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ASSESSMENT OF THE ATLANTIC MACKEREL STOCK FOR THE NORTHWEST ATLANTIC (SUBAREAS 3 AND 4) IN 2011

(Courtesy: M. Claude Nozères)

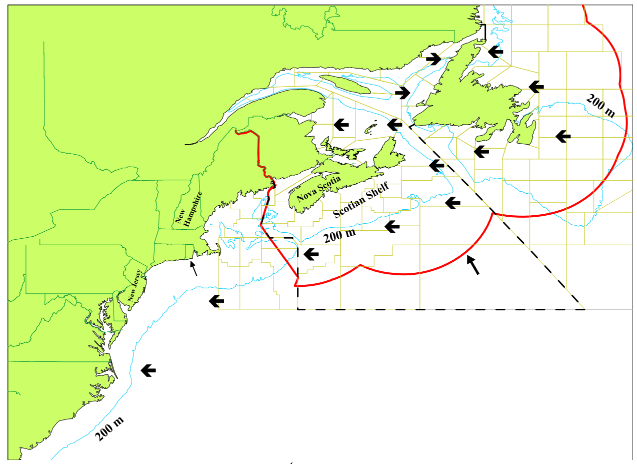

Figure 1. Distribution (←) of Atlantic mackerel (Scomber scombrus L.) in the Northwest Atlantic.

Background

Atlantic mackerel (Scomber scombrus L.) is found in the waters of the North Atlantic, from the Mediterranean to Norway, Iceland and the Faroe Islands in the east and from North Carolina to Newfoundland in the west (Figure 1). During spring and summer, Atlantic 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 main spawning areas characterize its distribution range. In Canadian waters, spawning occurs mainly in the southern Gulf of St. Lawrence during June and July. In American waters, spawning occurs during 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 fishers participate in the Atlantic mackerel fishery. They fish mainly inshore using gillnets, jiggers, handlines, seines (purse and "tuck") and traps. The type of gear used varies by region and time of year. Landings by Canadian fishers were stable and averaged 22,500 t per year in the 1980s and 1990s. However, landings increased significantly in the early 2000s, reaching a historical high of 54,621 t in 2005. Annual landings were approximately 40,500 t between 2000 and 2010, before falling to 8,544 t (preliminary) in 2011. Canadian Atlantic mackerel landings are underestimated because catches for bait are not all recorded. Summer recreational catches are not recorded either. The abundance of spawners from the Canadian contingent is assessed using an annual egg survey conducted in the southern Gulf of St. Lawrence.

The last assessment of the Canadian Atlantic mackerel contingent was completed in March 2008 and was followed by an assessment of the Canadian and American contingents in October 2009 and March 2010. The Fisheries and Aquaculture Management Branch requested another scientific advice on the Canadian mackerel contingent for the 2012 and 2013 seasons. The status of this contingent was reviewed at a meeting on April 18, 2012. This paper presents the results and conclusions from that meeting.

SUMMARY

- Reported landings in NAFO subareas 3 and 4 have increased substantially, from 16,080 t in 2000 to a historical high of 54,621 t in 2005. Between 2006 and 2010, landings decreased from 53,649 t to 38,753 t, before reaching 8,544 t in 2011.

- From 2000 to 2006, landings in the USA commercial fishery increased from 5,649 t to a maximum of 56,640 t. Between 2007 and 2010, they decreased from 25,547 t to 9,891 t, before reaching a historical low of 500 t in 2011.

- Age at 50% maturity has varied little over the years. However, length at 50% maturity decreased in the 2000s, and subsequently increased in 2010 and 2011.

- The spawning biomass index measured by egg surveys dropped substantially between 1993 and 1998. Following an increase caused by the strong year-class of 1999, the index dropped again to reach historical lows since 2005.

- In 2009 an additional egg survey was conducted on the Scotian Shelf and the south coast of Newfoundland. Egg densities found during the survey were very low, suggesting that spawning biomass on the Scotian Shelf was not very abundant.

- For the first time, a sequential population analysis was used to assess stock abundance. This analysis indicates that the biomass of the Canadian Atlantic mackerel contingent has been declining since the mid-2000s, reaching a very low value in 2011.

- This biomass decrease was caused by a lack of recruitment combined with historically higher-than-sustainable fishing mortalities. On two past occasions, biomass decreases associated with large increases in fishing mortality caused the population to decline.

- Given that stock abundance should not increase in the short term, the fishing mortality rate should be lower over the next few years compared to that of 2011. Therefore, in order to bring back this rate to the average sustainable level from 1968 to 1992, catches in 2012 and 2013 should not exceed 9,000 t.

INTRODUCTION

Fishery

Historical overview

With the arrival of foreign fishing, Atlantic mackerel (*Scomber scombrus* L.) landings in the Northwest Atlantic (NAFO subareas 2 to 6) increased significantly at the end of the 1960s, reaching historical highs of over 250,000 t per year between 1970 and 1976. Atlantic mackerel landings dropped considerably in 1977 with the introduction of the 200-nautical-mile exclusive economic zone (EEZ). However, as a result of agreements between the United States and the USSR in the early 1980s, they increased again to peak at 86,891 t in 1990 (Figure 2). Landings then dropped considerably as the US gradually reduced the quotas allocated to the USSR and closed the foreign fleet fishery completely in 1992.

Mackerel landings increased between 2001 and 2006 due to the arrival of a dominant year-class (1999) and a significant increase in fishing effort for this species. Landings have been decreasing since 2006 and reached their lowest point in the Canadian-US historical series in 2011.

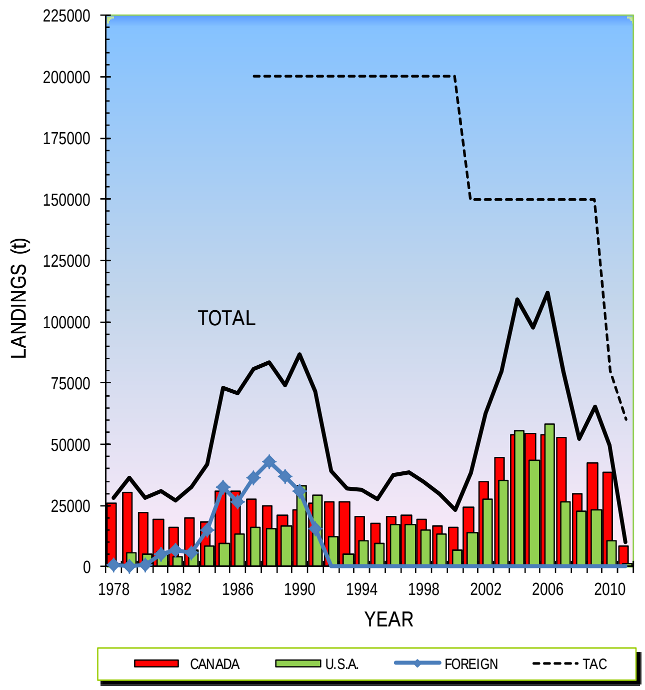

Figure 2. Annual Atlantic mackerel landings (t) and TAC (t) for the Northwest Atlantic (NAFO subareas 2 to 6) since 1978 (first full year of the 200-nautical-mile EEZ).

Between 1987 and 2000, the total allowable catch (TAC) for the Northwest Atlantic was 200,000 t (Figure 2). Following the low biomass estimates from the 1996, 1998 and 2000 egg surveys, Canada lowered the TAC to 150,000 t between 2001 and 2009. In 2005 the US proposed values of more than 200,000 t for the 2006-2008 period. The TAC was ultimately lowered to 80,000 t following the 2009-2010 joint Canada-US assessment, and to 60,000 t following the 2010 Advisory Committee.

2011 landings

For the Northwest Atlantic (NAFO subareas 2 to 6), 2011 preliminary Atlantic mackerel landings totalled 9,845 t, a significant drop compared to previous years (Table 1). In 2011, preliminary landings for Eastern Canada (NAFO subareas 3 and 4) totalled 8,544 t, also a considerable drop compared to previous years.

Table 1. Annual Atlantic mackerel landings (t) in NAFO subareas 2 to 6 between 1990 and 2011. Data for 2011 is preliminary. Unlike the US, Canada does not record recreational fishery catches.

YEAR	CANADA		U.S.A.			TOTAL
	Canadian vessels	Foreign vessels	Commercial	Recreational	Foreign	
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	284	0	38 783
1993	26 158	591	4 666	600	0	32 015
1994	20 564	49	8 917	1 705	0	31 236
1995	17 706	0	8 468	1 249	0	27 424
1996	20 394	0	15 812	1 340	0	37 547
1997	21 309	0	15 403	1 737	0	38 449
1998	19 334	0	14 525	690	0	34 548
1999	16 561	0	12 031	1 335	0	29 927
2000	16 080	0	5 649	1 448	0	23 177
2001	24 429	0	12 340	1 536	0	38 305
2002	34 662	0	26 530	1 294	0	62 485
2003	44 736	0	34 298	770	0	79 804
2004	53 777	0	54 990	530	0	109 297
2005	54 621	0	42 187	1 033	0	97 841
2006	53 649	0	56 640	1 633	0	111 923
2007	53 016	0	25 547	884	0	79 446
2008	29 671	0	21 734	691	0	52 096
2009	42 231	0	22 635	747	0	65 613
2010	38 753	0	9 891	778	0	49 422
2011*	8 544	0	500	801	0	9 845
AVERAGE:						
1990-1999	21 044	819	14 982	1 329	4 639	42 813
2000-2009	40 687	0	30 255	1 056	0	71 999

* Préliminary

Of the 8,544 t of Atlantic mackerel caught in Canadian waters in 2011, 7,320 t (85.7%) came from Newfoundland (Table 2). Of this number, 5,296 t (62%) were landed in Division 4R and 1,571 t (18.4%) in Division 3P (Table 3). The main fishing gear included the small (<65' or 19.8 m) purse seine with 4,501 t (52.7%), the large (>65') purse seine with 1,191 t (13.9%) and the "tuck" seine with 1,180 t (13.8%) (Table 4).

Table 2. Annual Atlantic mackerel landings (t) by Canadian province since 1995. Data for 2011 is preliminary.

PROVINCE	YEAR																	AVERAGE
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011 [1]	(1995-2010)
Nova Scotia	6 681	5 517	5 669	4 562	4 797	4 547	4 058	3 989	7187	5 325	4 935	2 526	2 831	1 961	1 454	666	381	4 169
New Brunswick	2 206	2 684	1 990	1 682	1 373	972	2 199	2 182	1734	1 398	1 047	1 499	1 426	1 205	1 762	1 260	7	1 664
Prince Edward Island	2 518	4 018	6 693	6 784	3 842	4 134	5 979	6 088	4543	4 692	4 946	3 552	2 756	1 606	2 463	1 959	4	4 161
Quebec	3 382	4 317	5 769	4 066	5 104	2 022	3 212	4 421	4597	1 979	1 221	1 818	1 750	1 863	2 316	1 709	821	3 097
Newfoundland	2 919	3 857	1 188	2 149	1 445	4 406	8 981	17 982	26675	40 383	42 471	44 196	44 253	23 036	34 237	33 159	7 320	20 709
Not known	0	0	0	91	0	0	0	0	0	0	0	58	0	0.2	0.2	0.2	11	9
TOTAL	17 706	20 394	21 309	19 334	16 561	16 080	24 429	34 662	44 736	53 777	54 621	53 649	53 016	29 671	42 231	38 753	8 544	

[1] Préliminary

Table 3. Annual Atlantic mackerel landings (t) by NAFO division since 1995. Data for 2011 is preliminary.

DIVISION AND AREA	YEAR																	AVERAGE
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011 [1]	(1995-2010)
2J[2]	0	0	0	0	0	13	0	0	0	0	0	0	26	0	0	0	0	2
3K	11	3	0	0	0	2 317	322	6 566	588	16 360	24 024	19 158	8 775	9 125	6 898	12 916	427	6 691
3L	11	0	0	0	0	55	10	3	0	59	4 068	7 960	10 340	4	39	830	37	1 461
3P	90	60	8	65	7	20	273	162	149	79	238	266	360	166	5 387	5 541	1 571	804
3O	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	2
4R	2 807	3 794	1 181	2 175	1 438	2 001	8 375	11 251	25 938	23 885	14 141	16 799	24 726	13 741	21 913	13 871	5 296	11 752
4S	30	9	1	1	2	0	16	2	0	0	35	76	19	23	64	123	107	25
4T	8 184	11 358	15 358	12 739	10 562	7 005	12 008	14 158	14 107	8 790	9 238	7 788	5 733	4 889	6 658	4 761	725	9 584
4V	1 475	1 591	838	554	762	576	125	308	60	13	126	222	370	111	55	7	1	449
4W	622	1 182	716	138	126	120	248	115	9	59	36	75	59	63	65	129	14	235
4X	4 477	2 398	3 208	3 662	3 663	3 663	2 743	1 771	3 669	4 169	2 529	1 304	1 928	1 000	980	416	366	2 599
5YZ[3]	0	0	0	0	0	1	0	0	0	0	0	0	0	0	16	0	0	1
Not known	0	0	0	0	0	311	308	326	217	362	186	2	651	549	157	158	0	202
Scotian Shelf (4VWX5YZ)	6 574	5 170	4 762	4 355	4 552	4 359	3 117	2 194	3 737	4 241	2 691	1 601	2 357	1 173	1 116	552	381	3 284
Gulf of St. Lawrence (4RST)	11 021	15 161	16 540	14 914	12 002	9 006	20 399	25 411	40 045	32 676	23 414	24 663	30 478	18 654	28 635	18 755	6 128	21 361
East and south coasts of NFLD (3KLPO)	112	63	8	65	7	2 405	605	6 731	737	16 498	28 330	27 384	19 529	9 295	12 324	19 288	2 035	8 961
TOTAL	17 706	20 394	21 309	19 334	16 561	16 080	24 429	34 662	44 736	53 777	54 621	53 649	53 016	29 671	42 231	38 753	8 544	

[1] Preliminary

[2] Mackerel is occasionally caught in Division 2J (Labrador)

[3] Caught in 5YZ but landed in subarea 4

For several years, 40% of the Canadian TAC has been allocated to large seiners (or for all exploratory fishing) and 60% to small seiners, the "tuck" seine and gear such as the traps, gillnets, lines and weirs. Large seiners caught only 5% of their allocation in 2011, compared to 20% for the other types of fishing gear (Table 5).

Table 4. Annual Atlantic mackerel landings (t) by fishing gear since 1995. Data for 2011 is preliminary.

GEAR	YEAR																	AVERAGE
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011 [1]	(1995-2010)
Trawl	59	68	92	9	12	1	3	5	0	2	1	7	7	0	1	1	1	17
Midwater trawl[2]	0	0	0	0	0	0	0	0	0	0	0	14	15	0	0	0	0	2
"Tuck" seine	0	0	0	0	0	0	0	0	0	2 460	845	2 696	3 982	1 718	3 019	3 428	1 180	1 134
Purse seine < 65'	1 415	1 853	801	1 406	1 044	3 431	4 518	10 833	11 686	25 338	28 232	29 161	26 731	15 659	20 552	20 688	4 501	12 709
Purse seine > 65'	1 312	1 782	315	167	304	492	3 579	6 074	14 645	11 612	5 065	6 011	8 686	5 178	9 015	7 024	1 191	5 079
Other seines	0	0	9	0	0	5	231	344	22	0	6 393	4 782	3 327	186	681	1 097	15	1 067
Gillnet	4 481	6 420	6 657	7 638	5 128	5 297	6 610	4 958	4 542	4 734	3 930	4 509	3 629	2 475	3 472	2 736	378	4 826
Trap	4 728	3 821	3 889	3 999	4 057	4 215	3 237	2 088	3 651	4 699	3 420	2 337	2 906	1 153	1 657	1 129	634	3 187
Longline	0	0	0	7	3	4	20	19	16	4	61	48	0	9	3	0	10	12
Handline	3 823	4 708	6 204	3 651	5 435	2 230	5 676	9 839	9 857	3 855	5 338	3 180	2 739	2 367	2 859	2 075	573	4 615
Jigger	899	1 231	3 029	1 998	569	90	200	129	9	694	1 118	877	321	62	0	0	0	702
Mechanized jigger	0	0	0	0	0	0	0	0	0	1	1	0	0	270	729	386	39	87
Weir	177	0	1	141	8	0	46	48	74	2	20	3	0	2	0	0	0	33
Other	812	510	313	320	0	311	308	326	217	363	191	2	651	549	157	160	0	324
Not known	0	0	0	0	0	6	0	0	18	12	4	22	23	43	88	31	21	15
TOTAL	17 706	20 394	21 309	19 334	16 561	16 080	24 429	34 662	44 736	53 777	54 621	53 649	53 017	29 671	42 231	38 753	8 544	

[1] Préliminary

[2] Midwater trawl, exploratory fishery in Nova Scotia

Table 5. Atlantic mackerel landings (t) and allocations (t and %) since 1995. Data for 2011 is preliminary.

ALLOCATION	GEAR	YEAR																	AVERAGE
		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011 [1]	(1995-2010)
40%	Midwater trawl	0	0	0	0	0	0	0	0	0	0	0	14	15	0	0	0	0	2
	Purse seine >65'	1 312	1 782	315	167	304	492	3 579	6 074	14 645	11 612	5 065	6 011	8 686	5 178	9 015	7 024	1 191	5 079
	Total	1 312	1 782	315	167	304	492	3 579	6 074	14 645	11 612	5 065	6 024	8 702	5 178	9 015	7 024	1 191	5 081
	TAC	*40 000*	*40 000*	*40 000*	*40 000*	*40 000*	*40 000*	*30 000*	*30 000*	*30 000*	*30 000*	*30 000*	*30 000*	*30 000*	*30 000*	*30 000*	*24 000*	*24 000*	33 375
	% caught	3	4	1	0	1	1	12	20	49	39	17	20	29	17	30	29	5	17
60%	Purse seine <65'	1 415	1 853	801	1 406	1 044	3 431	4 518	10 833	11 686	25 338	28 232	29 161	26 731	15 659	20 552	20 688	4 501	12 709
	Other	14 980	16 760	20 193	17 762	15 213	12 158	16 332	17 755	18 405	16 827	21 323	18 464	17 584	8 835	12 665	11 041	2 851	16 019
	Total	16 394	18 612	20 994	19 168	16 257	15 589	20 850	28 588	30 091	42 164	49 555	47 625	44 316	24 493	33 217	31 729	7 353	28 728
	TAC	*60 000*	*60 000*	*60 000*	*60 000*	*60 000*	*60 000*	*45 000*	*45 000*	*45 000*	*45 000*	*45 000*	*45 000*	*45 000*	*45 000*	*45 000*	*36 000*	*36 000*	50 063
	% caught	27	31	35	32	27	26	46	64	67	94	110	106	98	54	74	88	20	61
	GRAND TOTAL	17 706	20 394	21 309	19 334	16 561	16 080	24 429	34 662	44 736	53 777	54 621	53 649	53 017	29 671	42 231	38 753	8 544	33 808

[1] Préliminary

ANALYSIS

Description of catches

Catch-at-age

One of the main demographic characteristics of the Atlantic mackerel is the periodic arrival of dominant year-classes. Such year-classes, as those of 1967, 1974, 1982, 1988 and 1999, completely dominated commercial catches for several years and are very obvious in the catch-at-age (Figure 3A). For example, fish from the 1999 year-class contributed to 77% of all catches (in numbers) that were made between 2000 and 2004. The abundance of this year-class started declining in 2005 and since then, the catch-at-age of Atlantic mackerel is instead characterized by year-classes that are caught quickly. That is the case for the 2003, 2005, 2007 and 2008 year-classes (Figures 3A and 3B), the relative importance of which is higher than the mean but lower than that of the dominant year-classes (Figure 3C). The mean age of catches decreased between 1994 and 2000 (Figure 3D). It increased in the early 2000s with the arrival and aging of the 1999 year-class. The mean age increased slightly in 2011 after having decreased between 2003 and 2010.

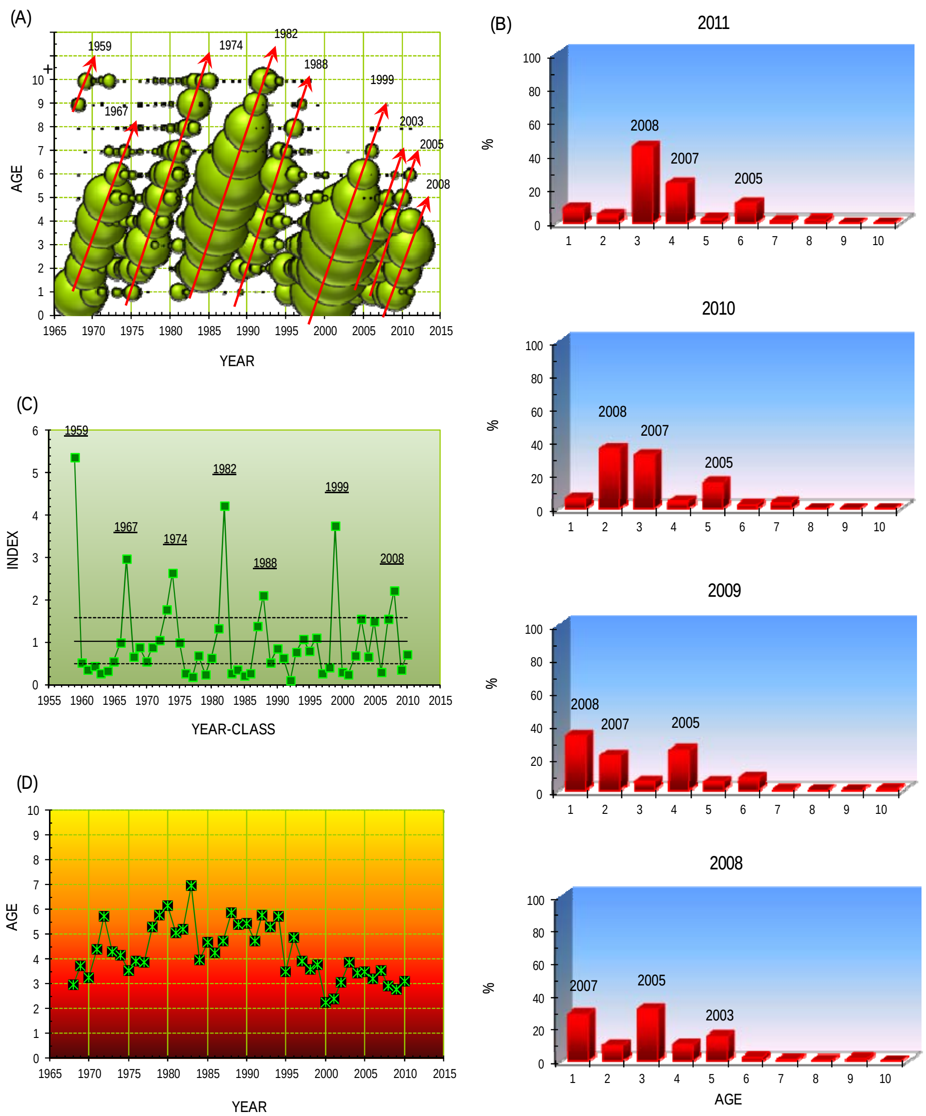

Figure 3. Catch-at-age in % (A and B) (dominant year-classes are indicated), Johnson index representing relative strength of year-classes (horizontal lines representing average ± 0.5 x standard deviation) (C) and mean age (D) of Atlantic mackerel catches from NAFO subareas 3 and 4.

Length frequencies

Mackerel length frequencies are characterized by the occurrence of a main mode that shifts toward larger sizes over the years (Figure 4). Such modes associated with dominant year-classes are observed in length frequencies for all fishing gear. However, their arrival in length frequencies varies according to the gear selectivity. That is the case for the 2008 year-class which was observed as early as 2009 in length frequencies of line (4T) and seine fisheries (4R), but only in 2011 in gillnet (4T) length frequencies.

In 2011, a reduction in the mean length was measured in the catches of the gillnet and line fisheries. The 2008 year-class was observed in the length frequencies of the gillnet, line and seine fisheries (4R) (Figure 4). However, the 2010 year-class was observed only in the length frequencies of the line fishery.

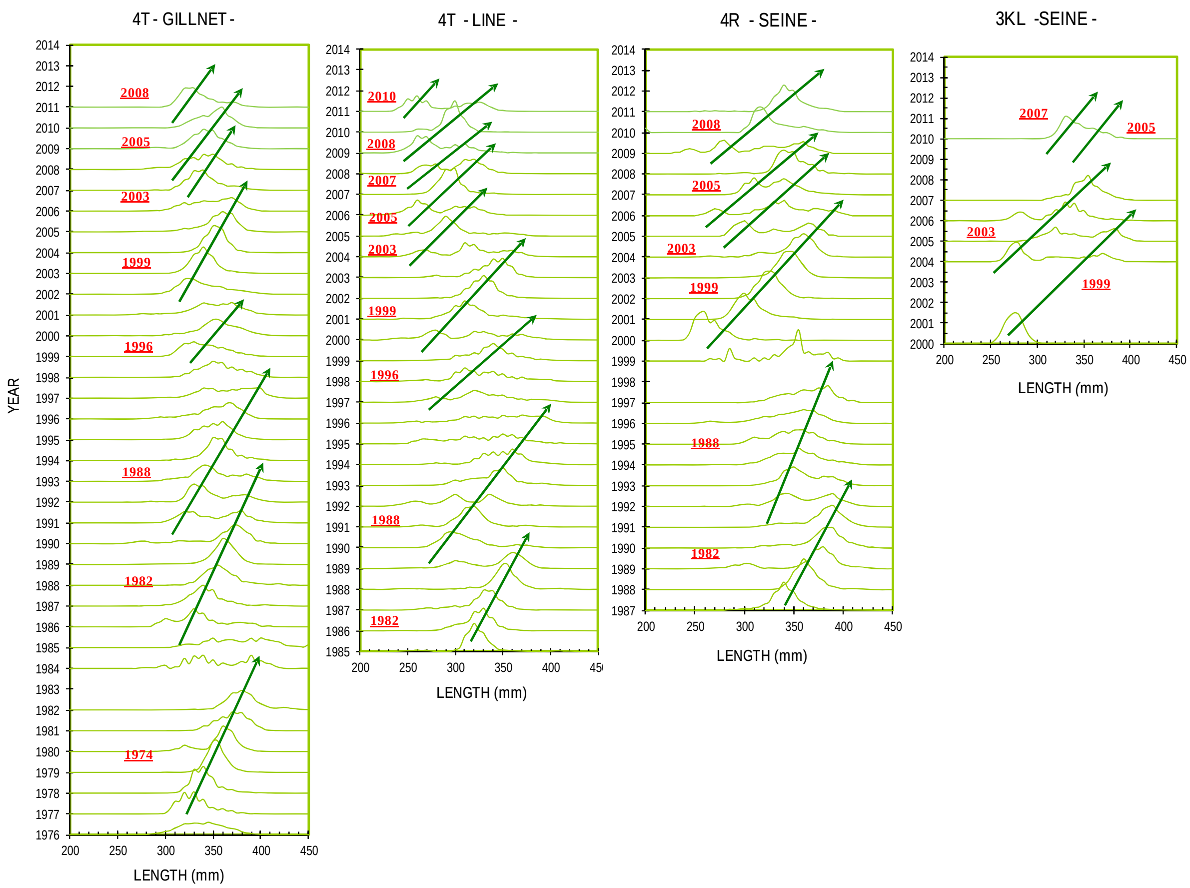

Figure 4. Annual length (mm) frequencies (%) of Atlantic mackerel caught with gillnets and lines in Division 4T and with seines in Divisions 3KL and 4R (the year-classes that dominated these fisheries are indicated).

Resource status

Biological indicators

The Fulton condition factor, measured in June, presented higher than average values (1973-2010) between 1973 and 1984 as well as in 1999, 2001, 2006 and since 2009 (Figure 5). Annual condition factor variations are associated with cold intermediate layer (CIL) temperature index variations.

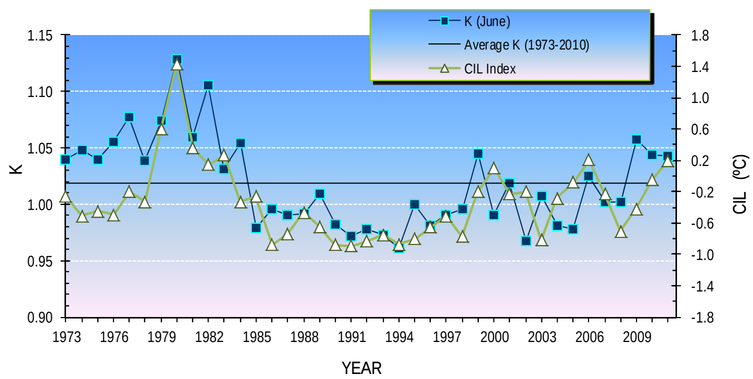

Figure 5. Fulton condition factor (K) calculated from samples collected in June in NAFO subareas 3 and 4 since 1973 and temperature index (°C) of the cold intermediate layer, or CIL. The mean condition factor for the 1973-2010 period is also indicated.

The proportion of mature fish at age has not varied much over the years (Figure 6A). Age at 50% maturity (A_{50}) increased from 1.35 in the 1980s to 1.48 and 1.40 in the 1990s and 2000s. In 2010 and 2011, A_{50} was 1.69 years (Figure 6B).

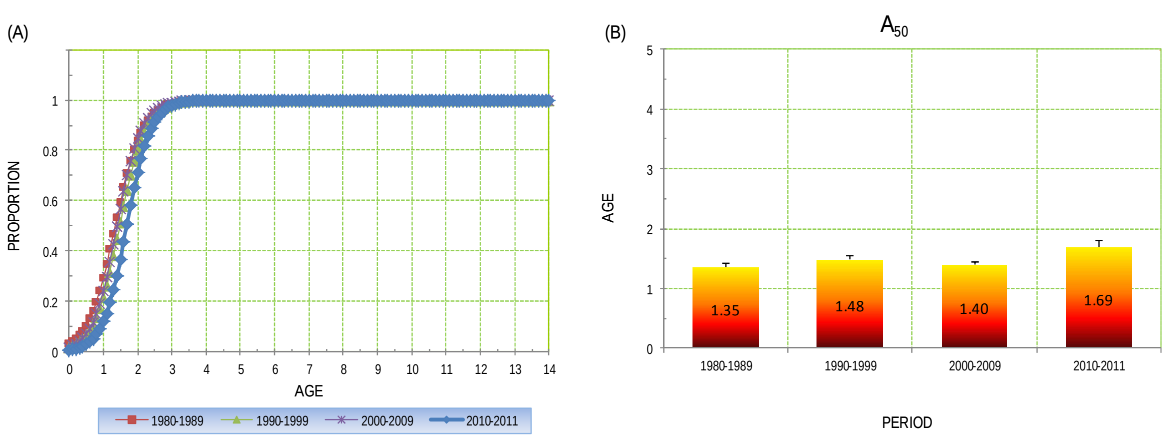

Figure 6. Proportion of mature fish at age calculated by period of years (A) and age at 50% maturity or A_{50} (B) (with confidence intervals at 95%) for Atlantic mackerel sampled in June in NAFO subareas 3 and 4 since 1980.

The proportion of mature fish at length has varied considerably over the years (Figure 7A). Length at 50% maturity (L_{50}) decreased from 272.91 to 259.57 mm between the 1970s and 1980s (Figure 7B). This length was 266.17 mm in the 1990s, before reaching a minimum of 245.03 mm in the 2000s. In 2010 and 2011, L_{50} was 273.92 mm.

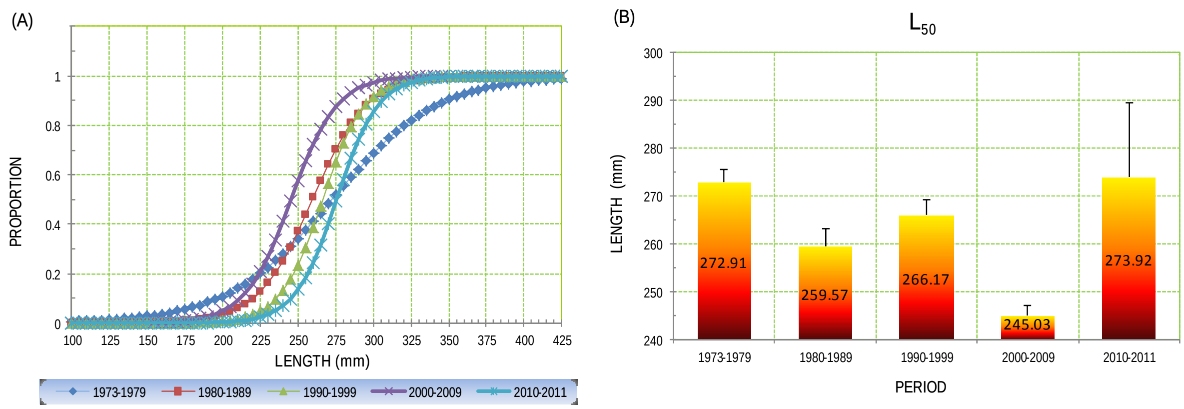

Figure 7. Proportion of mature fish at length calculated by period of years (A) and length at 50% maturity or L_{50} (B) (with confidence intervals at 95%) for Atlantic mackerel sampled in June in NAFO subareas 3 and 4 since 1973.

Egg surveys

The 2011 egg survey took place from June 11 to 19. The highest egg densities (eggs/m^2) were measured in the northwest part of the sampled area, especially in the area off the Miramichi Bay (Figure 8A). The densities measured in 2011 were generally higher than those in 2010 but lower than previous survey densities. The mean water temperature (0-10 m) was 9.5°C, compared to 9.3°C for the 2010 survey. The highest egg densities were found at stations with the warmest water temperatures (Figure 8B). Very few Atlantic mackerel larvae were sampled during the 2011 survey.

As indicated by the daily egg production curve (Figure 9), the median date (June 15 or day 166 of the year) of the 2011 survey corresponds to the maximum spawning date. The daily egg production measured at that date was used to calculate the total or annual egg production. Using the mean weight of the females, fecundity and sex ratio, the total egg production was converted into the spawning biomass index.

Spawning biomass index

The spawning biomass index has increased three times over the years; these increases are associated with the arrival of the dominant year-classes of 1982, 1988 and 1999 (Figure 10). The index fell sharply between 1993 and 1998. Since 2005, historically low values of approximately 66,590 t per year have been measured.

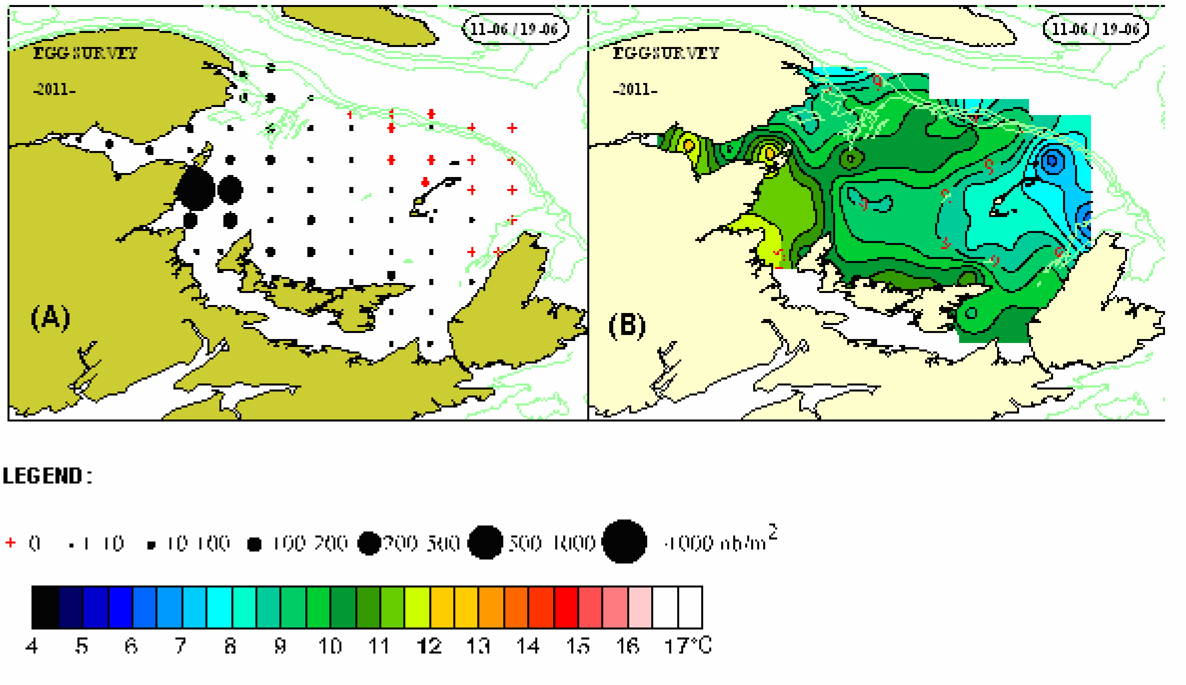

Figure 8. Atlantic mackerel egg (stages 1 and 5) abundance (nb/m^2) distribution (A) and average water temperatures (°C) (mean 0-10 m) (B) measured during the 2011 survey in the southern Gulf of St. Lawrence.

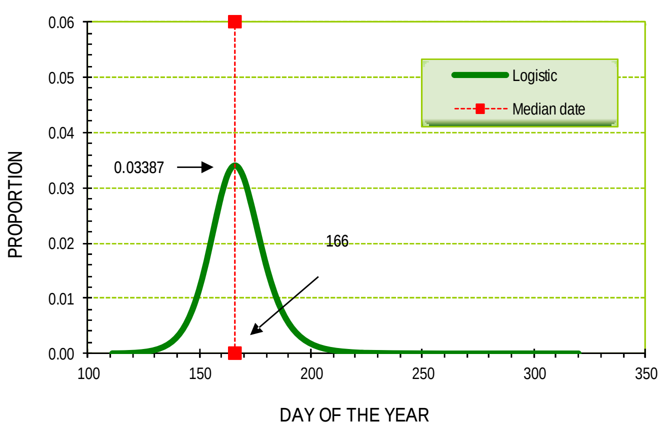

Figure 9. Density curve describing the proportion of eggs spawned daily during the 2011 spawning season (median survey date and proportion of eggs spawned at that date are indicated). This curve was adjusted using a logistic model applied to the mean daily gonado-somatic index.

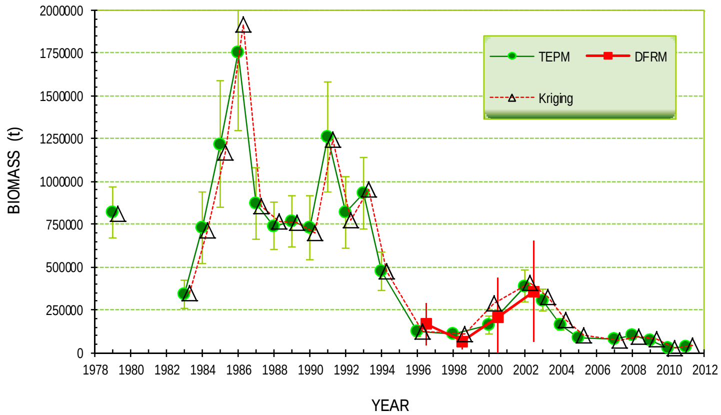

Figure 10. Spawning biomass (t) of Atlantic mackerel calculated using two approaches (TEPM: Total Egg Production Method; DFRM: Daily Fecundity Reduction Method) and two different techniques (stratified and kriging means). No index was calculated in 2006 because the survey was conducted at the end of the spawning season.

Egg survey on the Scotian Shelf and south coast of Newfoundland

An egg survey was conducted between June 2 and 19, 2009, on the Scotian Shelf and south coast of Newfoundland. This survey was carried out with funding from the Larocque Scientific Program to confirm the hypothesis that a large part of the Canadian contingent would spawn in this area. If this hypothesis is dismissed, the extremely low biomass values measured in the southern Gulf of St. Lawrence since 2005 would result in a real decrease in abundance.

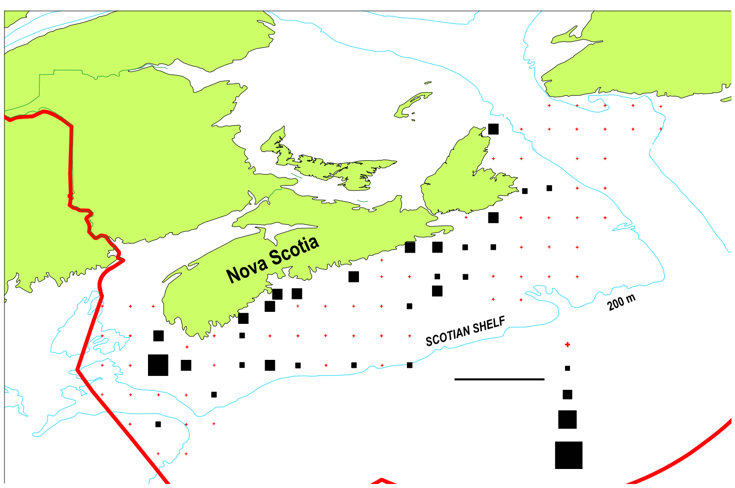

Figure 11. Atlantic mackerel egg (stages 1 and 5) abundance (nb/m^2) distribution measured during the 2009 survey on the Scotian Shelf and the south coast of Newfoundland.

Atlantic mackerel eggs were found at only 28 (30%) of the 93 stations sampled. Most of the eggs were found along the coast and in the area between southwestern Nova Scotia and

Georges Bank (Figure 11). Some eggs were also found offshore, at the edge of the continental shelf. Water temperatures varied between 4.8 and 11.7°C for an average of 8.8°C. The highest egg densities were measured at stations with the warmest temperatures. However, compared to similar temperatures, higher egg densities have been already measured in the southern Gulf of St. Lawrence. The spawning biomass associated with egg densities from the 2009 survey was estimated at just 2,576 t.

Analytical assessment

An analytical assessment based on a sequential population analysis (SPA) was undertaken using the Canadian catch-at-age (1968-2011) and the spawning biomass index from the southern Gulf egg survey (1996-2011). The diagnostic review resulting from this analysis does not suggest any major adjustment problems. However, a slight retrospective pattern was observed for the abundances and fishing mortalities, but no such pattern was present in the case of spawning biomasses.

The SPA results indicate a very strong recruitment in 1967, 1974, 1982, 1999 and 2003 (Figure 12). All of these year-classes have a higher abundance than the high recruitment level. The 2005, 2007 and 2008 year-classes have a higher abundance than the medium recruitment level, but are quickly caught as a result of high fishing mortalities (Figure 13). Fishing mortalities were stable between 1968 and 1992. They then increased since 1993 to reach values above 0.50 at the end of the 1990s. Following a decrease in mortality in young year-classes, a new increase was measured in the 2000s when older year-classes reached very high values. A decrease has been observed in all year-classes since 2008.

The two fishing mortality increases were accompanied by corresponding declines in the spawning and total biomasses (Figure 14). The lowest biomasses were estimated in 1999. Following an increase caused by the arrival of the 1999 year-class, biomasses have been declining since 2006.

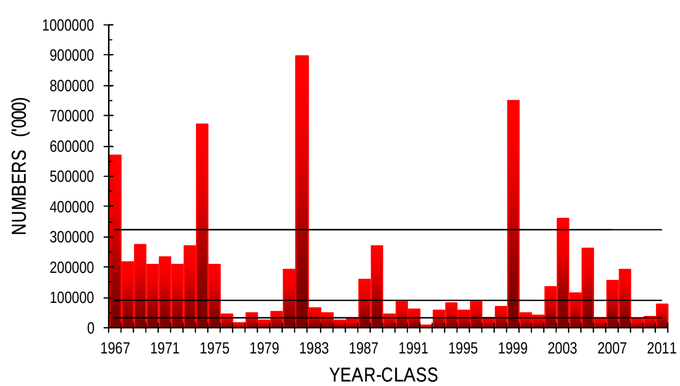

Figure 12. Estimation of Atlantic mackerel recruitment ('000) at age 1 in NAFO subareas 3 and 4 for year-classes from 1967 to 2011. Horizontal lines represent three levels of recruitment: low, medium and high.

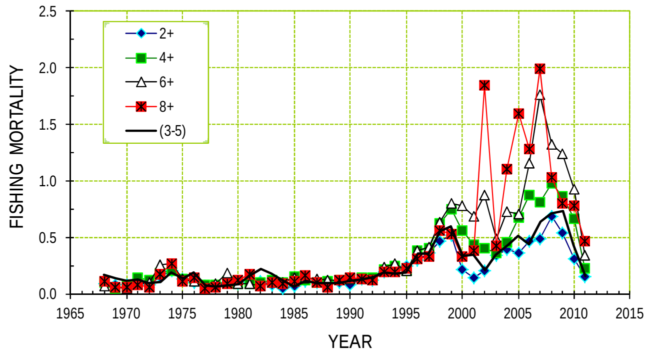

Figure 13. Atlantic mackerel fishing mortality in NAFO subareas 3 and 4 for various age groups from 1968 to 2011. Fishing mortalities were weighted by corresponding age abundances.

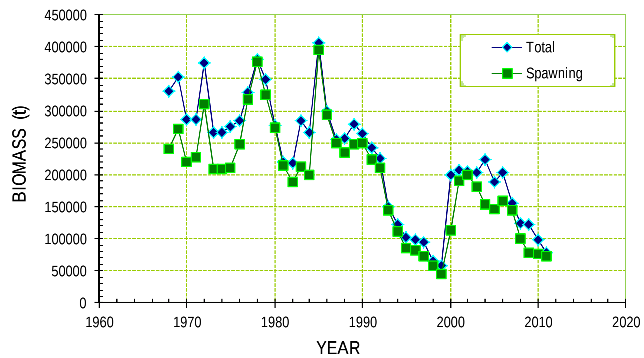

Figure 14. Total and spawning Atlantic mackerel biomasses (t) in NAFO subareas 3 and 4 for the 1968-2011 period.

Projections

Catches were projected over two years (2012 and 2013) from abundances at age ($1\text{-}10^{+}$) estimated at the beginning of 2012 by the SPA. Fishing mortality (average of ages 3-5 weighted by the corresponding abundances) was set at 0.124, or the average value for the 1968-1992 period. That period corresponds to a sustainable fishery level. Natural mortality was set at 0.2 for all ages.

Based on these projections, 2012 and 2013 catches should be 8,785 t and 8,636 t, respectively. A spawning biomass increase of approximately 3% would be associated with such catches.

Sources of uncertainty

Unrecorded catches

Catches used for bait, which account for several thousand tons, are not all counted in the statistics of the Department. Catches of the recreational fishery, which is very popular in summer, are not recorded too. Because this activity is practised throughout Eastern Canada by many people, including tourists (and on charter ships in certain cases!), the actual Atlantic mackerel catch statistics are largely underestimated. In view of future management of this activity and to improve statistics on fisheries overall, consideration should be given to developing methods for estimating these catches.

Discards of small Atlantic mackerel

The discarding of Atlantic mackerel under the minimum legal catch size (250 mm) or below industry requirements 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. Measures such as relocating fishing activities to reduce the impact of discarding on the abundance of future year-classes should be considered.

CONCLUSIONS AND ADVICE

The biomass index from the egg survey in the southern Gulf of St. Lawrence fell sharply in the mid-1990s. This index has also presented historically low values since 2005. As survey results from the Scotian Shelf and the south coast of Newfoundland have shown, these low values truly represent low abundances and exclude the possibility that a significant portion of the Canadian contingent spawns outside the Gulf of St. Lawrence.

Given that stock abundance is not expected to increase in the short term (lack of strong recruitment in catch-at-age and according to SPA), the fishing mortalities should be lower over the next few years compared to that of 2011. As a result, to bring back fishing mortality to the average sustainable level of the years 1968-1992, catches in 2012 and 2013 should not exceed 9,000 t.

SOURCES OF INFORMATION

This Science Advisory Report is from the April 18, 2012 Assessment of the Atlantic mackerel in subareas 3 and 4. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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