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The Herring and Mackerel Resources on the East Coast of Canada

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THE HERRING AND MACKEREL RESOURCES ON
THE EAST COAST OF CANADA

by

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ABSTRACT

Historical catch statistics, by major gear type, used as the basis for stock assessments and provision of biological advice for fisheries management initiatives are compiled for the major herring ^(Clupea harengus) _(Scomber scombrus) and mackerel fisheries on the east coast of Canada. The development of the fisheries and aspects of the current management activities in each area are outlined. Finally the existing hypotheses on the stock structure and current stock status are summarized.

RESUME

Nous avons compilé, par principaux types d'engins de pêche, les captures nominales des principales pêches de hareng et de maquereau de la côte est du Canada. Ces données sont celles qui ont été utilisées dans l'évaluation des stocks et dans la formulation de conseils biologiques visant la gestion des pêches concernées. L'histoire de ces pêches et les régimes actuels de gestion sont présentés. Finalement nous résumons la perception présentement acceptée de la structure de ces stocks et nous donnons la taille actuelle des stocks.

INTRODUCTION

Herring and mackerel have been fished on the east coast of Canada for hundreds of years. In the 1800's it is probable that mackerel catches exceeded those of herring in the Canadian zone, but in more recent times herring has been of major importance to Canadian fisheries. The Canadian herring fisheries expanded rapidly in the mid-1960's as a result of the development of a meal fishery. During the period 1968-1970 herring catches on the Canadian east coast exceeded 500,000 mt annually, and then declined as the large year-classes supporting the two major fisheries, those in the Gulf of St. Lawrence and the Bay of Fundy, were removed from the adult biomass.

Mackerel are a highly migratory species, with fish which were tagged in the summer off the east coast of Newfoundland, in the Gulf of St. Lawrence and in St. Margaret's Bay, Nova Scotia being recovered off Long Island, USA during winter months (Beckett et al., 1974; Moores et al., 1975; Stobo, 1976b). Herring migrations appear to be more variable in extent, with some stocks undergoing very limited movement, e.g. the Fortune Bay stock (Moores and Winters, 1979; Winters and Moores, 1977), while others migrate long distances, e.g. southwest Nova Scotia stock, Gulf of St. Lawrence stock (Stobo et al., 1975; Stobo, 1976a; Winters et al., 1978). Seasonal fisheries exploit these species at various times during the migratory cycle including times when components from different stocks are mixed. The historical winter foreign fishery for mackerel in the area southwest of Georges Bank, which exploited a mixture of the northern and southern contingents, and the summer Canadian herring fishery in the Bay of Fundy which exploits a mixture of Bay of Fundy, southwest Nova Scotia and Gulf of Maine stocks, are good examples of their mixing. Further complications arise when a fishery exploits a stock component of undetermined origin such as in the case of the winter Sydney Bight herring fishery.

High variability in year-class strength makes catch forecasting difficult since these species are exploited at a relatively early age (age 2 in many herring fisheries) before a good estimate of year-class size can be made. The Gulf of St. Lawrence herring stock with a difference of 80X in year-class strength, mackerel with a 16X difference, and 4WX herring with a 20X difference, makes projecting future yields from newly recruiting year-classes difficult. Yet the fishery is often dependent on these newly recruiting year-classes.

Although fisheries for these two species have existed for decades, management in the form of total allowable catch (TAC) and quotas became a reality only in 1973, when biological assessments of stock abundance were made and estimates of potential yields or TACs were determined. Catch quotas were imposed on the mobile fleets but not on inshore or fixed gears. However, the management strategy was to ensure that the total annual catch did not exceed the TAC, thus estimates were made of the inshore catches to be subtracted from the TAC. The residual amount was the quota allocation for the mobile fleet. Since the inshore gears were not

under specific quotas, the annual catch exceeded the TAC in various instances due to inshore catches higher than those originally estimated. Currently various inshore gears are being assigned catch quotas in order to manage the total fishery within the TAC.

In this report we have attempted to consolidate the catch statistics and stock status of the various herring and mackerel stocks on Canada's east coast as well as provide some perspective on the development and performance of the fisheries. In considering the future status of these stocks however we have made little attempt to project past 1980 since accurate predictions of the strength of year-classes expected to recruit to the various stocks are impossible except for one or two years in advance.

HERRING

There are a variety of herring stocks on the east coast of Canada. For the purpose of this paper they have been grouped by 6 areas (Figure 1). Maps of stock areas and place names are provided in Figures 2, 3 and 4). No attempt has been made to assess or discuss the stocks or complexes in the northern Gulf of St. Lawrence (i.e. Quebec north shore) or Labrador because little is known of their population structure or size and they are not currently of major importance. The Georges Bank - Gulf of Maine stocks are also not considered in this paper since current status and future prospects are in doubt. The comments provided in the "Resource Prospects for Canada's Atlantic Fisheries 1981-87"¹ aptly summarize the situation:

"The Gulf of Maine stock (5Y) has traditionally been managed separately from that on Georges Bank and south (5Z + 6). Both adult stocks have been at seriously depleted levels for several years due to overfishing in the late sixties and early seventies. The Georges Bank fishery has no evidence of recovery and thus the projected future catches are uncertain. Essentially no herring were caught on Georges Bank in 1978, compared to a high of 370,000 mt in 1968. In contrast to Georges Bank, however, there appears to be rebuilding of the stock in the Gulf of Maine due to the strong 1976 and 1977 year-classes. If there is appropriate regulation of the U.S. fishery on juvenile herring in the Gulf of Maine it should be possible to return to the historical adult catch levels of about 30,000 mt."

THE EAST COAST OF NEWFOUNDLAND

The east coast of Newfoundland herring management area extends from Cape Bauld in the north to Cape Race (Figure 2) in the south and encompasses four herring stock complexes:

- (1) White Bay-Notre Dame Bay;
- (2) Bonavista Bay;
- (3) Trinity Bay;
- (4) Conception Bay-Southern Shore

¹ Published by: Communications Branch,
Department of Fisheries and Oceans, Ottawa.

These four management zones were first established in 1976. The delineation of these areas is based primarily on the results of tagging studies (Winters and Moores, 1977; Winters and Moores, 1979).

Stock Structure

The herring stocks present along the east coast of Newfoundland are composed primarily of spring-spawners (>90%) (Winters and Moores, 1977). Spawning takes place in shallow water (generally <5 fathoms) from early May to mid June. Upon completion of spawning the schools disperse for feeding. During the summer months these herring undergo a general northward migration with the overwintering schools returning south into the bays in the fall. This migration pattern has been most clearly seen for the Notre Dame Bay-White Bay stock. In this stock spawning occurs primarily in the Notre Dame Bay area with the schools dispersing during the summer. In late August these schools reform in the Hare Bay area and gradually move south arriving back in Notre Dame Bay in September-October. While these stock areas are felt to be discrete, marginal interchange occurs between adjacent stocks.

Historical Fishery Trends (Table 1, Figure 5)

Prior to the late 1970's the east coast of Newfoundland was not a major contributor to the Newfoundland herring fishery. During the unlimited market conditions of the late 1940's, east coast landings averaged 7,200 mt compared to the average Newfoundland landings of 55,000 mt (Templeman, 1966). Landings declined in the 1950's and 1960's to between 1,000 and 2,000 mt. With the decline in herring landings along southwest Newfoundland and increasing demand for food herring, the early 1970's produced renewed interest in the east coast stocks.

Exploratory surveys conducted by large purse seiners in 1972 and 1973 indicated the presence of commercial concentrations of herring. This fleet was active along the east coast during the period 1972-1976. In 1974 the ring-net was introduced into the herring fishery. Introduction of this gear, which is basically a small purse seine, resulted in the development of a fleet of what are essentially small (<65' LOA) purse seiners and from 1976-78 this fleet took the major proportion of the catch (Table 1).

These stocks were placed under quota regulation in 1976, but the regulations were applied only to the purse seine and ring net fleets. The large purse seiners (in excess of 65' LOA) have been excluded from the area since 1977. Inshore gears, primarily gillnets, which were not regulated, took an increasing proportion of the catch reaching a peak of 13,000 mt in 1979. Regulations were introduced in 1980 to bring all gears under quota regulation.

While the east coast fishery was expanding from 1,300 mt in 1970 to 26,300 mt in 1979, the

stock was declining. The fishery in all four areas was based upon the 1968 year-class of spring-spawners. Since that year-class, recruitment has generally been poor and consequently, as the 1968 year-class passed through the fisheries, stock sizes have declined.

Projections show that, if poor recruitment continues, abundance of all east coast Newfoundland stocks will continue to decline in the early 1980's (Wheeler and Winters, 1981).

THE SOUTHEAST COAST OF NEWFOUNDLAND

The southeast coast of Newfoundland herring management area extends from Cape Race east to Pass Island (Figure 2) and encompasses two stock areas:

- (1) Fortune Bay;
- (2) St. Mary's Bay-Placentia Bay.

Stock Structure

Similar to those on the east coast of Newfoundland, these stocks are composed primarily of spring-spawners. The Fortune Bay stock remains almost exclusively within the confines of Fortune Bay with only minimal mixing with herring in adjacent areas (Moores and Winters, 1979). The schools are concentrated for overwintering and spawning and dispersed during summer feeding. The St. Mary's-Placentia Bay area encompasses a stock complex with spawning occurring in both bays. Greatest mixing occurs in Placentia Bay during the overwintering period. During the spring the overwintering concentration breaks up with one component migrating to St. Mary's Bay and the remainder moving to spawning sites within Placentia Bay. The age distribution within this area indicates a higher proportion of young fish in Placentia Bay suggesting that Placentia Bay may act as a nursery area for this stock complex.

Historical Fishery Trends (Table 2, Figure 6)

Historically, the southeast coast of Newfoundland has been one of the primary herring fishing areas of Newfoundland. During the period 1945-50, landings averaged 30,000 mt (Templeman, 1966). Landings declined during the 1950's and early 1960's to less than 3,000 mt annually, primarily due to market conditions. In the mid 1960's an extensive purse seine fishery developed first along the southwest coast of Newfoundland and then extended along the southeast coast. The large purse seiner fishery (boats >65' LOA) reached a peak of 18,000 mt in 1968 with a second peak of almost 15,000 mt in 1971, but subsequently declined to less than 1,000 mt by 1977. In 1974, as on the east coast, the ring net was introduced into St. Mary's and Placentia Bays. Since 1977 this gear type has been the major single contributor to the total catch. The ring net was never, however, licensed to fish in Fortune Bay. In 1981, due to the reduced abundance of the stocks along the southeast

coast, the large purse seiner fleet was excluded from both stock areas. The inshore component along the southeast coast has included bar seines, gillnets and traps; landings by these gears have been variable.

These stocks were first placed under quota management in 1973 but inshore gears were not placed under quota until 1980. The fishery was primarily based on the 1968 year-class of spring-spawners. Since then the only year-class of significant size has been the moderate 1974 year-class of spring-spawners which appeared in Fortune and Placentia Bays. This year-class however, was insufficient to maintain the stocks and consequently they have undergone a marked decline in recent years. Recent biological advice has suggested that catch levels be maintained at the lowest practical level until recruitment improves.

THE WEST COAST OF NEWFOUNDLAND

The west coast of Newfoundland herring management area extends from Cape Anguille north to Cape Bauld (Figure 2) and encompasses a stock complex of spring and fall-spawning herring.

Stock Structure

This stock complex appears to have distinct, and different, migration patterns for the spring and fall spawning components. The spring-spawning component of this stock is thought to overwinter in the southern extreme of the area. In the spring this component undergoes a northward migration with spawning "populations" branching off to inshore spawning sites which include St. George's Bay, Port-au-Port Bay and St. Paul's Inlet. After spawning is completed the schools disperse into the northern Gulf for feeding. Around October schools reform in the St. John Bay area and undergo a southward migration to the overwintering areas. Tagging studies (Moores and Winters, 1979) indicate that extensive mixing between spawning components occurs during the overwintering period.

The autumn spawning component appears to have an east-west migration pattern. Overwintering occurs along the edge of the Esquiman Channel with fish moving inshore during the summer prior to spawning. Spawning occurs from mid-August to October along the coast particularly in the St. John Bay area. After spawning these fish become mixed with the spring-spawners before moving back to the Esquiman Channel for the winter.

Earlier tagging studies (Winters and Parsons, 1972) showed recoveries of fish tagged in the Hawke's Bay area being reported from the southern Gulf of St. Lawrence and from along the southwest coast of Newfoundland between Cape Anguille and Fortune Bay. These recoveries were probably due to an expansion in the range of both the spring and fall-spawning components of the southern Gulf of St. Lawrence stock complex due to the large stock size present during this period (Winters and Beckett, 1978).

Historical Fishery Trends (Table 3, Figure 7)

Historically the west coast of Newfoundland and in particular the Bay of Islands has been noted as a major herring fishing area. During the post World War II period (1945-50) landings averaged 15,000 mt, subsequently declining in the 1950's and early 1960's with average landings of 3,200 mt from 1958-62 (Templeman, 1966). In the late 1960's a winter purse seine fishery developed in the area of Bonne Bay. During the early 1970's the centre of the winter fishery moved northward from Bonne Bay to Hawke's Bay and by 1973 had moved to St. John Bay. Expansion in the west coast fishery continued throughout the 1970's with a spring purse seine fishery developing in the St. George's Bay-Port-au-Port area in 1975. Since 1975 purse seine landings have remained steady between 8,000-10,000 mt. The total landings from this stock however have risen steadily since 1974 from 4,600 mt to 18,300 mt in 1979. The continued increase in landings has come primarily from the expansion of herring gillnet fisheries along the coast but particularly in St. George's and Port-au-Port Bays.

This stock was first placed under quota management in 1977 with the purse seine fleet being placed under quota control. The remaining gears were also placed under quota regulation in 1980. During the 1960's this stock complex was primarily composed of autumn-spawners but this situation was reversed in the 1970's with the recruitment of the strong 1968 year-class of spring-spawners. This year-class remained dominant in the fishery during the 1970's and the spring-spawning component has also been strengthened by the moderate 1974 year-class. Recruitment to the autumn-spawning component has been poor and their abundance continues to decline. However there appears to be a general improvement in recruitment to the spring-spawning component which may be sufficient to maintain current catch levels (Moores et al., 1981).

SOUTHERN GULF OF ST. LAWRENCE

The stock composition is complex and potential for intermix is high in the southern Gulf due to a combination of spring and autumn spawning herring and numerous geographically discrete spawning areas.

Stock Structure

This area is considered as a single stock complex for management purposes, although the discreteness and persistence of spawning in several locations indicates that there are numerous discrete spawning groups in the southern Gulf of St. Lawrence. The extent to which each of these individual spawning groups contributes to the offshore exploitable population has not been determined. The migratory pattern is basically east-west, with a mixture of spring- and fall-spawners being found in the area of the Laurentian Channel (i.e. "The Edge") during the spring. As they move westward the main concentrations of fish disperse, with groups of

spring-spawners segregating out to spawn around the Magdalen Islands, Northumberland Strait and Chaleur Bay; the fall-spawners probably spread out over the southern Gulf to feed. In the fall, the autumn-spawners concentrate mainly around the Gaspé and Miscou areas for spawning; during this time the spring-spawning group is also intermixed with the fall-spawners. Following fall spawning, it appears that both spawning groups move southeast towards the Laurentian Channel again. When the stock was large, as in the 1960's, there was an expanded overwintering migration with adults (>5 years old) moving to southwest Newfoundland (Winters and Beckett, 1978; Winters and Hodder, 1975).

Historical Fishery Trends (Table 4; Figure 8)

Prior to 1961 landings from the southern Gulf of St. Lawrence were restricted to inshore gears (gillnets and traps mainly). Between 1940 and 1956 inshore landings ranged between 28,000 and 43,000 mt with an average in the order of 35,000 mt. Landings declined in the late 1950's and early 1960's due to the reduced abundance of adult fish as a result of the fungus disease in the mid-1950's. With the recruitment of the very large 1958 and 1959 year-classes of fall- and spring-spawners respectively, inshore landings increased in the early 1960's, peaking at 44,000 mt in 1965. Subsequently fixed gear landings declined steadily, reaching a low of 8,000 mt in 1977. In the early 1960's however a large mobile fleet, mainly purse seiners, developed after the discovery of major concentrations of overwintering fish off southwest Newfoundland. Landings by the mobile fleet increased dramatically with 278,000 mt being taken in 1970. The very large 1958 and 1959 year-classes supported this fishery and with their depletion, the mobile fleet landings dropped quickly to 36,000 mt by 1973.

This stock complex has been under regulation since 1973. The mobile fleet has been regulated by a set quota while the inshore fishery has had no maximum catch restriction applied to it. Even with restrictions on catch levels however, the stock abundance has continued to decline since 1959 due to a lack of substantial new recruitment entering the fishery. The 1974 year-class appeared to be of moderate strength and there were many reports from the purse seine fleet of small fish in 1979 and 1980. Without substantial new recruitment to this stock complex, the catch levels will continue to decline; in 1981 a TAC of only 15,000 mt was set for the entire fishery with only 3,000 mt being available to the purse seine fleet.

It has proven difficult to assess the biological status of this stock complex because of the virtual dependence of the fishery on the two large year-classes, the historical lack of juvenile fish in the catch, and the apparent appearance of large quantities of small fish in 1979 and 1980. Did the dominance of young fish in the catch mean large new year-classes or substantially reduced abundance of adult fish? The TACs in recent years have been set substantially below the $F_{0.1}$ calculation.

Further, since the adult stock abundance has not recovered substantially even with these lower TACs, the current estimates of stock abundance may be high. Recent analyses have confirmed that the quantity of adult fish in this stock complex is very low.

SYDNEY BIGHT

This area appears to have some small local stocks of spring- and fall-spawning herring with a larger component of fish migrating from other areas to overwinter; these are primarily fall spawning fish.

Stock Structure

Little is known about the local stocks exploited during the summer. Neither the relationship between the local stocks and the overwintering component, nor the inter-relationships between the overwintering component and adjacent stocks have been determined. Tagging studies conducted during the Sydney Bight winter fishery have resulted in recoveries from both the Gulf of St. Lawrence and along the south coast of Nova Scotia, including the Bay of Fundy. It may be that a variety of stocks have components which overwinter in the Sydney Bight area and contribute in variable amounts to this winter fishery.

Historical Fishery Trends (Table 5; Figure 9)

Historically the Sydney Bight area has supported only a relatively small inshore fishery. In 1969 however, an offshore foreign herring fishery developed in 4Vn and took over 11,000 mt in both 1969 and 1970; this foreign fishery subsequently declined as the foreign effort moved further south on the Scotian Shelf. A Canadian mobile fishery also developed in the winter of 1969-70 when concentrations of overwintering herring were found in the nearshore areas. This fishery developed quickly as additional effort was directed into the Sydney Bight area with peak landings of over 17,500 mt being taken in the winter of 1972-73. Subsequently, landings declined quite steadily from 1972-73 to a low of 2,800 mt in 1979-80. The recorded inshore fishery landings have not exceeded 500 mt since the early 1960's.

The winter mobile fleet fishery was first put under regulation in 1974-75 as part of a Sydney Bight-Chedabucto Bay area management unit. The inshore fishery has never been subjected to catch restrictions. However, tagging studies conducted during 1974 indicated that the herring overwintering in Sydney Bight were not the same stock of fish as that being fished primarily in the Chedabucto Bay area in winter. Consequently since 1976-77 the Sydney Bight mobile fleet fishery has been managed as a separate unit. The expansion of the fishery in this area was associated with the recruitment of the 1970 year-class, and the decline in catches paralleled the removal of this year-class from the stock.

No further significant recruitment was observed in the fishery throughout most of the 1970's.

THE SOUTH AND SOUTHWEST COAST OF NOVA SCOTIA

This area (NAFO Div. 4WX) includes a combination of stocks and stock complexes, only some of which are under quota regulation. These stocks, or components, are composed almost entirely of autumn-spawning fish.

Stock Structure

It is well documented that a number of spawning areas exist along the Nova Scotia coast from Fourchu to Cape Sable Island, and into the Bay of Fundy. The movements and distribution of most of these relatively small 'local stocks' have not been determined, since most tagging studies have been directed at the major southwest Nova Scotia stock and the Bay of Fundy fisheries. The results of these tagging studies (Stobo et al., 1975; Stobo, 1976a; Stobo, unpubl.) have indicated that:

- (1) components of the fish found in the Bay of Fundy during the summer, overwinter in both the Chedabucto Bay and the Gulf of Maine areas;
- (2) a greater proportion of fish tagged on the New Brunswick side of the Bay of Fundy moves westward to the Gulf of Maine to overwinter than to Chedabucto Bay;
- (3) a greater proportion of fish tagged on the Nova Scotia side of the Bay of Fundy move eastward to Chedabucto Bay to overwinter than to the Gulf of Maine;
- (4) when tagging studies off southwest Nova Scotia concentrated on spawning fish, an even greater proportion of the recoveries occurred in the Chedabucto Bay area;
- (5) very few recoveries were made in the inshore fisheries between Cape Sable and Canso;
- (6) very few recoveries of fish tagged off southwest Nova Scotia were made in Sydney Bight;
- (7) some fish tagged in the weirs on the New Brunswick side of the Bay of Fundy were subsequently recovered in southwest Nova Scotia; (the reverse movement also occurred); and
- (8) some fish tagged in Liverpool Bay were recovered in the Bay of Fundy fixed gear and purse seine fisheries.

Historical Fishery Trends (Table 6; Figure 10, 11)

This area has supported a number of major fishery components (Figure 3) which have existed for decades and others which have developed only recently. However a reliable breakdown of catch

by gear type and fishery component is only available since 1963. Fixed gear fisheries (weir, gillnet, trap, and shut-offs, etc.) are the oldest traditional fisheries and exist all along the coast of Nova Scotia and Bay of Fundy. The fisheries on "local stocks" between Shelburne and Fourchu are almost entirely gillnet and trap fisheries, are not under specific catch quota regulation, and will not be discussed further in this report. The major migratory herring stock from southwest Nova Scotia and the associated fisheries on the Scotian Shelf and in the Bay of Fundy are the main concern for management and the following section will deal with these fisheries. Table 6 provides a summary of catches by major gear types in the NAFO 4WX area and indicates the fishery components which are under specific quota regulation based on biological assessments of stock status and projected TACs. The 4WX biological assessment includes:

- (1) the purse seine fisheries in the Chedabucto Bay area and the areas on the Nova Scotia side of the Bay of Fundy, including the area between Grand Manan Bank and German Bank;
- (2) the Nova Scotia weir fishery;
- (3) the Nova Scotia gillnet fishery catches west of Shelburne;
- (4) the recently developed Liverpool trap fishery; and,
- (5) the foreign fishery on the Scotian Shelf in 4WX.

Between 1963 and 1979, the average reported Nova Scotia gillnet landings for this stock area were 5,600 mt. The annual reported landings have been less than 6,000 mt every year except for 1976-78. During these three years landings were as high as 18,500 mt due to the recruitment of the very large 1970 year-class to the gillnet fishery and a major increase in effort. The Nova Scotia weir landings have averaged about 9,100 mt since 1963 although they have ranged from 5,200-12,600 mt. This fishery relies mainly on 2 and 3 year old fish and thus catch levels are related to year-class size as well as market demand for small fish.

The purse seine fishery on the N.S. side of the Bay of Fundy and off southwest N.S. is primarily a summer-fall fishery which exploits juvenile and adult fish. This fishery has been in existence for several decades, but in the mid-60's rapid expansion in the size and capacity of the fleet occurred as a result of the development of the meal fishery. The landings peaked in 1968 at over 133,000 mt, largely due to the presence of the large 1963 and 1966 year-classes. The landings subsequently declined steadily until 1972 when the large 1970 year-class recruited to the fishery and subsequently supported catches from 1972 to 1978. The 1976 year-class also appears to be large, but has not shown up substantially in the 1978 and 1979 catches due to a change in the market demand from juvenile to adult fish. The average landings from this fishery since 1965 have been

75,300 mt. The Chedabucto Bay area purse seine fishery developed in 1969 primarily as a juvenile fishery. The average landings in this fishery have been 25,800 mt. The catch peaked in 1971 at over 52,500 mt but then declined as the fleet concentrated on larger fish. In 1978 and 1979 the catch levels have been well under 20,000 mt but this has been partly due to restrictions on catching small fish. The foreign mobile fishery began in 1967 and rapidly expanded, with the 1970 catch exceeding 60,000 mt. Subsequently the catches declined to an average of about 25,500 mt between 1971 and 1975, and with Canada's extension of jurisdiction in 1977, this fishery ended.

The average landings since 1965 from these 4WX stock components has exceeded 123,000 mt and has largely been supported by the large 1963, 1966, 1970 and 1976 year-classes. Catch regulations have been used to regulate these fisheries since 1973. Since that time the purse seine fleet catch has been regulated by specific quotas in both 4X (southwest Nova Scotia and Bay of Fundy) and 4W (Chedabucto Bay area). The weir and gillnet fisheries had no catch restrictions; an estimated catch was determined for each gear type and deducted from the TAC. More recently the gillnet fisheries have been assigned catch allocations, and the newly developed Liverpool trap fishery has also been assigned a catch quota.

In the Bay of Fundy the New Brunswick winter purse seine, weir, and miscellaneous gears (shut-offs, beach seines, etc.) fisheries either do not have any catch quotas, or the quotas applied are not based on any biological analysis or assessment procedures. The main reasons for these exclusions from quota regulation are the historical precedent for not regulating traditional juvenile fisheries and the stock delineation problems (i.e. what proportion of these juveniles are from the Nova Scotia spawning stock and what proportion from the Gulf of Maine).

The New Brunswick winter purse seine fishery exploits small herring in the fall and winter months mainly in the Saint John to Point Lepreau area. The fishery experienced rapid expansion in the mid-60's with most of the catch being used as fish meal; the average landings between 1965 and 1970 were over 22,000 mt. Regulations on minimum size essentially ended utilization of the catches for fish meal, but catches have continued on a more limited scale to supply the food market. There have been reports of substantial discarding of small fish in this fishery in some years due to minimum size regulations. In the mid-1970's a 4,000 mt quota was placed on the January to April catch to further limit the catch of these juvenile or "brit" herring. The average landings from the New Brunswick weirs between 1963 and 1979 have been over 27,000 mt. This fishery is dependent on 2 and 3 year old fish (mainly 2 year olds) and the substantial decline in catch in 1970 and 1971 reflect the weakness of the 1968 and 1969 year-classes. The landings since 1975 have been relatively stable, ranging from 29,200-33,500 mt and averaging over 31,300 mt.

MACKEREL

The mackerel stock in the northwest Atlantic is composed of two populations: the southern population spawning between Cape Cod (Massachusetts) and Long Island (New York) in April-May and the northern population whose main spawning area is the southern Gulf of St. Lawrence (NAFO Division 4T) in June-July (Arnold, 1970; MacKay, 1979; Sette, 1943). Most of the Canadian catch is taken from the northern population although some schools belonging to the southern population may venture on the Scotian Shelf, as far up as St. Margaret's Bay during the summer (MacKay, 1967; Sette, 1950). The nature and discreteness of the two populations is not well known and it is believed that some exchange occurs between the two populations (Beckett et al., 1974; Moores et al., 1975; Stobo, 1976b). The relative abundance of the two populations has not been established and is believed to be variable depending on year-classes success and on the exchanges previously mentioned.

The northern population overwinters in warmer waters along the edge of continental shelf from Sable Island (Nova Scotia) to Long Island (New York). Although the presence of mackerel in Canadian waters during winter months is well established, its abundance has never been assessed and is believed to vary from year to year, depending on environmental conditions (MacKay, 1967; Sette, 1950).

Prior to the early sixties, the northwest Atlantic mackerel fishery was mainly pursued by Canada and the USA, with some small landings occasionally made by France (St. Pierre and Miquelon) (Anderson and Paciorkowski, 1980). In 1962, Poland reported a mackerel catch of 111 mt in NAFO Subarea 5. This marked the beginning of the involvement of East European countries (mainly Bulgaria, German Democratic Republic, Poland and the USSR) in the mackerel fishery which lead to extraordinary increases in landings (Figure 12).

Before 1966, the Distant Water Fleet (DWF) presence was still relatively modest but with the recruitment of the moderately strong 1966 year-class and the very strong 1967 year-class, the DWF landings more than tripled between 1967 and 1968 from 19,000 mt to 65,000 mt. Their landings increased steadily for the next five years to reach a maximum of 396,000 mt in 1973. The total commercial landings were then 420,000 mt. The DWF landings decreased after 1973 to reach 220,000 mt in 1976 just prior to the extension of jurisdiction over fisheries by Canada and the USA. The extended jurisdiction brought an end to the DWF involvement in the mackerel fishery. The first TAC was set by ICNAF in 1973 at 450,000 mt to limit the rapid expansion of the fishery in NAFO Subarea 5 and Statistical Area 6. NAFO Subareas 3 and 4 were later included within the single management area. The TAC was not reached in 1973 nor in any later years. Most of the DWF catches were made in NAFO Subarea 5 and Statistical Area 6 during winter months outside of Canadian waters. However tagging studies and some circumstantial evidence suggest that the northern population may have been a major

contributor to that winter fishery (Beckett et al. 1974; Moores et al., 1975; Stobo, 1976b). Of the Distant Water Fleet, only the USSR made significant mackerel catches in NAFO Subareas 2-4 as a by-catch in their silver hake fishery and this mainly in NAFO Division 4W during the summer months. Figure 13 shows the Canadian and DWF mackerel landings from NAFO Subareas 2-4 since 1950. It shows that the DWF landings from Canadian waters have been lower than Canadian catches for most years except 1974 to 1976. The evolution of Canadian catches is better depicted in this figure. The decrease starting in 1954 is probably due to the epizootic disease that decimated mainly herring but also affected mackerel in the Gulf of St. Lawrence (Sinderman, 1966). Most of the increase from 1960 to 1967 can be attributed to the 1959-1960 year-classes. The increase after 1967 is due to the 1966 and later year-classes which were of average or better than average sizes. After decreasing from 1973 to 1975 the Canadian catches have steadily increased to approximately 30,000 mt in 1979.

Mackerel has been, and still is fished with about every existing fishing gear, from hook and line to large otter trawlers. The Canadian catch can be partitioned into three main gear categories: 1) traps, weirs and beach seines; 2) purse seines, other seines and trawls (bottom and midwater), and 3) gillnet, longlines and handlines. Figure 14 shows the landings by each of these gear categories since 1972. Prior to 1972 the ICNAF Statistical Bulletins do not give a breakdown by gear. The figure shows that since 1976 the three categories are catching approximately the same amount. This figure however combines the data for the entire Canadian Atlantic coast and does not show regional differences. For example gillnets in the southern Gulf of St. Lawrence, traps in NAFO Division 4X and 4Vn and beach seines in Newfoundland are all locally predominant gears. Also the decrease in trap catches in NAFO Division 4X during the last few years and the increased catch by beach seines in Newfoundland is not apparent because the two gears have been included in the same category. The increased catch by Newfoundland fishermen is also hidden when all areas are combined. Landings have increased steadily (except in 1974) from 1,800 mt in 1972 to about 15,000 mt in 1979 while the Maritimes and Quebec landings have stayed approximately constant during the same period.

The northwest Atlantic mackerel stock is presently underexploited. The most recent Canadian stock assessment shows that the 1981 TAC could be 160,000 mt and that the TAC could go as high as 240,000 mt in the next few years depending on where and when the fish are caught. How much of this TAC can be caught in Canadian waters is still not known due to uncertainties about the winter distribution and relative abundance of the two populations. Mackerel is a transboundary species and hence management of this resource must be on a joint basis between Canada and USA.

ACKNOWLEDGEMENTS

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Fig. 1. Map of Canada's east coast showing the grouping of herring stocks and stock complexes discussed in this paper.

- 1) Newfoundland East Coast
- 2) Newfoundland Southeast Coast
- 3) Newfoundland West Coast
- 4) Gulf of St. Lawrence (4T)
- 5) Sydney Bight (4Vn)
- 6) Nova Scotia-Bay of Fundy (4WX)

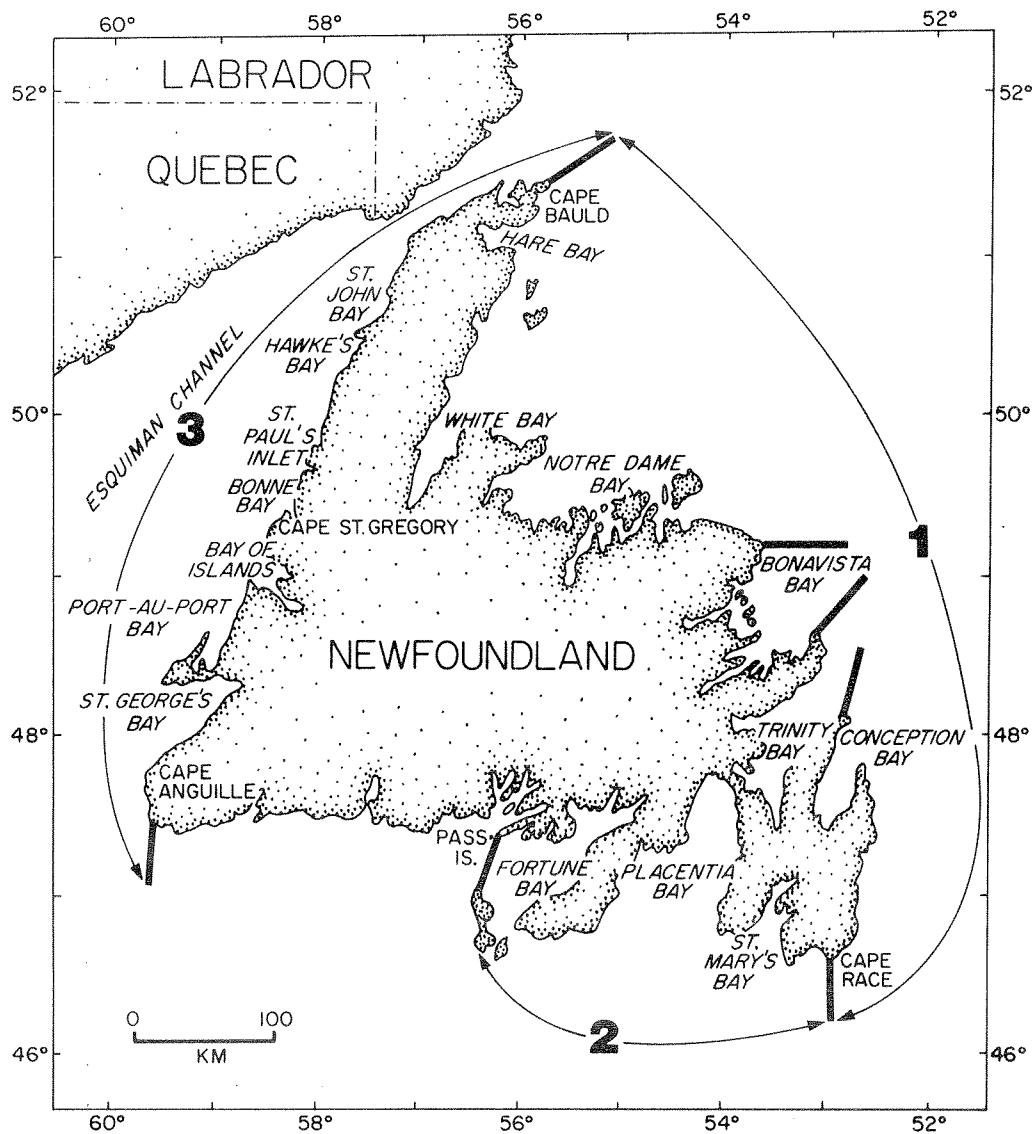


Fig. 2. Map showing stock complex areas and geographic locations referred to in text on herring stocks in the Newfoundland area.

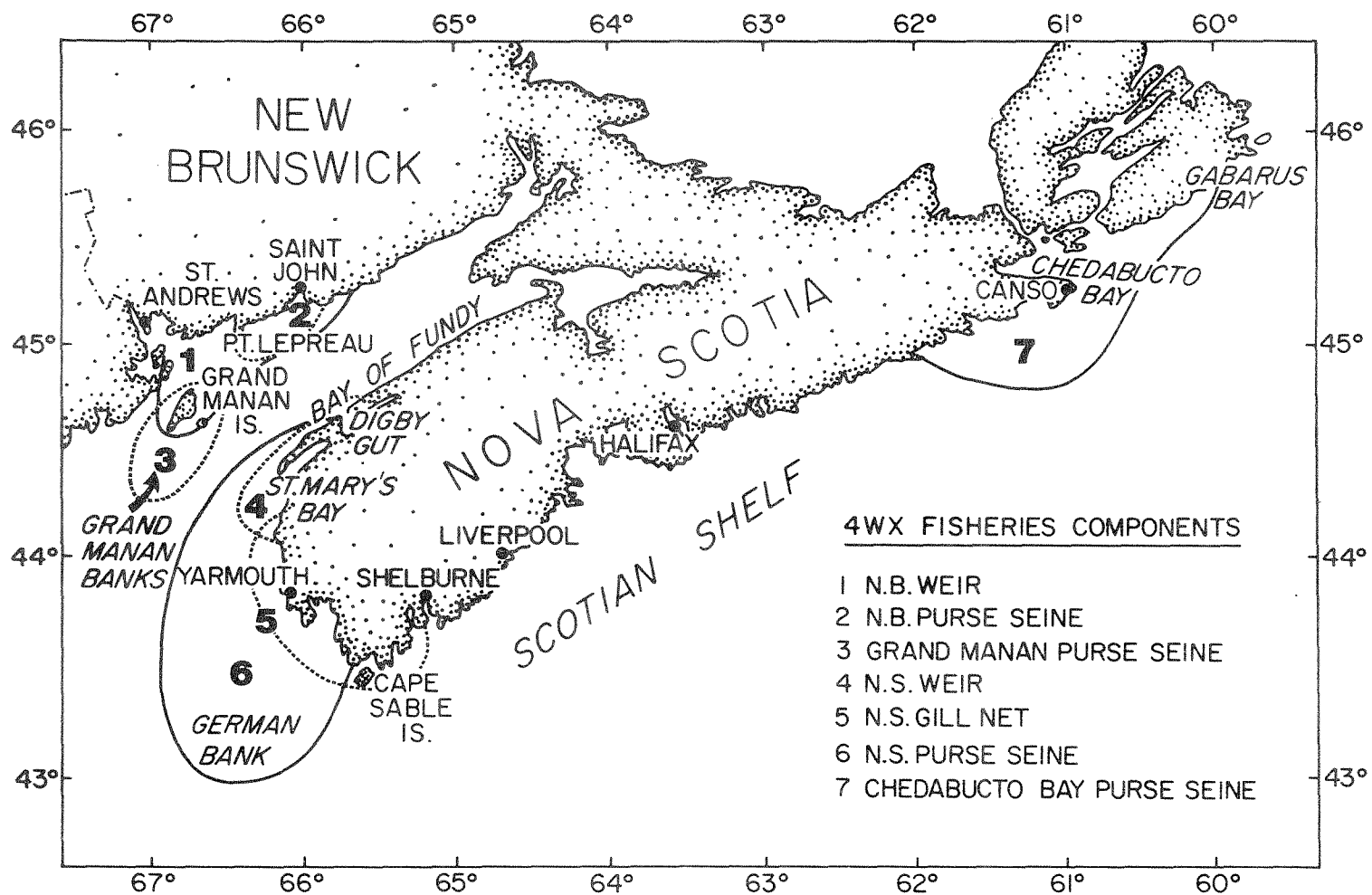


Fig. 3. Map showing the geographic locations of herring fisheries associated with the Div. 4WX herring stock complex.

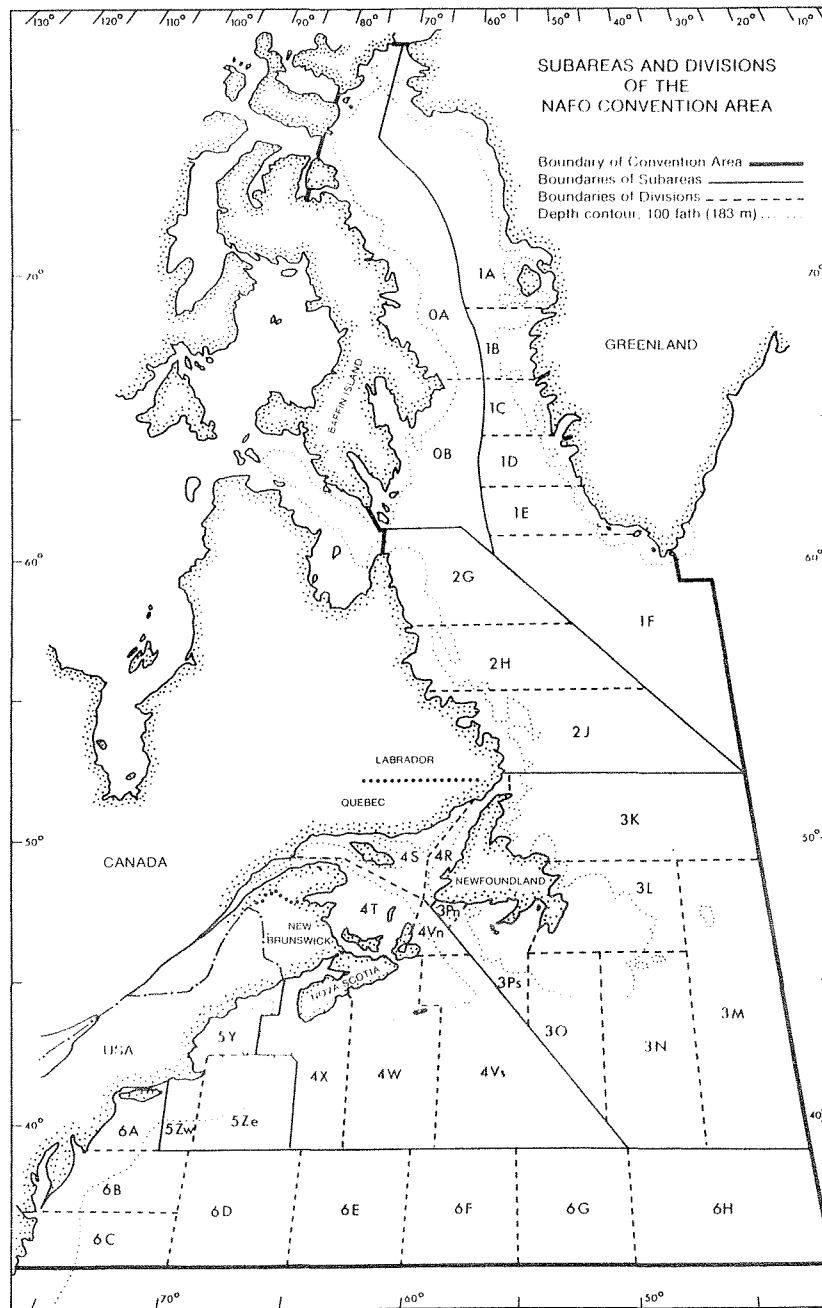


Fig. 4. Map of the northwest Atlantic showing the NAFO Convention area and various subareas and Divisions.

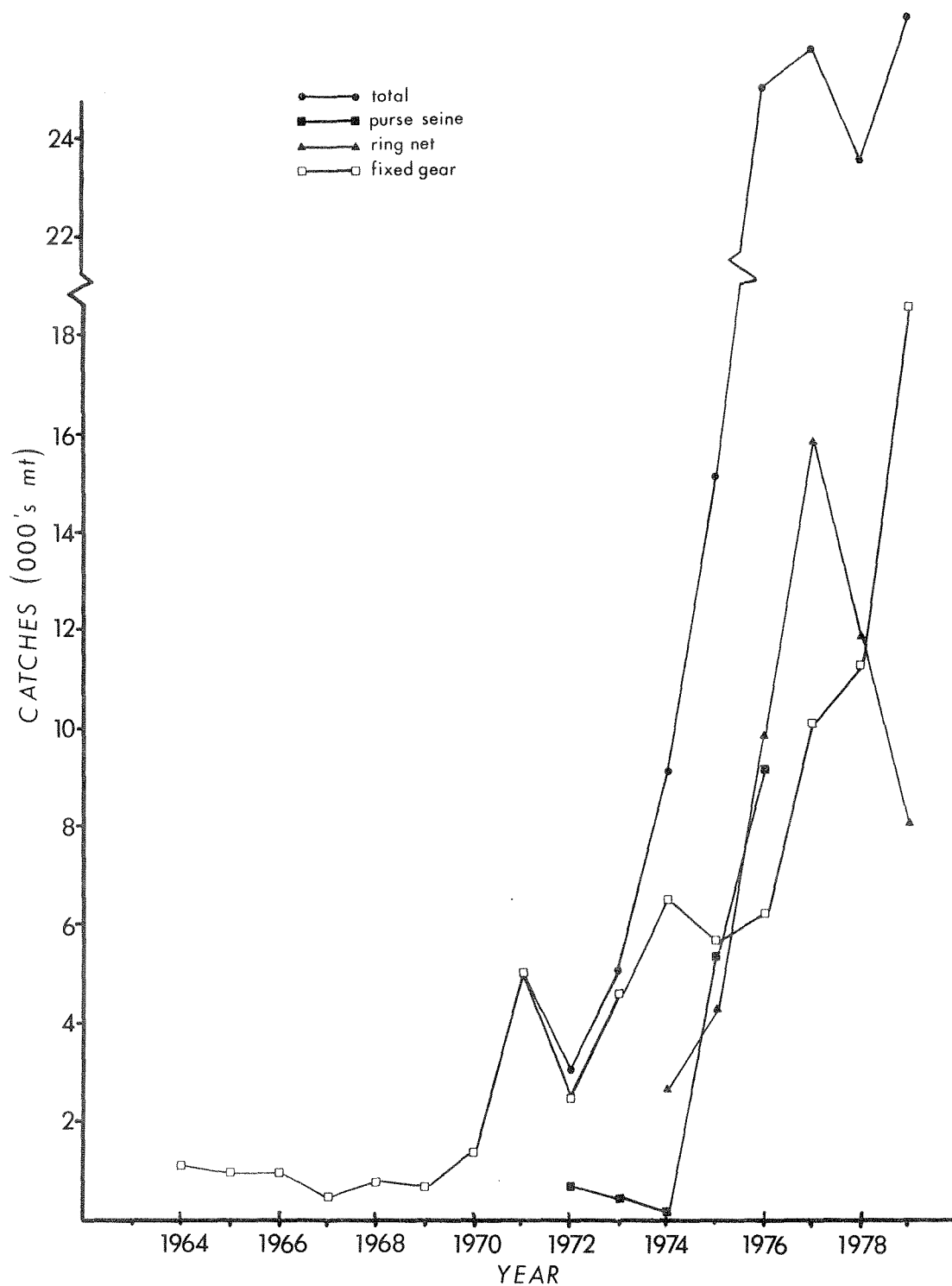


Fig. 5. Herring catches (metric tons) by gear type for the east coast of Newfoundland.

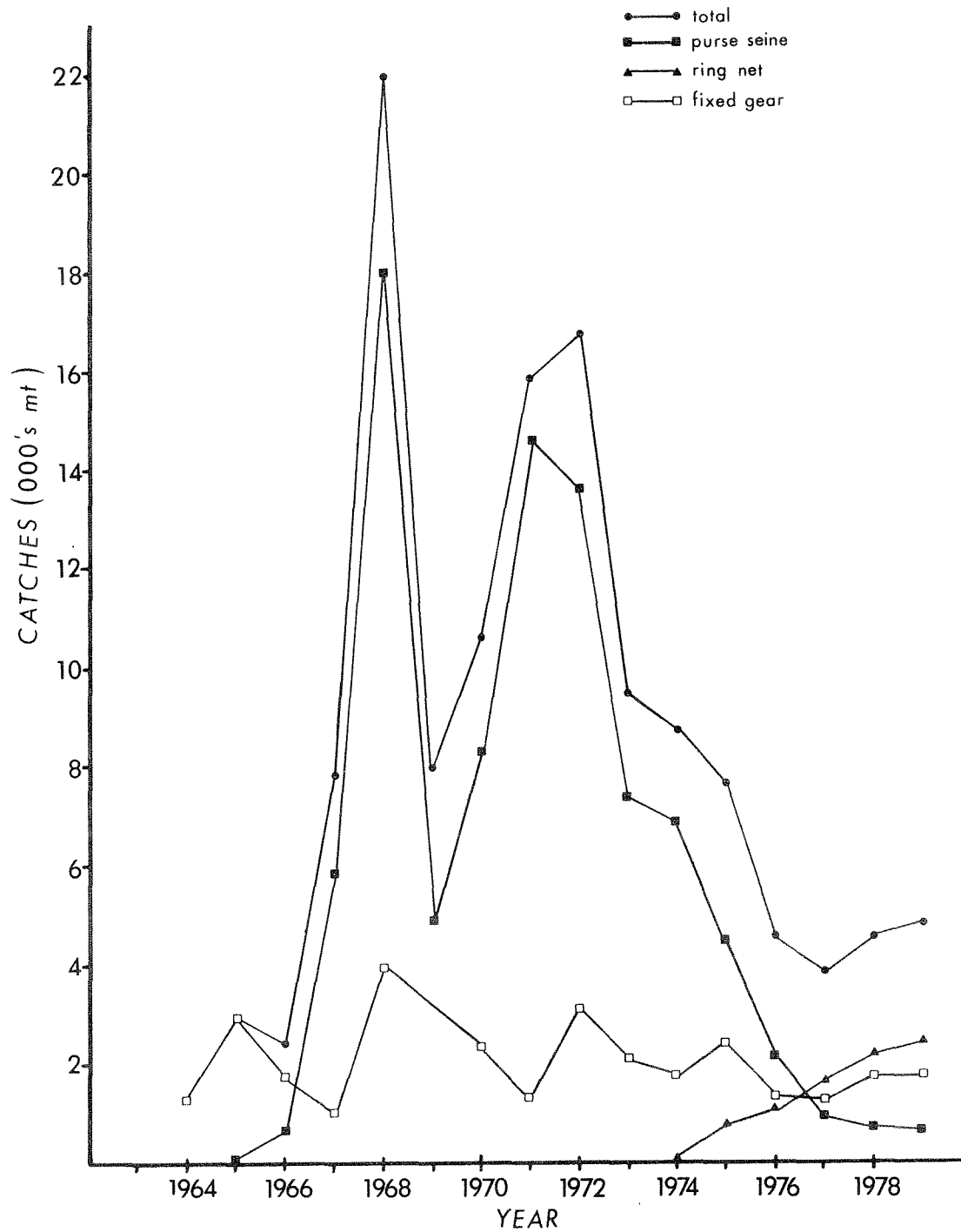


Fig. 6. Herring catches (metric tons) by gear type for the southeast coast of Newfoundland.

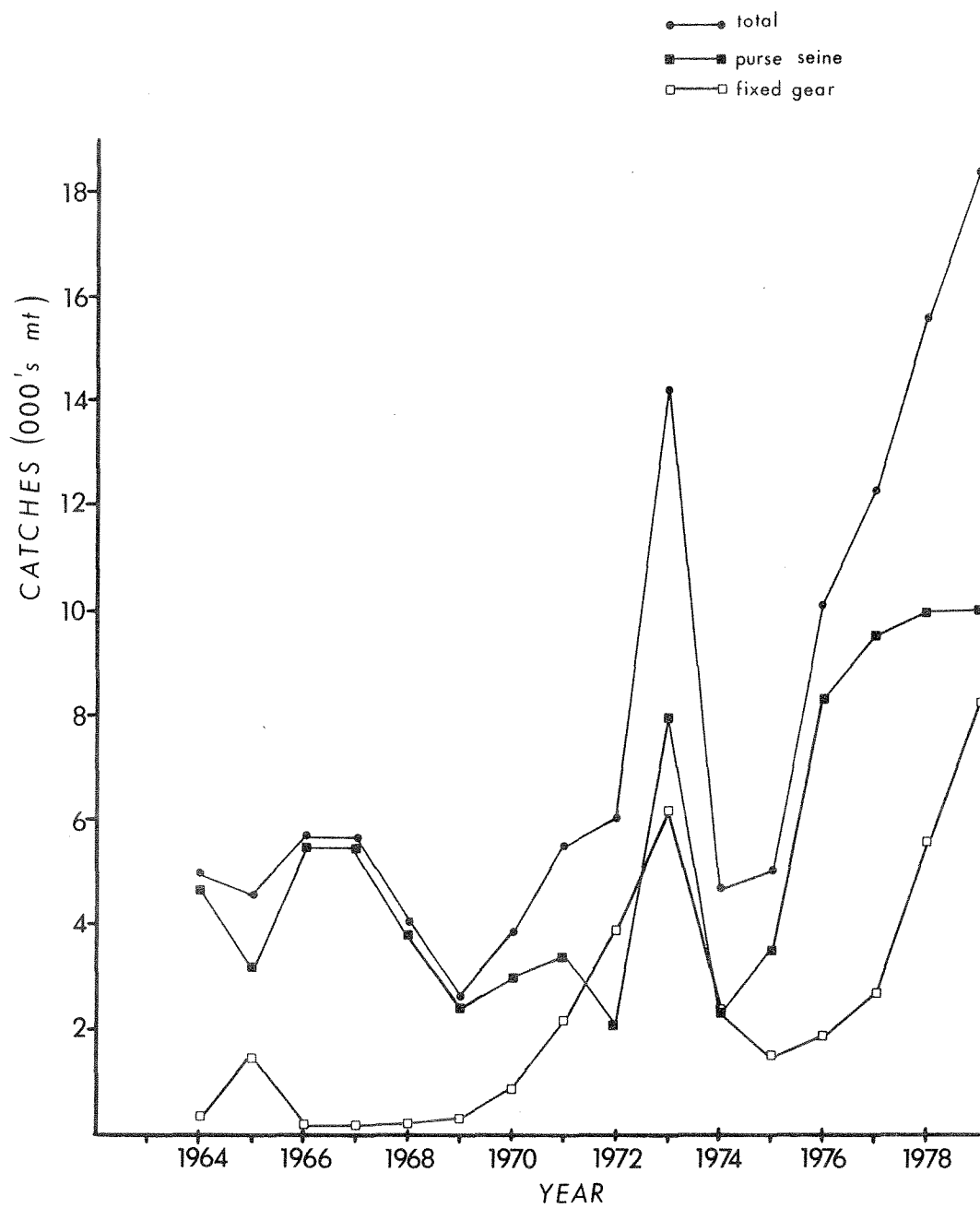


Fig. 7. Herring catches (metric tons) by gear type for the west coast of Newfoundland.

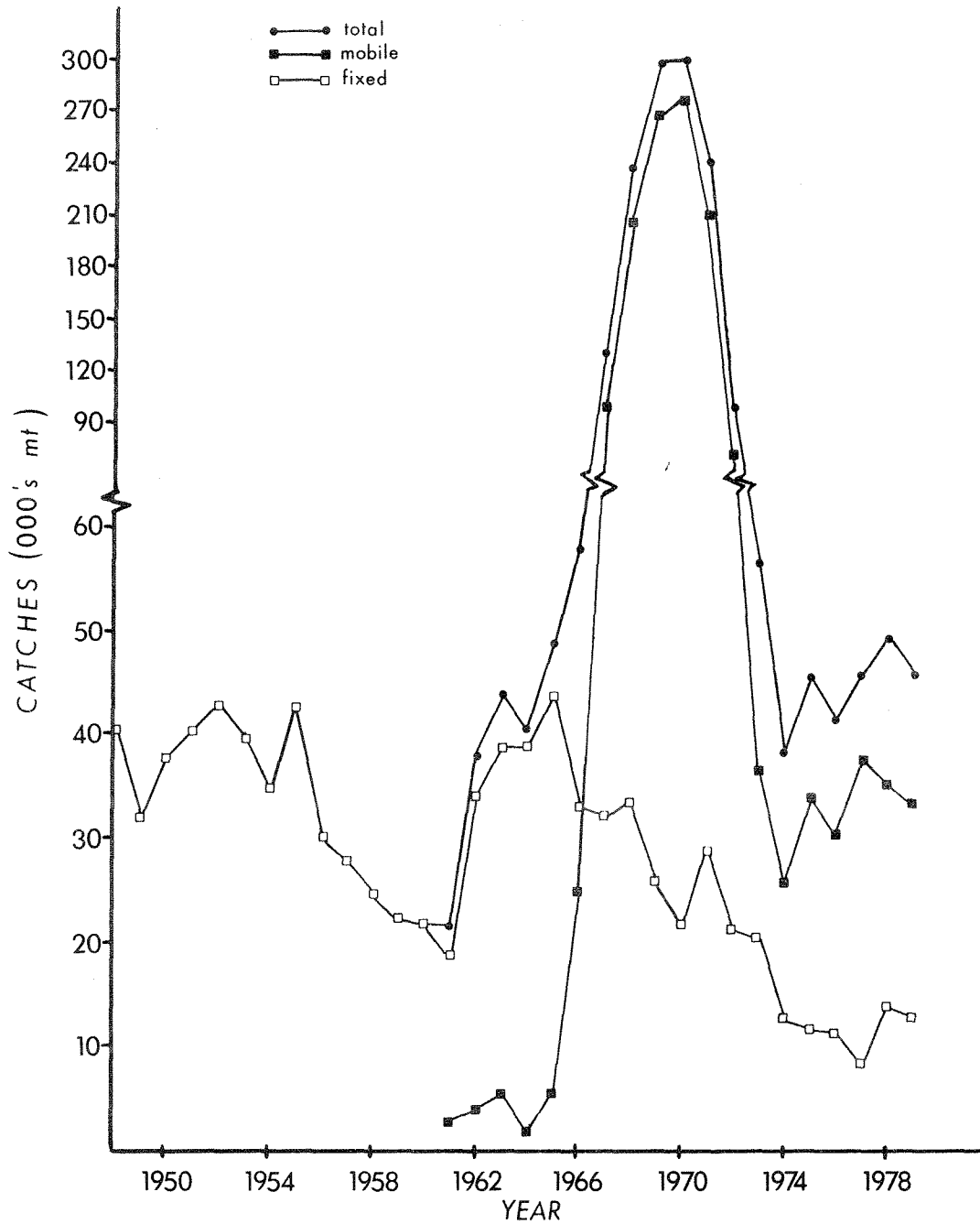


Fig. 8. Herring catches (metric tons) by gear for southern Gulf of St. Lawrence complex, 1948-1979. Note the change in scale for catches above 60,000 mt.

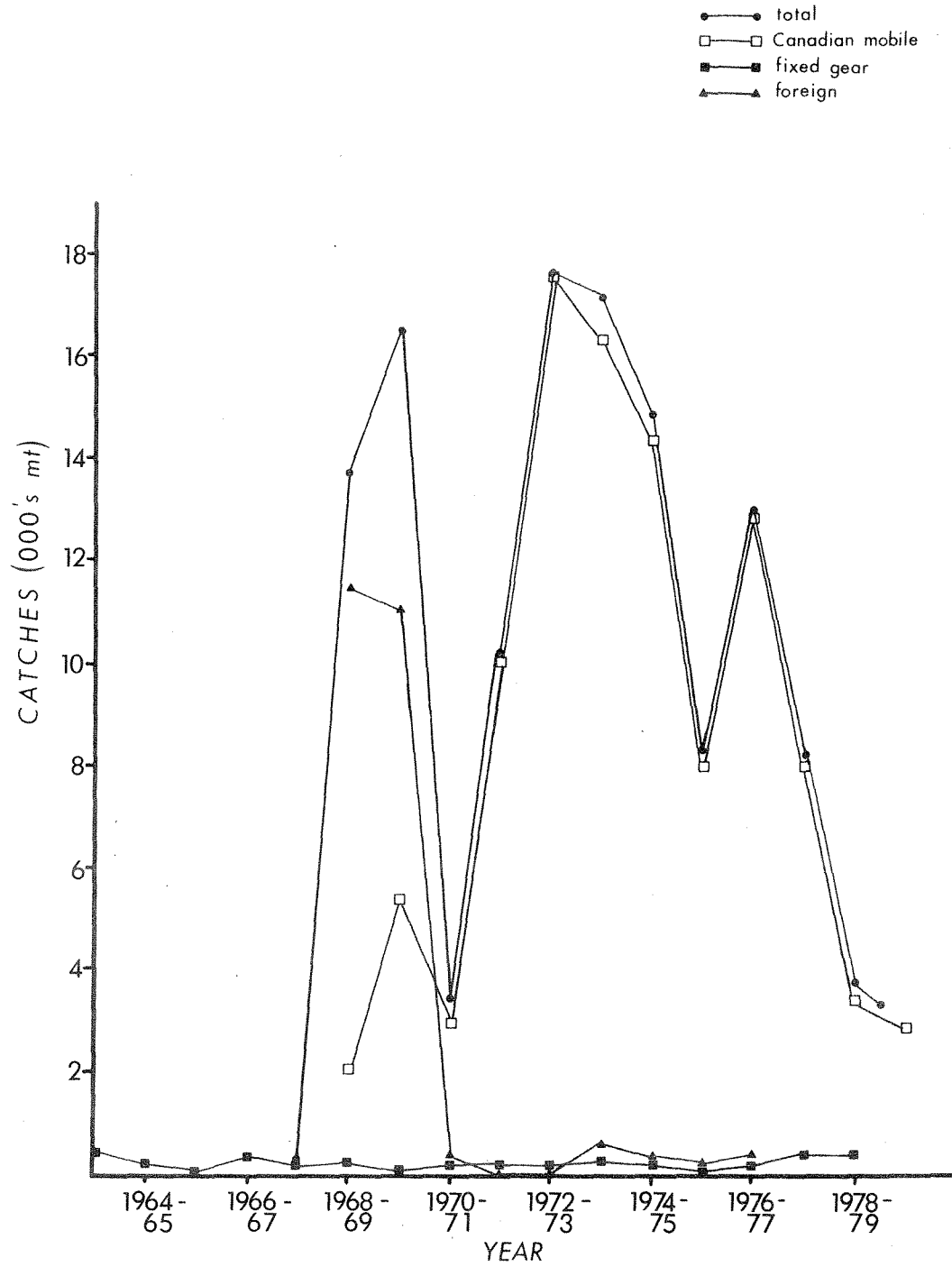


Fig. 9. Herring catches (metric tons) by fleet component for the NAFO 4Vn area, for the fishing years 1964-65 to 1979-80. Mobile catch only was available for the 1979-80 value.

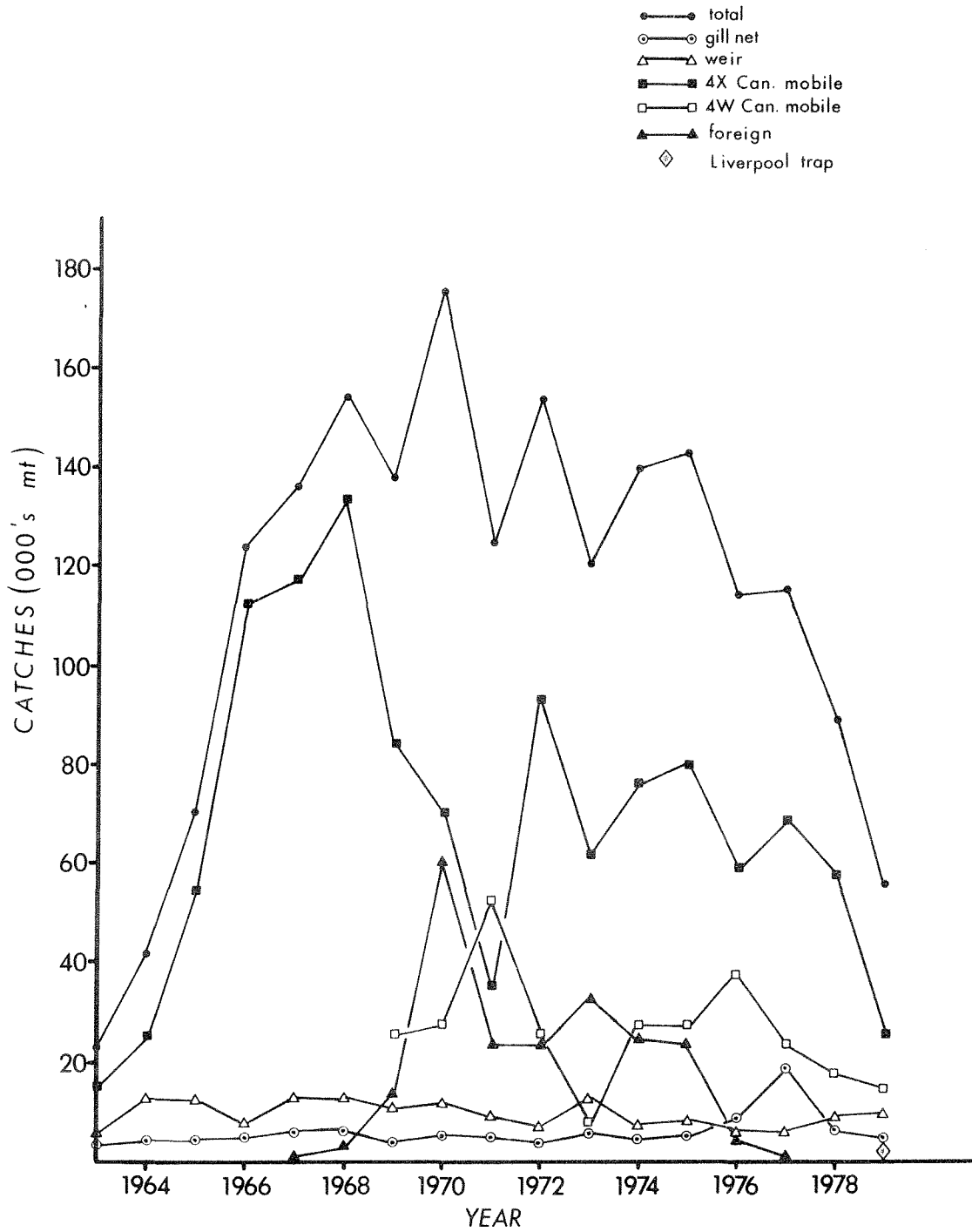


Fig.10. Herring catches (metric tons) from the NAFO 4WX area by gear for the TAC regulated portion of the fishery, 1963-79.

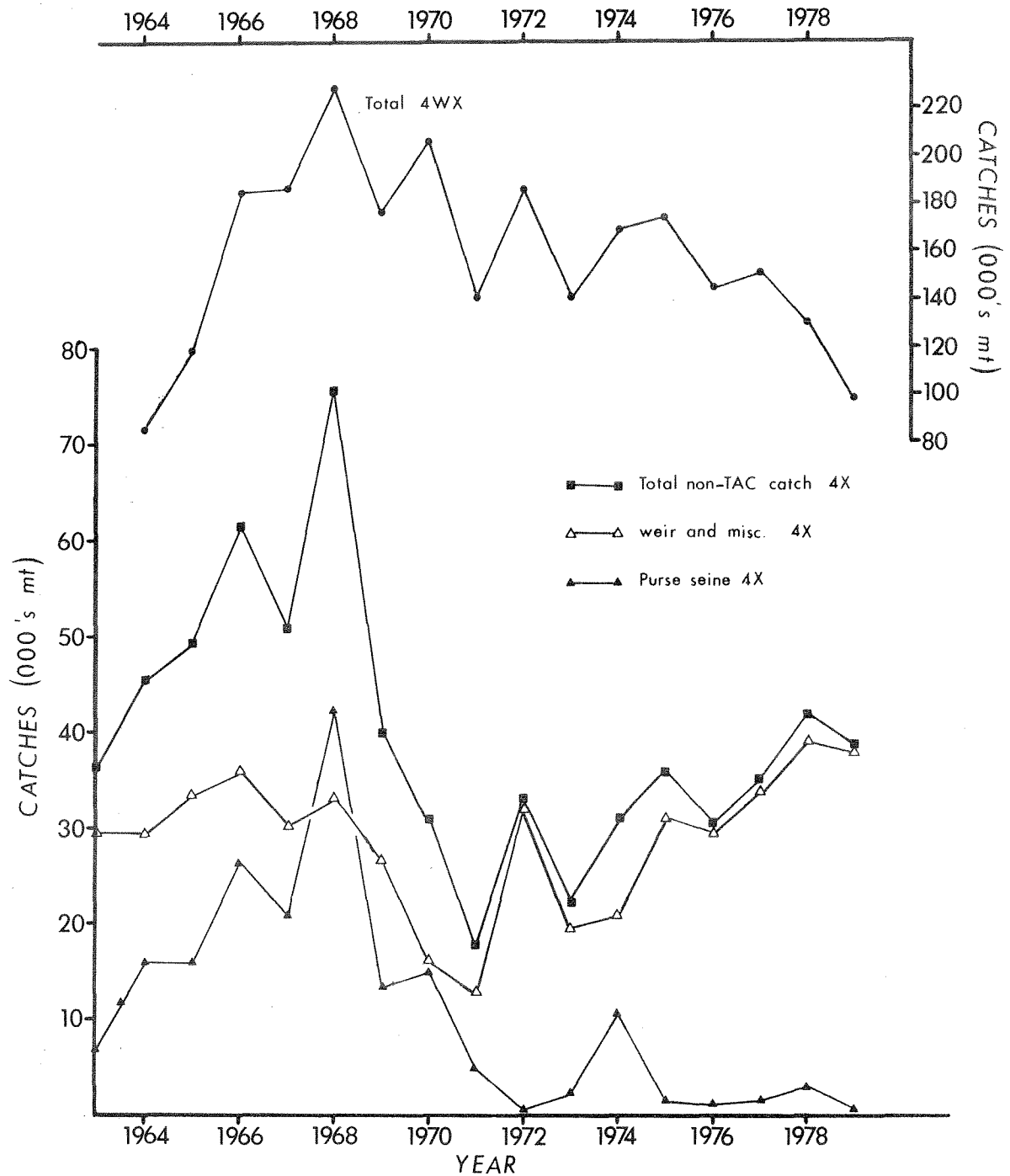


Fig. 11. Herring catches (metric tons) from the NAFO 4X area (Bay of Fundy) for the non-TAC regulated portion of the fishery. The total NAFO 4WX area catch is also shown but note change in scale for catch.

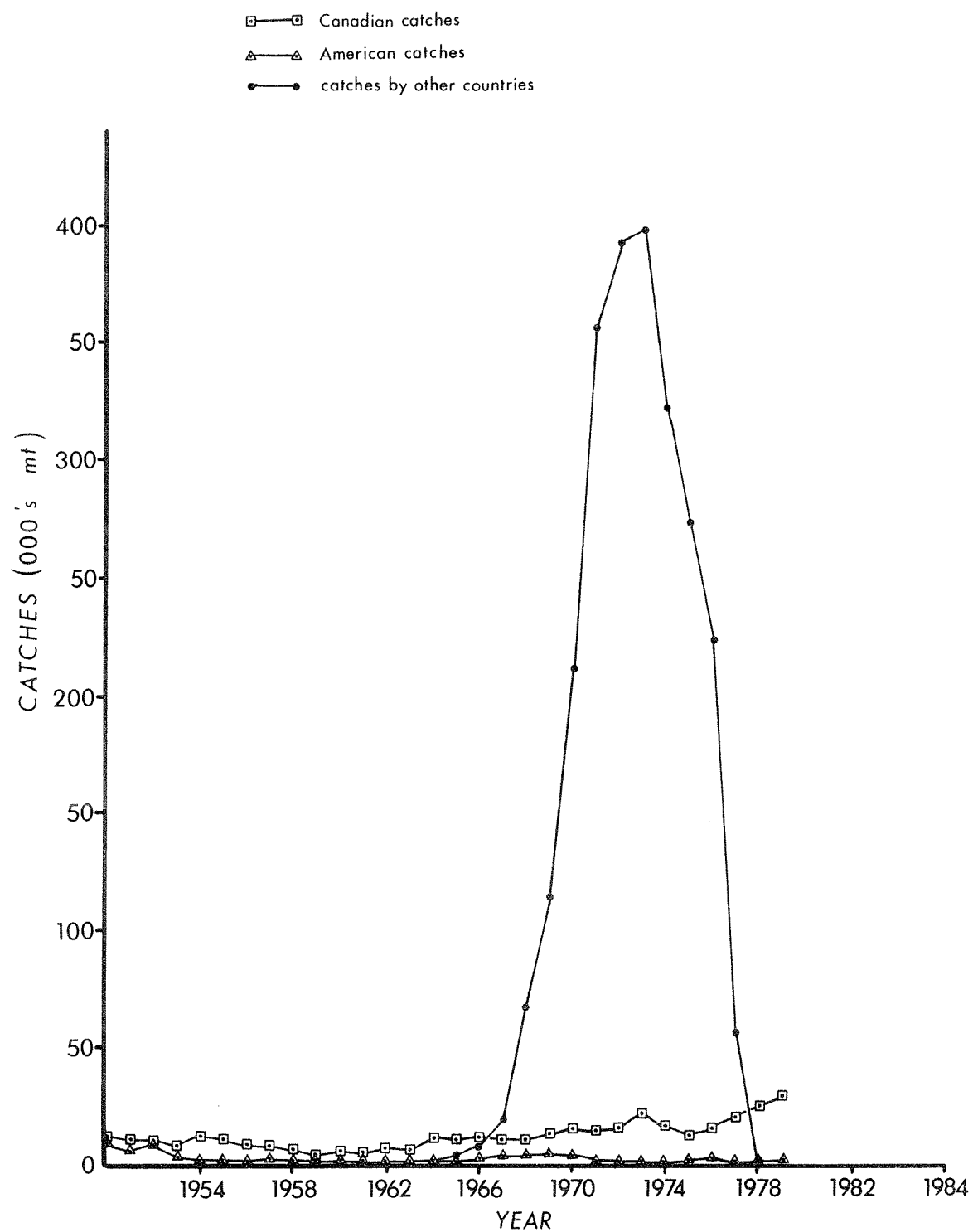


Fig. 12. Mackerel catches (metric tons) in NAFO Subareas 2-6.

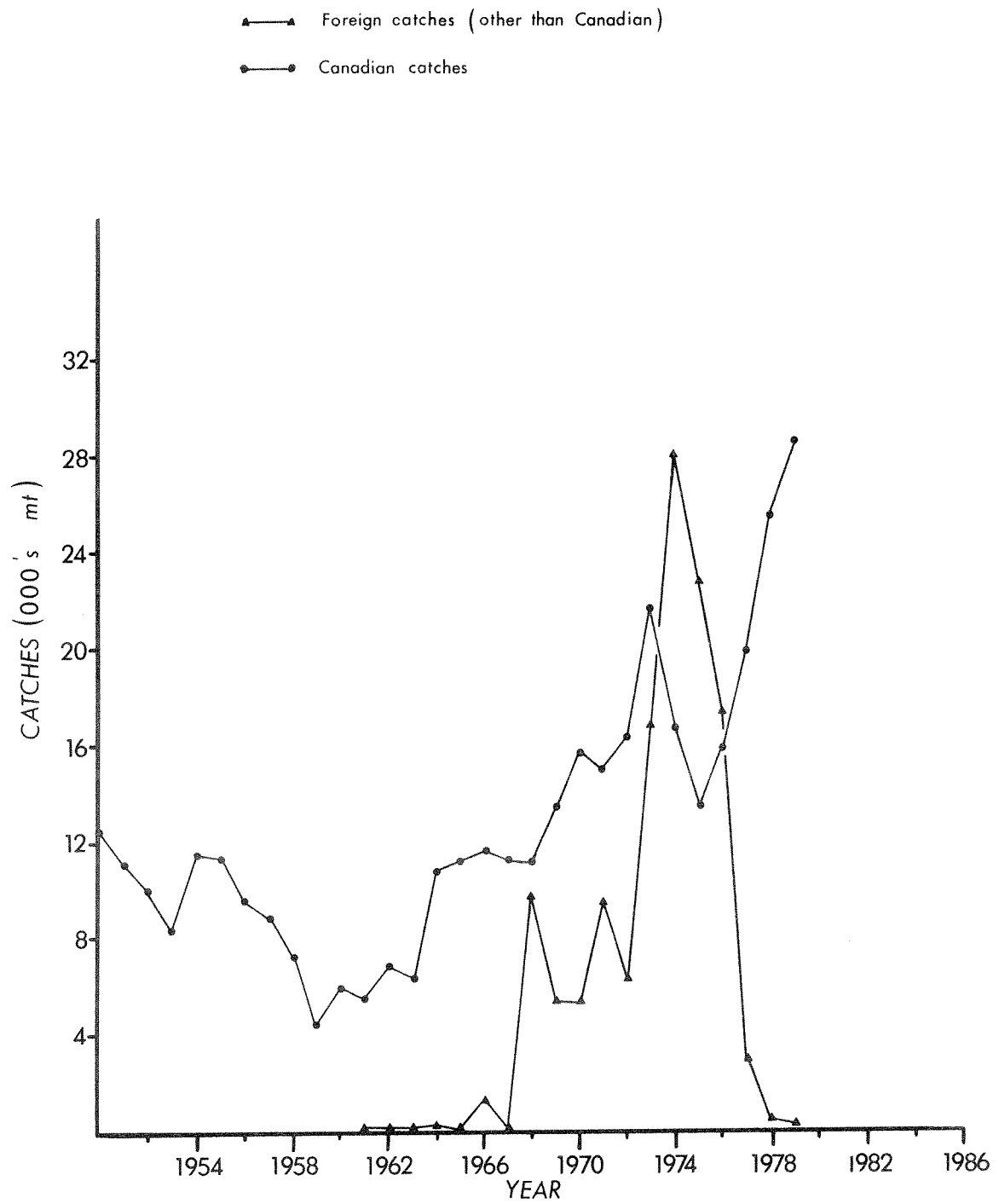


Fig. 13. Mackerel catches (metric tons) in NAFO Subarea 2-4.

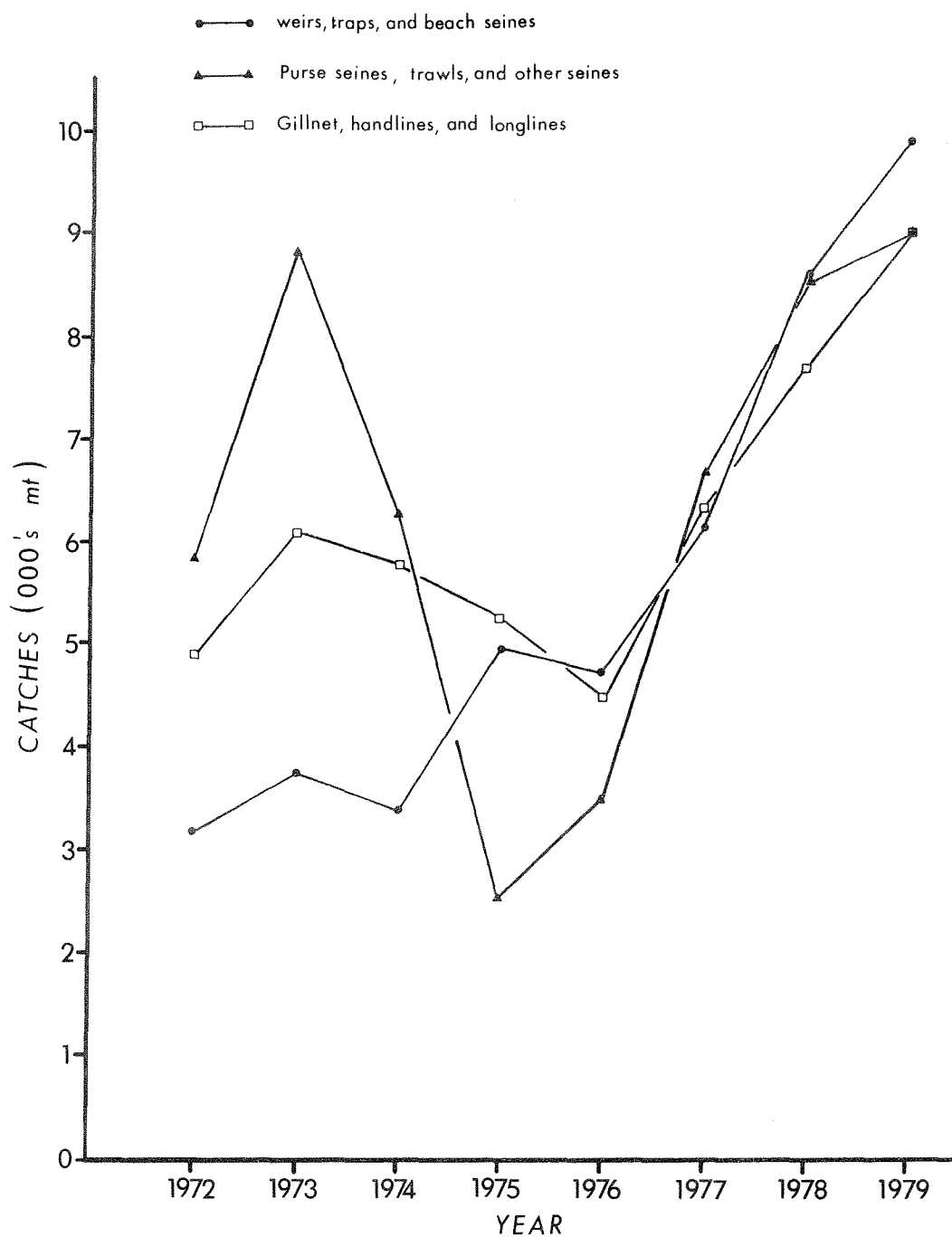


Fig. 14. Canadian mackerel catches (metric tons) by gear categories.

Table 1. Herring catches (metric tons) by gear type for the East Coast of Newfoundland (includes 4 stock areas: Notre Dame-White Bay; Bonavista Bay; Trinity Bay Conception Bay-Southern Shore), 1964-1979.

YEAR	GEAR TYPE						TOTAL
	PURSE SEINE	RING NET	GILLNET	TRAP	BAR SEINE	OTHER	
1964	-	-	(1,093) ¹	-	-	-	1,093
65	-	-	(945)	-	-	-	945
66	-	-	(975) ¹	-	-	-	975
67	70	-	(401) ¹	-	-	-	471
68	-	-	(709) ¹	-	-	-	709
69	-	-	665	2	13	1	681
1970	-	-	1,234	57	15	-	1,306
71	-	-	4,608	23	270	47	4,948
72	608	-	2,270	25	104	-	3,007
73	392	-	3,255	424	925	-	4,996
74	48	2,581	4,719	1,267	394	11	9,020
1975	5,268	4,179	3,991	823	745	-	15,006
76	9,058	9,753	3,659	1,009	1,172	258	24,909
77	-	15,650	3,381	852	5,615	236	25,734
78	-	11,759	9,113	849	1,687	-	23,408
79	-	7,913	13,262	895	4,293	-	26,363

()¹ - includes all inshore gear

Table 2. Herring catches (metric tons) by gear type for the Southeast Coast of Newfoundland (includes 2 stock areas: Fortune Bay; St. Mary's-Placentia Bays), 1964-1979.

YEAR	GEAR TYPE						TOTAL
	PURSE SEINE	RING NET	GILLNET	TRAP	BAR SEINE	OTHER	
1964	-	-	(1,270) ¹	-	-	-	1,270
65	42	-	(2,928) ¹	-	-	-	2,970
66	614	-	(1,764) ¹	-	-	-	2,378
67	5,881	-	(1,996) ¹	-	-	-	7,877
68	17,977	-	(3,930) ¹	-	-	-	21,907
69	4,862	-	1,500	-	1,630	-	7,992
1970	8,278	-	1,262	2	1,089	-	10,631
71	14,579	-	1,074	14	200	-	15,867
72	13,582	-	2,377	-	789	-	16,748
73	7,344	-	916	40	1,185	-	9,485
74	6,838	51	1,052	48	751	-	8,740
1975	4,479	711	1,143	431	860	-	7,624
76	2,165	1,092	572	25	710	-	4,564
77	928	1,655	631	34	599	-	3,847
78	661	2,135	745	36	949	-	4,526
79	644	2,461	720	10	977	-	4,812

()¹ - includes all inshore gear

Table 3. Herring catches (metric tons) by gear type for the West Coast of Newfoundland, 1964-1979.

YEAR	GEAR TYPE						TOTAL
	PURSE SEINE	RING NET	GILLNET	TRAP	BAR SEINE	OTHER	
1964	4,655	-	(332) ¹	-	-	-	4,987
65	3,125	-	(1,429) ¹	-	-	-	4,554
66	5,490	-	160	-	-	-	5,650
67	5,464	-	155	-	-	-	5,619
68	3,776	-	137	-	-	135	4,048
69	2,344	-	287	-	4	-	2,635
1970	2,951	-	847	-	3	-	3,801
71	3,320	-	2,121	14	8	-	5,463
72	2,057	-	3,838	-	139	-	6,034
73	7,956	-	6,185	2	8	-	14,151
74	2,266	-	2,345	3	4	22	4,640
1975	3,495	-	1,493	2	5	-	4,995
76	8,206	-	1,842	59	2	-	10,109
77	9,464	-	2,649	-	173	-	12,286
78	9,925	-	5,532	40	33	80	15,610
79	9,989	-	8,200	15	3	114	18,321

()¹ - includes all inshore gears

Table 4. Herring catches (metric tons) by gear for the Southern Gulf of St. Lawrence complex, 1940-1979.

Year	Gear Type		Total
	Fixed	Mobile	
1940	35,425	-	35,425
41	28,147	-	28,147
42	31,803	-	31,803
43	36,161	-	36,161
44	31,062	-	31,062
1945	28,691	-	28,691
46	35,178	-	35,178
47	35,395	-	35,395
48	40,171	-	40,171
49	31,938	-	31,938
1950	37,660	-	37,660
51	40,136	-	40,136
52	42,940	-	42,940
53	39,775	-	39,775
54	34,690	-	34,690
1955	42,871	-	42,871
56	30,038	-	30,038
57	27,643	-	27,643
58	24,705	-	24,705
59	22,350	-	22,350
1960	21,711	-	21,711
61	18,819	2,520	21,339
62	34,052	3,693	37,745
63	38,551	5,308	43,859
64	38,917	1,545	40,462
1965	43,583	5,246	48,829
66	32,975	24,866	57,841
67	32,063	101,664	133,727
68	33,279	204,977	238,256
69	25,865	265,257	291,122
1970	21,949	277,907	299,856
71	28,872	210,670	239,542
72	21,337	73,917	95,254
73	20,431	36,209	56,640
74	12,877	25,215	38,092
1975	11,938	33,601	45,539
76	10,274	30,936	41,210
77	8,219	37,483	45,702
78	13,909	35,429	49,338
79	12,771	33,110	45,881

Table 5. Herring catches (metric tons) by fleet component for the NAFO 4Vn area (Sydney Bight) based on an October to September fishing year.

<u>Year</u>	<u>Canadian</u>		<u>Foreign</u>	<u>Total</u>
	<u>Fixed gear</u>	<u>Mobile</u>		
1962-63	503	-	-	503
1963-64	408	-	-	408
1964-65	200	-	18	218
1965-66	94	-	-	94
1966-67	298	-	17	315
1967-68	235	-	-	235
1968-69	235	2,044	11,465	13,744
1969-70	82	5,342	11,050	16,474
1970-71	138	2,917	344	3,399
1971-72	164	10,036	1	10,201
1972-73	126	17,537	10	17,673
1973-74	213	16,285	588	17,086
1974-75	226	14,298	270	14,794
1975-76	74	7,947	188	8,209
1976-77	110	12,831	-	12,941
1977-78	307	7,879	-	8,186
1978-79	329	3,332	-	3,661
1979-80	?	2,807	-	

Table 6. Herring catches (metric tons) by gear from the Chedabucto Bay area (4W) and Bay of Fundy (4X) showing the catches used in current assessments separately from the non-quota catch.

4WX stock TAC catches ²												
YEAR	4W catch		Nova Scotia 4X catch				FOREIGN 4WX TOTAL	New Brunswick 4X catch ¹			TOTAL ² QUOTA CATCH	TOTAL 4X ¹ NON-QUOTA CATCH
	FIXED ¹ GEAR	PURSE SEINE	SUMMER/FALL PURSE SEINE	GILL NET ³	WEIR	LIVERPOOL TRAP		PURSE SEINE	WEIR	MISC. & SHUT-OFFS		
1963	-	-	15,093	2,955	5,345	-	-	6,871	28,203	1,163	23,393	36,237
64	-	-	24,894	4,053	12,458	-	-	15,991	27,337	2,095	41,405	45,423
65	-	-	54,527	4,091	12,021	-	-	15,755	31,684	1,662	70,639	49,101
66	-	-	112,457	4,413	7,711	-	-	25,645	35,601	204	124,581	61,450
67	431	-	117,382	5,398	12,475	-	598	20,888	29,932	100	135,853	50,920
68	375	-	133,267	5,884	12,571	-	2,417	42,223	32,114	1,031	154,139	75,368
69	343	25,112	84,525	3,474	10,744	-	13,405	13,202	25,646	893	137,260	39,741
1970	151	27,107	70,849	5,019	11,706	-	60,952	14,749	15,073	767	175,633	30,589
71	161	52,535	35,071	4,607	8,801	-	23,939	4,868	12,139	521	124,233	17,528
72	330	25,656	93,311	3,789	6,766	-	23,906	21	31,995	704	153,428	32,720
73	-	7,921	61,773	5,205	12,492	-	32,702	2,167	19,088	847	120,093	22,102
74	-	27,107	76,859	4,285	6,436	-	24,483	10,131	19,028	1,574	139,170	30,733
75	-	27,030	79,605	4,995	7,404	-	23,711	1,151	30,819	?	142,745	31,970
76	-	37,196	58,396	8,322	5,959	-	4,133	840	29,206	?	114,006	30,046
77	1,138	23,251	68,538	18,523	5,213	-	410	1,236	30,697	2,790	115,935	34,723
78	-	17,274	57,973	6,059	8,057	-	-	2,687	33,570	5,272	89,363	41,529
79	-	14,073	25,265	4,363	9,307	2,174	-	220	32,477	5,351	55,182	38,048

¹ Catches not currently considered as part of the major 4WX migratory stock and not included in the assessment or TAC.

² Catches considered to be from the 4WX migratory stock upon which the assessment is based.

³ Gillnet catches in Statistical Districts 32-44. Fixed gear catches from the remaining Statistical Districts in 4X are not considered in the assessment and are not given in this table.