Atlantic Mackerel of the Northwest Atlantic in 2002

Basic Information

In the northwest Atlantic, the Atlantic mackerel (Scomber scombrus L.) ranges from Cape Hatteras, North Carolina to the Gulf of St Lawrence and the east coast of Newfoundland (Figure 1). This area is characterized by the presence of two stocks of mackerel that reproduce at different places and times. In Canadian waters, mackerel spawn chiefly in the southern Gulf of St Lawrence, in June and July. This spawning is preceded by a long migration that begins on the Georges Bank. In US waters, the mackerel spawn in March and April, along the New Jersey coast.

In the Maritime Provinces, Newfoundland, and Quebec, over 15,000 commercial fishers participate in the mackerel fishery. They fish mainly inshore, using gillnets, jiggers, purse seines and traps. The type of gear used varies with the location and the time of year. The mackerel landings reported by Canadian fishers are generally stable from one year to the next and have averaged about 20,000 t per year since 1990. However, these landings can vary widely from one region to another, because of changes in mackerel migration routes. One of the reasons for these changes is the mackerel's sensitivity to water temperature. The fishers who catch mackerel for bait in the Gulf of St Lawrence are not required to maintain logbooks, so their catch is not recorded. Neither is the catch of recreational fishers who fish for mackerel in the summer months all along the Atlantic coast.

The abundance of the mackerel in the Gulf of St Lawrence is estimated from data gathered in an egg-sampling survey. This survey, which is unique in the northwest Atlantic, also gathers information on the abundance and diversity of the plankton communities that are present in June in the southern Gulf of St Lawrence.

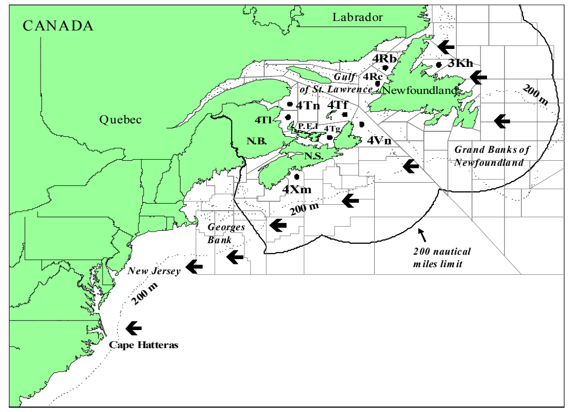

Figure 1. Distribution (🡐) of Atlantic mackerel (Scomber scombrus L.) in the northwest Atlantic and main fishery areas (•) in Canadian waters.

Summary

- In 2002, the most striking feature of the commercial mackerel catch was the presence of a high abundance and a very high proportion of fish from the 1999 year-class. In the past three years, this year-class has accounted for 63%, 68% and 77% of the total number of fish in the catch. Such dominance of fish ages 1 to 3 has never been observed before in any of the year-classes sampled since 1973.
- In Canadian waters, commercial landings of mackerel fell from 23,868 t in 2001 to a preliminary figure of 23,433 t in 2002. Close to 70% of the total landings or 16,493 t were made in a fall purse seine fishery in Newfoundland (with 11,026 t of this amount being caught off the island's west coast). Over the same period, US commercial fishers' landings more than doubled, from 12,335 t to 26,158 t.

- The mackerel's spawning biomass is currently estimated from an egg-sampling survey and an empirical model that can be used to calculate seasonal or total egg production. The spawning biomass calculated by the Total Egg Production Method (TEPM) is very similar to the values that have been estimated since 1996 by the Daily Fecundity Reduction Method (DFRM), for which the basic computations are done using daily egg production values only.
- The 2002 estimates of spawning biomass by the TEPM and the DFRM were 379,069 t and 359,330 t, respectively, representing increases of 56% and 42% from the year 2000.
- The spawning biomass of mackerel hit a record low in 1998. The increases measured in 2002 are basically attributable to the members of the 1999 year-class, who should be fully mature in 2003. Since this increase is recent and the landings are underestimated, the present advice recommends that the TAC be held to the same level as in 2002: 75,000 t.

Biology

The Atlantic mackerel (*Scomber scombrus* L.) belong to the scombrids, a major family that includes a very large number of fish species occurring in tropical and temperate waters throughout the world. Within the genus *Scomber*, Atlantic mackerel is the species with the most northerly distribution, and, unlike the other two species in this genus, it has no swim bladder. This biological characteristic forces the mackerel to swim continuously. They can thus change their position in the water column very quickly, which makes them harder to catch. During their long annual migrations, mackerel move in schools that are sometimes very dense, especially in spring and fall. These schools generally consist of individuals that are all the same size and all swim at the same speed.

Though some spawning does take place along the coasts of Nova Scotia, the mackerel that frequent Canadian waters spawn mainly in the southern Gulf of St Lawrence, in June and July. The largest concentrations of eggs are found in waters south of the Laurentian Channel, west of the Magdalen Islands. Spawning is described as multiple, because each female spawns several times, and asynchronous, because it can occur at any time of day or night. How long the eggs take to develop depends on water temperature. When the eggs hatch, the larvae measure about 3 mm. The larvae turn into juveniles at about 50 mm. The juveniles then form into schools, some of which migrate from the spawning grounds toward the coast, where they have been observed in inshore waters. Not much is known about what proportion of the juvenile population participates in this migration, nor about what roles these inshore habitats play for them. Mackerel feed mostly on plankton. According to a study conducted in the 1980s using samples gathered in the Gulf of St Lawrence and on the Scotian Shelf, the mackerel's diet is dominated by copepoda (mainly Temoridae), invertebrate and fish larvae, nematodes, and decapod crustaceans. Adult mackerel may also feed on small fish and squid.

Mackerel are a very fast-growing species. By the end of their second year (age 1^+), they average up to 270 mm in length and 200 g in weight (Figures 2A and 2B). Growth can vary not only from one year or period to another, but also from one year-class to another. For example, it is slower in the abundant year-classes of 1967, 1974, 1982 and 1988 (Figure 3). These year-classes can be readily identified in the distributions of average lengths by year and by age (Figure 4).

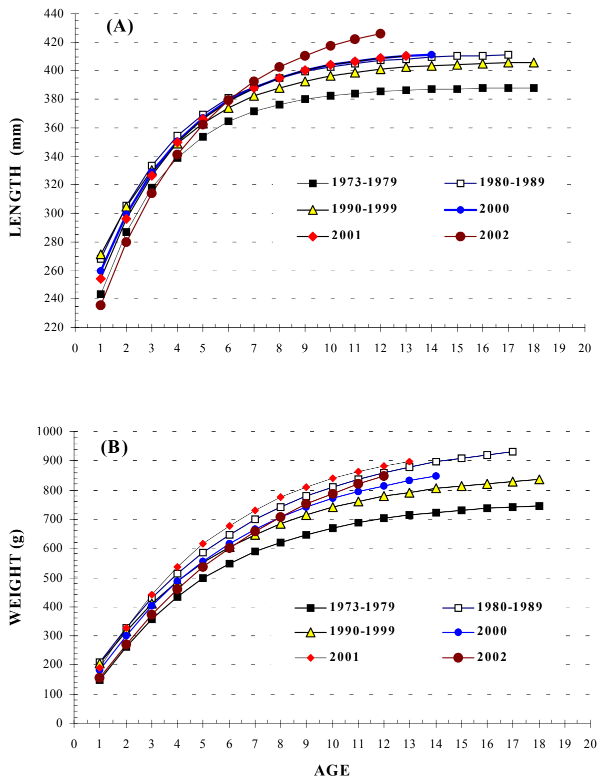

Figure 2. Length (A) (mm) and weight (B) (g) at age, calculated by von Bertalanffy's growth model, for mackerel sampled in Canadian coastal waters since 1973.

The mackerel's condition is at its lowest in the spring and at its highest in the fall. Up to and including 1984, the mackerel's condition on their arrival in the Gulf of St Lawrence and during spawning was higher than the average calculated for 1973 through 2001 (Figure 5). From 1985 to 2002, however, their annual condition was below this average (except in 1999). The annual

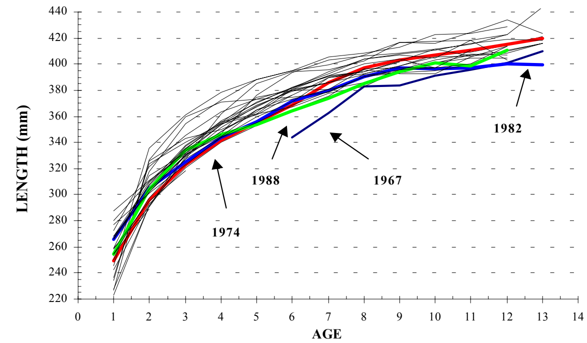

Figure 3. Mean length (mm) at age for the mackerel year-classes sampled since 1973 (the 4 largest year-classes that have dominated the fishery in recent years are identified).

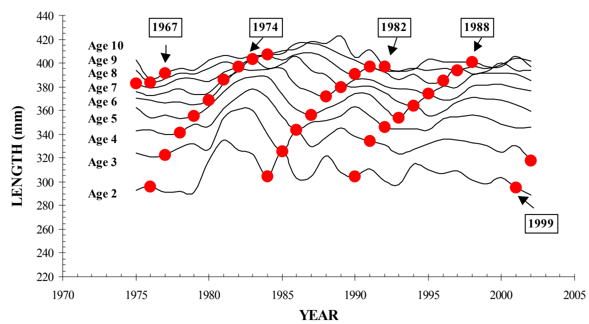

Figure 4. Mean length (mm) at age for the mackerel sampled since 1973 (ages are shown, and the year-classes that have dominated the fishery in recent years are identified).

variations in the mackerel's condition follow a very similar pattern to those in the average water temperature of the upper portion (30 - 100 m) of the cold intermediate layer (CIL) (Figure 5). The possible relationships between the mackerel's condition and these temperatures are not very well known, but it is assumed that a decline in condition such as was observed in the 1980s and 1990s might have had a

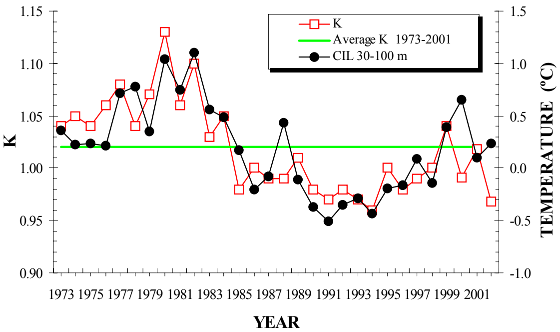

Figure 5. Mean condition factor (Fulton's) calculated in June and mean temperature (ºC) of the upper (30 to 100 m) portion of the cold intermediate layer (CIL) (Denis Gilbert, Maurice Lamontagne Institute, Mont Joli, Quebec, pers. comm.).

negative impact on the mackerel's natural mortality.

Compared with other fish species, mackerel reach sexual maturity early in life, so that the sizes at which 50% of the females and males are mature are only 299 mm and 270 mm, respectively (Figure 6). All of the mackerel over 340 mm in length and about half of the mackerel 2 years of age are mature. Maturity varies annually and appears to be a function of size rather than age. For

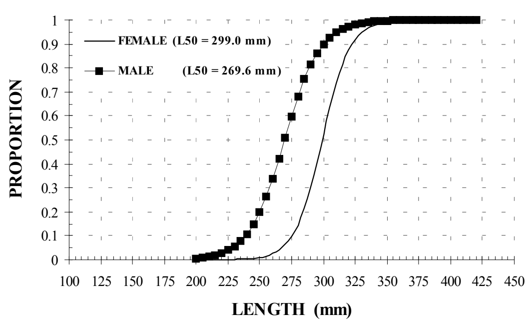

Figure 6. Maturity at length for mackerel sampled in St Margaret's Bay, Nova Scotia in 1996 (L50 represents the size starting at which 50% of the fish are mature).

the dominant year-classes, such as those of 1959 and 1967, which have been observed to grow more slowly, the age and length at which all the fish have reached maturity are 5 years and 330 mm.

Fishery

General

Mackerel landings in the northwest Atlantic, on the order of 300,000 t to 400,000 t in the early 1970s (Figure 7), fell considerably with the introduction of the 200-nautical-mile economic exclusion zone (EEZ). In the 1980s, because of agreements between the US and at that time the USSR, landings increased significantly, peaking at close to 85,000 t in 1988. In the ensuing years, landings again fell substantially, as the United States gradually reduced its mackerel quotas until it halted this fishery completely in 1992.

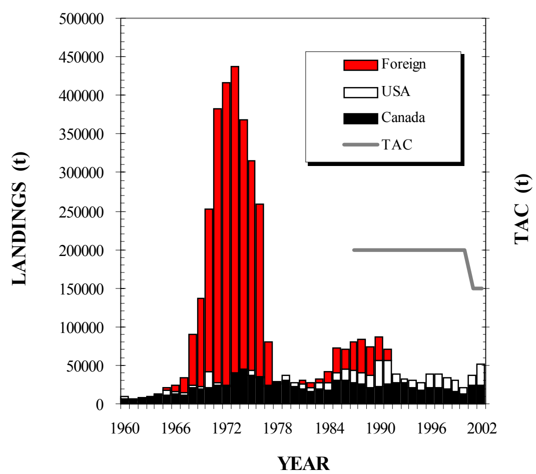

Figure 7. Annual landings (t) and TAC (t) of mackerel for the entire northwest Atlantic (since 1987, Canada has proposed dividing the TAC equally with the United States; in 2001, the Canadian portion of the TAC was set at 75,000 t).

Table 1. Annual landings (t) of mackerel from 1990 to 2002 in NAFO Subareas 2 to 6.

YEAR	CANADA		USA			TOTAL
	Canadian Vessels	Foreign Vessels	Commercial	Recreational	Other Countries	
1990	19 190	3 854	31 261	1 908	30 678	**86 891**
1991	24 914	1 281	26 961	2 439	15 714	**71 309**
1992	24 307	2 417	11 775	344	0	**38 843**
1993	26 158	591	4 666	540	0	**31 955**
1994	20 564	49	8 877	1 705	0	**31 195**
1995	17 650	-	8 479	1 249	0	**27 378**
1996	20 364	-	16 137	1 416	0	**37 917**
1997	21 309	-	15 400	1 735	0	**38 444**
1998	19 334	-	14 523	690	0	**34 547**
1999	16 561	-	12 026	1 335	0	**29 922**
2000	13 383	-	5 645	1 448	0	**20 476**
2001	23 868	-	12 335	1 538	0	**37 741**
2002*	23 433	-	26 158	1 286	0	**50 877**
AVERAGE:						
1960-2001	**18 079**	**3 982**	**6 817**	**2 802**	**64 201**	**94 217**
1970-2001	**20 800**	**4 889**	**8 211**	**2 755**	**77 634**	**112 617**
1980-2001	**21 593**	**836**	**11 011**	**2 003**	**11 597**	**46 774**
1990-2001	**20 633**	**1 638**	**14 007**	**1 362**	**3 866**	**40 551**

* Preliminary

Table 2. Annual landings (t) of mackerel since 1995, by Canadian province.

PROVINCE	YEAR								AVERAGE	
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002***	(1995-2001)	(1990-2001)
Nova Scotia	6 681	5 517	5 669	4 562	4 797	4 546	4 058	2 010	**5 119**	**6 355**
New Brunswick	2 206	2 683	1 990	1 682	1 373	972	2 199	810	**1 872**	**2 033**
Prince Edward Island	2 518	4 017	6 693	6 784	3 842	4 134	5 886	381	**4 839**	**4 296**
Quebec	3 382	4 317	5 769	4 066	5 104	1 711	2 904	3 739	**3 893**	**3 538**
Newfoundland	2 862	3 830	1 188	2 149	1 445	2 019	8 820	16 493	**3 188**	**4 380**
Not known	0	0	0	91	0	0	0	0	**13**	**8**
TOTAL	**17 650**	**20 364**	**21 309**	**19 334**	**16 561**	**13 382**	**23 867**	**23 433**	**18 924**	**20 611**

* Preliminary

Table 3. Annual landings (t) of mackerel since 1995, by type of fishing gear.

GEAR	YEAR								AVERAGE	
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002***	(1995-2001)	(1990-2001)
Trawl	59	68	92	9	12	1	3	3	**35**	**491**
Purse Seine	2 720	3 607	1 116	1 572	1 348	1 840	8 022	16 510	**2 889**	**4 300**
Other Seines	0	0	9	0	0	0	0	0	**1**	**19**
Gillnet	4 442	6 419	6 657	7 638	5 128	5 294	6 554	1 420	**6 019**	**6 408**
Trap	4 719	3 821	3 889	3 999	4 057	3 920	3 148	1 767	**3 936**	**3 746**
Longline	0	0	0	7	3	3	20	2	**5**	**9**
Handline	899	1 231	3 029	1 998	569	90	160	0	**1 140**	**848**
Jigger	3 821	4 705	6 204	3 651	5 435	2 229	5 676	3 682	**4 532**	**4 487**
Weir	177	0	1	141	8	0	46	48	**53**	**59**
Other	812	510	313	320	0	5	237	0	**314**	**245**

* Preliminary

Since 1987, Canada has proposed dividing the TAC of 200,000 t for the entire northwest Atlantic equally with the United States. Following the low biomass estimates from the 1996, 1998 and 2000 egg surveys, the Canadian proportion of the TAC was revised downward in 2001, from 100,000 t to 75,000 t.

Canadian landings

In 2002, preliminary reported mackerel landings in eastern Canada totalled 23 433 t, only 435 t less than in 2001 (Table 1). This figure for 2002 is still higher than the averages for recent years and, except for the 2001 figure, is the highest since 1993. US commercial mackerel landings totalled 26,158 t in 2002, which represents increases of 13,823 t and 20,513 t compared with 2001 and 2000. Recreational landings in the US totalled 1,286 t in 2002, compared with 1,538 t in 2001, and no foreign vessels are reported to have fished in US waters since 1992. For the northwest Atlantic as a whole, 50,877 t of mackerel were landed in 2002, which exceeds the annual averages calculated from 1980 and 1990 on (Table 1).

Out of the total reported mackerel catch in Canada in 2002, 16,493 t (70%) were landed in Newfoundland (11,026 t on the island's west coast alone) (Table 2). The main fishing gear used was the purse seine, which accounted for a total of 16,510 t of mackerel (Table 3). Next came jiggers, traps and gillnets, with landings of 3,682 t, 1,767 t and 1,420 t, respectively.

Description of landings

In 2002, for the third consecutive year, the mackerel landings were characterized by the presence of a very high proportion of fish from the 1999 year-class (Figure 8). Over the years 2000, 2001 and 2002, at ages 1, 2 and 3, these fish have accounted for 63%, 68% and 77% of the total recorded catch by number. Such a heavy dominance by a single year-class has never been observed before (Figure 8).

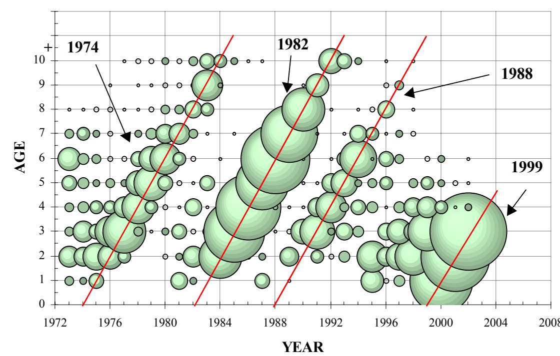

Figure 8. Catch at age (%) for mackerel in Canada from 1973 to 2002 (the year-classes that dominated the fishery for several years are shown; age group 10 represents all fish age 10 years and over).

In 2002, the average length of the fish in the 1999 year-class was 323 mm, and their average weight was 389 g. These fish were observed in the annual length frequencies for samples from the commercial line fishery in Division 4T and the commercial purse seine fishery in Division 4R (Figure 9). Because of the high selectivity of the gillnets, the 1999 year-class has not yet been observed in the length-frequency distributions for this type of fishing gear.

Industry Comments

The comments received from the industry vary from one region or fishing area to another, but for the past 3 years, they have consistently mentioned the high abundance of the 1999 year-class. More and more fishers are also drawing

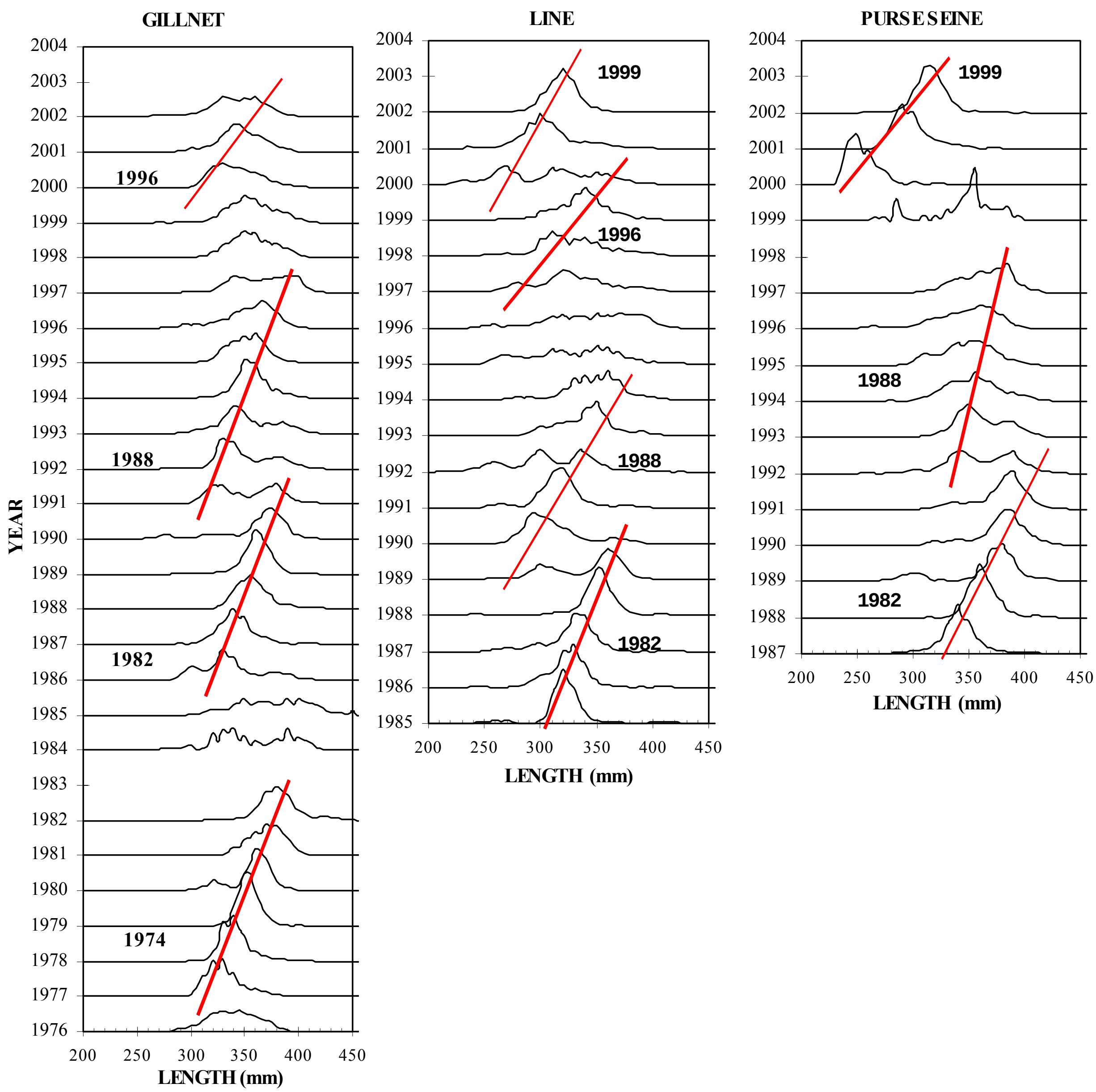

Figure 9. Annual frequency distributions (%) for length (mm) of mackerel caught with gillnets and lines in Division 4T and with purse seines in Division 4R (the year-classes that dominated these fisheries are shown).

particular attention to the possible links between catch levels and certain environmental variables such as water temperature. Some fishers even use satellite maps of surface water temperatures to locate masses of warm water where they then set their nets. Other comments, made in 2001 and again in 2002, dealt specifically with the following points: (1) changes in migration patterns, such that the mackerel arrive earlier or later in the spring in some areas and remain later in the fall in others, (2) the absence of large individuals in the spring, which has been observed for several years, (3) the larger numbers of seals found around fishing gear such as gillnets and traps, (4) the presence of very cold water and problems associated with clogging of nets ("slub"), (5) catches of very small fish with certain types of gear, (6) the delay in enforcing requirements that all fishers, including bait fishers, to fill in logbooks, (7) recreational catches which are quite large but not officially recorded, and (8) the total absence, in 2002, of species such as salmon (*Salmo salar*), cod (*Gadus morhua*) and lumpfish (*Cyclopterus lumpus*) in the mackerel traps set off Cape Breton. Until recently, these species were observed regularly in the spring mackerel fishery.

Lastly, several comments were received from the west coast of Newfoundland and the Magdalen Islands about the abundance of the mackerel in the fall. Several fishers said that they had not seen so many mackerel in many, many years.

Resource Status

1999 year-class

The 1999 year-class comes from a year when the adults spawned earlier in the season. This early timing of the spawning has been deduced from a review of the daily averages for the gonado-somatic index, which were only 5% on June 1 (day 158 of the year) compared with 12% in preceding years (Figure 10A). Several fishers also mentioned that the mackerel arrived in the Gulf of St Lawrence earlier than usual in the spring of 1999 and left it later than usual that fall.

For mackerel, the height of the first otolith ring (L1) is used as a measure of the size attained at the end of the first year of growth. A reduction in L1 was observed in the dominant 1974, 1982 and 1988 year-classes, which suggests an inverse relationship between growth and density. However, as for the dominant 1967 year-class, the average otolith height measured for the 1999 year-class is among the highest in the entire series (Figure 10B).

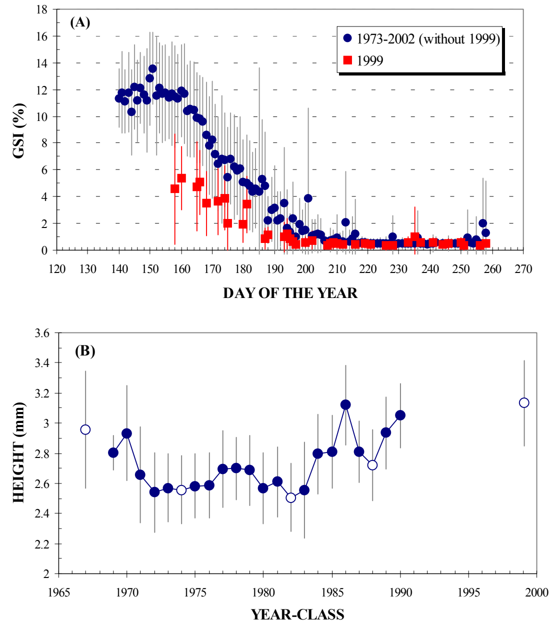

Figure 10. Mean daily gonado-somatic index (GSI) values for 1973-2002 (without values for 1999) and for 1999 (vertical bars represent standard deviations) (A) and mean otolith heights (mm) at 1 year (B) (the year-classes that have dominated the fishery in recent years are represented by the open circles).

Egg abundance index

The first pass of the 2002 egg abundance survey was conducted from June 15 to 22, 2002. The highest concentrations of eggs were found west of the Magdalen Islands (Figure 11A). This area was characterized by higher water temperatures. Few eggs were sampled north of the 8°C isotherm. This demarcation can be very clearly seen in

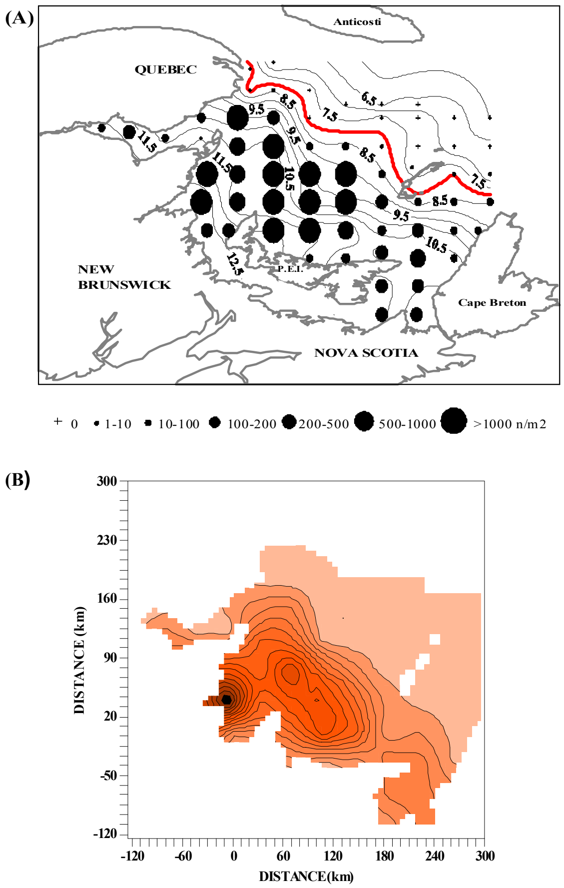

Figure 11. Distribution of mackerel eggs (number per square metre) and water temperatures (means for first 10 metres) (A) and kriged area of egg densities (B) for the first pass of the June 2002 egg-sampling survey.

Figure 11B, which represents the kriged egg densities.

Abundance estimate

An increase in the spawning biomass was measured in 2002 (Figure 12). Once again, the two analytical methods yielded very similar results. The spawning biomass was estimated at 379,069 t by the Total Egg Production Method (TEPM), compared with 359,330 t by the Daily Fecundity Reduction Method (DFRM).

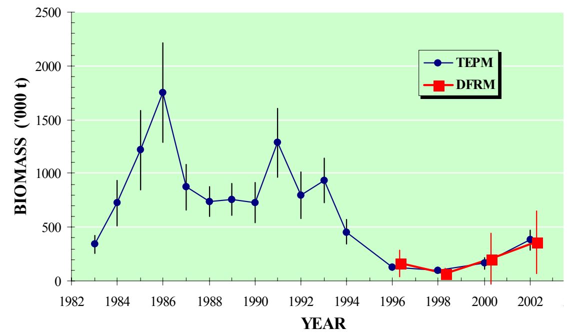

Figure 12. Spawning biomass ('000 t) of mackerel calculated by two different analytical methods: the Total Egg Production Method (TEPM) and the Daily Fecundity Reduction Method (DFRM). Daily egg production has been calculated from the (stratified) mean density of eggs per square metre measured in the surveys.

Outlook

An increase in the mackerel's spawning biomass has been measured in the last two egg-sampling surveys. However, given the high abundance and the very high proportion of the 1999 year-class in the catch, a larger increase in biomass might have been expected in 2002. However, not all of the fish in this year-class were mature in 2002, and their weight at age 3 was also lower than that of other year-classes at that age.

The biomass increase measured in 2002 was essentially attributable to the fish in the 1999 year-class which should be fully mature in 2003. Since this increase is recent and the landings are underestimated, the present advice recommends that the TAC be held to the same level as in 2002: 75,000 t for Canada and 150,000 t for the northwest Atlantic as a whole.

Sources of Uncertainty

The mackerel that are caught for bait do not appear in the Department's official statistics, which are based on purchase receipts from commercial fishers' sales to processing plants. Recreational fishing for mackerel, which is very popular in the summer, does not get recorded in the official statistics either. Since mackerel are fished both for bait and recreationally in many parts of the Maritimes, Newfoundland and Quebec, the actual total catch of mackerel is thus greatly underestimated.

Management Considerations

To improve the statistics on the mackerel fishing that takes place in the Gulf of St Lawrence, a mandatory logbook should be distributed to all mackerel fishers, including those who use the mackerel as bait. The use of logbooks would also provide better information on the locations of the fish, which would greatly facilitate analysis of the relationships between the mackerel's distribution and certain environmental variables. A possible alternative to the use of logbooks would be to weigh the mackerel catch and collect the other associated data dockside, as is currently done in Nova Scotia.

The recreational mackerel fishery is important. It involves a very large number of fishers, including tourists, along the entire Atlantic coast. With a view toward the possible management of this activity in future, as well as toward improving the statistics on the mackerel fishery as a whole, some thought should be given very soon to ways of estimating this catch.

For more Information

Contact: François Grégoire
Maurice-Lamontagne Institute
850 route de la Mer
P.O. Box 1000
Mont-Joli (Québec)
G5H 3Z4

Tel: (418)775-0589
Fax: (418)775-0679
E-Mail: GregoireF@dfo-mpo.gc.ca

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Regional Science Advisory Bureau
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
P.O. Box 1000, Mont-Joli
Quebec, Canada
G5H 3Z4

Phone Number : 418-775-0766
Fax Number : 418-775-0542
E-Mail address : Bras@dffo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

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