The Groundfish Resource in the Gulf of St. Lawrence

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PREFACE

This document was first produced to serve as a background paper for the Gulf Groundfish Seminar held at Memramcook, New Brunswick, 23-25 September 1980. The seminar, sponsored by the Department of Fisheries and Oceans and widely attended by representatives of the processing industry, fishermen's associations, unions and Provincial Governments, addressed future management policies and strategies for Gulf groundfish fisheries. Initial expectations that the seminar proceedings would be published have not been realized. The authors believe that, despite the delay this has caused, there is some value in producing the resource background paper in a form which can be referenced, as it provides a concise account of available groundfish resources in the Gulf and of the history of management actions through 1980. Revisions have been limited to provision of final 1979, and provisional 1980, statistics and to minor reorganization and clarification of the text.

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ABSTRACT

Halliday, R. G., and A. T. Pinhorn. 1982. The groundfish resource in the Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci. 1086: iv + 16 p.

Groundfish have been fished in the Gulf of St. Lawrence for hundreds of years. The traditional species caught was cod but in recent times redfish, American plaice, witch and, most recently, Greenland halibut and white hake have become important. In the last 20 yr, Gulf groundfish catches by all countries have been 11% of the total groundfish catch in the northwest Atlantic and the Canadian groundfish catches in the Gulf have been 31% of the Canadian groundfish catch in the northwest Atlantic. The biology of each stock is outlined and the history of the fishery and management interventions are described. Yield prospects are currently improving and groundfish catches are projected to be about 230,000 mt annually in the 1982-85 period, largely as a result of continuing increases in cod abundance, but the redfish stock also shows signs of improved recruitment. Yet longer-term projections suggest average catches in the 200,000-220,000 mt range. Continuing variability in resource productivity should be anticipated in management planning.

Key words: Gulf of St. Lawrence, groundfish, cod, redfish, resource projection, management

RÉSUMÉ

Halliday, R. G., and A. T. Pinhorn. 1982. The groundfish resource in the Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aquat. Sci. 1086: iv + 16 p.

La pêche aux poissons de fond a lieu depuis plusieurs siècles dans le golfe du St-Laurent. La pêche à la morue est la plus ancienne mais récemment le sébaste, la plie canadienne, la plie grise et encore plus récemment le turbot et la merluche blanche sont devenus importants. Au cours des 20 dernières années, les captures de poissons de fond pour l'ensemble des nations pêchant dans le golfe du St-Laurent ont représenté 11% du grand total et 31% des captures canadiennes de poissons de fond dans l'Atlantique du nord-ouest. Ce travail donne un aperçu de la biologie de chaque stock, décrit l'évolution passée de la pêche et les mesures de gestion qui ont été appliquées. Les perspectives de rendement s'améliorent et on prévoit que les captures de poissons de fond devraient être d'environ 230 000 tm par année entre 1982 et 1985, surtout à cause de l'augmentation de la taille des stocks de morue mais aussi à cause des indications que le recrutement s'améliore pour le stock de sébaste. Toutefois, les prévisions à long terme indiquent des captures moyennes légérement inférieures, aux environs de 200 000-220 000 tm. La planification de la gestion devrait tenir compte de la variabilité inhérente à la productivité de la ressource.

INTRODUCTION

The International Commission for Northwest Atlantic Fisheries (ICNAF) was established in 1950 as the regulatory body for fisheries in the northwestern Atlantic. The Convention Area extended from West Greenland to Long Island, New York, and to the Canadian three mile limit. Thus, the Gulf of St. Lawrence fisheries largely fell within ICNAF jurisdiction, and the ICNAF trawl (i.e. mesh size) regulations for Subarea 4, first implemented in 1957, applied in the Gulf as in other areas. However, in March 1971, Canada proclaimed the Gulf of St. Lawrence an exclusive Canadian fishing zone, and in 1971 and 1972 negotiated phase-out agreements with all foreign nations fishing there. Thus, when ICNAF introduced a comprehensive scheme of catch quota controls for northwest Atlantic fisheries in 1972-73, this had little impact on Gulf fisheries. Southern Gulf cod (Div. 4T-4Vn Jan-Apr), which overwinters largely outside the Gulf in Subdiv. 4Vn, was the one exception, being regulated by ICNAF TAC from 1974. Foreign fisheries in the Gulf were regulated by bilateral agreements with Canada. Canadian domestic fisheries in the Gulf were unregulated until Canada imposed catch restrictions on the main groundfish stocks in 1976 and 1977. Thus, control of the exploitation rate of Gulf groundfish is a relatively recent event in most cases.

As a result of these events, the Standing Committee on Research and Statistics (STACRES) of ICNAF provided management advice only on southern Gulf cod among Gulf stocks and then only until 1976. Extension of jurisdiction resulted in the creation of two new scientific organizations, the Northwest Atlantic Fisheries Organization (NAFO) Scientific Council which mainly advises on management of stocks which lie outside 200 miles or overlap the boundary, and the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) which advises on management of most stocks within 200 miles, including those in the Gulf of St. Lawrence. Prior to 1977, scientific advice on management of most Gulf groundfish resources was provided on an ad hoc basis.

As this is a general, and non-technical, report sources are not cited in the text. A selected bibliography is provided, however, for those who may wish to examine particular issues in more detail. Despite the desire to be non-technical, some technical terms must be used. Thus, before describing the Gulf groundfish stocks and the fisheries on them, we will explain some of these terms.

Fishing mortality, denoted by the letter "F", is an index of the proportion of fish removed from the stock by fishing. The biomass of a stock is simply the weight of fish belonging to that stock which is in the ocean. The offspring produced during one year's spawning are referred to as a year-class e.g. those fish which will develop from the eggs spawned in 1980 will be the 1980 year-class. When these fish grow large enough to be caught by the commercial fishery they will join that part of the stock which is fished i.e. they will recruit to the fishery and they are referred to as recruits. If the year-class which is joining the fished part of the stock is big in comparison to the average size of year-classes then there is good recruitment.

Several management options have been discussed in recent years (e.g. F_{max}, $F_{0.1}$, MSY, etc.) and the meanings of those referred to here are described below.

Let us suppose that a fishery commences on a hitherto virgin stock. Let us further suppose that in the first year of operation, only one vessel is used in the fishery. Let us also suppose that the vessel catches 5,000 mt in that first year. Prompted by this lucrative fishery, the vessel owner adds a second vessel in year 2 and these two vessels combined catch 9,000 mt. In other words, the addition of the second vessel has added 4,000 mt to the catch made in the first year. Suppose the vessel owner then adds a third vessel, and catches a total of 12,000 mt, then a 5th, a 10th, a 20th and finally a 50th vessel, after which the total catch is 25,000 mt. Suppose by adding the 51st vessel, the total catch becomes 25,400 mt. Then, the increase in yield by adding the 51st vessel is 10% (400 mt) of that when the 2nd vessel was added (4,000 mt). That is the level of $F_{0.1}$. It is the fishing mortality (F) which is generated by the level of fishery effort at which, by adding another unit of effort, the increase in catch (marginal yield) is only 10% of the increase by adding the same unit of effort in a lightly exploited fishery.

Let us continue to add vessels to the fishery each year until the addition of a vessel results in no increase in total catch. This might be after 75 vessels are in the fishery and the total catch is 27,500 mt. This is then the level of fishing effort associated with the long-term maximum physical catch. This long-term maximum physical catch is the MSY (Maximum Sustainable Yield), and it is obtained by fishing at a level of fishing mortality of F_{max}.

One important point to note is that the MSY catch at F_{max} requires about 50% more effort to take 10% more catch (in the hypothetical example an additional 25 vessels to catch an additional 2,500 mt). This of course implies a catch per vessel at F_{max} of about 75% of that at $F_{0.1}$.

OVERVIEW

Groundfish have been fished in the Gulf of St. Lawrence (Fig. 1) for hundreds of years. The traditional species caught was cod but in recent times redfish, American plaice, witch and, most recently, Greenland halibut and white hake have become important species.

The groundfish fishery in the Gulf of St. Lawrence is an important part of the total groundfish fishery in the Northwest Atlantic and is particularly important in the context of the Canadian fishery.

During the period 1960-79, the total groundfish catch in the Gulf of St. Lawrence represented 44% of the total groundfish catch in NAFO Subarea 4, 15% of the total groundfish catch in NAFO Subareas 2-4 and 11% of the total groundfish catch in NAFO Subareas 0-6 (Fig. 2). During the same period the Canadian groundfish catch in the Gulf of St. Lawrence represented 31% of the total Canadian groundfish catch in the entire northwest Atlantic (Fig. 3).

Figure 4 indicates the trends in nominal catches of the important groundfish species in the Gulf of St. Lawrence in the period 1960-79. Catches of cod declined from about 170,000 mt in 1960-61 to 130,000 mt in 1966-67, then increased to a peak of 180,000 mt in 1970 after which catches declined steadily to a low of about 100,000 mt in 1977. Catches subsequently increased sharply to almost 140,000 mt in 1979 (Fig. 4). Redfish catches increased from about 10,000 mt in 1960-62 to about 90,000 mt in the late 1960's and remained in the 80,000-90,000 mt range until 1972. Catches increased sharply in 1973 mainly as a result of increased catches by midwater trawl. Catches decreased sharply to 63,000 mt in 1974 and under TAC regulation (since 1976) stabilized at about 15,000 mt in 1977-80. Catches of American plaice, mainly from Div. 4T, have been relatively stable throughout the period mostly in the range of 7,000-10,000 mt during 1960-73. Since 1973 catches have tended to be above 10,000 mt with the 1979 catch being about 14,000 mt. Catches of other groundfish species (mainly witch, Greenland halibut and hake) have been fairly stable and small (<10%) throughout the period, although catches of witch decreased in the early 1970's while the catches of Greenland halibut have generally increased throughout the period and especially in 1978 and 1979.

BIOLOGY AND FISHERY OF THE MAJOR STOCKS

COD IN SUBDIV. 3Pn AND DIV. 4RS

This cod stock forms large winter concentrations during November-December in the area near Cabot Strait (Bay of Islands to Rose Blanche Bank) and disperses into the Gulf around March-April (Fig. 5). The eastward migration along the south coast of Newfoundland in winter reaches as far as Fortune Bay and the northwest slopes of St. Pierre Bank in some years, depending on hydrographic conditions.

Some mixing of this stock with the southern Gulf cod stock takes place in summer in the area of the Quebec north shore but is so small as to be negligible for management purposes. Similarly, the stock mixes with the Subdiv. 3Ps stock during winter at the time of the southwest Newfoundland winter fishery but these stocks separate again when the movement into the Gulf takes place in summer. Also, some of the cod tagged in and near the southern part of the Strait of Belle Isle have moved through the Strait and along the east coast of Newfoundland. Similarly, some of the cod tagged along the east coast of Newfoundland penetrated the Strait of Belle Isle during the summer feeding season to intermingle with the northern Gulf stock. However this movement is very small with only a small percentage of the fish tagged being recaptured in the Gulf. Thus, there is both some movement of northern Gulf cod out of the Gulf and Labrador-East Newfoundland cod into the northern Gulf but the net result of the movement is impossible to quantify. Therefore, for management purposes Div. 4RS-3Pn cod can be considered one unit.

During their migration back into the Gulf from the Cabot Strait area and southwest Newfoundland coast the cod also migrate into inshore areas and very shallow water along the Newfoundland west coast and the Quebec shore in summer, at which time they support the inshore fishery by cod traps, gillnets, and line-gear. During their winter concentration near the southern end of the Newfoundland west coast and outside the Gulf in the southwest Newfoundland coast area, they support both an offshore otter trawl fishery and an inshore line-gear fishery.

Catches and corresponding TACs for cod in Subdiv. 3Pn and Div. 4RS are shown below for the period 1960-80:

Year	Nominal Catch ('000 mt)	Year	Nominal Catch ('000 mt)	TAC ('000 mt)
1960	94	1970	107	-
1961	100	1971	84	-
1962	101	1972	57	-
1963	103	1973	66	-
1964	84	1974	66	-
1965	69	1975	60	-
1966	85	1976	77	-
1967	79	1977	74	55
1968	90	1978	78	55
1969	71	1979	83	75
		1980	94[1]	75

[1] provisional statistics

Catches during 1960-63 were in the range of 100,000 mt but declined to a low of 57,000 mt in 1972. Catches since then have increased to a high of 94,000 mt (provisional statistics) in 1980.

The major countries fishing in the Gulf during this period were Canada, France, Portugal and Spain, although in recent years all countries except Canada and France have been phased out of the fishery. Canada took about three-quarters of the catch during the 1960-79 period. The Canadian fishery includes an inshore component using traps, gillnets, long-lines and hand-lines mainly in June, July and August as well as an offshore component using otter trawls mainly in February, March and April.

TACs were first introduced on this stock in 1977 at a level of 55,000 mt based on scientific advice that a catch in 1977 of 62,000 mt would correspond to fishing at F_{max} and a catch of 45,000 mt to fishing at $F_{0.1}$. The long-term MSY was estimated to be in the range of 81,000-85,000 mt. The catch in 1977 was 74,000 mt. A TAC of 55,000 mt was again set in 1978 based on scientific advice that this level should control fishing at the $F_{0.1}$ level. The catch in 1978 was 78,000 mt. The scientific advice for the 1979 TAC was in the form of three options:

a) By fishing at $F_{0.1}$ in 1979 and beyond, the TAC in 1979 would be 49,500 mt and would increase to about 83,000 mt by 1986.

b) A TAC of 59,000 mt in 1979 would generate a fishing mortality in excess of $F_{0.1}$ for that year but in succeeding years fishing at the $F_{0.1}$ level would result in TAC levels increasing to 80,000 mt by 1986 as F slowly reduced to the $F_{0.1}$ level.

c) A constant catch of 75,000 mt (approximately the level of the 1977-78 catch) in each year from 1979-86 would result in fishing mortalities above $F_{0.1}$ initially but the fishing mortality would decline to $F_{0.1}$ by 1984-85.

Given these options the TAC for 1979 was set at 75,000 mt. The 1979 statistics indicate the catch was 83,000 mt. Based on the perception that catches seemed to be stabilizing in the vicinity of 75,000 mt, CAFSAC provided advice for the 1980 fishery on the basis of the effects on the stock of projecting a constant catch of 75,000 mt. This indicated that the biomass should increase by about 15% by 1986 and the fishing mortality should slowly be reduced to the $F_{0.1}$ level by the early 1980's. It was also pointed out that the catch corresponding to $F_{0.1}$ in 1980 would be about 65,000 mt. Given this advice the 1980 TAC was set at 75,000 mt. The assessment conducted in spring 1980 indicated that stock status had improved to the extent that fishing at $F_{0.1}$ in 1981 implied a catch of 75,000 mt and this was advised for 1981. The long-term average catch at $F_{0.1}$ is also 75,000 mt implying that the biomass in this stock was in fact at the $F_{0.1}$ level in 1981.

In reviewing the management history of this stock, one might correctly conclude that even though the stock was exploited above the $F_{0.1}$ level since at least 1977, the stock nevertheless rebuilt to the $F_{0.1}$ level by 1981. However, one must bear in mind three things, the first being that the stock size at the beginning of 1977 was not substantially below that which would give the long-term $F_{0.1}$ level of catch. The second is that, fortunately, a succession of five (5) above average year-classes entered this stock (1971-75 year-classes) and thus rebuilt the stock rather quickly. If such had not been the case, i.e. if a succession of poor year- classes had been entering the fishery, such management measures would have resulted in drastic stock declines. Thus in some sense we were lucky. The third is that if TACs had been set and catches controlled at the $F_{0.1}$ level since 1977, the stock would have been rebuilt much faster and catch rates would also have risen more quickly.

REDFISH IN DIV. 4RST

Redfish inhabit the deep areas of the Gulf, concentrations usually being found in depth greater than 100 fathoms. Because of difficulties in tagging redfish, less is known about their movement than in the case of cod. There is a strong diel movement of redfish off the bottom into the midwater areas at night and this affects their catchability by otter trawls. There is also some indication that redfish may migrate south in winter, as cod on both sides of the Gulf do, and may even to some extent migrate out of the Gulf but there is no clear scientific evidence of mixture with Div. 3P and Div. 4VWX redfish stocks. Similarly, there is no evidence of movement through the Strait of Belle Isle and mixture with the Labrador-East Newfoundland redfish stock.

Catches and corresponding TACs for redfish in Div. 4RST are shown below for the period 1960-80:

Year	Nominal Catch ('000 mt)	Year	Nominal Catch ('000 mt)	TAC ('000 mt)
1960	12	1970	88	-
1961	10	1971	79	-
1962	7	1972	80	-
1963	20	1973	130	-
1964	30	1974	63	-
1965	49	1975	65	-
1966	65	1976	38	30
1967	70	1977	16	18
1968	91	1978	14	18
1969	89	1979	15	16
		1980	15[1]	16

[1] Provisional statistics

Catches during 1960-62 were in the 7-12,000 mt range but increased steadily to a level of 80-90,000 mt by the 1968-72 period. In 1973 catches increased sharply to 130,000 mt because of greatly increased fishing activity resulting from the introduction of midwater trawling technology to the fishery. Catches decreased sharply to 63-65,000 mt during 1974-75 and under TAC regulation (since 1976) to 15,000 mt in 1980. Recruitment of young redfish in the Gulf has been very irregular and the increased catches during the late 1960's and early 1970's were composed almost entirely of two unusually large year-classes, those of 1956 and 1958. The year-classes of the 1960's were many times smaller than were those two year-classes.

In 1973, with the heavy fishing on what were then 15 and 17 year-old fish and with no signs of good recruitment to the stock, scientists became concerned that the spawning stock was being reduced to levels which could result in impairment of reproductive potential. Thus advice was given in 1975 to prohibit directed fishing for redfish in the Gulf in 1976. A TAC of 30,000 mt was set for 1976 and the catch was 38,000 mt. Based on annual assessments thereafter of stock status for the years

1977-80, TACs of 18,000 mt were set for 1977 and 1978 and 16,000 mt for 1979 and 1980. Catches were 14,000-16,000 mt. The assessment for 1981 indicated that the year-classes of the early 1970's are moderately strong but not nearly as strong as those of 1956 and 1958. Nonetheless, some modest increases in TACs in the early 1980's could be expected.

It should be pointed out that because of the very irregular nature of the recruitment in this stock, it is not possible to estimate meaningful long-term sustainable yields, but average yields at the levels realized from the large year-classes of 1956 and 1958 (approximately 80,000 mt per year for 10 years) cannot be expected in the long-term. These two year-classes were probably unusual occurrences in the history of this redfish stock and may very well never occur again. They probably resulted from mass mortalities of herring in the Gulf in the early 1950's, thus reducing predation on, or competition for food with, larval redfish.

One factor of importance in the Gulf redfish fishery is the by-catch of young redfish (ages 10 and less) in the shrimp fishery. Although studies are continuing on the impact of this by-catch on redfish recruitment, analyses thus far indicate that its long-term effect on the total redfish biomass may be less than was first suspected. This by-catch may, however, be a significant source of mortality for a particular year-class in a particular year depending on its distribution in relation to shrimp in that year.

WITCH IN DIV. 4RST

While very little is known of the movements of witch in the Gulf, the stock is probably discrete from that in Subdiv. 3Ps and also that in Div. 2J and 3K. Except for St. George's Bay, where the muddy bottom is very favourable to the species, they are widely dispersed in the Gulf for most of the year. However, localized prespawning concentrations occur off St. George's Bay in mid-winter and in recent years have supported a brief otter trawl fishery. Also, a Danish seine fishery for witch is prosecuted in St. George's Bay, while small otter trawlers also catch witch.

During the 1960-75 period, catches of witch in the Gulf were fairly stable in the range of 2,000-4,000 mt, most of which was taken by Danish seine. Catches since 1975 have however been higher, with a peak catch of 6,900 mt in 1976. Catches in 1977, 1978 and 1979 were 3,000 mt, 4,500 mt and 4,600 mt, respectively. These higher catches in the late 1970's reflect development of the winter fishery by otter trawlers.

TACs were first introduced for witch in Divisions 4RS in 1977 and 1978 at 3,500 mt based solely on average catch statistics. However, in 1978 an assessment suggested a TAC of 5,000 mt, based on the fact that the recently developed otter trawl fishery was based on an accumulated virgin stock of old, slow-growing fish. It was felt that fishing at the higher level would reduce the population numbers, especially of the older, slow-growing fish and stimulate growth in the stock. This TAC (5,000 mt) was also in effect in 1980. The assessment conducted in 1980 indicated that the older slow-growing fish have indeed been reduced in numbers, that the growth rate of individual fish has increased and that young fish are more abundant; all resulting in stable biomass in recent years.

GREENLAND HALIBUT IN DIV. 4RST

Greenland halibut are found throughout the Gulf of St. Lawrence at depths greater than 100 fathoms. Little is known of their movements but they concentrate in winter in Div. 4R southwest of St. George's Bay where the fishery has recently also concentrated. These are likely to be prespawning concentrations. In Div. 4S relatively large numbers are found along the south coast of Anticosti Island and even on the north shore of the St. Lawrence River's outer reaches.

Until 1974, landings were less than 1,000 mt annually. However, landings have since increased substantially and in 1979 were almost 9,000 mt. Historically, the main fishery was in Div. 4S with a smaller amount being caught in Div. 4R and with the catch in Div. 4T being only about 10% of the total.

The increase in landings of Greenland halibut from the Gulf over the past few years was primarily composed of year-classes that have shown exceptional strength in the Greenland halibut stock in the Labrador-northeast Newfoundland Shelf area and it is possible that the Gulf stock is being recruited from these stocks outside the Gulf. This is supported by the fact that the Gulf fishery is dependent mostly on immature fish. Possibly the larvae drift into the Gulf and the young halibut settle and reside there until maturity, when they leave to spawn. Tagging experiments should elucidate the relationship between Greenland halibut in the Gulf of St. Lawrence and those from outside. In the meantime no restrictions on the fishery have been recommended.

SOUTHERN GULF OF ST. LAWRENCE COD (DIV. 4T-4Vn JAN-APR)

Migrations

Southern Gulf cod mix to a small extent with northern Gulf cod in the St. Lawrence estuary region in summer months. However, most of the population spends the summer around the Gaspé and northern New Brunswick coast and on the banks offshore from these areas (Fig. 5).

When the water cools off in the fall, the cod begin their migration away from the shallow-water summer-feeding areas east toward the deeper waters of the Laurentian Channel and south through the Cabot Strait into Sydney Bight. The timing of the fall migration is variable depending on water temperatures, but normally begins in October-November and is complete by December-January.

Smaller fish migrate the shortest distance and overwinter in deep water along the edge of the Laurentian Channel between the Magdalen Islands and Cape North. Larger cod have narrower temperature tolerances and move completely out of the Gulf to yet warmer water off Sydney Bight and as far south as the northern edge of Banquereau Bank. The largest concentrations of commercial sized fish do, however, overwinter in Sydney Bight (Subdiv. 4Vn) usually in depths of 80-120 fathoms along the edge of the Laurentian Channel.

The return spring migration occurs in late April- early May as southern Gulf waters begin to warm. The cod move back into the Gulf onto the banks and into coastal areas. Mature cod, which ripened over the winter, spawn soon after re-entering the Gulf, peak spawning occuring in late May- early June. They then spend the summer feeding there.

Early Life History

Each female cod spawns several hundred thousand eggs which then float in the warm surface layers until hatching. The larvae also inhabit the surface layers feeding on small planktonic animals. By late summer, the larvae are large enough to take on the form of an adult cod (i.e. they metamorphose). However, these juveniles remain in the upper water layers, feeding on the larger planktonic animals. Even in their second year of life as one-year-old cod they spend most of their time off the bottom, feeding pelagically. By the time they are age 2 they begin to live and feed on the bottom and this transition is complete by age 3. At this age a few of the larger fish enter the fishery, but most fish in a year-class are not available to the fishery until age 4 or age 5.

Growth and Sexual Maturity

The growth rate and the size and age at sexual maturity of southern Gulf cod have varied substantially over time. In 1958 a 6 year old cod averaged 57 cm (22 inches) in length and weighed 1.9 kg (4.2 lbs). In 1964 cod of the same age measured 48 cm (19 inches) and weighed 1.0 kg (2.2. lbs). By 1975, age 6 cod were again attaining the size typical of that in the 1950's (i.e. about 56 cm). In 1959, most female cod matured at age 6 (length = 56 cm) but by 1978 maturation was mainly at ages 3 and 4 (length = 35 cm). There are indications that the trends towards higher growth rate and lower length and age at maturity have reversed in most recent years.

These changes affect the age composition and the proportion of immature fish caught by fishing gears. In the case of otter trawls, the mesh size which can be used is regulated. This mesh size controls the size of fish being caught. However, fish of the same size may be a different age in different years and the proportion of these fish which are immature will also be different. In the same way hook size used in line-trawl gear and mesh size of gillnets select for particular sizes of fish and the age and maturity of these fish will vary. It may appear to fishermen that biologists keep changing their story on, say, the proportion of immature fish in catches of particular gears, and indeed they have as the situation itself changed. What was said five years ago, although accurate at the time, is no longer applicable today.

The reasons for these changes in growth and sexual maturity are topics of continuing scientific debate. The increasing size at age and decreasing age and size at maturity correspond in time with the decrease in the size of the stock. Thus these may represent ways that the stock can increase its productivity when its abundance is low i.e. these are density-dependent responses. While this appears to be part of the answer, it is not the whole story and research continues.

History of the Fishery

Cod fishing in the southern Gulf has been going on for well over a century. Rough statistics indicate that landings during the 1930's and 1940's were about 30,000 mt, mainly by hook and line gear. Otter trawling was introduced to the Gulf fishery in 1947 with the construction of the Chaleur and Gloucester class vessels and foreign otter trawlers began to fish cod in Sydney Bight in the early 1950's, particularly those of France, Spain and Portugal. The larger Canadian trawlers (greater than 150 gross tons) fished this stock mainly in the winter Sydney Bight fishery. Gillnetting, mainly by Gaspé based vessels, began in the early 1960's.

The buildup of fishing effort in the 1950's coincided with a period of high productivity and high abundance of cod and landings peaked at about 110,000 mt in 1956. Strong year-classes and good growth of cod in the 1950's appears to have been associated with the massive herring die-offs due to disease in the mid-1950's. The abundance of cod gradually declined throughout the 1960's and 1970's, reaching an all-time low in 1975.

In 1977, landings had declined to 22,000 mt - the lowest since the 1930's. Substantial increases occurred in the next two years as stock abundance increased and preliminary landings figures for 1980 total 57,000 mt. Annual landings and corresponding TAC's for the period 1960-80 were as follows:

Year	Nominal Catch ('000 mt)	Year	Nominal Catch ('000 mt)	TAC ('000 mt)
1960	66	1970	64	-
1961	66	1971	56	-
1962	67	1972	65	-
1963	70	1973	50	-
1964	61	1974	47	63
1965	63	1975	41	50
1966	55	1976	33	30
1967	41	1977	22	15
1968	47	1978	38	38
1969	48	1979	56	46
		1980	57[1]	54

[1] Provisional statistics

Management Measures

This stock was first assessed in the early 1970's by STACRES of ICNAF. At this time the stock was in a temporary upswing and advice for 1973 and 1974 was for catch limitation at about the average level of historical catches, i.e. about 60,000 mt (Table 1). Advice for 1975 and 1976 reflected the increasing recognition that the stock had entered a phase of serious decline and this culminated in advice of a zero TAC for 1977. Advice for management through 1976 was based on the objective of achievement of maximum sustainable yield (MSY), i.e. the reference catch level was that associated with fishing at F_{max}.

TAC regulation by ICNAF was initiated in 1974 and followed STACRES advice closely. The 1977 TAC of 15,000 mt was judged to be the lowest practicable catch, a standard approach by ICNAF when faced with a formal zero TAC recommendation and one which followed the spirit, if not the letter, of the advice given.

Scientific advice for 1977 was based on stock size considerations rather than achievement of MSY, and this continued to be the basis of advice for 1978 and 1979. That is, advice was framed in terms of achieving a particular stock size rather than achievement of a particular level of fishing mortality, F. This approach developed with time, initial considerations for 1977 being to increase stock size from the then very low levels. (It was at this point, with Canadian extension of fisheries jurisdication, that CAFSAC took over provision of scientific advice from STACRES.) In giving advice for 1978, CAFSAC recognized that the stock was recovering and based its advice on rebuilding to an "optimal stock size" which should give fairly high and stable long-term yields. By the following year, it was apparent that several very strong year-classes were entering the fishery and that stock size was above the defined "optimum". Advice for 1979 was based on a strategy of reducing stock size toward the "optimum" over several years while maintaining fairly stable catches.

Subsequent advice for 1980 and 1981 (and revised advice for 1979) was based on the concept of an "optimal exploitation rate" rather than "optimal stock size". The reference point used was the catch associated with fishing at $F_{0.1}$, the management criterion most widely used in management of fish stocks in the Canadian zone. These assessments indicated that stock size was continuing to increase and that, by 1981, the $F_{0.1}$ catch would be about 60,000 mt.

With extension of jurisdiction, Canada adopted without change the TAC regulations agreed to by ICNAF in 1976 for application in 1977. For 1978-80, Canadian management plans set TAC's which were usually below the reference levels provided by CAFSAC. The aim was to encourage more rapid stock rebuilding, but also to allow a larger proportion of the fish to reach sizes at which they would contribute to the catches of longline and gillnet fleet components, which are more dependent on the availability of larger fish than are the otter trawl and Danish (and Scottish) seine fleets.

AMERICAN PLAICE IN DIV. 4T

The major concentrations of American plaice occur on the Magdalen Shallows in the southwestern Gulf (i.e. Div. 4T). Tagging experiments indicate that plaice do not move far. There appear to be two main groups in Div. 4T, northwest and southeast of a line between Prince Edward Island and the Magdalen Islands. There is some mixing within these groups but very little mixing between them. There is a seasonal migration, particularly of the large, mature plaice to the deep, warmer, water along the edge of the Laurentian Channel for overwintering and a return migration to the shallows for spawning in spring, and feeding throughout the summer.

Only small quantities of plaice (less than 300 mt per year) were landed from the southern Gulf prior to the introduction of otter trawling in 1947. These were large fish caught incidentally in the hook and line fishery for cod. After 1947, landings increased rapidly and by 1955 had peaked at about 12,000 mt. The introduction of Danish seiners to the fleet in the late 1950's - early 1960's did not result in any noticable increase in total landings despite the fact that these vessels depended more heavily on plaice than did otter trawlers. Landings and TAC's from 1960 were as follows:

Year	Landings[1] ('000 mt)	Year	Landings[1] ('000 mt)	TAC ('000 mt)
1960	10	1970	9	-
1961	9	1971	10	-
1962	6	1972	9	-
1963	8	1973	8	-
1964	8	1974	9	-
1965	10	1975	11	-
1966	12	1976	12	-
1967	9	1977	10	10
1968	10	1978	10	10
1969	8	1979	11	10
		1980	9[2]	10

[1] Landings include landings identified as plaice and also 90% of landings of "Unspecified Flounders" which are known to be mainly plaice.

[2] Provisional statistics

For American plaice it is particularly important to distinguish between landings and catches as a large proportion of catches are discarded at sea. In the above table "landings" are the quantities of fish actually brought to the dock and TAC's have been enforced on landings. Discards of plaice have been a problem since the introduction of otter trawling in 1947. Studies in 1959-61 showed that 30-60% of the weight of fish caught were discarded at sea (55%-85% by number). Another study in 1976 showed that 40-50% by weight were discarded (70-80% by number). The minimum acceptable size for plaice at the fish plant is about 30 cm (12 inches) but with present mesh sizes much of the catch is in the size range 20-30 cm (8-12 inches).

The first TAC advice given for Div. 4T plaice was by an ad hoc working group of Departmental biologists which met in September 1976. They concluded that exploitation rate was quite high but the stock was stable and recommended a precautionary TAC of 10,000 mt for 1977, slightly above long-term average catches. CAFSAC advice for 1978-80 was also for TAC's of 10,000 mt, but analyses in 1979 (for 1980) and in 1980 (for 1981) detected an increasing trend in plaice abundance and advice for 1981 was that landings of 13,000 mt would approximate fishing at $F_{0.1}$. Groundfish Management Plans set TAC's at 10,000 mt for 1977 through 1980 (and a cautious approach was also taken for 1981 when the TAC was again set at 10,000 mt).

WHITE HAKE IN DIV. 4T

White hake are fished primarily by inshore boats (less than 25 gross tons) in localized areas in the southwestern Gulf (Div. 4T), mainly off the eastern end of Prince Edward Island. Research vessel surveys indicate that the highest concentrations of white hake occur in the latter area (i.e. off eastern P.E.I.) but there are other concentrations off western P.E.I. and along the edge of the Laurentian Channel south of the Gaspé coast.

Spawning takes place in the summer, mainly east of Prince Edward Island, and larvae are abundant in the surface water layer in August. Hake begin to enter the commercial fishery at about age 3 when they are about 35 cm (14 inches) but they make their main contribution to the fishery at ages 4-8 when they are 45-65 cm (18-26 inches). Tagging experiments off eastern Prince Edward Island indicate localized movements only with no extensive migrations. It is possible that there is a movement to deeper water in Cape Breton Channel, and possibly as far as the Laurentian Channel, for the winter months.

Nominal catches of white hake from Div. 4T have averaged about 5,000 mt since 1960 with recent catches (1974-78) being below the long-term average. Annual nominal catches from 1960 are as follows:

Year	Nominal Catch ('000 mt)	Year	Nominal Catch ('000 mt)
1960	2.0	1970	5.7
1961	5.3	1971	5.7
1962	7.2	1972	5.8
1963	6.6	1973	5.7
1964	6.2	1974	3.6
1965	4.7	1975	4.2
1966	7.0	1976	3.8
1967	6.6	1977	4.0
1968	4.3	1978	4.8
1969	4.2	1979	8.1
		1980	12.4[1]

[1] Provisional statistics

The 1979 catch of 8,100 mt and provisional 1980 catch of 12,400 mt are the highest recorded.

The fishery for this resource is not managed. There are insufficient commercial fishery, or research, data to determine the status of the stock except in the most general terms. Research vessel surveys suggest that hake in Div. 4T increased in abundance in the early 1970's, declined in 1975-76, but increased again in 1978-79. Although these surveys are not particularly reliable for hake, they support the conclusion that hake were as abundant or more abundant in the late 1970's as in the early 1970's and that average catches of 5,000 mt can be sustained. The very substantial increase in catches in 1979 and 1980 strongly suggest that imposition of catch restrictions to control fishery expansion is required until the factors responsible for this increase can be determined.[1]

FUTURE PROSPECTS

Scientists are, on the whole, a cautious bunch preferring to base their statements on observation and to steer clear of speculation. We have however, albeit with great reluctance, been indulging in speculation about future resource prospects since 1975 and, in most recent years, these have been published. We quote from the introduction to a recent volume entitled "Resource Prospects for Canada's Atlantic Fisheries 1980-1985" (Department of Fisheries and Oceans, February 1980):

> "These projections, which are given in the form of a projected Total Allowable Catch (TAC) for each stock, should be viewed only as a general guide to likely events. While 1980 predictions are based largely on formal calculations, and actual events should not differ widely from those predicted projections of stock status in the later years are to a considerable extent best guesses, based on inadequate knowledge."

Also the following:

> "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; these "recruitment" predictions are, however, critical to any projections of catch and catch rates. Despite these uncertainties, an attempt has been made to provide long-term resource projections .... in order to provide a framework for fisheries development planning...."

[1] At the time of the Gulf Groundfish Seminar preliminary 1979 catches only were available and these indicated a catch level of 7,200 mt - within the historical range of catches. Thus, the need for regulation was not recognized.

It has been put to us that long-term projections are essential for rational planning and policy development and it is for this reason only that we put them forward. We emphasize these points so that the mistake of very detailed planning based on these numbers can be avoided. The abundance of individual resources will fluctuate in a presently undeterminable fashion. Planning should take into account this inevitable variability and should recognize the need for flexibility.

The following projections for Gulf groundfish were given in this February 1980 edition of "Resource Prospects":

Projection of Gulf groundfish catches ('000 mt)

Species/Year	1980	1981	1982	1983	1984	1985
All	188	205	210	210	210	210
Cod 4RS-3Pn	75	75	75	75	75	75
Cod 4T-4Vn (J-A)	54	68	71	70	68	65
Redfish 4RST	16	16	17	18	19	20
Witch 4RS	5	5	5	5	5	5
Flatfish 4T	14	14	14	14	14	14
Others	24	27	28	28	29	31

These projections were based on stock status reports prepared in spring 1979. A revised set of stock status report were prepared in spring 1980 and the above table can now be modified as follows:

Projection of Gulf groundfish catches ('000 mt)[1]

Species/Year	1980	1981	1982	1983	1984	1985
All	182	197	218	233	234	231
Cod 4RS-3Pn	75	75	87	93	94	93
Cod 4T-4Vn (J-A)	54	60	64	68	67	66
Redfish 4RST	16	22	27	32	33	32
Witch 4RS	5	5	5	5	5	5
Am. Plaice 4T	10	13	13	13	13	13
G. halibut 4RST	10	10	10	10	10	10
White hake 4T	5	5	5	5	5	5
Others	7	7	7	7	7	7

[1] The stock status reports from which these projections were derived were subsequently incorporated in "Resource Prospects for Canada's Atlantic Fisheries 1981-1987" published by the Department of Fisheries and Oceans, February 1981.

Our perception of the future status of northern (4RS-3Pn) Gulf cod has become more optimistic as we become increasingly convinced that a number of large year-classes are now entering the fishery. However, the projections for 1982-85 reflect an above average stock abundance and the yet longer-term average catches are still projected to be in the 75-80,000 mt range. There is also some greater optimism for redfish catches.

Total groundfish catches from the Gulf were about 200,000 mt in 1960-64. They then increased fairly rapidly to about 300,000 mt by 1970 and, equally rapidly, declined to a low of 150,000 mt by 1977. We are presently in a phase of increasing catch, and catches will again reach 200,000 mt by 1981-82. The projections imply that catches, at least through 1985, can be expected to be around 230,000 mt. The projections include, and indeed depend heavily on, cod being of above average abundance in the 1982-85 period and yet longer-term projections might suggest that average catches of Gulf groundfish would be in the 200,000-220,000 mt range.

We conclude by reiterating words of caution. Although we can reconstruct fairly well a description of events in the Gulf groundfish resources over the past 30 years, we are not yet in a position to explain why major changes in the productivity of these resources occurred during this period. That the projections given suggest future stability is only a reflection of the limitation on our knowledge. It should be expected that fluctuations in productivity will be as much a part of the future as it has been of the past. These fluctuations in productivity will translate into fluctuation in potential yields. As a result of management control and a strategy of harvesting at low exploitation rates, it should be possible to reduce the amplitude of yield fluctuations compared to those experienced historically with free fishing and high exploitation rates. Nevertheless, the need for flexibility and maintenance of options should be overtly recognized in the planning process.

ACKNOWLEDGEMENTS

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Table 1. Summary of stock assessment advice and regulatory measures for cod in Div. 4T-4Vn (Jan-Apr)

Assessment Advice			Regulatory Measures		
For	By	Was	For	By	Was
1973	STACRES May 72	An increase in F to the optimum of 0.40-0.45 can be expected to give a catch of 60,000-65,000 mt.	1973	ICNAF Ann. Mtg. June 1972	No regulation
1974	STACRES May 73	Catches in 1974 should not be allowed to increase above the 1972 level = 66,200 mt.	1974	ICNAF Ann. Mtg. June 73	No regulation
	STACRES Jan 74	Catches in 1974 should not exceed the long-term average of 60,000 mt.		ICNAF 4th Sp. Mtg. Jan 74	63,000 mt
1975	STACRES May 74	To maintain F in the range of F_{max} (0.4-0.5) implies catches around 50,000 mt.	1975	ICNAF Ann. Mtg. June 74	50,000 mt
1976	STACRES Apr 75	TAC be reduced to 45,000 mt in order to bring F within the range of F_{max} (0.4-0.5).	1976	ICNAF Ann. Mtg. June 75	Deferred
	STACRES Sept 75	A TAC of 30,000 mt for 1976 represents an F=0.4 (previously estimated to be F_{max}).		ICNAF 7th Sp. Mtg. Sept 75	30,000 mt
1977	STACRES June 76	TAC from 0-30,000 mt depending on measures to reduce catch of small fish.			
	Scientific Advisers to Panel 4 of ICNAF June 76	TAC for 1977 be set at zero to ensure an increase in spawning stock.	1977	ICNAF Ann. Mtg. June 76	15,000 mt
1978	CAFSAC May 77	25,000 mt TAC gives 70% chance of reaching optimal stock biomass. "Best estimate" of TAC giving optimal biomass is 37,000 mt.	1978	Federal Minister for Fisheries - Groundfish Management Plan for 1978 (Dec 77)	27,000 mt
				Amendment August 78	38,000 mt

Table 1. Cont'd. Summary of stock assessment advice and regulatory measures for cod in Div. 4T-4Vn (Jan-Apr)

Assessment Advice			Regulatory Measures		
For	By	Was	For	By	Was
1979	CAFSAC April 1978	Stock above optimal biomass in 1978 and 1979. TAC for 1979 should be set at about 50,000 mt to reduce biomass to optimum by 1985.			
	CAFSAC Sept 78	Given the increase in 1978 TAC to 38,000 mt the equivalent advice for 1979 TAC to that given in April is 42,000 mt.	1979	Federal Minister for Fisheries -Groundfish Management Plan for 1979 (Dec 78)	36,000 mt
	CAFSAC June 79	Fishing at $F_{0.1}$ in 1979 would give a catch of 49,000 mt.		Amendment August 79	46,000 mt
1980	CAFSAC June 79	Fishing at $F_{0.1}$ in 1980 would give a catch of 61,000 mt-63,000 mt depending on whether 1979 catch is increased to $F_{0.1}$ catch or kept at current TAC (i.e. 36,000 mt).	1980	Federal Minister for Fisheries -Groundfish Management Plan for 1980 (Dec 79)	54,000 mt
	CAFSAC May 80	Fishing at $F_{0.1}$ in 1980 would give a catch of 50,000 mt.		No amendments to 1980 plan.	
1981	CAFSAC May 80	Fishing at $F_{0.1}$ in 1981 would give a catch of 60,000-61,000 mt depending on whether 1979 catch is at current TAC or reduced to $F_{0.1}$.	1981	Federal Minister for Fisheries -Groundfish Management Plan for 1981 (Dec 80)	53,000 mt

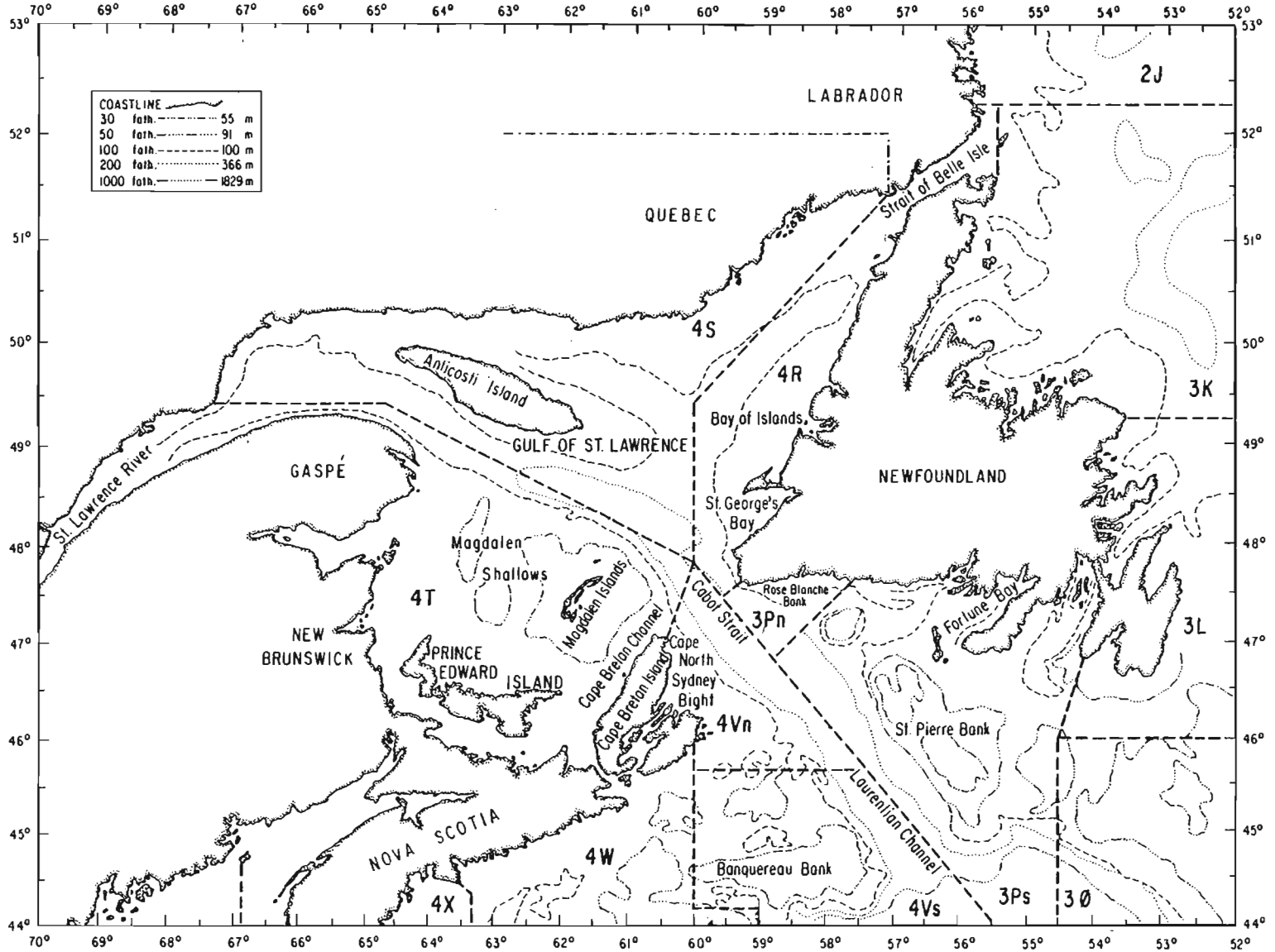

Figure 1. Gulf of St. Lawrence and environs showing place names mentioned in the text.

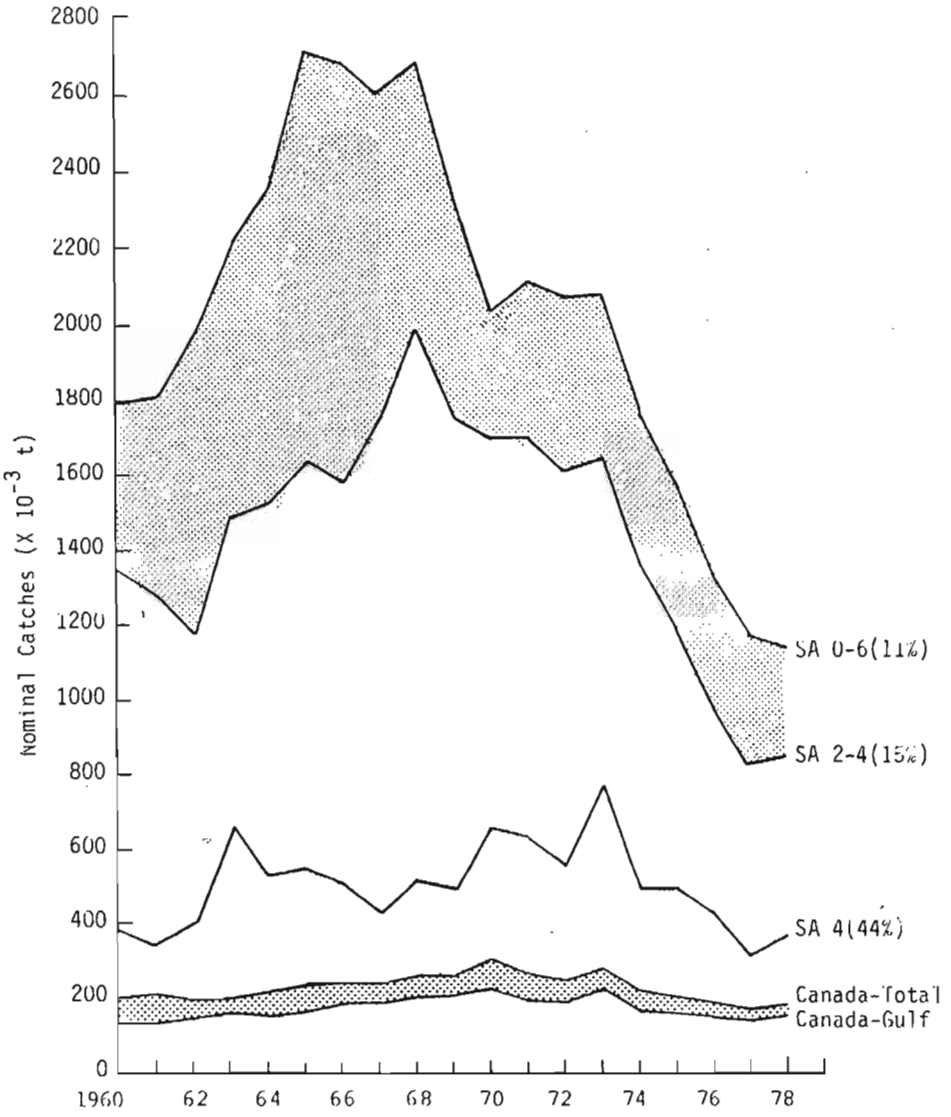

Figure 2. Nominal catches of groundfish in Gulf of St. Lawrence in relation to total groundfish catches in Subarea 4, Subareas 2-4, and Subareas 0-6, 1960-1978. Figures in parentheses indicate percentages total Gulf groundfish represents of respective totals.

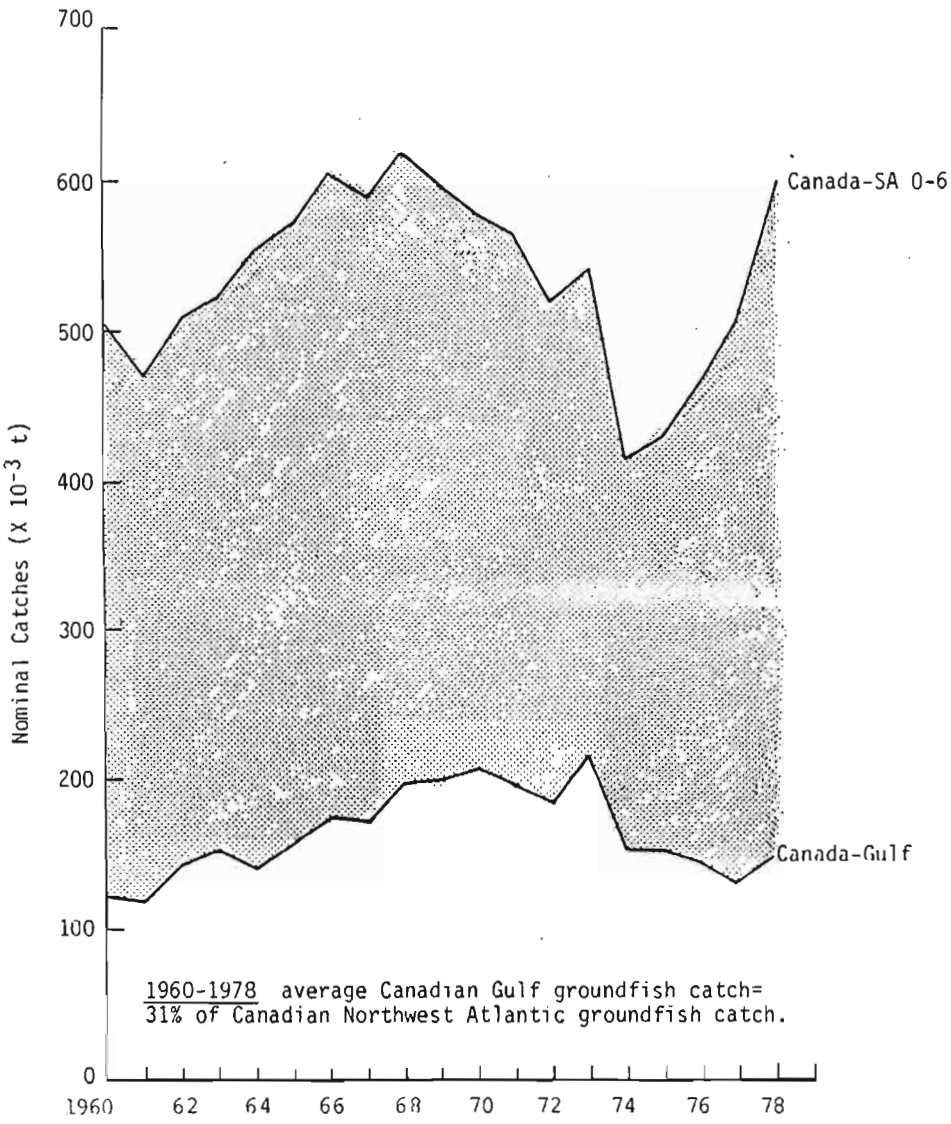

Figure 3. Nominal catches of Groundfish in Gulf of St. Lawrence by Canada in relation to total Northwest Atlantic Groundfish catches by Canada, 1960-78.

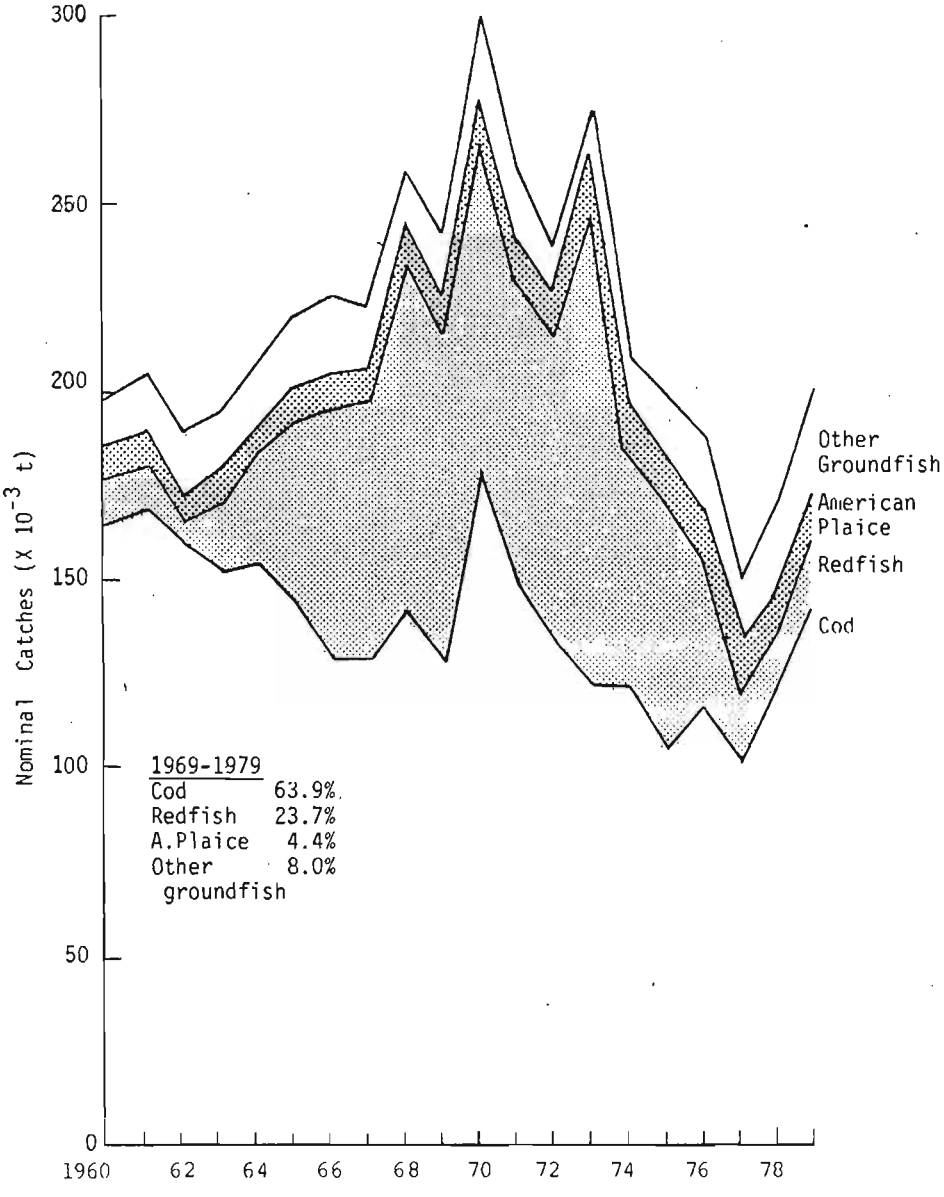

Figure 4. Nominal catches of major groundfish species in Gulf of St. Lawrence 1960-79. NAFO Divisions included: Cod-Subdiv. 3Pn, Div. 4RST, Subdiv. 4Vn. All other species-Div. 4RST only. Note that this graph is cumulative, in contrast to Figures 2 and 3 i.e. first line from bottom shows level of cod catch, second line from bottom shows cod plus redfish catch and distance between these lines shows redfish catch, etc.

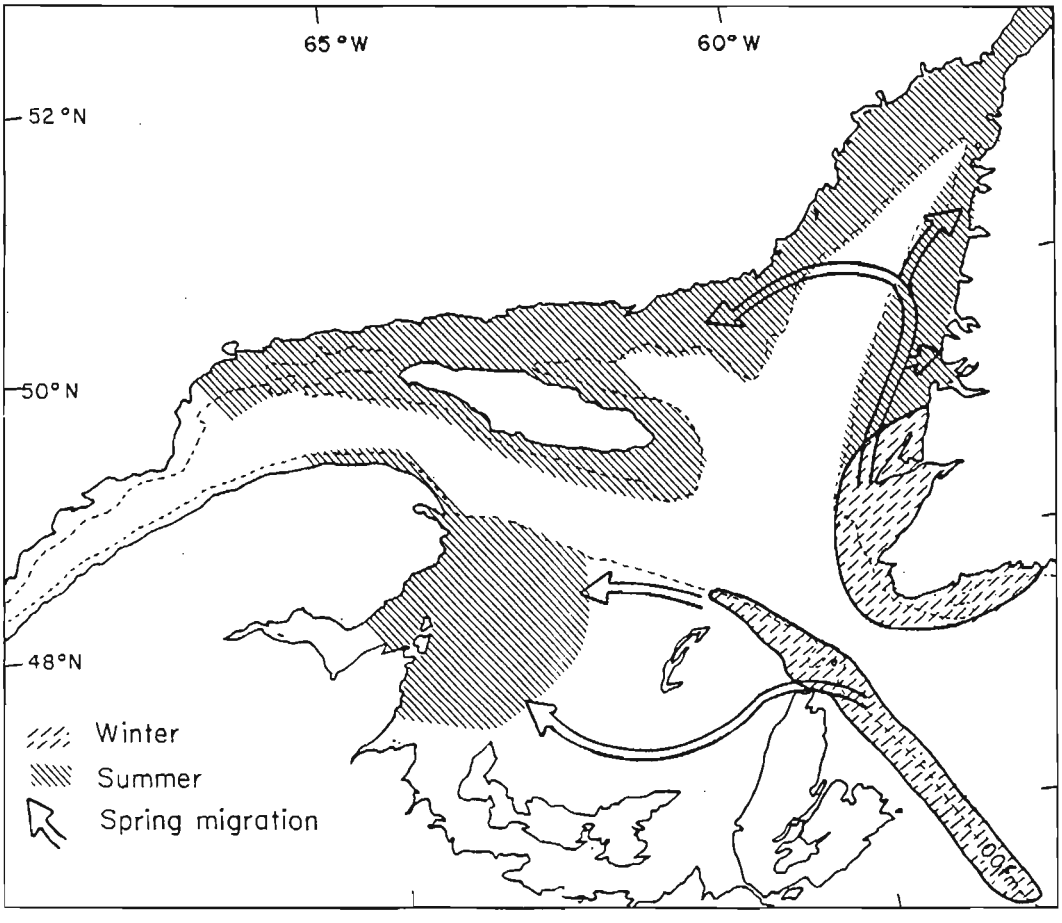

Figure 5. Gulf of St. Lawrence cod-distributions and migrations.