper layers are from the colder, westward part of the Labrador Current and the deeper, warmer layer from the more offshore and warmer part derived from the West Greenland Current.

On the east coast this deep warm layer is found only where the water is deeper than 100–120 fath: from Baccalieu Island and Trinity Bay to Labrador. In the coastal area from south of Baccalieu to the channel between St. Pierre and Miquelon Islands and the Burin Peninsula, including the water around the Avalon Peninsula, the channels are too shallow–less than 100 fath–for this deep warm layer to be present. There are some holes deeper than 100 fath but these are filled with relatively cold water. In the areas where the three water layers are found the thickness of the cold layer differs by as much as 20 fath or more from one year to another.

For a review of the hydrography of Canadian Atlantic waters, see Hachey (1961).

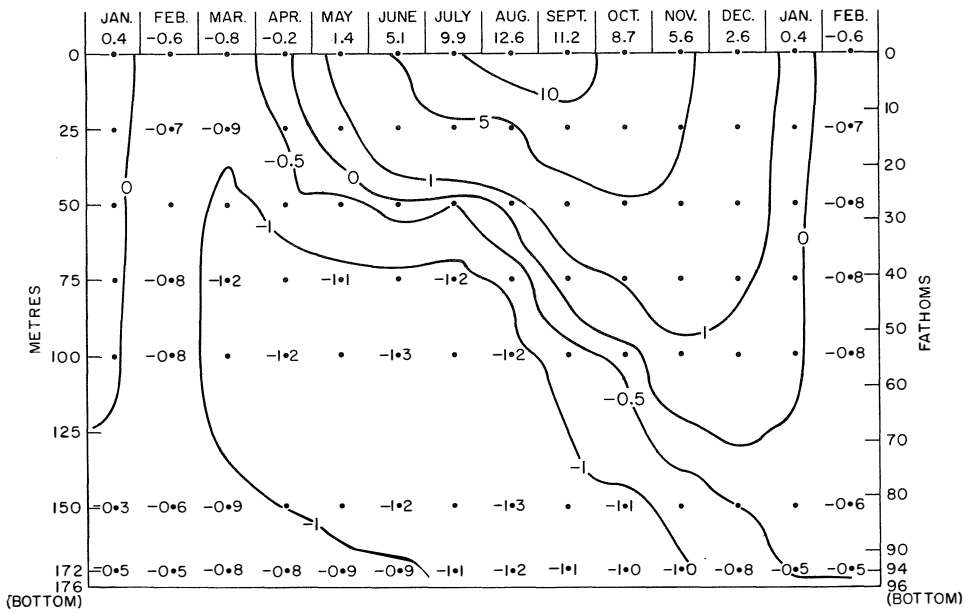


FIG. 11. Average monthly sea temperatures (degrees C) at various depths for 1950–62 at Hydrographic Station 27, two nautical miles off Cape Spear, near St. John's (From Templeman, 1965d, Fig. 1).

Off Cape Spear, near St. John's, where the depth is 96 fath, temperatures from top to bottom are taken monthly or oftener throughout the year at Hydrographic Station 27 (Fig. 11). This depth is not great enough to have warmer oceanic water (Fig. 10) underneath, and the average monthly bottom temperature throughout the year is below 0 C (32 F). The bottom temperatures at this depth are lowest between July and November and highest during the winter.

Hence, it is in winter and spring rather than in summer that cod are found in the deep water of this Avalon Channel area. In the upper layers of water, temperatures are below 0 C (32 F) and generally unsuitable for cod from late January to the end of March. From May to early August the temperature rises to 0 C (32 F) down to 20–30 fath, and temperatures of –1 C (30 F) and lower close underneath this level form a barrier to the downward movement of cod and other commercial fishes. From September onward, autumn storms and surface cooling mix the water; then temperatures of 0 C (32 F) and higher, suitable for cod, rapidly extend downward, reaching 70 fath by December. By the end of January and to mid April, the water from surface to bottom averages below 0 C (32 F).

Temperature Changes in the Sea

Temperature changes in the sea of only a degree or two can greatly affect the survival of fish year-classes. Such small changes can also affect the number of capelin spawning on the beaches and hence the availability of cod, especially to traps.

A study of sea and air temperatures in the St. John's area (Templeman, 1965 d) showed that average yearly air temperatures near St. John's and surface water temperatures at Station 27 near St. John's had similar trends in the 1950s. Air temperatures are available for a much longer period than sea temperatures. At Torbay–St. John's, the mean yearly air tempeartures rose in 1889 from below average earlier in the 1880s and fell slightly from 1890 to the 1920s. They have been above average since the 1930s and were highest in the early 1950s. The average annual sea temperatures fell slightly between 1950 and 1962.

Temperatures of the surface water at St. Andrews, New Brunswick, have been observed since 1922. Though fluctuating, they rose gradually on the average from the late 1920s to the early 1950s (Lauzier, 1958, 1965; Hachey, 1961) and fell slightly between the early 1950s and 1962.

Atlantic cod
Gadus morhua

Landings

Newfoundland and Labrador. The Newfoundland fishery for Atlantic cod (Fig. 12) is an ancient one. Even in the early years of the 19th century the

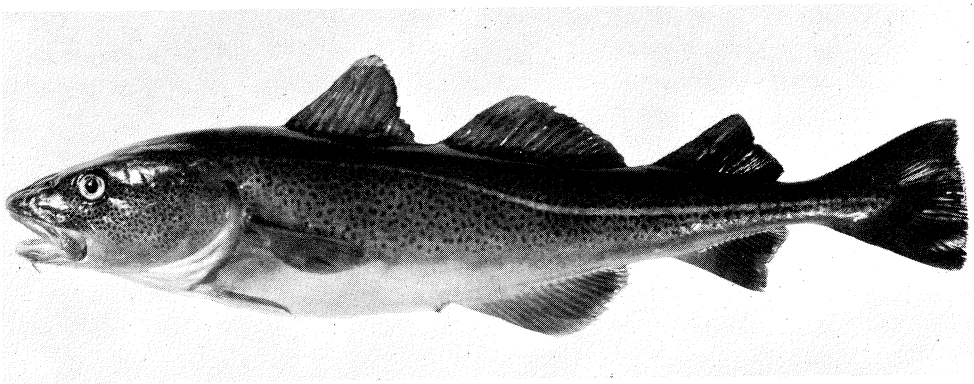


FIG. 12. The Atlantic cod.

landings were between 200 and 300 million lb (Fig. 13). Peak landings of 640–680 million lb were made in 1917–19, 1934–36, and 1945–47. Since 1947 the landings have declined and since 1952 have averaged about 470 million. The decline was due mainly to several factors: a smaller number of fishermen, decreased effort in the inshore fishery, a great reduction in the Labrador and bank fisheries, and in recent years a decline in the size and quantity of the inshore fish because of heavy offshore fishing, especially in winter and spring.

The landings, over 95% from the inshore fishery in recent years up to 1963 (90% in 1964), are taken mainly from June to September (86%) with

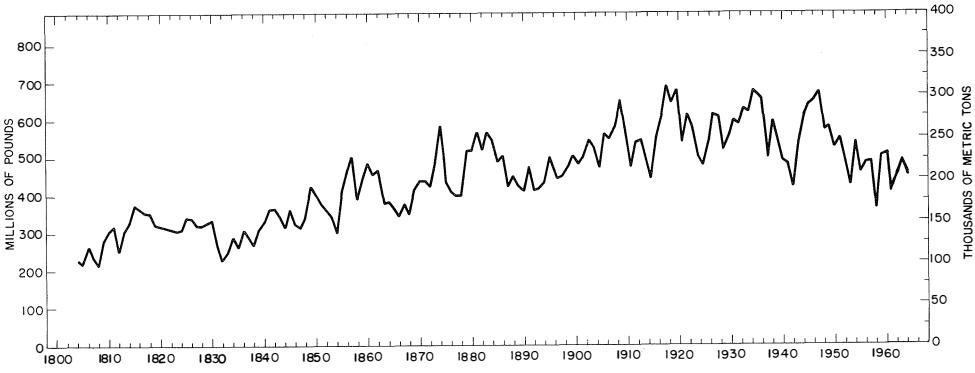


FIG. 13. Yearly landings of cod (round fresh weights) in Newfoundland (including Newfoundland Labrador), 1804–1964. (These estimates were taken from ICNAF statistical bulletins and suffer in accuracy especially up to 1926. The estimates for these years, derived from Sette (1928), are most likely too low. A metric ton equals 2204.6 lb.)

38% in July (Fig. 14). As percentages of the annual totals, the landings for the 12 months from January to December 1960–63 averaged as follows: 0.6, 1.0, 1.6, 1.7, 3.2, 20.8, 38.2, 18.3, 8.9, 4.2, 1.3, 0.3.

In the ICNAF area the greatest cod landings in recent years were from the Newfoundland region (Subarea 3, Fig. 6). The average annual ICNAF landings from this Subarea increased from 861 million lb in 1955–58 to 1046 million in 1961–64 (Fig. 15). Although the West Greenland region (Subarea 1) is next to Subarea 3 in importance for cod, the most notable increase has been off Labrador (Subarea 2).

Since 1960, European trawlers have carried out a great winter and spring fishery on the prespawning, spawning, and post-spawning concentrations of cod on the Southern Labrador Shelf, usually at depths of 125–200 fath. This fishery is mainly on the eastern and southeastern slopes of Hamilton Inlet Bank. Also, the autumn trawler fishery in this area (mainly Division 2J), which first produced large catches in 1952–53, has increased considerably in recent years. This fishery is closer to shore, and generally on or close to the southern and southwestern parts of Hamilton Inlet Bank. As a result, cod landings off Labrador increased from 4% of the total ICNAF landings in 1955–58 to 15% in 1959–61 and 18% in 1961–64. Tagging has shown that this deep-water winter–spring catch includes large numbers of cod which, after spending the winter in deep water, rise near the surface and move shoreward in late June and early July to provide the coastal fishery.

With this great development of the European offshore deep-water fishery, Newfoundland landings from the coastal fishery off Labrador (Subarea 2) declined from about 100% of the total in 1950 to 32% in 1955–58 and to 9% in 1961–64 (Fig. 15). The new offshore fishery affects the inshore fisheries of Labrador and northern Newfoundland by reducing both quantities and sizes of cod. The Newfoundland landings off Labrador, entirely from the inshore fishery, declined from 171 million lb in 1938 (and considerably greater landings in earlier years) to an average of 24 million per year in 1953–58 (Fig. 16). The decline was mainly due to decreased fishing resulting from low demand for Labrador salt cod and higher production costs. By 1962–63, landings increased to an average of 54 million lb per year; this increase was due to greater effort resulting from higher prices for salt cod and improvement of collection services. Landings fell again to 34 million lb in 1964 because of a scarcity of cod.

Meanwhile in 1952–53 Portugal, Spain, and France began catching significant quantities and several other countries small quantities of cod in Subarea 2; Spain had landed several million pounds and other countries smaller amounts in 1951. More recently Germany, the USSR, and other European countries began to fish cod in this subarea. As a result European landings from the Labrador Subarea soon greatly exceeded the Newfoundland landings.

The total landings from Subarea 2 reached a peak of 244 million lb in 1953, then fell rapidly because of lack of fishing and low availability of cod to the summer–autumn fishery. They increased abruptly to 415 million lb in 1960 and to 580 million lb in 1961 and declined to 469 million in 1964.

From the Newfoundland area (Subarea 3), most cod landings were made by Canada, mainly by the Newfoundland inshore fishery, from about 1935 until after World War II (Fig. 17). In 1947, Canadian landings from this subarea

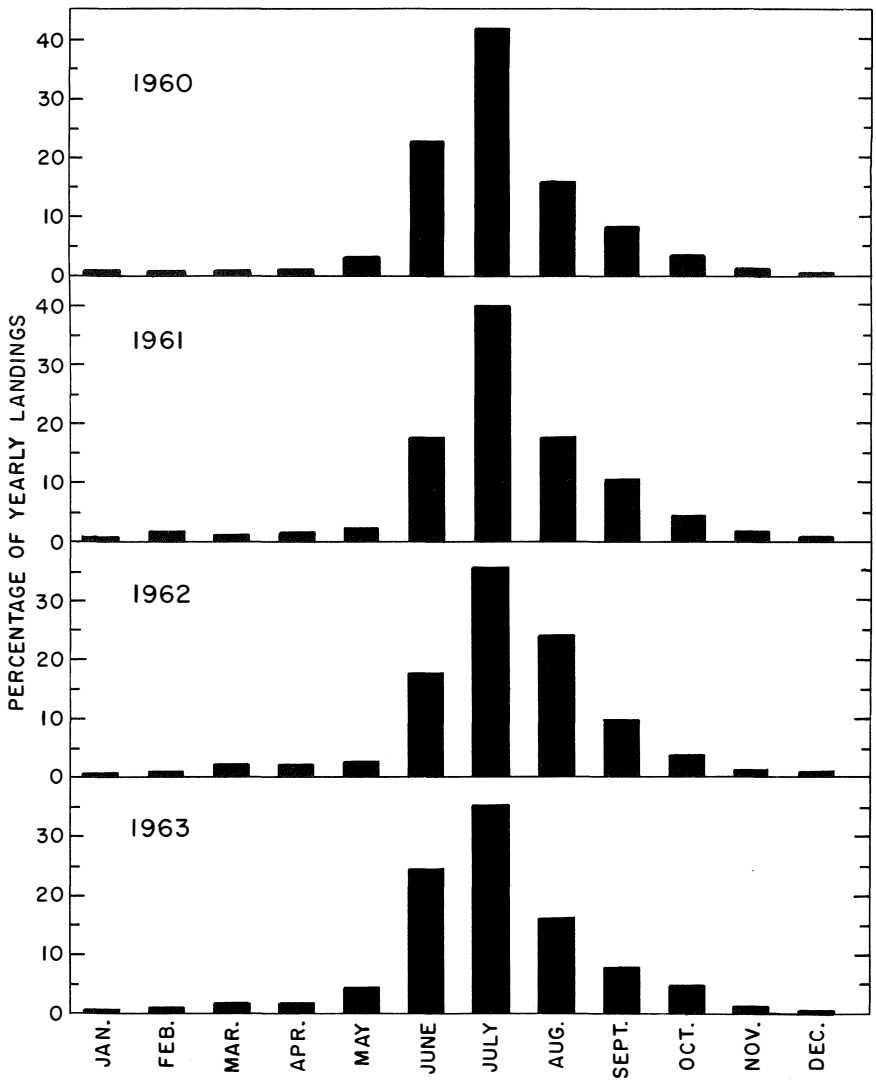


FIG. 14. Landings of cod in Newfoundland for each month as percentage of annual totals, 1960–63. (The totals for the years 1960–63 were 501, 403, 454, and 489 million lb of round cod, including less than 5% of offshore fish.)

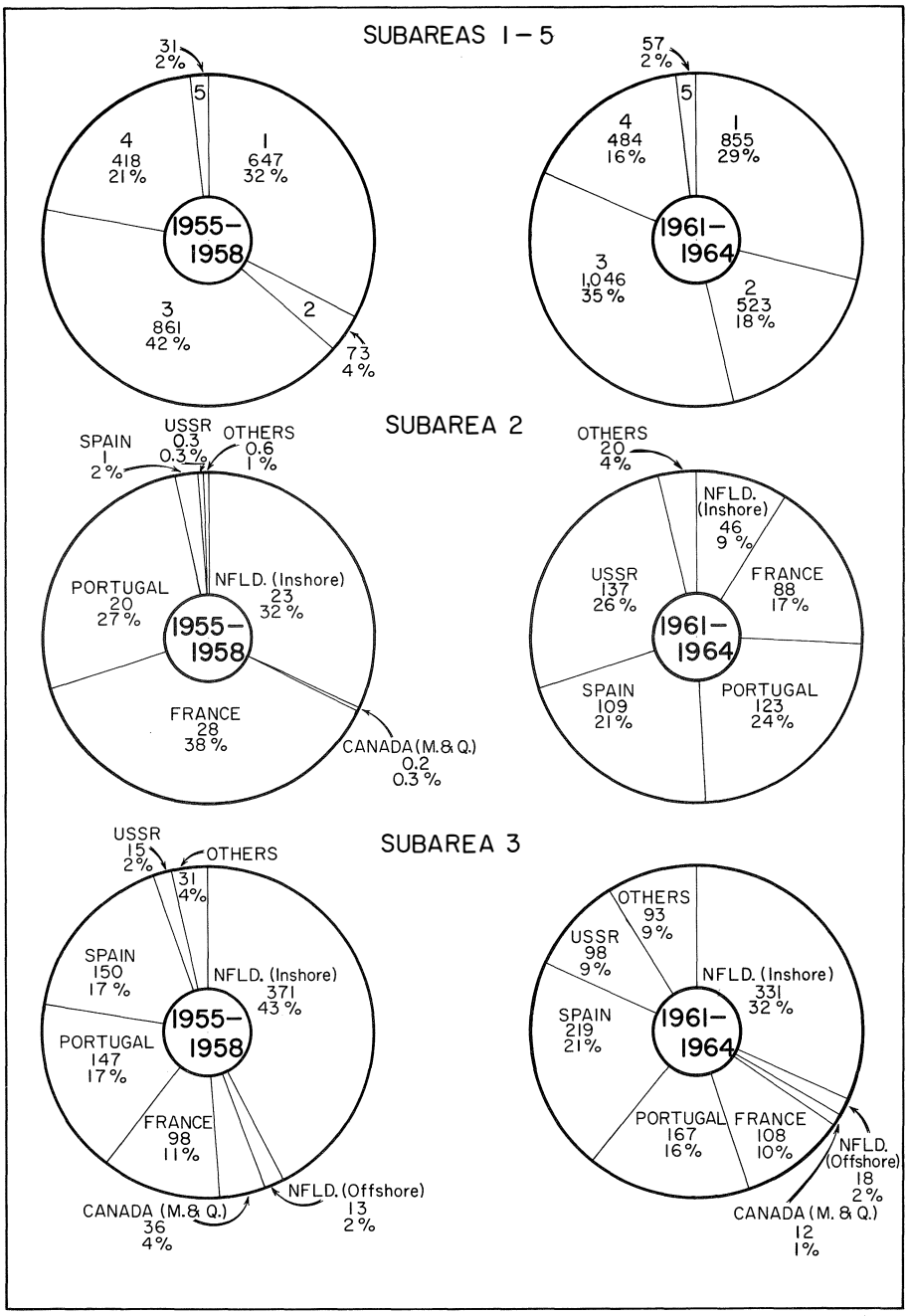


FIG. 15. Average yearly cod landings (round fresh weights in millions of pounds, and percentages of totals) from ICNAF Subareas 1–5 and landings from Subareas 2 and 3 by various countries and Newfoundland, 1955–58 and 1961–64.

were over 600 million lb. After the war the European salt-fish-producing countries, Portugal, Spain, and France, gradually increased their fleets; total landings increased and in 1961–64 annual landings of cod from the subarea averaged 1046 million lb. Meanwhile the Canadian annual landings decreased to 361 million lb. In 1955–58 Canadian landings were 49% of the total — 43% from the Newfoundland inshore fishery and 2% from the Newfoundland offshore fishery. But in 1961–64 Canadian landings were 35% — 32% from the Newfoundland inshore and 2% from the Newfoundland offshore fishery (Fig. 15). In 1964, total landings from this subarea rose to a new high of 1282 million lb of which total Canadian landings had fallen to 28.3% and the Newfoundland landings to 27.5%. In recent years other European countries have entered the fishery, and the gradually increasing spread between the European and Canadian landings seems destined to continue unless there is a very considerable increase in the Canadian offshore effort for cod.

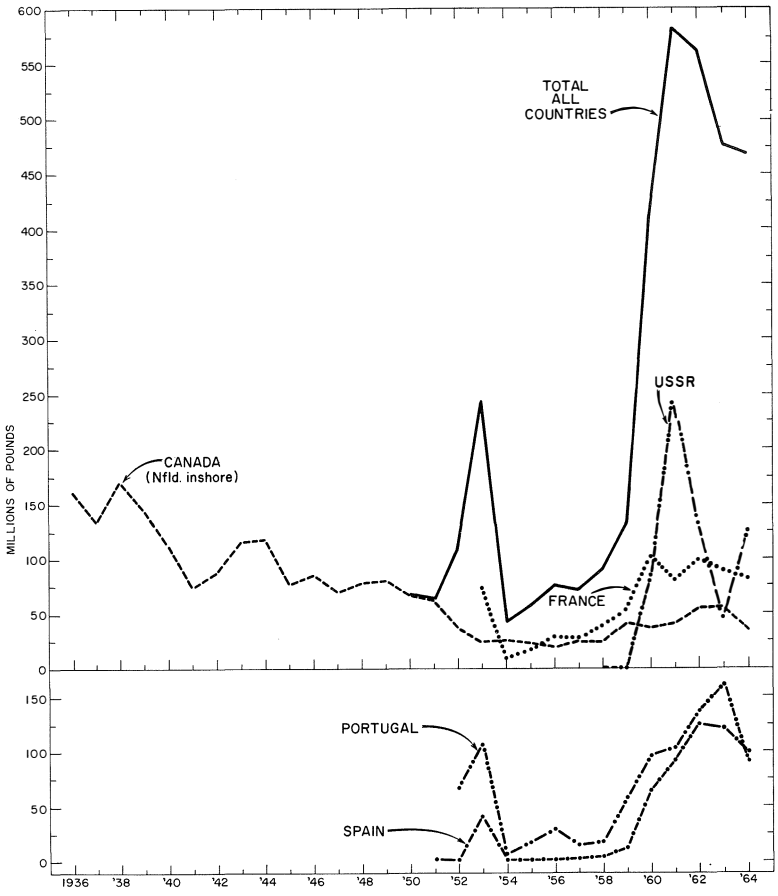


FIG. 16. Cod landings (round fresh weights) from Subarea 2 (Labrador subarea) by various countries, 1936–64.

Landings from divisions of the Newfoundland and Labrador subareas, 1955–58 and 1961–64. In Subarea 2, off Labrador, almost all the landings are from the southern Division 2J. The great increases, mainly by European countries, in the landings in recent years from 2J (Fig. 18) are similar to those already described for the whole of Subarea 2.

In the neighbouring Division 3K, (which includes the northeast coast of Newfoundland) there was also a large increase in the total landings from 1955–58 to 1961–64: from 175 million to 251 million lb (Fig. 18). But the amounts landed by Newfoundlanders from the inshore area declined from 127 million to 89 million lb and from 73 to 36%. The great increase in the catch by European trawlers in this division was due to the new deep-water trawling in summer during recent years.

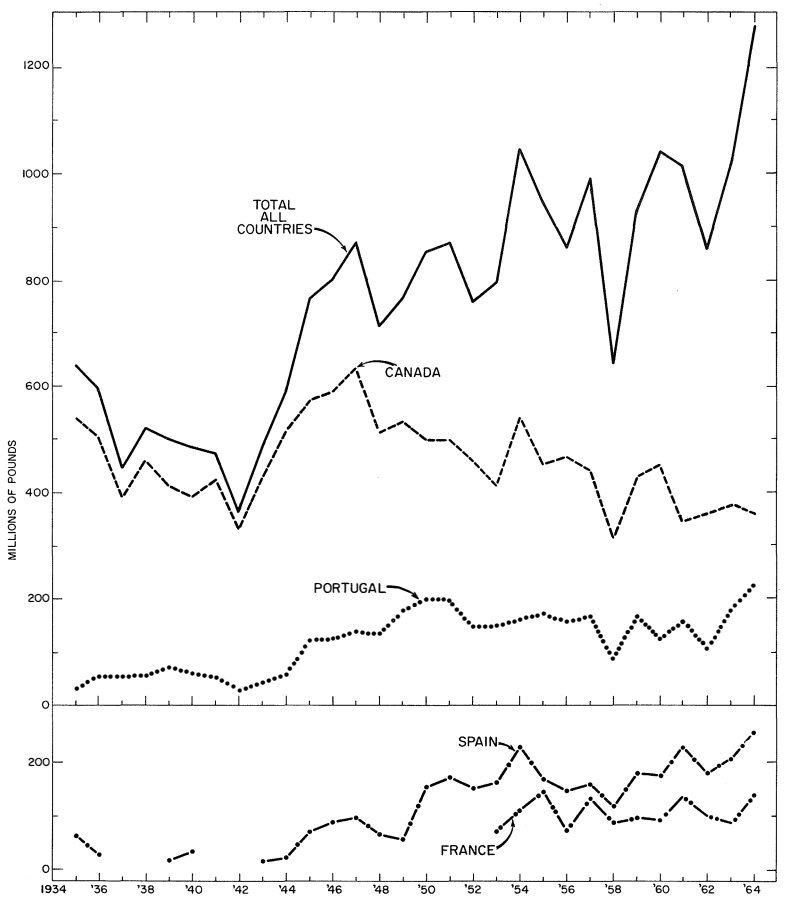


FIG. 17. Cod landings (round fresh weights) from Subarea 3 (Newfoundland subarea) by various countries, 1935–64. (Landings by France before 1953, not being available by subarea, are not shown or included in the total. St. Pierre and Miquelon landings are included with France.)

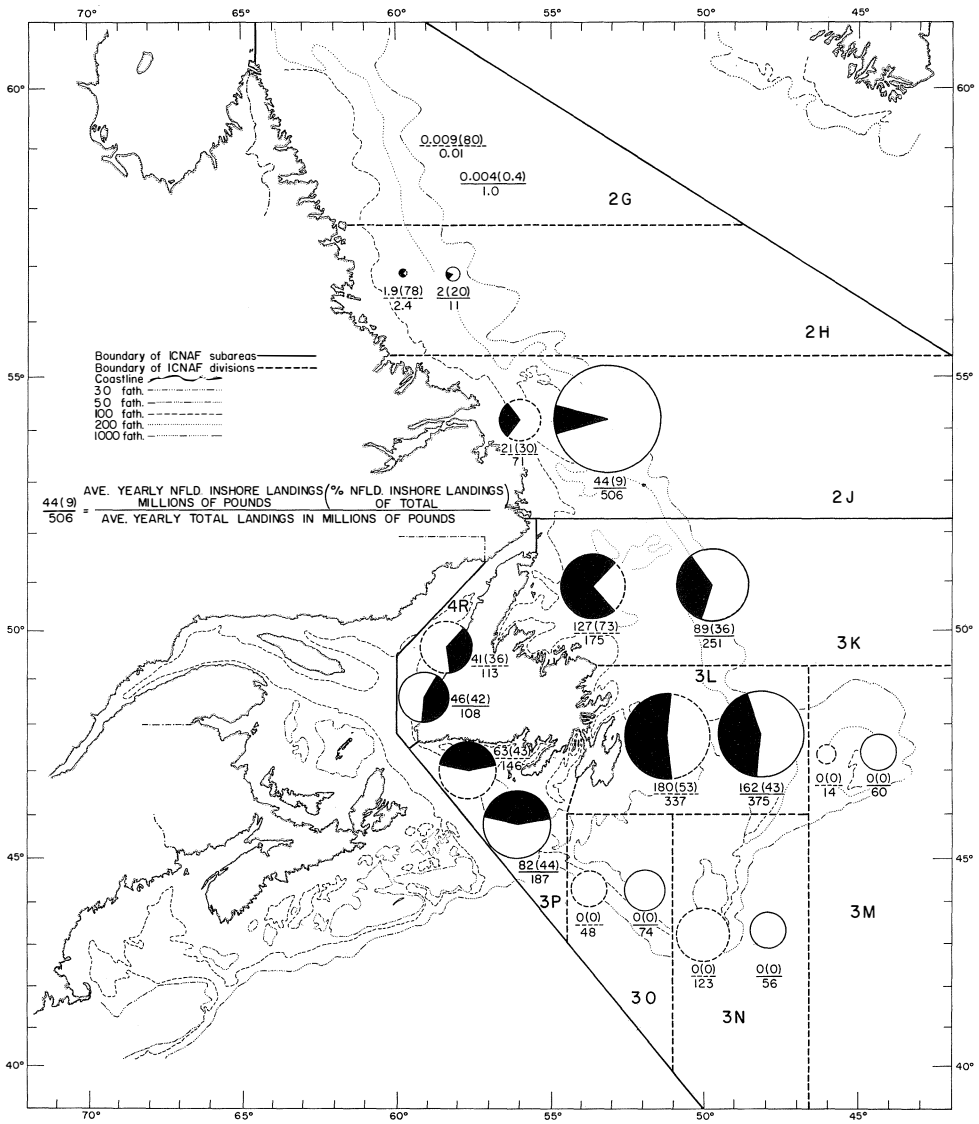


FIG. 18. Average yearly total landings of round fresh cod by all countries and by Newfoundland inshore fishermen from the divisions of Subareas 2 and 3 and from Division 4R, and the percentages that the Newfoundland landings from the inshore fishery were of the division totals, 1955–58 and 1961–64. The blackened areas represent the Newfoundland inshore landings; the white areas, landings by all other countries (including Newfoundland landings from the offshore fishery). Circles with any broken lines are for 1955–58; those with continuous lines, for 1961–64. The areas of the circles are in proportion to the landings. The Newfoundland share of landings from these offshore areas was negligible, for the period 1961–64 only 2.5% of the offshore landings from Subarea 3 and 0.0015% from Subarea 2.

In 3L, the next division to the south (including the southern half of the Newfoundland east coast) the total annual landings increased to 375 from 337 million lb from 1955–58 to 1961–64. But the Newfoundland inshore contribution to this total declined to 162 from 180 million lb per year and to 43 from 53% of the total.

In Division 3P (including most of the south coast of Newfoundland) in the same periods, the total landings increased to 187 from 146 million lb and Newfoundland landings increased slightly to 44 from 43% of the total.

In Division 4R (including the west coast of Newfoundland) in the same periods, Newfoundland landings increased to 46 million from 41 million lb and to 42 from 36%, although the total landings declined from 113 million to 108 million lb (Fig. 18). The decline was probably due to the diversion in 1961–64 of some European trawlers in spring from the Cabot Strait area and the southern part of the west coast area to the new deep-water fishery of 2J.

In the completely offshore bank areas, in Divisions 3M and 3O total landings by all countries increased from 1955–58 to 1961–64 but were still relatively small. They decreased greatly in Division 3N, probably mainly because of diversion of effort northward. In Divisions 3N and 3O, Newfoundlanders usually obtain cod only as an incidental part of their catch; in Division 3M they usually do no fishing.

Landings per Unit of Effort in Newfoundland Inshore Fishery, 1956–64

Only for 1956–64 is there moderately reliable information on the numbers of men and amounts of gear in the Newfoundland inshore fishery. Even for this period the kinds of gear used — trap, line trawl (longline hauled by hand from a small boat), longline, gill net, handline, and jigger — vary so much, both during a day's fishing and throughout the year, that statistics of landings and effort per gear are not available. The amounts of trap and line gear have increased a little faster and gill nets much faster than the numbers of fishermen. The increase in gill nets since 1961 is entirely due to the increasing use of the more effective nylon instead of cotton nets. To a great degree, nylon gill nets have been substituted for line trawls. In the absence of a better measure, landings per man (Fig. 19) were used as a rough measure of effort, although the amount of gear per man appears to have increased.

In Subarea 2, though total landings and the number of fishermen increased, the annual landings per fisherman declined from about 50 thousand to less than 40 thousand lb per man by 1963 and to below 20 thousand lb in 1964 (Fig. 19).

On the northeast coast (Division 3K) and on the southeast coast (3L), numbers of fishermen increased somewhat since 1956 but remained fairly stable in 3K in recent years. In 3K the total landings and the landings per man each declined, the variations being at about the same rates. In 3L, numbers of fishermen

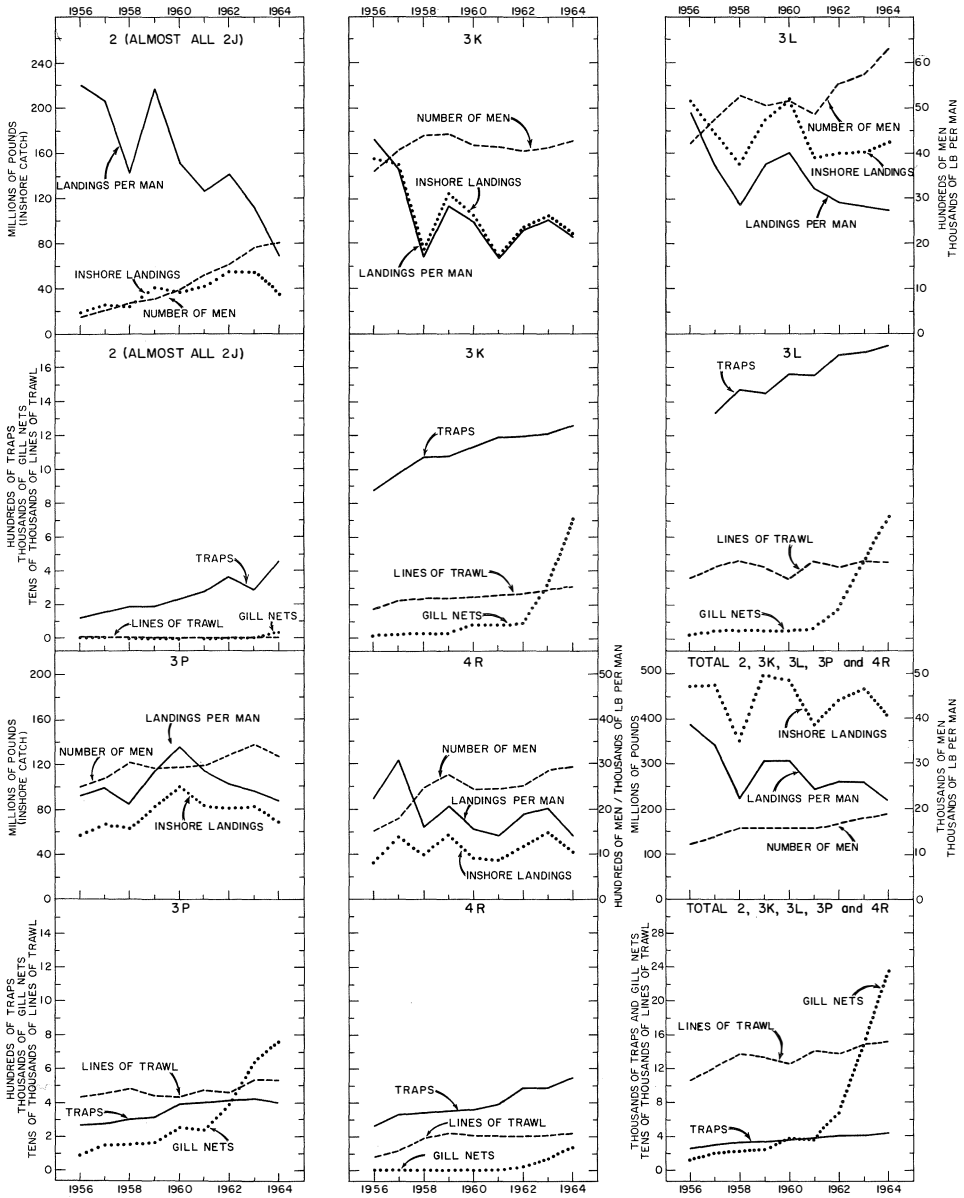


FIG. 19. Total landings of fresh round cod by Newfoundland inshore fishermen, numbers of fishermen, landings per fisherman, and numbers of traps, trawl lines (50 fathom longlines), and gill nets used by these fishermen in the divisions of the ICNAF areas adjacent to Newfoundland and Labrador (Fig. 6), 1956–64. (The data are for all boats under 25 tons and all longliners. The landings of Nova Scotian longliners in Newfoundland from 3P and 4R are included in the total landings, but their gear and men are not included nor are these landings included in catch per fisherman.)

increased in recent years and landings per man declined more rapidly than the total landings though the latter did not decrease as much as in 3K.

On the south coast (3P), the numbers of fishermen have risen slowly. Total landings and landings per man increased notably from 1958 to 1960 and have since declined to about the 1956 level. On the west coast (4R), landings fluctuated but showed no definite trend. The number of men increased notably, and the landings per man declined rapidly to 1961 and have since shown no definite trend.

In the total for all Newfoundland and Labrador divisions (Fig. 19), the number of fishermen increased by 53% and inshore fishing boats by 57%. The amounts of fishing gear increased considerably: traps by 69%, lines of trawl by 68%, and gill nets by 1819%. Although there were natural variations in the landings, there has been on the average no definite increase or decrease. In spite of more fishing gear per man, annual landings per fisherman declined from an average of 32 thousand lb in 1956–60 to 25 thousand in 1961–64. As a result of normal price increases and of the increases in fishermen, boats, and gear without corresponding increases in catch, the costs of obtaining the same amount of cod increased considerably.

Distribution of Landings in the Newfoundland and Labrador Inshore Fishery

Figures 20 and 21 show the distribution of landings of inshore cod in Newfoundland and Labrador for 1947–49 (Templeman, 1958c).

In Newfoundland the landings were taken mainly from the east coast (Fig. 20), chiefly in the headland and offshore island areas which continue seaward as extensive underwater shelves and shoals. Also cod were more common on eastern than on western sides of peninsulas. They favour cold water and, with prevailing west and southwest winds during summer, the warm surface water is blown offshore from the east coast, including the eastern sides of the great peninsulas. The warmer surface water blown offshore is replaced by colder water flowing shorewards along the bottom. This allows cod to approach close to shore, where they may be caught in quantity by traps and lines. On the east coast, also, the cold inshore portion of the Labrador Current (Fig. 9, 10) has an onshore tendency and is a continuing source of cold water. After passing Cape Race it turns westward to enter the southeast coast bays, but in normal years its onshore effect is not great beyond the Burin Peninsula. The most westerly large landings in 1947–49 were made in the Point Crewe to Lawn areas of the foot of the Burin Peninsula.

The west coast and the part of the south coast westward from Fortune Bay are affected little by the coldest water of the Labrador Current. This current is continually warming as it flows westward along the south coast, enters the Gulf of St. Lawrence at Cape Ray, flows northward along the west coast, and passes outward along the eastern side of the Strait of Belle Isle (Fig. 9). On the west

and south coasts, also, the prevailing west and southwest winds of summer blow the warm surface water onshore and force the underlying, colder water farther offshore. As a result the inshore water is usually too warm in summer along most of these coasts for cod to come into shallow areas and be easily caught in quantity with simple handline and trap gears.

In winter and early spring the current flowing into the Gulf of St. Lawrence and the northerly winds blowing offshore keep the western part of the south coast relatively ice-free. At this time there are large quantities of cod off this coast, mainly at 60–120 fath. Some are resident cod but most have migrated out

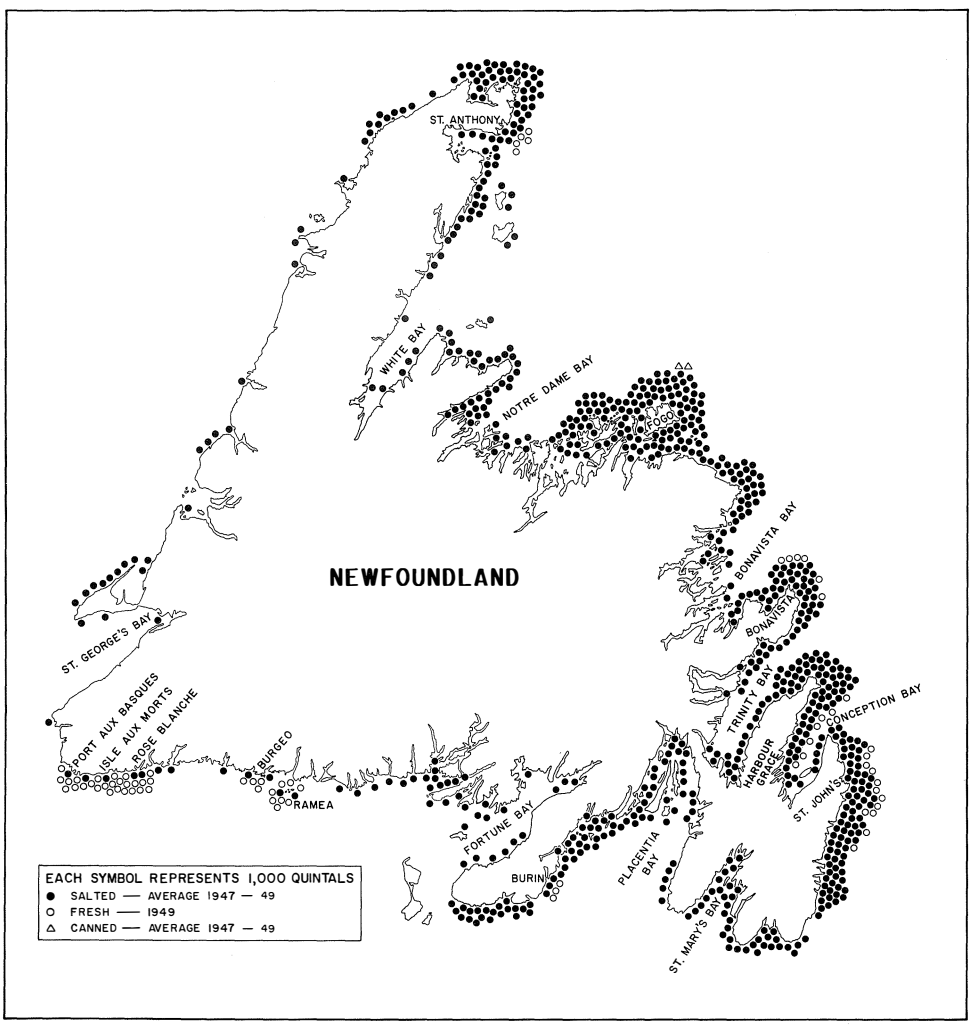


FIG. 20. Locations of capture (average yearly landings) of inshore cod in Newfoundland. 1947–49. (After Templeman, 1958c. 1000 quintals, mainly lightly salted, dried cod, equal about 500,000 lb of round fresh cod.)

of the Gulf of St. Lawrence with the approach of winter (Templeman and Fleming, 1962). These fish give an excellent deep-water winter fishery in this area until after April, when they return along the west coast of Newfoundland into the Gulf of St. Lawrence. Widely ranging boats such as longliners can follow the cod concentrations some distance into the Gulf. In May, large numbers of these cod rise to near the surface and may approach shore chasing herring and capelin in St. George's Bay and as far north as the southern entrance to the Strait of Belle Isle on both the Labrador and Newfoundland sides. Our tagging has shown that many cod tagged off the west coast of Newfoundland, the southern

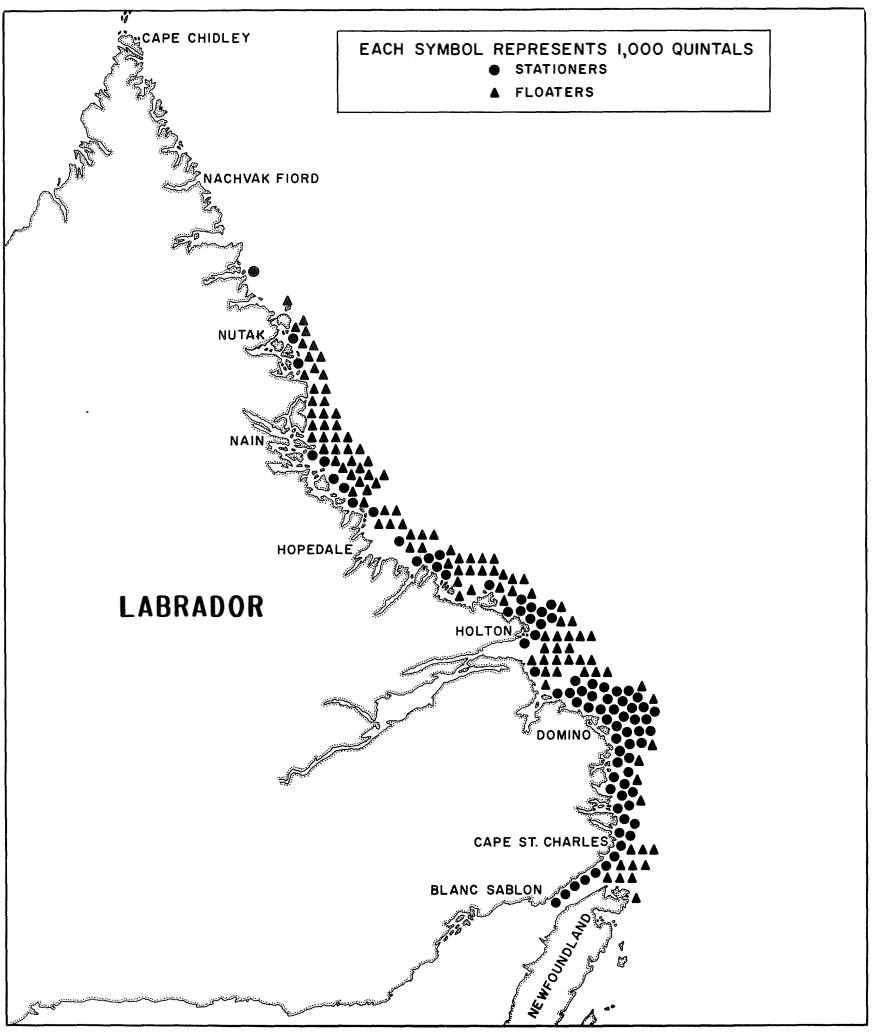


FIG. 21. Locations of capture of inshore cod in Labrador by stationers (shore-based fishermen) and floaters (schooner-based fishermen), 1949. (After Templeman, 1958c. 1000 quintals, all heavily salted, dried cod, equal about 420,000 lb of round fresh cod.)

part of the Strait of Belle Isle, and the north shore of the Gulf of St. Lawrence in summer and autumn are caught in the winter fishery off the coasts of south-western Newfoundland. Most of the significant landings shown in Fig. 20 in the area from Rose Blanche to Port-aux-Basques and in the Burgeo–Ramea area were taken in the winter and early-spring fishery.

In Labrador in 1949 (Fig. 21), fishing was well distributed from Nutak in the north to the Strait of Belle Isle in the south. The stationers' catches tended to be toward the south whereas the floaters with their schooners tended to move farther north to largely unoccupied grounds and, in some years, better fishing. Some floaters fished also at the entrance to the Strait of Belle Isle. The cod catches for 1949 were chosen to show the possibilities, since this was the most recent year in which an intensive fishery was carried out in this area.

Shallow- and Deep-Water Cod

Longlining experiments in the Bonavista area (Templeman and Fleming, 1956) showed that cod on the northeast coast of Newfoundland spend the winter in the warm, deep water (Fig. 10) below the intermediate, cold layer and that up to May all the cod of commercial size may be found in deep water. In June, large numbers of these cod, especially of the smaller sizes, rise toward the surface and move toward shore in the warmer surface layer which, heated by the sun, is forming above the intermediate layer. Cod follow the capelin toward shore and, if the upper layer of warm water is thin enough, may follow them right to the beaches in the latter third of June. Most of these cod have spawned in March to early June so that the onshore movement is mainly of spent and immature cod.

Meanwhile many cod, especially those 10–20 years old, remain all summer in deep water below the cold layer. Here they may be fished successfully throughout the summer and autumn by longline, gill net, or otter trawl at depths usually between 120 and 160 fath.

Longlining experiments on the possibility of a fishery for these deep-water cod were carried out by the Biological Station, St. John's, on behalf of the Industrial Development Service, Department of Fisheries of Canada, between 1950 and 1955. Professional longline crews and longline boats from Nova Scotia (Fig. 22) were used for both experimental fishing and commercial trials (Templeman and Fleming, 1963b).

Successful deep-water longlining catches were obtained along much of the outer fringe of the Newfoundland eastern coastal shelf at more than 100 and usually between 120 and 160 fath from the northern Grand Bank area off Baccalieu Island to southern Labrador (Fig. 23). Between this warm, deep water and the warm upper layer which also forms the inshore shallow water, there is an intermediate, cold layer (Fig. 10). This cold layer decreases in thickness as the

summer and autumn advance. Longlining in this layer, in which the water is often —1.0 to —1.5 C (30 to 29 F), is not successful.

Cod which follow the capelin toward the beaches live in the upper, warm layer (usually less than 10—15 fath deep in June) lying above the intermediate, cold layer. (Where the coastal water is less than 100 fath deep, the cold layer extends to the bottom.) These cod are, at first, almost entirely pelagic feeders, swimming off the bottom and feeding on capelin. Becoming glutted with capelin they sink toward the bottom to digest them, and then they are not readily caught by baited hooks but may move enough to be caught by traps or gill nets (Templeman, 1965b).

With heat from the sun and mixing movements due to wind and wave, the thickness of the warm, surface layer increases and that of the cold, intermediate layer decreases. The very shallow water soon becomes too warm for cod and with the decrease of fog and increasing sunlight in July it also becomes too bright for commercial-sized cod during the day.

At first, capelin spawn on the beaches; later, as the surface layer of warm water thickens, they move out and spawn at increasing depths to at least 20 fath (Templeman 1948a). The amounts of time they spend spawning at different depths depend mainly on temperature and possibly light conditions. As cod

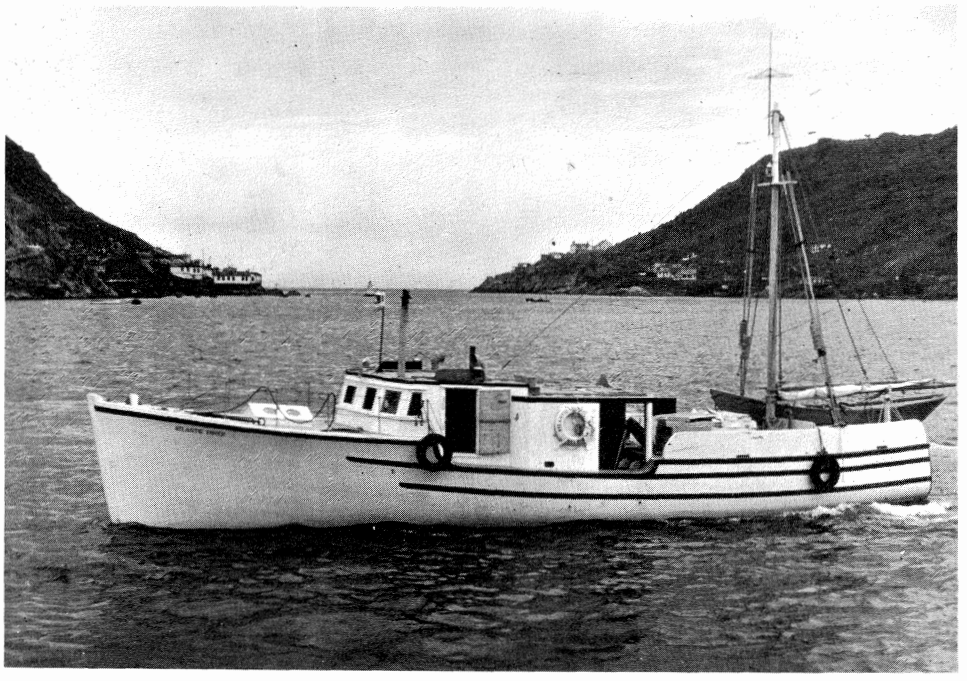


Fig. 22. The *Atlantic Rover*, a 54-ft Nova Scotian longliner used in longlining experiments in Newfoundland.

follow the capelin, this affects the depth at which cod are available in the inshore area.

Thus, in June and early July, in years when the warm surface layer is thin, cod are caught in shallow traps and in shallow areas by handline. By late July and early August they usually lie deeper and are caught by the deeper traps and to an increasing extent by line trawls. In many areas there is enough fishing ground for longliners to operate also, often at about 20–40 fath.

After the spent capelin disappear seaward, shallow-water cod which have not followed the capelin offshore usually become largely dependent on bottom food (Templeman, 1965b). Meanwhile the upper, warmer layer is continually thickening; and as the intermediate, cold layer retreats, cod descend into new bottom-feeding areas from which they were previously barred by the cold water. Whereas in late June and early July inshore cod may be restricted to a narrow inshore area and thus may be in very dense schools, by September–November they have extended their range downward and are dispersed in depths of about 20–70 fath. By early winter the coldest part of the intermediate layer has disappeared or become very thin. Then the upper layer cools again, so that by March all of the upper 100-fath layer is below 0 C (32 F). By this time the shallow-water cod have mainly retreated either to the lower part of the cold layer, where temperatures are not as low as in the shallower water, or to the warmer water below 100–140 fath, depending on the locality. On the western part of the south coast of Newfoundland, low temperatures do not extend so deep as on the east coast and winter fishing may be carried out at 60–90 fath, though large quantities of cod lie below 100 fath.

At Bonavista in 1950–53 (Fig. 24), trap cod were smallest, followed by, in increasing order of size, cod taken by handline, inshore line trawl, and longline in deep water about 20 miles offshore. Trap cod are caught in shallow water close to the coast, where small cod are numerous. The handlines fish shallow water but on the average farther offshore than the traps, and the large hooks used select somewhat larger cod. The inshore line trawls and the longlines fish still deeper and farther from the coast. Here cod are larger; also, though the hooks are small, the cod must catch themselves and this tends to select the larger fish.

European and Newfoundland Competition for Inshore Cod

Experiments in the Bonavista area illustrate the competition between European and Newfoundland fishermen for inshore cod. Our longlining experiments there began in 1950 and excellent deep-water fishing grounds were found at 120–160 fath, about 20 miles offshore (Templeman and Fleming, 1956). The first extensive local commercial longlining in this area began after these explo-

rations. In the early days of this fishery, from 1952 to 1955, longline fishing was excellent. The landings averaged about 100 lb of large, head-on, gutted cod per 50-fath line of gear (50 hooks).

In 1956 a few large European trawlers began fishing in this deep-water area. In 1957 and 1958 there was considerable increase in fishing effort by

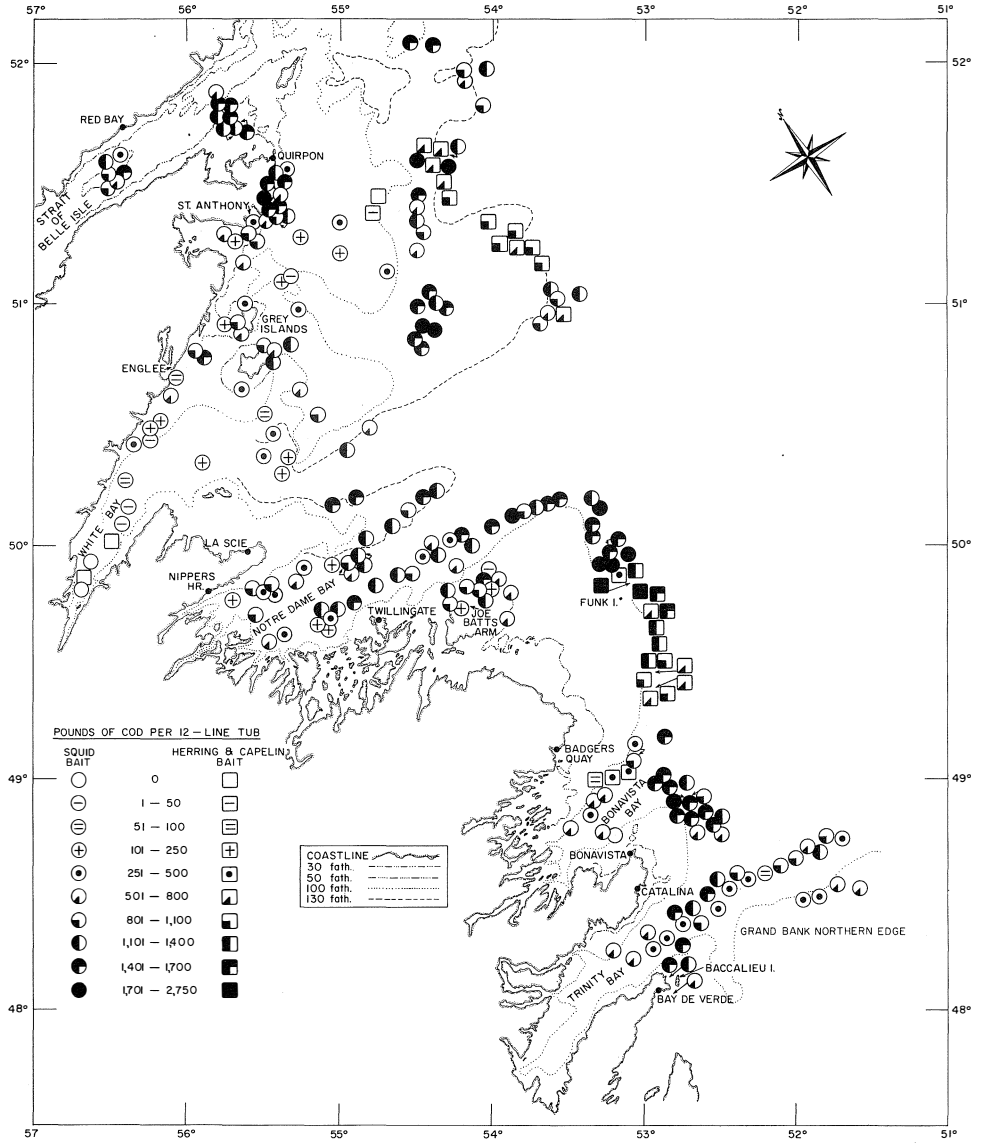


FIG. 23. Cod catches in longlining experiments on the northeast coast of Newfoundland, May—November, 1952—53. Pounds of head-on, gutted cod caught per 12 lines of 50 fath each, total 600 hooks (from Templeman and Fleming, 1963b).

foreign trawlers and a fleet of large Norwegian and Faroese longliners. As a result, the average catch of deep-water cod per line by Newfoundland longliners off Bonavista in the early 1960s fell to two-fifths of that in the earlier years. The average size of cod in the catch has decreased by 2 inches and the gutted weight by about a pound (Fleming, 1965).

Before June all the cod of the area, including those found inshore in summer, are available in the deep water. Thus, the reduction in the offshore population also affected the inshore fishery, and the catch per trap in the inshore area has gradually fallen to one-third of what it was in 1954.

With the decrease in abundance of offshore cod, European fishing in the area declined. But passing trawlers still make enough trials that, when the stock increases, European trawlers concentrate in the area soon afterwards. Then trawler fishing continues until the stock is again reduced.

Local Population of Cod

The total catch of cod in the Bonavista area increased little in 1959, even though the catches in the neighbouring Fogo area to the north and Baccalieu

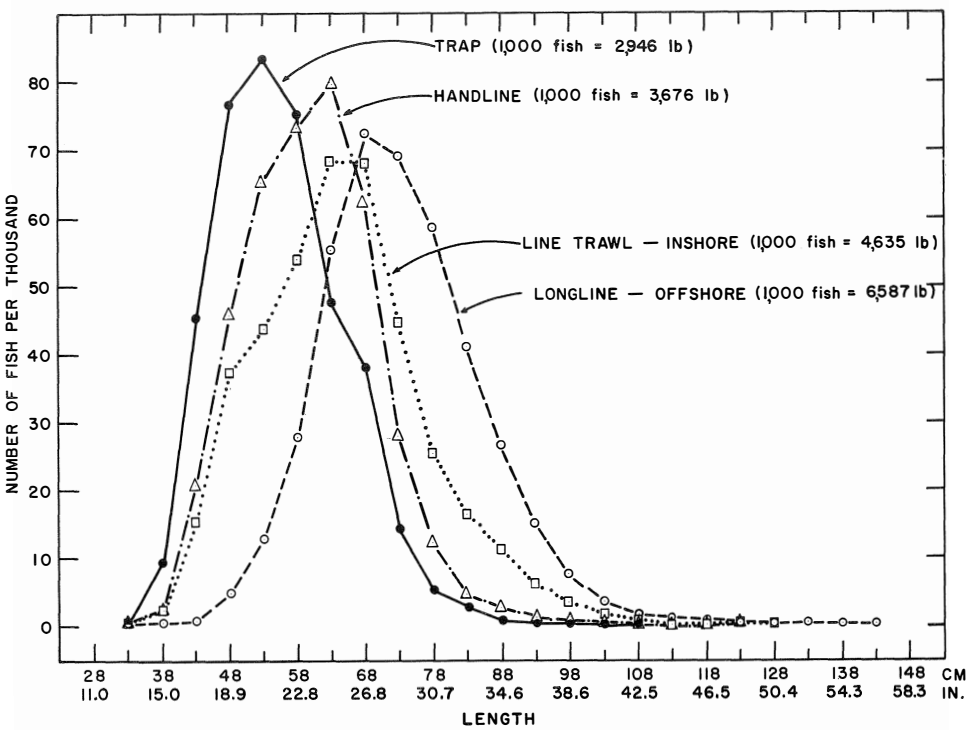


Fig. 24. Relative numbers of cod of various lengths (snout to tip of tail in midline) taken by trap, handline, inshore line trawl (longline hauled by hand), and offshore deep-water longline in experiments at Bonavista, 1950—53. (From Templeman and Fleming, 1956, Fig. 14. The weights per thousand shown are of gutted and gilled fish.)

Island area to the south increased considerably. Also, our cod tagging has indicated that, though cod move considerably, many of the tagged fish are found within 20–30 miles of the tagging area in the years after tagging. These facts lead us to believe that each large underwater coastal shelf with deep-water slopes and deep-water divisions from other shelves extending down to 100–130 fath or more has its own cod population. Examples of such shelves are those off Baccalieu, Bonavista, Fogo, La Scie, and St. Anthony to the Grey Islands (Fig. 7, 23).

These populations can be increased significantly by immigration and decreased by emigration, and they may spawn in deep water far away from the shelf. But on the average each population is related to an individual shelf and the deeper water adjacent to it. It is fairly evident from the Bonavista experience that one of the populations can be depleted more than another and that, in severe cases, movement between the large, semi-isolated coastal shelves is not rapid enough to balance the populations.

The extent to which present knowledge allows us to separate the cod of the Northwest Atlantic into different stocks is discussed by Templeman (1962), and the distinctness of groundfish stocks of this area, generally, by Templeman (1955).

Yearly Success of the Inshore Cod Fishery

Apart from the necessity of having enough men, boats, gear, and bait, two major factors determine the success of the fishery at any particular time: the size of the cod stock and its availability to fishermen. Trawlers and longliners can search widely. But the inshore handline fisherman is restricted to fishing shallow inshore water and shoals, and the trap fisherman is even more closely restricted for long periods to a particular fishing berth and must wait for the cod to come to him.

Much of the inshore catch is taken by traps (Fig. 25) and the availability of cod to the traps is of major importance in the success of the fishery. For a history of the origin and a description of the operation of the Newfoundland cod trap see Ronayne (1956), and for a diagram of the trap as it is set in the water see Anon. (1956). Black (1960) described the operation of cod traps in the inshore waters of Labrador.

Successful handlining also depends on the availability of large quantities of cod of suitably large size in shallow water. The large-meshed nylon gill net, which was recently introduced, catches cod of a large average size and competes with traps, handlines, and especially longlines. These gill nets can be used in deep as well as in shallow water.

Fishing with these gill nets involves a hazard noted in the Icelandic fishery, where they have been used for many years. If they are lost they may continue to

fish for a long time (so-called ghost fishing). The net fills with fish and sinks to the bottom; the first rot and the net rises; and the process is repeated over and over for a number of years until the floats become disengaged or the net is

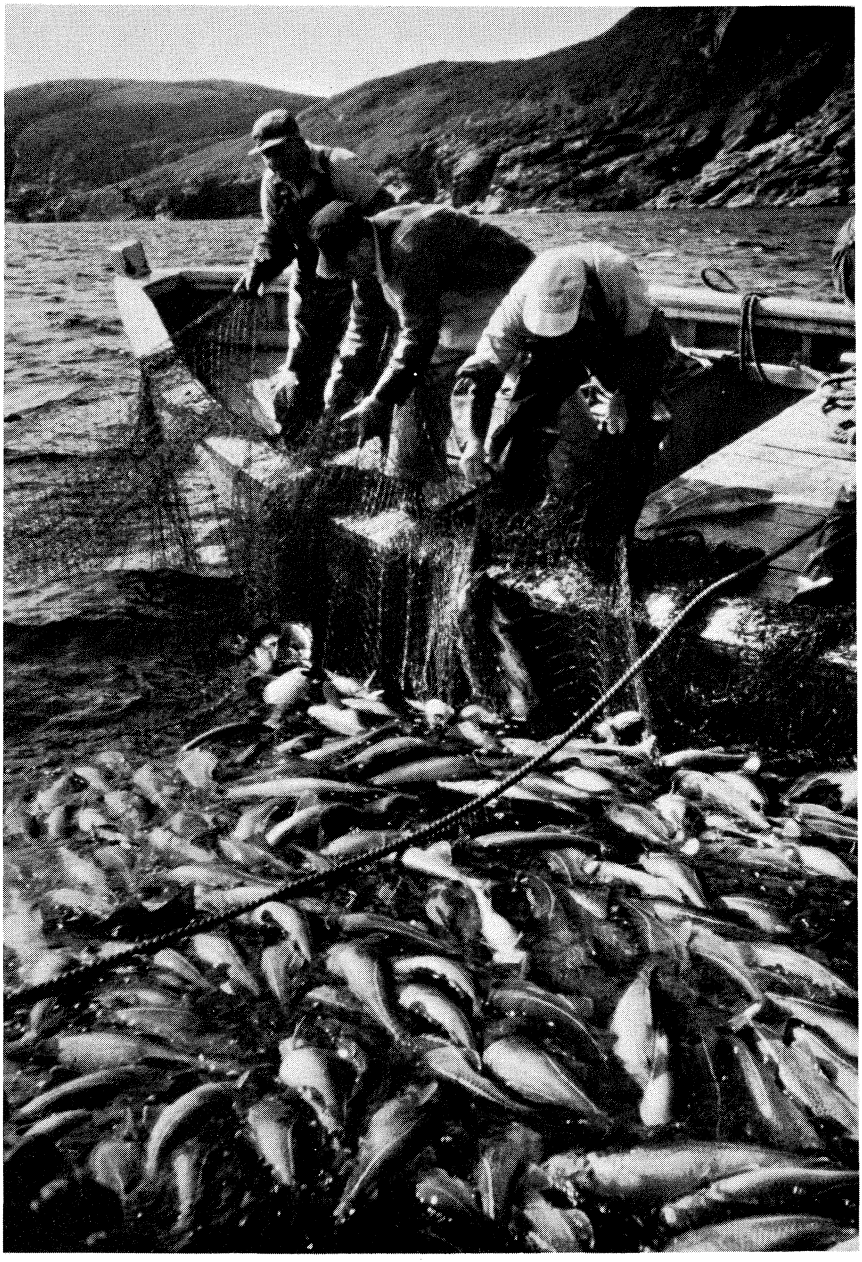


FIG. 25. A catch of cod being "dried up" in the final stage of hauling a cod trap off Bonavista.

destroyed. To reduce the danger, the floats should not be attached with nylon or other synthetic twine and where feasible every attempt should be made to retrieve lost nets.

Effects of hydrographic conditions on east coast. Figures 10, 11, 26, and 27 show some of the hydrographic conditions which may occur and how they affect the trap and handline fisheries on the east coast of Newfoundland. Every year by February or March the temperature of all the inshore water to a depth of 100 fath or more is likely to be about −1.0 to −1.5 C (30–29 F), that is, 2–3 F degrees below the freezing point of fresh water.

As the surface water warms in May and June, in some years there is very little onshore wind and thus there are no large waves to mix the warmer surface layer with the cold layer underneath (Fig. 26, A, 27, A). The warm layer near the surface, therefore, remains thin and the cod following the capelin in this layer come very near shore since there is only a small bottom area near shore with suitable water temperatures. If July continues without much onshore wind (Fig. 26, B) the upper layer thickens somewhat by mixing with the cold water underneath due to tidal and current movements. The upper layer, through its increasing temperature and additions of fresh water, now becomes increasingly lighter than the colder and more saline water underneath, and it takes a stronger onshore wind and sea to mix them.

Under these conditions cod may remain in shallow water close to shore and be available to traps and handlines throughout July and early August and in certain areas even later. A cold winter with considerable ice and a late spring is most likely to provide, in early summer, a thin warm surface layer with colder water, at about −1.0 to −1.5 C (30–29 F), underneath. This favours the approach of cod to shore when they pursue the spawning capelin shoreward in the surface layer in late June. In a cold year with slow warming, trap and handline fisheries begin later but usually last longer than in a warm year, when the shallow water warms more quickly.

In some years a storm of onshore wind and sea in June or early July mixes the warm surface layer with the cold water underneath to produce a water layer with temperatures suitable for cod to a depth of 20–30 fath. Without the storm at this time ice-cold water would be present at 10 fath or less. In other years, after warm winters and early springs, a relatively thick surface layer of warm water may develop by the latter part of June aided by only moderate onshore winds (Fig. 26C).

At capelin-spawning time, if cod are able to live and feed anywhere from the shore to 30 fath or deeper, they have a much greater bottom area to occupy than in years when the warm layer is only 5–10 fath thick. Therefore cod, especially the larger ones, do not approach as close to the shore and are thus less available to traps and handlines. Their period of availability in shallow water is also shortened; they are not concentrated in any one place for they can spread out over a much greater area of bottom. Then the deeper-water gears (the

deep-water trap, line trawl, longline, and gill net) are necessary to catch the cod of the inshore area even in July and early August. By August the upper warm layer is usually becoming thick enough that cod are not usually available

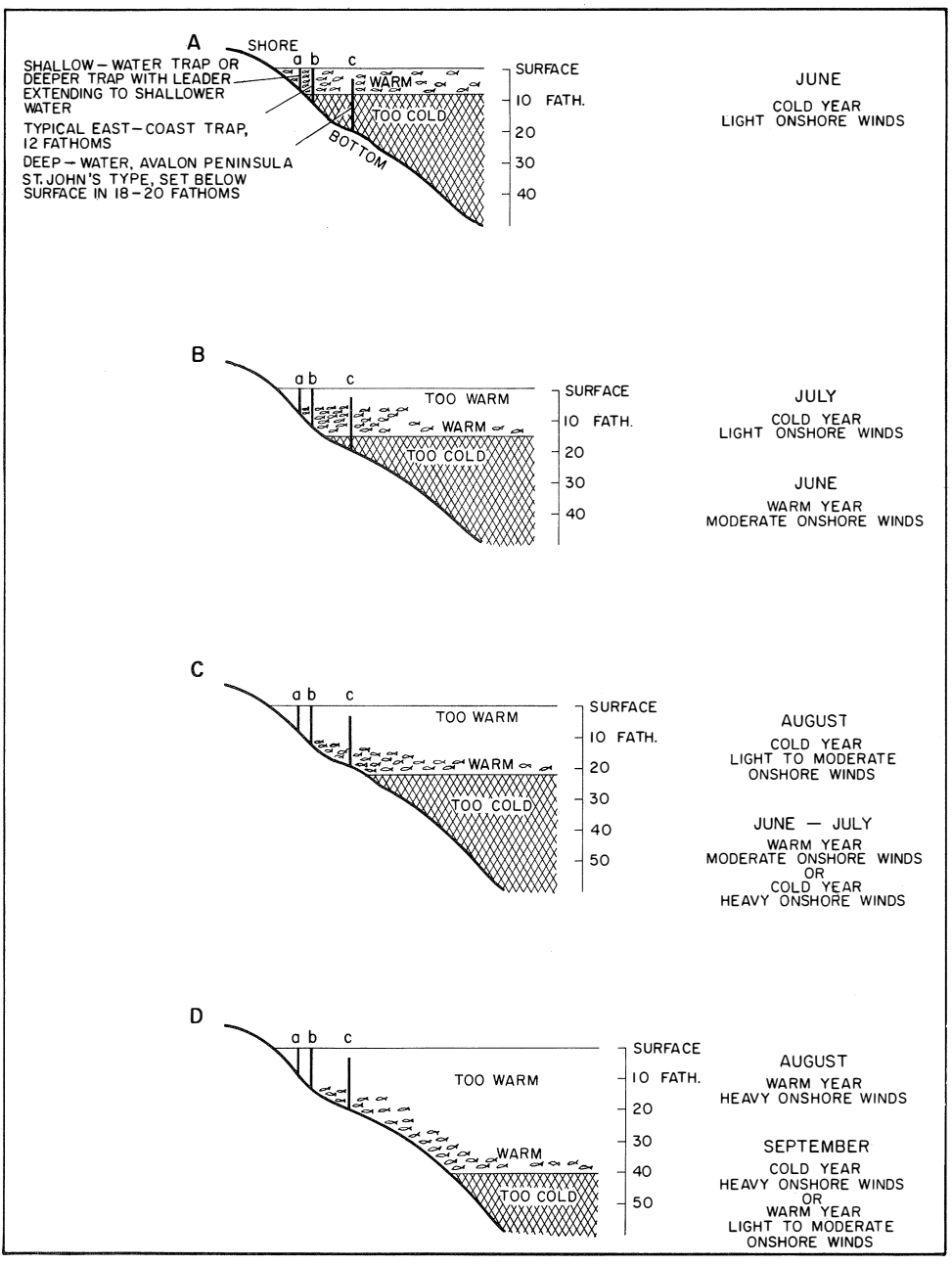


FIG. 26. Variations in temperature conditions in various months on the east coast of Newfoundland, and their effects on water layers and on availability of cod to the trap fishery.

in quantity to any but the deepest traps. Again the thickness of this layer will vary with the atmospheric temperature and wind conditions (Fig. 26, C and D).

In individual localities on the east coast, however, movements of inshore cod are not always as simple as described above. Many variations can occur and new elements change the situation.

A strong offshore wind can blow the light, warm surface water offshore and the heavier, colder bottom water moves shoreward to replace it. This may be unfavourable to the trap fishery if it is at the beginning of the fishery, when only a thin warm surface layer is suitable for cod and the deeper cold water is too cold (Fig. 27, A). Most of the cod may move off with the warm water (Fig. 27, C).

An offshore wind may be favourable if it occurs late in July or in early August (Fig. 27, B) when the surface or shallow water is too warm and most cod have descended beyond the trap depths. Then the mixed water from the bottom part of the warm layer, moving in as a replacement, has a temperature suitable for cod, and the cod may move shoreward in it (Fig. 27, D).

These conditions due to offshore wind are not stable. When the offshore wind decreases or ceases, the warm, unmixed surface layer flows shoreward, the cooler water underneath flows seaward, the layers are stable again, and the fish are likely to return to their original locations. Such conditions are highly local because an offshore wind on one side of a bay or cove may be an onshore wind on the opposite shore.

Onshore winds have opposite effects, bringing cod shoreward to the trap locations when the suitably warm water layer is very thin and not too warm (Fig. 27, E), and carrying them seaward away from the traps when too much warm surface water is piled up near shore (Fig. 27, F). If the onshore winds are light the water layers remain distinct and resume their former positions when the onshore wind ceases. Strong onshore winds, however, produce waves and mixing of the water layers; hence, after such a storm some of the cod usually lie deeper than before, since suitably warm water extends to a lower level.

Effects of other factors. Other factors than temperature also influence the fisheries inshore. One of the most important of these is light. Small cod can endure and be present in both higher and lower temperatures, and in brighter light, than large cod. The amount of light penetration depends not only on the brilliance of the sunlight and the presence or absence of fog but also on the transparency of the sea. This transparency in the inshore area is affected not only by the amount of floating microscopic plant and animal life, or plankton, but also by the amount of silt brought down by the rivers and the amount of stirring up of the inshore mud particles by the sea.

In 1961 the fishery on the east coast of Newfoundland was unusually affected by bright sunshine. After a cold winter and a late spring with abundant

ice a warm surface layer formed, little mixed by onshore winds. But the sunlight throughout the summer was unusually brilliant, and there was no fog even in the usually foggy periods in late June. The weather was unusually warm; there was no rain and no strong onshore winds. The shallow water not only warmed quickly, but due to the lack of rain and wind the inshore water became unusually clear so that the bottom could be seen much deeper than usual. Under these conditions, though cod of commercial size could move shoreward at night; they retreated to deep water during the daytime to escape the bright light and so tended to pass out of the range of the traps. As a result, trap fishing was unsuccessful in many areas. The capelin, also, after a brief stay at the beaches apparently found suitable temperatures and light for spawning in water at least

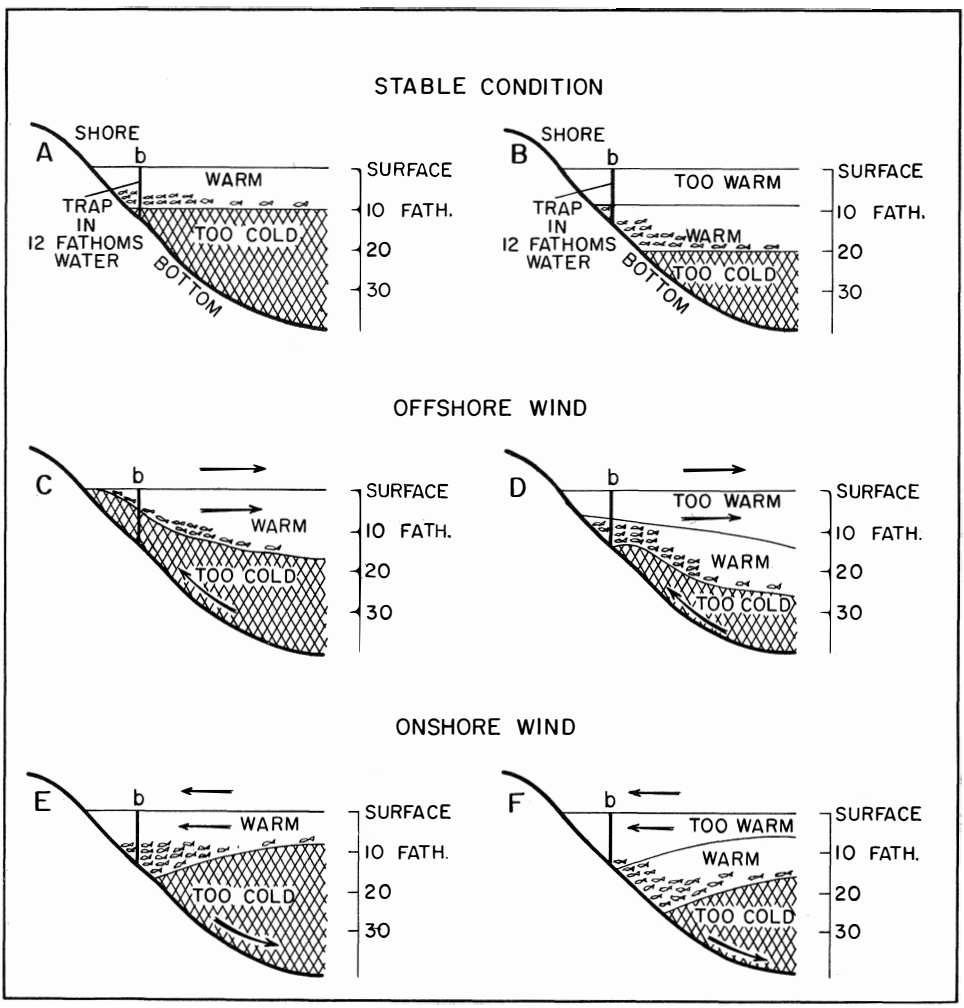


FIG. 27. Effects of offshore and onshore winds on water layers and water temperatures on the east coast of Newfoundland, and on availability of cod to the trap fishery.

20 fath deep. Here capelin were so numerous that cod feeding on them did not readily take bait.

There may have been another unfavourable factor in the 1961 situation, but it is difficult to estimate its importance. Mr. A. M. Fleming, Biological Station, St. John's, in his inshore cod studies in that year found many more cod than usual which had not spawned before moving to the shallow inshore water. Spawning was evidently delayed by cold water on the cod wintering grounds. Cod, like other groundfish, feed much more heavily after than before spawning. Therefore, for schools of cod passing into the shallow inshore area to be as great as possible, they must complete spawning in time to pursue and feed on the capelin schools in the surface layer as they move toward the beaches. A considerable delay in spawning may mean that an appreciable number of cod fail to make contact with the shoreward-moving schools of capelin. Also, the kinds and amounts of food available are of the highest importance in the concentration and retention of large quantities of cod in an area.

The standing stock of inshore cod of commercial size on the east coast of Newfoundland has been greatly reduced, and will presumably be still further reduced, by the combination of offshore winter and spring fishing on the spawning schools and intensive inshore fishery in summer. Possibly, too, a higher percentage of this reduced stock than previously will find enough food in the deep water after their April–June spawning, often 100 miles or more from the coast, and may not need to move to the coast for feeding. Also, as capelin become more plentiful or relatively more plentiful with the decrease of the predatory cod, the cod while inshore will become glutted with capelin more quickly and for a longer period. Then they will not take bait readily until late July or early August, when the spent capelin move offshore. Further, if cod fill their stomachs with capelin quickly enough they may remain quietly close to or resting on the bottom for much of the day and may not swim enough to be caught readily by either traps or gill nets.

There were some indications that the above situation existed on parts of the east coast in June and July 1964. Cod were often reported to be seen in great numbers but were not being caught in quantity by line or other gears. In this situation only gears used in pursuit, such as seines or trawls, either bottom or midwater, would be effective.

Cod Growth

The rate of growth of cod in the Newfoundland area varies greatly (Fleming, 1960; May et al., 1965). There is a gradual increase in growth rate from north to south. The fastest-growing cod are those of the southern Grand Bank. The slowest-growing are those off Labrador, and cod off northern Labrador are slower-growing than those off southern Labrador. The early growth does not vary greatly

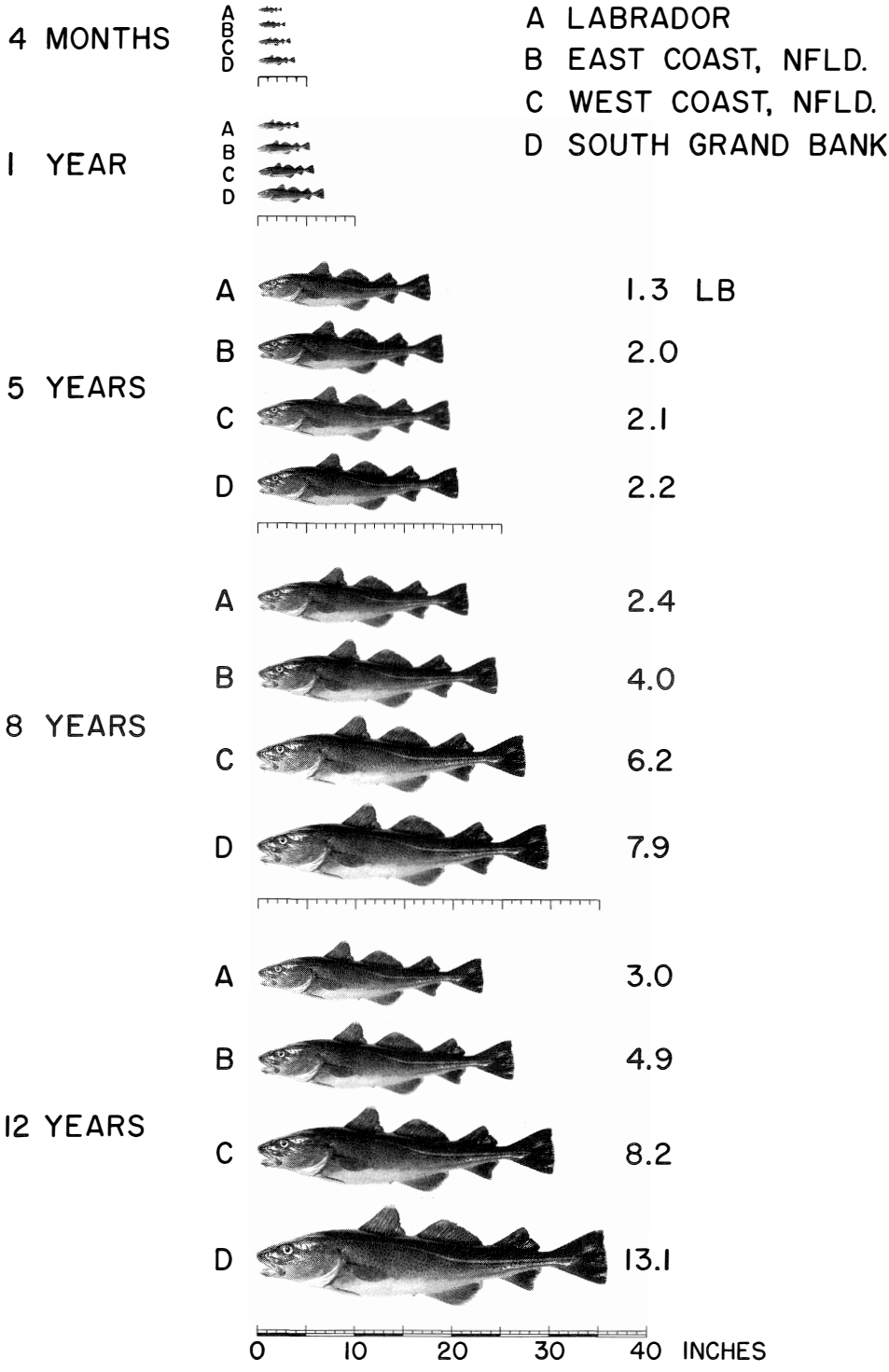


FIG. 28. Lengths and weights of cod (gutted, head on) of the same ages from various Newfoundland and Labrador areas.

from area to area: a 5-year-old gutted, head-on cod weighs 1.3 lb in Labrador and 2.2 lb on the southern Grand Bank. By 8 years of age the difference is much greater and by 12 years of age the weights are: Labrador, 3 lb; east coast of Newfoundland, 5 lb; west coast, 8 lb; and the southern Grand Bank, 13 lb (Fig. 28).

Survival of Year-Classes

Fish hatched in a particular year are called a year-class. Cod eggs are fertilized in the water shortly after being laid; in captivity, pairing of individual males and females has been observed during the spawning act (Templeman, 1958a; Brawn, 1961). The fertilized eggs float in the surface layers (Fig. 29) until hatching in several weeks, depending on temperature. The young cod pursue a pelagic or midwater life for several months after hatching. Then they gradually sink deeper, until when 2 or 3 inches long they begin to spend considerable time near the bottom.

Young cod can settle and survive over a wide part of the Newfoundland area, and the shoreward movement of the Labrador Current deposits, great quantities of them at the settling stage, presumably in August–September, near shore in the great bays of the east and southeast coasts. There are some years with unusually high survival. Such good year-classes may be 4 or 5 years apart and may be seen, often in great numbers, as 1- and 2-year-olds in harbours and near shore.

The young cod from these successful year-classes are caught first at about 4 years of age in the trap fishery and soon afterwards in the handline fishery. A year or two later they become important in the inshore line-trawl fishery. In 4 or 5 years after their entrance into the fishery, they begin to pass out of the shallow-water, inshore fishery and appear in appreciable numbers in the deep-water, longline fishery. From 1958 to 1961 cod of 4–6 years of age comprised on the average about 80% of the trap catches at St. John's and 94% at Burin. Hence, success or failure in year-class survival soon makes its presence felt in the inshore fishery. The appearance of a great year-class of small cod ensures a good stock of fish of increasing size for a number of years afterwards, though their availability in the inshore region chiefly determines the numbers landed in Newfoundland.

The Future

Of all the groundfishes in the Northwest Atlantic, cod are best able to stand an intensive fishery. Conditions are suitable for the larvae, young cod, and adults over a great area. Also, cod move a good deal both horizontally and vertically and are not constantly available to any of the commoner types of gear. They are the most abundant fish of the area and by their feeding largely control the numbers of other fishes. In the Labrador and Newfoundland areas (Subareas 2 and 3), their total mortality in recent years due to fishing and natural mortality is probably about 50–60% per year.

Fishing pressures on cod of the area are likely to become greater. The USSR and the eastern European nations are fishing more for cod, especially on the great prespawning concentrations in winter and spring. Higher prices for fresh cod, the increasing population of Newfoundland, and greater efficiency of gear in the Newfoundland inshore fishery may lead to an intensifying of this fishery. The European fleets, as in recent year, will fish as close as possible to the coast with otter trawls and longlines. Cod will be smaller, the reduced number of large cod remaining will have more natural food, and line fishing with baith will become more uneconomic though traps, otter trawls, and similar gears may still catch large quantities of small fish.

The autumn fishery has traditionally been a line-trawl fishery depending to a considerable degree on cod larger than those commonly caught by traps and handlines. The recent increasing use of large-meshed nylon gill nets, which catch large cod throughout the fishing season, may significantly hasten the reduction in numbers of large cod and hence make the autumn fishery relatively unprofitable.

Newfoundland otter trawlers, as supplies of haddock remain low, must fish the great winter and spring concentrations of cod in deep water in Cabot Strait, the Halibut Channel, and the Avalon Channel, and on the northern

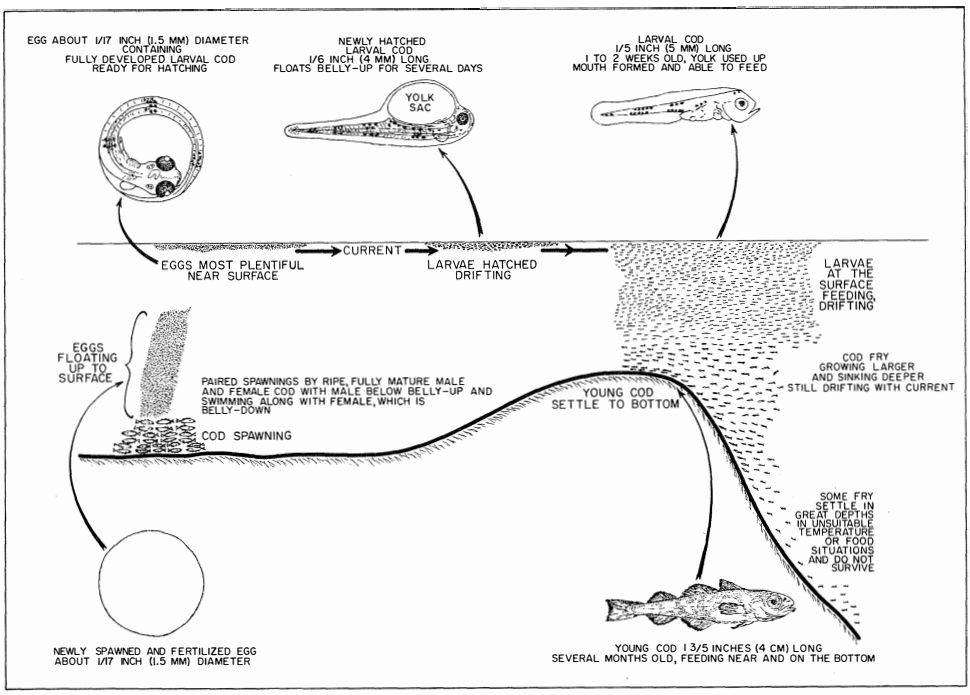


FIG. 29. Cod spawning, larval development, and settling of young near bottom. (Larval and young cod are after Bigelow and Schroeder, 1953.)

slope of the Grand Bank, Flemish Cap, the Northeast Newfoundland Shelf, the eastern slope of Hamilton Inlet Bank, and elsewhere. For summer and autumn fishing the trawlers will need to follow the European pattern of fishing in the northern part of Subarea 3, the southern part of Subarea 2, and, for larger freezer-trawlers, the West Greenland area.

More Information

For more information on cod of the Newfoundland area, see: Thompson (1943) for general biology; Fleming (1960), May et al. (1965), and papers by many authors in the various ICNAF Annual Proceedings for growth; Thompson (1943) and Templeman and Fleming (1962) for migration; Templeman et al. (1957) and Templeman and Fleming (1963a) for parasites; Templeman (1962) for divisions in stocks; Templeman and May (1965) for depth and temperature relations and locations of capture in the Hamilton Inlet Bank area off southern Labrador; Hodder (1965a) and May (1964) for effects of fishing on the stocks off eastern Newfoundland and Labrador and information on the new offshore fishery in these areas; Templeman (1965b) for food in relation to cod concentrations; Templeman (1965a) and Templeman and Fleming (1965) for reactions to low temperatures; Templeman and Fleming (1956 and 1963b) for longlining experiments; Fleming (1965) for trends in the commercial longline fishery at Bonavista; Sette (1928) and the various ICNAF statistical publications for statistics of catches; Black (1960) for the Labrador floater fishery; Prowse (1896) for the historical picture; Innis (1940) for the economic story of the cod fisheries of the Atlantic Provinces; Wise (1961) for a synopsis of biological data on cod; and Wise (1963) for a bibliography of the cod and related fishes. For information on the distribution of cod catches by commercial vessels in the Gulf of St. Lawrence, 1960–62, see Moussette et al. (1965); and for seasonal distribution of cod of the Gulf of St. Lawrence and the Scotian Shelf in relation to temperature see Jean (1964).

Haddock

Melanogrammus aeglefinus

Distribution and Landings

Large quantities of haddock (Fig. 30) were first reported on the southern Grand Bank, and smaller quantities on St. Pierre Bank, as a result of the Newfoundland Fishery Research Laboratory's explorations with the *Cape Agulhas* in 1931–35 (Thompson, 1939). Supposedly small populations were known on these banks previously (Needler, 1931).

A great increase in the Newfoundland haddock population may well have occurred with the above-average temperatures which have prevailed since the early 1920s. But, as there was no research on this species in the Newfoundland area before 1931 and no considerable fishery for it before 1945–46, the quantities in the area before 1931 are unknown. Since 1946 the Biological Station, St.

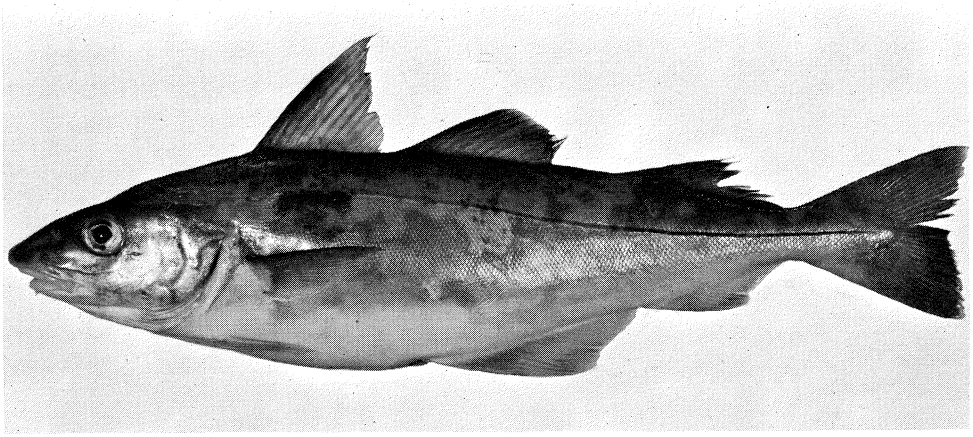


FIG. 30. The haddock.

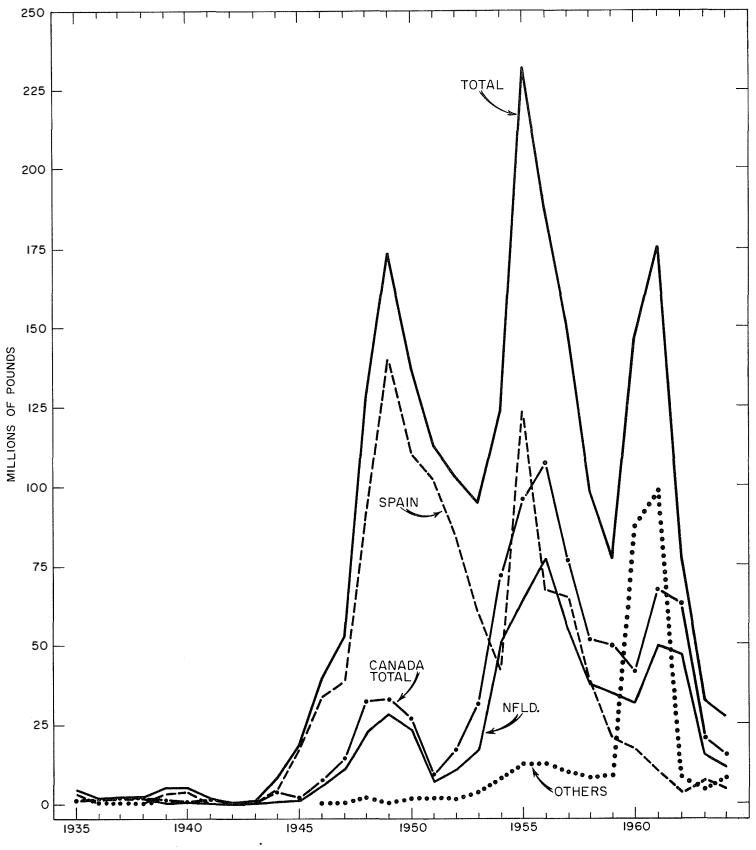


FIG. 31. Haddock landings (round fresh weights) by various countries and Newfoundland from Subarea 3 (Fig. 6), 1935–64.

John's, has carried out yearly surveys of abundance of this species and is usually able to predict increased or decreased populations and the approximate size of the fish several years before they enter the fishery.

The fishery in the Newfoundland region (Fig. 31) remained very small until Spain in 1945 and Canada in 1946 began catching many of these fish with otter trawls. Minor landings were previously made incidental to the cod fishery, and a Canadian fishery on St. Pierre Bank averaged over 4 million lb of haddock in 1938–40. (The statistics for St. Pierre Bank in 1938–40, collected by McKenzie (1946a), are mainly not included in the ICNAF statistics and are not included in Fig. 31.)

The first peak in the catch, in 1949, was at 173 million lb. This represented the fishery for the virgin stock. Moderately large fish were then numerous and the small fish — some as long as 20 inches — were discarded at sea (Fig. 32). After 1949 the haddock were smaller and less numerous and the fishery went into a period of decline which lasted in the Canadian catch until 1951, in the total catch until 1953, and in the Spanish catch until 1954.

Landings increased rapidly to 230 million lb in 1955, mainly due to the entrance into the fishery of a very abundant year-class hatched in 1949, and to the retention and use by the Canadian and especially by the Newfoundland fleet of small haddock which they once discarded. By 1960 few haddock over 20 inches long were present on the Grand Bank and almost all those caught and retained were less than 18 inches long (Fig. 32, 33).

Very small codend mesh sizes were still used until March 1957 for Canada, and on January 1, 1958, a 4-inch internal mesh size became the minimum legal standard in trawl codends used by all ICNAF countries for cod and haddock fishing in Subarea 3. However, a cover over the upper surface of the codend of the trawl is generally still used as a chafing gear to prevent wear. Hence, though smaller fish are being used commercially, when they are plentiful many are caught and discarded dead at sea.

In the early years of the fishery when the haddock were of moderate size, most of the catch was taken by Spanish vessels and salted. Since 1955, with very small haddock predominating, Spain's landings have declined considerably below those of Canada as these small fish are not very valuable for salting. Up to 1959, landings by other European countries were low. In 1960, USSR trawlers entered the haddock fishery in Subarea 3 for the first time and landed 80 million lb, compared with 66 million lb for all other countries.

The great new Russian fishing effort for haddock led to a third peak in the total landings for Subarea 3, 176 million lb, in 1961. Of this the USSR landed half (88 million lb), and though Canadian landings had increased (Fig. 31, 36) they were still about 21 million lb below those of the USSR. The landings from the subarea fell rapidly to 77 million lb in 1962 and 27 million lb in 1964. Those for 1963 and 1964 were lower than for any other year since 1945, when the

fishery was beginning. Of the 1964 landings, Newfoundland's share was 41% and the total for Canada was 56%. Also, in 1964 Newfoundland landed 1 million lb of haddock from Subarea 4.

The haddock fishery in the Newfoundland area is mainly a trawler fishery on the southern Grand Bank. In occasional periods when there is a good year-class survival on St. Pierre Bank the fishery is good on this bank, but the Grand Bank provides the continuing fishery.

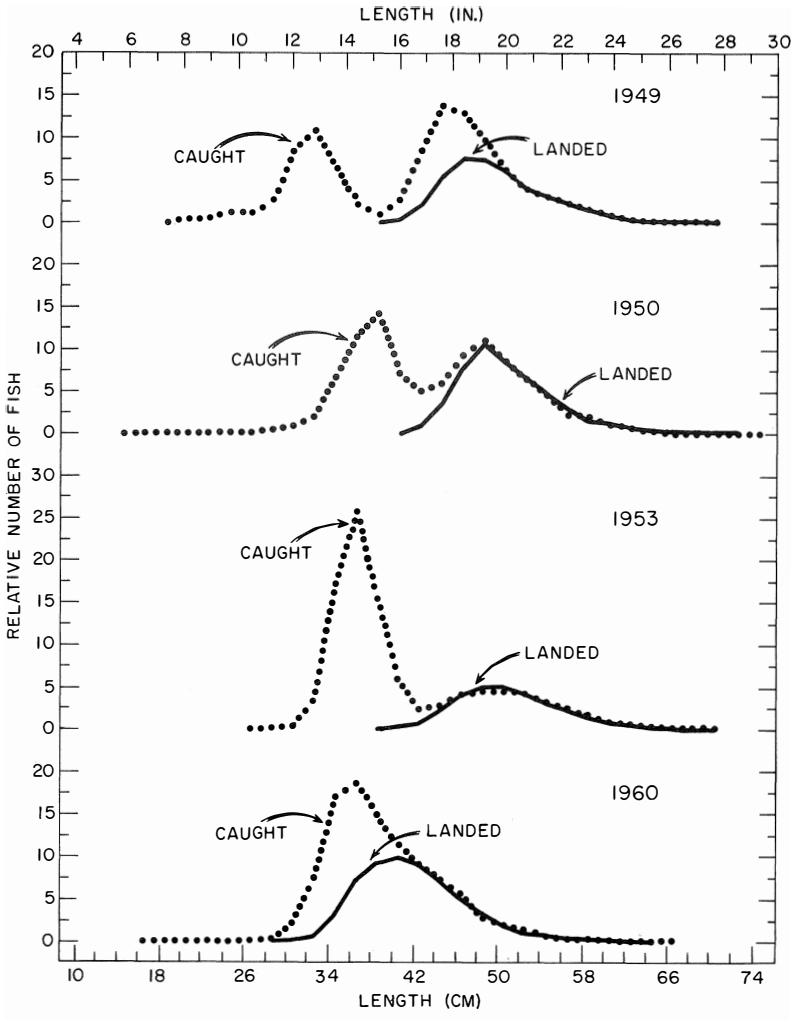


FIG. 32. Relative numbers and sizes of haddock caught and landed from the Grand Bank by Newfoundland commercial trawlers during January to June, 1949, 1950, 1953, and 1960. The differences indicate the numbers and sizes discarded at sea.

The Newfoundland trawler fishery for haddock on the Grand Bank is chiefly from December–January to April–May, the catches being small during the

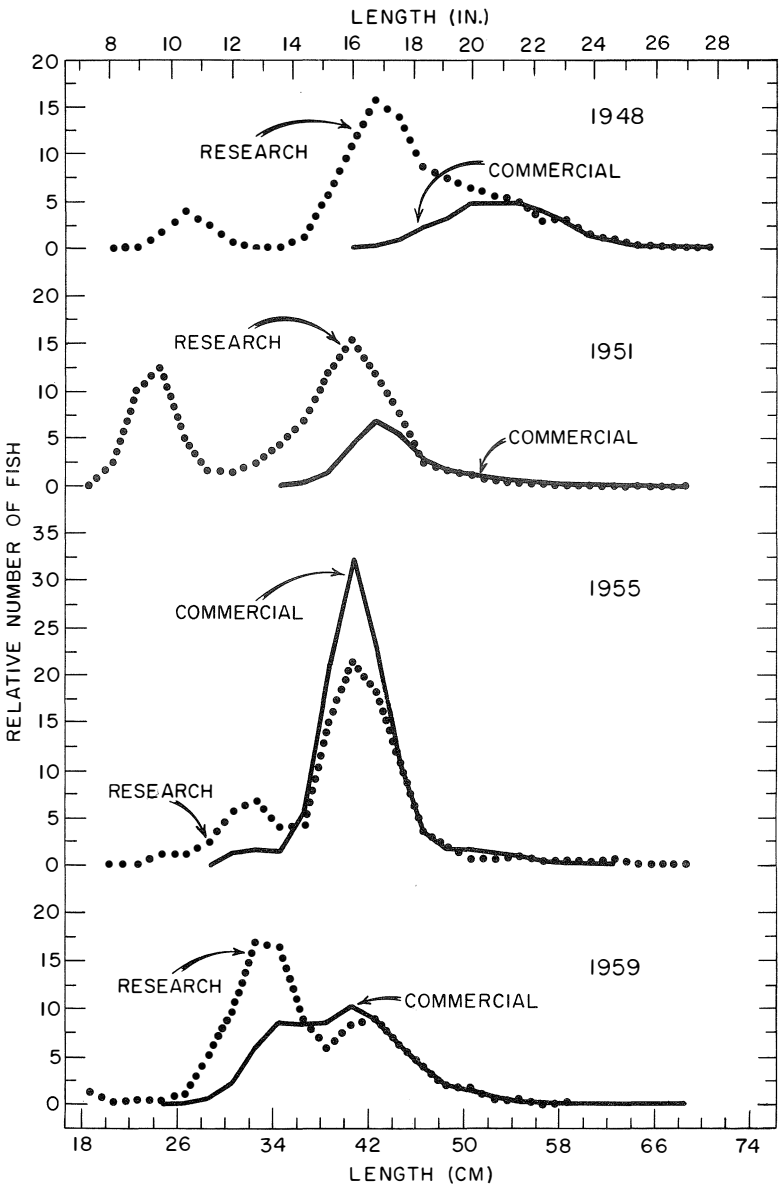


FIG. 33. Relative numbers and sizes of haddock landed by Newfoundland commercial trawlers from the Grand Bank during January to June 1948, 1951, 1955, and 1959, and of those present on the bank as indicated by research-vessel catches in March to June of the same years.

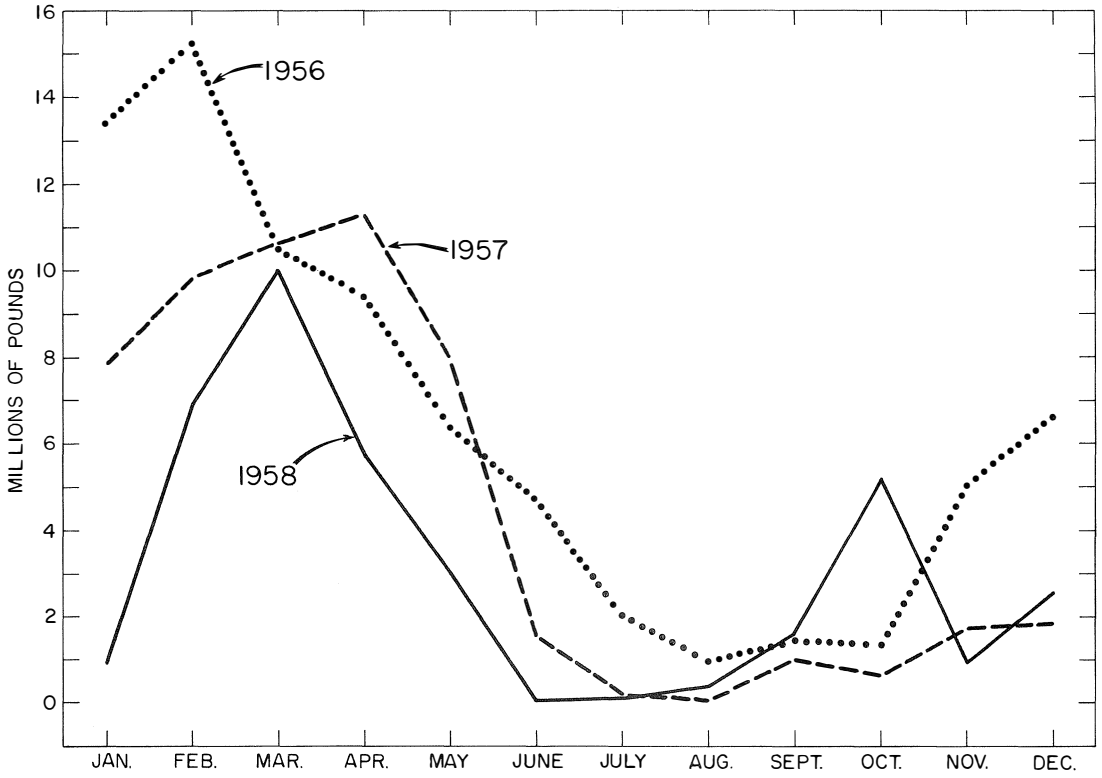


FIG. 34. Monthly landings of haddock (round fresh weights) by Newfoundland otter trawlers, 1956–58.

remainder of the year (Fig. 34). In winter, low temperatures on the Grand Bank or the natural behaviour of the fish cause the haddock to retreat to depths of 50–140 fath on the southwestern slope of the bank, the fish lying deeper during cold winters and shallower during warm ones (Templeman and Hodder, 1965a). The winter fishery on the Grand Bank is on the southwestern slope. By April many haddock pass northward toward and shallower than the 50-fath contour bounding this slope. In summer these haddock spread over the bank, especially the southern half, but generally in too small concentrations to be fished commercially.

Some Grand Bank haddock rise to the surface layer and travel to the southern part of the east coast of Newfoundland, where they are caught in occasional years in moderate and sometimes in large numbers in cod traps. Far greater numbers, however, travel northward, northeastward, or eastward and concentrate at first on the shallower parts of the Southeast Shoal of the Grand Bank — about 25 fath (Templeman and Hodder, 1965a). Here they have been found by the research vessels *Investigator II* and the *A. T. Cameron,* in most years between 1950 and 1960, to accumulate in huge shoals in July and August, feeding largely on spawning capelin and on capelin eggs which are laid year after year at this time on the same small sandy areas of the shoal. The concentrations are sometimes so large that the *A. T. Cameron* has taken catches as high as 40,000 lb in 40 min of dragging (Fig. 35).

These large concentrations attracted the USSR fleet of factory vessels in July 1960. The Newfoundland trawler fleet was aware of the concentrations as early as 1950, but after a few preliminary trials failed to exploit them because of spoilage due to the warm weather and the long haul.

In Subarea 3 the Canadian haddock fishery is usually on the Grand Bank in Division 3O (Fig. 36). Only in 1954–56 were large quantities taken from 3P (St. Pierre Bank). Except in 1954–55, most of the Spanish catch was taken on the Grand Bank in Division 3N, which includes the Southeast Shoal area. The great Russian catch of 1960 was almost entirely from 3N and in 1961 about equally from 3N and 3O. The 3N fishery is mainly in summer and autumn and the 3O fishery in winter and spring.

On St. Pierre Bank the haddock usually go to 100–120 fath on the southern and western slopes in winter. They probably rise to the upper water in late spring and soon go to the northern and southern shoal-water areas of the bank, where the depth is about 25 fath (Templeman and Hodder, 1965b). The only years when the Newfoundland haddock fishery was large in summer were 1954 and 1955, when haddock were abundant in summer in the shallow water of this bank. Some of the St. Pierre Bank haddock migrate in summer to the inshore waters of the Burin Peninsula.

In 1960–64, the Newfoundland haddock landings from Subarea 3 were 75% of the total Canadian landings from this area (Fig. 31).

Figures 37–39 show the distributions of the Newfoundland catches in three years: when the catch was mainly on St. Pierre Bank (1955), almost equally distributed over both banks (1956), and mainly, as usual, on the Grand Bank (1957). In 1954 and 1955, when large quantities of haddock were caught on St. Pierre Bank, they were also abundant on the Grand Bank, but it was more economical to fish St. Pierre Bank as it is closer to the fish plants.

Year-Class Survival

In the Newfoundland area, haddock are at the northern end of their range in the Northwest Atlantic.

Fig. 35. A large haddock catch from the Southeast Shoal of the Grand Bank (3N), on the deck of the *A. T. Cameron*, August 2, 1959, 23–25 fath.

They spawn mainly in May and June. The fertilized eggs float near the surface, and hatch in several weeks. The larvae and young haddock are still pelagic for several months before they settle to the bottom and begin to feed on bottom food. During this period, too low or too high temperature, too little food of the right size, and many other factors affect their survival and growth.

Probably, however, the most significant factors in survival are water currents. These young haddock develop close to the southern part of the Grand Bank and on St. Pierre Bank, where water over a mile deep is close by to the south and bottom water too cold for haddock covers large areas to the north. When the haddock in their first year begin feeding on bottom organisms in early autumn,

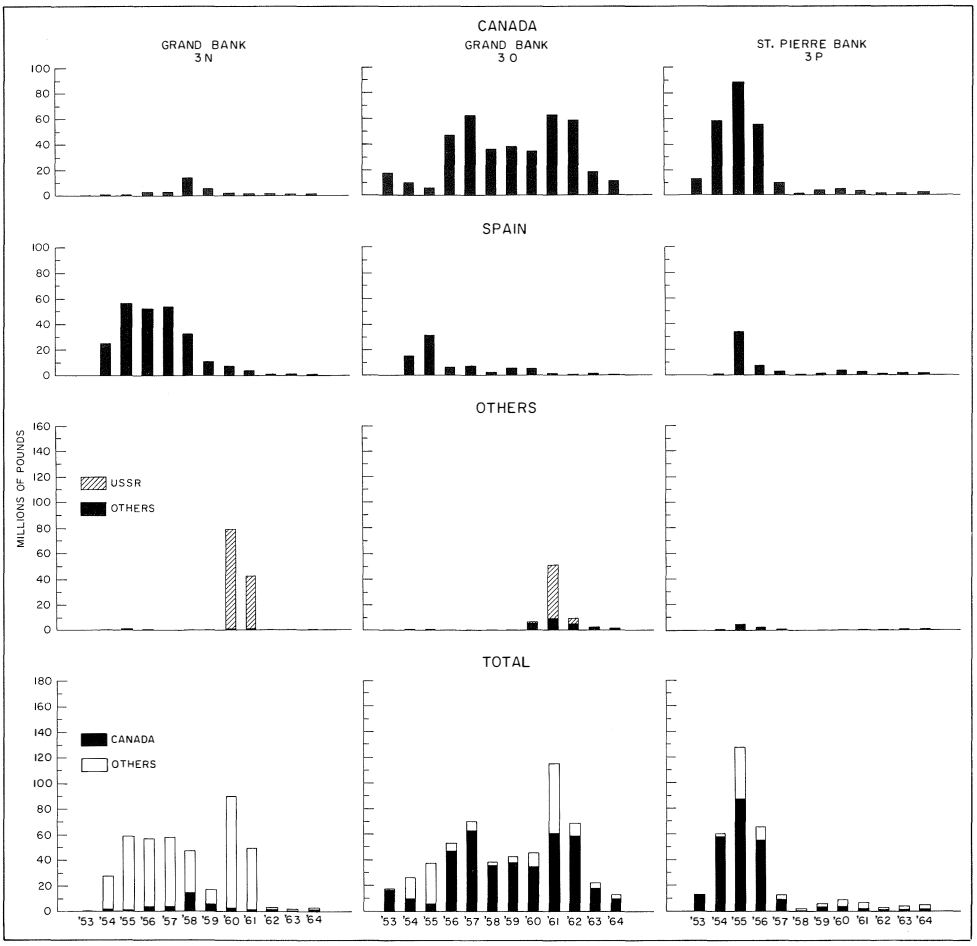


FIG. 36. Haddock landings by countries (round fresh weights) from ICNAF Divisions 3N, 3O, and 3P, 1953–64. (Spanish catch statistics are not available by divisions for 1953.)

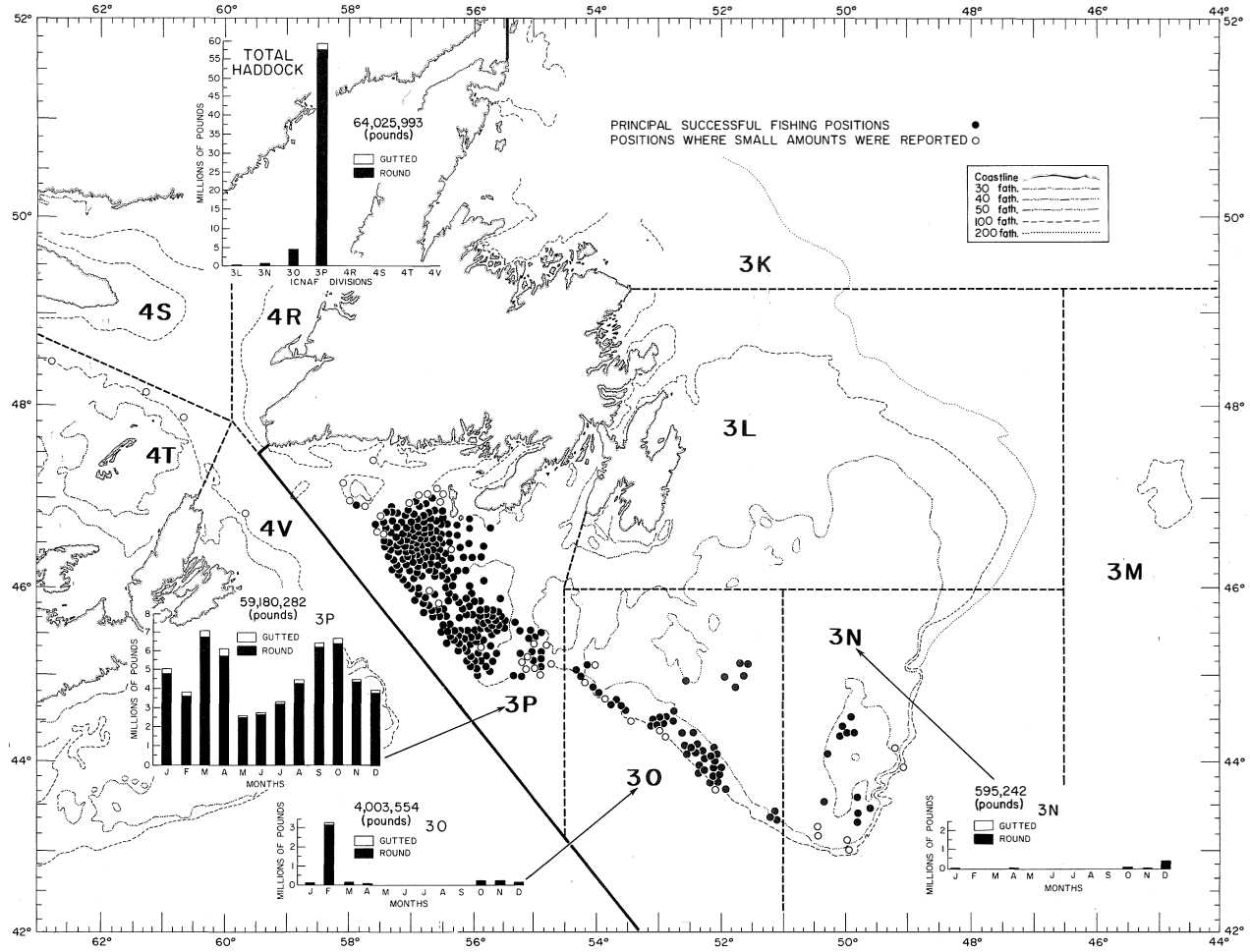


FIG. 37. Locations of haddock catches by Newfoundland otter trawlers from ICNAF divisions, 1955. Catches chiefly from St. Pierre Bank.

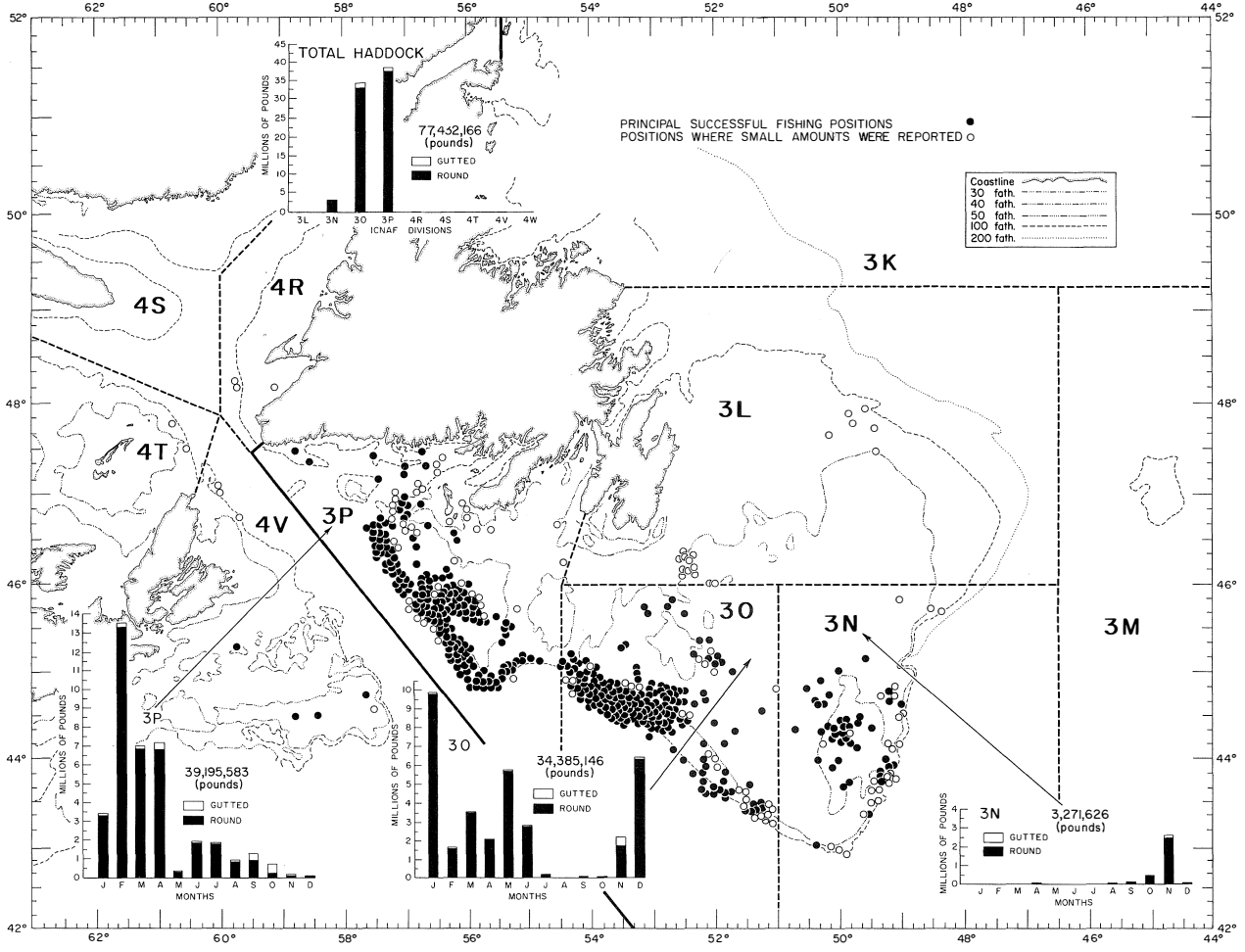


FIG. 38. Locations of haddock catches by Newfoundland otter trawlers from ICNAF divisions, 1956. Catches almost equally from St. Pierre and Grand banks.

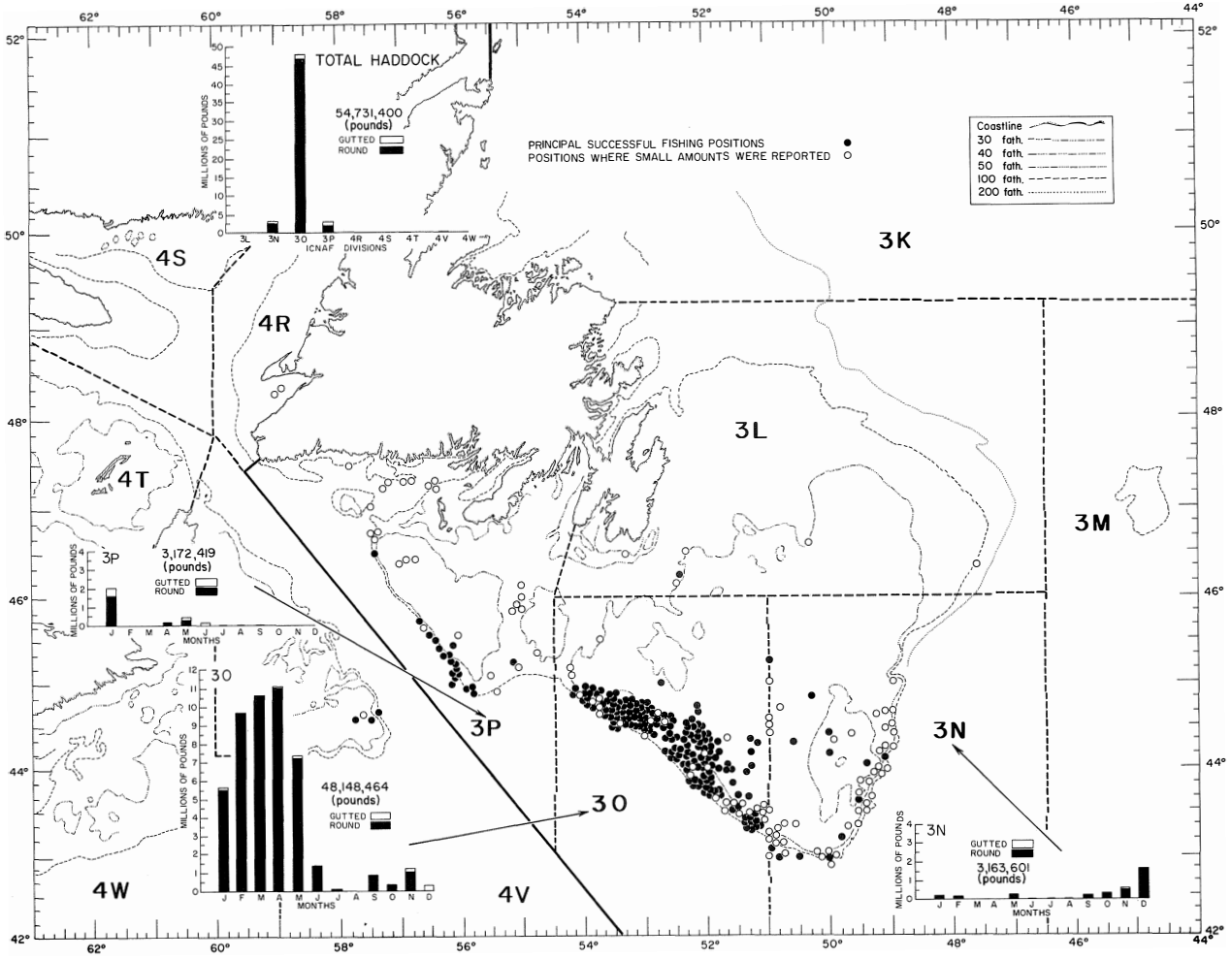


FIG. 39. Locations of haddock catches by Newfoundland otter trawlers from ICNAF divisions, 1957. Catches mainly from the Grand Bank.

to survive they must be in water not much more than 100 fath deep. Doubtless in some summers the bank water with the larvae in it circulates mainly on the bank. In other years the bank water is sucked off into the current eddies between the Gulf Stream and the Grand Bank, and larvae are lost in too warm or too deep water. In some years the larvae may drift northward or northwestward into water too cold for survival.

Hence there is great yearly variation in the quantities of young haddock surviving their first few days, weeks, or months. For the Grand Bank during our years of study there has been good survival of young haddock only in 1942, 1946, 1949, 1952, and 1955, survival being significant but lower in 1947, 1953, and 1956. For the 1958 and 1959 year-classes, survival was not of much commercial importance. The 1961 and 1962 year-classes survived in somewhat greater numbers and, particularly that of 1962, will be of some but apparently not great commercial importance. In the remaining years there was no commercially significant survival of young haddock.

Examples of the effects of these variations in survival on the numbers of haddock at various ages and on the sizes available on the bank are shown in Fig. 40. The 1949 year-class was the most productive of young haddock and it

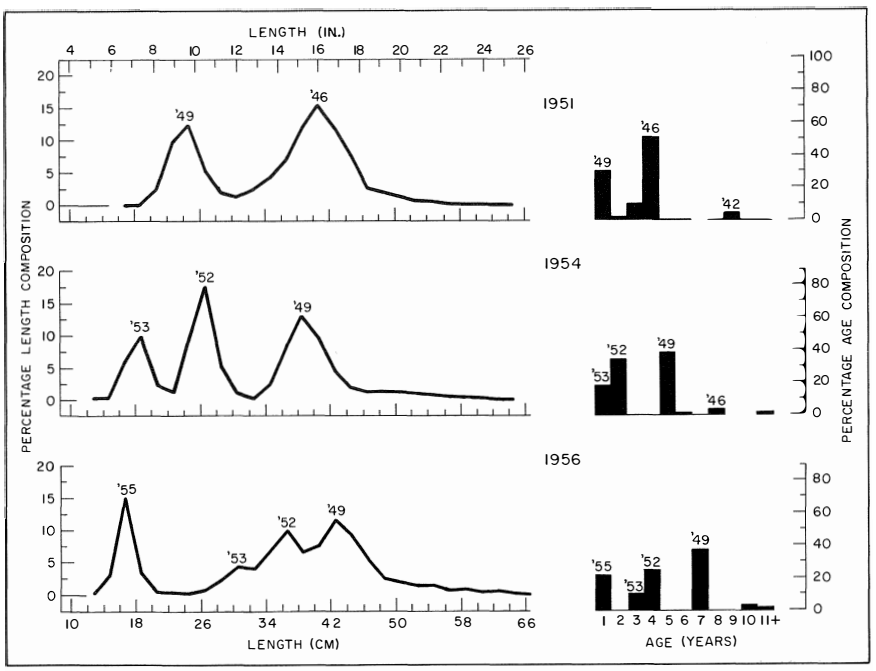


FIG. 40. Length and age compositions of haddock in research-vessel catches from the Grand Bank in April to June, 1951, 1954, and 1956. The numbers on the age graphs indicate the year-classes present, and those on the length-frequency curves the parts of the curves formed mainly by these year-classes.

was equally abundant on the Grand and St. Pierre banks. The 1955 year-class was also very large on the Grand Bank, probably as abundant on this bank as the 1949 year-class, but not abundant enough to produce a commercial fishery on St. Pierre Bank.

On St. Pierre Bank only the 1949 year-class settled in large enough numbers to produce a major commercial haddock fishery on the bank. The fishery — due almost entirely to this year-class — lasted from the autumn of 1953 to the spring of 1956. Before that time there was a small and spasmodic Newfoundland fishery for haddock on St. Pierre Bank in late winter and spring in the deep water (about 110 fath) of the southern and western slopes. Also, there was a comparatively small Nova Scotian fishery in summer–autumn (McKenzie, 1946a), presumably on the shallower parts of the bank. The Nova Scotian fishery depended on virgin stocks of large haddock produced before 1940; also, the Newfoundland fishery depended in part on the 1942 and 1946 year-classes.

On St. Pierre Bank there has been no significant commercial haddock fishery since 1956. Though good survival of a year-class on this bank has always been accompanied by good survival of the same year-class on the Grand Bank, in years such as 1952, 1953, and 1955 there was significant commercial survival of young haddock on the Grand Bank but not on St. Pierre Bank. St. Pierre Bank, possibly because of its smaller size, does not hold its haddock larvae as well as the Grand Bank.

Since 1949 on St. Pierre Bank and since 1956 on the Grand Bank there has been no survival of young haddock in numbers great enough to provide a large commercial fishery.

Growth

Haddock of the Newfoundland area grow more slowly than those of the Nova Scotian and Georges Bank areas. The year-classes from 1949 to 1956 took about 5 years to reach an average length of 15 inches (head-on, gutted weight of 1.0 lb) and about 8 years to reach a length of 18 inches (1.6 lb). At the recent rate of fishing, relatively few haddock live beyond 8 or 9 years of age.

In the Newfoundland area, therefore, when year-classes are large, haddock require about 5 years on the average to reach small commercial size. When year-classes are small, as at present, the fish grow faster so that the small commercial size is reached a year earlier. At the rate of fishing before 1960 a good year-class usually provided good fishing for about 3 years, which was also the usual period between successful year-classes.

The Future

The haddock fishery in the Newfoundland area is in a critical condition, small landings being in view over the next few years. There has been no very successful

year-class since 1955 and survival has been low since 1956. Also, with greatly increased effort when haddock are abundant, the period of good fishing provided by a year-class may be reduced from 3 to 2 years or less.

More Information

Additional information on haddock of the Newfoundland area may be found in Thompson (1939), Templeman (1965c), Templeman and Hodder (1965a, b), and Hodder (MS, 1965b).

Redfish

Sebastes mentella and *S. marinus*

There are two species of redfish, or ocean perch (Fig. 41, 42), in the Newfoundland area. *Sebastes mentella* (rosefish) is sharp-chinned, thin-skinned, loose-

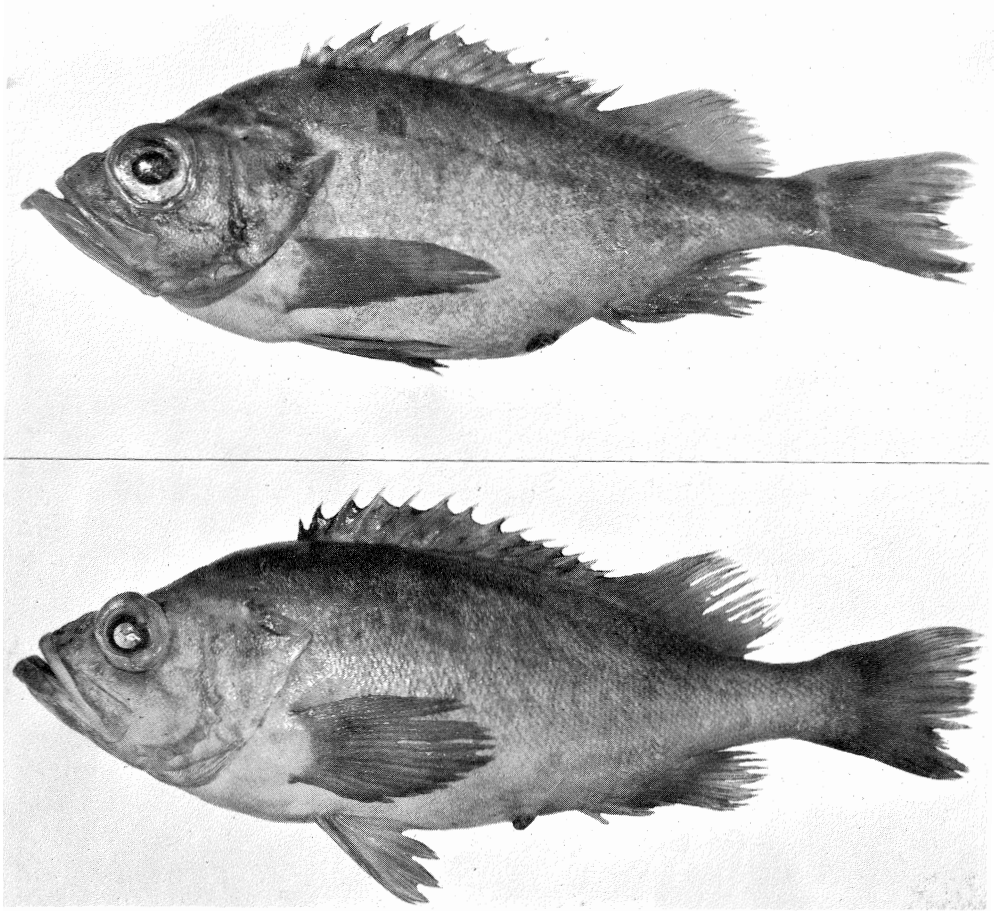


Fig. 41. Redfish. *Above, Sebastes mentella; below, S. marinus;* both from off the south coast of Newfoundland.

scaled, large-eyed, and bright red or rose-red. *Sebastes marinus* is round-chinned, small-eyed, thick-skinned, firmly scaled, and golden-red or orange-red. *Sebastes mentella* is found mainly in deeper water than *S. marinus* and is generally smaller.

The fishery in general depends on *S. mentella.* But in the southern part of the Labrador area and on Flemish Cap, good commercial concentrations of *S. marinus* are sometimes found, usually, in summer and autumn, at about 125–150 fath. Also, *S. marinus* is occasionally caught in commercial quantities off the south coast of Newfoundland, usually, in summer and autumn, at about 100–110 fath. The redfish of the Gulf of St. Lawrence and of the southern and southeastern parts of the Grand Bank are almost entirely *S. mentella.*

Distribution and Landings

Redfish live in the deep, warm water below the intermediate, cold layer. In the Gulf of St. Lawrence, the south coast of Newfoundland, and the Burgeo–St. Pierre Bank–Green Bank areas they are mainly found below 100 fath (Fig. 10, 43–45). From the mid-eastern slope of the Grand Bank northward along the northern slope of this bank, and along the Northeast Newfoundland and Labrador shelves, they are found usually below 125 fath. On the southwestern Grand Bank,

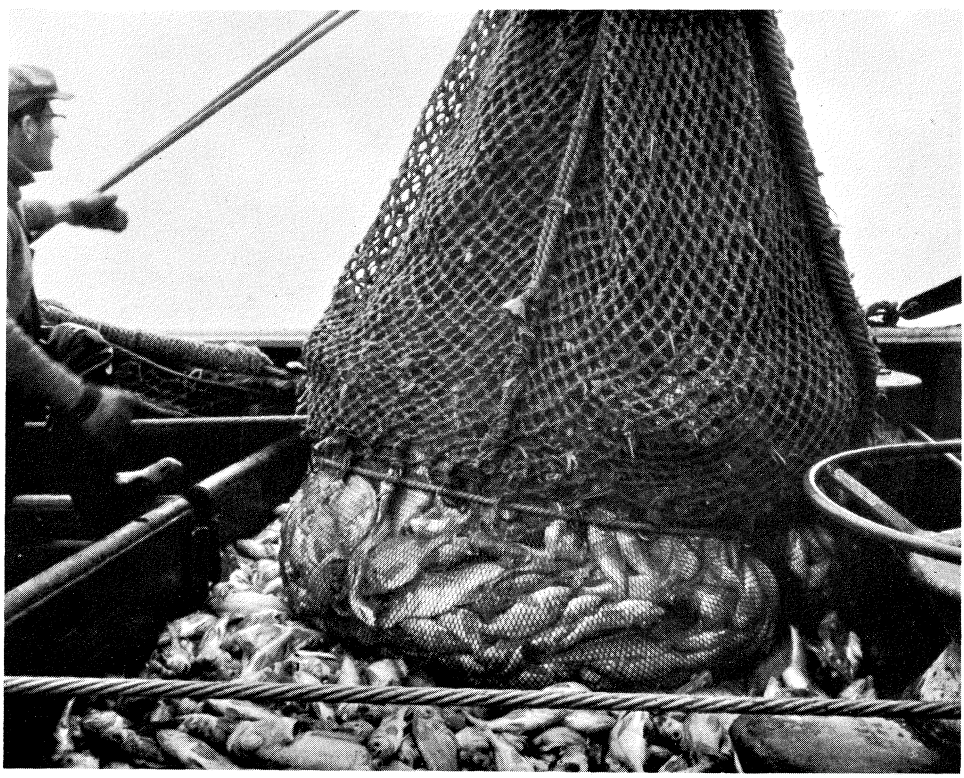


Fig. 42. Redfish catch on the deck of the *A. T. Cameron.*

where warmer water passes over the bank, small redfish are often present at 60 fath or less and abundant at 80–100 fath.

The centre of abundance of redfish of commercial size usually ranges from 120 to 160 fath in the Gulf of St. Lawrence and off the south coast of Newfoundland, and from 150 to 250 fath in the area from Flemish Cap and the northern Grand Bank to Hamilton Inlet Bank in Labrador. A few are found as deep as 400 fath. Commercial quantities are sometimes present at 300–350 fath,

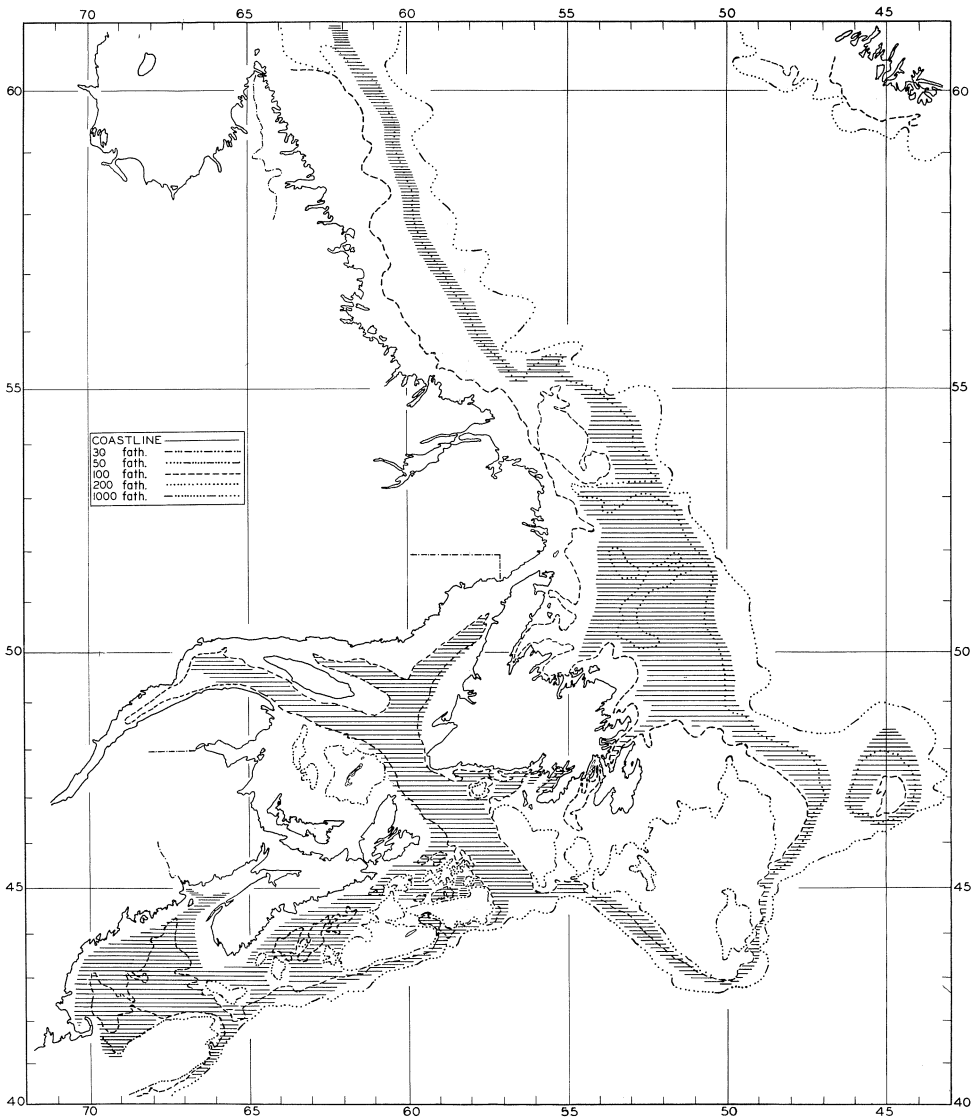


FIG. 43. Distribution of redfish in ICNAF Subareas 2–5 (from Templeman, 1959, Fig. 43).

especially in winter; then redfish, like other groundfish, apparently go deeper than in summer.

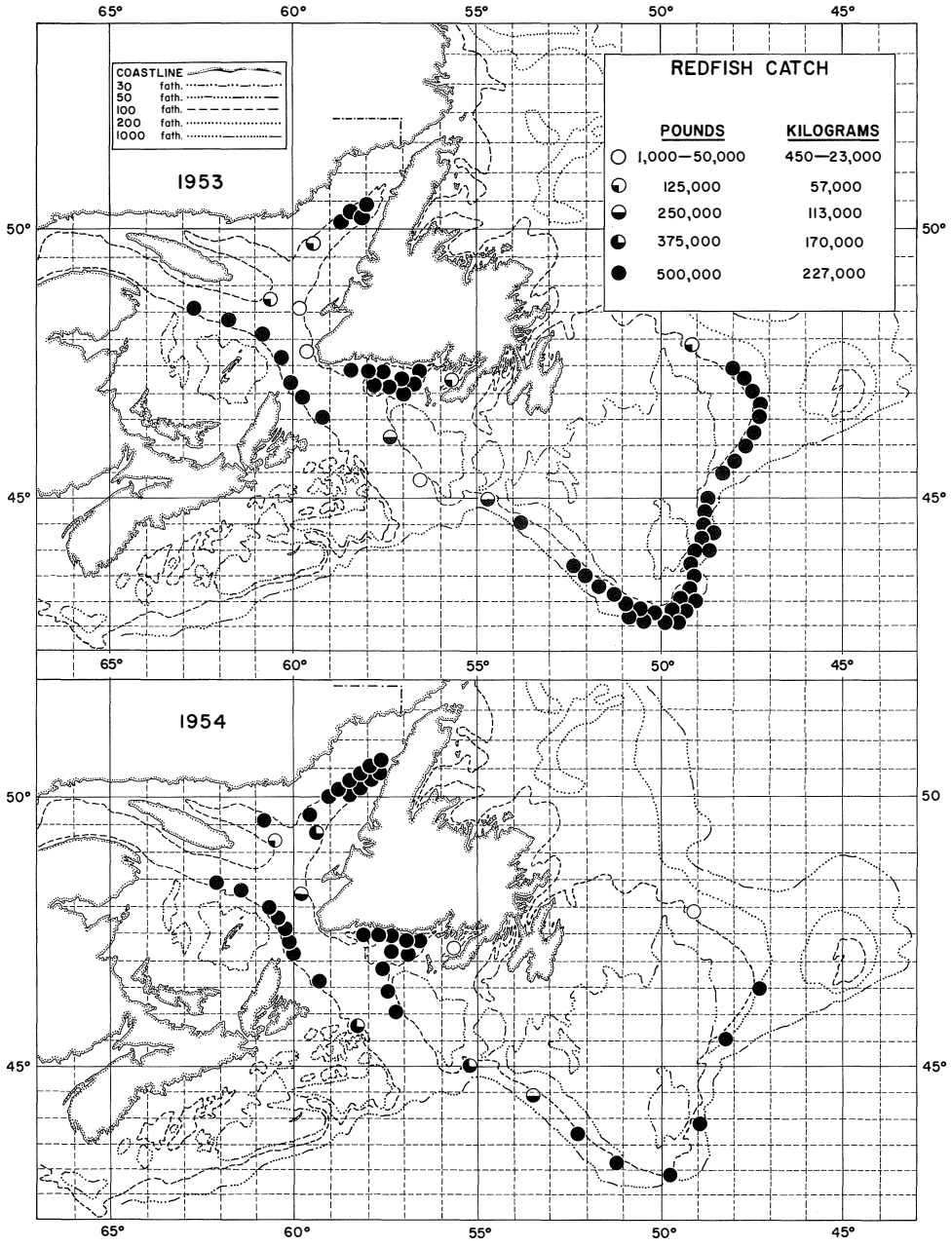


FIG. 44. Locations of capture of Newfoundland landings of redfish in 1953 and 1954 (from Templeman, 1959, Fig. 24).

In recent years, redfish landings from the ICNAF area have exceeded those of haddock and are second only to cod. In this area a fishery especially for redfish began in 1935 in the Gulf of Maine (Subarea 5) and spread northward, but before

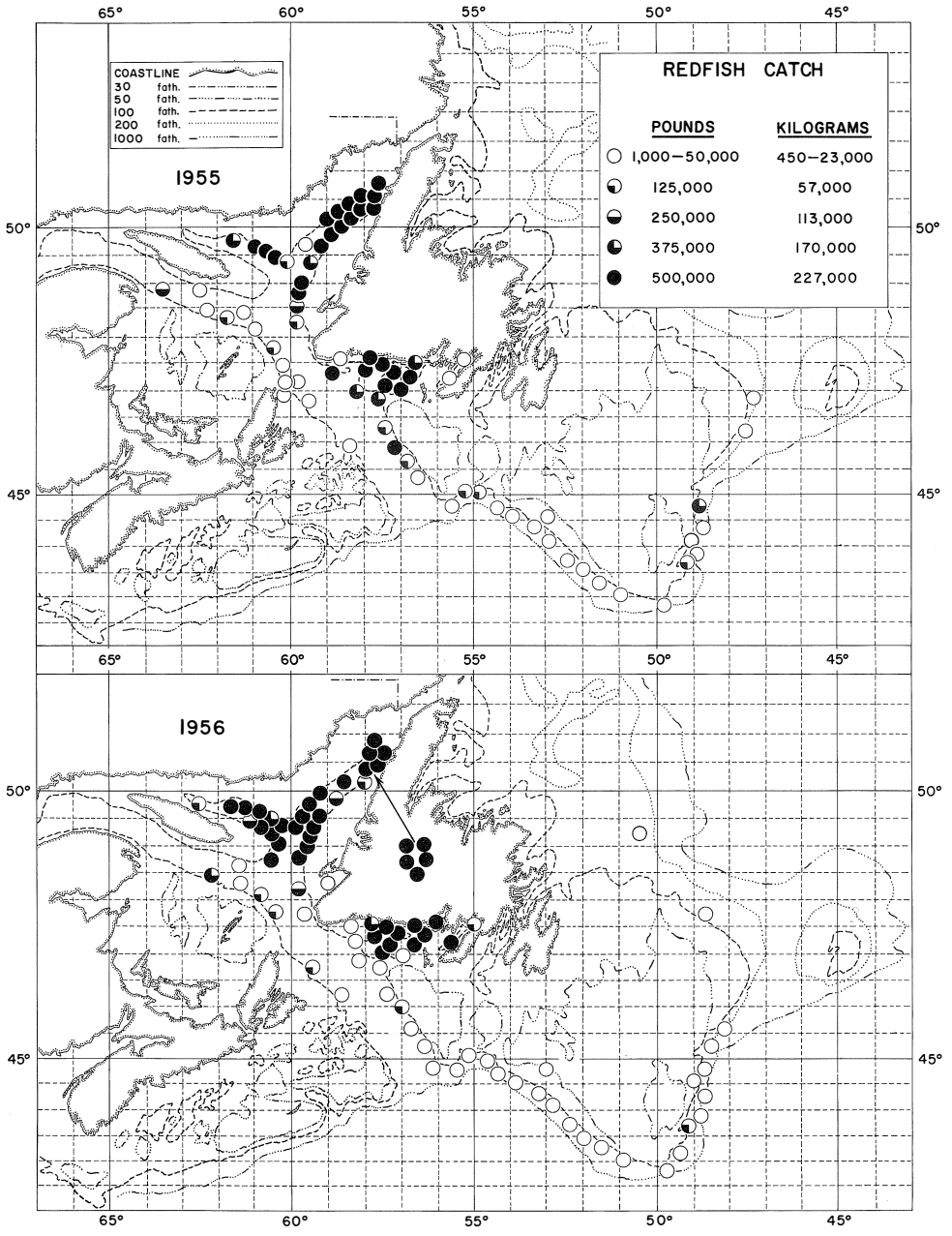


FIG. 45. Locations of capture of Newfoundland landings of redfish in 1955 and 1956 (from Templeman, 1959, Fig. 25).

1950 the United States fishery had not moved northward beyond the Scotian Shelf, Subarea 4.

From 1947 to 1965, as a result of deep-water explorations with the research vessel *Investigator II* and since 1958 with the *A. T. Cameron,* much information was obtained on the distribution of the species. In the Gulf of St. Lawrence, off the south coast of Newfoundland, and on the southwestern Grand Bank, appreciable quantities were obtained from 1947 onward. Off the northeast Grand Bank and Labrador and on Flemish Cap, otter-trawl surveys beginning in 1950 showed that they were abundant.

Largely because of these explorations, the fishery spread to the Gulf of St. Lawrence in 1951, to the northeast Grand Bank in 1953, to Flemish Cap in 1956, and to the Northeast Newfoundland Shelf and the Southern Labrador Shelf in 1958 (Templeman, 1959). There are apparently no further great unexploited areas for redfish on the continental shelf of the Northwest Atlantic, and future catches will depend on conservation of presently known stocks.

In a survey by the research vessel *A. T. Cameron* in 1959 (Templeman, 1961) northward from the northern part of Labrador, some redfish were found in much of the area but no commercial concentrations. The survey was conducted from off Cape Mugford (about 58°N lat) to off Cape Dyer on Baffin Island, just north of the Arctic Circle, and also in Ungava Bay. In 1960 a similar cruise was carried out on the Labrador shelf south of Cape Mugford. In this area, though moderate quantities were found, commercial quantities were not caught except from Hamilton Inlet Bank southward.

Redfish landings from the ICNAF area (Subareas 1–5 of the Northwest Atlantic) were almost entirely by the United States until 1948. Then Canada's landings increased slowly to 83 million lb in 1963 and 79 million in 1964, of which Newfoundland's share was 49 million and 42 million, respectively (Fig. 46). United States landings have continued to decline, from a high of 258 million lb in 1951 to 89 million in 1964.

From 1956 to 1959 the European and especially Russian landings from the ICNAF area rapidly increased. Germany and Iceland also landed significant amounts. But from 1959 to 1963 the Russian landings fell greatly as the fleet turned to the abundant stocks of herring in Subarea 5 and of silver hake in Subareas 4 and 5.

The total landings of redfish from the ICNAF area in 1959 were 858 million lb. Most of this great expansion came from Subarea 3, the Newfoundland area (Fig. 47, 49), in which Canadian landings in 1964 averaged only 16.5% of the total. After 1959 the total landings decreased rapidly to 412 million lb in 1962 and rose to 469 million in 1964. Seventy-two million pounds caught by nonmember countries were, however, included in the landings for 1964, but the landings by nonmembers were not available for 1961–63. Hence landings by member countries of ICNAF fell to 397 million lb in 1964. The drop was brought about by a

decrease in the quantities of redfish available and by diversion of part of the European redfish fleet to other fisheries in the ICNAF area.

Apart from small landings in 1958 and occasional token landings, Canada and the United States do not engage in the redfish fishery of Subarea 2. They do, however, catch almost all (92% in 1964) of the redfish landed in Subarea 4, the Gulf of St. Lawrence and the Scotian Shelf (Fig. 47–48).

Growth and Survival

Redfish are very slow-growing fish. Age estimates on the basis of otolith bands have been made for *S. mentella* from Hermitage Bay on the south coast of Newfoundland (Sandeman, 1961). At 10 inches, the smallest length at which redfish are generally acceptable in the Canadian fishery, redfish from this bay are 10 or 11 years old. At 12 inches the males are about 16 and the females 14 years of age. At 14 inches the males average 41 and the females 18 years of age.

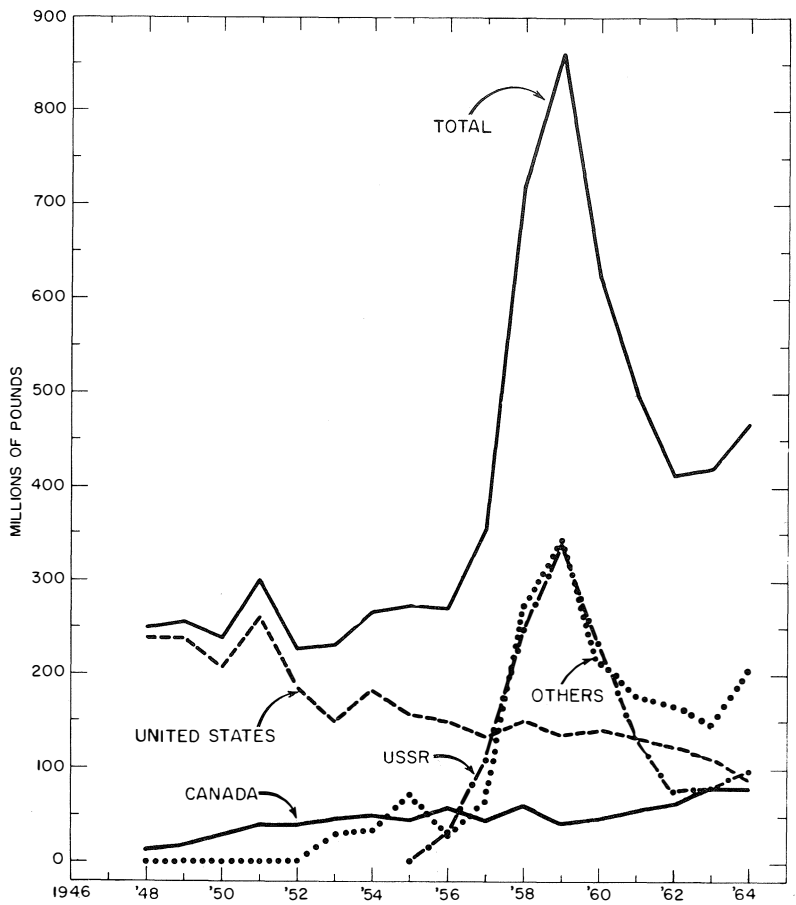


FIG. 46. Redfish landings (round fresh weights) by various countries from the ICNAF area, 1948–64.

At 15.4 inches females average 41 years of age. Though some redfish apparently live to 50 years or more, the Hermitage Bay redfish grow only about 1 inch in length between 24 and 48 years of age.

The redfish, unlike the other common groundfish, liberates young (Fig. 50), about ¼ inch long, instead of eggs. In some areas such as the southwestern Grand Bank, production of young seems to be fairly regular. In other areas such as the southwest coast of Newfoundland and the Gulf of St. Lawrence the survival of large year-classes is highly irregular.

For the Gulf of St. Lawrence in 1957, 1959, and 1960, a research survey indicated the abundance of redfish of various sizes, the larger ones according to

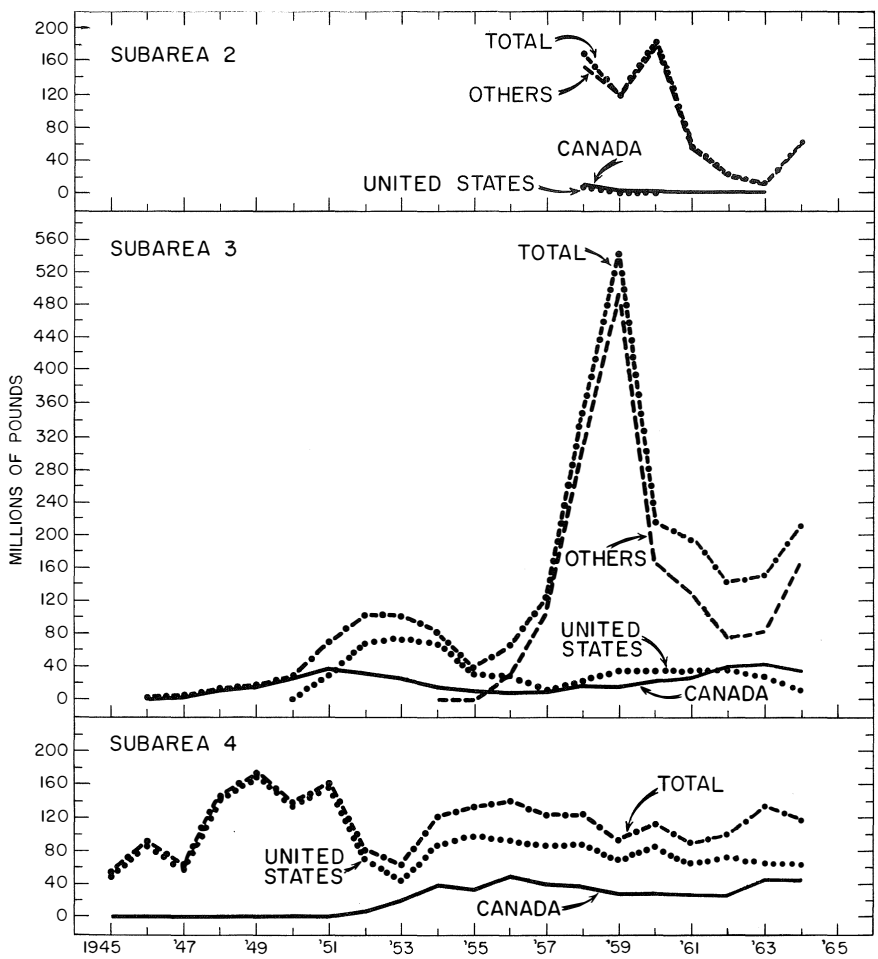


FIG. 47. Redfish landings (round fresh weights) by Canada, USA, and other countries from ICNAF Subareas 2–4, 1945–64.

sex (Fig. 51). Evidently the survey showed one group of successful year-classes in 1957 and two groups in 1959 and 1960. As in 1959 the peak lengths of the older year-classes were about 14 inches for males and 15 for females and those for the younger year-classes about 5 inches, a successful year-class occurs in the Gulf only rarely. Presumably, in almost all years most of the redfish larvae die, or drift out of the Gulf before the resulting fry have established a bottom relationship.

The Future

The redfish fishery in the Northwest Atlantic increased greatly up to 1959 by fishing the accumulated virgin populations of old fish and by moving farther northward to new virgin populations as the old accumulations were temporarily reduced below the economic level. This process has now largely come to an end.

Apart from the possibility of pelagic populations in the open ocean outside the continental shelf in the northern part of the area, it is not likely that any great new populations of redfish remain to be discovered in the Northwest Atlantic.

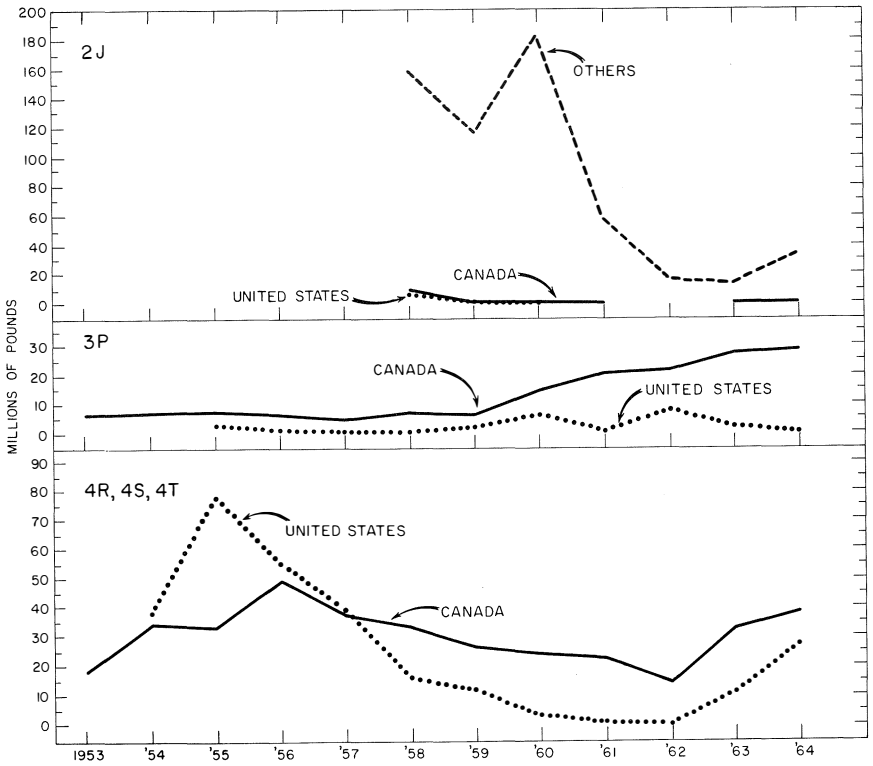


Fig. 48. Redfish landings (round fresh weights) by Canada, USA, and other countries from ICNAF Divisions 2J, 3P, and 4R, 4S, 4T (Fig. 6), 1953—64. (United States landings in 1953 were not given by ICNAF divisions and are not included.)

The slow growth, and in some areas the inadequate recruitment of young fish to the population, will not permit a continually expanding fishery. Hence the maximum sustainable yearly landings from the ICNAF area are likely to be less than the 858 million lb landed in 1959.

Redfish in the United States and Canada have a relatively low landed value per pound and hence have to be caught in quantity to provide economic fishing. Those fished first are the biggest concentrations of intermediate ages and sizes, which are present at intermediate depths. After these are greatly reduced in numbers there often remain great quantities of smaller fish at shallower depths, and sometimes fairly great quantities of larger fish at depths beyond those previously fished. At present the United States industry and possibly the USSR salting fleet can use smaller redfish than Newfoundland vessels usually land.

In the usual fishing areas of the Newfoundland fleet the concentrations of large, old redfish have been greatly reduced and are being replaced by large concentrations of much younger, small redfish. From Labrador to the north of the Grand Bank, where Newfoundland trawlers have fished very little, and where redfish grow considerably larger than farther south, the concentrations are on

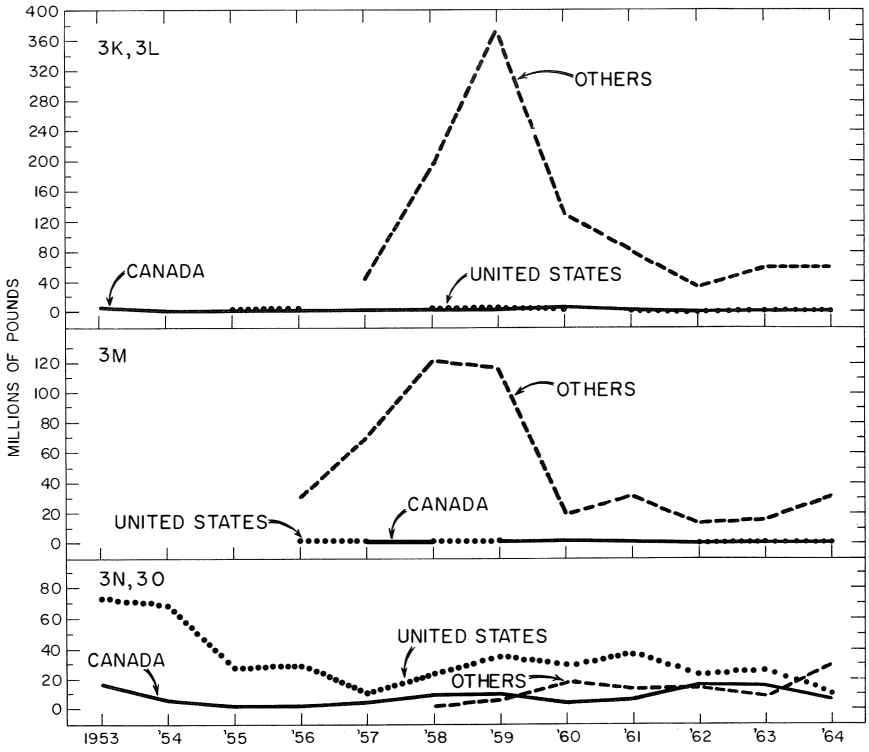


FIG. 49. Redfish landings (round fresh weights) by Canada, USA, and other countries from ICNAF Divisions 3K, 3L, 3M, 3N, and 3O, 1953–64.

the average deeper than in more southern areas. The concentrations are greatest and deepest in winter. The future redfish fishery of the Newfoundland fleet, therefore, depends largely on the ability of our plants to utilize small redfish from the southern fishing grounds and the adequacy of our trawlers in size, power, resistance to icing, and winch size and speed to catch large redfish in deep water and to work the northern areas at all seasons.

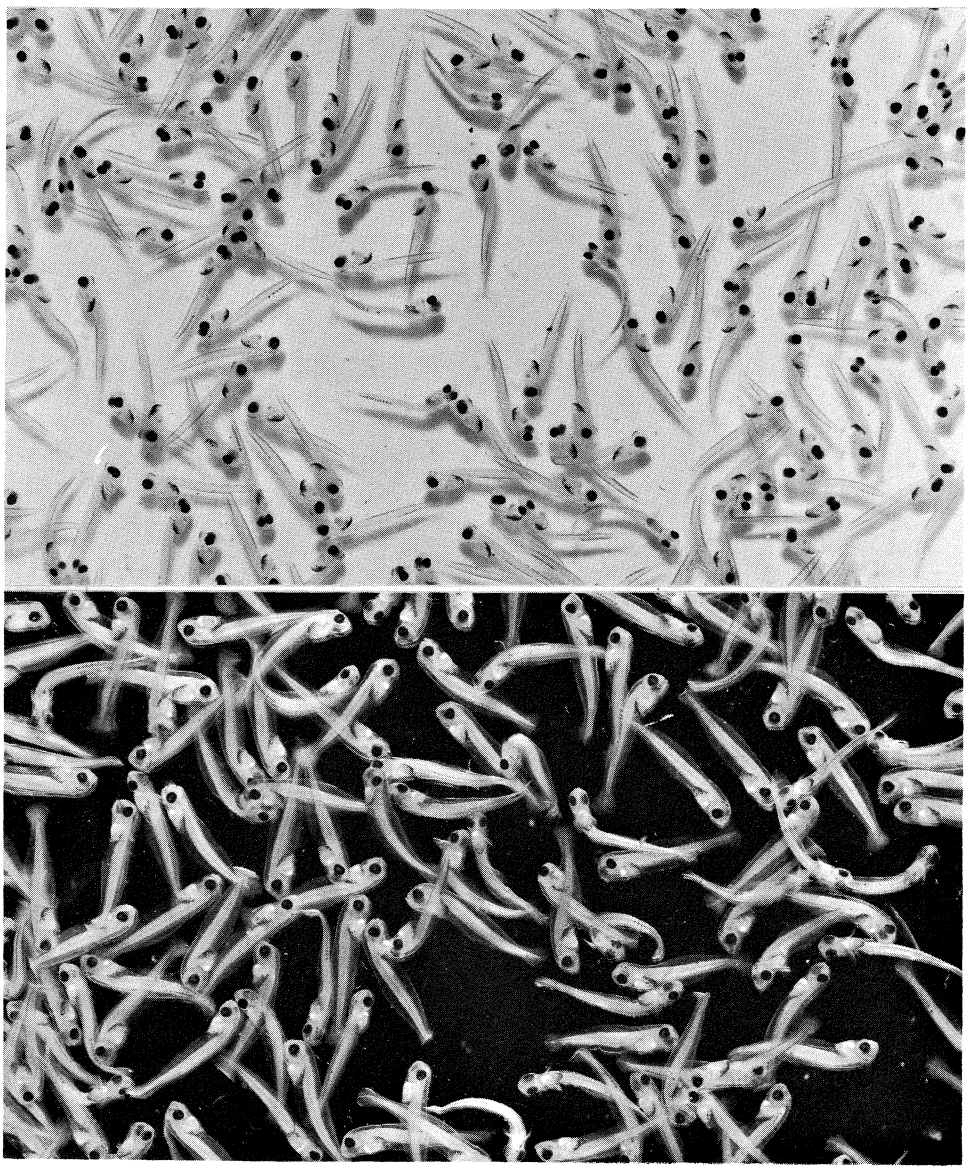


FIG. 50. Redfish larvae, *Sebastes mentella,* 7.7 mm long, at time of extrusion from female from Hermitage Bay, Newfoundland, June 23, 1956 (from Templeman, 1959, Fig. 9).

More Information

For additional information on redfish of the Newfoundland and neighbouring areas see Steele (1957), Templeman (1959, 1961), Templeman and Sandeman

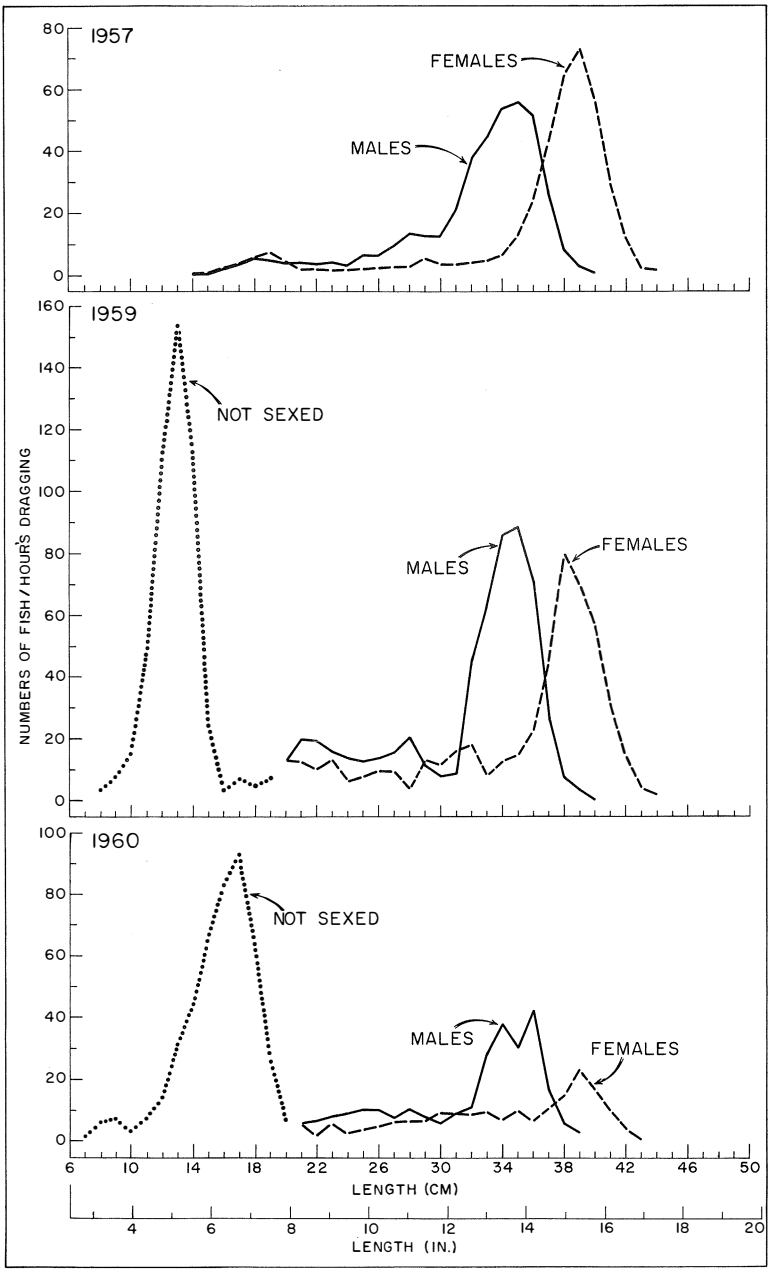


Fig. 51. Average numbers of redfish of various lengths taken per hour in research fishing in the Gulf of St. Lawrence, 1957, 1959, and 1960.

(1959), Lambert (1960), Templeman and Squires (1960), Bergeron (1961), Henderson (1961), Martin (1961), Sandeman (1961), Sindermann (1961), Templeman and Pitt (1961), Kashintsev (1962), Surkova (1962), and Yanulov (1962a, b). Also, as for other commercial fishes, much information is contained in the various research reports to ICNAF by member countries, especially, for redfish of the Newfoundland area, by the USSR and Canada. The reports are published in the ICNAF Proceedings and Redbooks. For a bibliography of papers on North Atlantic redfish see Trout (1961).

American plaice

Hippoglossoides platessoides

The American plaice or rough dab (Fig. 52), the flounder of the Newfoundland fish trade, is by far the most common flatfish in the Newfoundland area. It lives in even colder water than cod, and large populations occur where the water is usually between −1 and 1 C (30 and 34 F).

Distribution

In the Newfoundland area the main fishing grounds for American plaice are in the path of the colder water of the Labrador Current on the northwestern, northern, and eastern slopes of the Grand Bank (Fig. 53). There is a small fishery on the northern tip of St. Pierre Bank. In the haddock area of the warm, southwestern part of the Grand Bank, American plaice of commercial size are scarce. The plaice are also abundant in the St. Mary's Bay and neighbouring areas and along the coastal shelves of eastern and southeastern Newfoundland. In these areas they are sometimes taken in significant numbers by longliners when their lines are set in water too cold for cod to be abundant — that is, too

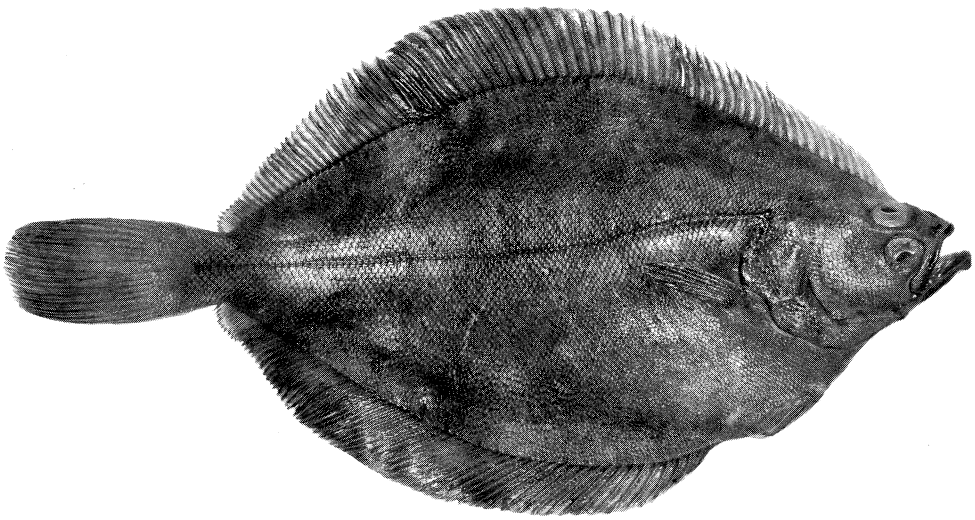


Fig. 52. The American plaice.

deep for the shallow-water, inshore fishery and too shallow for the deep-water, longline fishery. Over 95% of the landings, however, come from the offshore banks.

The early investigations of the Newfoundland Fishery Research Laboratory in 1931–35 with the *Cape Agulhas* revealed large quantities of American plaice eggs and larvae floating over a great portion of the Newfoundland area. Also a few otter-trawl hauls on the eastern and northern slopes of the Grand Bank and in and near St. Mary's Bay during this period showed that the plaice were relatively numerous in these localities (Frost, 1938). Beginning in 1948, detailed surveys with the *Investigator II* showed large quantities of the plaice all along

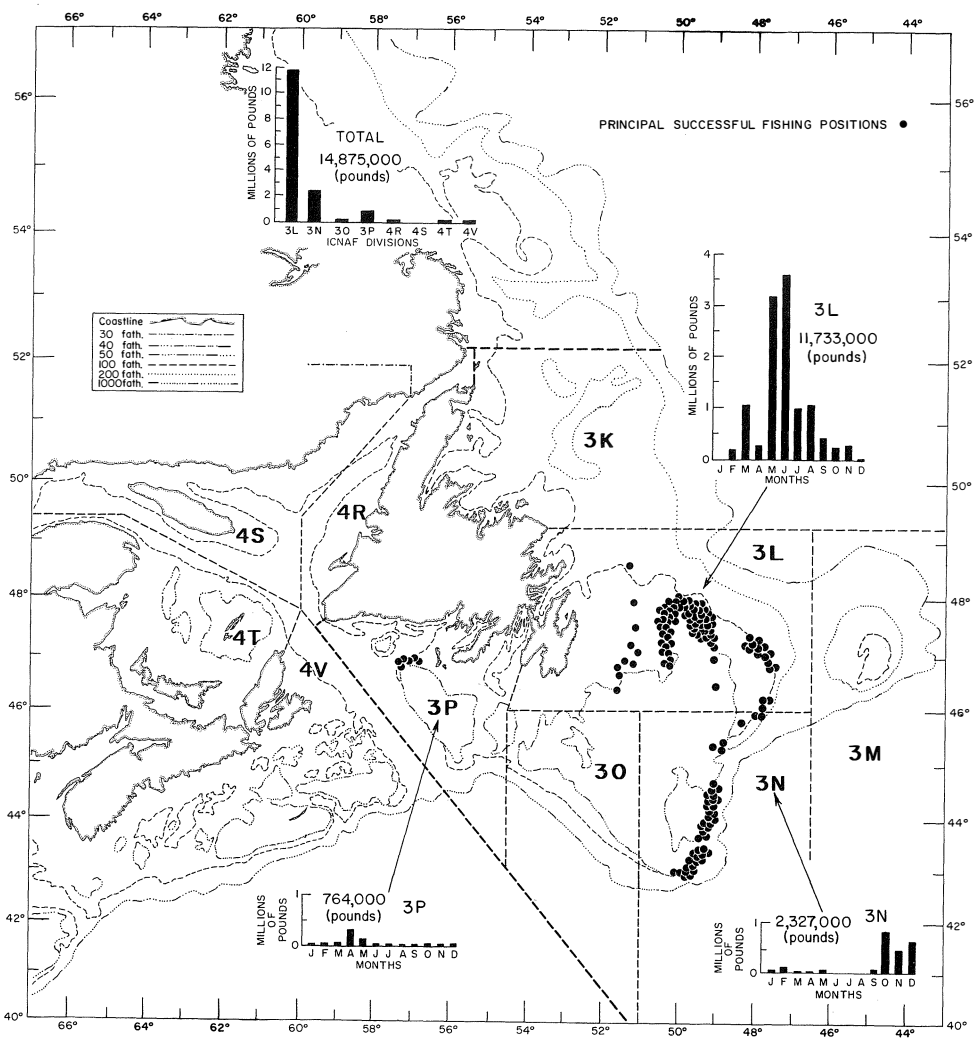


FIG. 53. Localities from which the Newfoundland trawler catches of American plaice in various ICNAF divisions were landed in 1955.

the eastern slopes of the Grand Bank. At the same time Newfoundland trawlers began to engage in the American plaice fishery in this area.

On Hamilton Inlet Bank, American plaice have been taken by research vessels: on April 2, 1964, fish averaging 2.4 lb on the southeastern slope at 7000 lb per hour's dragging at 152 fath; and in September 1952, on a small area of the bank, in commercial quantities of small commercial size. Also, in 1960 fair numbers of small commercial size were taken with cod on the Southern Labrador Shelf somewhat north of the bank, but not in commercial quantity.

Landings

The American plaice fishery in Subarea 3 increased rapidly after 1948–49 and in 1960 the total landings from this subarea were over 60 million lb (Fig. 54, A). In that year, for the first time other countries than Canada landed more than 10 million lb. Over half the total landings were made in Newfoundland. The landings fell in 1961 and 1962 but rose considerably in 1963 to 66 million lb, of which 56 million were landed in Canada (46 million in Newfoundland) and 10 million by other countries. In 1964 the landings were probably close to 100 million lb with Newfoundland landings of 60 million and total Canadian landings of 82 million. The great increase in the Newfoundland landings was due to much greater effort for American plaice because of the great scarcity of haddock. Also, in 1964 Newfoundland landed 1.3 million lb of American plaice from Subarea 4. The decrease in landings in 1954 (Fig. 54, A) was not due to scarcity of American plaice but rather to the abundance of the 1949 year-class of haddock. These haddock were available in great numbers as 5-year-old fish and attracted the attention of trawlers which would usually — in the summer and autumn — be fishing American plaice.

Growth, Survival, and Quality

The American plaice is a very slow-growing fish. The female reaches a length of about 20 inches in 20 years and the male grows even slower. Most commercial plaice are over 10 years of age and many exceed 20 years. Probably due to the large area and practically stable conditions in the habitat of this flatfish, the survival of the year-classes is not nearly so variable as it is for haddock.

The Future

Due to slow growth, lack of great migrations, and general availability of these fish near or on bottom, the plaice can readily be overfished. But the small amount of trawling over most of the flat area of the Grand Bank provides considerable protection for large numbers of plaice. The present codend mesh sizes are too small to protect small plaice, and a considerably larger mesh than 4½ inches could be used in the codend without loss of plaice of commercial size.

The salt fish trawlers often catch large quantities of American plaice and discard them in a dead or dying condition. Any reduction in fishing for cod on the Grand Bank will save corresponding quantities of medium-sized and larger American plaice to be caught and retained in the commercial fishery for these fish. This has presumably happened in the southeastern Grand Bank, Division 3N, in recent years with the considerable reduction in the cod catch in this division

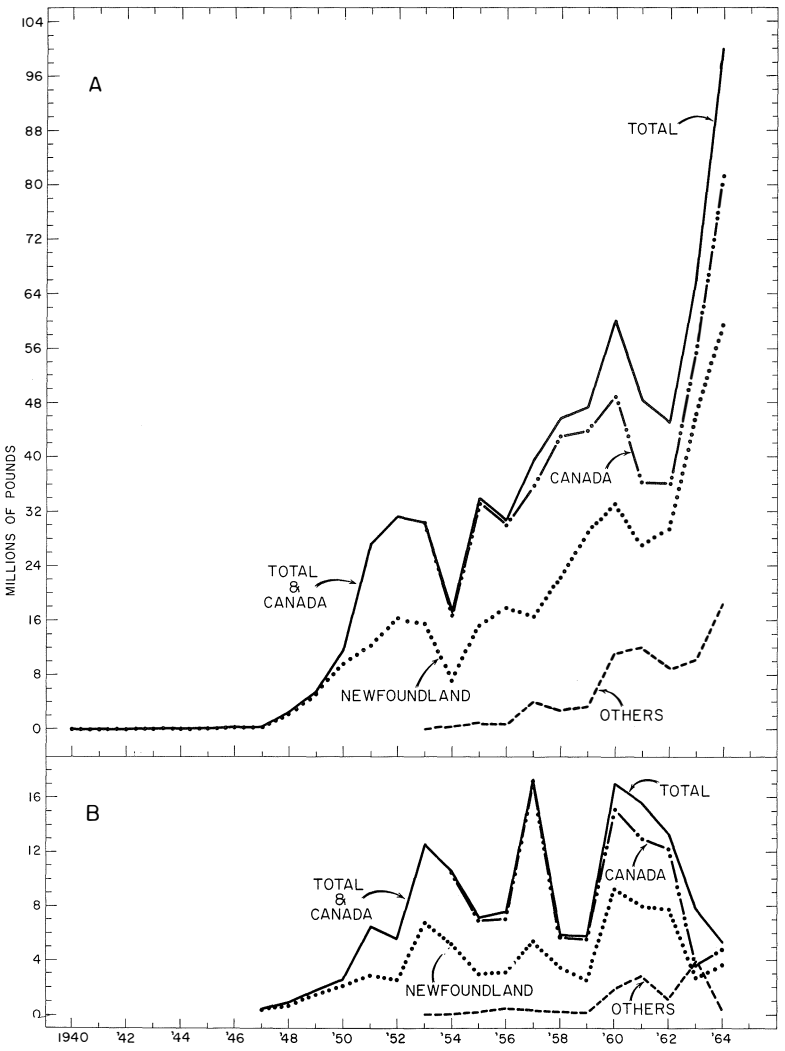


FIG. 54. A, landings of American plaice (whole fresh weights) by various countries and Newfoundland from ICNAF Subarea 3, 1940–64. (United States landings in the early 1950s were small, could not be separated from those of other flatfishes, and are not included.) B, landings of witch flounder (whole fresh weights) by various countries and Newfoundland from ICNAF Subarea 3, 1947–64.

(Fig. 18). Also, a decline in the abundance of cod reduces the numbers of small American plaice which are eaten by cod.

There was formerly considerable difficulty with a jellied condition of the flesh (Templeman and Andrews, 1956). This condition was increasingly evident in the older and larger fish, particularly large females. The jellied flesh had too much water and too little protein. The condition appeared to be due to lack of ability to digest enough highly nutritious food to keep body protein at a high level and also to provide protein for the great quantities of eggs produced. The fishery has reduced the numbers of these old fish and the jellied condition has not given so much difficulty in recent years and will give less in future as the fishery is intensified.

More Information

Additional information on American plaice of the Newfoundland and neighbouring areas may be found in Huntsman (1918), Templeman and Andrews (1956), Yanulov (1962c), Pitt (1963, 1964), Powles (1965), and Templeman (1965e).

Witch flounder

Glyptocephalus cynoglossus

The witch flounder, or greysole, is a small-mouthed species that lives in relatively deep water. The Newfoundland landings began in the mid 1940s with the establishment of the local otter-trawling fleet.

Distribution and Landings

Some of the landings have been made by Danish seining in Fortune Bay and St. George's Bay; this method of fishing is especially efficient for witch. The St. John's Station's exploratory operations by Danish seine, mainly for witch but also for American plaice, were described by Stewart (1956). The best grounds found for Danish seining for witch and American plaice were west of Cape Breton Island and on the southwestern slope of the Grand Bank. St. George's Bay is also a good ground for Danish seining for witch.

Usually, most of the witch landings come as a by-product of the winter and spring fishery for haddock on the southwestern slope of the Grand Bank. Total witch landings from Subarea 3, the main area for the Newfoundland landings (Fig. 54, B), rose to 12.5 million lb in 1953 and 17 million in 1957 and 1960. Newfoundland landings since 1958 have usually been a little over half the total landings of this species.

With the decline of the haddock fishery, witch landings from Subarea 3 declined greatly to 8 million lb in 1963, 2.7 million being taken by Newfoundland.

In 1964, Newfoundland landings from this subarea were 3.6 million lb from a total of about 5.2 million. They are expected to remain at a low level as in 1963–64 until the haddock fishery increases again. From Subarea 4 Newfoundland landed only 0.3 million lb of witch in 1962 but 4 million in 1963 and 3 million in 1964.

The witch flounder occurs also in deep water north of the Grand Bank and off Labrador and northeast Newfoundland. North of the Grand Bank there are only a few individuals in the usual otter-trawl catch. At the mouth of Hawke Channel off southern Labrador, however, the research vessel *A. T. Cameron* caught very large witch at 5000 and 3000 lb per hour in two sets at 300 and 350 fath in early April 1963. On April 4, 1964, in the same area the *A. T. Cameron* in a half-hour drag at 300 fath caught 7300 lb of witch averaging 3.1 lb, along with 2100 lb of redfish and 450 lb of American plaice. In 1964 the witch in this area were largely concentrated at about 300 fath since less than 30 lb per drag were obtained at 250 and 350 fath. These were apparently prespawning concentrations, as no significant catches of witch were obtained by the research vessels *Investigator II* and *A. T. Cameron* during many otter-trawl sets over a number of years in deep water in summer–early autumn in the Labrador and Northeast Newfoundland shelf areas. There is no Canadian fishery at present in the offshore Labrador area.

The Future

With present trawling methods only a relatively small production of witch flounders can be expected from the southwestern slope of the Grand Bank in the near future. In this area these flounders are mainly a by-product of the haddock fishery and there is no evidence at present that the haddock stock of the Grand Bank is likely to return to its former abundance in the next few years. On the other hand it is probable that witch may be caught by Danish seining in this area, as was demonstrated to some degree by the *Matthew II* when operated by the St. John's Station (Stewart, 1956). A moderately large Danish seiner would, however, be necessary and might also have to be adapted to otter trawling to be profitable. Witch are usually close to or on a rather soft bottom and are caught much more readily by a gear such as a Danish seine which scrapes the bottom than by a typical trawl with large rollers. Trawlers using one or more of the following methods more adaptable to catching witch might catch commercial quantities in this area at least in late winter and in spring: a thickened and weighted groundline without rollers, a groundline with small rollers, slow dragging, and a tickler chain in front of the groundline.

Some fishing for witch by Danish seine should still be possible in Fortune Bay. Danish seiners based near or in St. George's Bay might make use of the witch stock of this bay and also of the American plaice and witch populations west of Cape Breton Island (Stewart, 1956) and possibly east of Cape Breton Island.

On the Scotian Shelf east of Cape Breton Island, witch flounders concentrate in the deep holes in winter and may then often be fished by trawlers as a primary fishery.

There is no reason to believe that the large catches of witch in deep water off Labrador by the *A. T. Cameron* in early April represent a large population, but for a period it is very likely possible to make significant catches from this prespawning and spawning concentration.

More Information

Further information on witch flounder may be found in Bigelow and Schroeder (1953) and in Stewart (1956). Although researches on witch distribution and life history are in progress at the St. John's and St. Andrews Biological Stations of the Fisheries Research Board of Canada, the results of these have not yet been published. Information is available, however, in some of the mimeographed annual reports of these Stations.

Atlantic halibut

Hippoglossus hippoglossus

Most Atlantic halibut landed in Newfoundland are taken by line vessels as a by-product of the cod fishery and in deep-water otter trawling for haddock in winter and spring. There is some fishing, especially for halibut, by longliners. In recent years the European fishery in the area has increased rapidly, but most of the catch is still being landed in Nova Scotia.

Distribution

The best halibut grounds of the area extend from the southern slope of St. Pierre Bank to and along the southwestern slope of the Grand Bank. The seaward slope of the Scotian Shelf, the slopes of the Esquiman and Mingan channels of the Gulf of St. Lawrence, and most of the area around Anticosti Island are also excellent fishing grounds for this fish. Halibut also come into shallow water in summer along the west coast of Newfoundland, but only rarely on the east coast. Though moderate amounts have been caught in the deep water from north of the Grand Bank to Labrador by Norwegian and Faroese cod longliners and by German and Russian otter trawlers fishing for redfish and cod, there is no evidence of enough halibut in this area to supply a specialized halibut fleet.

Landings

Newfoundland landings of halibut changed little between 1910 and 1961, usually varying within 200 thousand lb above or below half a million lb (Fig.

55, A). In one year, 1927, there must have been a special effort to catch halibut and 1.3 million lb were landed. In 1962 there was a marked increase to 1.7 million lb and in 1963 and 1964 a decline to 1.0 million and 1.2 million. Whereas from 1910 to 1928 the United States and Canada shared the halibut landings equally, from 1929 the Maritimes and Quebec share increased and the American fishery declined.

The total landings from Subareas 2, 3, and 4 from 1956 to 1964 ranged between 7.9 and 12.8 million lb. In 1961, 5.2 million lb were landed from each of Subareas 3 and 4 and 0.4 million from Subarea 2. By 1963, with the great decline of the haddock fishery in Subarea 3, halibut being produced as a by-product, the landings from this subarea fell greatly to 2.8 million lb. The landings from Subarea 4 fell slightly to 4.6 million lb, and only 64 thousand lb were taken in Subarea 2. Total landings from these 3 subareas in 1964 were 9.3 million lb, with Canadian landings of 5.5 million and European landings of 3.7 million. Some of the latter may have been Greenland halibut.

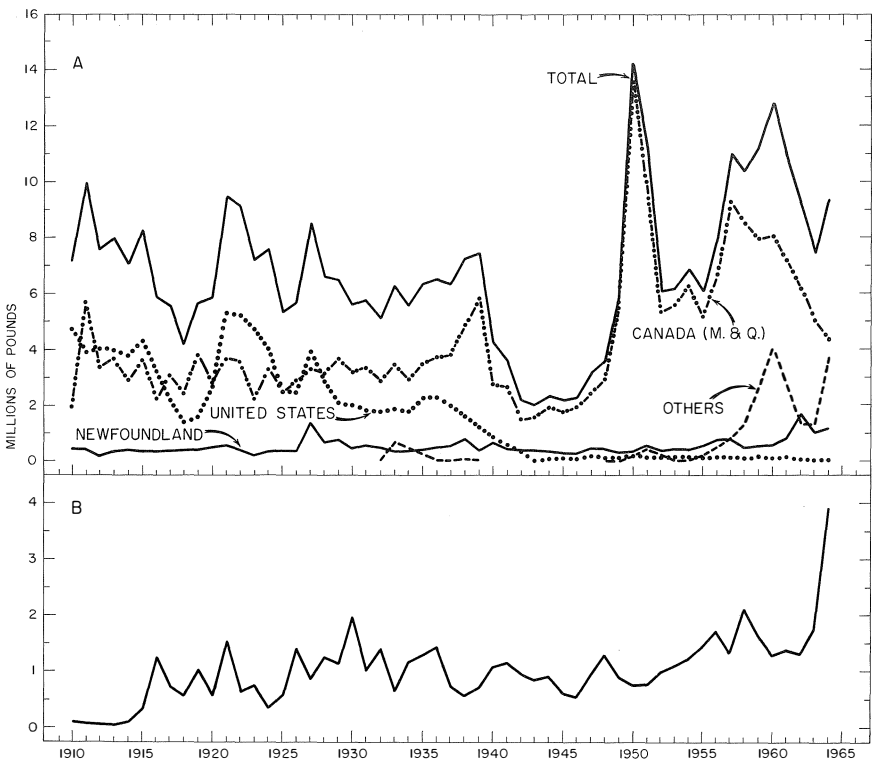


FIG. 55. A, landings of halibut (whole fresh weights) from ICNAF Subareas 2, 3, and 4, 1910–64. B, Newfoundland landings of Greenland halibut, 1910–64. (The production of pickled Greenland halibut was multiplied by 1.5. It is uncertain whether the result represents the head-on, gutted weight or the whole fresh weight.)

The Future

The Newfoundland share of the Canadian and ICNAF halibut fishery could be increased considerably. But most landings by specialized halibut-fishing vessels owned by other than local fish plants may continue to be made in Nova Scotia, where landed prices are higher.

More Information

For more information on halibut, particularly in Subareas 3 and 4 of the Northwest Atlantic, see McKenzie (1946b), McCracken (1958), and Kohler (1962).

Greenland halibut, or turbot

Reinhardtius hippoglossoides

The Greenland halibut, always called turbot in Newfoundland, is caught by a line fishery in the deep water of many Newfoundland bays. Notre Dame, Trinity, and White bays have traditionally been the most important. At present the fishery is concentrated chiefly in the western part of Notre-Dame Bay and in Trinity Bay. A winter–spring fishery was formerly carried on in Fortune Bay and to a limited extent in Trinity Bay.

This fish has typically been salted in barrels, but in 1964 more than 50% of the landings were exported as frozen fillets. The fish is rather fatty and needs to be salted under cool conditions.

The Greenland halibut has a market in Europe, and Norway alone landed 17.6 million lb from the Northeast Atlantic in 1960. Lightly smoked Greenland halibut is regarded as a delicacy in Denmark and Germany.

In exploratory cruises northward with the *A. T. Cameron* we have found this fish in moderate numbers, up to 1000 lb of large Greenland halibut per hour's dragging, along the Labrador and Baffin Island slopes as far north as Davis Strait. Good catches of 500–1000 lb were made at 200–400 fath, the best being usually at 300 fath and toward the northern part of this range.

Landings

In recent years the Newfoundland landings have been determined mainly by the available market, and more Greenland halibut could have been caught if it had been commercially profitable.

Almost all the landings recently have been made between May and December, the greatest being from August to October in 1962–63 and from July to September in 1964.

The highest landings, 3.9 million lb, were made in 1964 (Fig. 55, B). The highest previous landings, slightly over 2 million lb, were made in 1958, and the landings were almost as great in 1930. The 1963 landings were 1.7 million lb.

The reported landings of Greenland halibut from the ICNAF area in 1964 were 14.5 million lb. This being a northern deep-water fish, the landings from Subareas 1, 2, and 3 were 6.3, 1.2, and 7.0 million lb and only 4 thousand lb were reported for Subarea 4 and none for Subarea 5. Additionally in 1964 it is very likely that more than 1 million lb of this fish were included in the "unspecified flounder" category in the ICNAF statistics for the southern part of Subarea 2 and the northern part of Subarea 3. The recent increases in landings of Greenland halibut were produced by the intensification of this fishery by Greenlanders, by the increased fishing by European trawlers at greater depths for redfish in the northern Newfoundland areas, and by an increase in the Newfoundland catch with the opening of a European market for the frozen product.

The Future

The future of the Greenland halibut fishery depends largely on the markets for the fresh or frozen product; at present the demand appears to be good, especially in Europe. The fish is a nutritious food with a moderately high fat content. It is caught readily by lines and gill nets and is a by-product of the Polish, German, and Russian fishing for redfish in deep water in the northern parts of the Newfoundland area. The landings of Greenland halibut from such deep bays as Trinity Bay and the various deep arms and bays of Notre Dame Bay can be increased well beyond former levels but there are definite limits to fisheries for large flatfishes such as halibut and Greenland halibut.

What the yield of Greenland halibut may be for any one of these deep arms or bays can only be determined by fishing, but if the fishery is pursued too intensively in any one area the landings will eventually drop to a lower level.

More Information

Some research on Greenland halibut of the Newfoundland area has been begun but the results have not yet been published. For an account of the biology and distribution of this species in the neighbouring West Greenland area see Jensen (1935) and for the relationships of Atlantic and Pacific Greenland halibut, Hubbs and Wilimovsky (1964).

Atlantic herring
Clupea harengus harengus

Landings and Distribution

Since 1910 there have been two periods of large landings of Atlantic herring in the Newfoundland area, one during and immediately after each of the first

and second world wars (Fig. 56, B). The greatest landings, over 160 million lb, were made in 1946. These great landings were made possible because only during these periods could the thin herring, available so plentifully in spring near spawning time, be sold in quantity as salted fish. Since 1946, landings have rapidly declined and in recent years have been below 20 million lb.

Some large herring populations have disappeared. The Fortune Bay and the Labrador herring fisheries, once major fisheries, have largely gone out of existence. The centre of the herring fishery on the west coast, for many years in the Bay of Islands, shifted to the neighbouring Port au Port Bay and more recently to Bonne Bay.

In the period 1958–62 most of the herring (Fig. 56, A) were landed in the area from Port au Port Bay to Bay of Islands (District L) and in the St. Mary's Bay and Placentia Bay areas (Districts G and H). In a former period of much larger landings (1945–50) the greatest quantities were landed from Placentia Bay (H), Fortune Bay (I), and Bay of Islands (L), with significant quantities from Trinity Bay (D) and the western part of the south coast (J).

The Newfoundland herring fishery is entirely a coastal fishery carried out mainly by gill nets and purse seines. No great quantities of herring have been found offshore on the Newfoundland banks, a catch of even as large as several hundred herring in an otter-trawl set on the Grand Bank or St. Pierre Bank being unusual. In the Gulf of St. Lawrence, herring are often available in quantity in many areas: off the west coast of Newfoundland, the Magdalen Islands, Prince Edward Island, and mainland areas.

Spawning, Disease

Most of the herring in the Newfoundland area are spring spawners. These spawn mainly from mid May to mid June in shallow water near shore on many parts of the coast, particularly at the heads of the bays and other inlets (Tibbo, 1956). Spawning is earliest on the south coast. There are also fall spawners (Olsen, 1961), which spawn in deeper water than the spring spawners.

In 1955–56 a fungal disease caused heavy mortalities of herring in the Gulf of St. Lawrence, including the west coast of Newfoundland.

The Future

The recent low catches of herring in the Newfoundland area are due partly to scarcity of the fish in autumn and winter on the west coast of Newfoundland and in Fortune Bay. Other factors are scarcity of catching facilities, and presumably lack of markets and of a price high enough to encourage fall fishing for fat herring or spring fishing for thin herring. It is, however, unlikely that more than 5% of the herring available in the Newfoundland–Labrador area have been caught in recent years.

Large increases in landings will depend on obtaining much more information on the herring stocks of the area, their condition, and their periods and localities of concentration.

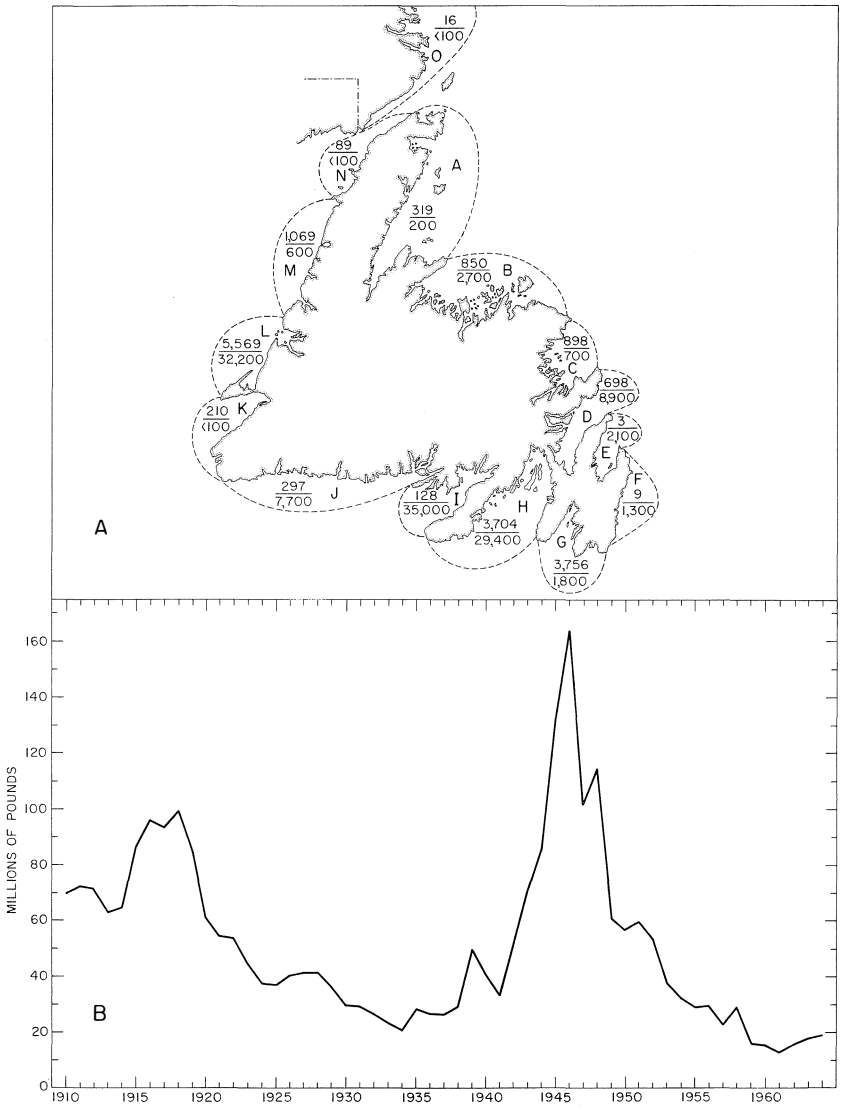


FIG. 56. A, average yearly landings of herring (thousands of pounds. round fresh weights) in the statistical districts (A to O) of Newfoundland, 1958—62 (upper figures) and 1945—50 (lower figures). B, Newfoundland landings of round fresh herring, 1910—64. (In this and succeeding figures of the same type, district O includes all of the Labrador area. In the maps of Fig. 56—58 and 60—62, statistical data of landings were adjusted by Mr C. R. Molson from answers to inquiries and questionnaires to agree with actual areas of capture.)

More Information

For an account of herring explorations in this area with echo sounder, purse seine, otter trawl, drift net, and set gill net see Leim et al. (1957). For an account of the herring of the Gulf of St. Lawrence, Fortune Bay, Nova Scotia, and the Bay of Fundy, including herring biology, exploratory fishing for herring, and hydrographic relationships, see the report of the Atlantic Herring Investigation Committee (Leim et al., 1957). Scattergood and Tibbo (1959) gave information on the herring fishery of the Northwest Atlantic, including statistics of catch, fishing methods, and utilization of the catch. For a bibliography of herring in the Northwest Atlantic see Biological Laboratory, Boothbay Harbor, Maine (MS, 1964).

Atlantic mackerel

Scomber scombrus

Mackerel are moderately warm-water fish. They are very common off the eastern United States from Virginia northward, common on the Scotian Shelf and in the southern part of the Gulf of St. Lawrence, and only intermittently present in large numbers on the east or south coast of Newfoundland. In some years, small numbers go to the west coast. In one year of abundance (1871) they were reported by Brown (1872) to be plentiful at St. Charles Harbour and at Battle Harbour, Labrador. The southern part of the Gulf of. St. Lawrence is presumed to be the northern limit of their spawning range.

There are regular southward fall migrations to wintering areas, presumably at the edge of the continental shelf, and northward winter–spring and early-summer migrations into the inshore areas of the southern Gulf of St. Lawrence. Those arriving on the northeast coast of Newfoundland are likely to come, mainly at least, from the Gulf of St. Lawrence through the Strait of Belle Isle. Those of the south and southeast coasts may be a direct offshoot from the northward migration over the Scotian Shelf.

Landings

Newfoundland landings of mackerel are entirely from the coastal area. The largest landings in recent years have been from Notre Dame Bay, District B. Lesser landings have been made in District A, where they were very plentiful in White Bay in 1962, and still smaller landings have been made in the more southern areas I, D, J, C, H, and L (Fig. 57, A).

The Newfoundland landings (Fig. 57, B) from 1856 to 1885 indicate two short periods of minor abundance: 1870–72 and 1879–80. The greatest landings in the period, 860 and 730 thousand lb in 1879 and 1880, were taken during the last of four great periods of abundance as indicated by New England catches

between 1820 and 1890. The catches in 1870–72 (270–420 thousand lb) were made in the latter part of the third period of abundance in New England.

After 1880 the Newfoundland fishery disappeared and on the east coast mackerel were almost unknown (Templeman and Fleming, 1953) until the recent period of climatic warming. Some were caught in the 1930s but large numbers only since 1946, the peak catches being 5.1 million lb in 1952 and 5.7 million in 1953. The catch declined to near zero by 1959 but mackerel became moderately abundant again in 1960–64.

The market desires the very fat fish available in the latter part of the year. Also, this fish should be kept cool and frozen quickly after catching, or salted under cool conditions. For these reasons, and also presumably because they are then

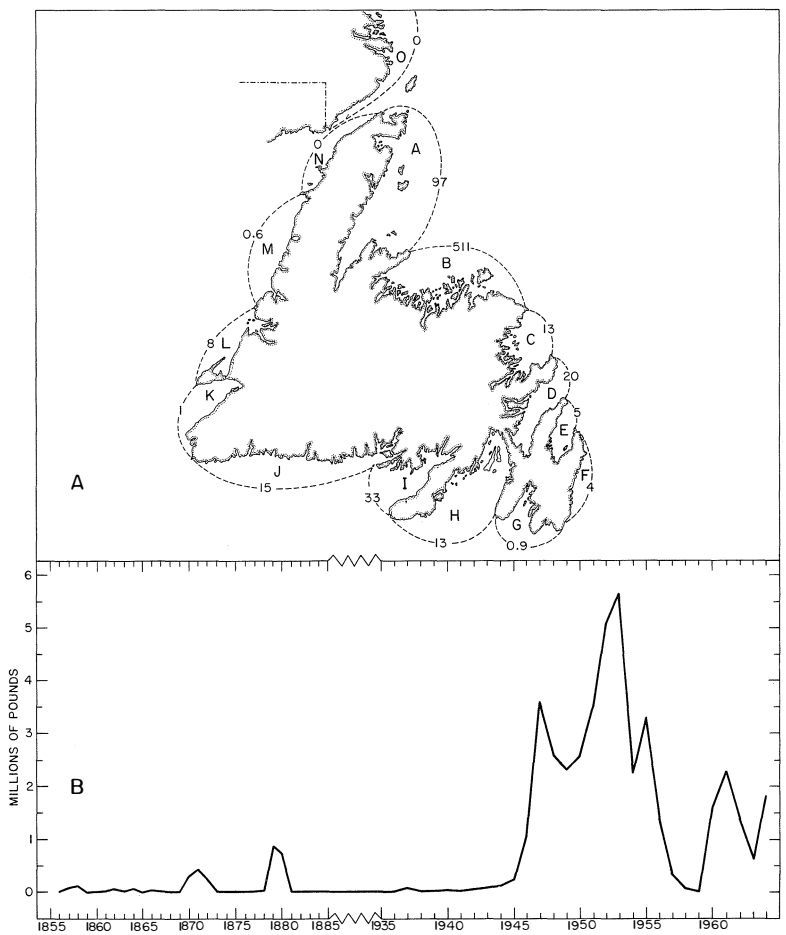


FIG. 57. A, average yearly landings of mackerel (thousands of pounds, round fresh weights) in the statistical districts of Newfoundland, 1958–62. B, Newfoundland landings of round fresh mackerel, 1856–1964.

more plentiful, they have been caught in Newfoundland mainly from August to December. Small catches have been made in June and July.

Methods of Capture

The usual method of capture in Newfoundland is by placing a bar seine across the mouth of some cove into which mackerel have chanced to enter. Mackerel may be caught in quantities by purse seine, the usual American method of capture. They may also be caught by hook and line and, in some areas, by gill net.

The Future

Evidently the supply of mackerel in Newfoundland waters will fluctuate according to whether, as in recent decades, the water temperatures are higher than usual. Significant quantities are likely to be available only when there are large populations in the southern Gulf of St. Lawrence and Nova Scotian areas. Much larger quantities than heretofore could be caught in Newfoundland during the periods of abundance if enough suitable gear were available, but the fluctuations in supply make it difficult to plan long-term operations with specialized gear and freezer or cool-storage space.

More Information

No research on mackerel has been carried out in Newfoundland, and little during the past 30 years in Canada or during the past 25 years in the United States. The best references for the biology of this species and for an account of the mackerel fishery of the east coast of North America are by Sette (1943, 1950).

Bluefin tuna

Thunnus thynnus

The bluefin tuna of the Newfoundland area, or horse mackerel as they are known by Newfoundland fishermen, average about 450 lb.

Distribution, Methods of Capture, and Landings

These giant tuna, like those in the Nova Scotian area, are likely to be adults that after spawning migrate from the Bahamas region through the Florida Strait in May. Travelling at 80 miles a day in the earlier part of their journey, they arrive in the Cape Cod area by early June and off Wedgeport at the southern end of Nova Scotia by early July (Rivas, 1954). They may arrive on the southern part of the east coast of Newfoundland by the latter half of July. They are often common around the Newfoundland coast in August and September, and decrease in numbers in October and November as they retreat southwards again.

These fish do not feed during spawning and are hungry when they begin their northward migration. Their journey northward brings them to an abundant food supply and cooler water, and they become very fat. In Conception Bay they are reported to feed heavily on squid when these are abundant and to a considerably lesser degree on herring, mackerel, and billfish. On the east coast of Newfoundland they are found in the upper, warm layer of water above the intermediate, cold layer. When they arrive in July the water is apparently usually too cold for feeding and except when the water is warmer than usual they do not bite. Feeding is resumed and troll fishing is successful in August and September (the months with the highest surface temperatures but usually not over 15 C (59 F) in the open bays of the east coast).

At least seven bluefins tagged off the USA coast have crossed the Atlantic. Five of these were giant tuna, one of which made the 5000-mile journey in 50 days and another in 118 days (Lineweaver and Bartlett, 1963).

Tuna are not fished commercially in Newfoundland but are caught in Conception Bay for sport by trolling with baited hooks. They have at times also been reported to be in the bays of the west and south coasts and on the east coast in Bonavista Bay and even Notre Dame Bay.

In Conception Bay the Newfoundland Tourist Development Office began the sport fishery by angling in 1956 after some preliminary attempts on various parts of the coast. The three most successful years have been 1961 (133 tuna, 68 thousand lb between August 1 and September 28), 1963 (270 tuna, 116 thousand lb), and 1964 (316 tuna). Only a small amount of this production was used locally for food and the remainder was discarded. These tuna are usually between 300 and 700 lb and occasionally over 800 lb.

The Future

Large quantities of the tuna could possibly be caught by purse seine. They have been reported in large schools. Also, as they are found in warm surface water above a cold layer they would be somewhat impeded in escaping a deep purse seine by diving below it. The bluefin tuna, however, possesses dark meat, does not bring a high market price at present, and purse seining is costly.

A tuna seiner would be unlikely to make a profit if it depended only on the tuna which reach Newfoundland. It would be necessary also to follow the tuna southward in winter and to fish southward in spring and early summer before they arrive in Newfoundland waters. Also, in the south some of the more valuable, white-meated tunas would be obtained as well as smaller bluefins. Such southward-ranging cruises would very likely land in the southern Maritimes. United States catches of tuna on the Atlantic coast, mainly by purse seine, are rising rapidly and in 1963 purse seine fishing for tuna was begun in southern New Brunswick.

Where tuna come close to shore they could be caught in a strong trap as they are in St. Margaret Bay, Nova Scotia, and near Cape Cod. They may be harpooned

or caught with floating longlines, but the latter might be restricted to the warmer months or weeks by the rather low temperatures prevalent around Newfoundland, especially on the east coast.

More Information

For more information on bluefin tuna in Newfoundland, see Williamson (MS, 1962); and for information on the distributions of bluefin and other tunas and the possibility of a Canadian fishery for tuna in the Atlantic, see Canada, Department of Fisheries (MS, 1963) and McKenzie (MS, 1965).

Swordfish

Xiphias gladius

Swordfish are northerly migrants into the Newfoundland area in summer after spawning. They spawn mainly before June, probably north and northeast of the Lesser Antilles in the southern part of the Sargasso Sea, and in parts of the Caribbean (Tåning, 1955). As a rule only the larger fish reach the Newfoundland area. They do not school closely, though as many as 20–40 fish may be seen at one time at the surface.

Swordfish grow to a large size. A fish of 1100 lb whole weight has been recorded for Georges Bank. The dressed weight of the individual fish landed in the Canadian area is mainly between 40 and 350 lb and only occasionally beyond 450 lb.

Distribution, Landings, and Methods of Capture

The main fishing ground for swordfish in the Newfoundland area is the southwestern Grand Bank. For five days, July 12–16, 1953, the research vessel *Investigator II* was fishing redfish in deep water (200–400 fath) on the southwestern slope of the bank. During this period, staff of the St. John's Station saw large numbers of swordfish at the surface all along the southwestern slope from south of Whale Deep to the extreme southern tip of the bank. Surface temperatures were between 14.6 and 16.7 C (58.3 and 62.1 F). In the the same year, Nova Scotian and Newfoundland vessels reported large catches of swordfish from this southern Grand Bank area but made all the landings in Nova Scotia. In recent years, good fishing for swordfish on the southwestern Grand Bank has been reported at least to mid October.

Swordfish are reported to be sometimes fairly numerous on the western half of the south coast of Newfoundland, from the latter half of July to October. Fishery officers have reported them in small numbers at least as far north as Little Bay Islands in Notre Dame Bay.

The landings in Newfoundland have been very small. Yearly landings between 1937 and 1948 averaged 31 thousand lb, with highs of 67 thousand in 1946 and 58 thousand in 1947. From 1949 to 1962 they averaged only 1300 lb, with a high of 9 thousand in 1954. In 1963, however, the 200-ton, 117-ft longliner *Beinir,* operated by the Newfoundland Department of Fisheries, obtained good catches from longlines set at the surface. This vessel operated at first southward off Georges Bank and followed the swordfish in their northeastward migration. On a 12-day cruise to Banquereau and the western Grand Bank, with a crew of 11 men, the catch was 59 thousand lb. The landed dressed swordfish from this cruise averaged slightly more than 200 lb. As a result of the *Beinir*'s landings in Harbour Grace from two trips, the landings up to the end of October 1963 totalled 91 thousand lb (123 thousand lb round).

The Canadian Atlantic landings, almost all in Nova Scotia, are much greater. These landings rose slowly from a beginning in 1909 or earlier to about 2–3 million lb between 1940 and 1950; then they rose rapidly to 6.7 million lb with a landed value of $1,400,000 and an exported value of $2,300,000 by 1959 (Tibbo et al., 1961). During this period the fish were harpooned at the surface. In 1961 and 1962, Norwegians fishing in the Northwest Atlantic with floating longlines for mackerel sharks also caught swordfish. Canadians and Americans also began fishing for swordfish with floating longlines. The larger catches resulting from this method increased Canadian swordfish landings in 1963 to 19 million lb.

The main Canadian landings are made from June to October, with modest landings in May, November, and December and small landings from January to April. In October to December 1962 an American longline vessel fished swordfish successfully south of Cape Cod (Lineweaver and Bartlett, 1963). By January most of the swordfish had migrated still farther southward. Thus, a well-equipped vessel can continue to fish swordfish in winter during their southward migration. In 1959 the Canadian fishery extended from Georges Bank to the Grand Bank but was concentrated near Sable Island Bank and on the seaward slopes of Banquereau (Tibbo et al., 1961). In 1964, Canadians landed 7.1 million lb from off Georges Bank in Subarea 5, 7.6 million from the slopes of the Scotian Shelf in Subarea 4, and 1.2 million from the slopes of the southwestern Grand Bank and southern St. Pierre Bank in Subarea 3. Additional landings were made in winter from as far south as off Cape Hatteras. Newfoundland landings were only 480 lb.

Swordfish are caught at moderately high temperatures. For the Scotian Shelf–Georges Bank area, Tibbo et al. (1961) stated that they are most common where surface temperatures slightly exceed 60 F (15.6 C). Lineweaver and Bartlett (1963) said that, in the recent autumn and winter fishing south of Cape Cod, the longline fishing is done at night at the edge of the continental shelf and the best fishing is where the surface water is at or on the cool side of 60 F (15.6 C).

The Future

The swordfish fishery is still developing and is highly profitable at present levels. But it is too early to predict the future of the fishery. The recent fishery with longlines, which catch males as well as females, offers a better biological utilization of the stock than the former harpoon fishery, which caught almost only females.

More Information

For more information on swordfish, see Tibbo et al. (1961).

Atlantic salmon

Salmo salar

Landings

Atlantic salmon have been used commercially in Newfoundland and Labrador for centuries as salted fish. Newfoundland landings rose in the 1920s with increasing use of salmon for exporting fresh or frozen and in 1930 the fishery reached its highest commercial production, close to 7 million lb (Fig. 58, B). Since then the landings have declined, but were almost 6 million lb in 1938 and averaged over 4 million from 1946 to 1949. In the period 1954–64 they have averaged 2.2 million lb a year, but landings have been rising since 1956. In 1963 they were 2.7 million lb, and in 1964, 2.8 million, the highest since 1953.

The landings are highest in southern Labrador and on the northeast coast of Newfoundland (O, A–D of Fig. 58, A), high in southwestern Newfoundland (J, K), and lowest on the eastern part of the south coast and the northern part of the west coast (G–I, L–N).

In addition to the commercial landings in 1962–64, about 26–43 thousand salmon (89% grilse of 6 lb and under in 1962–63), or about 120–190 thousand lb per year, were caught in Newfoundland rivers by anglers. These angling catches have risen from 17 to 22 thousand salmon in 1958–61 to 42,500 in 1964.

Origins

Many of the large Atlantic salmon landed on the east coast of Newfoundland appear to originate as smolts in New Brunswick and Quebec rivers of the Gulf of St. Lawrence (Elson and Kerswill, 1955; Blair, 1956). Their numbers and availability in the Newfoundland coastal area, therefore, depend largely not only on local ice conditions, favourable wind, and other environmental factors, but also on river conditions in these Gulf of St. Lawrence areas, especially the Miramichi and Restigouche rivers. Spraying of DDT over these areas in recent years to control the spruce budworm destroyed great quantities of young salmon (Keenleyside, 1959). Most of the grilse (about 3-6 lb) in the Newfoundland catch, on the other hand, are produced locally. The Labrador landings presumably depend

chiefly on local production but some of the salmon come from rivers of the Gulf of St. Lawrence.

Landlocked Form

In addition to the sea run, landlocked Atlantic salmon are common in many Newfoundland river systems. These are usually smaller than the seagoing form and mature in lakes. At their smaller sizes, they are known in Newfoundland as salmon peel, as are parr and smolts of the seagoing form.

The Future

Some increase can be made in the Atlantic salmon catch through increasing the river space available to them. Almost all the tributary space of many of the south-coast rivers and even of the great Exploits River is unavailable to salmon.

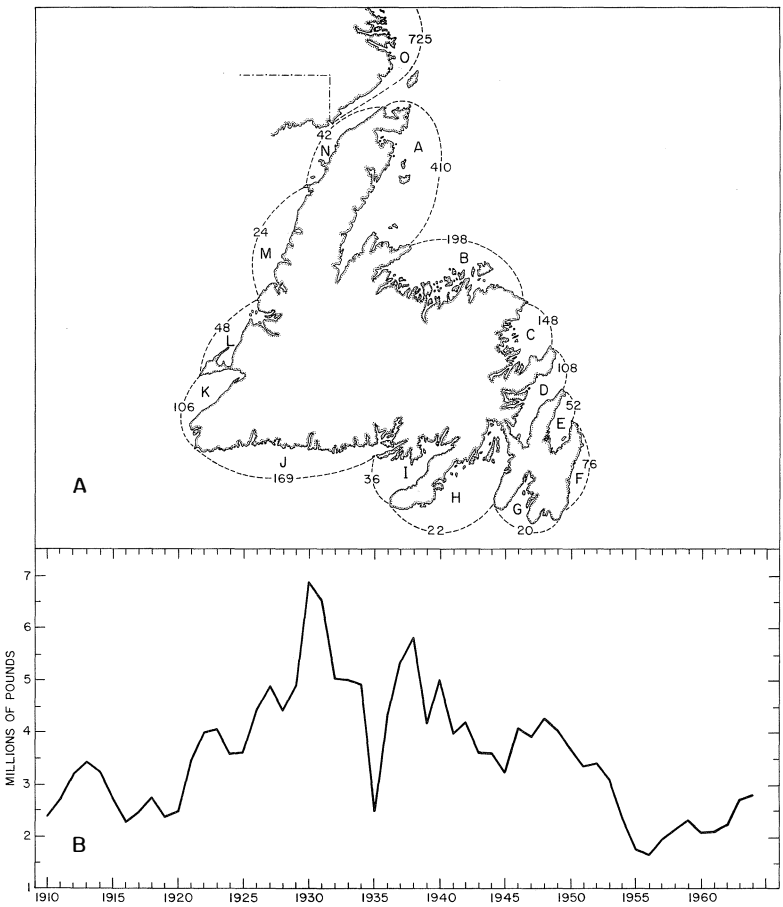


FIG. 58. A, average yearly landings of Atlantic salmon (thousands of pounds, round fresh weights) in the statistical districts of Newfoundland, 1958–62. B, Newfoundland commercial landings of round fresh salmon, 1910–64.

No great increases in the salmon, however, are likely because factors affecting fresh water — destruction of forested areas by fire, building of hydroelectric and other dams, and drainage of land areas — are all either decreasing the summer flow and increasing the temperatures of rivers or creating barriers to salmon movements. Also, forest spraying, pollution from paper mills, mines, sewage, and other sources, and access roads to headwater spawning areas are all increasing. Affecting the commercial fishermen, also, is the inevitably increasing pressure to preserve more Atlantic salmon for angling. Atlantic salmon of the Newfoundland area are restricted in numbers by spending a long period — usually 3–5 years — in the river before they go to sea as smolts (Lindsay and Thompson, 1932; Blair, 1943). Their numbers in the river are reduced by eels, mergansers (shell ducks), trout, competition among themselves, and the relatively small amount of food in the river waters.

An increasing fishery for Atlantic salmon off West Greenland is likely to reduce greatly Newfoundland and other Canadian landings. The salmon are common along the west coast of Greenland, especially in September to November, and on the banks, especially at Store Hellefiskebanke (about 67° 30′N). They are found also on the east coast. The bank catches are taken by trawlers at depths of usually 15–20 fath, chiefly in September and October. Usually trawlers take only a few salmon at a time, but captures of 50 or more have been made in a trawl haul taken for cod. Very few of the salmon caught in West Greenland can be of West Greenland origin: very few salmon are produced in Greenland rivers and the scales of the commercial fish show lower river ages than those of the salmon of the only Greenland stream which has a spawning run of Atlantic salmon (Nielsen, 1961).

Before 1959, the West Greenland landings of Atlantic salmon were apparently too small to be recorded in the fisheries statistics (Bulletin Statistique des Pêches Maritimes, Conseil Permanent International pour l'Exploration de la Mer).

Jensen (1939, 1948) said that Atlantic salmon were numerous in West Greenland in 1935 and 1936, especially in the autumn, about 200 being caught at Ikerasak in the autumn of 1935. In these years the salmon were apparently used for home consumption.

The West Greenland landings of Atlantic salmon since 1959 have been (in thousands of pounds): 1959, 31; 1960, 132; 1961, 265 (+4 by Germany); 1962, 639 (Bulletin Statistique); 1963, 1028 (unpublished Bulletin Statistique data from Dr Arni Fridriksson). The 1964 West Greenland exports of 3056 thousand lb head-on gutted weight (Hansen, 1965) would be equivalent to about 3450 thousand lb round weight. Additionally there is some local consumption, which Dr Hansen (in conversation with the author, June 1965) said would not be higher than 100 thousand lb. West Greenland landings in 1964, therefore, were in the vicinity of 3½ million lb round weight. Additionally there

are some, but presumably small, quantities of salmon caught on the West Greenland banks by trawlers of many nations. These are either eaten or discarded and not reported in the statistics.

Hansen (1965) reported recaptures in West Greenland of 64 salmon tagged in Canadian and European rivers. These were from the following countries (and in the following numbers): Canada (23), USA (2), Ireland (4), England and Scotland (33), Sweden (2). Forty-seven were tagged as smolts and 17 as kelts, grilse, or salmon. Two were salmon from Newfoundland: one tagged as a grilse in the Little Codroy River in June 1960 and caught in West Greenland in November 1961; and a second tagged at Great Rattling Brook, Notre Dame Bay, Newfoundland, in August 1961 and caught in West Greenland in October or November of 1963.

The West Greenland landings are caught mainly in September–October in synthetic gill nets along the coast from about 61 to 69°N. They are feeding salmon of 1+ sea year and older, ranging from about 5¼ to 9 (average 7) lb and not preparing for spawning in the year that they are caught. They are mainly (about 90%) the group that provides the small salmon of about 8–14 lb which return to their native rivers after 2 years at sea. The remainder are recovering spent fish (kelts), and fish of 2+ sea years and older which would return to their native rivers at 3 sea years or older as the large salmon of 15–30 lb or more.

More Information

For more information on the Atlantic salmon of the Newfoundland area, see Belding and Préfontaine (1938, 1961) and Blair (1957a, b). For a more detailed account of the recovery of tagged Canadian salmon in West Greenland, see Saunders et al. (1965) and Hansen (1965). For a bibliography of Atlantic salmon see Bergeron (1962) and for a review of Atlantic salmon and an annotated bibliography see Dymond (1963).

Pacific salmon

Oncorhynchus gorbuscha and *O. nerka*

On the Pacific coast the great quantities of salmon are made possible by the short river or lake life before the young salmon enter the sea with its abundant food. In some, such as the pink salmon, the young go down to sea 2–3 months after hatching so that all that is needed in the river is a spawning ground, often close to sea in a small river, though they live in large rivers also. Pink salmon live only 2 years. The most valuable Pacific salmon, the sockeye, generally lives only 1 year in a lake before going to sea as a smolt, and returns usually 3 or 4 years later for spawning.

Newfoundland has many small rivers where pink salmon could spawn and some lakes which may be suitable for young sockeye if the food supply is suffi-

cient. Some of the largest lakes like Gander Lake are deep and probably relatively lacking in food for young salmon. Because young Atlantic salmon live in streams, neither of these Pacific salmons is likely to compete significantly with the Atlantic salmon in its younger stages. The main competition would be for spawning areas, and presumably the stock of young Atlantic salmon in rivers would not be adversely affected.

These two species of Pacific salmon merit consideration for introduction to the Newfoundland area. But it must be realized that, though the rivers and river temperatures appear to be suitable, there may be in the Newfoundland inshore area many more capelin, young cod, pollock, squid, and other predators of young salmon than on the Pacific coast. Herring spawn in the inshore waters from the latter half of May to mid June. Thus spent, hungry herring are present in the estuaries and inshore areas close to the time of the seaward run of pink salmon fry (from May 7 to June 16 with the peak on May 24 in the 1963 experiment on introducing the species in Newfoundland). Also, Pacific salmon range thousands of miles to sea. In the Newfoundland area, because the variations in ocean temperatures and in ocean current patterns are considerably different from those of the North Pacific, the return may not be adequate. Further, if Pacific salmon became abundant, they would presumably be fished at sea internationally, as in the Pacific Ocean. The chances of success are small, therefore, but the rewards for success might be great.

At present a moderately large-scale attempt is being made by the Fisheries Research Board to introduce pink salmon in North Harbour River, St. Mary's Bay, Newfoundland. The returns of adults up to the present are far too few to replace the eggs from which these salmon were produced. The returns, however, are biologically interesting in that some adults have returned and spawned in their home river. For further information on this experiment see Quigley (1965).

Trout

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

Brook trout (speckled trout, mud trout) occur in almost every pond and stream in Newfoundland and the small trout are usually plentiful. Generally their size is restricted because of the lack of suitable small fishes as food. The native sea trout is a seagoing form of the brook trout. The brook trout is our most abundant and most used angling resource.

Brown trout were introduced into ponds and streams on the Avalon Peninsula from several European sources between 1884 and 1906. In many heavily fished ponds near St. John's these trout are more common than native trout since they are not so readily caught, grow larger, stand higher temperatures better, and control the abundance of the native trout by feeding on them. Brown trout have also established a large sea run in many of the streams of the Avalon Peninsula,

many individuals being over 10 lb and some over 20 lb in weight (Frost, 1940; Williamson, 1963; Scott and Crossman, 1964).

Rainbow trout were first planted in Long Pond near St. John's in 1887 (Frost, 1940). A hatchery at Murray's Pond has since liberated many rainbow fry, especially in the ponds north of St. John's, and the trout thrive in many of these ponds. There has been no indication of seagoing runs of rainbow (steelhead) trout, and introduction of the seagoing form is worth consideration. Commercial pond-rearing of rainbow trout, as in Denmark, is a possibility. In Denmark in 1964, 18 million lb were reared in about 700 trout farms. Newfoundland temperatures, however, might be low for fast growth.

Arctic char are present in some Newfoundland lakes and two small sea runs are known, at Parsons Pond River and in Parker's River, Pistolet Bay. But they are most abundant in the Labrador area, especially north of Cape Harrison (Andrews and Lear, 1956). Here there is a commercial gillnet sea fishery for these char (sea trout). Between 1947 and 1954 the amounts marketed from this area ranged from 70 to 270 thousand lb. In 1958–62 the average yearly landings were 263 thousand lb; 399 thousand lb were landed in 1963 and 338 thousand in 1964. The arctic char fishery is in July and August, during the short period which these trout spend at sea and in which they move only a few miles from their native rivers. Such a fishery related to river mouths and estuaries needs to be carefully regulated.

More Information

For more information on arctic char and other anadromous fishes of the Newfoundland area, see Andrews and Lear (1956) and Scott and Crossman (1964).

American eel
Anguilla rostrata

Landings

Eels were exported from Newfoundland, mostly to the United States, from at least the early 1900s. At first the eels were salted and later they were frozen. In most years from 1930 to 1961 there were no eel exports, but 6 thousand lb were exported in 1930, 29 thousand in 1931, 8 thousand in 1940, and smaller quantities in some other years. In 1962 the fishery was revived, the eels being mainly shipped alive to Europe. In 1962 the landings totalled 47 thousand lb; in 1963, 56 thousand; and in 1964, 26 thousand.

Landings of eels in the Atlantic provinces of Canada in 1960 totalled 735 thousand lb with a landed value of 19 cents per pound. Quebec landed 561 thousand of this total, mainly from the St. Lawrence River and its tributaries. In 1957 Quebec landed 1025 thousand lb.

Distribution and Life History

The American eel is numerous in many Newfoundland streams, rivers, ponds, estuaries, and barachois. It occurs in Labrador but very likely in small numbers. Young eels or elvers, about 2½–3 inches long, approach the river mouths probably in late spring or early summer in the Newfoundland area. Numerous elvers have been seen entering Salmon River, Bay d'Espoir, in late June.

Large numbers of elvers enter the rivers, streams, and lakes and remain in fresh water for many years. For the closely related European eel in Lake Windermere in England, the freshwater period ranges from 9 to 19 years (average 12) for females and from 7 to 12 (average 9) for males. It is possible that American eels are a little younger than European ones when they migrate to sea. Presumably, as in Europe, the females are much larger, and more numerous in fresh water, than the males. Many of the males and possibly some of the females remain and grow up in the estuaries, barachois, or harbours.

Having attained their full growth, occasionally in the St. Lawrence River up to more than 4 ft for females and less than half as long for males, the eels migrate to sea. These migrating eels are now at their fattest and in Europe possess silvery white bellies and are called silver eels. In Canada the bellies of the eels at this migrating stage are darker than those of the European eels, although not as dark as the backs of the fish. These migrating eels in Canada are from their colour called bronze eels or black eels. The fishery for these migrating eels in the St. Lawrence River, the centre of the largest Canadian fishery, is from the end of August to the end of November (Vladykov, 1955). They migrate chiefly during the hours of darkness; and in greatest numbers during floods after heavy rainfall; more migrate in the dark than in the bright quarters of the moon.

The American eel spawns in the Sargasso Sea, in deep water in the region between Bermuda and the West Indies. The young drift in the surface currents of the sea. They grow into elvers and enter North American rivers about a year later, whereas the young of the European eels originating a little to the east take 3 years to reach the European coast as elvers. The adult eels all die after spawning and never return to fresh water.

The Future

Eels are caught in Newfoundland with baited eelpots and fykenets in areas relatively close to shipping points. To attain the considerably higher catch levels possible in this fishery it is very likely that eeltraps such as are used in Nova Scotia (Anon., 1960) will need to be used in the larger streams and rivers. For continued production, landings should mainly consist of the fully grown eels migrating to sea for spawning.

MORE INFORMATION

Very little research has been done on the eel in the Newfoundland area. For information on the eel in streams of the Maritimes, see Smith and Saunders (1955); for the eel and the eel fishery in Quebec see Vladykov (1955); and for the European eel in the British Isles, see Frost (1945 and 1950). For the breeding of the eel, see Schmidt (1925).

Capelin

Mallotus villosus

In the Newfoundland area, capelin (caplin, whitefish) are very abundant and in the colder parts come (Fig. 59) yearly to all suitable beaches to spawn. The adults are mostly 6–8 inches long, females being smaller than males.

Where the water at spawning time is too warm, as in certain parts of the west coast, they may spawn off the beaches in deeper water and only roll on the beaches in occasional years. On the beaches of the east coast, spawning generally begins in the last third of June and continues at intervals until about mid July. On the west and south coasts, beach spawning begins earlier, usually during the first half of June. After spawning on the beaches is completed, spawning continues throughout July and August on sandy bottoms in progressively deeper water down to at least 20 fath. Capelin also spawn on the Grand Bank; great quantities have been found there in our investigations since 1950, spawning in about 25 fath on sandy bottom on the Southeast Shoal in July or July and August.

In recent years it has been estimated by the Department of Fisheries of Canada that about 10 million lb of capelin are taken yearly in Newfoundland. They are used mainly as bait for cod and as fertilizer (especially for potatoes). They are also dried for dogfood and, to a limited extent, smoked, salted and dried, or frozen for human food or prepared for pet food. In former years, when the numbers of cod fishermen and the agricultural efforts of the outport population were much greater than now, very likely as much as 50 million lb were taken yearly.

Capelin may be as abundant as cod in the Newfoundland area, and very great catches could be obtained both inshore and on the Southeast Shoal of the Grand Bank. On this shoal the research vessel *A. T. Cameron* in July 1961 obtained two catches of 3000 and 7300 lb per hour's dragging with a trawl having only the codend lined by shrimp netting and capelin able to pass out of the remainder of the net. Eventually as fishing pressure reduces the stocks of cod, haddock, and other commercial fishes, capelin may be the most abundant fish in the area.

In Norway, where capelin are abundant only in the northern Finmark area, over 480 million lb were landed for fish meal in 1961. There is no doubt that, as

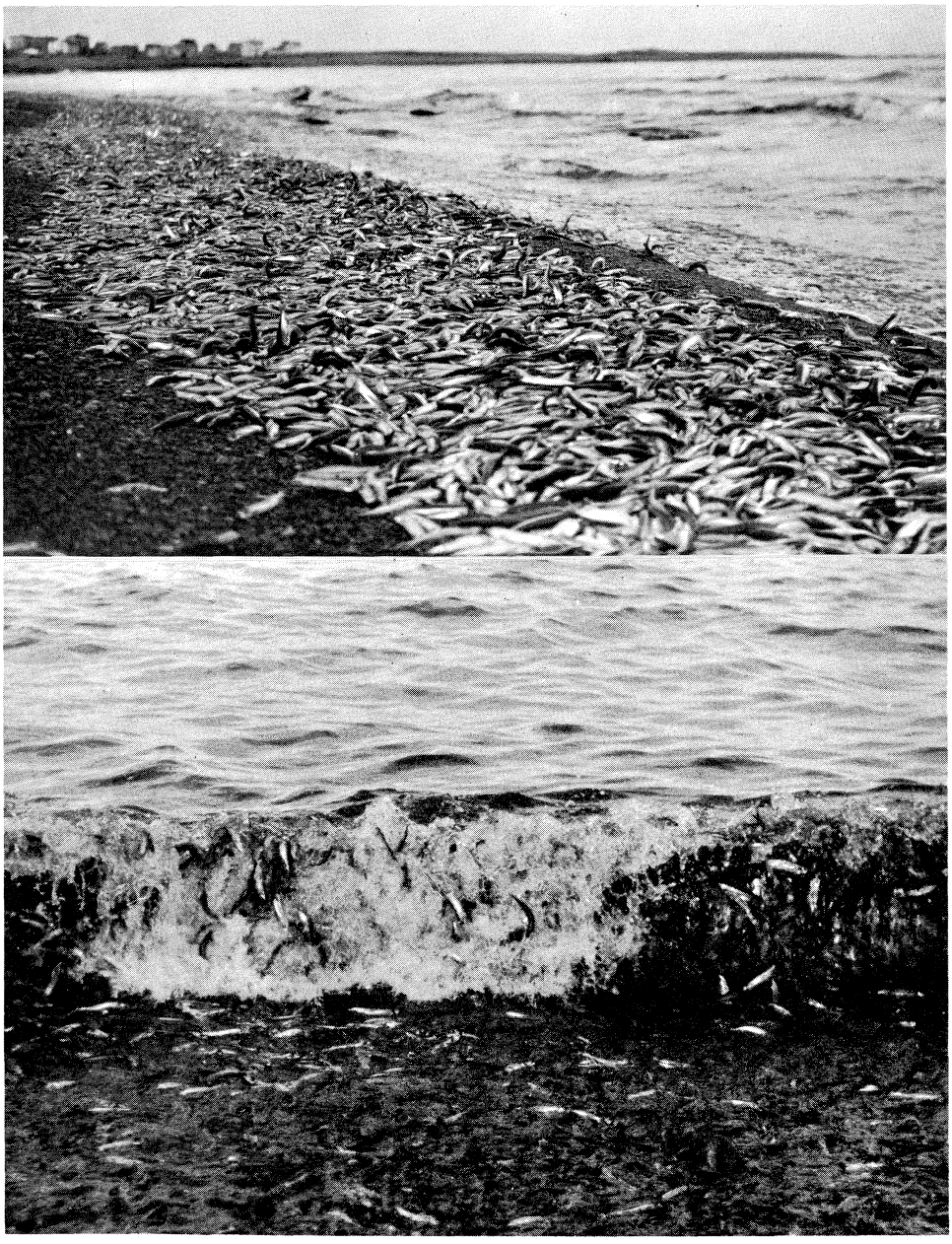


FIG. 59. Capelin spawning. *Above,* beach-spawning capelin thrown into hollow from which few can escape (near Lories, Burin Peninsula, June 27, 1948). *Below,* a wave full of capelin during beach spawning (Northern Bay, Conception Bay, Newfoundland, June 1957).

the world's need for protein food increases, capelin will form a very acceptable human food when frozen, canned, salted and dried, or smoked. It should be possible to land at least several hundred million pounds a year from the Newfoundland area without injury to the inshore cod-fishery. There could be danger, however, in concentrating a very intensive fishery in a limited area.

For information on the life history of capelin, see Sleggs (1933), Templeman (1948a, 1965a, b), and Pitt (1958a, b).

American smelt

Osmerus eperlanus mordax

American smelt are taken by gill net in the river estuaries, mainly from September or October to May as they approach the rivers for spawning; they probably spawn from late April or from May to early June. The landings have been greatest in October and November.

The Newfoundland landings (Fig. 60, B) have declined in recent years after reaching peaks of 410, 458, and 431 thousand lb in 1931, 1937, and 1939. In 1964, only 28 thousand lb were landed. In 1958–62 the main landings were made (Fig. 60, A) in Placentia Bay (District H), especially in the Burin area, in Port au Port Bay (L), and in the northeastern districts A, B, and C. In districts A and C, Pistolet Bay and Gambo are the most important fishing areas. Smelt are found in many other Newfoundland localities.

It is not likely that the recent decline of this fishery is due entirely to lack of smelt, and the fishery could probably be expanded in some areas now fished and extended into new areas.

These fish must enter rivers and brooks for spawning and, unlike salmon, are unable to surmount great obstacles. Even small impediments can prevent them from reaching spawning areas and the runs can be readily destroyed. But small changes in many rivers or brooks would make them accessible to smelt, and new runs might be established in them by transfers of eggs.

Smelt usually spawn in the lower reaches of brooks and rivers and are thus very susceptible to pollution and other changes caused by civilization near the river mouths.

In relatively minor fisheries, such as that for smelt, research and development are often neglected. This is one small fishery in which both the resource and the fishery might be gradually enlarged by a research and development program.

Due to the small fishery for smelt in Newfoundland there have been little research and no publications as yet on the species in this area. For information on the smelt and the fishery in northeastern New Brunswick, see McKenzie (1958, 1964).

Pollock and white hake

Pollachius virens
Urophycis tenuis

Pollock and white hake, though members of the cod family, do not live so close to the bottom as haddock or cod.

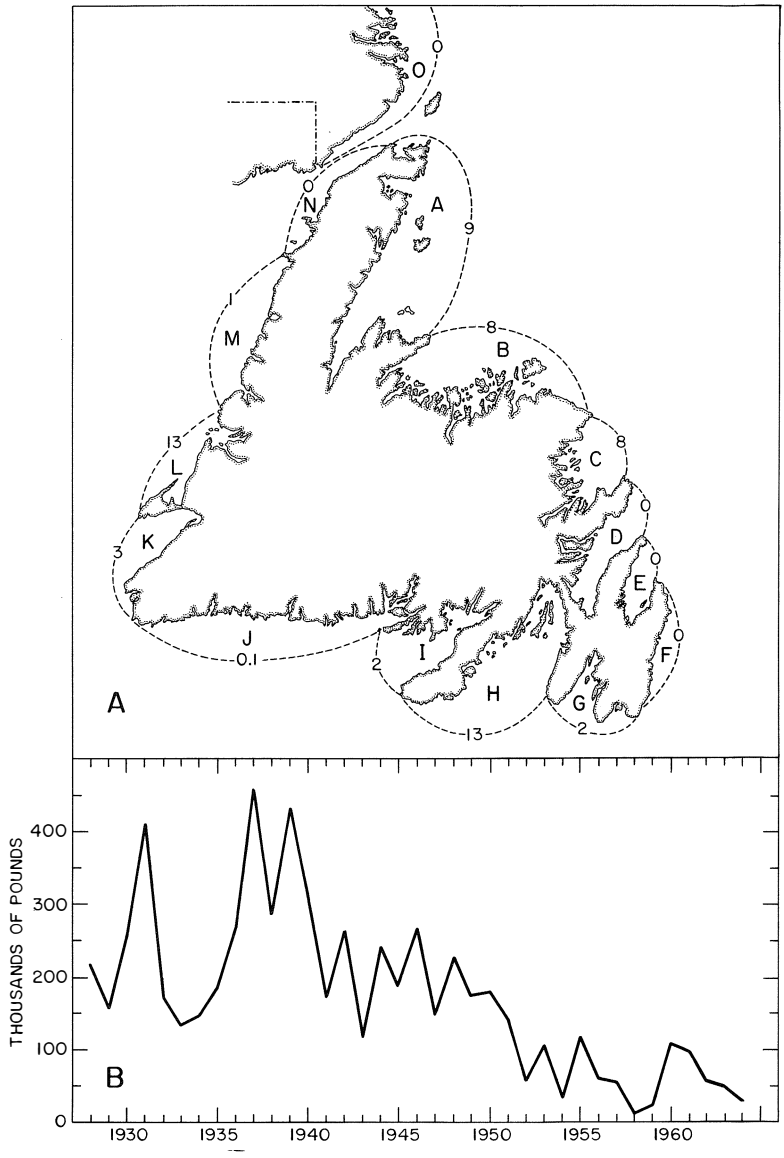


FIG. 60. A, average yearly landings of smelt (thousands of pounds, round fresh weights) in the statistical districts of Newfoundland, 1958–62. B, Newfoundland landings of round fresh smelt, 1928–64.

In the Newfoundland area these fish are at the northern part of their range. They occur on the south coast (the hake numerous only on the western half), on St. Pierre Bank, and on the southern part of the Grand Bank. They may be salted or used fresh but, bringing a lower price than cod or haddock, are not sought after to the same extent as these two species.

In our records of about 200 pollock from the Newfoundland area the greatest length was 39 inches and the heaviest was 18.3 lb whole weight (38 inches long). In those of about 200 white hake (often called ling in Newfoundland) the greatest length was 45 inches and the heaviest was 26.9 lb whole and 20.3 gutted and gilled (42 inches long).

Pollock landings in Newfoundland, almost all from the southern part of ICNAF Subarea 3, are small. Landings were 0.7 million lb in 1960, 1.4 million in 1962, 1.8 million in 1963, and 1.0 million in 1964. About a third are from otter trawlers and the remainder from the inshore fishermen of the south coast.

Total pollock landings from the Newfoundland area, Subarea 3, were 12.8 million lb in 1960, 7.3 million in 1961, 4.5 million in 1962, 4.1 million in 1963, and 3.5 million in 1964. Most of the catch came from Divisions 3Ps and 3O. Landings have fallen as the Grand Bank haddock fishery, of which this fish was a by-product, declined. The landings from Subarea 4, almost all by Canadians, were much higher, 67 million lb in 1963 and 71 million lb in 1964. Almost all the landings were from the southern Divisions 4W and 4X.

Newfoundland *landings of white hake,* almost all from Subarea 3, were less than those for pollock: 192 thousand lb in 1960, 207 thousand in 1961, 287 thousand in 1962, 384 thousand in 1963, and 355 thousand in 1964.

Total landings of white hake from Subarea 3 were 3 million lb in 1960, 0.8 million in 1961, 6 million in 1962, 0.6 million in 1963, and 3.3 million in 1964. Some of these are incorrectly recorded as red hake in the ICNAF statistics. About half the Newfoundland landings are usually from the inshore area along the western half of the south coast. The offshore catch is mainly from Divisions 3Ps and 3O.

From Subarea 4 the landings were considerably greater (22 million lb in 1962 and 18 million in 1963) than from Subarea 3. Almost all this catch was taken by Canada (Maritimes and Quebec), mainly in Division 4T (the southern part of the Gulf of St. Lawrence) and to a lesser extent in the more southerly Divisions 4X and 4W. From these southern divisions some of this catch is red hake.

Pollock require higher temperatures than are found in the northern parts of the Newfoundland area. In the harbours of the south coast we have noticed occasional unusually successful year-classes. But there are no indications at present that there are enough pollock in the Newfoundland area to supply a large fishery. The supply will fluctuate. In periods of increasing temperature there will very

likely be more successful year-classes and in periods of low temperature the reverse.

For white hake also there is no evidence that large quantities exist at present in the area. It is usually caught incidentally to fishing for redfish or haddock 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. It softens quickly and needs quick icing. The Newfoundland offshore catch would be increased somewhat if the hake now being discarded at sea were retained as they are by more Canadian mainland than by Newfoundland vessels.

Wolffish

Anarhichas lupus, A. minor,
A. denticulatus

There are three species of wolffish in the Newfoundland area: the Atlantic, spotted, and northern. The Atlantic and spotted species are valuable food fishes (catfish, or ocean catfish, on the market). But the northern wolffish, or jelly-cat, has flesh which is always jellied and hence is not used for food.

The *Atlantic (striped) wolffish* is by far the most common in the southern part of the area and is found as far north in the Canadian area as off southern Baffin Island. In the southern part of its range it grows to a large size and specimens over 3 ft long are not unusual. Our largest measured specimen was 49 inches in length and 43 lb in round weight. Off Labrador this wolffish is smaller, few more than 2 ft long being encountered. The Atlantic wolffish is reported to be most common on hard bottom and may occur from the deep water along the slopes to shallow water of 40 fath or less on the banks.

The *spotted and the northern (broadheaded) wolffishes* are plentiful in deep water from north of the Grand Bank to off Baffin Island, and occur in small numbers on the eastern and southern parts of the Grand and St. Pierre banks. Most spotted wolffish are less than 3 ft long but individuals over 40 inches long are not uncommon; our largest individual was 48 inches in length. A fish 43 inches long weighed 35 lb whole and 27.4 lb gutted and gilled.

Wolffish appear to spawn in late autumn or early winter. The large eggs, more than a fifth of an inch in diameter, are laid on the bottom.

Wolffish, as a rule, do not appear in large schools. Hence, they are not the object of a specialized fishery in our waters and are caught incidentally in fisheries for other groundfish.

Wolffish are valued on the market and the landings in Newfoundland have gradually increased from 272 thousand lb in 1954 to 1.1 million in 1963 and 1964. In the period 1958–62, the average yearly landings were 589 thousand lb. Of these, 367 thousand lb were from the inshore fishery, especially from deep-

water longlining in the Bonavista Bay, Notre Dame Bay, and Trinity Bay areas and on the western part of the south coast. In the same period, 222 thousand lb per year were landed from the offshore area by trawlers.

In both 1963 and 1964, the total yearly landings from the ICNAF area were 19 million lb, of which 13 and 11 million lb came from Subarea 1 off West Greenland. Much of the wolffish catch in the ICNAF area is discarded by salt fish trawlers and line vessels.

The Newfoundland catch will be increased considerably if the trawlers move into deep-water fishery in the area from southern Labrador to the northern Grand Bank and with increasing longlining in deep water for cod and Greenland halibut.

Porbeagle

Lamna nasus

The porbeagle, or mackerel shark, is another migrant from southern waters. It is common in the southern part of the Newfoundland area from July to at least early September. This is a valuable food fish with a market in Italy. Other large sharks visit the Newfoundland area but at present none of them are of commercial interest.

Porbeagles need to be cleaned, chilled, and frozen as soon as possible after catching. Fourteen thousand pounds of dressed shark were landed in Newfoundland in 1964, the first Newfoundland landings of this species.

In 1961, Norwegian vessels using surface longlines landed over 4 million lb of porbeagles from the Northwest Atlantic, mainly or all from ICNAF Divisions 3M, 3N, 3O, and 3P of the Newfoundland area and from 4V, 4W, and 5Z. Faroese and other Danish vessels have also successfully engaged in the fishery in the Newfoundland area.

These fish evidently move northward during the summer and southward in the autumn. The Norwegians found small numbers on Flemish Cap from March to May, but the fish were more plentiful during this period on the western part of Sable Island Bank and in the Gulf of Maine. On St. Pierre Bank their fishing in 1961 was best in early September, after they fished the Gulf of Maine up to early August and Misaine Bank later.

The Norwegians generally made their best catches at depths between 5 and 16 fath. For a research cruise of the *G. O. Sars* to Newfoundland, Nova Scotian, and Gulf of Maine areas in June–July 1962, Mr Olav Aasen, Institute of Marine Research, Bergen, Norway, reported that one porbeagle, averaging several hundred pounds, was caught per 10 hooks.

Our research vessels have found these sharks very numerous on the Southeast Shoal of the Grand Bank in July, and Newfoundland trawlers sometimes catch 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. Our earliest coastal record is in May and the latest in November, but most have been between July and early September.

For more information on porbeagles and other sharks in the Canadian area, see Aasen (1963) and Templeman (1963).

Spiny dogfish

Squalus acanthias

Spiny dogfish are small sharks. In Europe they are commercial fish and are used in large quantities, in England especially in the fish-and-chip establishments. Like all sharks and skates, this dogfish must be cleaned and chilled rapidly after capture so as to preserve it in a perfectly fresh condition. If this is done it is an excellent food fish although at present the market for it is in Europe.

Norwegian landings of this species in the Northeast Atlantic have increased from about 17 million lb in 1950 to an average of 67 million per year in 1961–63. Very small quantities of these fish have been filleted and frozen in Newfoundland fish plants in recent years.

Most spiny dogfish in the Newfoundland area are between 2 and a little over 3 ft long, the females growing considerably larger than the males. In winter the large dogfish, mainly females carrying young, migrate southward to United States waters, where the young are born. Some males and immature females remain over winter in the Newfoundland area and are often killed by cold water.

This dogfish is found mainly during the warmer part of the year all around Newfoundland and occasionally off southern Labrador. It is probably most common on the south coast of Newfoundland, where it is often very numerous from June to November or December. It often occurs in large numbers on the east coast from July or August to November or December.

In the absence of a fishery and because of the considerable variations in abundance from year to year, it is difficult to estimate the numbers which could be caught. However, in Placentia Bay in 1938, during a subsidized attempt to reduce the numbers of these dogfish, about 10 million lb were caught without any noticeable reduction in the supply. In one area on the slope of northwestern St. Pierre Bank during the last week of May and the first week of June, large catches have been made in many years by our research vessels (21,600 lb in a half-hour set by the *A. T. Cameron* on June 8, 1960). Because this fish is a visitor from the south, the numbers reaching the various parts of the Newfoundland coast vary greatly from year to year.

The spiny dogfish is a good food fish if gutted and iced immediately after capture and filleted and frozen while in an excellently fresh condition. It is only a matter of time before it will be used commercially and the frozen fillets exported

in quantity to the European markets. In 1964, 7 thousand lb of dogfish were landed in Newfoundland and used commercially for export in the dressed and frozen condition.

For further information on the spiny dogfish of the Newfoundland area, see Templeman (1944a, 1954, 1963, 1965a).

Skates

Raja spp.

Skates are at present little used by the Newfoundland fleet though there are some landings of skate wings from the Newfoundland area by European countries. Skate wings (pectoral fins) are excellent food with a flavour somewhat like that of scallops. In 1964, 2700 lb of skate were landed in Newfoundland and 225 lb of skate wings were exported in the frozen condition.

In 1961, landings of 300 thousand lb (whole weight) of skates were reported from Subarea 3 and 250 thousand from Subarea 4. In the Northeast Atlantic, skates are a regular object of the fishery; landings of skates and rays by European countries in 1961 were 118 million lb.

The most numerous skate in the Newfoundland area is the *thorny skate* (thornback). This fish is common throughout the area, and especially numerous in the colder parts. The largest thorny skates are found on the Grand and St. Pierre banks, where they often grow to over 3 ft long. North of the Grand Bank, on the Northeast Newfoundland Shelf and off Labrador, few grow much beyond 2 ft.

The largest skates in the area are the barndoor skate and the spinytail skate. The *barndoor skate* is found only in small numbers, in the warmer parts of the area: on the southwestern slope of the Grand Bank, the southern and western slopes of St. Pierre Bank, along the south coast of Newfoundland, and in the Gulf of St. Lawrence. This skate grows to a length of 5ft. As no small specimens or egg capsules of the species have been found in the Newfoundland area (the smallest being 3.3 ft long), it probably does not breed here.

The *spinytail skate* is common, but not caught in large numbers, in deep water from north of the Grand Bank to the slopes of the southern Labrador Shelf. It is present in small numbers in deep water around the slopes of the remainder of the area, including the Esquiman Channel in the Gulf of St. Lawrence. It grows to over 5 ft long.

The *winter skate* (eyed skate) is fairly common at St. John's and in the southeastern bays of Newfoundland, such as St. Mary's Bay, Placentia Bay, and Conception Bay. It is present but probably less numerous as far north as Notre Dame Bay. It is also found along the south coast, in Bay of Islands, and on St. Pierre Bank. It is rare on the southern part of the Grand Bank and is not found

on the northern part of this bank or northward along the seaward part of the Northeast Newfoundland and Labrador shelves. It grows to over 3½ ft long.

The *smooth skate* is caught in small quantities on the Grand Bank and in the Gulf of St. Lawrence. It occurs northward to the southern part of the southern Labrador Shelf, where it is found in very small numbers. This skate grows to a length of about 2 ft but is very thin. It would have no commercial importance unless the whole body were used for food, as is the common practice with small skates in France.

The remaining skates of the Newfoundland area are too rare or too small to be of commercial significance.

As a rule, skates are only fished as a by-product of other fisheries. On three occasions, however, on the slopes of the Grand Bank our research vessels have encountered thorny skates in large numbers, several thousand pounds per half-hour drag of the otter trawl.

Other marine fish

There are many other fishes in the Newfoundland area, but they are not so common as or are less likely to be used in the near future than most of the foregoing.

The *Atlantic argentine,* the *silver hake,* and the *monkfish* (angler or goosefish) are all found in small numbers on the southwestern slopes of the Grand and St. Pierre banks. The argentine has recently been the object of a commercial fishery by the Russians on the Scotian Shelf. The silver hake is a regular object of a primary fishery by both Americans and Russians in Subarea 5 and by the Russians in Subarea 4. Although it is not yet recorded in the available statistics the angler has recently been used by the Nova Scotian industry and, to a small degree (in 1965), in Newfoundland. In the Northeast Atlantic it is regularly retained and 23 million lb were landed from this area in 1961. For an account of the angler in Canadian waters, see Connolly (1920) and Jean (1965).

The *lumpfish* is moderately numerous in the coastal waters in spring and early summer. This fish is an excellent and tasty article of food and is eaten at Cook's Harbour and Port au Port and very likely in other Newfoundland localities. In Newfoundland the smaller, reddish males are preferred to the larger, greenish females. In Germany and Sweden, smoked lumpfish are favoured. The large eggs from the large ovaries of the mature fish are collected and salted in Greenland and sent to Denmark to be used as caviar locally and for export. For more information on the lumpfish in the Canadian area, see Cox (1920) and Cox and Anderson (1922), and for the West Greenland area, Jensen (1944).

Atlantic saury (billfish) are southern, warm-water fish common in Newfoundland only in occasional years. They are very good food but in Newfoundland

have only been used for bait. They are caught with seines, and the largest landings reported in recent years were 82 thousand lb in 1959 and 98 thousand in 1961.

The *winter flounder* is common inshore in shallow water in Newfoundland and even in Labrador, but does not occur on the Newfoundland banks; in the United States it is called blackback and is one of the most favoured flounders. It is especially available close to the shore at capelin-spawning time feeding on capelin eggs. This small-mouthed flounder will undoubtedly be used, but probably no long-continued intensive fishery could be maintained in any one area since the depth range during the warmer months is narrow. For more information on the winter flounder, see Perlmutter (1947) and McCracken (1963).

Northern sand launce (offshore launce, sandeel) and *inshore launce* (sand launce, sandeel) are very common on the Grand Bank and are found in many inshore areas of Newfoundland and Labrador; they are caught in Europe, especially by Denmark, in large enough quantities to be used for fish meal. The large quantities of these fish on the Grand Bank will very likely be used at some time, but it would probably be far too expensive at the present time to land them in Newfoundland for fish meal.

Other large edible fishes are the *pouts* (eelpouts). Of these the ocean pout (common eelpout) is regularly found in the coastal Newfoundland area in summer and has the same range as the winter flounder. Is is probably most common in the first 5 fath from the shore. In the United States this pout has been used for food and over 5 million lb per year were landed on the Atlantic coast in 1943 and 1944. These landings were not maintained as the fish fell into disapproval due to the presence of a parasite. For more information on the ocean pout of the southern New England area (with some comparisons with samples from St. Andrews, N.B.), see Olsen and Merriman (1946) and Nigrelli (1946), and on the species in the Canadian area, Clemens (1920) and Clemens and Clemens (1921).

In deep water off Labrador and Baffin Island there are great quantities of rock (roundnose) and lesser quantities of roughhead *grenadiers,* close relatives of the cod. We found the roughhead grenadier almost as acceptable as cod for food on the *A. T. Cameron* off Labrador in 1960. Both of these grenadiers are likely to be used for human food when world food pressure becomes greater.

All the edible fishes present in significant numbers in the Newfoundland area will very likely be used in due course.

For an assessment of the prospects of the Canadian fishery for some of these underutilized species, see Ricker (1962).

American lobster

Homarus americanus

Lobsters account for less than 1% of the Newfoundland landed weight of commercial fish and invertebrates, but about 9% of the landed value (Fig. 8).

In the Newfoundland area, American lobsters are coastal animals whose along-shore migrations average only about 2–5 miles a year. The catch is taken by traps at depths mainly less than 5 and almost always less than 10 fath. When the season opens, in late April, the fishing begins in the deeper part of this range. It progresses toward the shallower depths in May and June and, in the northern districts, to early July. Toward the end of the season the catch falls off, due to reduction of the population by trapping and to the approach of moulting, when the lobsters feed little.

There was some sale of live lobsters at least as early as 1856, but landings were below 50 thousand lb before 1874. In 1874 (Fig. 61, B; Templeman, 1941) they rose to 120 thousand lb, and by 1878 to 7 million. From 1882 to 1885 they fell considerably, to a low of 2½ million lb in 1883, very likely due mainly to economic conditions; but by 1889 they rose to 17½ million. After falling to 7½ million lb in 1892, they rose to 14 million in 1897. The high landings in these years were from the virgin population of old, large lobsters. After 1897 the landings gradually declined to a low of 0.8 million lb in 1924. After a 3-year closed season (1925–27) they rose to 4½ million in 1928 and declined again to 1½ million by 1934. Since 1949, landings have ranged usually between 4 and 5 million lb.

In 1958–62 the landings were highest in Notre Dame and Bonavista bays (B and C of Fig. 61, A) on the east coast, in districts K, L, M, and N on the west coast, and in Placentia and Fortune bays (H and I) on the south coast. The catches were zero in Labrador, less than 1000 lb per year in districts A and F, and low in districts D, E, and G.

Catch in Relation to Effort

Between 1956 and 1964, the numbers of fishermen and lobster traps increased rapidly (Fig. 61, B), and the number of traps per man fell slightly from 72 to 67. In this period the total catch did not increase and consequently the yearly landings fell to 557 from 1129 lb per fisherman and to 8.2 from 15.8 lb per trap. The increases in effort were motivated by increases in the landed price of lobsters and the lack of alternative employment.

That the present great effort is not needed to produce a catch close to that now taken is indicated by the experience after the closed season of three years (1925–27). In 1928, the year after the closed season, 1381 employees in the industry, presumably not all fishermen, with 45 thousand traps landed 4.6 million lb of lobsters, an average of 3350 lb per man and 102 per trap. In 1929, 2052 employees with 101 thousand traps landed only 2.8 million lb, or an average of 1347 lb per man and 27 per trap. In 1964, with 8090 fishermen and 550 thousand traps the landings were 4.5 million lb, an average of 557 lb per fisherman per year and 8 per trap. The actual landings per man and per trap in 1964 were very likely lower since 10,000 lobster licenses were sold and only

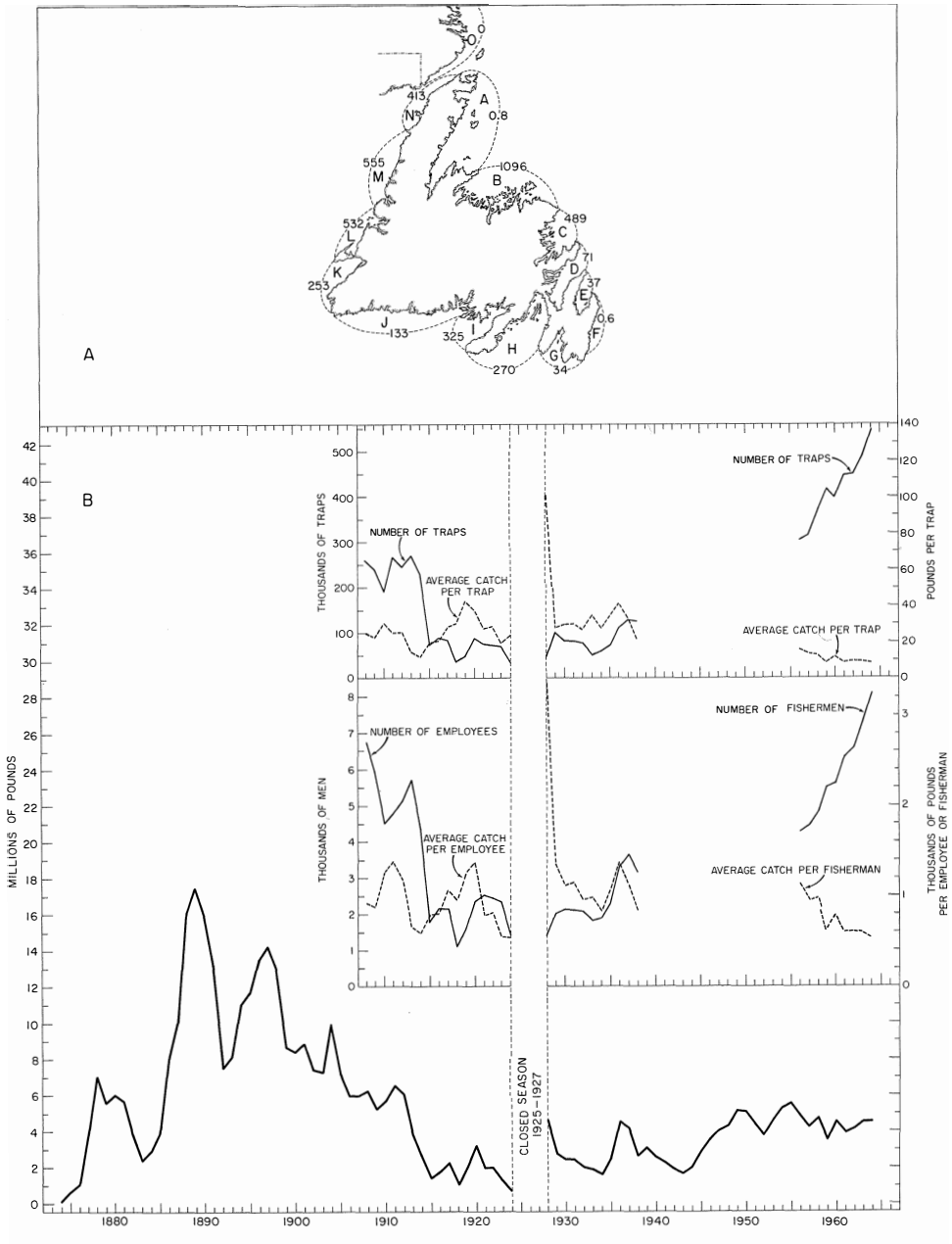


FIG. 61. A, average yearly landings of lobster (thousands of pounds, alive in shell) in the statistical districts of Newfoundland, 1958–62. B, Newfoundland landings of lobster, 1874–1964. Insets give catch and effort data for 1908–38 and 1956–64. (For 1908–38, only the number of employees is available; this includes not only fishermen but other people who worked in the lobster canneries. Usually, however, fishermen canned or assisted in canning their own lobsters.)

8090 fishermen were reported in the statistics. In the Maritime Provinces, where lobsters are more plentiful, 16,973 fishermen landed 36.05 million lb in 1963, an average of 2124 lb per man.

Life History

The size at which lobsters mature varies with locality, probably depending on temperature, light, and food. In most Newfoundland localities some females lay eggs at lengths of 8—9 inches and almost all are probably producing eggs by the time they are 12 inches long (Templeman, 1936a, 1944c; Templeman and Tibbo, 1945).

In the Newfoundland area the females lay their eggs mainly from early July to September. The eggs are fertilized as they are laid (by sperm received while the female was in the soft-shelled condition) and are attached to the long hairs, mainly of the swimmerets, below the tail of the female. They hatch 11—12 months later, from the latter part of June to September of the following year (Templeman, 1934, 1936b, 1937a, 1940d).

The young are free-swimming, and are about a third of an inch long immediately after hatching. They undergo three moults, or shell changes, and hence enter a fourth stage while they are free-swimming. When they settle to the bottom, in the latter part of this stage, they are about three-fifths of an inch long. During the free-swimming period the young are moved around by sea currents, especially those due to wind, as they spend much of their time near the surface (Templeman, 1937b; Templeman and Tibbo, 1945). Also, they are very vulnerable to fish and other enemies and may drift over areas too deep, too cold, or too far from the coast.

High temperatures shorten the periods between moults and low temperatures considerably increase them and thus the length of the free-swimming period. At temperatures as high as 21 C (70 F) the free-swimming period may last only several weeks, whereas at 10 C (50 F) it may last close to 2 months (Templeman, 1936c). Also, high temperatures allow lobsters to live in deeper water than low temperatures, and shelving and protected shores increase the area of bottom that is suitable. These factors are largely responsible for the fact that the Maritime Provinces produce about 40 million lb of lobsters per year compared with only 4—5 million for Newfoundland with a coastline at least as great and much greater if Labrador is included.

Under apparently favourable circumstances, survival of lobster larvae from stage 1 to stage 4 may be as low as 1% (Scarratt, 1964).

Once the lobster settles, toward the end of the fourth stage, it can seek some protection under stones from fish and some other predators. But it is vulnerable to being eaten, especially when out of its shelter feeding and at moulting times. The main factors which determine how many of these little lobsters, about three-

fifths of an inch in length, will reach the legal Newfoundland size of 3 3/16 inches carapace length (approximately equal in total length to 9 inches for the male and 9.4 inches for the female, Templeman, 1944b) are: the abundance of rocky bottom with rocks of many different sizes which provide shelter from light and protection for lobsters as they grow; the availability of food; the quantities of skates, wolffish, cod and other fish present as predators; the bottom competitors and predators such as crabs and other lobsters; and the water temperatures which determine the rapidity of moulting. Only a very small percentage of the fourth stage lobsters will attain the Newfoundland legal size, and the period required may be 8 years or more (Wilder, 1953).

Distribution and Abundance

In the Newfoundland area, lobsters are most abundant on the west and south coasts and in Notre Dame and Bonavista bays on the east coast (Fig. 61, A). On the west and south coasts the prevailing west and southwest winds of summer blow onshore, making the inshore water temperatures suitable for lobsters of all sizes, but the boldness of many parts of the shore reduces the area suitable. In many localities here, young lobsters at the end of their free-swimming period are concentrated by the wind currents at the bottoms of bays and arms except where rivers cause outgoing surface currents.

On the east coast, where the prevailing winds of summer are offshore, only in Notre Dame and Bonavista bays are there many inlets, islands, and shoals. These retard the offshore movement of the warming surface water, retain many of the free-swimming lobsters until they settle to the bottom, and also provide suitable shallow water and sheltering places for their bottom life. In the open bays with few arms or islands such as Trinity and Conception bays (D and E of Fig. 61, A), lobsters are scarcer and especially on exposed shores (such as A and F of Fig. 61, A) with a prevailing offshore wind in summer, there are relatively few lobsters. Also, these unimpeded offshore winds lower the temperature of the inshore waters and so greatly lengthen the free-swimming period and decrease survival. On bold shores such as those of A and F, with rapid deepening of the water close to the shore and no protection seaward, lobsters can live only in a small area and only very favourable shelter keeps them from being thrown on shore by the autumn storms.

The Labrador area is too cold for establishment of lobsters, though the occasional one may settle as a larva or migrate into its southern border. The free-swimming period in the Labrador area would last for several months, and the southward-drifting currents would carry the young much farther southward than the bottom-living lobsters could move northward along the bottom.

Abundance of lobsters is affected very much by temperature. Newfoundland is their northern outpost in the western Atlantic, and their northward advance to Labrador is limited by low temperatures and a southward-flowing current. High

temperatures not only shorten the pelagic period and increase the survival of the free-swimming larvae, but also increase the feeding rate and thus the catchability of lobsters (McLeese and Wilder, 1958). Most of the lows and highs in the landings from 1921 to 1951 were associated with low and high mean annual surface water temperatures on the Canadian Atlantic coast (Templeman and Fleming, 1953). The water temperatures near St. John's (Templeman, 1965d) and the Newfoundland lobster landings, though well above the average since 1930, have decreased somewhat since 1954–55.

The Future

Lobster fishing in Newfoundland is already very intensive and covers most of the good fishing areas. More intensive fishing is certain to be unprofitable and unlikely to increase long-term landings.

Granted suitable protection of the stocks, the future of the fishery depends mainly on the water temperature. A reversion to low temperatures as in the early 1920s would decrease landings. High temperatures as in the early 1950s would presumably increase landings, and still higher temperatures would increase them further.

More Information

For more information on lobsters in the Newfoundland area, see Templeman (1939, 1940a–c, 1941, 1948b, 1958b) and Templeman and Tibbo (1945). For a popular account of Canada's lobster fishery see Wilder (1957) and for an account of live lobster storage and shipment, McLeese and Wilder (1964). For a bibliography of the lobster see Dawson (1954), and for anatomy, egg and larval development, and the natural history of the lobster as known at the time see Herrick (1896, 1911).

Shrimp
Pandalus spp.

Shrimp are not fished commercially in Newfoundland now, but surveys have suggested that sooner or later there likely will be a fishery in the Gulf of St. Lawrence and neighbouring areas.

In 1957–58, shrimp trawling was carried out by the St. John's Station on behalf of the Industrial Development Service of the Department of Fisheries of Canada with a 59-ft Danish seiner, the *Fortune Breeze* (Squires, 1961). Pink shrimp, *Pandalus borealis,* fished commercially in Norway, Greenland, British Columbia, and Maine, were found to be usually present at depths below 100 fath, and often moderately plentiful and large for this species. The best areas were in the Esquiman Channel along the west coast of Newfoundland, in the Mingan Channel north of Anticosti, and off the southwest coast of Newfoundland between

Ramea and Rencontre West. In these areas, usually at depths between 120 and 170 fath, catches of pink shrimp of commercial size (per hour's trawling with a Norwegian deep-sea shrimp trawl) were often over 100 lb, occasionally as high as 200, and once 400.

In 1958, also, the M. V. *Fortune Bay,* chartered by the Government of Newfoundland, fished shrimp in the Esquiman Channel off Port au Choix. The largest catches were from 650 to 800 lb per 3-hour tow.

In April 1963 the research vessel *A. T. Cameron* obtained catches of 52 and 60 lb of good-sized pink shrimp in ½-hour tows at two stations 20 miles apart in 180 and 200 fath in the western part of Hawke Channel. These catches were unusually large for the fishing gear of the vessel, which had large rollers and a standard groundfish otter trawl with a 1⅛-inch liner only in the codend. In early September 1959 the *A. T. Cameron,* with the regular groundfish trawl described above, obtained 87 lb of a closely related shrimp of small commercial size, *Pandalus montagui,* in a ½-hour tow at 200 fath in Ungava Bay.

Crabs

The crabs most likely to be of some commercial importance are a spider crab with long flat legs, *Chionoecetes opilio,* and the common rock crab, *Cancer irroratus,* with shorter legs. *Chionoecetes* often reaches a large size, especially in deep water. It is common from moderately shallow water to depths of over 100 fath, and is numerous enough to be abundant food for cod. It is often caught in cod traps and presumably also would be entangled in cod gill nets. Commercial exploitation of this crab on a small scale has begun in the Gaspé Peninsula. The rock crab is common in shallower water, especially in lobster areas.

Squid
Illex illecebrosus

The commercial squid of the Newfoundland area, our greatest molluscan resource, is the short-finned squid. Though large quantities of dried squid were once exported to China for human food, in recent years it has been used almost entirely as bait. Besides being used in the local line fishery for cod, it has been exported as bait, especially for the Portuguese line fishery and the Norwegian and Faroese longline fishery in the Northwest Atlantic.

The entire Newfoundland catch is taken close to the shore. On the Newfoundland banks this squid is mainly pelagic and is not readily available in quantity to the otter trawl. In the inshore area, squid usually occupy the shallower water after it has become too warm for large cod and very often after the cod have become bottom feeders in August. Hence, cod and squid do not often come in contact and, though squid is an excellent bait for cod, it is rarely found (other than bait) in cod stomachs.

In summer the short-finned squid may be found northward at least to Hamilton Inlet Bank, westward to the western shore of the Gulf of St. Lawrence, and eastward at least to Flemish Cap. It occurs southward to the Gulf of Mexico and the Caribbean Sea.

Because the smallest individuals appearing on the southwestern Grand Bank in May and later inshore are already half-grown, and no larvae or small young have been caught, the squid probably spawn a considerable distance away from the Newfoundland banks. They very likely spawn in deep water; otherwise the eggs or young and the spawning accumulations should have been found. Apparently the adults die after spawning, as all the squid that move to shore are small, immature individuals.

Landings, Distribution, and Abundance

The fishery for the short-finned squid has fluctuated markedly between abundance and scarcity over the past 80 years (Fig. 62, B and C; Templeman and Fleming, 1953; Squires, 1957). Since most of the catch has been used locally for bait, the information, except for the past few years, has been from notes in publications of the Newfoundland Department of Fisheries and from newspaper items on abundance or scarcity. From 1953 to 1964, the years for which some definite records are available on total landings, including an estimate of the squid caught and used by fishermen, the greatest landings were: 23 million lb in 1964, 19.8 million in 1961, and 17.1 million in 1956; squid were unusually abundant in 1964 and much greater quantities could have been caught if handling facilities and markets had been available. In this period the lowest landings were: 1.1 million lb in 1962 and 1.6 million in 1958.

From 1958 to 1962 the greatest landings were taken in Bonavista, Trinity, and Conception bays (C, D, and E of Fig. 62, A), and significant quantities in districts F, B, H, A, and J. The landings were negligible on the west coast of Newfoundland. No landings were reported from Labrador, though in cruises of the research vessel *A. T. Cameron* short-finned squid have been found in summer in small numbers on the seaward slope of Hamilton Inlet Bank.

In our research explorations by bottom otter trawl, small, half-grown squid are usually taken in deep water on the southwestern slope of the Grand Bank by May or June. In the years when large numbers of squid were caught by our research trawlers on the southern and southwestern slopes of the Grand and St. Pierre banks in May and June, they were usually abundant inshore later in the season. When scarce offshore in May and June they were usually, but not always, scarce in coastal waters later in the year (Squires, 1957; Hodder, 1964a). In June of 1964, Hodder (1964a) forecast the unusually great abundance of squid inshore later in the year on the basis of large catches (up to 1300 lb per ½-hour drag) taken by the *A. T. Cameron* between 50 and 150 fath (in greatest abundance at 100 fath) on the southwest slope of the Grand Bank between May 29

and June 14, 1964. They are found inshore occasionally in late June but usually in July or early August. They apparently come inshore in the upper, warmer-water layer, and if they arrive in late June or early July when this layer is thin they often run ashore in considerable numbers on the beaches. Inshore they grow rapidly. Hence they leave the coast as large squid in November, retreating presumably southward to spawn.

If, as is almost certain, the young are produced a considerable distance away and migrate for feeding to the Newfoundland area, great variations in the local supply are bound to occur. These may be caused either by differences in survival

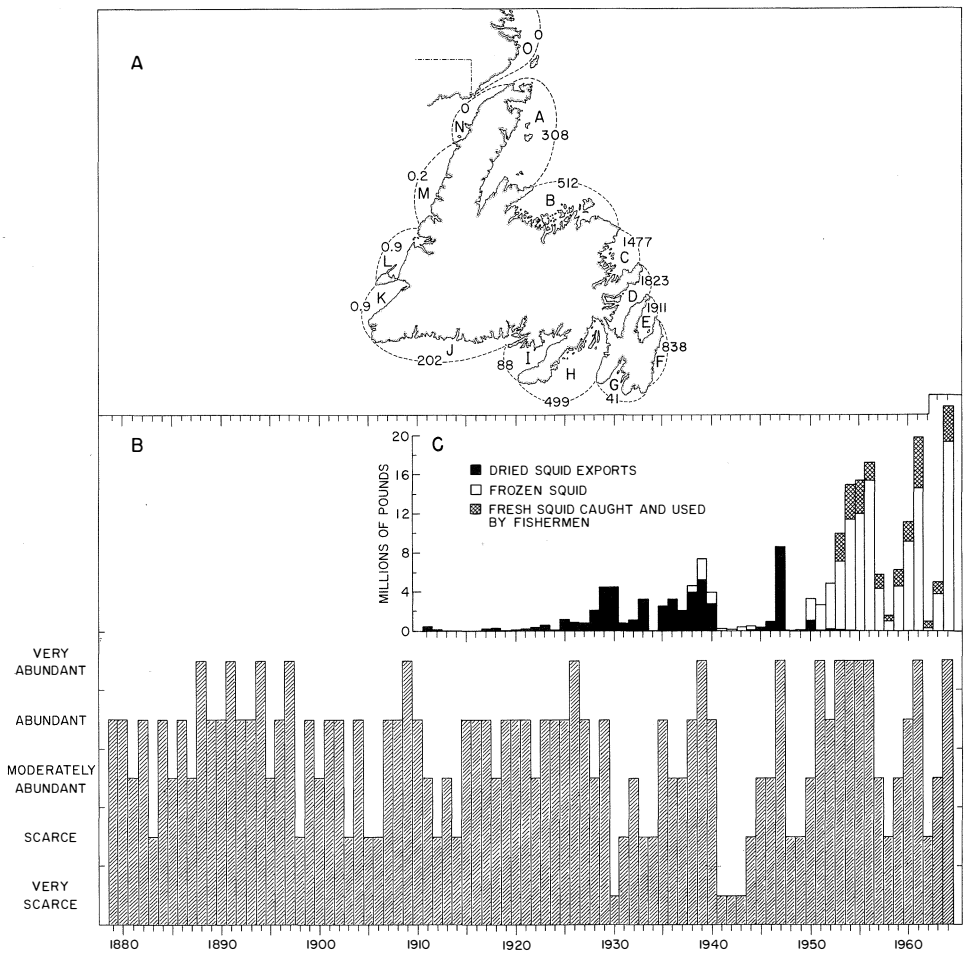


FIG. 62. A, average yearly landings of squid (thousands of pounds, round fresh weights) in the statistical districts of Newfoundland, 1958–62. B, estimates of relative squid abundance in the Newfoundland inshore area, 1879–1964. C, records and estimates of the Newfoundland catches, round fresh weights, 1911–64. (In C, estimates of the amounts used fresh as bait by Newfoundland cod fishermen were begun in 1953.)

of year-classes or by some change in the direction or intensity of migration. The spiny dogfish, which liberates its young southward off the United States and migrates northward in summer, shows similar great variations in numbers in the Newfoundland inshore area. Often when squid are scarce near shore they may be numerous in places on the offshore banks. In other years, possibly because of favourably high temperatures, they may become thinly spread over a great area.

Value as Bait

In comparing squid and frozen herring as bait for cod in deep-water longlining, Templeman and Fleming (1963b) concluded that, if frozen herring could be obtained free and cod were only moderately plentiful, the extra cod (at 2¾ cents per pound) obtained with squid would make squid worth about 15 cents per pound. At higher prices or at a higher abundance for cod the squid value would be correspondingly higher. Compared with frozen capelin, squid would be even more valuable.

The Future

It is inevitable that, at some time in the future, Newfoundland squid will again be used for human food. The yearly Japanese catch of squid, of a closely related species, *Todarodes pacificus,* is often more than 900 million lb. This is largely used for human food.

Meanwhile it is an extremely valuable bait. It is easily possible that 100 million lb or more could be caught in years of abundance such as 1964. When these large amounts can be sold the fishery will need to be modernized and squid taken not only by the single jig but also by multiple jigs, purse seines, surface trawls, attraction by lights, and other methods. One method of finding concentrations at sea might be an aerial or other search for concentrations of pothead, or pilot, whales; the squid is almost the sole food of the pothead and, in years when squid are scarce inshore in Newfoundland, pothead whales are also scarce.

More Information

Additional information on the short-finned squid in the Newfoundland area may be found in Squires (1957) and Hodder (1964a). For an account of the great Japanese fishery for the related squid, *Todarodes pacificus,* and the methods and gear used in this fishery see Suzuki (1963).

Scallops

Placopecten magellanicus
Chlamys islandicus

There are two species of scallop in the Newfoundland area: the sea scallop and the Iceland scallop. The fishery for the sea scallop is evidently a good example of the overfishing of a limited resource.

The sea scallop (giant, smooth, Digby, or Atlantic deep-sea scallop) may grow to a diameter of 6 inches or more; the Iceland scallop is smaller, usually below 4 inches in diameter. At present in the Newfoundland industry, only the white adductor muscle which holds the shells together is used for food. Scallops can move by flapping the upper and lower valves of their shells, but the beds usually move little if at all.

The giant scallop is the commercial species. There are many small, local concentrations of this scallop around the coast of Newfoundland, the quantities being significant in Port au Port Bay and on the shallower parts of St. Pierre Bank (Squires, 1962; Dickie and Chaisson, 1955; Somerville and Dickie, 1957).

Iceland scallops are found everywhere in shallow and moderately shallow waters on the cod fishing grounds. There is no evidence at present that these are commercially abundant, but fishermen often find them attached to line trawls, especially on the east coast of Newfoundland (also, see Squires, 1962). In some Norwegian fjords this species appears to be sufficiently abundant to support a small commercial fishery (Wiborg, 1963).

Landings

The Newfoundland scallop fishery began as a canning industry in Port au Port Bay in the 1930s and shifted to export of frozen meats in the early 1940s. By 1941, landings were over 30 thousand lb of meats. Later in the war the industry almost disappeared but it was revived in 1946, with landings of about 35 thousand lb. Landings rose steadily to almost 180 thousand lb of meats in 1953, about 95% from Port au Port Bay. This represented the catch of only a few small local vessels.

In 1951, 1954, and 1955, large vessels from Nova Scotia entered the fishery in Port au Port Bay. In 1954 the total landings from the inshore Newfoundland area rose to 460 thousand lb of meats, almost all from Port au Port Bay: nearly half of the catch (221 thousand lb) was landed in Nova Scotia. In 1955, landings fell to 392 thousand lb, 49 thousand by Newfoundland and 343 thousand by Nova Scotian vessels. In 1956 the fishery collapsed from lack of scallops with a total catch of 20 thousand lb, 15 thousand by Newfoundland vessels. Since then landings have risen slightly but in 1958–63 they averaged only 27 thousand lb, all by Newfoundland vessels and almost all from Port au Port Bay. In 1964, Newfoundland landings of meats were 20 thousand lb from the Port au Port area. The collapse was evidently due to overfishing. It is not likely that bottom temperatures in Port au Port Bay were high enough to cause mortalities similar to those described by Dickie and Medcof (1963) for beds of sea scallops in the southern part of the Gulf of St. Lawrence.

From a scallop bed on the northern shallow-water part of St. Pierre Bank, a total of over 1 million lb of scallop meats was landed from 1953 to 1956 (Somerville and Dickie, 1957). These landings were all or almost all by vessels

from the Canadian mainland. The fishery on this bank decreased in 1957 to about 150 thousand lb and then rapidly disappeared as the offshore scallop draggers turned to the more productive Georges Bank. In 1964, total Canadian landings from St. Pierre Bank rose to 720 thousand lb of shucked meats, 173 thousand being landed in Newfoundland. Except for small landings in 1963, virtually no Canadian scallop dragging effort had been expended here since 1958. The 1964 catch was divided fairly evenly between the beds on the northern and southern shallow-water parts of this bank.

The Future

No large Newfoundland scallop industry can be expected unless our vessels, like those of Nova Scotia and New Brunswick, begin to fish Georges Bank. A modest fishery should be possible, however, in Port au Port Bay and on St. Pierre Bank in the years when the beds in these areas are flourishing. There are also many small inshore beds which could be fished by small scallop draggers, not concentrating on one bed but fishing a number of them systematically and allowing time for recovery and growth.

More Information

More information on giant scallops in the Newfoundland area can be found in Dickie and Chaisson (1955), Somerville and Dickie (1957), and Squires (1962). For information on the much greater Canadian Maritimes fishery for giant scallops see Dickie (1955), Dickie and Medcof (1963), and Bourne (1964).

Other molluscs

The Newfoundland area is in general too cold for spawning of the American oyster though adults will survive and grow. The introduction of the European oyster is a possibility, and also the production of American oysters from imported seed oysters. Experiments are being carried out by the Department of Fisheries of Canada on the latter. The soft-shell clam is present in many places, especially on the mud-sand beaches in the bays, but evidently in limited quantity. The edible mussel is present and the horse mussel, a larger species, is sometimes numerous in some bays but these are not commercially important at present. An average yearly production of 1200 lb of mussel meats in 1958–62 came from a small cannery which operated in Trinity Bay from 1956 to 1961. The ocean quahaug occurs at least in St. George's Bay and on the Southeast Shoal of the Grand Bank, but it is difficult to market in quantity at the present time and its abundance is not yet evaluated. Large periwinkles and whelks are numerous in places but are not used commercially.

Seals

Newfoundlanders have always been interested in the seal fishery. It often gave them a great emotional and economic lift at a rather depressing season

before the cod fishery began. It provided, also, the greatest local tragedies apart from those of war. The great decline in the fishery in recent years has been a real loss to the Newfoundland character and tradition far beyond the economic one.

The harp seal is an excellent example of a marine resource in which the stock has been greatly reduced by overfishing. Throughout its long history, because of the intense local interest, the fishery has been much better documented than any of our other fisheries.

Also, the fishery, unlike our ocean fisheries for groundfish and similar species, has great research and management advantages: from a given number of parents the numbers of young surviving to the stage when they are caught by the fishery can be fairly well estimated.

The principal commercial seals are the harp, or saddleback (Fig. 63, 64), and the hood seal. The more important, the harp, has since 1932 made up 98% of the Newfoundland landings and 97% of the Norwegian landings from the Northwest Atlantic. Also, there are on the drifting ice occasional stray specimens of the bearded seal, or square flipper, and more rarely of the ringed seal, or jar. The grey seal, or horsehead, has colonies especially in the southern part of the Gulf of St. Lawrence, on the east coast of Cape Breton Island, and at Sable Island; it breeds on shore or on fast ice near shore, in late January or early February (Mansfield, 1963). In summer the harbour, or bay, seal is common in many areas; it produces young on shore, in Newfoundland usually during the first half of June (Templeman et al., 1957; Mansfield, 1963).

The great Newfoundland catches of harps have been mainly of whitecoats, or pups, 1–3 weeks old.

Life History of the Harp Seal

The harp seals which come to Newfoundland in winter and spring spend the summer on the coast of West Greenland and in the eastern Canadian Arctic. They begin to migrate southward in autumn, and by late December and early January they migrate partly along the east coast of Newfoundland and partly through the Strait of Belle Isle into the Gulf of St. Lawrence. In February they turn northward again until they meet suitable ice. The east coast, or Front, herd mount the ice and produce their young off the northern part of the east coast of Newfoundland or off southern Labrador, usually in the general region east of the Strait of Belle Isle (the "Front"). The Gulf females usually whelp in the area between Prince Edward Island, the Magdalen Islands, Anticosti, and Gaspé.

The young harps of the eastern Canadian area are almost all born in the first 2 weeks of March (Sergeant, 1965a). In the Gulf, whelping usually begins and ends a few days earlier than on the Front. With rare exceptions, only one pup is born to a female.

The newly born young, or whitecoats (Fig. 63, 64), remain helpless on the ice. The long, white, wool-like hair is firmly seated in the skin (fast-fur) for about

a week to 9 days. Then the hairs begin to loosen and can be pulled out. About 12 days to 2 weeks after birth the white hairs begin to fall out and the underlying, short, grey-hair coat becomes visible in patches. The pup in this condition is

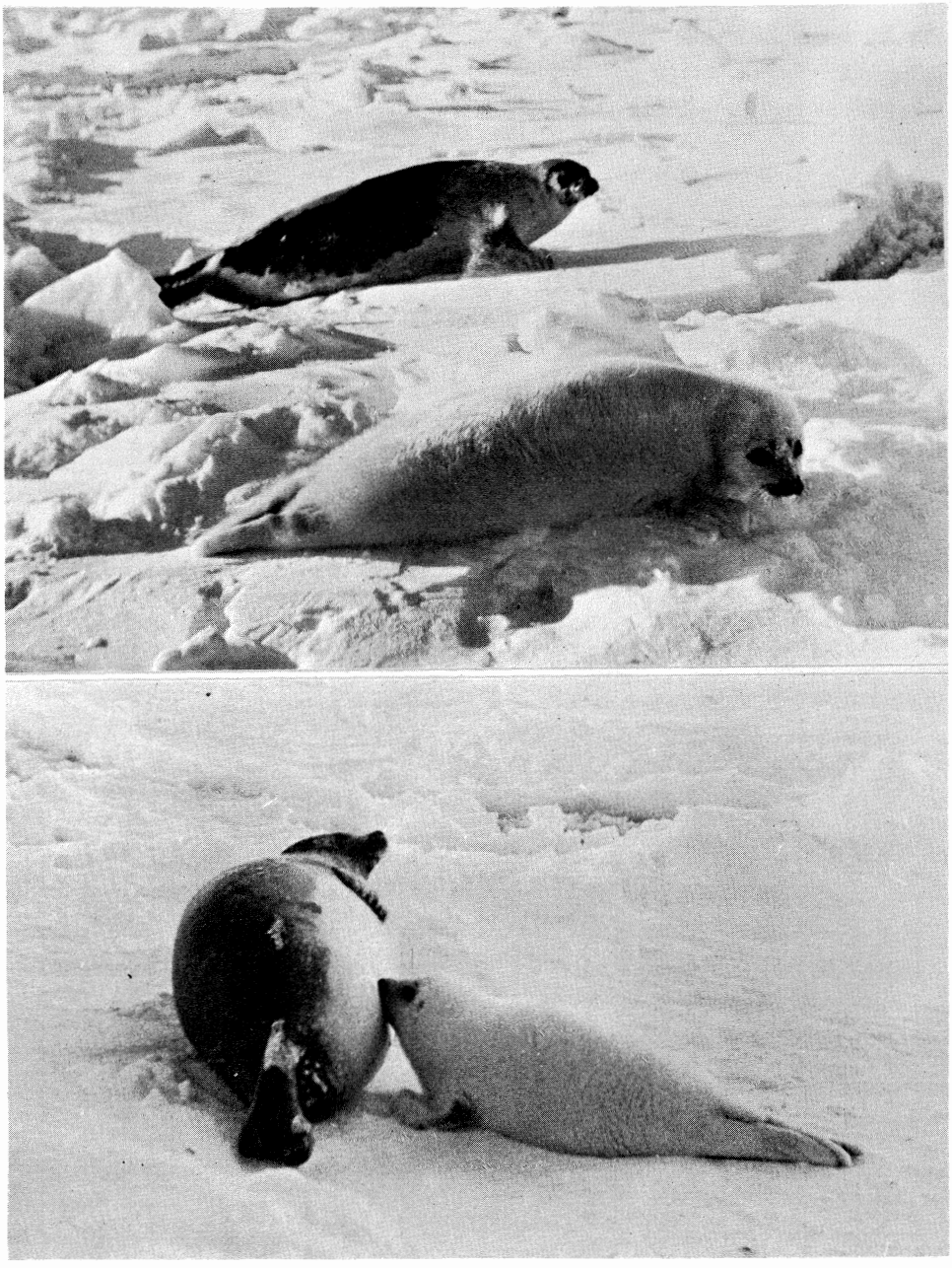


FIG. 63. *Above,* adult harp seal and whitecoat. *Below,* female harp suckling a whitecoat. (Photos by Crawley Films Ltd., Ottawa.)

called a ragged-jacket. Moulting is completed in about 3 or 4 weeks after birth, and the young seals begin to enter the water toward the end of March. These moulted young with short-haired, grey-spotted fur are called beaters. Occasional

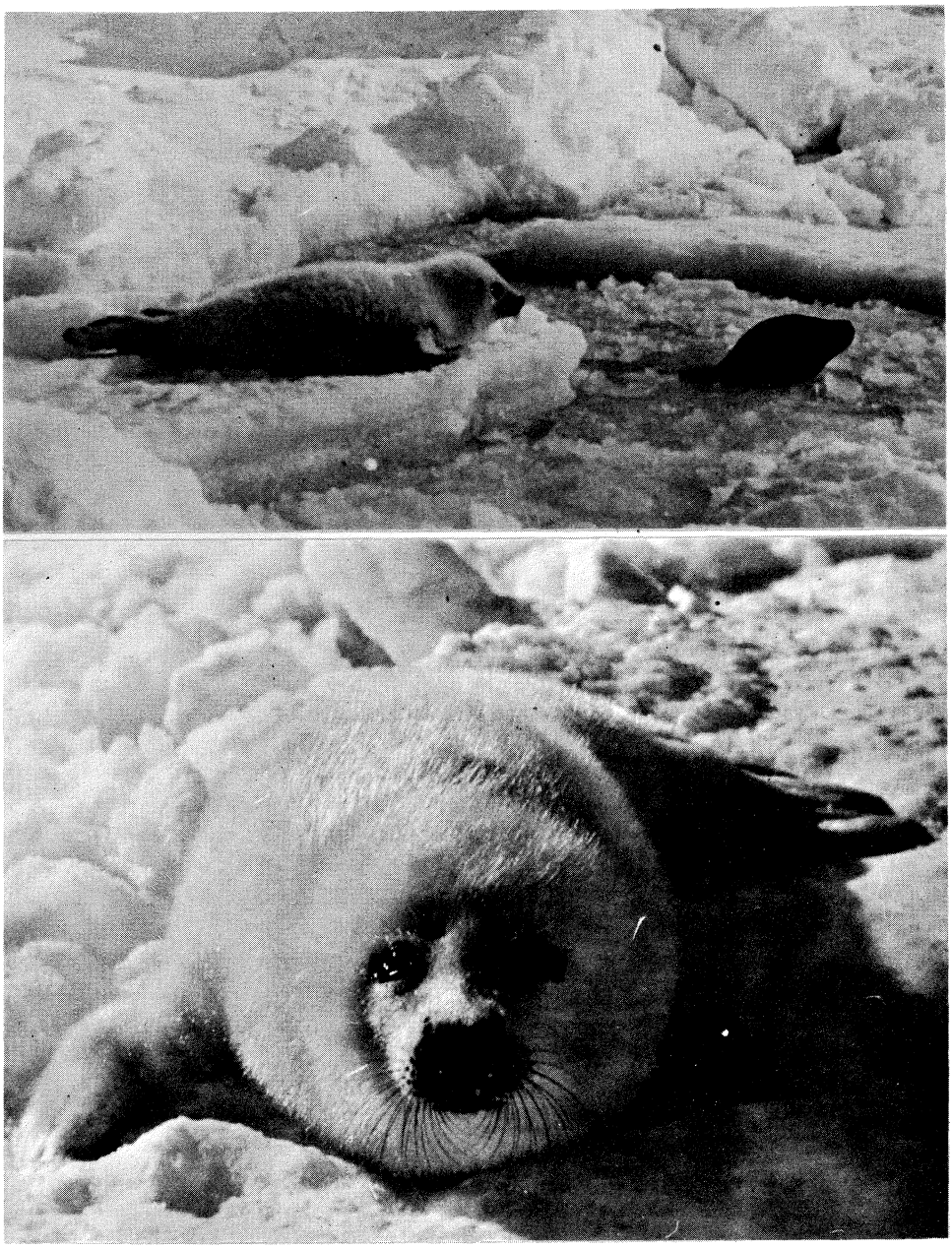


FIG. 64. *Above,* whitecoat on ice and adult harp in water. *Below,* a harp whitecoat. (Photos by Crawley Films Ltd., Ottawa.)

still-born whitecoats are found, called cats by the Newfoundland sealers. The young harps are smaller than young hood seals, or bluebacks, and enter the water later; the hood sheds its coat before birth and has a darkish-blue, fast-fur, short-haired coat from the beginning.

Immature harps more than 1 year old have a spotted coat and are called bedlamers. In the early years of sexual maturity the saddle- or harp-shaped markings of the old harp seal gradually develop; they develop at an earlier age in the male than in the female.

The whitecoats are born close together in large patches on relatively few square miles of ice (usually in patches of 15—100 square miles in area in recent years). There is a tendency for two main patches to form on the Front and one or two in the Gulf.

The female harps suckle their young on the ice for 2 or 3 weeks after birth, then leave the moulting pups and mate with the males, apparently mainly in the water. Usually very few adults are seen with the pups later than about March 20, (Fisher, MS, 1954).

Meanwhile the seals on the Front have been drifting southward in the Labrador Current along the east coast of Newfoundland, and the Gulf seals in the Gaspé Current eastward toward Cabot Strait.

Beginning in late March and continuing into May the adults and bedlamers of the Front herd mount the ice (Fig. 65) east of Newfoundland to moult. The herds come out on the ice to continue moulting farther and farther northward as the southern ice disintegrates. By June they are usually north of Belle Isle.

The harps of the Gulf herd do not join the Front herd to moult but moult in the Gulf, partly in the water (Sergeant, 1965a). After moulting, they move through the Strait of Belle Isle and follow the Front herd up the Labrador coast (Mansfield, 1963).

The young harps weigh about 20 lb at birth, and the pelt about 6—8 lb. They gain weight rapidly (feeding on milk with 43% fat and 11% protein, i.e. fat 10 times as much and protein over 3 times as much as in cow's milk) until in 2 weeks they usually weigh from 60 to 70 lb. Of this, two-thirds is skin and blubber and is removed as the pelt, or sculp. In the next few days they may reach larger sizes; Fisher and Sergeant (MS, 1954) have recorded average sculp weights in different years of 45—55 lb.

Between 2 and 2½ weeks after birth the female ceases to attend the moulting young. The latter then loses weight until after it takes to the water, when it can catch enough food to build up fat and protein again. The adult harp may weigh up to 350 lb or more, the male being a little larger than the female.

The female harp begins to produce young at 3—7 years of age (Sergeant, 1965b), and may live and produce young until more than 30 years of age. The

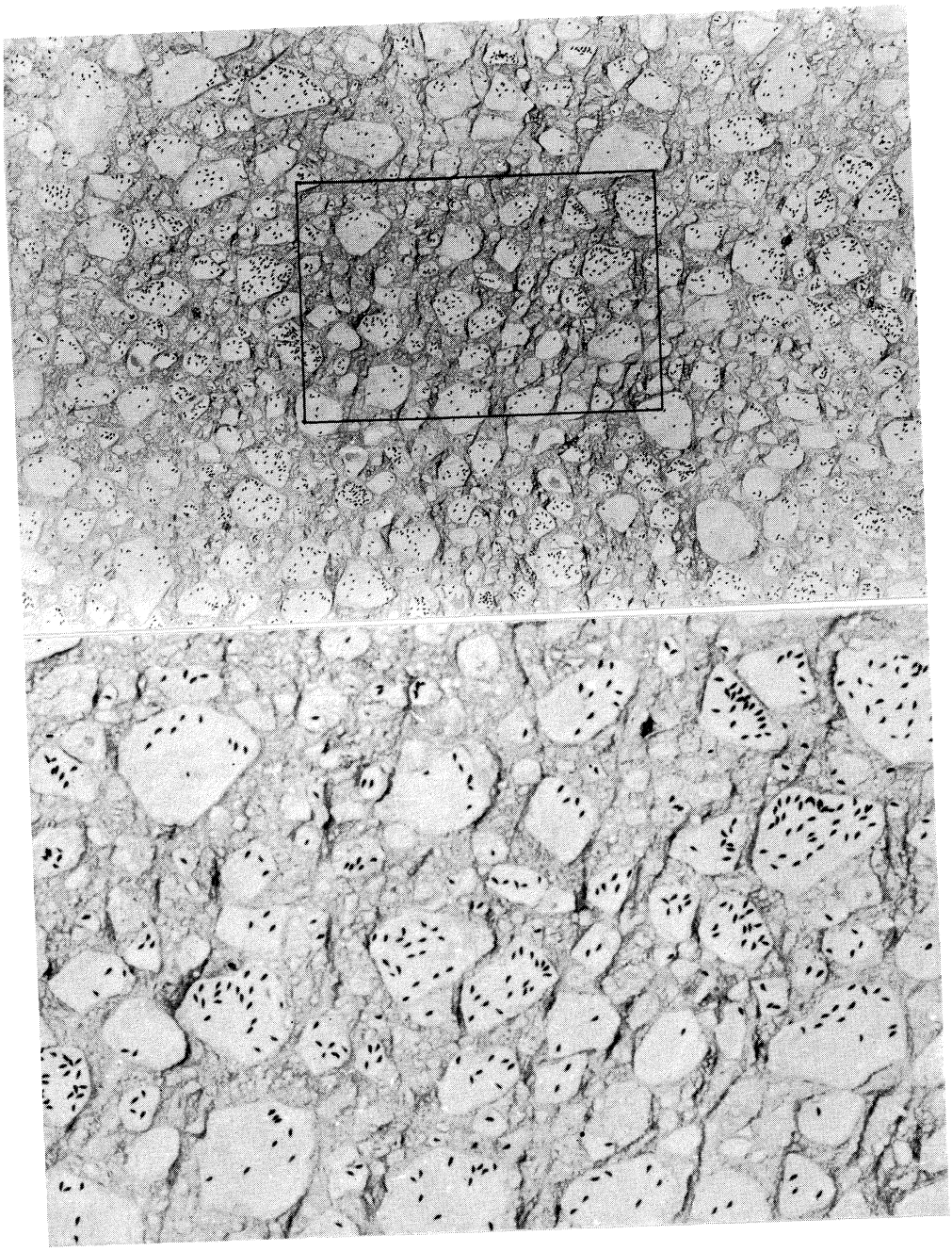


FIG. 65. *Above,* aerial photograph of part of a moulting patch of harp seals, east of Belle Isle, April 13, 1962. *Below,* enlargement of area in rectangle. (Photo by Aero Photo Inc., Quebec, courtesy Dr D. E. Sergeant, Fisheries Research Board of Canada, Arctic Biological Station.)

mean age of sexual maturity for female harps was formerly 5 years in both herds but has fallen to 4 years in the Front herd, probably in response to heavier fishing, but remains at 5 years in the Gulf herd (Sergeant, 1965b). In 1965 the Gulf population also showed a reduced age at maturity (letter from Dr Sergeant, July 14, 1965). In any one year about 90% of the adult females produce young. Mature males and mature females are about equal in number, and the number of bedlamers about equals that of mature individuals (Sergeant, MS, 1961). The number of pups produced is about 22% of the total herd of immature and mature harps. Ages of seals may be determined from sections of the canine teeth.

Seal Landings from the Northwest Atlantic

Seals were killed by Newfoundlanders from the time of the earliest settlers. The fishery developed rapidly in the early part of the 19th century. Exports increased from 81 thousand skins in 1805 to 281 thousand in 1819, and were highest at 687 thousand in 1831 (Fig. 66, A). The exports then fluctuated markedly, some of the larger amounts being 631 thousand skins in 1840, 651 and 686 thousand in 1843 and 1844, 534 thousand in 1852, 508 thousand in 1858, 486 thousand in 1871, and 458 thousand in 1879.

From 1881 to 1910 the landings by Newfoundland ships (Fig. 66, B) fell little on the average, but great annual variations occurred. Since then they have gradually fallen, reaching very low levels in both world wars and in the 1931–32 period of depression, and with each successive recovery reaching lower and lower levels. Landings were above 300 thousand in only 8 years between 1882 and 1911, and above 200 thousand in only 9 years between 1912 and 1948. Total landings by all countries rose to above 200 thousand skins in all years from 1949 to 1964, from negligible totals during the Second World War due to lack of seal fishing. They exceeded 300 thousand in 8 of these years, and exceeded 400 thousand in 1951 and 1956. In 1946 Norway re-entered the fishery after making small catches in 1938 and 1939, and since 1952 has taken more than half the vessel catch. In 1949, Nova Scotian vessels entered the fishery, and since 1954 their catch has considerably exceeded that of the Newfoundland vessels. Some Nova Scotian vessels operate with Newfoundland crews. Newfoundland landings from 1954 to 1964 ranged between 32 thousand and 78 thousand seals, over 40% of which were taken by landsmen.

Allen (1880) quoted from Rink, whose publication date was 1877, that the annual catch of harp seals in Greenland at that time was 33 thousand. Dr D. E. Sergeant (personal communication, April 26, 1963) said that the average yearly catch of harp seals in West Greenland for 1954–60 was close to 15 thousand.

Before 1951 the fishery was mainly on the Front, the landings from the Gulf herd being relatively small. In more recent years both the Gulf and the Front herds have been heavily attacked. Hunting mortality of pups increased from

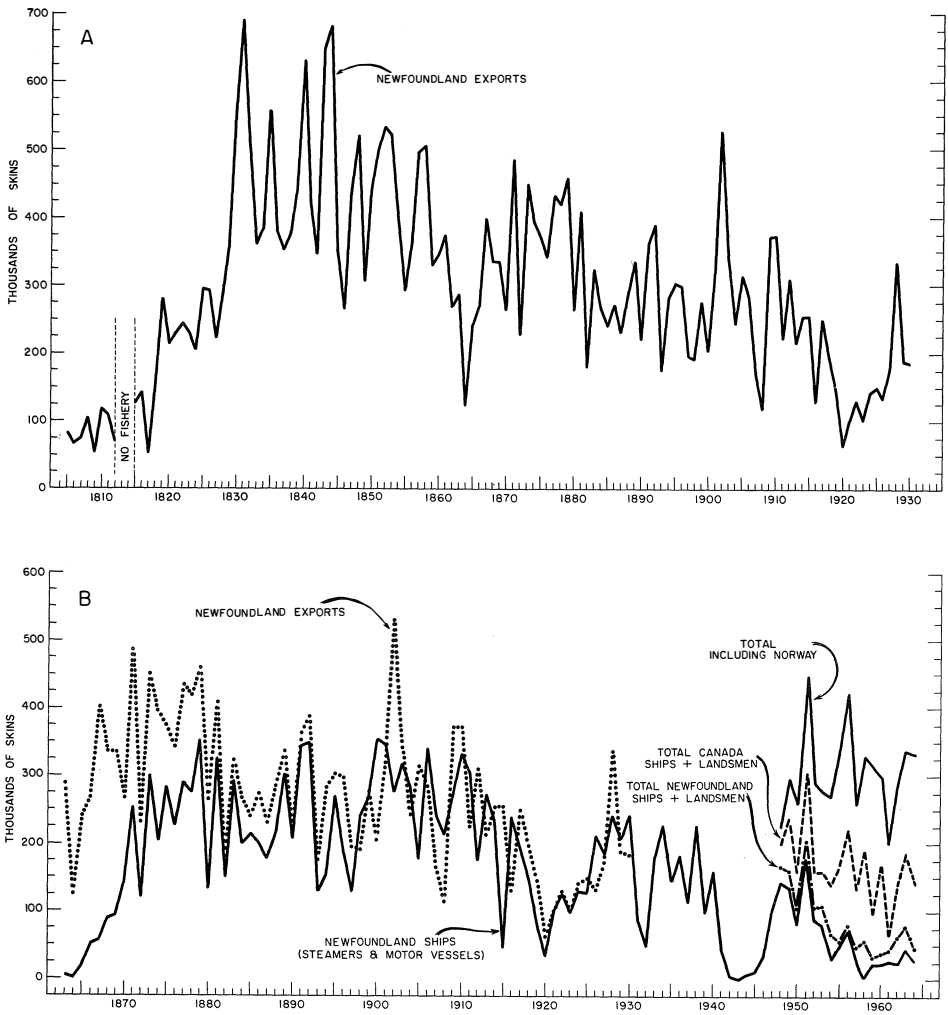


FIG. 66. A, Newfoundland exports of seal skins from herds of the eastern Canadian area (Front and Gulf), 1805–1930. B, landings by Newfoundland ships, 1863–1964; and total landings by Newfoundland, Canada, and all countries, 1948–64. (The seals landed were almost all harps and hoods, and almost entirely harps in recent years. Catches by Newfoundland landsmen are included in the export figures. Landsmen's catches are included in the total catch from 1948 onward for Newfoundland and presumably for the Maritimes and Quebec. Norwegian ships landed 16 thousand and 31 thousand skins in 1938 and 1939, respectively. Up to 1948 the only serious deficiencies in the data are landsmen's catches by Quebec from the north shore of the Gulf of St. Lawrence and from the Magdalen Islands; probably some schooner landings in the 19th century on the Canadian mainland; landings in West Greenland; and in 1946 and 1947, Norwegian landings of 6894 and 9081 seals. When Newfoundland dominated the fishery, some of the mainland landings may have been occasionally sold in Newfoundland and thus form part of the Newfoundland exports. For 1961, landings by a Russian ship of about 17,000 seals and by a Greenland vessel of 5655 seals are included in the total for all countries.)

about 30% in 1950–51 to nearly 75% in 1959–60, and total mortality of pups from about 50 to 80% in the same period (Sergeant and Fisher, MS, 1960).

Hood seals occur in family groups (male, female, and pup) much more scattered than the harps and hence require more individual hunting. Often the parent hoods defend the young, and one or both are killed with the pup. In the Newfoundland vessel fishery in the periods 1895–1913, 1914–31, and 1932–61 the harp and hood seal kills totalled about 5 million, 2.7 million, and 2.5 million. Hood seals made up 6.3, 3.7, and 1.9% of the totals and the mature hoods made up 28, 33, and 35% of the hoods taken. In the same periods, in the Newfoundland vessel fishery the mature harps made up 3.1, 3.5, and 6.3% of the harps taken, and the mature harps and bedlamers together made up 8.6, 10.8, and 20.4%.

In recent years the ratio of bedlamers and adult harps to whitecoats in the catch has increased. In 1930–39, when the vessel fishery was almost entirely from Newfoundland, bedlamers and adults made up 17% of the harp seal landings from vessels; but in 1949–58, with increased landings and sealing by other than Newfoundland ships, bedlamers and mature harps made up 29% (Sergeant and Fisher, MS, 1960).

Population Studies and Consequent Recommendations

Sergeant and Fisher (MS, 1960) estimated from aerial photography surveys in 1950–51 and 1959–60 that the pup production and the population of harp seals breeding in the northwestern Atlantic was reduced by 1960 to less than half those of 1950. It was also certain that the early seal population, which prior to 1854 permitted some kills of 500 thousand to over 600 thousand, mostly harp whitecoats, was greater than that of 1950.

With the reduced catches after 1930 and especially during 1941–46, when vessel catches were negligible, the herd apparently built up again. In 1950–51 the surveys (Fisher and Sergeant, MS, 1954) indicated that bedlamer and adult seals of the Gulf and Front herds totalled at least 3.3 million, the Front herd being about twice the size of the Gulf herd.

The 1959–60 aerial surveys (Sergeant and Fisher, MS, 1960), interpreted on the same basis as those in 1950–51 from observations of pups, indicated a minimal total of 1.2 million immatures (bedlamers) and adults in the Front and Gulf herds. The Fisheries Research Board of Canada (MS, 1964) reported that, on the basis of an aerial survey in the spring of 1964, present population estimates are about 0.5–0.6 million harp seals for the Gulf herd and 0.7–0.8 million for the Front herd. Sergeant's (1965b) most recent estimates of the yearly production of young harps are: in 1950–51, Front 430,000, Gulf 215,000; in 1959–60, Front 215,000, Gulf 150,000; and in 1964, Front 200,000, Gulf 150,000. The Front herd has been reduced more rapidly than that in the Gulf because of the

much greater amount of killing of moulting adult and immature seals at the Front.

Between 1840 and 1853 Newfoundland annual exports of seal skins averaged about 480 thousand. Also, some landings were made in West Greenland and on the Canadian mainland and often considerably more young were killed than were taken on board and many adults were killed or wounded for each one secured. The slow decrease in landings indicates that the sustainable catch was not greatly exceeded, but the continuing (though irregular) decline shows that it was exceeded until the herd was allowed to build up again by the low kills of 1930–48. During this latter period, and actually beginning about 1925, there was reduced effort in Greenland as the harp seals became scarcer; cod became much more numerous and the Greenlanders changed from a seal-hunting to a cod-fishing economy (Jensen, 1939). Seals had, in fact, decreased on the coast of West Greenland by 1908, when Jensen began his investigations in that region.

Fisher and Sergeant (MS, 1954) recommended that the killing of parent females attending their pups in March should not be permitted and that (assuming that the male harp is polygamous and that all mature males are not needed for reproduction) killing in the moulting patches should cease by the end of April. The reasons for these recommendations were: first, the pups are most easily secured and have generally been most valuable, at least in relation to their weight; second, from about seven pups which escape the spring fishery of their year of birth only one mature female is added to the breeding herd. Further (Sergeant and Fisher, MS, 1960), mature females are very scarce in the moulting patches before about April 20.

Killing of pups will still need to be restricted to a reasonable quota. Also, the numbers of immature and mature females killed in the moulting patches and the percentages of mature females bearing young will need to be carefully watched, and the total kill of immature and adult seals reduced considerably, as the percentage of adult males in the herd is reduced. At least for the Front herd all the above and other restrictions on killing must be obtained by international agreements. With the present apparent size of the herd, the total allowable kill at first would not be much greater than the present total of Canadian landsmen's and West Greenland landings. Beginning in 1965 new regulations for the Gulf of St. Lawrence — setting a quota of 50,000 harp seal pups, and forbidding the taking of adult seals in the breeding patches and the killing of hood seals — were an important advance toward meeting the objectives of conservation for the Gulf herd.

Retrospect and the Future

The Newfoundland seal fishery began with landsmen using seal nets and small boats, and with pedestrian captures when the winds brought the ice and seals close to land. The great landings before the 1860s were obtained by sailing

schooners. According to Chafe (1923), in 1851 there were 323 vessels (30,216 tons) and 10,682 men engaged in the seal fishery; in 1857, over 400 vessels (from 70 to 200 tons) with about 13,000 men; and in 1860, 292 vessels (34,852 tons) and 14,121 men. In 1863 the first steam vessels were used. As these were successful, their numbers increased and they rapidly replaced the sailing vessels. Chafe (1923) reported that four schooners took part in the fishery in 1898 and two in 1910 but there may have been more, and occasional schooners have engaged in the hunt since then.

The number of vessels and men in the steamer fishery was greatest in 1881: 27 vessels and 5815 men. The tonnage of steamers used was greatest in 1912: 12,670 tons (23 vessels and 4179 men). By 1920 the vessels had been reduced to nine with about one-quarter the 1912 tonnage and 1583 men (Colman, 1937).

The use of spotting planes began in 1921, and though at first unsuccessful they are now found to be very useful. In 1962–64, helicopters and planes based on mainland areas were used to hunt seals in the Gulf of St. Lawrence. On the Front a few helicopters based on ships have been used since 1961, and four based on land in 1964.

At the beginning of the First World War the Newfoundland sealing fleet was an excellent one with nine steel vessels and 10–12 wooden vessels. Most of these were sold or sunk during the war. The relatively low prices for fat, occasional unsuccessful years, and the difficulty of finding profitable employment for sealing vessels after the sealing voyage was over have prevented the replacement of this fleet by one equally or better fitted for sealing.

Unless there is some prospect of building up the herd, Norwegian and Nova Scotian competition and the reduction in the size of the herd since 1950 make the future doubtful, except possibly for efficient sealing vessels which can also be used profitably for other purposes.

More Information

Information on the seal catches and the fishery in the Newfoundland area may be found in Carroll (1873), Hatton and Harvey (1883), Prowse (1896), Chafe (1923), Bartlett (1929), Colman (1937, 1949), Andrews (1951), Fisher (1952, MS, 1954, 1955), Fisher and Sergeant (MS, 1954), Sergeant and Fisher (MS, 1960), and Sergeant (1965a). Accounts of the fishery for the hood seal are given by Rasmussen (1960); of tagging of harp and hood seals, by Rasmussen and Øritsland (1964); of the Norwegian fishery for harp and hood seals in the Jan Mayen and Denmark Strait area east of Greenland, by Nansen (1925) and Rasmussen (1957); of the exploitation and conservation of harp and hood seals of the North Atlantic, by Sergeant (1965b); of the fishery for the ringed seal and the bearded seal of the Canadian Arctic, by McLaren (1958a, b); of that for the grey seal, by Mansfield and Fisher (MS, 1962) and Mansfield (MS,

1962); and of distribution of the harbour seal in the Newfoundland area, by Templeman et al. (1957). A good account of the biology of the harp seal of the White Sea is given by Sivertsen (1941). For notes on all seals of the area, consult Allen (1880), Dunbar (1949), Fisher (1950), and Mansfield (1963).

Whales

Large Whales

The large whales of the Newfoundland area are the whalebone or baleen whales, the blue, finback, humpback, and sei; and a toothed whale, the sperm. There are also occasional right whales, the easiest to kill with small boats and the main kill of the earliest whalers in the Northwest Atlantic but now relatively scarce and protected.

The *blue whale* is the largest animal that ever lived, growing occasionally to over 100 ft long; one 89 ft long weighed more than 119 tons and yielded 166 barrels of oil. The calf is 23–26 ft long at birth and is nursed by the mother for about 7 months, when it is about 52 ft long. *Finback whales* are faster swimmers and thus more difficult to catch than humpbacks or blue whales; they grow to about 80 ft. Old *humpbacks* (Fig. 67) average about 50 ft. long but have a proportionately greater girth than the other large whalebone whales. The *sei whale* rarely exceeds 56 ft in length and is usually hunted only when the larger blues, finbacks, and humpbacks are not available. The male *sperm whale* is larger than the female and may grow to over 65 ft long. Its oil is not edible. Adult male sperms come into the Newfoundland area in summer, but the females and immatures remain in tropical wintering quarters.

The large baleen whales in the Newfoundland area feed mainly on capelin and on euphausiids. The capelin they feed on are usually immature or not in spawning condition, and are known to the whalers as whitefish. The euphausiids, small shrimp-like Crustacea, are called krill by the Norwegian whalers.

Landings. The earliest whaling in the Newfoundland area, for the right whale, was begun by Basques, apparently before the middle of the 16th century. From 1796 to 1807, American vessels carried out a whale fishery on the south coast of Newfoundland, using 12 vessels in the first 3 years (Prowse, 1896). Between 1840 and 1888 there was some whaling in occasional periods, mainly from Gaultois in Hermitage Bay; the catches were as high as 100 whales per year but usually much less.

Modern Norwegian-style whaling began in Newfoundland in 1898. The number of catchers and land stations rapidly increased. In 1904 there were 14

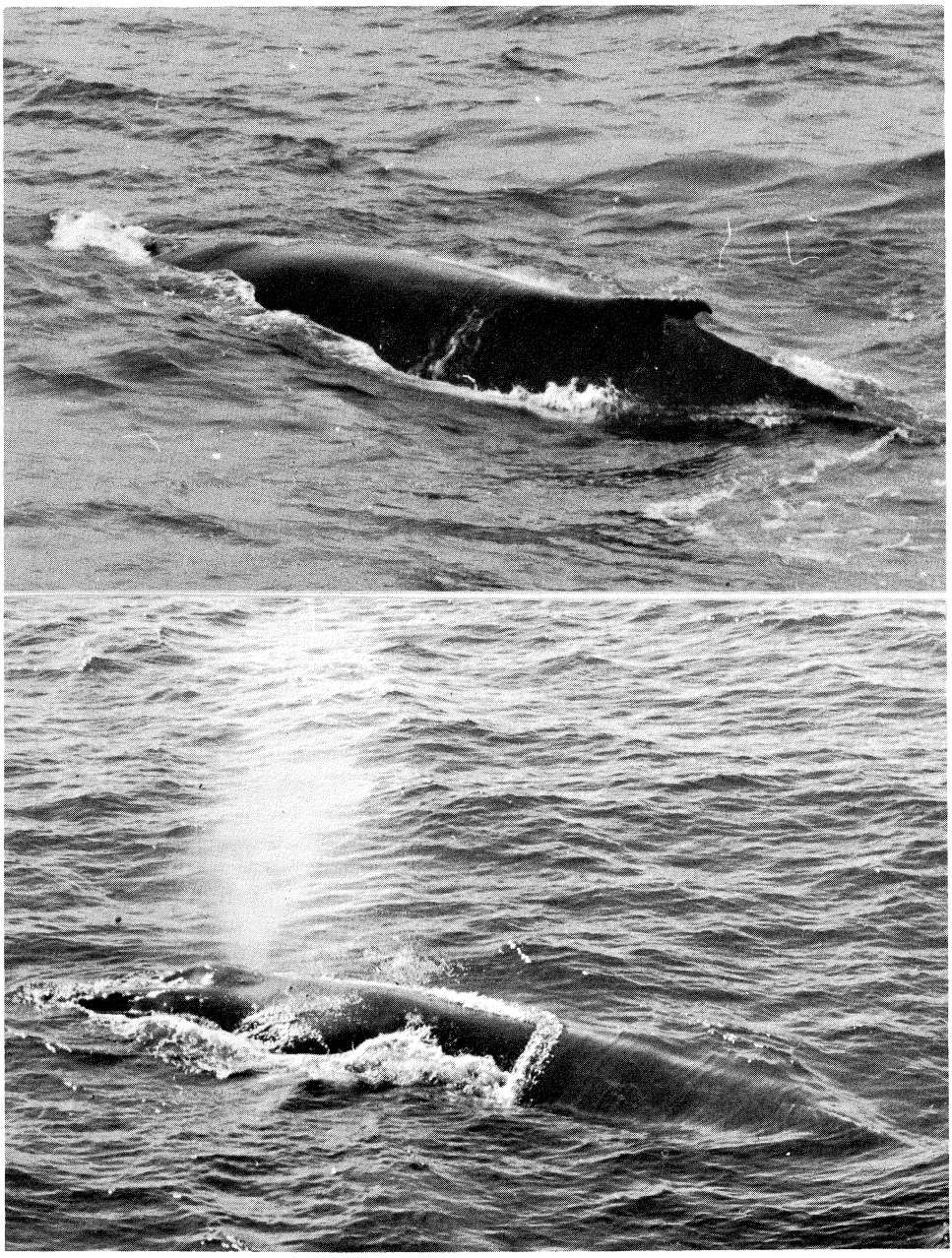


FIG. 67. Humpback whales on the Southeast Shoal of the Grand Bank, August 3, 1959. The one in the upper picture has an unusually well developed dorsal fin.

stations and 1275 whales were taken (Fig. 68). In 1905 the stations increased to 18 but the catch fell to 892 whales. Then the landings continued to decrease rapidly until whaling ceased during the First World War. Blue and humpback whales, being less active and much less numerous than finbacks, were reduced in numbers faster and were caught in relatively small numbers after 1905. In three periods since 1918 the landings were close to or greater than 500 whales, the most recent high point being 759 whales in 1948. By this time only two whaling stations remained, at Williamsport in northeast Newfoundland and at Hawke Harbour in southern Labrador.

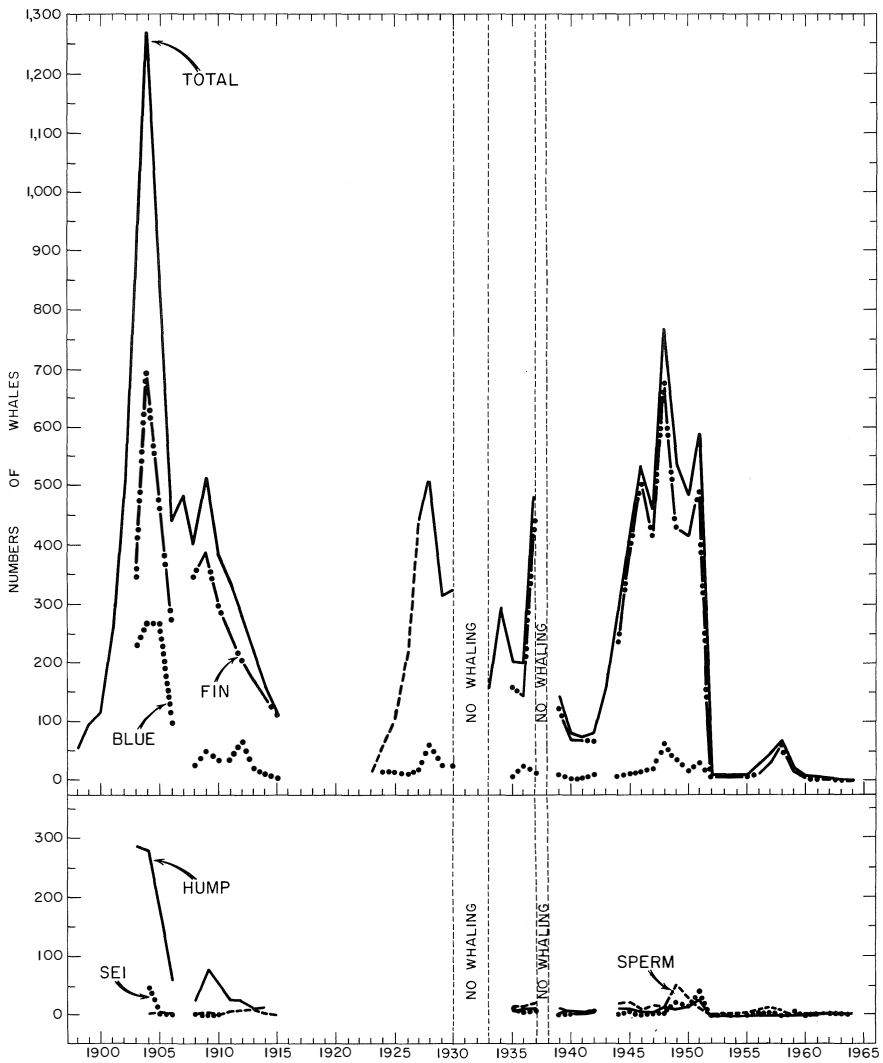


FIG. 68. Newfoundland landings of large whales, 1898–1964.

Since 1951 the Newfoundland fishery for large whales has been limited to a small effort at Hawke Harbour from 1956 to 1959 that took about 20–60 large whales per year, and to an occasional kill of finbacks or of sei whales by the small-whale vessels stationed at Dildo. All four declines in the landings to zero or near zero since 1900 (Fig. 68) were due to economic conditions or war. The main products from the whaling plants in recent years have been whale oil, whale meal, and guano; the reduction in value of whale oil prevented profitable operation. The decline after 1909 is often attributed to lack of whales in relation to the effort expended, but there is no certainty that fin whales were excessively exploited during this period.

The future. The landings between 1945 and 1950 suggest that the stock of large whales may be able to sustain a yearly kill of about 400, but no period of operation since the beginning of the fishery has been long enough to provide a reliable figure for the sustainable yield. It may be below 400. However, the revival of the Newfoundland fishery presumably depends on use of the meat for animal food (and possibly for human consumption) and on higher prices for oil and meal.

Small Whales

The small whales of importance to Newfoundland are the pilot, or pothead, and the minke. The pothead is a toothed whale, and the minke is a small baleen whale.

Potheads. The male potheads reach a maximum size of about 20 ft and the females 16 ft. They occur in herds of 10 to over 200 individuals; the larger herds occur most often near shore, where a number of herds may combine or be driven together (Sergeant, 1962). They have the habit of following the leader, usually the largest male of the group, and thus are susceptible to natural strandings or to being driven ashore in complete herds.

For several centuries there has been a small amount of local exploitation of the pothead whale, by the whalers before 1900 and by fishermen removing the blubber from herds which they drove ashore or which stranded naturally.

The modern industry for small whales began in 1947 at Dildo in Trinity Bay. Up to 1950 the small number of potheads taken were all harpooned and the first large landings, of 3100 in 1951, began with the practice of driving the whales onshore in this area.

Since 1951 the exploitation of pothead whales has been considerably increased. A few have been harpooned but most have been driven ashore by fishermen (Fig. 69), at first almost entirely in Trinity Bay but more recently in both Trinity and Bonavista bays. The fat is used for oil and the meat frozen for mink food.

The landings of potheads were greatest in 1956 and 1957, at 9799 and 7831 (Fig. 70). They dropped sharply to 789 in 1958 but rose again to 6262 in 1961. In 1962 and 1963 the landings dropped sharply to 150 and 221. This was accompanied by a scarcity of squid inshore. In 1964, with squid very abundant, landings of potheads rose to 2849.

In the Newfoundland area the potheads feed almost entirely on the short-finned squid, and in the years when squid are scarce inshore these whales are scarce also. Our methods of estimating squid abundance, however, are crude, as

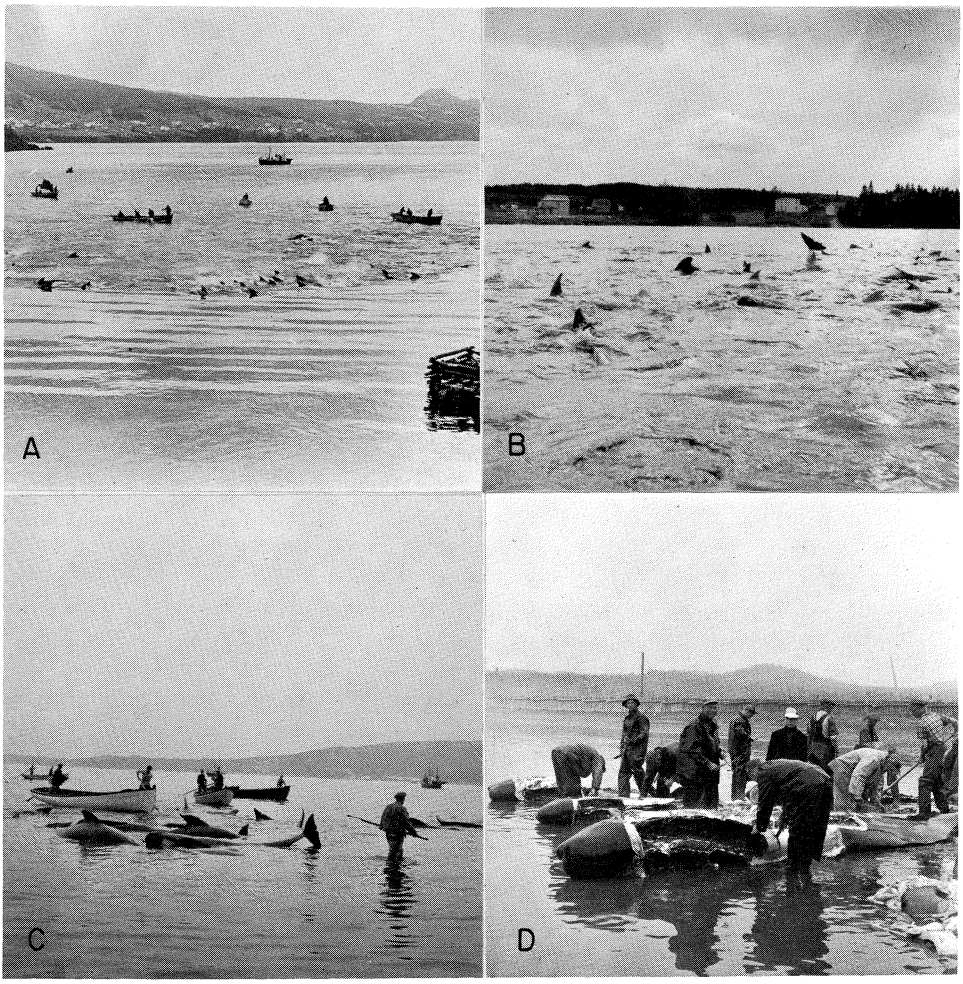


FIG. 69. Herds of pothead whales: A, potheads being driven toward shore at Chapel Arm, Trinity Bay; B, potheads driven to shallow, muddy water near shore, Southern Bay, Bonavista bay; C, potheads stranded on shore, and D, fishermen removing fat and meat from stranded potheads, at Old Shop, Trinity Bay.

they are based largely on availability of squid inshore to fishermen. Squid must be available within a few hundred yards of the shore to be available to fishermen with their present methods. Also, in some years many or most of the reports of squid abundance are from the south coast, whereas the pothead fishery is on the east coast. Hence, there is not perfect agreement between the fluctuations in abundance of squid inshore in Fig. 62 and those of pothead whales in Fig. 70. Squid were scarce in 1948, 1949, 1958, and 1962 and in these years very few potheads were taken (in 1949 none).

Sergeant (1953) said that the oil production of 2325 barrels from 3155 potheads in 1952 was comparable to the amount taken from about 80 fin whales. Thus, the oil production from the large 1956 catch would have been equal to that from about 250 fin whales. This small whale can therefore provide an industry of significant proportions.

Two of the usual criteria of the degree of fishing pressure — the increase in total mortality at the ages fished commercially and the reduction in size of the average animal killed — are not available for the pothead whale; the whole herd is usually driven on shore and all sizes are killed indiscriminately. It is also difficult to estimate the total stock of potheads with appreciable accuracy. The pothead, however, occurs widely over the northern part of the North Atlantic and should

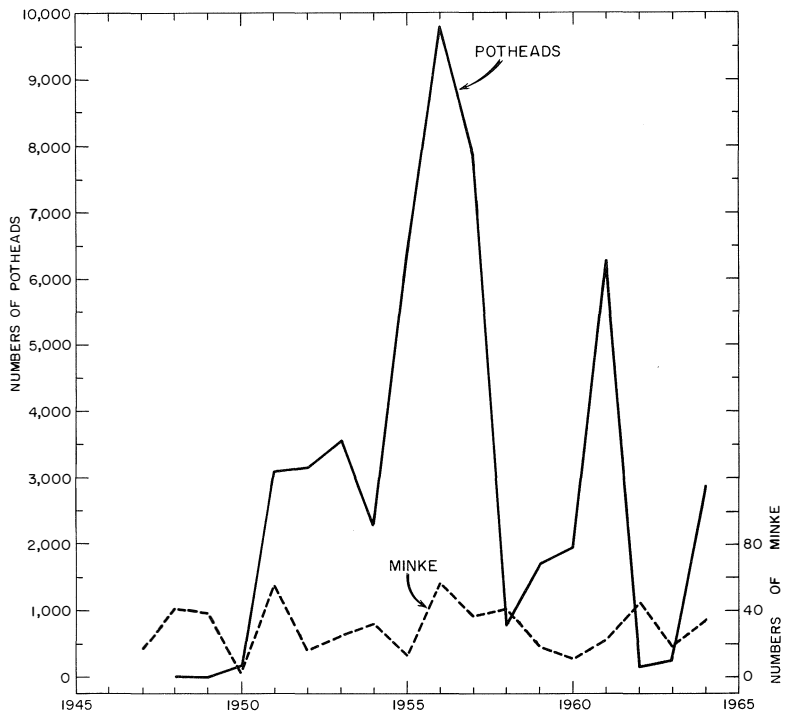


FIG. 70. Newfoundland landings of small whales, 1947–64.

be able to stand the present intermittent fishing unless the herds being killed are local. In the latter case it may be necessary to spread the killing over a greater area of the coast instead of concentrating it in two bays; and to regulate the numbers killed or, if it were feasible, to kill only the larger males by harpooning after driving the herd into a retaining pound.

Minke. A few minke whales, small baleen whales which grow to about 30 ft long, have also been harpooned in Trinity Bay. They usually feed on capelin, herring, and other small fishes. Much of the meat of this whale is excellent for human food. The landings (Fig. 70) averaged about 30 per year between 1947 and 1964, with peaks of 55 in 1951, 57 in 1956, and 45 in 1962, and were made mainly in June–July (Sergeant, 1963). This whale is hunted off Norway with ships of 60–80 ft and smaller, and about 3000 were taken per year in 1947–53 (Jonsgård, 1955). If it were economically worthwhile, much greater numbers of the whales could presumably be captured in the various bays along the coast of Newfoundland.

Killer whale. The killer whale, a small toothed whale which grows to about 30 ft, is occasionally seen during the seal fishery and is not uncommon in the Newfoundland area. An occasional specimen is included among the small whales harpooned in the small-whale industry in Trinity Bay (Sergeant and Fisher, 1957).

More Information

A general review of whaling in Newfoundland was given by Sergeant (1953). Prowse (1896) gave some information on the early Basque and American whale fisheries in the area, and Millais (1907) an account of Newfoundland whales, whaling, and of personal experience on Newfoundland hunts for the blue whale.

Sergeant and Fisher (1957) described the distribution of the smaller whales, dolphins, and porpoises of eastern Canadian waters, and Sergeant (1962, 1963) dealt with the biology of the pilot, or pothead, whale and of the minke whale in the Newfoundland area. For a description of whales, dolphins, and porpoises generally, see Kellogg (1940) and Norman and Fraser (1948).

Seaweeds

At present no commercial use is made of the seaweed (algal) resources of Newfoundland and relatively little is known about them. However, in the early 1940s Irish moss (*Chondrus crispus* (Linnaeus)), a commercially important red alga (Fig. 71), was harvested from St. Mary's Bay and exported to the United States in the following amounts and values:

1941–42	28,795 lb	$2328
1942–43	15,506 lb	$1930
1943–44	11,534 lb	$1434

A survey of the seaweed resources of Newfoundland, with special attention to Irish moss, was carried out for the Industrial Development Board of Newfoundland in August 1948 (Humm, MS, 1948). The survey covered the greater part of the coast of the Avalon and Burin peninsulas and Notre Dame Bay, but Humm included reports by the Newfoundland Rangers and others on the abundance of seaweeds generally, especially the kelps, in many Newfoundland and Labrador areas.

Humm concluded that the most important seaweed resources of Newfoundland were the brown algae, which include the kelps (*Laminaria, Agarum*, etc.) and the rockweeds (*Fucus* and *Ascophyllum*). These species are available in large quantities and from them algin and other products can be made. The principal resources of Irish moss seen on this survey were in Colinet Harbour, Placentia Sound, Ship Harbour (Placentia Bay), Sound Island, Marystown, Trepassey Bay, and Gander Bay. Humm believed that Irish moss occurs in Newfoundland in sufficient abundance to justify its commercial use, but not in sufficient quantity to keep a factory in operation the year round. Recently, as a result of scuba diving in Port au Port Bay, beds of Irish moss have been found in shallow water and, it is believed, in sufficient quantity to be harvested.

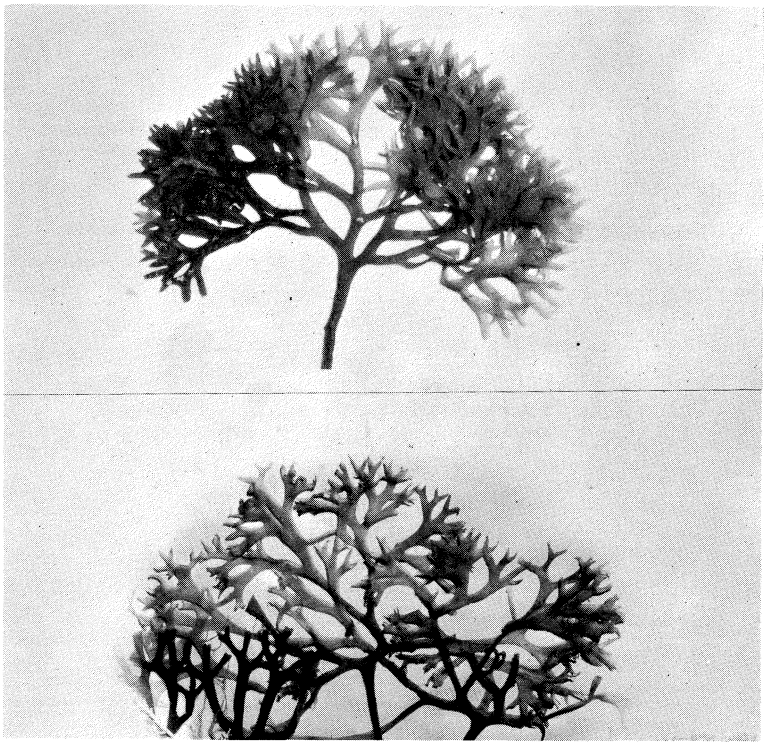


FIG. 71. Irish moss.

In addition to the kelps and rockweeds, the fall storms bring in to many beaches great quantities of a finely divided red seaweed, presumably mainly *Plumaria (Ptilota).* This was formerly collected and used in very large amounts by Newfoundland fishermen as a fertilizer, especially for potatoes.

More Information

Wilce (1959) gave further scientific information on the marine algae of Labrador and northwestern Newfoundland, and Taylor (1937) on the species on the northeastern coast of North America.

Future of the Newfoundland fisheries

The future of the Newfoundland fisheries will be determined not only by natural events and Newfoundland enterprise but also by the activities of our many competitors. To foretell the future it is necessary to begin from the only base available, the past and the present.

Recent Changes

The years since 1948, especially those since 1953, have brought a great and rapid change in the fisheries of the Northwest Atlantic, especially of the Labrador–Newfoundland area (Subareas 2 and 3 of ICNAF). It has been the final period of discovery of great new resources of groundfish — cod, redfish, and American plaice — largely by the Fisheries Research Board's Station at St. John's. In the period, all the great groundfish populations — the most recent being the redfish — have come under intensive exploitation. New information, however, on the localities and seasons of commercial concentrations of these populations is constantly being obtained.

The period has witnessed great increases in the European fleets, the introduction of European pair-trawling and longlining to the area, and most recently the great development of factory trawlers and mother ships in which fresh fish can be filletted and processed on the fishing grounds. These new, large factory trawlers are stern trawlers which can fish in much rougher weather than the conventional side trawler.

In the inshore Newfoundland fishery, since 1961 there has been a great increase in gillnetting for cod with the introduction of nylon gill nets. It will be 10 years or more before the long-term importance of this new inshore gear can be properly assessed.

The past 15 years have been a period of great world efforts to investigate oceanography, largely from a purely scientific point of view but providing greatly increased physical, chemical, and biological knowledge of the oceans. The period has witnessed a considerable increase in fisheries research by Canada and the

beginning of intensive fisheries research in the Northwest Atlantic by the USSR. The first international attempts at making maximum use of the groundfish populations have been taken with the introduction of larger mesh sizes for otter trawls.

Fishing Effort, Trends, and Effects of the Fishery in the ICNAF Area

The numbers and tonnages of vessels of 51 gross tons and over and the numbers of crew members employed in the fishery of the ICNAF area for various years from 1952 to 1962 are given in ICNAF (1955–64). The data provided (Table I) are not a very exact measure of fishing effort since all ships and crews which have fished the area for one trip or more in the year concerned are included. It is probable, however, that such matters usually even out between years.

In the period 1952–62 the vessels of 51 tons and over increased to 599 from 295 thousand tons and the crew members to 35 from 19 thousand. In the same period the Canadian Maritimes and Quebec tonnages increased at the same rate and thus held about constant at 4.4% of the total tonnage; but the numbers of crew members, though increasing, fell to 6.1 from 7.7% of the total.

For Newfoundland there was a decrease in tonnage between 1952 and 1959 and a small increase in 1962, the decline over the period being to 1.3 from 2.1% of the total and in men to 1.5 from 2.2%. The total tonnages in 1962 were actually somewhat greater than recorded as East Germany (German Democratic Republic) fished the area, though not a member of ICNAF, and the East German ship tonnage fishing this area (10,362 tons in 1959) has been increasing rapidly but was not reported for 1962. Thus, the Newfoundland declines in relation to the true total were also slightly greater than shown in Table I.

Most countries with large, traditional fisheries in the ICNAF area have reported increases in tonnage fishing the area during this period. But the greatest increases have been made by USSR: from zero in 1952–54 to 198 thousand tons and 11 thousand men (33% of the tonnage and 32% of the men) in 1962. There was a small amount of fishing in the area by the USSR in 1956, unrecorded in Table I. The very large tonnage shown by the United Kingdom in 1952—54 was due mainly to a very small number of trips (usually only 1–3 per vessel) to the West Greenland area by a large number of vessels and probably does not represent as large a fishing effort as the smaller number shown in recent years.

The total landings of groundfish (bottom fishes such as cod, haddock, redfish, flatfishes, and hake) from the ICNAF area have been increasing rapidly in recent years: from 1625 thousand metric tons in 1957 to more than 2291 thousand in 1964. The number of vessel fishing days increased up to 1963, to 167 from 115 thousand. There were, however, decreases in fishing activity in terms of vessel days in 1962 and 1963 in Subarea 2, and from 1961 to 1963 in Subarea 3. The vessel catch per day's fishing showed little change except in

TABLE I. Approximate gross tonnages and approximate numbers of crew members of vessels 51 tons and over fishing the ICNAF area annually from 1952–54 to 1962 (ICNAF, 1955–64). (In 1952–54 each country reported for only 1 of the 3 years. Missing data in the ICNAF vessel lists, such as the numbers of crew for some vessels, were estimated from other vessels of the same size and type from the same country for the same or other years.)

	Per cent of yearly total				No. of crew				Per cent of total			
	1952–54	1956	1959	1962	1952–54	1956	1959	1962	1952–54	1956	1959	1962	1952–54	1956	1959	1962
Canada																
Maritimes and Quebec	13,050	14,424	21,009	26,566	4.4	4.8	4.1	4.4	1,457	1,321	1775	2,132	7.7	6.6	6.1	6.1
Newfoundland	6,109	6,085	5,733	7,959	2.1	2.0	1.1	1.3	417	424	386	508	2.2	2.1	1.3	1.5
Total:	19,159	20,509	26,742	34,525	6.5	6.8	5.3	5.8	1,874	1,745	2,161	2,640	10.0	8.7	7.4	7.6
Belgium	.....	.....	1,538	1,388	.....	.....	0.3	0.2	.....	.....	36	38	.....	.....	0.1	0.1
Denmark	.....	172	200	.....	.....	0.1	0.04	.....	.....	20	25	.....	.....	0.1	0.1	.....
Denmark (Faroes)	8,205	10,176	15,694	22,635	2.8	3.4	3.1	3.8	942	1,105	1,639	1933	5.0	5.5	5.6	5.6
France	39,129	42,916	44,269	43,274	13.2	14.2	8.7	7.2	1,736	1,834	1,823	1,789	9.2	9.2	6.3	5.2
France (St. Pierre and Miquelon)	495	849	1,119	699	0.2	0.3	0.2	0.1	36	66	76	44	0.2	0.3	0.3	0.1
Germany (Fed. Rep.)	.....	40,029	53,083	66,110	.....	13.2	10.5	11.0	.....	1,531	1,994	2,425	.....	7.7	6.8	7.0
Iceland	15,430	10,679	27,191	9,373	5.2	3.5	5.4	1.6	805	560	1,435	420	4.3	2.8	4.9	1.2
Italy	4,200	4,200	3,299	1,650	1.4	1.4	0.6	0.3	190	190	112	50	1.0	0.9	0.4	0.1
Norway	13,929	15,881	13,432	10,433	4.7	5.2	2.6	1.7	1,245	1,476	1,089	908	6.6	7.4	3.7	2.6
Poland	.....	.....	2,037	10,956	.....	.....	0.4	1.8	.....	.....	88	384	.....	.....	0.3	1.1
Portugal	59,311	65,935	71,696	72,958	20.1	21.8	14.1	12.2	4,635	5,217	5,552	5,437	24.6	26.1	19.0	15.7
Spain	41,936	46,437	60,441	62,986	14.2	15.3	11.9	10.5	2,676	2,828	3,619	3,794	14.2	14.1	12.4	10.9
United Kingdom	60,837	8,153	25,635	29,613	20.6	2.7	5.0	4.9	1,920	257	759	889	10.2	1.3	2.6	2.6
USA	32,852	36,776	34,998	34,558	11.1	12.1	6.9	5.8	2,775	3,175	3,150	2,830	14.7	15.9	10.8	8.2
USSR	.....	.....	126,596	198,196	.....	.....	24.9	33.1	.....	.....	5,602	11,134	.....	.....	19.2	32.1
Total:	295,483	302,712	507,970	599,354	100.0	100.0	99.94	100.0	18,834	20,004	29,160	34,715	100.0	100.0	99.9	100.1
Germany (Dem. Rep.)			10,362	?							464	?				

Subarea 2, off Labrador, where the catch per day increased considerably beyond that in the earlier part of the period. This was due to a change in the fishing pattern from summer and autumn to a fishery whose major catches were from the spawning concentrations of cod in winter and spring (Table II).

In the Newfoundland area the chief fishes affected by the increasing international effort are the cod, redfish, and haddock; and mainly owing to the increasing Canadian effort, the American plaice. As indicated in Table II the total groundfish landings are still increasing slowly and the vessel catch per day of all groundfish has not fallen. However, the effects of the increased effort are evident in many fish populations in declines in size of these groundfish and in reduction in their standing stocks so that catch per unit of effort for these stocks has decreased. The consequences for established fisheries of this increased effort have been mitigated up to the present because much of the new effort was directed to underfished stocks of redfish throughout most of the ICNAF area, of cod off Labrador, of silver hake in Subareas 4 and 5, and of herring in Subarea 5. None of these resources can now be presumed to be underfished. Further increases in fishing effort in the area, directed in large part to the groundfishes, are planned or in prospect by many ICNAF countries and by non-members. There appear to be no further large underfished stocks of the major groundfishes in the area. Consequently, for these fishes, which are the major interest of the Newfoundland fisheries, further decreases in size and in standing stock will occur.

More information. For an assessment of the effects of the fishery on the fish stocks of the ICNAF area in relation to regulation problems, see ICNAF (1962); for the Newfoundland area (Subarea 3), Hodder (MS, 1964b). For a survey of trends in the cod fishery off the east coast of Newfoundland and Labrador, see Hodder (1965a). For an economic survey of the Newfoundland fishing industry and its trends and the extent and effect of government assistance, see Copes (MS, 1964); and for a comparison with trends in the rapidly developing fisheries on the Canadian mainland, see Martin (1963).

Fish Concentration in the Newfoundland area and the Related Hazards of Overfishing

In winter and early spring the inshore waters of the Newfoundland area, and those of the adjacent banks, are so cold that groundfish, chiefly cod, must retreat offshore and to deeper water. Also, at this time they gather in prespawning and spawning concentrations. These dense schools are thus concentrated in the restricted areas of warmer water on the deeper slopes of the bank and shelf areas, where they are readily caught by trawlers. It is thus likely, as apparently occurred with the southern Grand Bank haddock, that as these schools decline under the effects of heavy fishing the spawning group and the immatures of commercial size of a particular stock or for a particular coastal area will continue to concentrate. This concentration may thus form a school in a smaller and smaller area, and the school will still be vulnerable to heavy fishing when it is found. In this case

TABLE II. Total landings, effort, and vessel catches per day for groundfish from the ICNAF Convention area, 1957–64. (The information was obtained from ICNAF, 1965. One metric ton equals 22 04.6 lb. The table does not include some additional landings for 1964 subsequently reported by non-member countries.)

	Subarea	1957	1958	1959	1960	1961	1962	1963	1964	
	Landings of groundfish, thousands of metric tons									
1	West Greenland[a]	304	345	273	295	414	526	474	382	
2	Labrador	32	119	114	279	296	266	224	227	
3	Newfoundland	611	532	753	691	674	522	592	711	
4	Maritimes and Gulf of St. Lawrence	368	403	395	406	376	423	586	550	
5	New England	310	262	276	221	228	300	391	421	
	Total:	1,625	1,661	1,811	1,892	1,988	2,037	2,267	2,291	
	Estimated fishing activity for groundfish, vessel-days fishing									
1	West Greenland	15,980	23,750	28,940	22,990	32,170	32,340	31,950		
2	Labrador	1,960	5,250	3,590	9,310	10,580	8,720	7,260		
3	Newfoundland	32,300	30,400	39,000	38,400	36,000	32,400	33,100		
4	Maritimes and Gulf of St. Lawrence	26,400	27,100	27,900	31,000	29,800	35,200	45,000		
5	New England	38,000[b]	36,000	39,000	34,000	31,000	36,000	50,000	56,000	
	Total:	114,640	122,500	138,430	135,700	139,550	144,660	167,310		
	Vessel groundfish catch per day, metric tons									
1	West Greenland	19.6	19.6	16.1	17.7	18.7	22.4	19.7	.....	Trawlers
2	Labrador	16.4	22.6	31.7	30.0	28.0	30.5	30.8	.....	Trawlers over 500 gross tons
3	Newfoundland	18.9	17.5	19.3	18.0	18.7	16.1	17.9	.....	Trawlers
4	Maritimes and Gulf of St. Lawrence	14	15	14	13	13	12	13	.....	Trawlers over 50 gross tons
5	New England	.....	7.3	7.0	6.5	7.3	8.2	7.9	.....	Trawlers over 50 gross tons

[a] All species except shellfish but almost all groundfish.
[b] From ICNAF Redbook (1964).

there would still be good deep-water trawling in winter and spring until the stock has been greatly reduced.

Newfoundland Inshore Fisheries

The reductions in the quantities and sizes of groundfish will have many consequences, some of which can be surmised.

Many of the cod of the offshore winter and spring concentrations move inshore during the summer, and concentrate in shallow inshore waters and around shoals. But, as the stock declines, not every inshore and shoal area may be well populated and the concentrations of cod may become very spotty.

All the large groundfish of the area feed at times on either young or adult capelin and launce. Cod of the Newfoundland area feed heavily on both adult and young capelin. Grand Bank cod, and occasionally American plaice and haddock, also feed heavily on launce. As stocks of groundfish are reduced, and especially as those of cod are reduced in quantity and size, capelin (and to a lesser degree launce) should increase greatly in numbers in the Newfoundland area. (On the Grand Bank area, capelin will benefit also from the decreased abundance of haddock, which eat large quantities of capelin spawn on the Southeast Shoal of this bank.)

It is difficult to say what final effect the increase in capelin and launce will have. An increased abundance of capelin will greatly reduce the effectiveness of the inshore line fishery, both handline and shallow-water longline or line trawl in June, July, and early August. These fish can destroy large numbers of cod and haddock eggs and also cod and haddock in their first few months after hatching. But the increased quantities of capelin and launce should provide more food for and increase the growth rate of the smaller stock of cod. Herring are not numerous on the Newfoundland banks, but in the east and south coast bays and other inshore areas and in the Gulf of St. Lawrence they should increase in abundance with decrease in the numbers of large cod.

In the inshore area, which is under direct Canadian control, the total landings in the cod fishery, far more important than all the other fisheries, have not increased in recent years in spite of considerable increases in men and gear. The landings recently are considerably below those of earlier years, but the inshore stocks are also being caught offshore at other periods by other countries and the total cod landings from the Newfoundland area have greatly increased.

Under the increasing offshore fishery in prospect, the standing stocks and the fish size and, with present or increasing efforts inshore, the catch per unit of real effort (per hook or per net) in the inshore fishery will continue to decrease. In the Labrador area, a well-organized fishery using other gears as well as the present traps and jiggers should increase the landings. The great offshore fishery in the Labrador area, however, has been so recent that it is not yet possible to judge its full effects on the inshore Labrador fishery, which had much reduced landings in 1964.

The intensifying offshore fishery on the same stocks means that the inshore fishermen will need correspondingly increasing effort, either increases in men or in quantity or efficiency of gear; otherwise the total inshore landings will decline.

Of the other significant or potential fisheries of the inshore area, the lobster landings will probably not increase greatly unless the water becomes warmer. These landings should decrease if the water becomes cooler. Apart from landings from outside Canadian territorial waters it should be possible to manage the Canadian Atlantic salmon population toward some increased production. However, the increasing West Greenland salmon fishery, although not affecting the grilse, will presumably greatly reduce the numbers of salmon of 2 sea years and older available to the Newfoundland and the Canadian mainland fisheries. This includes the salmon larger than about 6 lb. The herring fishery could be increased considerably if this were profitable. Capelin can be landed in much greater quantities and squid landings in favourable years could be greatly increased, but in both cases it is necessary to develop markets for the increases. Dogfish will eventually be marketed in quantity and in some years considerable amounts could be caught. Landings of Greenland halibut should increase somewhat as markets for the frozen product are developed. The export of seaweeds should become important in some areas. The possibility of bringing back the fishery for large whales should be continually reviewed, and encouragement given to restoring the harp seal population closer to its former numbers.

There are many fishery enterprises which, as has been noted in the text, can be developed on a small scale in local areas or of which the future is as yet in doubt because of lack of profitable markets.

Conclusion

We are entering an era of great exploitation of fisheries, one in which our competitors have long-range plans, better ships, and usually an assured market at their own price in their own countries. We are passing from a period of abundant supply in which technology was considered more important than supply. We are entering a period when most of the ordinary technological practices necessary to put an excellent fresh, frozen, or salted fish into the market are well known and when, though technology and technological research will still be extremely important, knowledge and ability to obtain the necessary supplies of fish are becoming of overwhelming importance. Fish companies will no longer be able to secure their shares of these supplies if their only knowledge of fish distribution, availability, and fishing efficiency is tightly concealed in the heads of their vessel skippers. Inter-company organization and planning and long-term government planning will be necessary. There must be improvements in vessel and gear efficiency, especially in the highly competitive and international offshore fisheries. In an unsubsidized inshore fishery, unless the area for operation of gear is correspondingly increased, the expected overall effect of improved and additional gear and boats in an already intensive fishery would be to so increase the competition for the least efficient fishermen whose gear and boats are not

improved, as to reduce the numbers of fishermen and to improve the earnings of those remaining in the industry. Neither of these is likely to occur on the expected scale if an inshore fishery for a limited fish population in a restricted area is so subsidized that the least efficient fishermen still remain in the industry.

The groundfish fisheries, especially that for cod, are likely to remain most important for Newfoundland. Evidently if greatly increased landings are to be made by Newfoundland from these fisheries we must not only take advantage of and maintain our favourable position with regard to cod in the inshore fisheries, but we must also realize that this favourable position is being weakened with every increase in the offshore fishery for cod by other nations. Consequently, to remain in a competitive position we must quickly expand our offshore trawler fishery and the efficiency of fishing by this fleet far beyond the small effort at present. Increases in inshore effort, for fisheries already intensive, would be directly competitive between the inshore Newfoundland boats and indirectly competitive with offshore vessels for species like cod which are also fished offshore. Increases in offshore effort would be directly competitive with the fishing vessels of other nations and indirectly competitive with the inshore fishery to the degree that cod became a main object of the offshore fishery. In the offshore area, though American plaice provides a valuable fishery and haddock, greysole, and other species will add to the landings, the most abundant groundfish is the cod and redfish the next. Newfoundland's greatest unused resource is the offshore fishery for cod. In 1964 Newfoundland took only 2.5% of the total landings of about 930 million lb of cod from the offshore part of Subarea 3. In the same year she took only 0.007% of the approximately 440 million lb of cod taken offshore in Subarea 2.

Though only 3–4% of the Newfoundland fishermen fish offshore, they produce about a quarter of the total landed catch and almost a quarter of the landed value (Copes, MS, 1964). In 1965 about a third of the landings came from the offshore otter-trawling fleet, using only about 700 men. Because they land mainly American plaice, redfish, haddock, and witch flounder and usually only a small percentage of cod from the Newfoundland area, Newfoundland offshore trawlers are not at present highly competitive with the inshore fishery. The landings of groundfish per man from the offshore fishery are about 10 times as great as those per man in the inshore fishery; and for each person employed at sea in the offshore fishery the number of others employed onshore in the fish plants and services which the trawler landings and earnings make possible is much greater than that for the overcrowded inshore fishery.

For any large plan of fisheries development to increase Newfoundland landings markedly, great attention should be paid to the possibilities of the offshore fisheries, especially for cod and redfish as these are the most abundant fishes that can be marketed now. If her fishing is efficient, Newfoundland should be able to compete favourably with nations which must cross the Atlantic, use much larger ships, and process fish at sea.

Clearly, the future of the Newfoundland fisheries will call for deep thinking, long-term planning, and increasing cooperation between the federal and provincial governments, the fishing industry, fishermen, and scientists.

Note added in proof. ICNAF Research Doc. No. 66–3, issued in mimeographed form at the 1966 Annual Meeting, provides preliminary information on fish landings from the Northwest Atlantic in 1965. The most significant items from a Newfoundland viewpoint are added here:

Cod landings from Subarea 2 (Labrador) increased greatly to 731 million lb in 1965 from landings of 469 million in 1964 and the previous high of 580 million in 1961. Canadian (Newfoundland) landings were 8% of this total in 1965 compared with 9% in 1961–64. Cod landings from Subarea 3 (the Newfoundland subarea) in 1965 were 1112 million lb, slightly below the 1282 million landed in 1964, but yet the second highest yearly landings from the subarea. The Canadian share of these 1965 landings was 26.8% and the Newfoundland share 26.1%, down from the previous low of 28.3% for Canada and 27.5% for Newfoundland in 1964.

Haddock landings from Subarea 3 continued to decline in 1965 to 19 million lb and Newfoundland landings from this subarea declined to 31% of the total.

Redfish landings from the ICNAF area in 1965 rose to 508 million lb, and Canadian landings reached their highest level of 126 million, Newfoundland landings being 50% of the total Canadian landings.

American plaice landings from Subarea 3 (assuming, as is reasonable, that, in addition to the recorded American plaice, at least 90% of the nonspecified flounders from this subarea were of this species) rose greatly to about 143 million lb in 1965 from about 100 million in 1964. Newfoundland landings from this subarea in 1965 were 58% of the total.

Yellowtail flounder landings in Newfoundland increased to 5.7 million lb in 1965 from 2.1 million in 1964. The amount for 1965 includes the first significant landings (4.5 million lb) of yellowtail from the Grand Bank.

Greenland halibut (turbot) landings in Newfoundland, almost entirely from the deep bays and especially Trinity Bay, rose sharply to 18 million lb in 1965 from 4 million in 1964.

Herring landings in Newfoundland rose to 29 million lb in 1965 with the increased use of herring for meal.

Wolffish landings in Newfoundland almost doubled to 2.0 million lb in 1965, the increase being due to landings incidental to the greatly increased fishery in deep water for Greenland halibut.

There were no great changes in landings from the remaining Newfoundland fisheries.

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Common and Scientific Names of Species

FISHES	
Angler — *see* monkfish	
Argentine, Atlantic	*Argentina silus* Ascanius
Billfish — *see* saury, Atlantic	
Capelin	*Mallotus villosus* (Müller)
Caplin — *see* capelin	
Catfish (ocean catfish) — *see* wolffish, Atlantic and spotted	
Char, arctic	*Salvelinus alpinus* (Linnaeus)
Cod, Atlantic	*Gadus morhua* Linnaeus
Dab, rough — *see* plaice, American	
Dogfish, spiny	*Squalus acanthias* Linnaeus
Eel, American	*Anguilla rostrata* (LeSueur)
Eelpout, common — *see* pout, ocean	
Flounder — *see* plaice, American	
winter	*Pseudopleuronectes americanus* (Walbaum)
witch	*Glyptocephalus cynoglossus* (Linnaeus)
yellowtail	*Limanda ferruginea* (Storer)
Goosefish — *see* monkfish	
Grenadier, rock	*Coryphaenoides rupestris* Gunnerus
roughhead	*Macrourus berglax* Lacépède
roundnose — *see* grenadier, rock	
Greysole — *see* flounder, witch	
Haddock	*Melanogrammus aeglefinus* (Linnaeus)
Hake, silver	*Merluccius bilinearis* (Mitchill)
white	*Urophycis tenuis* (Mitchill)
Halibut, Atlantic	*Hippoglossus hippoglossus* (Linnaeus)
Greenland	*Reinhardtius hippoglossoides* (Walbaum)
Herring, Atlantic	*Clupea harengus harengus* Linnaeus
Launce, inshore	*Ammodytes hexapterus* Pallas
northern sand	*Ammodytes dubius* Reinhardt
offshore — *see* launce, northern sand	(*A. dubius* is possibly synonymous with *A. hexapterus* (Richards, 1965), as is *A. americanus*)
sand — *see* launce, inshore, and northern sand	
Lumpfish	*Cyclopterus lumpus* Linnaeus
Mackerel, Atlantic	*Scomber scombrus* Linnaeus
horse — *see* tuna, bluefin	
Monkfish	*Lophius americanus* Valenciennes
Perch, ocean — *see* redfish	
Plaice, American	*Hippoglossoides platessoides* (Fabricius)
Pollock	*Pollachius virens* (Linnaeus)
Porbeagle	*Lamna nasus* (Bonnaterre)
Pout, ocean	*Macrozoarces americanus* (Bloch and Schneider)

Redfish (ocean perch)	*Sebastes marinus* (Linnaeus)
(ocean perch, rosefish)	*Sebastes mentella* Travin
Rosefish — *see* redfish	
Salmon, Atlantic	*Salmo salar* Linnaeus
pink	*Oncorhynchus gorbuscha* (Walbaum)
sockeye	*Oncorhynchus nerka* (Walbaum)
Sandeel — *see* launce, northern sand, and launce, inshore	
Saury, Atlantic	*Scomberesox saurus* (Walbaum)
Shark, mackerel — *see* porbeagle	
Skate, barndoor	*Raja laevis* Mitchill
eyed — *see* skate, winter	
smooth	*Raja senta* Garman
spinytail	*Raja spinicauda* Jensen
thorny	*Raja radiata* Donovan
winter	*Raja ocellata* Mitchill
Smelt, American	*Osmerus eperlanus mordax* (Mitchill)
Swordfish	*Xiphias gladius* Linnaeus
Thornback — *see* skate, thorny	
Trout, brook	*Salvelinus fontinalis* (Mitchill)
brown	*Salmo trutta* Linnaeus
mud — *see* trout, brook	
rainbow	*Salmo gairdneri* Richardson
speckled — *see* trout, brook	
Tuna, bluefin	*Thunnus thynnus* (Linnaeus)
Turbot — halibut, Greenland	
Whitefish — *see* capelin	
Wolffish, Atlantic	*Anarhichas lupus* Linnaeus
broadhead — *see* wolffish, northern	
northern	*Anarhichas denticulatus* Krøyer
spotted	*Anarhichas minor* Olafsen
striped — *see* wolffish, Atlantic	

MARINE INVERTEBRATES

Clam, soft-shell	*Mya arenaria* Linnaeus
Crab, common rock	*Cancer irroratus* Say
Crab, spider	*Chionoecetes opilio* (Fabricius)
Lobster, American	*Homarus americanus* Milne-Edwards
Mussel, edible	*Mytilus edulis* Linnaeus
blue — *see* mussel, edible	
northern horse	*Volsella modiolus* (Linnaeus)
Oyster, American	*Crassostrea virginica* Gmelin
European	*Ostrea edulis* Linnaeus
Periwinkle, common	*Littorina littorea* (Linnaeus)
Quahog, ocean	*Arctica islandica* (Linnaeus)
Scallop, Atlantic — *see* scallop, sea	
deep-sea — *see* scallop, sea	
Digby — *see* scallop, sea	
giant — *see* scallop, sea	
Iceland	*Chlamys islandicus* Müller
sea	*Placopecten magellanicus* Gmelin
smooth — *see* scallop, sea	

Shrimp, pink	*Pandalus borealis* Krøyer
Squid, short-finned	*Illex illecebrosus* (LeSueur)
Whelk, common northern	*Buccinum undatum* Linnaeus

MARINE MAMMALS

Seal, Atlantic — *see* seal, grey	
bay — *see* seal, harbour	
bearded	*Erignathus barbatus* (Erxleben)
bladdernose — *see* seal, hooded	
common — *see* seal, harbour	
crested — *see* seal, hooded	
fiord — *see* seal, ringed	
Greenland — *see* seal, harp	
grey	*Halichoerus grypus* (Fabricius)
jar — *see* seal, ringed	
harbour	*Phoca vitulina* Linnaeus
harp	*Pagophilus groenlandicus* (Erxleben)
hooded	*Cystophora cristata* (Erxleben)
horse head — *see* seal, grey	
ringed	*Phoca hispida* Schreber
saddle — *see* seal, harp	
saddleback — *see* seal, harp	
squareflipper — *see* seal, bearded	
Whale, blackfish — *see* whale, pilot	
blue	*Balaenoptera musculus* (Linnaeus)
fin	*Balaenoptera physalus* (Linnaeus)
finback — *see* whale, fin	
humpback	*Megaptera novaeangliae* (Borowski).
killer	*Grampus orca* (Linnaeus)
little piked — *see* whale, minke	
minke	*Balaenoptera acutorostrata* Lacépède
North Atlantic right — *see* whale, right	
pilot	*Globicephala melaena* (Traill)
pothead — *see* whale, pilot	
right	*Eubalaena glacialis* (Borowski)
sei	*Balaenoptera borealis* Lesson
sperm	*Physeter catodon* Linnaeus