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ASSESSMENT OF THE ATLANTIC MACKEREL STOCK FOR THE NORTHWEST ATLANTIC (SUBAREAS 3 AND 4) IN 2007

(Courtesy: M. Claude Nozères)

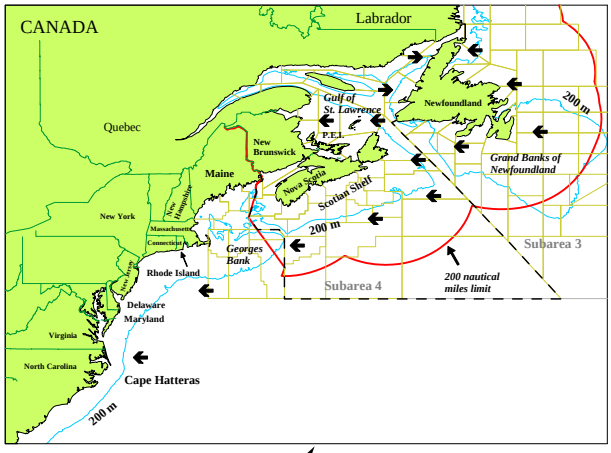

Figure 1. Distribution (←) of Atlantic mackerel (Scomber scombrus L.) in the Northwest Atlantic. The dotted line indicates the borders between Subareas 3 and 4 of the Northwest Atlantic Fisheries Organization (NAFO).

Context

Atlantic mackerel (Scomber scombrus L.) is found in the waters of the North Atlantic, from the Mediterranean to Norway in the east and from North Carolina to Newfoundland in the west (Figure 1). During spring and summer, mackerel is found in inshore waters. From late fall and in winter, it is found deeper in warmer waters at the edge of the continental shelf. In the Northwest Atlantic, two intense spawning areas characterize its distribution range. In Canadian waters, spawning mainly occurs in the southern Gulf of St. Lawrence during the months of June and July. This spawning period is preceded by a long migration that begins early in spring in the Gulf of Maine and Georges Bank area. In American waters, spawning occurs during the months of March and April, between the coasts of Rhode Island and Virginia.

In the Maritime Provinces, Newfoundland, and Quebec (NAFO Subareas 3 and 4), over 15,000 commercial fishermen participate in the mackerel fishery. They fish mainly inshore using gillnets, jiggers, handlines, purse seines and traps. The type of gear used varies according to the region and time of the year. Landings by Canadian fishermen have been rather stable from one year to the next and have averaged around 22,000 t per year during the 1980s and 1990s. However, there has been a significant increase since the early 2000s, reaching a record high of 54,279 t in 2005, due to the marked increase of the catches by seiners on the east and west coasts of Newfoundland (Divisions 3KL and 4R). Canadian landings of mackerel are underestimated as bait fishermen are not required to fill a logbook, and there is no dockside monitoring for this fishery. As well, the catch from the recreational fishery, which occurs during summer months all along the Atlantic coast, is not reported. Spawning stock abundance for mackerel is estimated based on an egg survey in the southern Gulf of St. Lawrence.

A meeting of the Regional Advisory Process was held 20 March, 2008 in Moncton, N.B. to assess the status of the mackerel resource in NAFO Subareas 3 & 4 in support of the management of the 2008 fishery.

SUMMARY

- Mackerel reported landings in NAFO Subareas 3 and 4 have increased substantially in recent years, from a low of 13,383 t in 2000 to an all-time high of 54,279 t in 2005. Canadian preliminary landings for the 2007 fishing season totalled 50,578 t, but are incomplete.

- The increased landings are explained by the marked increase of catches by seiners on the east and west coasts of Newfoundland.

- From 2000 to 2006, landings in the USA commercial fishery increased from 5,646 t to 56,637 t, and landings from the Northwest Atlantic as a whole (NAFO Subareas 2-6), increased from 20,477 t to 110,286 t. In 2007, preliminary USA landings totalled 25,285 t, and those for the Northwest Atlantic, 75,863 t.

- The actual proportion of the Canadian TAC caught is higher because of unrecorded landings in several fisheries. This is a concern that needs to be addressed.

- USA catches of Canadian origin mackerel are not included in the Canadian landings and catch at age.

- Between 2000 and 2005, the fishery was supported by the 1999 year-class. In 2006 and 2007, the fishery was supported by the 2003 year-class.

- During the 2007 egg survey, the most significant densities of eggs were found in the area between the Magdalen Islands and Chaleur Bay. Spawning biomass was estimated at 76,532 t, which represents one of the lowest values of the series that begins in 1983.

- Recent changes in water temperature may have affected the distribution and timing of migration of mackerel into the southern Gulf of St. Lawrence. The sampled area of the egg survey in the southern Gulf may no longer represent the whole spawning area and period in eastern Canada.

- The strong 1999 year-class, which contributed more than 150,000 t in landings between 2000 and 2006, is no longer an important contributor to the fishery or to the spawning stock. The strength of the year-classes since 1999 does not appear to be strong.

- Catches in the order of 50,000 t in recent years have been supported by a strong year-class. It is uncertain that catches of that level can be realized with the year-classes presently available to the fishery.

INTRODUCTION

The Fishery

Historical Overview

Mackerel landings in the Northwest Atlantic (NAFO Subareas 2-6) peaked in the early 1970s at over 400,000 t per year (Figure 2). Landings dropped considerably in 1977 with the introduction

of the 200-nautical-mile economic exclusion zone (EEZ). Owing to agreements between the United States (USA) and the USSR, landings increased again in the early 1980s, peaking at 86,891 t in 1990. In the ensuing years, landings dropped considerably as the USA gradually reduced their mackerel quotas, which was followed by a complete closure of the foreign fleet fishery in 1992. Since 2001, catches have been increasing due mainly to an abundant year-class (1999) and a considerable increase in fishing effort on this species.

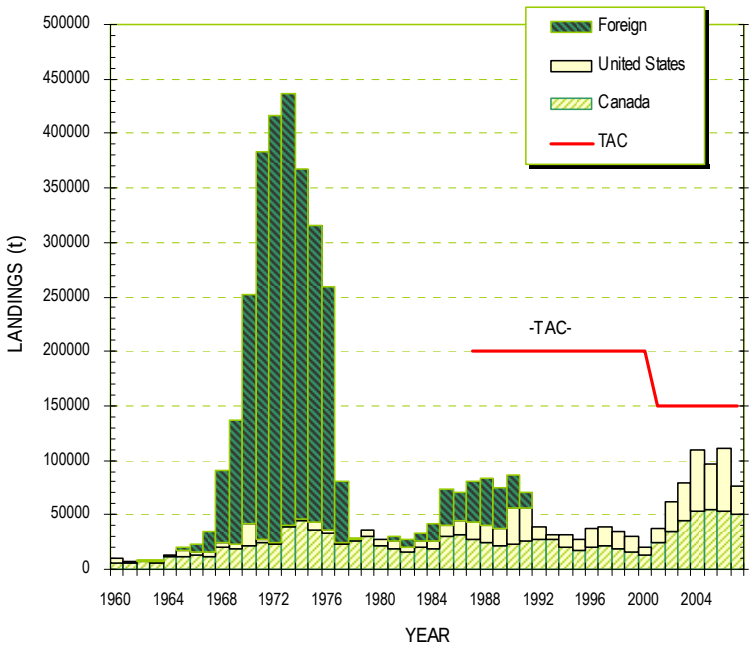

Figure 2. Annual landings (t) of Atlantic mackerel and TAC (t) for the Northwest Atlantic (NAFO Subareas 2-6).

Since 1987, the 200,000 t TAC (Total Allowable Catch) for the Northwest Atlantic has been divided equally between Canada and USA. Following the low biomass estimates from the 1996, 1998 and 2000 egg surveys, the total TAC was lowered to 150,000 t, with the Canadian TAC set at 75,000 t since 2001.

Landings in 2007

For the Northwest Atlantic (NAFO Subareas 2-6), preliminary mackerel landings in 2007 totalled 75,863 t, compared with 79,491 t to 110,286 t during 2003 to 2006 (Table 1). In 2007, reported and preliminary mackerel landings in eastern Canada (NAFO Subareas 3 and 4) totalled 50,578 t, similar to values since 2004 (Table 1). Final landings for 2007 will be higher because not all the fishery landings have been accounted for (Division 4T was not available). There are no recreational mackerel fishery data for Canada.

No distinction to stock origin is made in the mackerel fisheries of Canada and USA. Catches of Canadian origin mackerel in the USA fisheries are therefore not included in the Canadian landings. Preliminary landings in the USA commercial fishery are 25,285 t in 2007 (Table 1), only 45% of the landings in 2006. Recreational landings in the USA (chartered trips) were not available at the time of the assessment neither for 2006 nor for 2007 but averaged about 1,200 t between 1995 and 2005. No foreign vessels are reported to have fished in USA waters since 1992.

Table 1. Atlantic mackerel landings (t) in NAFO Subareas 2 to 6 during 1992 to 2007. Data for 2007 are preliminary.

YEAR	CANADA		UNITED STATES		TOTAL
	Canadian vessels	Foreign vessels	Commercial	Recreational	
1992	24,307	2,417	11,775	344	38,843
1993	26,158	591	4,666	540	31,955
1994	20,564	49	8,877	1,705	31,195
1995	17,706	0	8,479	1,249	27,434
1996	20,394	0	16,137	1,416	37,947
1997	21,309	0	15,400	1,735	38,444
1998	19,334	0	14,415	670	34,419
1999	16,561	0	12,026	1,335	29,922
2000	13,383	0	5,646	1,448	20,477
2001	23,950	0	12,336	1,538	37,824
2002	34,309	0	26,452	1,286	62,047
2003	44,475	0	34,292	724	79,491
2004	53,365	0	54,939	515	108,819
2005	54,279	0	41,017	1,042	96,338
2006	53,649	0	56,637	*	110,286
2007	50,578	0	25,285	*	75,863
AVERAGE:					
1992-2006	29,583	204	21,540	1,111	52,363

* Not yet available

Table 2. Annual Atlantic mackerel landings (t) by Canadian province (NAFO Subareas 3 and 4) since 1995. Data for 2007 are preliminary.

PROVINCE	AVERAGE	YEAR								AVERAGE
	(1995-1999)	2000	2001	2002	2003	2004	2005	2006	2007	(1995-2006)
Nova Scotia	5,445	4,546	4,058	3,989	7,187	5,325	4,935	2,579	2,647	4,987
New Brunswick	1,987	972	2,199	2,182	1,734	1,398	1,047	1,517	797	1,749
Prince Edward Island	4,771	4,134	5,979	6,088	4,543	4,692	4,946	3,552	2,005	4,816
Quebec	4,528	1,711	2,904	4,095	4,380	1,618	1,035	1,818	1,098	3,350
Newfoundland	2,312	2,020	8,810	17,955	26,631	40,333	42,315	44,183	44,032	16,151
Not known	18	0	0	0	0	0	0	0	0	8
TOTAL	19,061	13,383	23,950	34,309	44,475	53,365	54,279	53,649	50,578	31,060

Of the 50,578 t of mackerel caught in Canadian waters in 2007, 87% were landed in Newfoundland (Table 2), with 8,611 t (17%) in Division 3K, 10,552 t (21%) in Division 3L, and 24,577 t (49%) in Division 4R (Table 3). The two main fishing gears were the small (<65' or 19.8 m) and large (>65') purse seiners, followed by the other seines, "Tuck ring" seines and gillnet (Table 4).

Table 3. Annual Atlantic mackerel landings (t) by NAFO Division (Subareas 3 and 4) since 1995. Data for 2007 are preliminary.

DIVISION AND AREA	AVERAGE	YEAR								AVERAGE
	(1995-1999)	2000	2001	2002	2003	2004	2005	2006	2007	(1995-2006)
3K	3	0	322	6,566	588	16,360	24,024	19,158	8,611	5,586
3L	2	0	10	3	0	59	4,068	7,960	10,552	1,009
3P	46	19	102	135	105	30	82	266	294	81
4R	2,279	2,001	8,375	11,251	25,938	23,885	14,141	16,799	24,577	9,482
4S	9	0	16	2	0	0	35	76	19	14
4T	11,640	7,005	12,008	14,158	14,106	8,790	9,238	7,788	4,189	10,941
4V	1,044	576	125	308	60	13	126	224	375	554
4W	557	120	248	115	9	59	36	75	57	287
4X	3,482	3,663	2,743	1,771	3,669	4,169	2,529	1,304	1,905	3,105
Scotian Shelf (4VWX)	5,082	4,358	3,117	2,194	3,737	4,241	2,691	1,603	2,336	3,946
Gulf of St. Lawrence (4RST)	13,928	9,006	20,399	25,411	40,044	32,676	23,414	24,663	28,784	20,438
East and South coasts of Newfoundland (3KLP)	51	19	434	6,704	693	16,449	28,174	27,384	19,457	6,676
TOTAL	19,061	13,383	23,950	34,309	44,475	53,365	54,279	53,649	50,578	31,060

Table 4. Annual Atlantic mackerel landings (t) by gear type in NAFO Subareas 3 and 4 since 1995. Data for 2007 are preliminary.

GEAR	AVERAGE	YEAR								AVERAGE
	(1995-1999)	2000	2001	2002	2003	2004	2005	2006	2007	(1995-2006)
Bottow trawl	48	1	3	5	0	2	1	7	7	22
Midwater trawl*	0	0	0	0	0	0	0	14	0	1
" Tuck-ring " seine	0	0	0	0	0	2,448	6,393	4,782	3,560	1,135
Purse seine < 65'	1,304	1,348	4,443	10,833	11,668	25,334	28,212	29,161	26,650	9,793
Purse seine > 65'	776	492	3,579	6,074	14,645	11,612	5,065	6,011	8,686	4,280
Other seines	2	0	226	344	0	0	845	2,696	4,056	343
Gillnet	6,065	5,294	6,607	4,948	4,541	4,734	3,929	4,509	3,078	5,407
Trap	4,099	3,920	3,148	2,073	3,628	4,690	3,330	2,356	2,842	3,637
Longline	2	3	20	18	13	3	59	48	0	15
Handline	4,764	2,229	5,676	9,839	9,856	3,843	5,296	3,180	1,374	5,312
Jigger	1,545	90	200	129	9	694	1,118	877	322	904
Mechanized jigger	0	0	0	0	0	1	1	0	0	0
Weir	65	0	46	48	74	2	20	3	0	43
Other	391	5	0		40	2	4	2	0	183
Not known	0	0	0	0	0	0	6	4	3	1
TOTAL	19,061	13,383	23,950	34,309	44,475	53,366	54,279	53,649	50,578	31,060

* Exploratory fishery in Nova Scotia

The actual proportion of the Canadian TAC caught is higher than reported because of unrecorded landings, which occur in the mackerel bait fishery and in the recreational fishery in eastern Canada. For several years, 40% of the TAC has been allocated to vessels (purse seiners or trawlers) over 65' (or for all exploratory fishing), and 60% to small purse seiners and gear such as traps, gillnets, lines and weirs. In the case of the large purse seiners in 2007, almost 30% of the 30,000 t TAC was reached (Table 5). For all the other gears, 93% of the

45,000 t TAC was reached in 2007, compared with 106% in 2006 and 109% in 2005, the first time the TACs were exceeded since 1987. The largest increase in landings for those years has occurred in the Newfoundland small purse seine fisheries which totalled about 60% of that sector's landings since 2004 (Table 5).

Table 5. Landings (t) and quotas (t) of Atlantic mackerel by vessel size for NAFO Subareas 3 and 4 since 1995. Data for 2007 are preliminary.

GEAR	AVERAGE	YEAR								AVERAGE
	(1995-1999)	2000	2001	2002	2003	2004	2005	2006	2007	(1995-2006)
-- QUOTA 40% --										
Midwater trawl	0	0	0	0	0	0	0	14	0	1
Purse seine >65'	776	492	3,579	6,074	14,645	11,612	5,065	6,011	8,686	4,280
Quota		*40,000*	*30,000*	*30,000*	*30,000*	*30,000*	*30,000*	*30,000*	*30,000*	
%	2	1.23	11.93	20.25	48.82	38.71	16.88	20.04	28.95	14
-- QUOTA 60% --										
Purse seine <65'	1,304	1,348	4,443	10,833	11,668	25,334	28,212	29,161	26,650	9,793
Other	16,982	11,543	15,928	17,402	18,162	16,420	21,002	18,464	15,242	16,986
Total	18,285	12,891	20,371	28,235	29,830	41,754	49,214	47,625	41,892	26,779
Quota		*60,000*	*45,000*	*45,000*	*45,000*	*45,000*	*45,000*	*45,000*	*45,000*	
%	30	21.49	45.27	62.74	66.29	92.79	109.36	105.83	93.09	55
TOTAL		13,383	23,950	34,309	44,475	53,366	54,279	53,649	50,578	

ANALYSIS

Description of catches

Catch at age

During 2000 to 2005, the 1999 year-class has been the dominant component of the mackerel landings (Figure 3). Between 2000 and 2003, fish from this year-class accounted for 63% to 77% of the catch (in number). The predominance of such a year-class in the catches has not been observed since 1968, i.e. since Canada began collecting biological data on mackerel. The relative importance of the 1999 year-class declined in 2005 to be replaced by the 2003 year-class, with the latter representing 32% and 39% of all catches in 2006 and 2007 (Figure 4).

Length frequencies

In 2007, the mean length and weight of fish from the 1999 year-class was respectively 378 mm and 724 g. Fish from this year-class have been observed for the first time in 2000 in the annual length frequency samples of the commercial line fishery in Division 4T and purse seine fishery in Divisions 3KL and 4R (Figure 5). However, these fish have only been observed since 2002 in the length frequency distributions of the gillnet fishery in Division 4T due to this gear's selectivity.

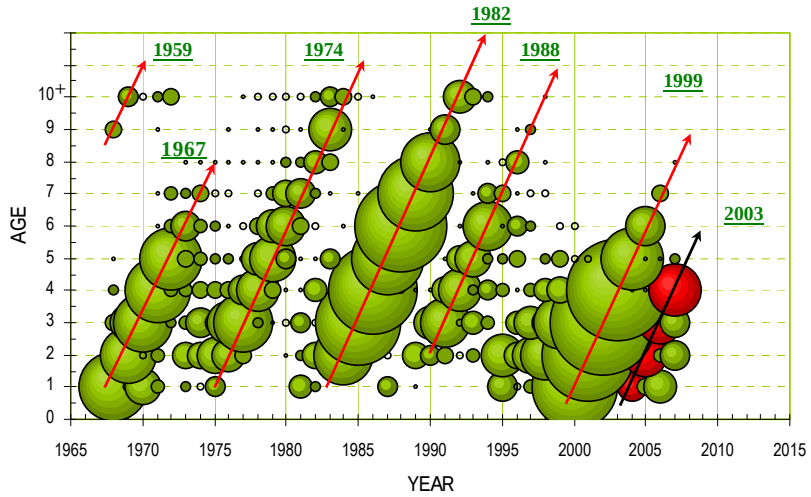

Figure 3. Catch at age (%) of Atlantic mackerel from NAFO Subareas 3 and 4 for the period between 1968 and 2007 (the year-classes that dominated the fishery over several years are indicated; the 10+ age group represents all fish older than 10 years old). The diameter of the bubble indicates the importance of the age group.

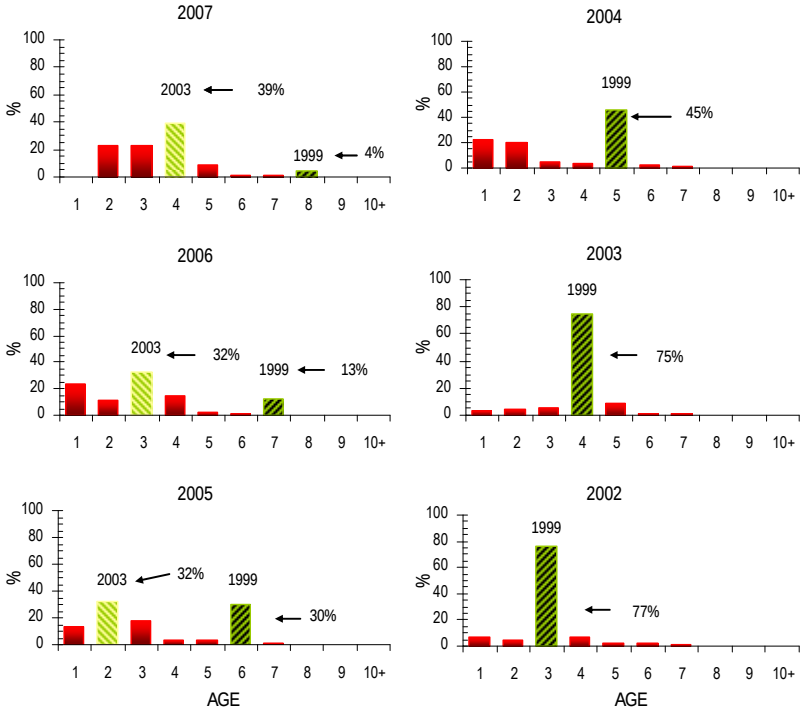

Figure 4. Relative catch at age (%) of Atlantic mackerel in the 2002 to 2007 fisheries, indicating the relative importance of the 1999 year-class since 2002, and the 2003 year-class since 2005.

In 2007, the mean length and weight of fish from the 2003 year-class was 340 mm and 494 g, respectively. These fish have been observed since 2004 in the samples from the commercial line fishery in Division 4T (but not in 2007) and purse seine fishery in Divisions 3KL. They have

also been observed since 2005 in the 4R purse seine fishery and since 2007 in the 4T gillnet fishery.

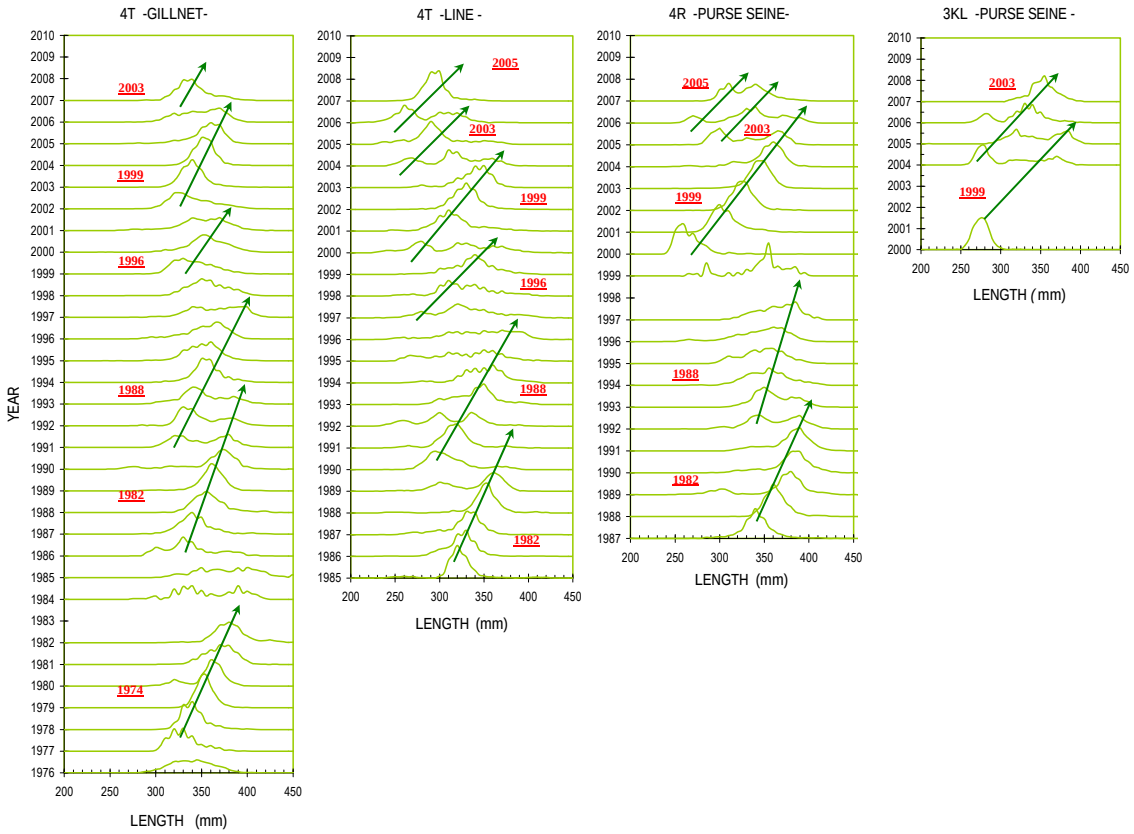

Figure 5. Annual length (mm) frequencies (%) of mackerel caught with gillnets and lines in Division 4T and with purse seines in Divisions 3KL and 4R (the year-classes that dominated these fisheries are indicated).

Resource Status

From 2000 to 2006, annual landings attributed to the 1999 year-class ranged from 4,927 t to 35,970 t (Figure 6A). By age 8, cumulative catches for this year-class have totalled 150,532 t (Figure 6B). In comparison, the second most important year-class to date has been from 1982 with a cumulative catch over its life span in the fishery of 65,000 t (Figure 6B).

The 1999 year-class comes from a year when spawning took place earlier in the season than usual. This early spawning was deduced from the mean daily values of the gonado-somatic index, which stood at only 5% at the beginning of June 1999 in the Southern Gulf, compared to a mean value of 12% in the other years (Figure 7). Several fishermen also mentioned that the mackerel had arrived earlier in the Gulf of St. Lawrence in 1999. Samples from bottom trawl surveys conducted offshore Nova Scotia during the winter of 1999 indicate that ovaries were at a more advanced stage of development than in previous years. It should be noted that the winter and spring of 1999 were exceptionally warm on the Scotian Shelf.

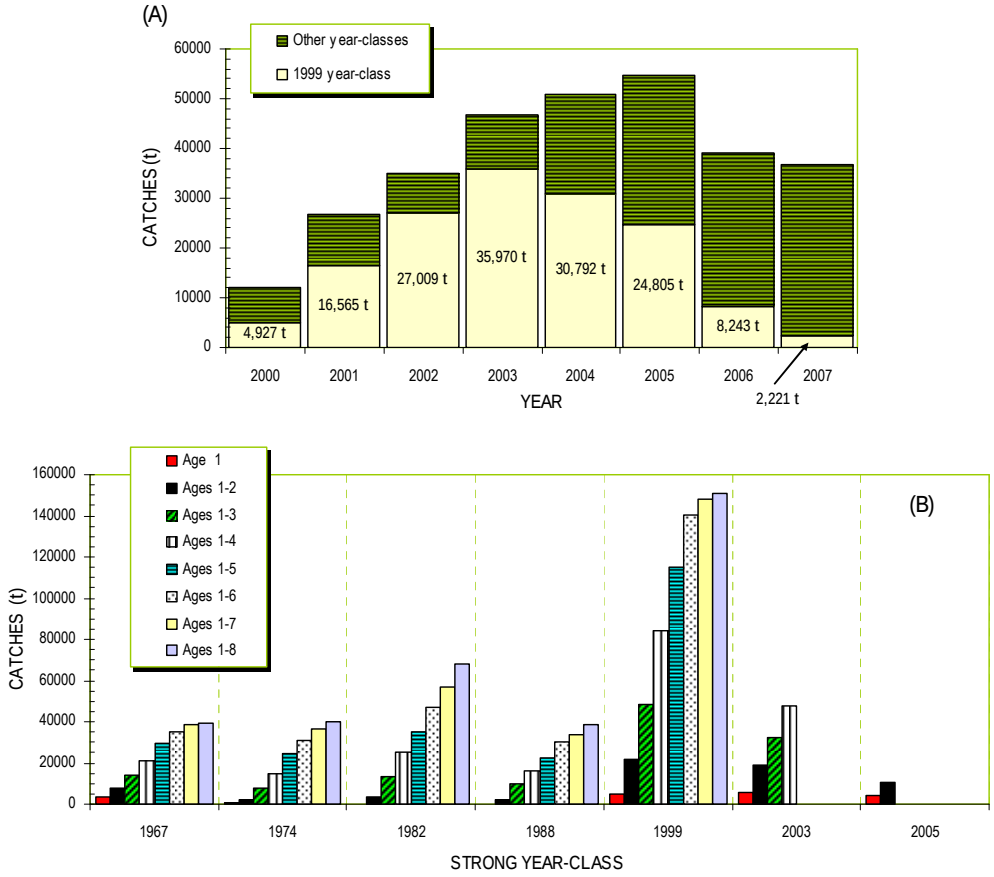

Figure 6. Annual catches (t) attributed to the 1999 year-class between 2000 and 2007 (A) and cumulative catches (t) at age for year-classes which dominated the fishery in recent years (B).

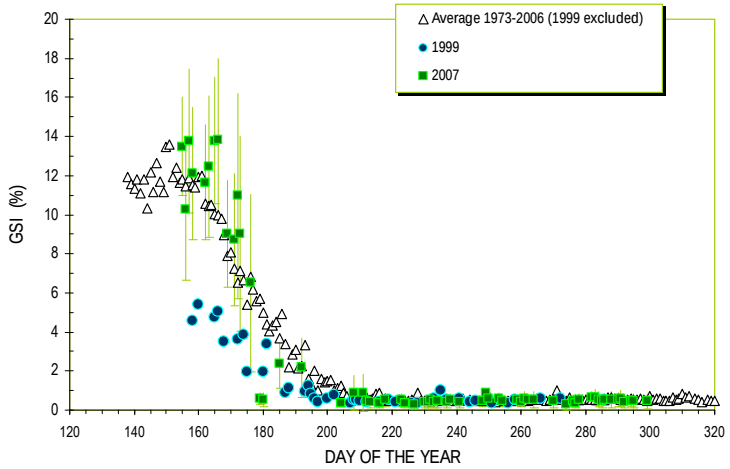

Figure 7. Daily means of the gonado-somatic index (GSI) for the 1973-2006 period (excluding 1999) and for 1999 and 2007 (vertical lines represent standard deviations).

The 2003 year-class has been the most abundant year-class in the fishery since 2005. Annual and cumulative catches at ages 2, 3, and 4 of fish from the 2003 year-class were exceeded only

As indicated by the daily egg production curve (Figure 9), the 2007 survey was made during the maximum of the spawning season in contrast to 2006 when the survey timing sampled the end of the spawning period.

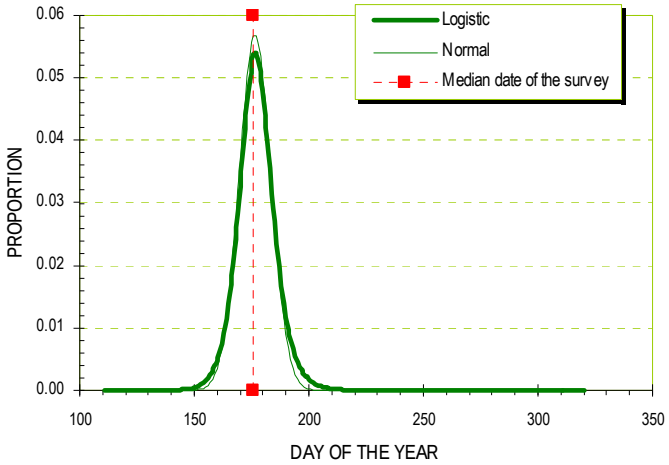

Figure 9. Density curves describing the daily proportion of egg production in 2007. The normal theoretical curve traditionally used has now been replaced by a curve derived from the parameters of a logistic model describing the decrease in mean daily gonado-somatic values during the spawning season.

Spawning Biomass Assessment

A reduction in the daily and total egg production has been estimated since 2002. In 2007, spawning biomass was estimated at 76,532 t, which represents one of the lowest values of the series (Figure 10).

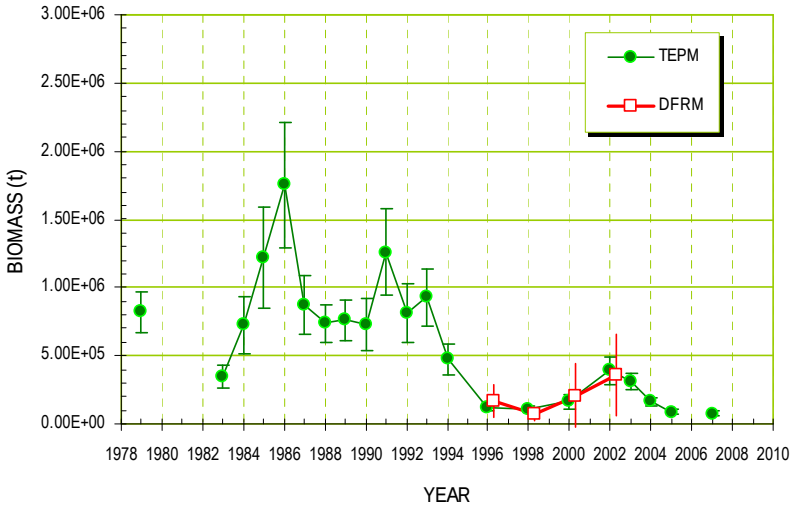

Figure 10. Spawning biomass (t) of mackerel calculated according to two different approaches (TEPM: Total Egg Production Method; DFRM: Daily Fecundity Reduction Method). No biomass was calculated in 2006 because the survey was conducted at the end of the spawning season.

by those of the 1999 year-class. By age 4, cumulative catches of the 2003 year-class were close to 50,000 t, compared to 85,000 t for the 1999 year-class (Figure 6B).

Egg Survey

The 2007 egg survey was conducted between June 21 and June 29. The highest densities of eggs were found in the northwestern part of the sampled area between the Magdalen Islands and Chaleur Bay (Figure 8A). Recorded concentrations were generally higher than in 2006, with a maximum reaching 1,165 eggs/m^2 (Figure 8A). Water temperature (Figure 8B) was as high as in 2006, and mackerel larvae were collected at almost every station in the southern part of the sampled area (Figure 8C).

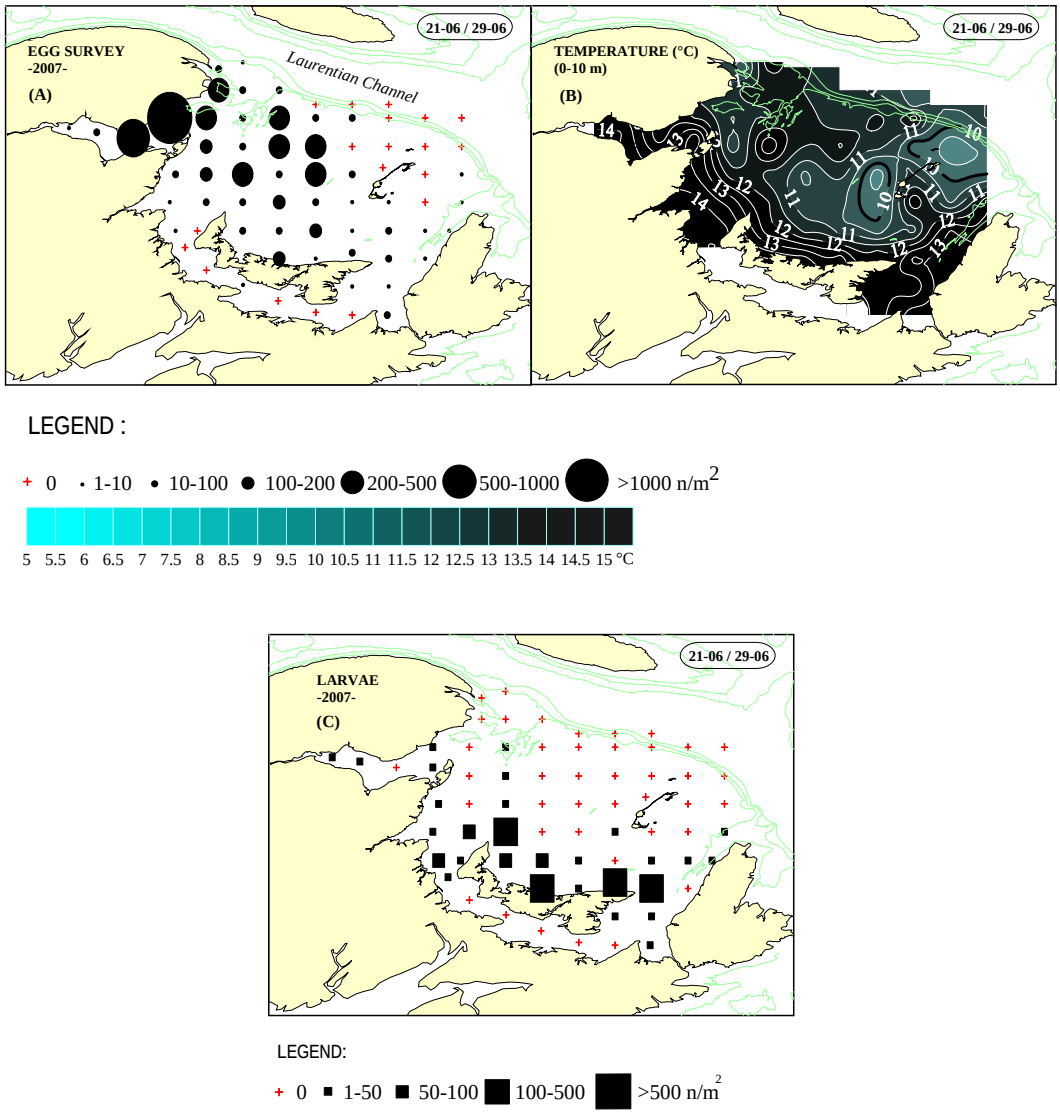

Figure 8. Egg distribution (number per square meter) (A) and water temperature (° C) (mean 0-10 m) (B) and larvae distribution (number per square meter) (C) measured during the 2007 survey.

Oceanographic conditions

Compared to the 1980s, an important reduction in the estimated mackerel spawning stock biomass was observed during the 1990s and 2000s (Figure 10). Landings alone cannot explain this reduction of biomass that occurred at the same time as the waters of the Gulf of St. Lawrence, i.e. the cold intermediate layer or CIL, were cooling (Figure 11). The annual variations in mackerel condition follow a pattern similar to average water temperature of the CIL (Figure 11).

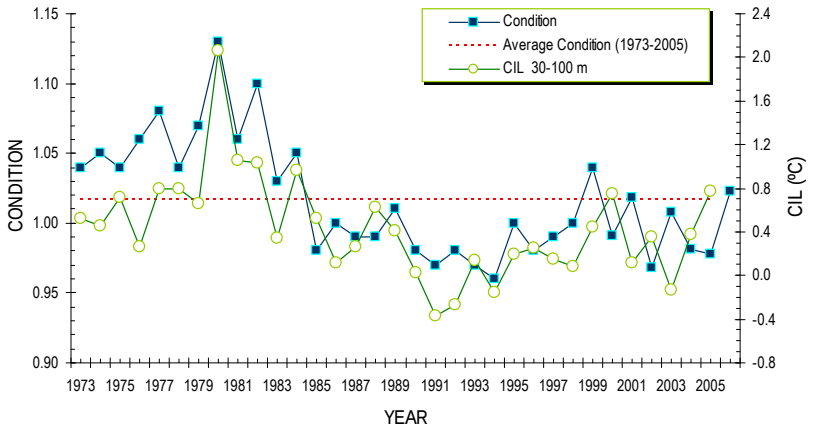

Figure 11. Mean condition factor (Fulton) calculated in June, and mean temperature (^{o}C) in the upper portion (30 to 100 m) of the cold intermediate layer, or CIL for the 1973-2006 period (Denis Gilbert, DFO, MLI, pers. comm.).

It is generally recognized that mackerel migrate northward when water temperature reaches 8° C and eggs for the most part are found in waters with temperatures of 9° C and above. In the southern Gulf of St. Lawrence, the percentage of the surface area during the egg survey corresponding to temperatures of 9° C and above showed a decreasing trend from 1983 to 1994. It increased in 1996 and 1998 and decreased again from 1998 to the lowest values in 2004 and 2005, but recovered in the past two years (Figure 12).

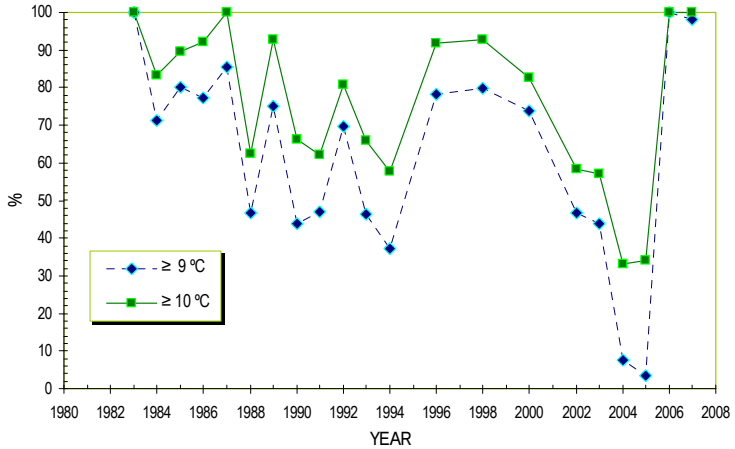

Figure 12. Surface area (%) in the southern Gulf of St. Lawrence associated with water temperatures of more than 9° C and 10° C as measured during the egg survey.

These changes in water temperature may have affected the timing of migration and spawning. If mackerel were present in the southern Gulf in 2004 and 2005, they were not detected as the egg surveys were conducted at the beginning of the spawning season. An opposite situation was observed in 2006 when the survey was conducted towards the end of the spawning season. In 2007, even if the survey was conducted during the maximum of the spawning season, the high water temperatures recorded and the presence of eggs of advanced stages of development and larvae at a great number of stations indicated that the spawning was well advanced at the time of the survey and the biomass may have been underestimated.

Sources of Uncertainty

Unrecorded Catches

Mackerel that are caught using personal license for bait are not all recorded in the Department's official statistics. Recreational fishing is very popular in summer but these statistics are not recorded. Since these activities are carried out throughout eastern Canada, the actual total number of mackerel caught is considered to be largely underestimated.

Discards of Small Mackerel

The discarding of mackerel under the minimum legal catch size (250 mm) or below what industry requires is of concern. The extent of the discarding and the impact of this activity on the abundance of the year-classes at older ages are difficult to quantify.

Recent Changes in Migration Routes

Recent changes in mackerel migration and distribution may be responsible for the marked increase of landings on the east coast of Newfoundland (Divisions 3K and 3L) since 2004. This increase in landings was also accompanied by a drop in the catches in the southern Gulf of St. Lawrence (e.g. Magdalen Islands).

To date, it has been assumed that the Canadian mackerel stock spawns for the most part in the southern Gulf of St. Lawrence. Plankton surveys conducted in unit area 4Rc in 2004 and 2005 revealed the presence of mackerel eggs off the west coast of Newfoundland, an area not included in the standardized egg survey from the southern Gulf of St. Lawrence.

The cooler oceanographic conditions that have been occurring in the southern Gulf of St. Lawrence in recent years could be a reason for the change in distribution, migration routes, and spawning areas. Mackerel spring migration may be delayed or occur elsewhere in response to the cooler surface waters in the Gulf of St. Lawrence of recent years.

CONCLUSION AND ADVICE

The 1999 year-class supported the fishery like no other abundant year-class ever had since monitoring began in 1968. Despite the uncertainties concerning the fishery statistics and the results from recent egg surveys, it appears that this year-class no longer contributes to the fishery or to the spawning stock. The strength of the year-classes since 1999 are uncertain, but do not appear to be strong.

Catches in the order of 50,000 t in recent years have been supported by a strong year-class. It is uncertain that catches of that level can be realized with the year-classes presently available to the fishery.

Statistics on the fishery occurring in the southern Gulf of St. Lawrence would be improved by the use of mandatory logbooks in all the fisheries, including the mackerel bait fishery, or alternatively by a dockside monitoring program.

Recreational catches are likely important, considering that fishing is carried out by a large number of individuals, including tourists, all along the Atlantic coast. In view of the possible future changes in management of this activity and in order to improve statistics on fisheries overall, consideration should be given to developing methods to estimate these catches.

There are instances when small (undersized) mackerel are captured incidentally in fisheries targeting market size fish and these undersized fish are discarded and unaccounted for in the landings. Measures, such as for example relocation of fishing activity, to reduce the impact of discarding on the abundance of the year-classes in the future should be considered.

The present coverage of the egg survey in the southern Gulf may no longer represent the whole spawning area and period in eastern Canada. Information from other areas suggests the spawning area may be much larger. To determine the full extent of the mackerel spawning area, the egg survey should be expanded outside the southern Gulf of St. Lawrence. Such a broad scale egg survey, that would extend into US waters, has never been done before in the Northwest Atlantic.

It is assumed that there are two distinct spawning stocks of Atlantic mackerel in the western Atlantic. As mackerel is a transboundary species with mixing of these stocks at certain times of the year, the issue of stock identity and resource sharing is important. In the absence of stock discrimination tools to distinguish the stock origin of mackerel caught in the different fisheries, refinements to the assessment of the status of these stocks are not possible.

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