



## ATLANTIC MACKEREL IN THE NORTHWEST ATLANTIC

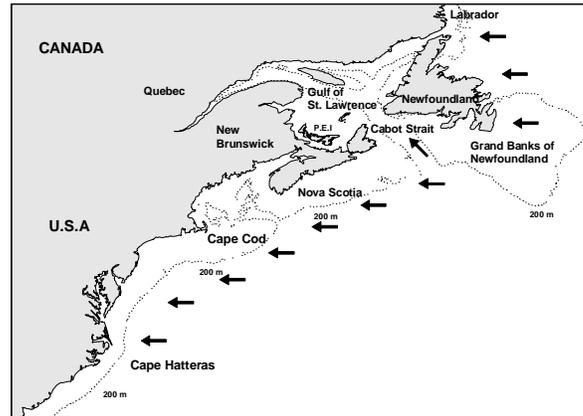


Figure 1. Distribution (←) of Atlantic mackerel in the northwest Atlantic.

### Background

Landings of Atlantic mackerel (*Scomber scombrus* L.) in the northwest Atlantic, which ranged from 300,000 t to 400,000 t in the early 1970s, declined sharply with the advent of the 200-mile limit. As a result of agreements signed with the United States and the Commonwealth of Independent States, catches rebounded considerably in the early 1980s, peaking at nearly 90,000 t in 1988. A gradual reduction in quotas set by the United States ending with the complete closure of this fishery in 1992 explains the major reduction in landings that occurred in later years. In fact, since 1992, landings for the entire northwest Atlantic have averaged 32,363 t annually. In Canada, the mackerel fishery is an inshore fishery carried out mainly with fixed gear. Canadian catches are generally about 20,000 t per year.

Two indices are used to determine the abundance of mackerel, an egg survey conducted every two years in the Gulf of St. Lawrence and a U.S. index based on an annual groundfish survey. According to the egg survey, the size of the Canadian stock was roughly 210,000 t in 1996, which represents the lowest value in the time series. However, owing to technical problems, the survey began later than usual and so did not coincide with the peak spawning period. The 1996 estimate should thus be considered as a minimum value.

### Biology

The Atlantic mackerel (*Scomber scombrus* L.) is a member of the family Scombridae, which is distributed widely throughout the world and includes a large number of species, the most famous of which are tunas. Unlike tunas, which are able to maintain a high body temperature thanks to their unique vascular system, the Atlantic mackerel is an ectothermic fish like most of the 30,000 species of bony fish. In this type of fish, body temperature does not remain constant, but varies between 1 and 2° C above the surrounding water temperature. Scombrids occur in tropical and temperate seas the world over, with the Atlantic mackerel having the most northerly distribution. One of this species' main distinguishing features is the lack of a swim bladder, requiring it to swim continually so that it will not sink. However, unlike species with a swim bladder, mackerel can change depth rapidly. Although mackerel feed primarily on plankton, the diet of adults may consist largely of small fish and squid. Mackerel sometimes occur in very dense schools, especially in the spring and fall. The

schools tend to be composed of identical-sized individuals because of the relationship between fish length and swimming speed.

In the northwest Atlantic, mackerel range from Cape Hatteras, off North Carolina, to the Gulf of St. Lawrence and the east coast of Newfoundland (Figure 1). They sometimes occur on the southern and southeastern coast of Labrador. Since mackerel are warm-water fish, their presence along the coast of Newfoundland and Labrador depends on water temperature.

Two stocks of mackerel are found in the northwest Atlantic, and each has its own spawning areas. The southern stock spawns in March and April along the U.S. coast between New Jersey and Long Island, while the northern stock spawns in June and July mainly in the Gulf of St. Lawrence, but also along the coast of Nova Scotia and, possibly, on the Grand Banks of Newfoundland. The largest egg concentrations are always found to the south of the Laurentian Channel, west of the Îles-de-la-Madeleine. Egg development time depends on water temperature. Mackerel are called multiple spawners because each female spawns several times during the spawning season. Spawning takes place at any time during the day or night. Larvae measure about 3 mm long upon hatching. Young mackerel become juveniles when they reach 50 mm in length. They also begin to form schools at this size. Some of these schools are found in inshore waters, possibly due to the migration of juveniles from spawning areas toward the coast. Little is known about the size of the juvenile contingent that participates in this migration or the importance of coastal habitats for juveniles.

Mackerel grow very quickly and can reach a length exceeding 26 cm and a weight greater than 200 g by the end of the first year (Figure 2). Most of their growth takes place

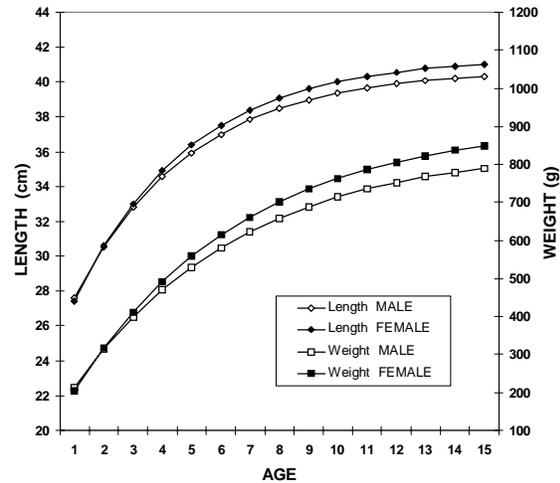


Figure 2. Length (cm) and weight (g) at age in Atlantic mackerel sampled along the Canadian coast since 1990.

in the first few years of their life, with females growing more rapidly than males after the age of four. Atlantic Mackerel may live for more than 15 years, but rarely measure over 45 cm in length. Individuals from large year-classes grow more slowly. The condition of mackerel is most variable at the beginning of the season. The lowest values are observed in early spring, just prior to and during spawning, while the highest are observed in the fall. Fat content is also lowest during spawning, rising gradually thereafter to 20% or more in the fall. Year-to-year variations occur in fat content, along with variations in length and weight. For example, fat content increases faster in larger mackerel. The size at which 50% of males and females are sexually mature is 284 mm (Figure 3a). All mackerel reach maturity by the time they are 340 mm in length. Nearly half of two-year-old mackerel and all mackerel aged four and over are sexually mature (Figure 3b). Size rather than age is the determining factor. All individuals from large year-classes, like the 1959 and 1967 year-classes, in which slower growth was ob-

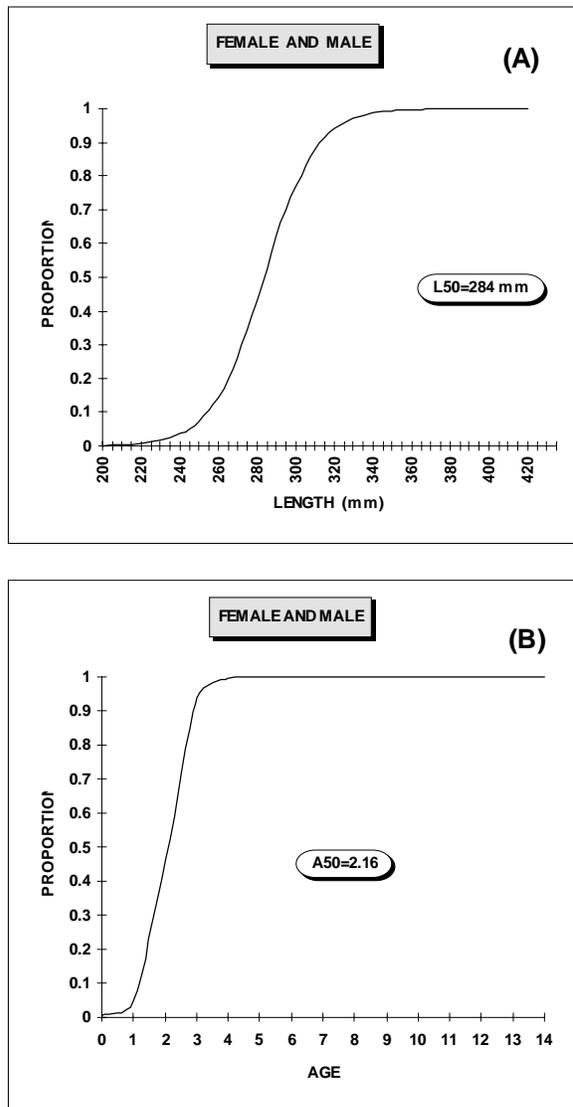


Figure 3. Maturity at length (A) and age (B) for mackerel sampled in Nova Scotia in 1996 (Grégoire et al. 1997): L50 = Length at which 50% of individuals are mature; A50 = Age at which 50% of individuals are mature.

observed, reached maturity at age five and a length of 330 mm.

**Description of the fishery**

Mackerel are fished in their overwintering grounds along the U.S coast and as far as the Gulf of St. Lawrence and the east coast of Newfoundland. In winter and early spring, the trawl is the most effective fishing gear because mackerel are generally not concentrated in dense schools but are spread out near the bottom. The largest mackerel catches ever recorded in the northwest Atlantic were made at that time of the year near the U.S. coast by a fleet of trawlers, beginning in the late 1960s. The northern and southern stocks share certain regions in this sector. Mackerel seem to migrate in the spring mainly in response to rising water temperature. Near the U.S. coast, if the water takes longer to warm up or is warmer offshore, the spring migration takes place mainly in a seaward direction, to the detriment of the inshore fishery. Trap and gillnet fishermen from Nova Scotia are faced with a similar situation in May and June. It is generally acknowledged that mackerel move in successive waves into the waters off the province and come directly inshore only if water temperature and food conditions are favourable. Water temperatures at the entrance to the Gulf of St. Lawrence also appear to influence the spring migration. Abnormally cold temperatures are believed to be the reason for the small catches observed several years ago in the Gulf. Within the

Table 1. Mackerel landings (t) in the northwest Atlantic

COUNTRY	YEAR								
	1988	1989	1990	1991	1992	1993	1994	1995	1996 <sup>1</sup>
Canada	25,016	21,142	23,044	26,828	25,515	27,226	20,459	17,706	17,710
United States	21,245	17,168	12,178	17,766	12,744	4,502	11,233	9,679	15,042
Others	42,858	36,823	30,678	15,714	0	0	0	0	0
<b>TOTAL</b>	<b>89,119</b>	<b>75,133</b>	<b>65,900</b>	<b>60,308</b>	<b>38,259</b>	<b>31,728</b>	<b>31,692</b>	<b>27,385</b>	<b>32,752</b>

<sup>1</sup> Preliminary statistics

Gulf of St. Lawrence, mackerel are usually fished with gillnets in the spring and lines in the late summer. Purse seines are used in the fall along the east and west coasts of Newfoundland.

*The fishery in 1996*

Mackerel landings for the northwest Atlantic as a whole have declined gradually since the late 1980s (Figure 4). Totalling nearly 90,000 t in 1988, they fell to around 33,000 t in 1996.

This decrease is mainly attributable to the lower quotas allocated to the Commonwealth of Independent States fleet fishing in U.S. waters and the complete shutdown of the fishery in 1992 (Table 1). Since then, landings have been quite stable, averaging 32,363 t per year.

Canadian landings averaged about 20,000 t per year from 1965 to 1995. Based on pre-

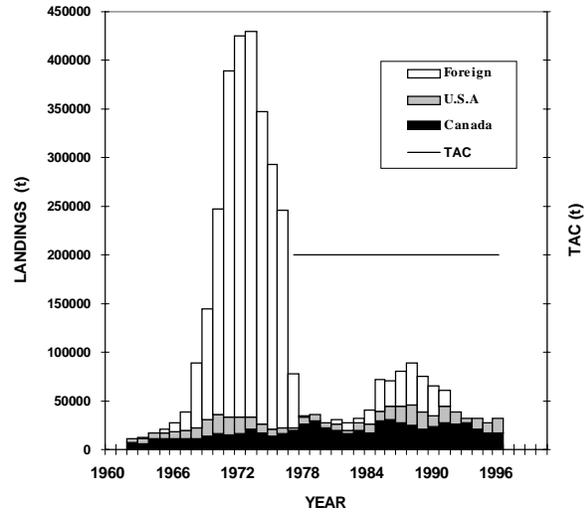


Figure 4. Mackerel landings (t) and TAC (t) in the northwest Atlantic.

liminary statistics, they amounted to around 17,710 t in 1996, exceeding those of U.S. fishermen, which nonetheless rose from 9,679 t in 1995 to 15,042 t in 1996. The

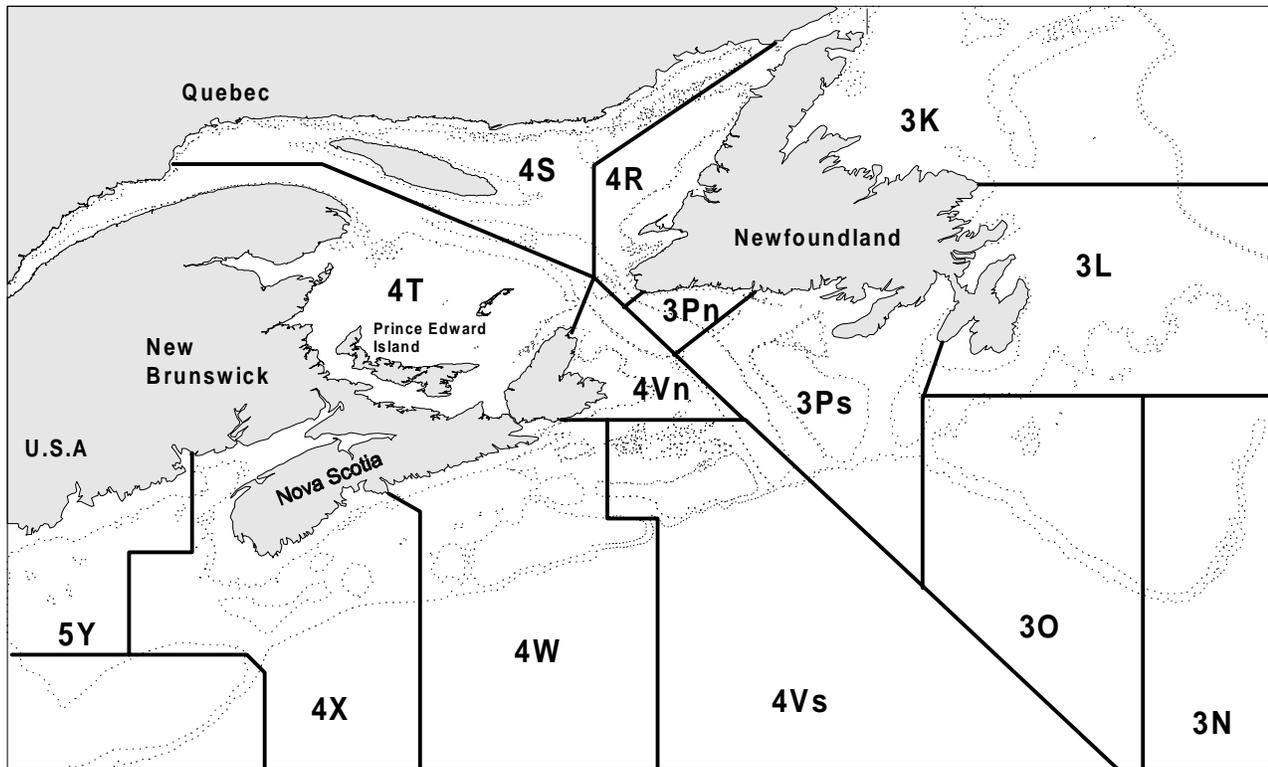


Figure 5. Map of NAFO divisions.

largest Canadian landings were taken in divisions 4T, 4R and 4X (Figure 5), where they totalled 10,004 t, 3,175 t and 1,898 t respectively. The provinces with the biggest catches were Nova Scotia, New Brunswick and Québec, with landings of 4,730 t, 3,979 t and 3,745 t respectively. Mackerel landings by province do not fluctuate widely from year to year, except in Nova Scotia and Newfoundland (Figure 6).

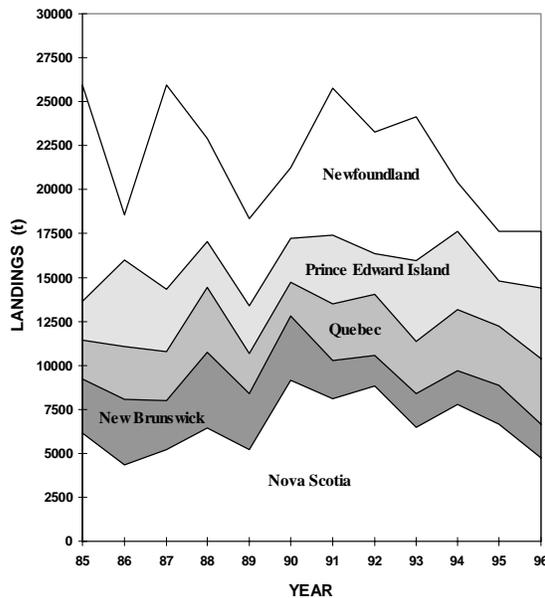


Figure 6. Cumulative total (t) of commercial mackerel landings by province since 1985.

The substantial increase in Nova Scotia landings between 1986 and 1992 is largely attributable to a gradual intensification of the fishing effort by foreign vessels off the Scotian Shelf.

In Newfoundland, however, and especially along the east coast, the fluctuations in landings are related to environmental conditions, particularly water temperature.

Annual landings in Prince Edward Island show no obvious trend, fluctuating between 2,000 t and 5,000 t since 1985. Since 1990, landings in New Brunswick have been fairly

stable, unlike the situation in Québec where catches have risen slightly. Most mackerel landings in Québec come from the Îles-de-la-Madeleine.

When landings are analysed on a finer geographical scale, *i.e.* by statistical district or fishing community, major fluctuations can be observed. Moreover, their patterns are often different or even contrary and may be attributed to the considerable variability in seasonal movements of the fish.

Catches per unit of effort by the Canadian fishery vary greatly with locality and from year to year. These fluctuations are related much more to mackerel distribution, fishing power and market demand than to real variations in abundance. Therefore, catches per unit of effort are not used as an abundance index for mackerel. However, over the past few years, or more precisely, since the advent of an African market for canned mackerel, a significant relationship has emerged between catches and the line fishing effort in the fall in the Îles-de-la-Madeleine.

Catches per unit of effort in the U.S. sport fishery were fairly high between 1983 and 1991. They have declined, however, in recent years. These sport and commercial catches per unit of effort are not used as abundance indices owing, in the first case, to mackerel availability problems in the inshore fishery and, in the second, to the number of vessels going after mackerel schools and to market demand.

The two year-classes that dominated the fishery in 1996, like in 1995, were those of 1994 and 1993 (Figure 7). They accounted for 23% and 17% respectively of all catches. The corresponding mean lengths were 31 cm and 34 cm, and the mean weights 295 g and 392 g.

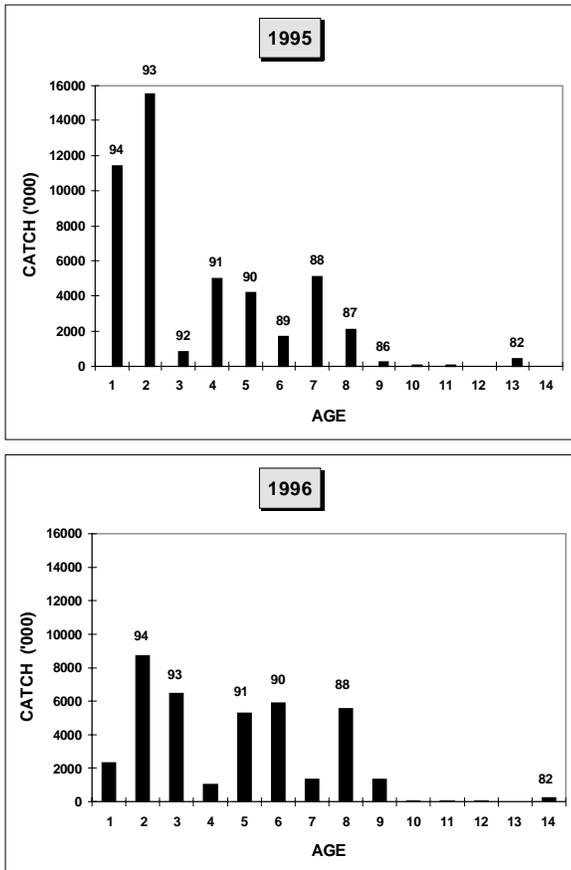


Figure 7. Mackerel catches at age in 1995 and 1996 in the Gulf of St. Lawrence (the number above each bar represents the year-class or year of birth).

**Abundance indices**

The indicators of stock size for mackerel are derived mainly from two surveys. The first consists in an egg survey conducted in the Gulf of St. Lawrence every second year, with the latest one done in 1996. This survey is used to estimate the spawning biomass of the northern stock on the basis of egg production. The second is a stratified random bottom trawl survey carried out by the Americans in the spring when the northern and southern stocks share relatively the same territory. This survey is conducted annually between Cape Hatteras and Georges Bank, off Cape Cod.

**U.S. bottom trawl survey**

The average catch per tow during the U.S. survey declined from 1968 to the late 1970s, but has risen gradually since the early 1980s (Figure 8a). The 1996 catch per tow value is the second largest in the data series. In terms of mean weight per tow, the general trends observed in this survey are comparable to the results of the first pass of the egg survey (Figure 8b). During this survey, however, the availability of mackerel is variable on account of the type of fishing gear used.

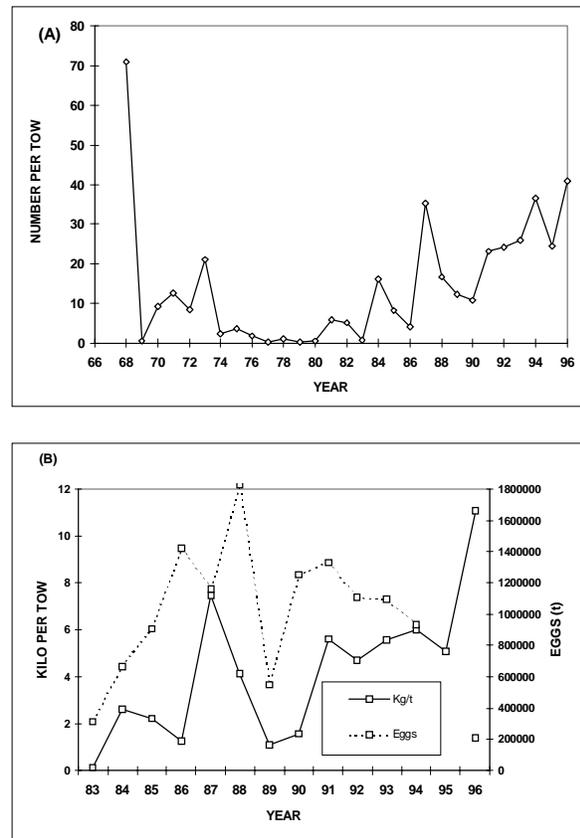


Figure 8. U.S. abundance indices: (A) Number of fish per tow; (B) Weight (kg) per tow. The estimated biomass (t) derived from the first pass of the egg survey in the Gulf of St. Lawrence is superimposed to permit comparison.

**Egg survey in the Gulf of St. Lawrence**

During the 1996 survey, as in previous years, the largest egg concentrations were observed in the southern Gulf of St. Lawrence, more precisely in the region to the west of the Îles-de-la-Madeleine (Figure 9a). This is also the region with the highest water temperatures in the surface layer, which is where most of the eggs are found (Figure 9b).

During the 1996 survey, the egg densities were much smaller than those observed in previous surveys. These results are attributable to the fact that the survey was delayed due to mechanical problems with the DFO

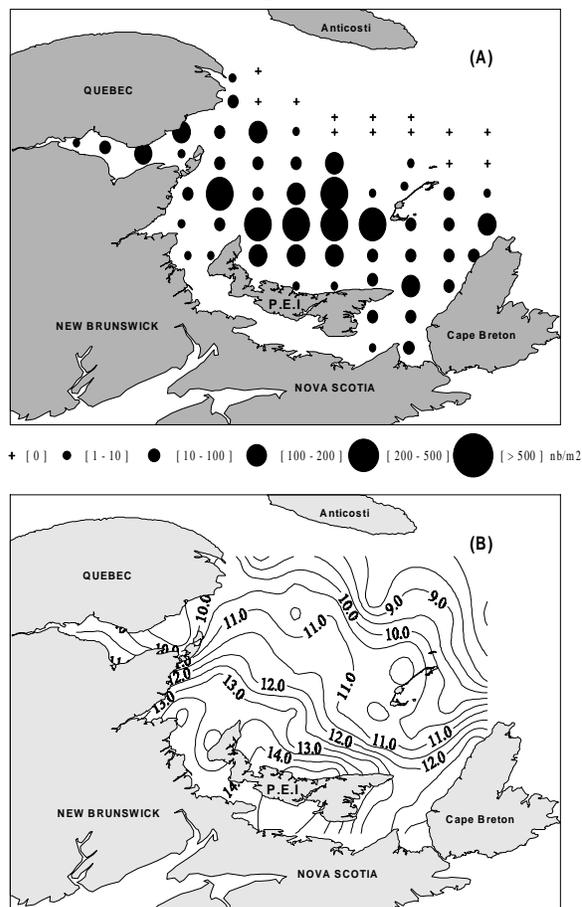


Figure 9. Distribution of mackerel eggs (number per square metre) and (A) mean water temperature (°C) (B) of the first 10 metres sampled during the first pass of the 1996 survey.

research vessel. This vessel was replaced by the *Grande-Entrée*, owned by the Îles-de-la-Madeleine firm Madelipêche.

Right from the first pass, the higher water temperatures and the greater concentrations of late-stage eggs and mackerel larvae, indicated that much of the spawning had already taken place. In 1996, daily egg production values were once again calculated by the geostatistical method. This technique also makes it possible to confirm the link existing between egg densities and water temperature. In terms of biomass, the mean value obtained for the two 1996 passes was nearly 210,000 t, the smallest value in the entire data series (Figure 10). This type of poor match between the timing of the survey and spawning occurred in 1989 also.

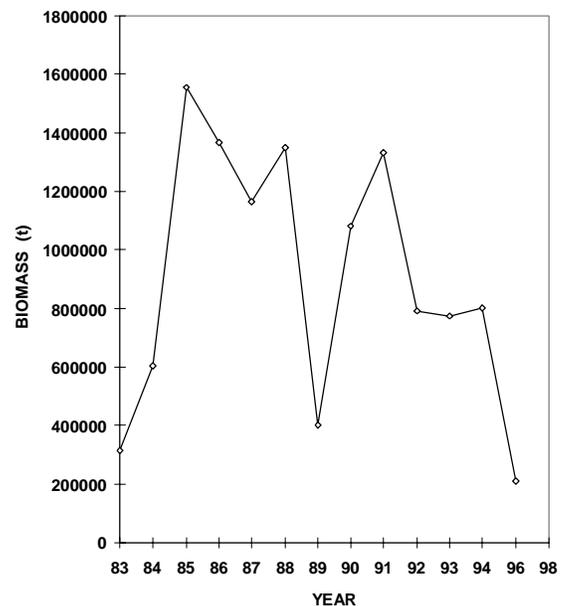


Figure 10. Spawning biomass of the Gulf of St. Lawrence mackerel stock based on annual egg production (See text for 1989 and 1996 values).

The batch fecundity method, which can be used to identify a more solid relationship between egg production and stock abundance, was abandoned, as it has been in

Europe, because certain important parameters proved to be difficult to measure with sufficient precision. However, a new approach based on the daily reduction in fecundity was tested. This method also permits a more accurate determination of the relationship between egg production and stock abundance, while averting the difficulties encountered with the batch fecundity method since the requisite values are easier to estimate.

### *Comments from the industry*

As in the past, various meetings were held with the industry in 1996. This gave representatives from all the provinces the opportunity to express their views and comments on the mackerel fishery. The most frequent comments related to unreported catches of mackerel. In view of the serious consequences of this problem, Nova Scotia fishermen agreed to record all their catches, beginning in 1997, in the Index Fishermen Program logbooks. Fishermen also stressed the importance of completing these logbooks correctly. Checks will be made on a regular basis, and it is hoped that a similar system will be implemented in other provinces in the future. It has to be noted that on the west coast of Newfoundland, the dockside weighing system is an effective means of accurately quantifying mackerel catches. Fishermen realize that the current TAC of 100,000 t is not biologically based. They also agreed that the TAC serves a protective function since mackerel is a transboundary stock and foreign fleets from the U.S. coast can make substantial catches.

The Index Fishermen Program, which began three years ago, continued in 1996. Logbooks and thermographs were distributed in Nova Scotia with the co-operation of the provincial Department of Fisheries. Trap fishermen from St. Margaret's Bay, Nova

Scotia, participated in a study on maturity at length and age in mackerel. This research was undertaken in response to their request for a management measure that would consider catches of small mackerel.

### *Conclusion*

The Canadian mackerel fishery is an inshore fishery whose success depends largely on the availability of mackerel near the coast. On account of their life cycle, mackerel move constantly and therefore travel long distances, passing only briefly, if at all, near certain coasts and moving to other regions to spawn, feed and overwinter. Their movements are also governed by environmental conditions. Since mackerel are warm-water fish, water temperature, like the presence of food, determines whether they occur alone or in the presence of other species. Sometimes, mackerel concentrate in schools inshore or offshore, near the surface or the bottom. These factors make it harder to catch this species and are partly responsible for the year-to-year fluctuations observed in catches in a given location. It should be noted that such fluctuations are not new. Even in the early days of the mackerel fishery, they were a source of considerable concern to inshore fishermen.

Because exploitation rates are generally low, sequential population analysis cannot provide a precise picture of stock abundance or permit quantitative catch projections. Hence, it is not possible to derive an estimate of the catches that would correspond to an exploitation rate of  $F_{0.1}$  or assess the suitability of the current TAC of 200,000 t.

All indications point to the stock being at a high level. The only exception is the abundance index, which was derived from the 1996 egg survey. It must be viewed with caution given the delayed start of the survey. Because the egg survey was late, sampling

could not be conducted during the peak spawning period. In 1996, catches included not only individuals from the abundant 1988, 1990 and 1991 year-classes, but also a substantial number of two- and three-year-old mackerel, a phenomenon that points to the recruitment of two very large year-classes. However, the landings of some provinces appear to be greatly underestimated since a large portion of the mackerel is not sold to processing plants and therefore does not show up in the official statistics. In view of this situation, it is difficult to determine the real level of harvesting of the stock. Any increase in harvesting should thus be envisaged very carefully. If effort were to increase rapidly, closer monitoring of the fishery would then be required.

***For more information:***

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