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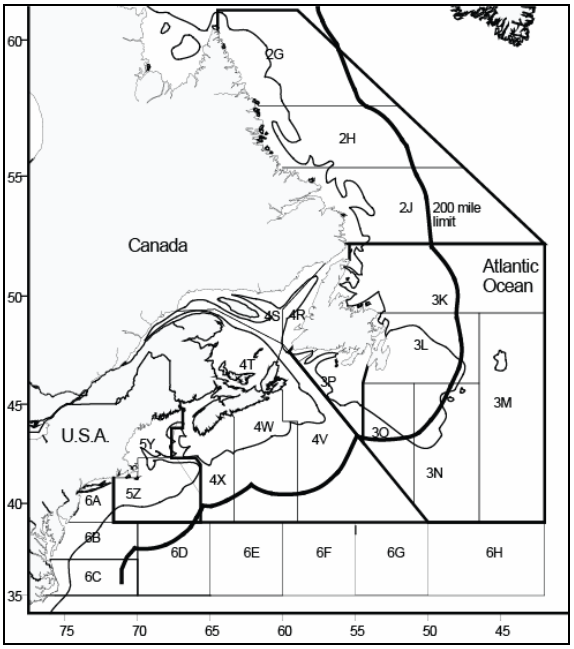
NOAA FISHERIES NATIONAL MARINE FISHERIES SERVICE

Transboundary Resources Assessment Committee

Status Report 2010/01

ATLANTIC MACKEREL IN THE NORTHWEST ATLANTIC

[NAFO Subareas 2 - 6]



Summary

- Combined Canada and USA catches for the 2008 calendar year were 50,685 metric tons (mt).

- A number of different models and model formulations were evaluated. A VPA-ADAPT model including variable natural mortality at age, the spring Northeast Fisheries Science Center (NEFSC) survey index split in 1984-1985 and 1992-1993, a commercial bottom trawl CPUE index split in 1988-1989, and a mid-water trawl CPUE index with no split, was selected as the best available model at the time of the assessment.

- Given the uncertainty in the assessment results, the TRAC agreed that short term projections and characterization of stock status relative to estimated reference points would not be an appropriate basis for management advice at this time.

- Given current indications of reduced productivity and lack of older fish in the survey and catch, it is recommended that annual total catches not exceed the average total landings (80,000 mt) over the last three years (2006-2008) until such time that new information suggests that a different amount is appropriate.

Landings (mt), Biomass (mt), Recruits (thousands of fish)

		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Avg[1]	Min[1]	Max[1]
Canada	**Commercial**	16,561	13,383	23,950	34,309	44,475	53,365	54,279	53,649	53,016	28,245	27,524	13,383	54,279
USA	**Commercial**	12,031	5,649	12,340	26,530	34,298	54,990	42,187	56,640	25,547	21,749	16,371	1,605	56,640
	Recreational	1,335	1,448	1,536	1,294	770	530	1,033	1,633	884	691	1,748	284	4,223
	US Total	13,366	7,097	13,876	27,824	35,068	55,520	43,220	58,273	26,430	22,440	17,949	1,605	58,273
Total	**Landings**	29,927	20,480	37,826	62,133	79,543	108,885	97,499	111,922	79,446	50,685	53,744[2]	20,480	111,923
Values Below are Indicative of Trend Only														
Total Biomass			752,000	640,000	520,000	460,000	532,000	404,000	368,000	246,000	200,000			
Spawning Stock Biomass (SSB)			155,000	313,000	354,000	280,000	222,000	209,000	136,000	113,000	154,000[3]			
Age 1 Recruits (000s)			2,989,000	382,000	280,000	711,000	1,192,000	377,000	746,000	210,000	376,000			
Fishing mortality (4-6)[4]			0.17	0.18	0.23	0.32	0.53	0.52	1.11	0.98	0.51			

[1] commercial, 1978-2008; recreational, 1981-2008
[2] includes foreign landings
[3] adjusted for retrospective [using 7-year peel]
[4] age-varying M precludes exploitation rate estimation

Stock Distribution and Identification

Northwest Atlantic Mackerel (Northwest Atlantic Fisheries Organization, NAFO, Subareas 2-6) are assessed as a single stock that ranges from North Carolina to Labrador, with northern and southern spawning contingents. This transboundary stock is migratory and seasonal distribution patterns are influenced by water temperature.

Fishery

Prior to 2001, the Canadian quota was 100,000 mt. From 2001-2008, it was reduced to 75,000 mt following the low biomass estimates from the southern Gulf of St. Lawrence egg survey (DFO 2008). USA quotas, which vary annually based on biomass and other factors, are reduced by anticipated Canadian landings. USA Allowable/Acceptable Biological Catches (ABCs) have declined from 383,000 mt in 1999 to 156,000 mt in 2008, as new information from stock assessments and Canadian catches have been incorporated.

Canadian and USA quotas and USA Allowable/Acceptable Biological Catch (ABC).

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Canadian Quota	100,000	100,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000	75,000
US ABC	383,000	347,000	347,000	347,000	347,000	347,000	335,000	335,000	186,000	156,000
US Quota	75,000	75,000	85,000	85,000	175,000	170,000	115,000	115,000	115,000	115,000

Atlantic mackerel were heavily exploited by foreign fleets during the 1970s. **Total landings** in NAFO Subareas 2-6 peaked at an average of 347,000 mt during 1970-1976 (Figure 1), but were less than 50,000 mt annually during 1978-1984. During 1985-1991, total landings averaged 76,000 mt per year, but averaged only 32,501 mt from 1992-2001. Total landings averaged 72,047 mt from 2002-2008. In 2008, total landings were 50,685 mt.

USA commercial landings averaged 2,368 mt from 1960 to 1983, but peaked at 31,261 mt in 1990 before declining to 4,666 mt in 1993. Annual commercial landings averaged 23,673 mt during 1994-2008, with a record-high of 56,640 mt in 2006. Landings from 2005-2008 averaged 37,000 mt. Commercial discards have been estimated since 1989, and constitute a small fraction of the catch. **USA recreational catches** have been estimated since 1981 (Figure 1). The recreational catches average 1,748 mt over the time series, with a high of 4,223 mt in 1986 and a low of 284 mt in 1992.

Canadian commercial landings were relatively stable at approximately 20,000 mt per year during 1968-2000 (Figure 1). Canadian commercial landings increased to a peak of 54,279 mt in 2005, remained over 50,000 mt in 2006 and 2007, and were 28,245 mt in 2008. The Canadian bait and recreational catches of mackerel are not known. Due to lack of data availability, discards of mackerel in Canadian commercial fisheries have not been estimated.

Harvest Strategy and Biological Reference Points

The Atlantic mackerel 2010 TRAC recommends that a strategy be adopted to maintain a low to neutral (less than 50%) risk of exceeding the fishing mortality (F) limit reference point ($F_{40\%}$). The TRAC further recommends that when stock conditions are poor, fishing mortality rates should be further reduced to promote rebuilding. Deterministic per recruit reference points (proxies for F_{msy}) were estimated as: $F_{0.1}$=0.29 and $F_{40\%}$=0.25.

Projections, with stochastic sampling of recruits from 1985-2008, produced an estimate of $SSB_{40\%}$ (proxy for SSB_{msy}) of 194,000 mt (10^{th}-90^{th} percentiles of 143,500 mt and 296,600 mt). This implies a Maximum Sustainable Yield (MSY) proxy (yield at $F_{40\%}$) of 37,200 mt (10^{th}-90^{th} percentiles of 27,400 mt and 55,300 mt,). Confidence intervals provided here incorporate only a fraction of the uncertainty. **As the estimates of $SSB_{40\%}$ and $MSY_{40\%}$ are dependent on the model results and both estimates are also highly uncertain, the TRAC does not recommend their adoption.**

Projections were also done using the 1962-2008 recruitment series, which generated an estimate of $SSB_{40\%}$ of 441,000 mt; however, evidence for recent reductions in productivity suggests the use of the 1985-2008 recruitment period may be more appropriate. A methodology to adjust recruitment estimates prior to the terminal year relative to Mohn's rho (retrospective adjustment) has not yet been developed. This creates an inconsistency when comparing Mohn's rho adjusted estimates of 2008 SSB to biomass reference points derived using unadjusted recruitment estimates.

State of Resource

Atlantic mackerel was last assessed in 2005 in the USA (NEFSC 2006) and in 2008 in Canada (DFO 2008). The 2005 USA assessment was based on an ASAP model, tuned using the NEFSC spring survey, split in 1984-1985 (and the assessment also included Canadian landings). The 2008 Canadian assessment was based on spawning stock biomass estimates derived from the southern Gulf of St. Lawrence egg survey (but the

assessment did not include USA landings). Given that Atlantic mackerel is a transboundary stock, the first joint Canada/US TRAC assessment was conducted. To develop a joint assessment approach, two benchmark review meetings were held during which a number of different models and model formulations were evaluated.

The benchmark review agreed to use the NEFSC spring survey index and two commercial catch per unit effort (CPUE) indices (bottom-trawl and mid-water trawl) as tuning indices for the TRAC assessment. A VPA-ADAPT model was selected with (a) the spring NEFSC survey index split in 1984-1985 and 1992-1993; (b) the bottom trawl CPUE index split in 1988-1989 and the mid-water trawl CPUE index with no split and (c) using a variable natural mortality (M) at age (from the ASAP model) to account for predation. The VPA-ADAPT model exhibits a strong retrospective pattern (Figure 2), with the terminal year population estimates uncertain (high coefficients of variation) and perhaps biased.

The assessment model was faced with resolving disparate trends between the NEFSC spring survey and CPUE indices and total landings. Despite very large annual catches in the 1970s, there was very little change in the spring survey index during these years. Later in the assessment time series, a generally increasing trend in the survey index was co-incident with a rapid disappearance of older age classes in both the survey catches and the commercial landings. This situation contributed to a large retrospective pattern (aliasing survey catchability with the two opposing trends).

The retrospective patterns in the model were addressed by applying a survey split in 1984-1985 (which was used in the 2005 USA assessment), as well as applying an additional split in 1992-1993. The 1984-1985 split is justified by a change in survey trawl door at this time, as well as indications in the survey of changing mackerel distribution from deeper to shallower water. The mechanism for the 1992-1993 split has not yet been established; however, this split improved model diagnostics. In both instances, the splits may be aliasing other factors. Simulations presented at previous USA groundfish assessments indicated that assessments that exhibit strong retrospective pattern provided more reliable catch advice (i.e., closer to F_{ref} in the simulated population) by splitting the surveys, regardless of the cause of the retrospective pattern (GARM 2008).

Estimated fishing mortality for Atlantic mackerel (F; averaged over ages 4-6) increased from 0.17 in 2000 to a peak of 1.11 in 2006 (the highest in the time series), but decreased to 0.51 in 2008 (Figure 3A). The 10^{th} and 90^{th} percentiles of F in 2008, obtained from bootstrap runs of the selected VPA model, were estimated as 0.33 and 1.91, respectively. Retrospective analysis showed that, for a given year, F estimates generally declined with each additional year of data (Figures 2A and 2B).

Estimated SSB declined from 1,359,003 mt in 1972 to 96,968 mt (unadjusted for retrospective) in 2008 (Figure 3). The 10^{th} and 90^{th} percentiles of SSB in 2008 from bootstrap runs of the selected VPA were 71,710 mt and 141,196 mt, respectively. Retrospective analysis showed that, for a given year, SSB estimates generally increased with each additional year of data (Figures 2C and 2D).

Estimated recruitment (age 1) was characterized by occasional large year classes, especially the 1967, 1982, and 1999 cohorts (Figure 3). However, in recent years, recruitment has generally been lower, averaging 566 million age 1 fish during 1985-2009. By comparison, recruitment averaged 2.1 billion fish at age 1 during 1962-1984, and 1.3 billion age 1 fish over the entire assessment time series. Retrospective analysis showed that, for a given year, recruitment estimates generally increased with each additional year of data (Figure 4).

The large magnitude of the retrospective pattern warranted application of Mohn's Rho (the average of the relative difference between the terminal value and the previous 7 years) to the terminal year estimates of F, SSB and recruitment. For F, the Mohn's Rho value was 1.81, which resulted in the 2008 F being adjusted from 0.51 to 0.18. For SSB, Mohn's Rho was -0.35, which resulted in adjusting the 2008 SSB from 96,968 mt to 153,100 mt. For recruitment, Mohn's Rho was -0.20, which resulted in adjusting the size of the 2007 year class at age 1 in 2008 from 376 million to 467 million fish.

Productivity

The relatively low estimated recruitment after the 1982 year class suggests that the productive potential of the stock may be less than previously believed. The lack of older fish since the late 1990s in the NEFSC spring survey and also in the USA and Canadian commercial catches may be an indication of low stock productivity and high mortality. The Canadian egg survey in the southern Gulf of St. Lawrence has been low for several years; the Scotian Shelf was surveyed for mackerel eggs in 2009 and densities were extremely low. Mackerel in Canadian waters appear to have been maturing at smaller length since 2000, and, in USA waters, mackerel appear to have been maturing at younger ages since 1995. However, no trend is evident in mackerel mean weights at age over the time series.

Outlook

Given the uncertainty in the assessment results, the TRAC agreed that short term projections and characterization of stock status relative to estimated reference points would not be an appropriate basis for management advice at this time. Given current indications of reduced productivity and lack of older fish in the survey and catch, the TRAC recommended that total annual catches not exceed the average total landings (80,000 mt) over the last three years (2006-2008) until such time that new information suggests that a different amount is appropriate.

Special Considerations

Results of the current TRAC assessment differ substantially from those in the 2005 USA assessment (using an ASAP model), which indicated an increasing trend in SSB, although the 2005 assessment had a severe retrospective pattern that was not taken into account. A comparison of the 2005 retrospective pattern with the comparable ASAP

model updated to 2008 and with the current VPA model is shown in Figures 5 and 6, respectively. These comparisons indicate that the marked change in estimates of F and SSB between the 2005 USA assessment and the current TRAC assessment can be explained by the magnitude of the retrospective patterns (that is, if the 2005 assessment results had been adjusted for the retrospective pattern, the adjusted results would have been similar to the current assessment results). Previous reference points generated from the 2005 USA assessment were: F_{MSY} = 0.16; $F_{40\%}$ = 0.24; SSB_{MSY} = 644,000 mt; and MSY = 89,000 mt. However, given the significant retrospective pattern in the 2005 USA assessment, these reference points are now considered to be inappropriate.

The current TRAC assessment results are consistent with the decreasing trend in SSB estimates in the Gulf of St. Lawrence during the past decade as derived from the egg surveys reported in the 2008 Canadian mackerel assessment (DFO 2008).

The distribution of the USA mackerel fishery is currently inshore relative to the historical foreign fishery. Exploration further offshore (e.g., deeper than 200 m) may help to provide a better understanding of the stock dynamics of mackerel.

For the purposes of status determination under the *USA Magnuson-Stevens Fishery Conservation and Management Act*, the TRAC considers the status of Atlantic mackerel to be 'unknown'.

Source Documents

Deroba, J., G. Shepherd, F. Gregoire, J. Nieland, and P. Rago. 2010. Stock Assessment of Atlantic Mackerel in the Northwest Atlantic for 2010. TRAC Ref. Doc. 2010/01.

DFO. 2008. Assessment of the Atlantic Mackerel Stock for the Northwest Atlantic (Subareas 3 and 4) in 2007. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2008/041.

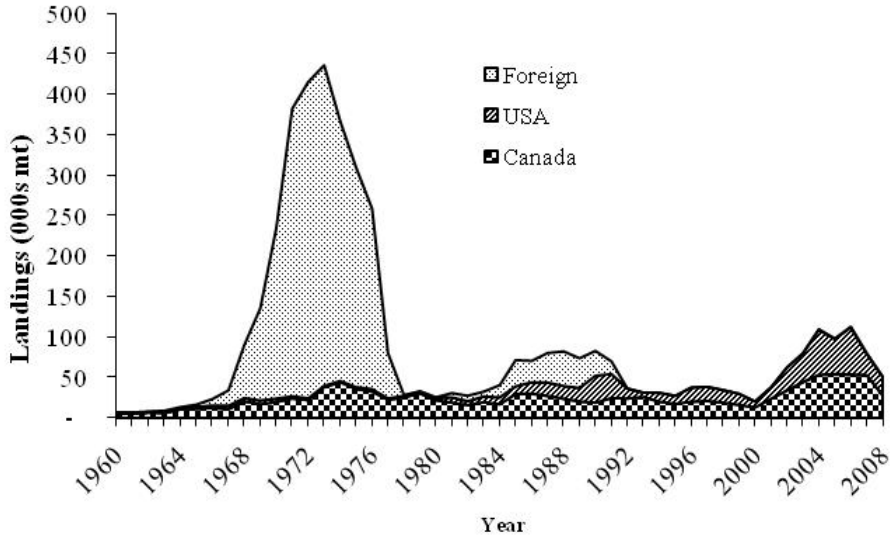
GARM. 2008. Report of the Retrospective Working Group. A Working Paper in Support of Term of Reference 4. Working Paper 4.1 GARM 2008 Methods Meeting Woods Hole, MA; 25-29 February 2008. http://www.nefsc.noaa.gov/GARM-Public/2.%20Models%20Meeting/for%20review/TOR4%20Retrospective%20Patt/

NEFSC. 2006. 42nd Northeast Regional Stock Assessment Workshop (42nd SAW): 42nd SAW Assessment Summary Report. US Dep. Commer., Northeast Fish. Sci. Cent. Ref. Doc. 06-01; 61 p.

Correct Citation

TRAC. 2010. Atlantic Mackerel in the Northwest Atlantic. TRAC Status Report 2010/01.

(A)



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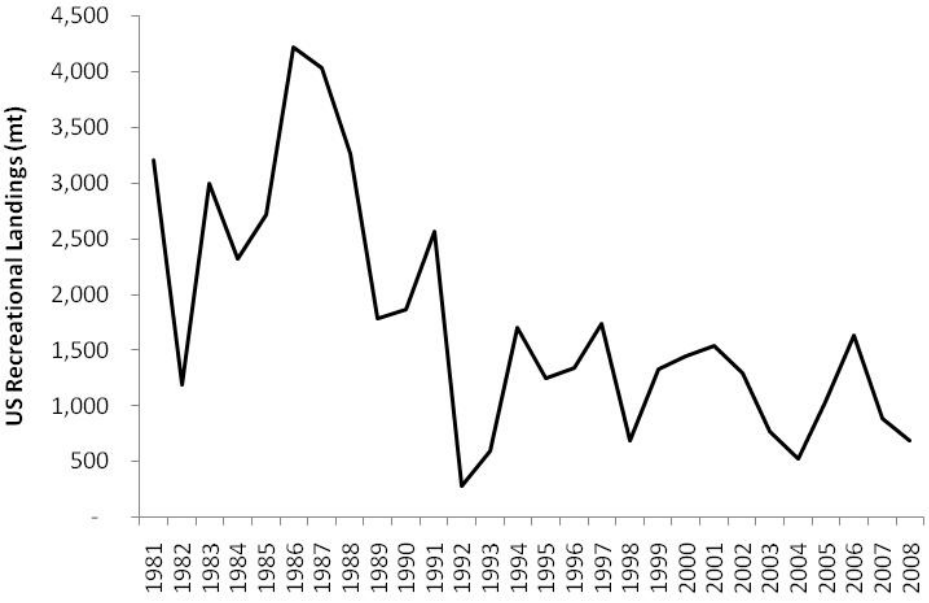

Figure 1. Commercial (A) and recreational (B) landings in the Northwest Atlantic since 1960.

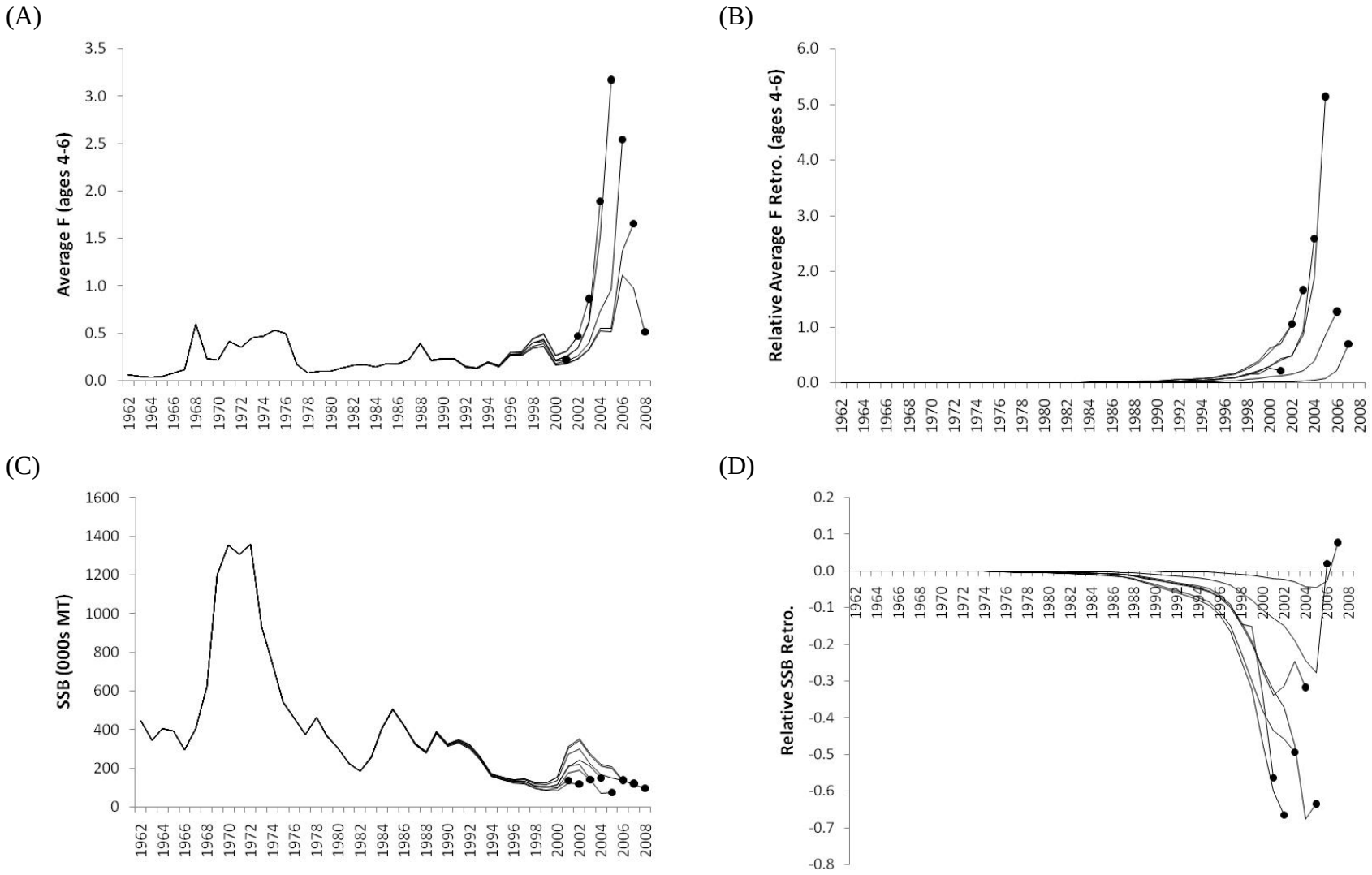

Figure 2. Retrospective patterns in average fishing mortality rate (ages 4-6) (A and B) and spawning stock biomass (C-D) from the final VPA model selected by the TRAC.

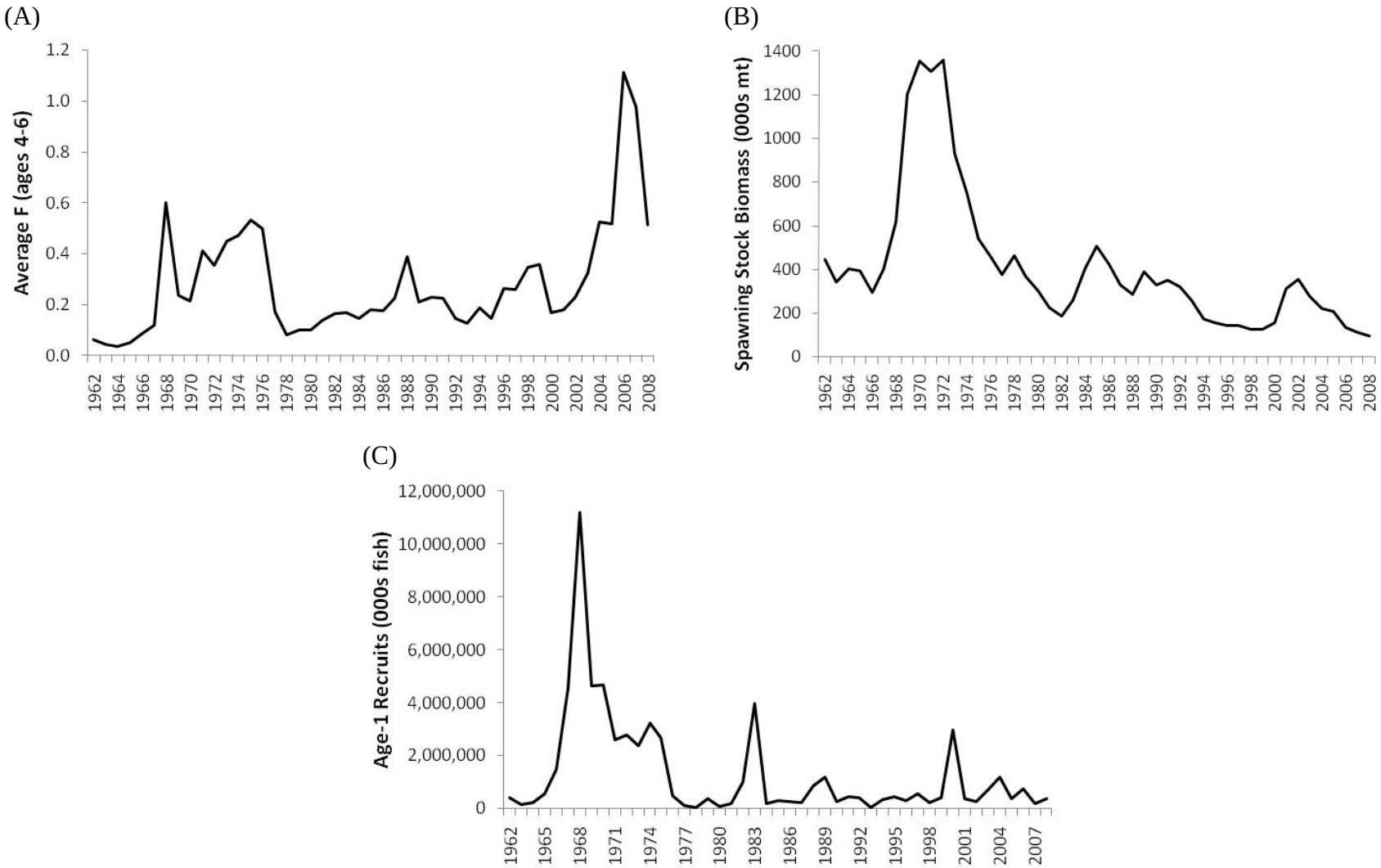

Figure 3. Average fishing mortality rate (ages 4-6) (A), spawning stock biomass (B), and age 1 recruitment (C) from the final VPA model selected by the TRAC.

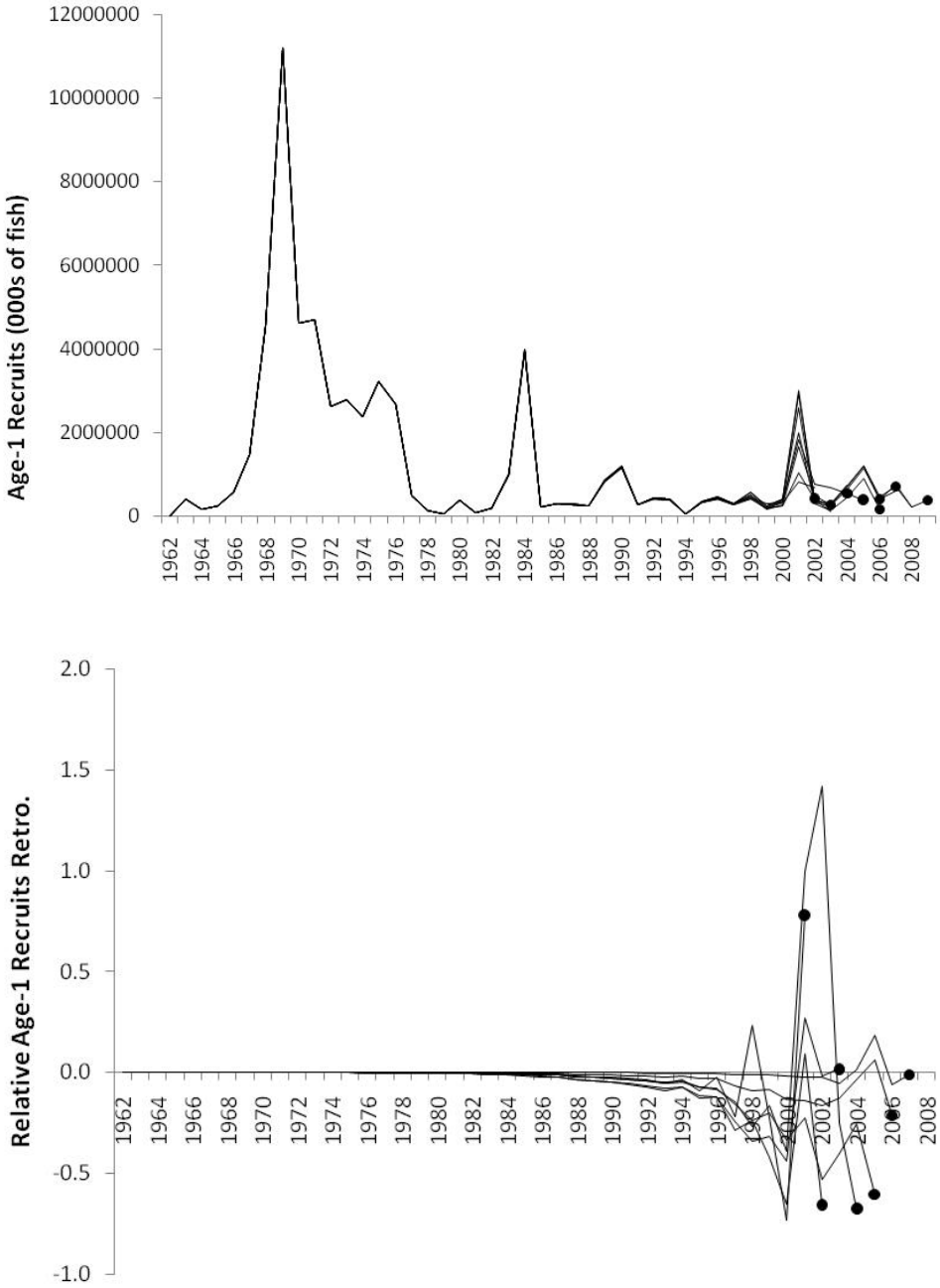

Figure 4. Retrospective pattern in age-1 recruits from the final VPA model selected by the TRAC.

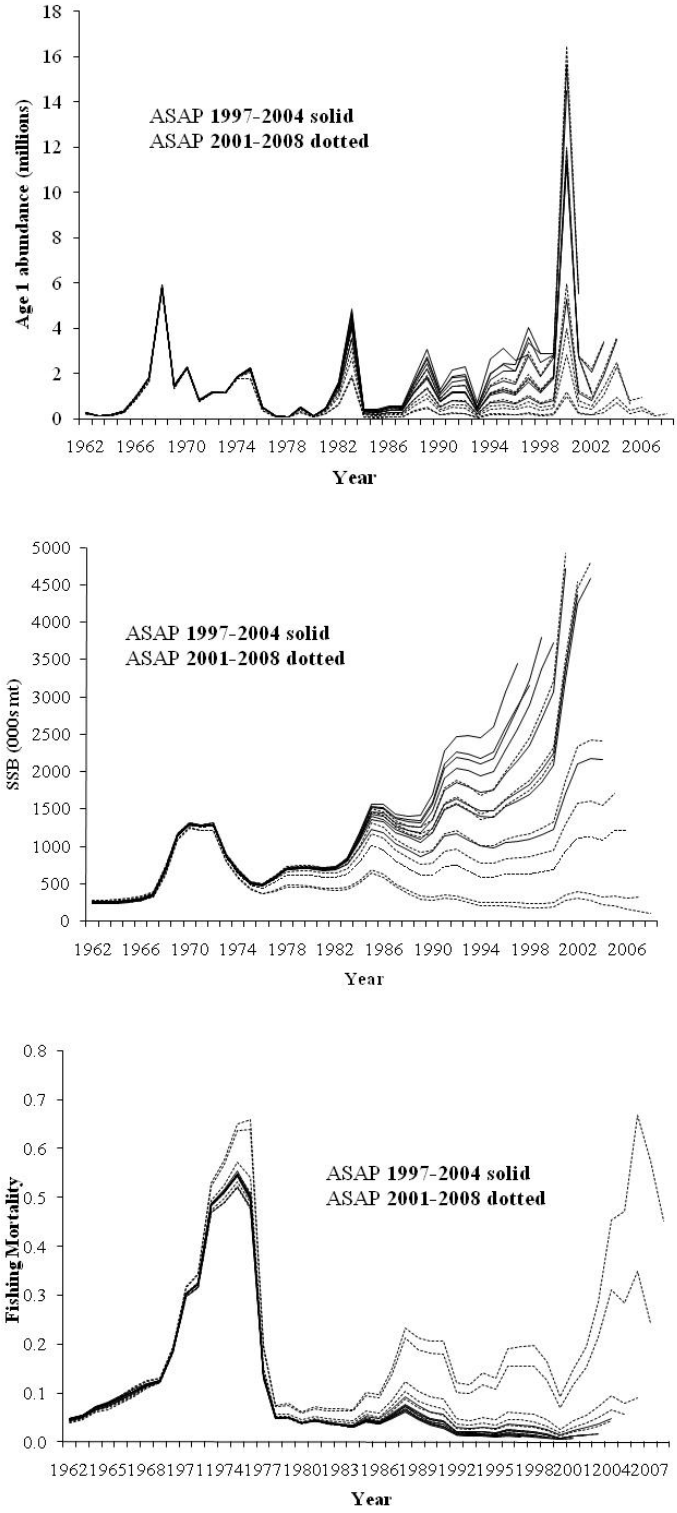

Figure 5. Comparison of the retrospective patterns between the 2005 ASAP assessment model and that same model updated through 2008.

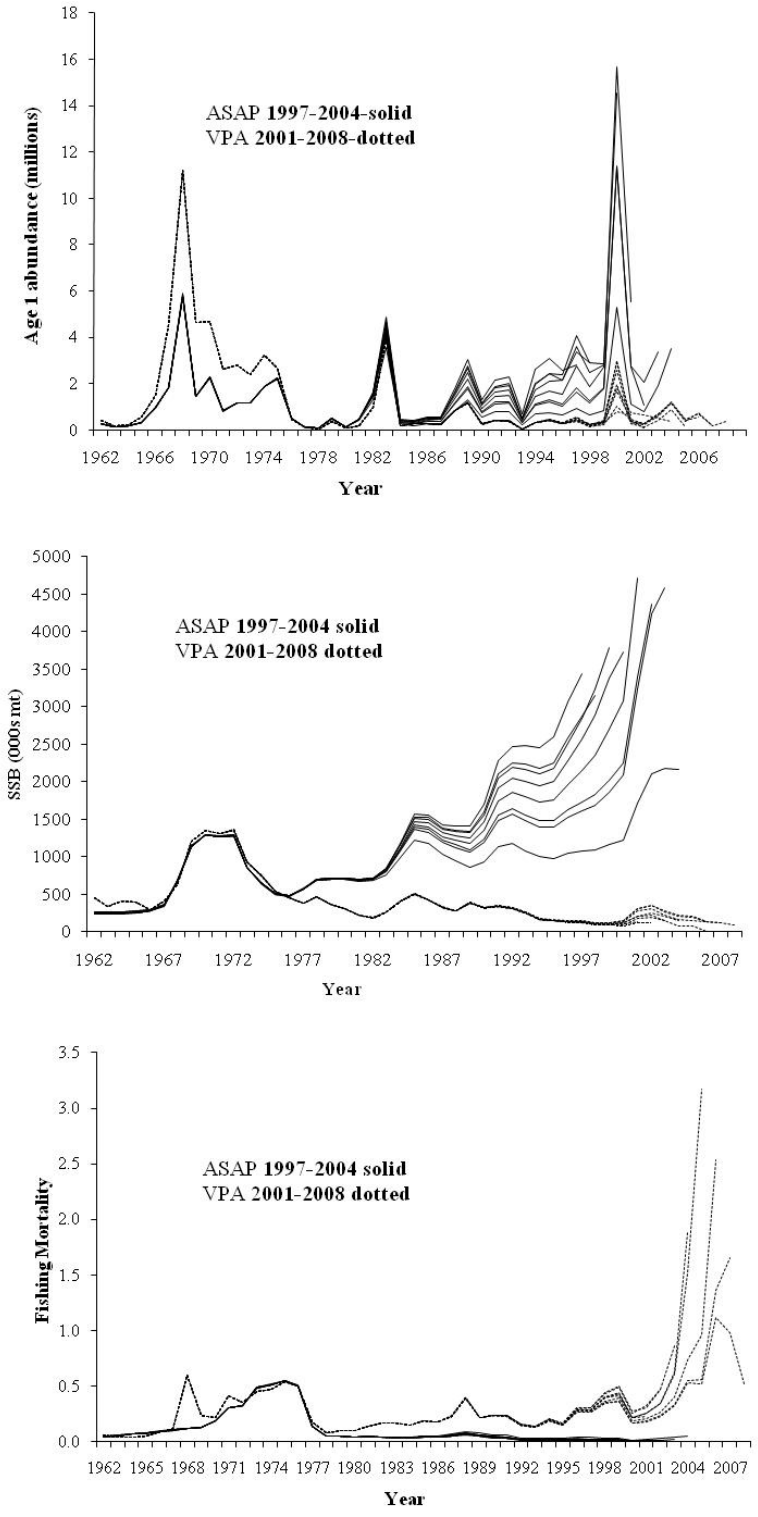

Figure 6. Comparison of the retrospective patterns between the 2005 ASAP assessment model and the selected 2010 VPA assessment model.