Moore, Christopher

To: Christopher M Moore (Christopher.M.Moore@noaa.gov)
Subject: FW: National SSC Workshop

From: Moore, Christopher
Sent: Monday, March 14, 2011 1:34 PM
To: Exec Directors
Cc: Seagraves, Richard J.; Robins, Rick; Anderson, Lee (lgafish@udel.edu); 'jboreman@nc.rr.com'
Subject: National SSC Workshop

Everyone -

The Mid-Atlantic Council is hosting the Fourth National SSC Workshop at the Kingsmill Resort in Willamsburg, VA, October 4-6, 2011. The program steering committee, consisting of the eight SSC Chairs and Rick Methot, held their first meeting on March 2 to begin planning the workshop program. They identified two major topic areas for discussion at the workshop - social/economic and ecosystem considerations as they relate to ABC and OY specifications.

The Steering Committee has decided to form two program subcommittees (social/economic and ecosystems) to assist them with the planning of the workshop. Please identify two individuals from your SSC that would be interested in serving on the planning subcommittees (i.e., one social/economic expert and one ecosystems expert). **Please send your nominees for the program planning subcommittees to Rich Seagraves (rseagraves@mafmc.org) by COB Friday April 1, 2011.**

Thanks!

C

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Meeting Notice

Review of Modeling Approaches in Support of Ecosystem-Based Fishery Management

Northeast Fisheries Science Center, Woods Hole MA 02543

March 29-31 2011

An independent peer-review of modeling approaches in support of Ecosystem-Based Fishery Management (EBFM) on the Northeast U.S. Continental Shelf will be conducted in Woods Hole March 29-31, 2011 under the auspices of the Center for Independent Experts. The purpose of this review is to evaluate the appropriateness and performance characteristics of community-level and ecosystem models being evaluated at the Northeast Fisheries Science Center as potential operating models for EBFM in the region. The signing of an Executive Order in July 2010 implementing a new National Ocean Policy (NOP) has recently elevated the importance of this issue. The NOP designates Ecosystem-Based Management as the guiding principle in ocean resource management for the nation.

The meeting will convene at 9:00AM on Tuesday March 29 in the Stephen H. Clark Conference Room (NMFS Aquarium Building, Albatross St., Woods Hole). A draft agenda for the panel review meeting is provided below.

March 29 2011

900 Welcome to Workshop and Overview of Objectives for the Review
930 Review of Overview Modeling Strategy and Philosophy for Multi-Model Inference (TOR A)
1030 Break
1100 Empirical Multivariate Models (TOR G)
1145 Review of Energy Transfer Models (TOR B)
1230 Lunch
1330 Review of Energy Transfer Models (TOR C)
1530 Break
1600 Discussion
1730 Adjourn main meeting
1730-1800 Panel Deliberations, as needed (TOR A)

March 30 2011

0900 Transition Approaches to Enhance Single Species Advice
1030 Break
1100 Review of Aggregate Production Models (TOR D)
1230 Lunch

1400 Review of Multispecies Production Models (TOR E)
1530 Break
1600 Discussion
1730 Adjourn main meeting
1730-1800 Panel Deliberations, as needed (TOR A)

March 31 2011

0900 Review of Full System Models (TOR F)
1030 Break
1100 Discussion of Model Uses for Production Potential, Ecosystem Overfishing & Related BRPs
1230 Lunch
1400 Discussion on Model Uses for MSE, Tradeoffs & Multisector Uses
1500 Panel Deliberations (TOR A)
1730 Adjourn

Point of Contact: Dr. Michael J. Fogarty

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REVIEWS

The summer flounder chronicles II: new science, new controversy, 2001–2010

Mark Terceiro

Received: 18 September 2010 / Accepted: 1 March 2011

Abstract The summer flounder, or fluke, *Paralichthys dentatus*, supports the most important commercial and recreational flatfish fisheries of the US Atlantic coast. The stock and fishery range from Massachusetts to North Carolina. The assessment and management of the summer flounder fishery has been very contentious since implementation of the joint Atlantic States Marine Fisheries Commission/Mid-Atlantic Fishery Management Council Fishery Management Plan (FMP) in 1989, when the poor status of the summer flounder stock was evident to scientists, managers, and fishermen. Management efforts to control fishing mortality in the face of increasing stock abundance and competing demand for fish from both the commercial and recreational sectors continue to evoke the question of "How much fish is enough?" to provide for long-term sustainability. In spite of the numerous controversies, however, by 2010 the fishing mortality on summer flounder had declined to its lowest level in at least 30 years, and summer flounder stock biomass was the highest since the stock assessments began in the 1960s. From a scientific perspective, future assessments need to: (a) better account for the uncertainty resulting from "internal model" retrospective error, (b) better integrate environmental, ecological, and other non-traditional calibration indices into the modeling framework, and (c) better discern summer flounder stock-recruitment dynamics by considering covariates such as environmental factors and predator/prey abundance. Initiatives are underway to acquire improved fishery and biological data to allow the assessments to better reflect the true "state of nature."

Keywords Summer flounder · Fisheries · Assessment · Management

> There was always a minority afraid of something, and a great majority afraid of the dark, afraid of the future, afraid of the past, afraid of the present, afraid of themselves and shadows of themselves.
> from "Usher II" in *The Martian Chronicles* by Ray Bradbury (1997).

Introduction

The assessment and management of the summer flounder, or fluke, *Paralichthys dentatus*, fishery has been very contentious since implementation of the joint Atlantic States Marine Fisheries Commission

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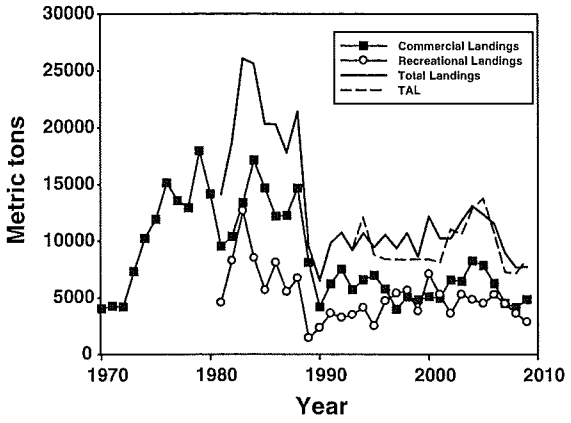


Fig. 1 Recent commercial (1970–2009), recreational (1981–2009), and total fishery (1981–2009) landings in metric tons, and the corresponding fishery total allowable landings (TAL)

(ASMFC)/Mid-Atlantic Fishery Management Council (MAFMC) Fishery Management Plan (FMP) in 1989 (MAFMC 1988). A previous paper (Terceiro 2002) chronicled the sequence of stock assessments, the FMP and Amendments, and the series of lawsuits filed by various user and advocacy groups that together constituted the history of the assessment and management of the summer flounder fishery from 1975 to 2000. This second installment of the story provides an update of the stock assessments, management actions, lawsuits, and associated commentary from various user and advocacy groups during 2001–2010 as the vested parties have struggled to implement the allocation and harvest of summer flounder (Fig. 1). Management efforts to control fishing mortality in the face of increasing stock abundance and competing demand for fish from the commercial and recreational sectors continue to evoke the inevitable question of "How much fish is enough?" to provide for long-term sustainability.

The summer flounder supports important commercial and recreational flatfish fisheries of the US Atlantic coast from Massachusetts to North Carolina. Small scale coastal fishing by trawlers and pound nets during May to November has occurred in the Mid-Atlantic region since at least 1880 (Hildebrand and Schroeder 1928; Neville et al. 1939). Large scale offshore commercial exploitation of summer flounder began about 1920, when trawlers from New Jersey initiated exploratory winter fishing off the coasts of Virginia and North Carolina (Pearson 1932). The fishery expanded during the 1920s and 1930s, with about 50 large trawlers participating in the offshore winter trawl fishery by 1935 (Eldridge 1962). By 1940, commercial landings of summer flounder had reached 4,900 mt (11 million lb), and landings were consistently between 9,000 and 10,000 mt (20–22 million lb) during 1952–1961. Under regulations that currently limit the annual commercial landings to about 13,000 mt (29 million lb), summer flounder is the most important commercial flatfish species, in terms of weight and value landed, in the southern New England and Mid-Atlantic regions (USDOC 2009; Terceiro 2010). Summer flounder have historically also been highly sought by sport fishermen, especially in New York and New Jersey waters. The 1965 and 1970 Salt-Water Angling Surveys (Deuel and Clark 1968; Deuel 1973) indicated that summer flounder was the second most frequently caught flatfish by anglers in the New England and Mid-Atlantic regions, trailing only winter flounder. The catch of winter flounder has declined greatly since the 1970s, and today summer flounder is by far the most frequently recreationally caught flatfish (USDOC 2009).

Summer flounder spawning takes place during a protracted season that can extend from September to March, with a peak in October and November during the annual offshore and southern migration to the outer continental shelf off Virginia and North Carolina (O'Brien et al. 1993). The development of post-larvae and demersal juveniles occurs primarily within bays and estuaries during the following spring and summer, notably Pamlico Sound, Chesapeake Bay, and coastal New Jersey (Able and Kaiser 1994). The fish are concentrated in bays and estuaries from late spring through early autumn, when the next offshore migration begins. The maximum observed age of female summer flounder is 14 years, while the maximum observed age of males is 12 years. The natural mortality rate is assumed to be about 22% per year (an average instantaneous natural mortality rate of $M = 0.25$), based on an assumed potential maximum age averaged for both sexes of about 15 years (NEFSC 2008). Summer flounder are among the largest and fastest growing flatfish along the US Atlantic coast. They can attain total lengths of up to 12 in (30 cm) by the end of their first year of life, and most fish are fully sexually mature by age 2 at a mean length of about 16 in (42 cm; NEFSC 2008). Bigelow

and Schroeder (1953) reported that summer flounder as large as 26 lb (11.8 kg) and 37 in (94 cm) were taken in commercial fisheries. The official sport fishing world record, set in 1975 in New York waters, is 22 lb 7 oz (10.2 kg; IGFA 2000). In 2007, a woman sport-fishing in New Jersey waters landed a summer flounder reliably reported to be 38 in (97 cm) and 24 lb 5 oz (11.0 kg) (Rose 2007).

Numerous studies were conducted in the last century on the stock structure of summer flounder along the US Atlantic coast. These studies used meristic and morphometric techniques (Ginsburg 1952; Smith and Daiber 1977; Wilk et al. 1980; Fogarty et al. 1983), electrophoretic analysis of cell constituents (Van Housen 1984), mark-recapture studies (Westman and Neville 1946; Poole 1962; Hamer and Lux 1962; Murawski 1970; Desfosse et al. 1988; Holland 1991; Mercer et al. 1987; Jesien et al. 1992; Monaghan 1992), and genetic diversity as revealed by mitochondrial DNA (Jones and Quattro 1999). Most of these studies suggested the existence of one to three stocks of summer flounder along the US Atlantic coast.

More recently, Burke et al. (2000) examined the importance of the zoogeographic boundary at Cape Hatteras, NC on the stock structure of summer flounder through a mark-recapture study and analyses of larval meristics and growth. Burke et al. (2000) supported the concept of separate stocks of summer flounder north and south of Cape Hatteras, NC, and suggested further studies using genetics and other natural markers such as otolith chemistry to help clarify the stock structure north of Cape Hatteras, NC. Kraus and Musick (2001) reviewed the information available on the ecology and movements of summer flounder and concluded that the stock separation at Cape Hatteras, NC was valid and that there was evidence of two spawning aggregations north of Cape Hatteras, NC.

Finally, Able et al. (2011) investigated the patterns of larval ingress north and south of Cape Hatteras, NC as potential indices of spawning stock stocks and indicators of stock structure, and concluded that the timing of larval ingress into US Atlantic coast inlets supported the concept of separate stocks north and south of Cape Hatteras, NC.

These studies collectively suggest the existence of one or two spawning aggregations, and therefore potentially stocks, north of Cape Hatteras, NC. The joint ASMFC/MAFMC FMP for summer flounder (MAFMC 1988) has a management unit that includes all summer flounder from the southern border of North Carolina to the US–Canada border, closely following the definition of Wilk et al. (1980) of a unit stock extending from Cape Hatteras, NC north to the US–Canada border. The Wilk et al. (1980) unit stock is the basis of the current benchmark stock assessment (NEFSC 2008).

The stock assessments, lawsuits, and other controversies: 2001–2010

As noted above, Terceiro (2002) summarized the assessment and management history of summer flounder through 2000. Ongoing controversy over the status of the stock, reference points, and annual quota specifications has required triennial benchmark assessments along with annual updates during 2001–2010 (Table 1). Two more FMP Amendments and seven Framework adjustments to the FMP have been implemented since 2001, although some of these applied only to scup and black sea bass (Table 2). There have also been significant national legislative actions that have been influenced by summer flounder assessment and management, including the reauthorized Magnuson-Stevens Act (MSA) of 2006.

The 2001 total allowable landings (TAL) specification and new lawsuits

In July 2000, the National Resources Defense Council (NRDC; the Plaintiffs), the National Marine Fisheries Service (NMFS), and the US District Court negotiated a Settlement Agreement. Under this agreement the NMFS agreed to set the 2001 total allowable landings (TAL) to achieve, with at least a 50% probability, a stock biomass equal to that which would have occurred at the end of 2001 if fishing mortality in 1999–2000 had been restricted to the overfishing definition of Fthreshold = Fmax = 0.26 (USDC 2000; Terceiro 2002). The Settlement Agreement TAL, published in the Federal Register as a proposed quota in November 2000, specified a 2001 TAL of 8,125 mt (18 million lb), about 3% lower than the 2000 TAL. Despite this relatively minor decrease in TAL, the ASMFC Summer Flounder

Table 1 Chronology and summary of the 2001–2010 stock assessments for summer flounder

Year	Source	Results and conclusions
2001	MAFMC (2001a, b)	2000 Commercial landings (5,085 mt, 11.2 million lb) were reported to be about 4% above the final adjusted quota; estimated 2000 recreational landings of 7,090 mt (15.6 million lb), over twice the harvest limit. Together, the fisheries landed 12,175 mt (26.8 million lb), 40% above the final 2000 TAL of 8,400 mt (18.5 million lb). VPA results indicated that fishing mortality had steadily declined since 1994, and was estimated to be 0.30 in 2000, about 15% higher than the FMP overfishing definition of Fmax. Spawning stock biomass on 1 November 2000 was estimated to be 37,000 mt, the highest level of the VPA series. The age structure of the spawning stock had expanded substantially since 1990, with 78% at ages 2 and older, and 16% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January increased substantially since 1989, and in 2001 was estimated to be 46,400 mt, 13% below the FMP biomass threshold. Retrospective analysis showed that the VPA tended to underestimate the abundance of recent year classes. Biological reference points from the 1999 MAFMC SSC assessment were retained in the 2000 assessment, due to the stability of the input data. The stock was overfished and overfishing was occurring with respect to the FMP Amendment 12 overfishing definition, since fishing mortality was 15% above the fishing mortality threshold and biomass was 13% less than the biomass threshold of one-half BMSY. Advised that the TAL in 2002 should not exceed 11,021 mt (24.3 million lb) to meet the fishing mortality threshold of F = 0.26 for 2002
2002	NEFSC (2002a): 35th SAW	2001 commercial landings (4,916 mt, 10.8 million lb) were reported to be about 1% over the final adjusted quota; estimated 2001 recreational landings of 5,250 mt (11.6 million lb), 62% above the harvest limit. Together, the fisheries landed 10,166 mt (22.4 million lb), 25% above the final 2001 TAL of 8,296 mt (18.3 million lb). VPA results indicated that fishing mortality had steadily declined since 1994, and was estimated to be 0.27 in 2001, marginally above the overfishing definition. Spawning stock biomass on 1 November 2001 was estimated to be 38,200 mt. The age structure of the spawning stock had expanded substantially since 1990, with 72% at ages 2 and older, and 14% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January increased substantially since 1989, and in 2002 was estimated to be 42,900 mt, 19% below the biomass threshold. Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates by about 33% and slightly overestimate SSB, but underestimate the abundance of recent year classes. Biological reference points from the 1999 MAFMC SSC assessment were retained in the 2002 assessment. The stock was overfished and overfishing was occurring with respect to the overfishing definition, since fishing mortality was above the fishing mortality threshold and biomass was less than the biomass threshold. Advised that the TAL in 2003 should not exceed 10,580 mt (23.3 million lb) to meet the fishing mortality threshold of F = 0.26 for 2003. Also advised that during each of the past 6 years the recreational fishery had exceeded its harvest limit and, for the entire period, exceeded the limit by 58%. During the same period the commercial fishery exceeded its harvest limit by 5%. These excesses resulted in a fishing mortality that exceeded the target

Table 1 continued

Year	Source	Results and conclusions
2003	SDWG (2003)	2002 commercial landings (6,407 mt, 14.1 million lb) were reported to be about 3% under the final adjusted quota; estimated 2002 recreational landings of 3,610 mt (8.0 million lb), 18% under the harvest limit. Together, the fisheries landed 10,000 mt (22.0 million lb), 9% below the final 2002 TAL of 10,968 mt (24.2 million lb). VPA results indicated that fishing mortality had steadily declined since 1994, and was estimated to be 0.23 in 2002, below the overfishing definition. Spawning stock biomass on 1 November 2002 was estimated to be 42,200 mt. The age structure of the spawning stock had expanded substantially since 1990, with 80% at ages 2 and older, and 19% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January increased substantially since 1989, and in 2003 was estimated to be 56,100 mt, 5% above the biomass threshold. Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates by about 40% and slightly overestimate SSB. Biological reference points from the 1999 MAFMC SSC assessment were retained in the 2003 assessment. The stock was not overfished and overfishing was not occurring for the first time since FMP Amendment 12 (MAFMC 1999) implemented the Sustainable Fisheries Act (SFA) of 1996 overfishing definition, biomass target, and rebuilding date of 2010. Advised that the TAL in 2004 should not exceed 12,790 mt (28.2 million lb) to meet the fishing mortality threshold of F = 0.26 for 2004. Also advised that given that there was a persistent retrospective underestimation of fishing mortality, managers should consider adopting a lower TAL than that implied by the current overfishing threshold
2004	SDWG (2004)	2003 commercial landings (6,450 mt, 14.2 million lb) were reported to be about 3% over the final adjusted quota; estimated 2003 recreational landings of 5,265 mt (11.6 million lb), 25% over the harvest limit. Together, the fisheries landed 11,715 mt (25.8 million lb), 9% below the final 2003 TAL of 10,501 mt (23.2 million lb). VPA results indicated that fishing mortality had steadily declined since 1994, and was estimated to be 0.29 in 2003, above the overfishing definition. Spawning stock biomass on 1 November 2003 was estimated to be 49,400 mt. The age structure of the spawning stock had expanded substantially since 1990, with 72% at ages 2 and older, and 20% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January increased substantially since 1989, and in 2004 was estimated to be 67,500 mt, 27% above the biomass threshold. Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates by about 40% and slightly overestimate SSB. Biological reference points from the 1999 MAFMC SSC assessment were retained in the 2003 assessment. The stock was not overfished but overfishing was again occurring. Advised that the TAL in 2005 should not exceed 14,799 mt (32.6 million lb) to meet the fishing mortality threshold of F = 0.26 for 2005. Also advised that given that there was a persistent retrospective underestimation of fishing mortality, managers should consider adopting a lower TAL than that implied by the current overfishing threshold
2005	NEFSC (2005): 41st SAW	2004 commercial landings (7,748 mt, 17.1 million lb) were reported to be about 2% over the final adjusted quota; estimated 2004 recreational landings of 4,841 mt (10.7 million lb), 5% under the harvest limit. Together, the fisheries landed 12,589 mt (27.8 million lb), 1% below the final 2004 TAL of 12,687 mt (28.0 million lb). Fishing mortality was estimated to be 0.40 in 2004, 54% above the overfishing definition. Spawning stock biomass on 1 November 2004 was estimated to be 38,600 mt. The age structure of the spawning stock had expanded substantially since 1990, with 75% at ages 2 and older, and 16% at ages 5 and older. Under equilibrium conditions at Fmax, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older. Total stock biomass on 1 January 2005 was estimated to be 54,900 mt, slightly above the biomass threshold. Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates and overestimate SSB. Biological reference points were updated to Fthreshold = Fmax = 0.276, MSY = 19,072 mt (42 million lb), Btarget = 92,645 mt (204 million lb), and Bthreshold = 46,323 mt (102 million lb). The stock was not overfished but overfishing was occurring. Advised that the TAL in 2006 should not exceed 14,969 mt (33.0 million lb) to meet the fishing mortality threshold of F = 0.26 for 2006. Also advised that given that there was a persistent retrospective underestimation of fishing mortality, managers should consider adopting a lower TAL than that implied by the current overfishing threshold

Table 1 continued

Year	Source	Results and conclusions
2006	Terceiro (2006b): NMFS S&T Peer Review	2005 commercial landings (7,765 mt, 17.1 million lb) were reported to be about 4% over the final adjusted quota; estimated 2005 recreational landings of 4,550 mt (10.0 million lb), 16% under the harvest limit. Together, the fisheries landed 12,315 mt (27.1 million lb), 9% below the final 2005 TAL of 13,553 mt (29.9 million lb). Fishing mortality was estimated to be 0.41 in 2005, 45% above the updated Fthreshold. Spawning stock biomass on 1 November 2005 was estimated to be 47,498 mt, 53% of the updated Btarget = SSBmax = 89,411 mt (197 million lb). Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates by 34% and overestimate SSB by 12%. Biological reference points were updated to Fthreshold = Fmax = 0.280, MSY = 21,444 mt (47 million lb), Btarget = 89,411 mt (197 million lb), and Bthreshold = 44,706 mt (99 million lb). The stock was not overfished but overfishing was occurring. Advised that the TAL in 2007 should not exceed 6,421 mt (14.2 million lb) to meet the fishing mortality rebuilding rate = 0.15 for 2007 and ensure stock rebuilding to Btarget by 2010
2007	SDWG (2007)	2006 commercial landings (6,262 mt, 13.8 million lb) were reported to be just under the final adjusted quota; estimated 2006 recreational landings of 5,261 mt (11.6 million lb), 23% over the harvest limit. Together, the fisheries landed 11,523 mt (25.4 million lb), 9% over the final 2006 TAL of 10,537 mt (23.2 million lb). Fishing mortality was estimated to be 0.35 in 2006, 25% above Fthreshold. Spawning stock biomass on 1 November 2006 was estimated to be 42,316 mt, 5% below Bthreshold. Retrospective analysis showed that the assessment tended to underestimate recent fishing mortality rates by about 30% and overestimate SSB. The stock was overfished and overfishing was occurring. Advised that the TAL in 2008 should not exceed 7,936 mt (17.5 million lb) to reduce fishing mortality to Frebuild = 0.199 and ensure stock rebuilding to Btarget by 2013
2008	NEFSC (2008): SAW 47	2007 commercial landings (4,489 mt, 9.9 million lb) were reported to be 5% under the final adjusted quota; estimated 2007 recreational landings of 4,445 mt (9.8 million lb), 36% over the harvest limit. Together, the fisheries landed 8,934 mt (19.7 million lb), 20% over the final 2007 TAL of 7,471 mt (16.5 million lb). The assessment model changed from ADAPT VPA to ASAP SCAA, and the value assumed for M changed from a constant value of 0.20 to an age-varying schedule with a mean of 0.25. Fishing mortality was estimated to be 0.29 in 2007, 6% below the revised Fthreshold = 0.31. Spawning stock biomass on 1 November 2007 was estimated to be 43,363 mt, 72% of the revised Btarget = 60,074 mt. Retrospective analysis showed that the assessment still tended to underestimate recent fishing mortality rates and overestimate SSB. The stock was not overfished and overfishing was not occurring. Advised that the TAL in 2009 should not exceed 8,626 mt (19.0 million lb) to reduce fishing mortality to Ftarget = F40% = 0.255 and ensure stock rebuilding to Btarget by 2013. Also advised that managers should consider adopting future TALs lower than those indicated by forecast median values to decrease the chance that overfishing will occur
2009	Terceiro (2009)	2008 commercial landings (4,143 mt, 9.1 million lb) were reported to be 3% under the final adjusted quota; estimated 2008 recreational landings of 3,584 mt (7.9 million lb), 25% over the harvest limit. Together, the fisheries landed 7,727 mt (17.0 million lb), 8% over the final 2008 TAL of 7,153 mt (15.8 million lb). Fishing mortality was estimated to be 0.25 in 2008, 19% below the revised Fthreshold = 0.31. Spawning stock biomass on 1 November 2008 was estimated to be 46,029 mt, 77% of the revised Btarget = 60,074 mt. Retrospective analysis showed that the assessment still tended to underestimate recent fishing mortality rates and overestimate SSB. The stock was not overfished and overfishing was not occurring. Advised that the TAL in 2010 should be 9,261 mt (20.4 million lb) to achieve Ftarget = F40% = 0.255 and ensure stock rebuilding to Btarget by 2013. Also advised that landings that correspond to fishing at or near the threshold fishing mortality rate (FMSY = F35% = 0.310) may result in overfishing if the retrospective pattern of underestimation of fishing mortality occurs in the future

Table 1 continued

Year	Source	Results and conclusions
2010	Terceiro (2010)	2009 commercial landings (4,848 mt, 10.7 million lb) were reported to be 1% under the final adjusted quota; estimated 2009 recreational landings of 2,856 mt (6.3 million lb), 12% under the harvest limit. Together, the fisheries landed 7,704 mt (17.0 million lb), 8% under the final 2009 TAL of 8,369 mt (18.5 million lb). Fishing mortality was estimated to be 0.24 in 2009, 23% below the revised Fthreshold = 0.31. Spawning stock biomass on 1 November 2009 was estimated to be 53,458 mt, 89% of the revised Btarget = 60,074 mt. Retrospective analysis showed that the assessment still tended to underestimate recent fishing mortality rates and overestimate SSB. A recent pattern of overestimation in recruitment was also evident. The stock was not overfished and overfishing was not occurring. Advised that the TAL in 2011 could be 13,371 mt (29.5 million lb) and achieve Ftarget = F40% = 0.255. Also advised that Fishing at Ftarget = F40% = 0.255 during 2011–2012 was projected to maintain the stock above SSBMSY = SSB35% = 60,074 mt through 2012. Projections indicated that fishing at Ftarget = 0.255 in 2011 could provide landings that exceed MSY (13,122 mt landings = 28.9 million lbs) in 2011. Cautioned that landings that correspond to fishing at or near the threshold fishing mortality rate (FMSY = F35% = 0.310) may result in overfishing if the previous retrospective pattern of underestimation of fishing mortality occurs in the future

Management Board concluded that management of summer flounder fisheries in state waters (which is under the jurisdiction of the ASMFC) was not bound by the Settlement Agreement. The Board indicated that the ASMFC would enact a 2001 TAL of 9,281 mt (21 million lb) to meet the Fthreshold in 2001.

In December 2000, shortly after the ASMFC adopted their higher 2001 TAL, the NRDC and other environmental groups filed a lawsuit to enforce the 2000 Settlement Agreement. In response, the NMFS delayed official publication of the final 2001 TAL and indicated that it would close the federal Exclusive Economic Zone to fishing for summer flounder as landings approached the federal TAL specification, in hopes of persuading the ASMFC to adopt the Settlement Agreement quota. This delay prompted the North Carolina Fisheries Association (NCFA) and other commercial industry groups to file two lawsuits in March 2001 to (a) enforce a 1997 legal judgment (in a NCFA suit to set aside the 1997 quota; Terceiro 2002) that quota specifications be published "...within a reasonable period of time to enable fishermen to utilize the quota appropriately," and (b) ensure that no overages from 2000 in the North Carolina commercial fishery would be subtracted from the proposed 2001 TAL. The suits also demanded that the NMFS cease determining the summer flounder TAL based on the existing overfishing definition and instead use a higher value based on alternative analyses. The NCFA also asked that an additional 1,300 mt (3 million lb) be added to future quotas to account for the difference between the Settlement Agreement and ASMFC 2001 TALs. The same judge who presided in the 1997 suit also presided in the NCFA 2001 suit, and in April 2001 ordered enforcement of the proposed 2001 TAL specification (with no additional quota), but with no overage subtractions from the 2000 North Carolina fishery (USDC 2001). In the interim, the ASMFC agreed to abide by the Settlement Agreement quota and in April 2001 a 2001 TAL of 8,125 mt (18 million lb) was approved.

The 2001 assessment update

The 2001 assessment updated the 2000 SAW 31 benchmark assessment (NEFSC 2000; Terceiro 2002) and included fishery catches through 2000 and surveys through spring 2001. The update concluded that the stock was overfished and that overfishing was

occurring; fishing mortality (F) in 2000 was estimated to be 0.30, about 15% above the Fthreshold (MAFMC 2001a). The assessment noted that the retrospective pattern, which was first recognized in the 1995 SAW 20 assessment (NEFSC 1996), was still present and that the 2001 Virtual Population Analysis (VPA) modeling results tended to underestimate recent fishing mortality rates by up to 30% in the most recent years (i.e., the terminal years) included in the assessment. Although the 2001 assessment indicated that total stock biomass had increased substantially since 1989, estimated stock biomass in 2000 (46,400 mt or 102 million lb) was still 13% below the biomass threshold (Bthreshold), with a retrospective pattern of biomass overestimation. The incoming 1999 and 2000 year classes were estimated as below-average, which did not bode well for further biomass rebuilding or quota increases. However, using long term average recruitment, catch projections indicated that the 2002 TAL could be 36% higher than in 2001 and still achieve the Fthreshold and continue stock rebuilding (Table 1). The MAFMC therefore recommended—and the NMFS adopted—a 2002 TAL of 11,021 mt (24 million lb).

Estimates of substantial landings overages in the 2001 recreational fishery indicated that major restrictions would be needed to prevent similar overages in 2002. Various combinations of increased minimum size and reduced possession limits and seasons were discussed as likely measures. At the MAFMC and ASMFC meetings held in late 2001 to set recreational measures for 2002, the potential for these restrictions generated heated debate and provided the impetus for the MAFMC to implement "conservation equivalency" in Framework 2 to the FMP (Table 2). Framework 2 allowed state-specific regulations tailored to meet each state's required reduction in harvest based on advice from their anglers—or as portrayed in the popular fisheries press, "...so anglers can choose which brand of 'poison' they'd like to consume" (Ristori 2001). Recreational fishery conservation equivalency, and the ensuing inequities in regulations between states and user groups, would foster even more controversy in the coming years.

The biological reference points from the 1999 assessment (Terceiro 1999) were retained in the 2000 SAW 31 assessment and also initially again in the 2001 update, because of the stability of the input data and estimated parameters. An Fthreshold value of

Table 2 Summary of the summer flounder, scup, and black sea bass fishery management plan (FMP), 2001–2010

Year	Document	Plan species	Management action
2001	Framework 1	Summer flounder, scup, and black sea bass	Established quota set-aside for research for all three species
2001	Framework 2	Summer flounder	Established state-specific conservation equivalency measures for summer flounder
2003	Amendment 13	Summer flounder, scup, and black sea bass	Addressed disapproved sections of Amendment 12 and included new EIS
2003	Framework 3	Scup	Allowed the rollover of winter scup quota
			Revised start date for summer quota period for scup fishery
2003	Framework 4	Scup	Established system to transfer scup at sea
2004	Framework 5	Summer flounder, scup, and black sea bass	Established multi-year specification setting of quota for all three species
2006	Framework 6	Summer flounder	Established region-specific conservation equivalency measures for summer flounder
2007	Amendment 14	Scup	Established rebuilding schedule for scup
2007	Framework 7	Summer flounder, scup, and black sea bass	Built flexibility into process to define and update status determination criteria for each plan species
			Scup Gear Restricted Areas made modifiable through framework adjustment process

Fmax = 0.26 was used as the proxy for FMSY; Btarget (the BMSY proxy) was estimated at 106,400 mt (235 million lb); and Bthreshold was estimated to be 53,200 mt (117 million lb). However, in 2001, several scientists contributing peripherally to the assessment commented that the biomass target was too high and that the fishing mortality threshold was too low. In response to both the reference point component of the 2001 NCFA lawsuit and the comments from these "outside scientists," the MAFMC Science and Statistical Committee (SSC) conducted a peer review of the summer flounder Overfishing Definition in tandem with the 2001 assessment update (MAFMC 2001a, b). The SSC reviewed six alternative analyses to estimate biological reference points for summer flounder. These analyses had been conducted by members of the ASMFC Summer Flounder Biological Reference Point Working Group, which was composed of the "outside scientists" and the scientists directly involved in compiling the assessment data and analyses.

One of the alternative analyses suggested a dome shaped stock-recruitment relationship existed for summer flounder implying lower recruitment at higher SSBs. Under this alternative analysis, FMSY was 0.90 (over 3 times the existing Fthreshold reference point), BMSY was about 57,000 mt (126 million lb) of total stock biomass (about one-half the existing Btarget reference point), and SSBMSY was about 25,000 mt (producing an average recruitment of about 40 million fish) (Gibson 2001). MSY under this alternative was estimated to be 18,000 mt (40 million lb). Another alternative analysis indicated that FMSY was in the range of 0.72–0.83 and SSBMSY in the range of 15,000–22,000 mt (Crecco 2001), implying that the stock should be reduced to about half of the existing biomass to realize better stock production in terms of recruits per spawner. After much deliberation and discussion, the SSC decided that none of the six analyses provided a reliable alternative set of reference points for summer flounder. The SSC therefore recommended that Fthreshold remain at Fmax = 0.26. The SSC also reviewed the biomass target (BMSY) and concluded that the alternative analyses did not justify a new estimate.

The SSC endorsed the recommendation of the 2000 SAW 31 which stated that the use of Fmax as a proxy for FMSY should be reconsidered as more information on the dynamics of growth in relation to biomass and the shape of the stock recruitment function became available (NEFSC 2000). The SSC agreed that additional years of stock-recruitment data should be collected and encouraged further model development through simulation studies. The SSC also encouraged (a) the evaluation of alternative proxies for biological reference points that might be more appropriate for an early maturing species like summer flounder and (b) the development and evaluation of management strategies for fisheries where BMSY was unknown. The SSC indicated that as the stock size increased, population dynamic processes that could reflect density dependent mechanisms should be closely monitored and corresponding analyses should be expanded (i.e., rates of size and age, maturity, fecundity, and egg viability should be examined as potential indicators of compensation at higher stock sizes). Finally, the SSC recommended that potential environmental influences on recruitment, including oceanographic changes and predation mortality, should be re-evaluated as additional recruitment data became available. As an outcome of the SSC peer review (MAFMC 2001b), the Terceiro (1999) reference points were retained in the 2001 stock assessment update (MAFMC 2001a). This was the first of several major summer flounder reference point reviews to occur over the next several years.

The 2002 SAW 35 benchmark assessment

The 2002 SAW 35 benchmark assessment (NEFSC 2002a) indicated the stock was still overfished and that overfishing was still occurring. Although fishing mortality had declined to 0.27 in 2001, it was marginally above the reference point (Fthreshold = Fmax = 0.26). Total stock biomass had increased substantially since 1989, but was estimated to be 42,900 mt (95 million lb) in 2001, still below the biomass threshold (Bthreshold = 53,200 mt = 117 million lb). The retrospective patterns persisted in the benchmark assessment, and the SAW cautioned that the VPA results tended to underestimate recent fishing mortality rates by about 33% in the last three terminal years of the assessment. The catch forecast indicated that a 2003 TAL of 10,580 mt (23 million lbs), a 4% decrease from 2002, would not exceed the Fthreshold and would allow rebuilding of

the stock to above the biomass target by 2004 (Table 1). The MAFMC recommended this TAL, with final approval by the NMFS in January 2003.

In spite of the nearly *status quo* TAL for 2003, the recreational fishing community expressed very serious concerns about the state of summer flounder management. In general, as the stock size increased (and therefore the availability of fish to anglers), recreational size limits were increased, possession limits decreased, and open seasons shortened because state fishery managers strived to ensure that their state's annual recreational harvest limits would not be exceeded, requiring even more severe restrictions the following year. To ease restrictions on anglers, the United Boatmen of New York and Recreational Fishing Alliance (New Jersey) petitioned the NMFS in March 2003 for rule-making to change the long-standing 60% commercial to 40% recreational allocation of the TAL (established in the FMP based on the ratio of landings during 1980–1989) to a balance more favorable to the recreational fishery (i.e., 50–50%). The petitioners argued that the 60–40% split was "...arbitrary, capricious, and unreasonable, and contrary to the National Standards for Fishery Conservation and Management as contained in the Magnuson-Stevens Fishery Conservation Act" (Geiser 2003). A coalition of commercial industry groups submitted a response to the petition pointing out that consistent recreational fishery harvest limit overages had occurred during 1996–2001, averaging about 2,000 mt (4 million lb) annually, and that these overages had "cost" the commercial industry significant landings opportunities. The "allocation war" rhetoric waged for most of the summer of 2003 in both the popular fisheries press and at management meetings. Nevertheless, proposed changes to the allocation basis never made it beyond the draft document stage. In the end, the MAFMC and NMFS concluded there was no viable basis for changing the share calculation, and the 60–40% split remains in place.

The 2003 assessment update

The 2003 assessment updated the 2002 SAW 35 benchmark assessment and included fishery catches through 2002 and surveys through spring 2003 (SDWG 2003). For the first time since 1999, the assessment results indicated that the stock was not overfished and that overfishing was not occurring. Fishing mortality in 2002 was estimated to be 0.23, about 10% below Fthreshold. However, the retrospective patterns were even more of a concern than in the 2002 benchmark, with the VPA results underestimating recent fishing mortality rates by up to 40% in the terminal years of the assessment. Total stock biomass in 2002 was estimated to be 56,100 mt, 5% above Bthreshold, but still only about 53% of Btarget. However, given signs of recent average recruitment, the short-term catch projections indicated that the TAL could be increased to 12,790 mt (28 million lb) in 2004 and still promote further biomass rebuilding (Table 1). The MAFMC recommended and the NMFS implemented this TAL for 2004.

As the 2004 TAL represented a 21% increase over the 2003 TAL, it was met mostly by a grudging "it's about time" response by many fishery user groups. The main controversy in 2004 was the failure of the State of New York to meet conservation equivalency requirements with its regulations. This precipitated discussion that out-of-compliance states be required to "pay back" in the next year any harvest overages due to such non-compliance. Proposals to implement "pay-back" provisions—essentially assigning fault or blame to individual states for failure to limit recreational landings to their harvest limits—have never been implemented, and so "penalties" for overages in the commercial and recreational fisheries continue to be "paid-back" by all when overages are accounted for in the next assessment.

The 2004 assessment update

The 2004 assessment, another update between benchmarks, included fishery catches through 2003 and surveys through spring 2004 (SDWG 2004). The assessment results indicated that the stock was not overfished, but that overfishing was again occurring, as the estimated F in 2003 was 0.29, about 12% above Fthreshold. The VPA results continued to underestimate recent fishing mortality rates, by up to 40% in some of the terminal years of the assessment. Total stock biomass in 2004 was estimated to be 67,500 mt, 27% above Bthreshold and about 65% of Btarget. Given the persistent retrospective underestimation of fishing mortality, the scientific advice suggested that managers consider adopting a lower TAL for 2005 than that implied by the overfishing

threshold. Nonetheless, the catch projections indicated that a 2005 TAL of 14,799 mt (33 million lb) (e.g., 16% greater than the 2004 TAL of 12,790 mt) would not exceed Fthreshold and would still promote stock rebuilding (Table 1).

The annual assessment update-and-quota specification cycle was now beginning to be perceived as an excessive burden on scientific and management staff resources. Therefore, Framework 5 to the FMP (enacted in 2004) allowed the MAFMC to specify TALs for summer flounder, scup, and black sea bass for a period of up to three years, potentially eliminating the need for annual updates between benchmark assessments (Table 2). Projections were used to provide TAL specifications with a 75% chance of meeting the Fthreshold = 0.26 for 2005–2006 (in contrast to the standard 50% chance) to account for assessment uncertainty and "retrospective bias" (i.e., the consistent pattern of underestimation of F and overestimation of biomass). These alternative projections indicated that TALs corresponding to the 75% chance of meeting Fthreshold would be 13,734 mt (30 million lb) in 2005 and 14,952 mt (33 million lb) in 2006. The 2005 TAL of 13,734 mt (30 million lb), the highest yet approved under the FMP, was approved in January 2005. However, the even higher projected 2006 TAL of 33 million lb would never make it to approval.

The 2005 SAW 41 assessment update

In spite of the intent of Framework 5, another annual assessment update was scheduled for review in 2005 in SAW 41. Following the 2004 update, considerable discussion occurred among managers, scientists, and fishermen on whether the Terceiro (1999) reference points were still appropriate and whether the biomass target was attainable (as the Btarget total stock size of 106,400 mt was larger than any observed in the 1982–2004 assessment times series). The terms of reference for the 2005 assessment directed that the assessment model be updated, with no potential for a new configuration as in a benchmark, but that the biological reference points be revised if necessary.

The 2005 assessment was updated using fishery catches through 2004, survey indices through spring 2005, and using the same model configuration as in the 2004 update. As with the 2004 update, the 2005 update indicated that the stock was not overfished but that overfishing was still occurring. Fishing mortality in 2004 was estimated to be about 54% above Fthreshold, while total stock biomass was estimated to be 54,900 mt, slightly above Bthreshold (NEFSC 2005; Table 1). The retrospective pattern of underestimation of F by about 40% and overestimation of biomass by about 20% was about the same as in the 2004 assessment. Of particular concern were the projection results indicating that the approved 2005 TAL of 13,744 mt (30 million lbs) would result in a median F in 2005 = 0.40 and that the expected 2006 TAL of 14,969 mt (33 million lbs) would result in a median F in 2006 = 0.41, both of which would exceed Fthreshold and foster continued overfishing. It was now clear that the expected 2006 TAL could not be implemented under the existing reference points. To have at least a 50% chance of preventing overfishing in 2006, a TAL of 10,853 mt (24 million lb) would be required in 2006, a reduction of 20% from 2005.

The 2005 SAW 41 updated the reference points for summer flounder using both "parametric" (i.e., stock-recruitment model based) and "empirical non-parametric" (i.e., yield and biomass per recruit model based) approaches, following the procedures adopted by the 2002 Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002b). The SAW also heeded the recommendations of the MAFMC SSC 2001 Overfishing Definition Review (MAFMC 2001b) to use any new data on the population dynamics of summer flounder (e.g., age, growth, and maturity) in revising the biological reference points. Accordingly, the mean weights in the catch and stock, maturity schedule, and partial recruitment pattern were updated to include data from 1992 to 2004.

The 2005 SAW subsequently recommended adoption of summer flounder reference points based on the "empirical non-parametric" approach. These reference points were: Fthreshold = Fmax = 0.276, Maximum Sustainable Yield (MSY in total fishery catch) = 19,072 mt (42 million lb), Btarget = 92,645 mt (204 million lb), and Bthreshold = 46,323 mt (102 million lb). The fishing mortality threshold thus increased by 8%, while the estimates of the biomass target and threshold decreased by 13%. The MAFMC and NMFS adopted the new reference points and used these in deriving a revised 2006 TAL. However,

fishing at the new Fthreshold = 0.276 in 2006 implied a 2006 TAL of 10,700 mt (24 million lb), a decrease of 27% from the previously expected 33 million lb TAL.

The recreational fishing industry became the loudest critic of summer flounder science in general, and the proposed 2006 TAL in particular. In response to the 2005 assessment, the decreased TAL for 2006, and the new biomass reference point to be reached in 2010, columnist John Geiser wrote in the Asbury Park Press: "NMFS is making a case for overfishing, and the scientists are not beyond creating new or adjusting laboratory models that might bolster their position. Whether that occurred or not is unknown." (Geiser 2005a). In *The Fisherman* magazine, columnist Al Ristori wrote: "The 2010 goal is just an arbitrary figure, and many experts aren't even sure it's attainable." (Ristori 2005). The issue of an "unattainable" summer flounder biomass reference point was a popular theme in the summer of 2005. Thomas P. Fote, legislative chairman of the Jersey Coast Anglers Association, stated: "They're talking about rebuilding to the levels of the 1920s and 1930s. That may be unrealistic given the fact that we no longer have the wetlands, the natural environment that juvenile fluke need when they are inshore in the summer. We're no longer able to build the stocks to the point they were at 60 or 70 years ago. The National Marine Fisheries Service is adhering to a rebuilding schedule that may be unattainable, and further restrictions are going to be a hardship on anglers and the party and charter boat industry." (Geiser 2005b).

Many of the comments in 2005 indicated increased public suspicion that the state and federal scientists conducting the summer flounder assessments were practicing precautionary science. The comments also demonstrated that both the popular fisheries press and the politicians who were quoted therein were becoming much better informed about the stock assessment and fisheries management process, including the evaluation of stock status, calculation of biological reference points, and projection of rebuilding trajectories. Unfortunately, problems in getting the facts straight between scientists, managers, and the public would lead to much confusion and distrust over the following years. The NMFS nevertheless approved the 2006 TAL of 10,700 mt (24 million lb) in December 2005.

The 2006 United Boatmen et al. lawsuit

In January 2006, the United Boatmen of New York, the Recreational Fishing Alliance, the New York Fishing Tackle and Trade Association, the New York Marine Trades Association, and Capt. P.A. Focazio filed suit in United States District Court (USDC) in New York against the United States Department of Commerce (USDOC, the parent agency of the NMFS), the ASMFC, and the State of Connecticut, seeking to overturn the approved 2006 TAL and have it set higher. This was the first lawsuit filed by the recreational fishing sector over summer flounder science and management. The Plaintiffs argued that the 2006 TAL violated the National Standards of the Magnuson-Stevens Act (MSA), the National Environmental Policy Act (NEPA), and the Administrative Procedures Act (APA), and that the TAL would cause severe and irreparable harm to the recreational fishing industry in NY, NJ, and CT. On May 1, 2006, the presiding judge ruled "The contested rule for a 2006 TAL of 23.69 million pounds for fluke was properly promulgated and should not be set aside." The Plaintiffs' request for a reconsideration of the decision was denied on May 18, 2006 (USDC 2006), and so the 2006 TAL remained in effect.

The 2006 assessment update

The 2006 assessment update included fishery catches through 2005 and surveys through spring 2006. As in 2004 and 2005, the updated assessment indicated the stock was not overfished, but that overfishing was still occurring (Terceiro 2006a; Table 1). The fishing mortality rate in 2005 was estimated to be 0.53, nearly twice the new reference point established in SAW 41 (Fthreshold = Fmax = 0.276). Retrospective analyses again showed that the assessment model underestimated recent fishing mortality rates, with the annual retrospective underestimate averaging 33% over the last five terminal years. Total stock biomass was estimated to be 47,800 mt on January 1, 2006, just above the new Bthreshold (46,323 mt = 102 million lb), but the model showed a tendency to overestimate stock biomass by about 17% annually over the last five terminal years.

Continued overfishing, combined with the retrospective "bias" in the annual assessments, was causing havoc in accurately projecting the rebuilding

trajectory of the stock. Progress in rebuilding was now well "behind schedule." Stock biomass was only about one-half the biomass target with just a few years left to rebuild, requiring progressively lower projected annual fishing mortality rates (and therefore correspondingly lower annual TALs) to have even a 50% chance of reaching the Btarget of 92,646 mt (204 million lb) by January 1, 2010. To meet Fthreshold in 2007, a 2007 TAL of 9,026 mt (20 million lb) was needed, a reduction of 16% from the 2006 TAL. Even fishing at the Fthreshold during 2007–2009 was no longer projected to have the required 50% chance of rebuilding the stock by January 1, 2010. Therefore, lower fishing mortality rates (i.e., the new concept of Frebuild) and associated TALs were required, and these would have to be lower still if the persistent 33% underestimation in F was taken into account.

The August 2006 MAFMC meeting

As it does every year, the MAFMC met in mid-summer in 2006 to develop summer flounder fishery regulations for the following year. The August 2006 meeting was unusual in that the lead stock assessment scientist (Dr. Mark Terceiro) was "invited" to attend to the meeting and, after presentation of the assessment and TAL recommendation by MAFMC staff member Jessica Coakley, answer questions from the MAFMC and the public about the science. The meeting was also unique in that two special guests—Congressman Frank Pallone (D-NJ) and NOAA Deputy Assistant Administrator Samuel Rauch—were in attendance to provide remarks and ask questions. The atmosphere in the packed meeting room was captured by the opening remarks of the MAFMC chairman, Ronal Smith of the State of Delaware: "...I'd like to say I expect everybody to exercise good judgment, civil behavior, and we'll discuss this appropriately and come to whatever decision we come to. But remember this is a public body and we have to observe public decorum." (MAFMC 2006).

The key points made by Coakley were (in her words; MAFMC 2006):

(1) So, the bottom line from all this stock assessment information is in terms of our fishing mortality rates we've seen a decline. We've gone from a value of about 1.32 in 1994 to a value of 0.53 in 2005, but we've never been below our fishing mortality target rate of 0.276 over this time period.

(2) The spawning stock biomass has increased six-fold from the low 1980s levels, but in the most recent year there's been a slight downward shift in the spawning stock biomass. And recruitment for the stock has been at or below median recruitment levels since 2001. 2005 was the poorest recruitment we've seen since the 1988 low value for the time series. And this is important because our modeling projections assume an input of median recruitment over the time series, and we've been falling steadily below—below that median recruitment level.

(3) The first one is a projection that looks at a 50 percent probability of achieving our fishing mortality target rate of 0.276. So, this is the target F that we have in our rebuilding plan. This would result in a total allowable landings level of 19.89 million pounds in 2007, but based on these projections we would not be rebuilt by January 1, 2010, which is the deadline in the rebuilding program.

(4) Another projection that was done was at an F rate of 0.099, and this is the fishing mortality rate that is projected to just rebuild the stock to the biomass target of 204 million pounds by January 1, 2010. And this would result in a 2007 total allowable landings level of 7.69 million pounds. But this does not account for the retrospective pattern that we're seeing in the assessment. So, the next—the next projection that was done was at an F of 0.066, which is adjusted for that retrospective pattern, so it's 67 percent of 0.099. This would result in a TAL of 5.22 million pounds for the 2007 fishing year, and it would result in the stock—it's predicted to result in the stock being rebuilt by January 1, 2010.

The potential for a 2007 TAL as low as about 5 million lb (2,359 mt) elicited much discussion at the MAFMC meeting. Although concern was expressed over the severity of the socio-economic impacts that such a TAL would have on the commercial and recreational fishing industries, much of the discourse focused on the stock-recruitment pattern and the

biomass target. Congressman Pallone weighed in with the following: "I speak today not only for myself but specifically for Congressman Saxton and also our two Senators, Menendez and Lautenberg. Yesterday we drafted a letter to both the Mid-Atlantic regional council as well as the Atlantic States Commission which I hope you have a copy of, if not I'll make sure that you get it. And I am basically summarizing what the four of us said in that letter. The concern that we have really is that just 2 years ago we had a healthy quota of 30.3 million pounds and last year we fought for a constant quota of 26 million pounds over 3 years, but we were rebuffed and were dropped to the 23.6 million pounds. And now we have NMFS here advocating for a reduction of just over 5 million pounds almost 80 percent down from last year" and "...I can't help thinking that—you know, these quirks in the fishery science and in particular this target biomass of 204 million pounds should be relooked at, that perhaps it's not accurate, it's not based on historic fact, that it's not based on science" and finally "Now, I know all of you are going to say—you know, here comes Congressman Pallone talking about the science again. We talk about the science at every fishery subcommittee hearing we have, and we are always looking for a better method of figuring out—you know, what the quota should be and what the science is. But I just think that this number is just way too high. I don't really understand where it came from, I'm not a fishery scientist; but it seems that we don't even have definitive evidence that it ever existed in nature and if that level did exist it was probably early in the last century the time when coastal development and pollution were a lot less then they are now." and finally "So basically my plea on behalf of the four of us is that you reexamine the target, consider whether it's really appropriate for the stock and because of the fact that the biomass of the stock has done well and the spawning biomass is nearly triple since the rebuilding plan began—you know, I don't really understand why we have to have these drastic quota cuts, particularly the one that NMFS has talked about. I don't know whether this 5.2 million is the likely result of that, I certainly hope not." (MAFMC 2006).

After Congressman Pallone told the MAFMC to reexamine the biological reference points for summer flounder—and not enact a low TAL for 2007 that would harm the fishing industries until that reexamination was done—the room filled with applause (MAFMC 2006). Most of the subsequent debate concerned whether the biomass target could be attained and the reasons for the recent depressed level of recruitment (at or below average since 2001 with a poor year class in 2005; Fig. 2). As the morning meeting wore on, MAFMC members picked up on the Congressman's suggestion to "reexamine the target." For example, MAFMC member Eric Smith of Connecticut stated: "So, I'm not at all confident that given the passage of time and those last five or six data points that we actually can reach even the reduced BMSY that came out of the last assessment, the one in 2005. I guess my question is—it's a process question. If we become more and more confident that we've set—you know, I use this "set the bar" analogy. If you put a bar out here in the room 15 feet high and told me to go jump and hit it, I could jump all day, all month, I'd never get there. I can't jump that high. At some point I'm going to stop jumping. And I think that's the position I think we're in with this stock, that we've got a target out there and a good healthy maybe best ever spawning stock biomass level, yet we're seeing persistently poor recruitment. And that may mean that the bar is set too high." (MAFMC 2006).

The managers, fishermen, and politicians in the room became convinced that the true BMSY for the

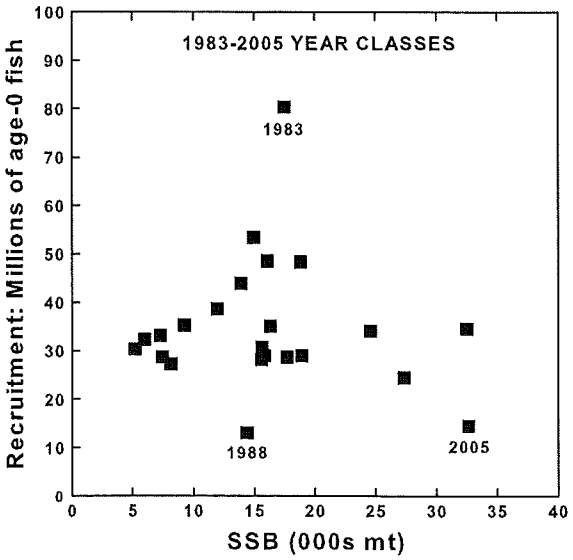


Fig. 2 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for the 1983–2005 year classes from the initial 2006 assessment update (Terceiro 2006a)

summer flounder stock had in reality been achieved, and that the assessment needed to be revised to reflect this situation. In response, the NMFS Regional Director and NEFSC Science and Research Director agreed to convene a special peer-review of the summer flounder stock assessment and biological reference points. The August 2006 meeting ended with the MAFMC recommending to the NMFS the initially proposed 2007 TAL of 9,026 mt (20 million lb), pending the results of the special peer-review to be completed in time for consideration by the MAFMC later in 2006.

The 2006 NMFS S&T peer review

Given the short time-frame to conduct the special peer-review, the NMFS decided to run the review under the auspices of the NMFS Office of Science and Technology (S&T). The update and peer review of the summer flounder biological reference points were accomplished during September 14–15, 2006. The 2006 NMFS S&T Peer Review Panel consisted of Drs. Richard Methot and Owen Hamel of the NMFS, and Dr. Joseph Powers of Louisiana State University. The peer-reviewed stock assessment document was made available to the MAFMC in October 2006 (Terceiro 2006b).

The Panel's technical recommendations required revisions to: (a) the VPA assessment model, (b) biological reference points, and (c) the short-term catch projection calculations, and the Panel advised that the revised analytical results should supersede those presented in the initial 2006 assessment (Terceiro 2006a). The Panel's most important recommendation was that stock status should be assessed using spawning stock biomass (SSB) on November 1 rather than total stock biomass (TSB) on January 1, as used in the past. As in the 2005 SAW 41 assessment, the Panel used an "empirical non-parametric" approach (i.e., the product of a reference level of recruitment and yield per recruit or biomass per recruit) in deriving revised biological reference points. The revised value of the FMSY proxy (= Fthreshold = Fmax) was 0.280, virtually identical to the existing reference point value (Fmax = 0.276). Mean recruitment during 1982–2005 was re-estimated at 37 million fish, and MSY was updated to 21,444 mt (47 million lbs). The revised Btarget (now based on SSB) was 89,411 mt (197 million lb) and the revised Bthreshold (1/2 Btarget) was 44,706 mt (99 million lb). The corresponding total stock biomass estimate at Fmax (analogous to the existing Btarget) was 97,430 mt (215 million lb), an increase from the existing value of 92,645 mt (204 million lb).

The assessment revisions (Terceiro 2006b) did not result in any change in the status of the summer flounder stock relative to that indicated by the results of the initial 2006 assessment (Terceiro 2006a). The revised estimate of F in 2005 was 0.41, 45% above the revised Fthreshold, indicating that overfishing was still occurring. The revised estimate of SSB in 2005 was 47,498 mt (105 million lbs), 53% of the revised Btarget, indicating that the stock was not overfished. The Panel confirmed that future fishing rates needed to be substantially reduced to provide at least a 50% chance of rebuilding to the revised Btarget by 2010. However, the fishing mortality rate that would rebuild the stock by 2010 was now estimated to be higher (Frebuild = 0.15) than the one calculated in the initial 2006 assessment (Frebuild = 0.10; Terceiro 2006a).

New projections incorporating the Panel's recommendations were made to determine the TAL for 2007 and the SSB trajectories to the revised Btarget. A projection at the revised FMSY proxy (0.28) indicated a 2007 TAL of 11,280 mt (25 million lbs), but continued fishing at this rate in subsequent years did not result in reaching the revised Btarget until about 2020. To reach Btarget by 2010 required Frebuild = 0.15 and a corresponding 2007 TAL of 6,421 mt (14 million lbs). A lower projected TAL for 2007 of 5,889 mt (13 million lbs) provided an increased chance (75% probability) that Frebuild would actually be achieved in 2007. The Panel also acknowledged the persistent retrospective patterns in the assessment, noting that the population model consistently underestimated F by 34% in the last three terminal years, and overestimated stock biomass by 12% and recruitment by 4%. The Panel made no recommendation on how to adjust the population model and associated projections for these patterns, but indicated that these patterns should be taken into account when setting management targets (Table 1).

The revised assessment and projections did little to quell the controversy over summer flounder science in general, or the 2007 TAL in particular. The revised assessment results and new 2007 TALs were viewed in some circles as a victory for fluke fishermen over the

government: "Any fluke fisherman who thinks politicians—and bureaucrats—are not listening to the public should consider Thursday's announcement by the National Marine Fisheries Service...The suspicion is that the Bush Administration sent the word down: Raise that quota, find those fish; I don't care how you do it, get the job done...Insisting that the rebuilding process be accelerated at the cost of great socioeconomic damage to those associated with the harvest of fluke defies common sense and demonstrates a callous disregard for people." (Asbury Park Press 2006).

Yet there was still much concern that the TAL recommendations of 13–14 million lb were lower than the 20 million lb recommended by the MAFMC in August 2006. The differing TAL proposals for 2007 brought the NMFS, the MAFMC, and the ASMFC into direct conflict in late 2006. The MAFMC had recommended 20 million lb in August; after the Peer Review, NMFS was recommending 13–14 million lb; in October, the ASMFC again proposed the 20 million lb, along with a measure to delay the rebuilding deadline from 2010 to 2015. In response, the NMFS warned that if the ASMFC specification was adopted, then NMFS would reduce the commercial share (60%, much of it taken from federal waters) of the TAL from about 13 million lb (under the 20 million lb TAL) to 6 million lb, to ensure that the effective TAL would be 13–14 million lb. This warning caused the ASMFC to withdraw its proposal, pending a joint meeting with the MAFMC in December 2006. In a harbinger of things to come, James A. Donofrio of the RFA stated: "The fishing community is being used a pawns by NMFS to get the Magnuson Act changed. That Act is not going to get changed without the environmental community giving its stamp of approval. NMFS hands are tied and the ASMFC is not going to help us. This fix will not come from the regulatory agencies but from putting long hours speaking with Members of Congress on how important this fishery is to the Mid-Atlantic. Recreational anglers need to ban together to fix this looming disaster." (Hutchinson 2006).

The 2006 Magnuson–Stevens Act (MSA) reauthorization and 2007 TAL

In fall 2006, reauthorization of the Magnuson-Stevens Act (MSA) was being debated in the 102nd Congress. The New York and New Jersey Congressional delegations, lead by Senator Charles Schumer (D-NY) and Representative Frank Pallone (D-NJ), were working to find ways to provide more "flexibility" for their constituents in the commercial and recreational fishing industries; that is, more annual quota. Having been unsuccessful during 2006 in getting the summer flounder biomass target lowered substantially, the two legislators next turned their attention to extending the rebuilding horizon to reach that target. As a consequence of their efforts, the MSA was amended to include a 3 year extension to the summer flounder rebuilding deadline from 2010 to 2013. Projections based on the 2006 S&T Peer Review assessment results, now accounting for the new rebuilding schedule, indicated that the 2007 TAL could be 7,761 mt (17 million lb). This was 28% less than the 2006 TAL, but 3–4 million lb higher than the options proposed by the NMFS. This TAL, approved by the NMFS in January 2007, provided an increased chance (75% probability) that the new Frebuild = 0.20 (the fishing rate to rebuild the SSB to Btarget by November 1, 2012, equivalent to January 1, 2013) would be met in 2007, and thereby improved the chances that stock rebuilding would continue. Key requirements for allowing the MSA extension provision to apply were thus satisfied: no overfishing was occurring, the stock biomass levels were increasing, and stock rebuilding was on track. The text of the MSA 2006 Flexibility Extension is below:

P.L. 109–479, sec. 120
CLARIFICATION OF FLEXIBILITY.

(a) IN GENERAL.—The Secretary of Commerce has the discretion under the Magnuson–Stevens Fishery Conservation and Management Act (16 U.S.C. 1851 et seq.) to extend the time for rebuilding the summer flounder fishery to not later than January 1, 2013, only if:

(1) the Secretary has determined that:

(A) overfishing is not occurring in the fishery and that a mechanism is in place to ensure overfishing does not occur in the fishery; and

(B) stock biomass levels are increasing;

(2) the biomass rebuilding target previously applicable to such stock will be met or exceeded within the new time for rebuilding;

(3) the extension period is based on the status and biology of the stock and the rate of rebuilding;
(4) monitoring will ensure rebuilding continues;
(5) the extension meets the requirements of section 301(a)(1) of that Act (16 U.S.C. 1851(a)(1)); and
(6) the best scientific information available shows that the extension will allow continued rebuilding.

(b) AUTHORITY.—Nothing in this section shall be construed to amend the Magnuson–Stevens Fishery Conservation and Management Act (16 U.S.C. 1851 et seq.) or to limit or otherwise alter the authority of the Secretary under that Act concerning other species.

The 2007 assessment update

The 2007 assessment updated the 2006 S&T assessment (Terceiro 2006b) and included fishery catches through 2006 and surveys through spring 2007. The update concluded that the stock was now overfished and that overfishing was still occurring (SDWG 2007; Table 1). Fishing mortality in 2006 was estimated to be 0.35, above the 2006 S&T assessment Fthreshold = 0.280. Retrospective analyses showed that the VPA model still underestimated recent fishing mortality rates, with annual underestimates ranging between 20 and 40% in the last three terminal years. SSB in 2006 was estimated to be 42,316 mt (93 million lb), slightly lower than the 2006 S&T assessment Bthreshold = 44,706 mt (99 million lb). Retrospective analyses indicated a tendency to overestimate SSB in recent years, by between 8 and 22% in the last three terminal years. To have a 50% chance of rebuilding the stock to the 2006 S&T assessment Btarget of 89,411 mt (197 million lb) by the new rebuilding date of Nov 1, 2012 (to meet the MSA codified January 1, 2013 date when using November 1 SSB), fishing at an Frebuild = 0.199 would be required during 2008–2012. The recommended 2008 TAL with a 75% chance of meeting this Frebuild was 7,155 mt (16 million lbs), an 8% decrease from the 2007 TAL.

Discussion at the subsequent meetings to make recommendations for the 2008 TAL focused on the need to adopt a lower quota to account for the retrospective "bias" in the assessment, and the possibility that because the SSB had stopped increasing in the most recent years, the stock had reached its true BMSY. For example, MAFMC member Jeffrey Deem from the Commonwealth of Virginia stated: "Let me explain some of my own experience with this, but it's my understanding that as you reach your peak carrying capacity, things start to level out. The spawning stock biomass now in the last 4 years has leveled out. And to me, as a novice, it looks like this and some other indicators, such as weight at length, drops in recruitment, are all signs of a stock that is topped out. You show it in yours the last three or f4 years of the projection, the rates of growth drop—now let me see if I've got it here—2009 in your projection is 14 percent higher than 2008. 2010 is only 11 percent higher than 2009. 2011 is seven percent higher than projection for 2010. And it goes down to six and a half percent. Then it goes down to five and a half percent growth in the last year. So, it looks to me like you're following the normal routine. And when you get up here, it's going to start to level out. It looks like we're already at the leveling out point right here." (MAFMC 2007). Ultimately, the MAFMC recommended and the NMFS approved the proposed "75% chance" TAL of 7,155 mt (16 million lbs) for 2008.

The 2008–2010 State of New York and United Boatmen lawsuit

In August 2008, the State of New York filed suit against the NMFS challenging the recreational fishery measures for 2008, which were implemented under the rules of "conservation equivalency," instead of as coastwide measures. The "conservation equivalency" option allows the conservation measures of individual states to apply to the anglers from these states fishing in federal waters because the state measures are considered to be at least the "conservation equivalent" of the possession, season and size limit that would have been imposed as federal coastwide measures. For 2008, as in previous years, New York's allocation of the recreational fishery harvest limit was about 18%, reflecting its share of the base year 1998 landings, the last year in which all states recreational measures were roughly

equivalent. However, because New York significantly exceeded its harvest limit in five of the seven preceding years, the New York allocation for 2008 was reduced to only about 13%, requiring the largest minimum size, smallest daily possession limit, and shortest open season of all the Atlantic coast states.

The State of New York's primary contention was that because the recreational fishery allocations to the individual states were based upon data from the Marine Recreational Fisheries Statistical Survey (MRFSS; Van Voorhees et al. 1992)—the accuracy of which was criticized in a National Research Council Report (NRC 2006)—the NMFS decision to use the conservation equivalency option was arbitrary and capricious, and violated MSA National Standard 2, as it was not based on the best scientific information available. The State of New York further alleged that use of the MRFSS information resulted in unfair and inequitable treatment, which was inconsistent with MSA National Standard 4. The State of New York also argued that because the size of the summer flounder stock had increased substantially since 1998, and now consisted of many more larger and older fish that tended to migrate further north into New York waters over the course of the summer, that a larger portion of the stock was available to New York anglers in 2008 than in 1998—and so the State was entitled to a larger percentage allocation.

The 2008 recreational fishing season passed with no decision in the case, and in July 2009 the State of New York filed a new suit challenging the 2009 measures, this time also listing the ASMFC as a defendant. In the 2009 lawsuit, the United Boatmen of New York, the New York Fishing Tackle Trade Association, and the Fishermen's Conservation Association joined as Intervenor-Plaintiffs. The 2009 recreational fishing season also passed with no decision in the case. In June 2010, the US District Court ruled in favor of the NMFS, stating that the NMFS did not ignore the "best scientific information available" in promulgating the 2008–2009 regulations, but rather elected to regulate the fishery through state-by-state regulations in view of its comparative benefits to coastwide regulations, despite the Agency's awareness of the limitations of the MRFSS data, and therefore did in fact satisfy the MSA National Standards in question (USDC 2010).

The 2008 SAW 47 benchmark assessment

As noted previously, representatives of the recreational fishing industry in New York and New Jersey influenced summer flounder science and management through their efforts to have the 2006 assessment revisited and the MSA amended to extend the rebuilding period. Commercial fishing groups were also pursuing avenues to influence summer flounder science and management, primarily through cooperative research projects that would feed data and analyses directly into the assessment. All of this industry activity resulted in scientists sponsored by commercial and recreational fishing interests participating actively in the SAW Southern Demersal Working Group as the 2008 assessment process got underway in late 2007. Of particular note was the participation of a respected fisheries consultant hired by the Save the Summer Flounder Fishery Fund (SSFFF), a newly formed recreational industry group. This scientist possessed broad experience in assessing fish stocks around the world, was very familiar with the catch-at-age models used in the summer flounder assessment, and was to play an important role in structuring the 2008 SAW 47 assessment models.

The development of the 2008 SAW 47 assessment was a complex process, with meetings via conference call and in person occurring in November 2007, February 2008, April 2008, and May 2008 to discuss data and model configurations. In addition to providing estimates of fishing mortality rates and stock sizes, and an evaluation of stock status with respect to reference points, the 2008 assessment was also expected to include analyses related to several major research topics (some of which were suggested by the 2001 and 2006 reference point reviews) including:

(1) statistical methods of combining research survey indices outside of the assessment model to obtain an independent evaluation of stock trends,
(2) statistical methods to deal with "zero" observations in survey data, other than treating them as "missing",
(3) evaluating changes in the spatial distribution of the stock as fishing rates decline and the age structure of the stock expands,
(4) evaluating changes in mean lengths-at-age, mean weights-at-age, and the sex ratio of the

stock as fishing mortality declines and age structure expands,

(5) assessing the relationship of environmental factors such as regional water temperature anomalies and larger scale climate indices in relation to metrics of summer flounder recruitment success, and

(6) reconsideration of the assumed value of the instantaneous natural mortality rate (M) in the assessment (NEFSC 2008).

The most important changes in the assessment were due to revision of the assumed value of M. Arguments for changing M from the existing constant value of 0.20 were based on (a) evidence that males were shorter-lived (maximum observed age of 12) with greater relative abundance and higher initial growth rate at younger ages than females (maximum observed age of 14), and (b) likelihood profiles of the assessment models generally fit better for M values higher than 0.20, ranging up to about 0.50. Arguments for retaining the constant value of 0.20 were that (a) fishing mortality had not been low enough for long enough for the population to have fully realized the true maximum age (potentially older than 15 years given the large sizes of some measured but un-aged fish), and (b) the model structure and configuration strongly influence the conclusions that could be drawn from the likelihood profiles on M. The scientific debate over the appropriate value for M lasted nearly 2 days. Eventually, the Working Group consensus was to change the assumption for M from the existing value of 0.20 for all ages (0–7+) to an abundance weighted, combined sex, schedule at age that ranged from 0.26 at age 0–0.24 at age 7+, with a mean of 0.25, an increase of 25%.

All summer flounder stock assessments from 1990 to 2007 used a VPA population model that "back-calculates" stock size at age based on the estimates of catch at age, assumptions for the natural mortality rate at age, and trends in abundance at age from research survey calibration indices. Another more recently developed class of catch-at-age models, generically called "forward-projecting" models, use the same input data as VPA but, rather than starting at the "terminal year" and calculating back in time, start at the initial (first) year and calculate forward. This "forward-calculation" approach uses slightly different mathematics and assumptions than the VPA, but generally provides similar results for the same input data and assumptions. These models (also called "statistical catch-at-age models") offer more flexibility than VPA in that they can estimate expected values for nearly all the input data. As such, these models are increasingly used in stock assessments worldwide.

Three modeling approaches were explored in detail in the 2008 SAW 47 assessment. A VPA of commercial and recreational total catch at age (landings plus discards) was conducted, both to "build-a-bridge" from previous assessments and to serve as the baseline model for the 2008 assessment. In addition, two statistical catch-at-age models (SCAA) were explored: Age Structured Assessment Program (ASAP) and Stock Synthesis version 2 (SS2). The same suites of survey calibration indices of stock abundance used in almost all previous assessments were used in all three modeling approaches. One major change in model structure in the SCAA models was the disaggregation of the single VPA fishery catch-at-age matrix into separate matrices for landings and discards. After many comparative runs with all three models, the ASAP model was selected as the best analytical tool to assess the summer flounder population. The combined effects of the new assumption for M and the modeling of landings and discards as distinct fleets (which resulted in a slightly domed-shaped combined fishery selectivity pattern) resulted in higher estimates of the fishing mortality (F) reference points, lower estimates of MSY, lower estimates of the SSB reference points, and improved stock status with respect to both the F and SSB reference points, as compared to the 2006 S&T and 2007 assessments (Terceiro 2006b; SDWG 2007). Also of note was that the new assumption for M meant that the newly estimated fishing mortality rates and biomass levels were no longer directly comparable to those of the 1990–2007 analytical assessments (NEFSC 2008).

Based on the 2008 SAW 47 assessment results (using the new model, new assumption for M, and the revised biological reference points), the summer flounder stock was no longer overfished and overfishing was not occurring. The fishing mortality rate in 2007 was estimated to be 0.288, below the new Fthreshold = F35% = 0.310. Retrospective analyses indicated that the new model still tended to underestimate recent fishing mortality rates, with the annual retrospective change in fishing mortality

ranging from +30 to −5% in the last three terminal years. SSB in 2007 was estimated to be 43,363 mt (96 million lb), about 72% of the new Btarget = SSB35% = 60,074 mt (132 million lb). Retrospective analyses showed a tendency to overestimate the SSB in the last three terminal years, with the annual retrospective change ranging from −29 to +6%. The arithmetic average recruitment from 1982 to 2007 was now estimated to be 42 million fish at age 0. The 1982 and 1983 year classes were the highest in the new time series (at 74 and 82 million fish, respectively), while the 1988 year class was still the lowest at only 13 million fish. The 2007 year class was estimated to be about average at 40 million fish. No consistent retrospective pattern in recruitment was evident (NEFSC 2008; Table 1).

The 2008 assessment stock status determination of not overfished and no overfishing was a major change from the 2007 assessment (SDWG 2007), when the stock was found to be overfished with overfishing. The projections performed for the 2008 assessment indicated that if the 2008 TAL was landed, F in 2008 would be 0.238, below the new Fthreshold, with SSB = 46,992 mt (104 million lb) on November 1, 2008, above the new Bthreshold of 30,037 mt (67 million lb). Fishing at Frebuild = 0.274 in 2009 (now defined as the constant F projected to have a 50% chance to rebuild to the biomass target by November 1, 2012) provided a candidate 2009 TAL of 9,211 mt (20 million lb; 50th percentile of the landings distribution for F = 0.274), with a second candidate TAL of 8,653 mt (19 million lb; 25th percentile) projected to have a 75% change of meeting Frebuild. Fishing at F40% = 0.255 (the newly defined Ftarget) during 2009–2012 was projected to result in SSB = 62,181 mt (137 million lb) in 2012, above the new Btarget, with candidate 2009 TALs of 8,626 mt (19 million lb; 50th percentile of the landings distribution for F = 0.255) and 8,104 mt (18 million lb; 25th percentile; 75% chance of meeting Ftarget). However, fishing at the new Fthreshold = F35% = 0.310 during 2009–2012 was projected to result in SSB = 56,471 mt (125 million lb) in 2012, still below the new Btarget. The MAFMC recommended an intermediate level of quota for the 2009 TAL (8,369 mt; 18.5 million lb; about the 38th percentile of the landings distribution for Ftarget = 0.255; MAFMC 2008), which the NMFS approved in December 2008. The approved 2009 TAL was a 17% increase over the 2008 TAL.

The results of the 2008 SAW 47 benchmark assessment and subsequent increase in the TAL for 2009 were noted in the popular fisheries press as a victory for fishermen. *Asbury Park Press* columnist John Geiser wrote: "The truth on fluke numbers is leaking from the fisheries management system like an incoming tide through a wooden Sea Bright skiff that has not tasted salt water in years. Robert "Dusty" Rhodes, former vice chairman of the Mid-Atlantic Fishery Management Council, has spent weeks checking the leaks, and found this week there is no denying the rising water in the bilge. "The new model that they've used on summer flounder proves we are not overfishing and overfishing is not occurring" he said. "We've been right all along." Even government scientists admit that there are probably four times as many fluke today as there were 50 years ago. The rub was that they believed there should be twice as many again, and Congress went along with it. Clinging to this mistake would have meant closing the fluke fishery this year or the year after in an attempt to achieve an arbitrary biomass of 214 million pounds by the end of 2012 and, when that was not attained, keeping it closed until it was reached." (Geiser 2008). *Asbury Park Press* columnist John Oswald wrote: "The temporary fix was a modest increase in 2009 summer flounder quotas as a result of new science provided by Dr. Mark Maunder, who was hired by the SSFFF and whose specialty is the development of statistical methodology for fisheries stock assessment. Maunder's research was instrumental in demonstrating that the fluke stocks were not in the dire shape that the National Marine Fisheries Science had indicated and led fishery management to reassess the state of the fishery." (Oswald 2008).

The 2009 assessment update

The 2009 assessment updated the 2008 SAW 47 assessment (NEFSC 2008) and included fishery catches and surveys through 2008. The update concluded the stock was not overfished and overfishing was not occurring, the same findings as indicated by the 2008 assessment (Terceiro 2009; Table 1). Fishing mortality in 2008 was estimated to be 0.250, below the Fthreshold = F35% = 0.310. SSB in 2008 was estimated to be 46,029 mt (101 million lb), about 77% of the Btarget = SSB35% = 60,074 mt

(132 million lb). The arithmetic average recruitment from 1982 to 2008 was still 42 million fish at age 0. The 2008 year class was estimated to be about 62 million fish, the largest cohort since 1986. The assessment model still exhibited a retrospective pattern of underestimation of F and overestimation of SSB over the last five terminal years, with the annual retrospective error in fishing mortality ranging between −34 and +13% and the annual retrospective error in SSB ranging from −12 to +41%. No consistent retrospective pattern in recruitment was evident. Projections indicated that if the 2009 TAL was harvested, F in 2009 would be 0.247, below the Fthreshold, and SSB = 55,065 mt (121 million lb), above the Bthreshold. Fishing at Ftarget = F40% = 0.255 in 2010 was projected to result in SSB = 60,837 mt (134 million lb), above the Btarget, with candidate 2010 TALs of 10,036 mt (22 million lb; 50th percentile of the landings distribution for F = 0.255) and 9,261 mt (20 million lb; 25th percentile; 75% chance of meeting Ftarget). The MAFMC recommended and the NMFS approved a 2010 TAL of 10,036 mt (22 million lb), a 20% increase over the 2009 TAL.

The 2010 assessment update

The 2010 assessment update included fishery catches and surveys through 2009. The assessment results indicated that stock was not overfished and overfishing was not occurring, the same findings as in the 2008 and 2009 assessments (Terceiro 2010; Table 1; Fig. 3). Fishing mortality in 2009 was estimated to be 0.237, below the Fthreshold = F35% = 0.310 (Figs. 3, 4), and SSB in 2009 was estimated to be 53,458 mt (118 million lb), about 89% of the Btarget = SSB35% = 60,074 mt (132 million lb; Fig. 3, 5). The size of the 2008 year class, estimated at 62 million fish in the 2009 assessment, was reduced by about 20% to 49 million fish, but was still 17% above the average. The 2009 year class was estimated to be about 82 million fish, about twice the average, and the largest in the assessment time series (Fig. 5). The assessment model still exhibited retrospective patterns in underestimation of F and overestimation of SSB, although these deviations were less severe than in previous assessments (Figs. 6, 7). A pattern of overestimation of recruitment became more evident in the

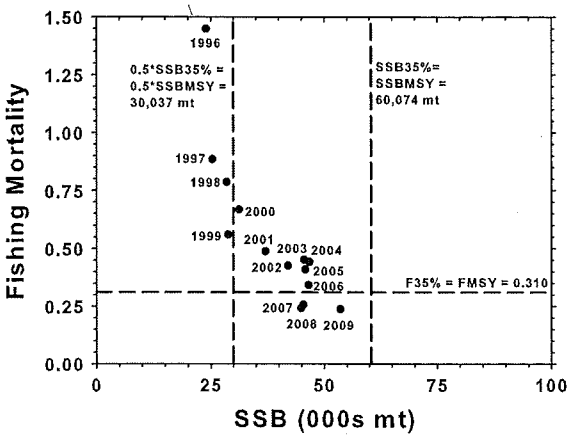


Fig. 3 Spawning stock biomass (SSB; 000s metric tons [mt]) and fishing mortality (F, ages 3–7+) as estimated in the 2010 assessment update (Terceiro 2010), compared with the 2008 SAW 47 reference points (NEFSC 2008)

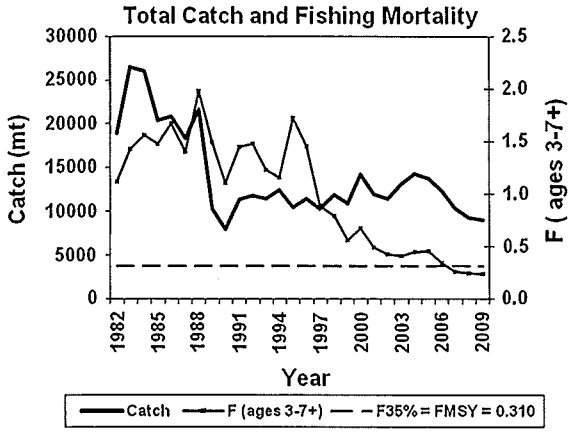


Fig. 4 Total catch (landings and discards, metric tons [mt]) and fishing mortality (F, ages 3–7+) as estimated in the 2010 assessment update (Terceiro 2010). The *dashed horizontal line* is the fishing mortality rate threshold (Fthreshold), F35% = FMSY = 0.310

2010 assessment, especially in the last three terminal years (Fig. 8). Projections indicated that if the 2010 TAL was landed, F in 2010 would be 0.241, below the Fthreshold, and SSB on November 1, 2010 would be 72,367 mt (160 million lb), above the Btarget. Fishing at Ftarget = F40% = 0.255 during 2011–2012 was projected maintain the SSB above Btarget, and generate landings in 2011 (e.g., a median of 13,371 mt [29.5 million lb]) above MSY (13,122 mt [29 million lb]).

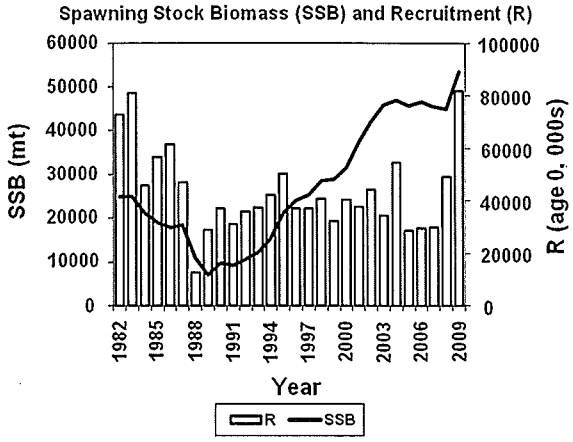


Fig. 5 Spawning stock biomass (SSB; metric tons [mt]) and recruitment (R; 000s of age 0 fish) as estimated in the 2010 assessment update (Terceiro 2010)

Discussion

Retrospective patterns

The persistent "internal model" retrospective pattern of underestimation of fishing mortality (F) and overestimation of SSB appears to have abated somewhat in the last few assessments. With the 2010 update, the pattern reversed itself; for the previous two terminal years (2007–2008), fishing mortality had been overestimated by about 10% and SSB underestimated by about the same amount (Figs. 6, 7). The mathematical cause of the retrospective patterns is the inability of the assessment models, whether the "back-calculating" VPA or the "forward-projecting" SCAA, to closely match the approximately three-fold increase in stock size that occurred from the early 1990s through 2004 with the 50% decrease observed in most of the survey age 3 and older calibration indices in the late 2000s. Figures 9a–c present an illustration of the problem, by comparing most of the aggregate numeric survey indices (the individual recruitment indices are excluded for clarity) to the population model estimates (expressed here in aggregate as Assess 2010 N) that smooth the inter-annual variability in the indices. The model estimates "chase" influential increases (e.g., during 2003–2004) and decreases (e.g., during 2006–2007) in the survey indices as they accumulate over time. The severity of the retrospective pattern therefore depends on the magnitude of inter-annual survey index variability and the degree to which this is consistent with variability in the fishery catch-at-age data.

It remains unclear if this degree of consistency, and thus the underlying cause of the retrospective pattern, is due to missing fishery catch, variability in

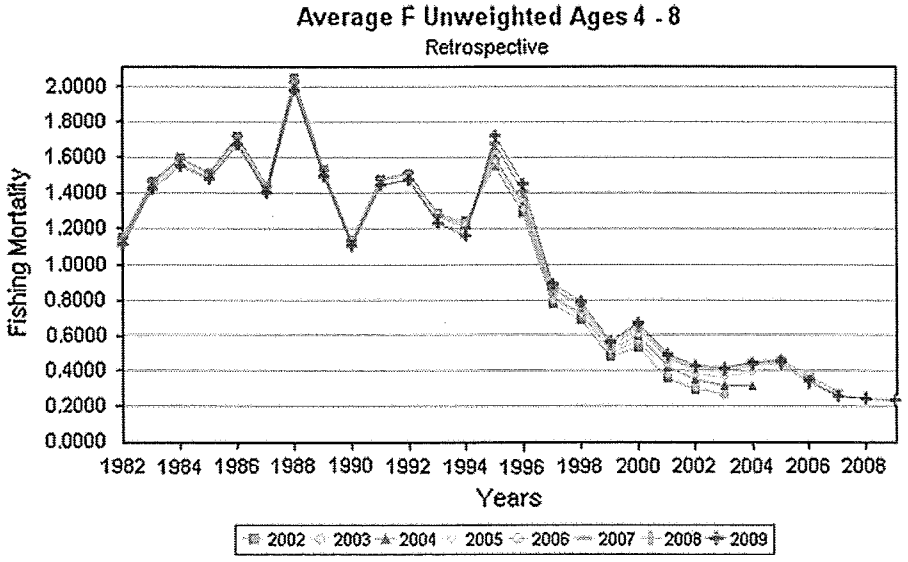


Fig. 6 Retrospective analysis of Fishing Mortality (F, ages 3–7+) from the 2010 assessment update (Terceiro 2010). Note that model ages 4–8 are true ages 3–7+

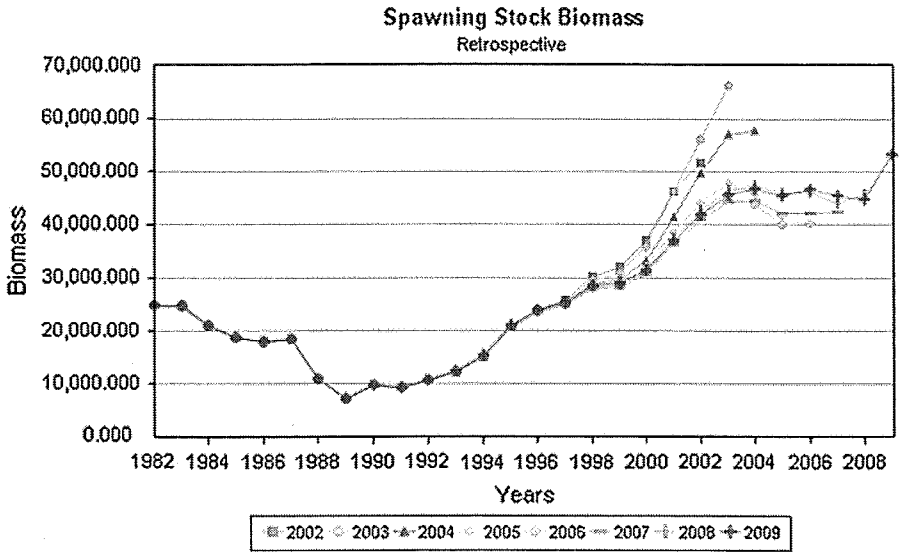


Fig. 7 Retrospective analysis of Spawning Stock Biomass (metric tons [mt]) for summer flounder from the 2010 assessment update (Terceiro 2010)

survey catchability due to fish behavior or environmental conditions, changing natural mortality (M), or some combination of these and other factors. Most recently, the "internal model" retrospective uncertainty is greatest for the youngest age (Fig. 8), with the current ASAP SCAA model unable to adequately account for recent large increases in many of the survey recruitment indices. It is likely that only through improvements in the accuracy and precision of the inputs to the models, specifically the accuracy of the catch and survey data and the representation of the biological characteristics of the stock, will the retrospective patterns and associated uncertainty be reduced.

Another way to consider the uncertainty of the summer flounder science is to compare "historical" estimates from the time series of stock assessments—a "historical retrospective." Because of the change in assessment model and the revised natural mortality (M) schedule used in the 2008 SAW47 and subsequent assessments, the most recent three assessments are not directly comparable with earlier ones. Nevertheless, such a comparison reveals that from a qualitative standpoint, the summer flounder analytical assessments

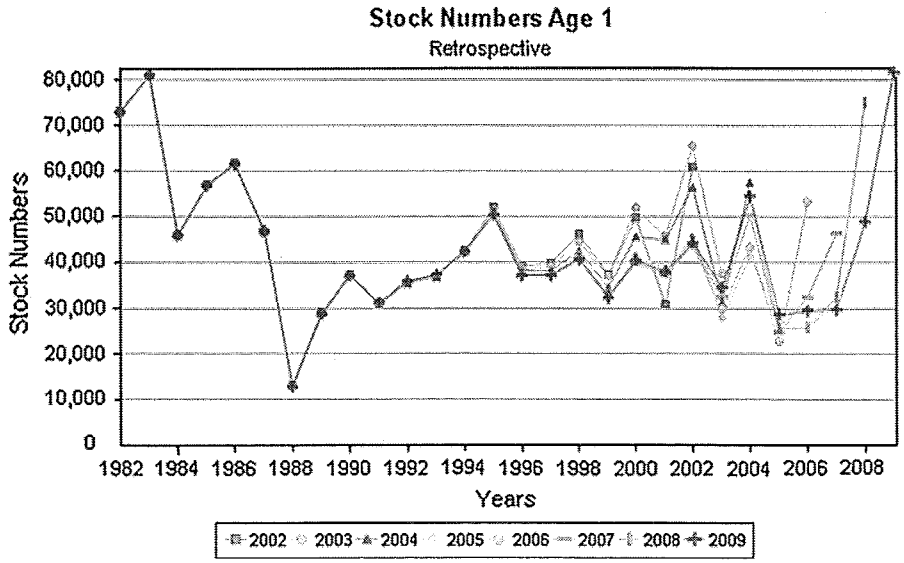
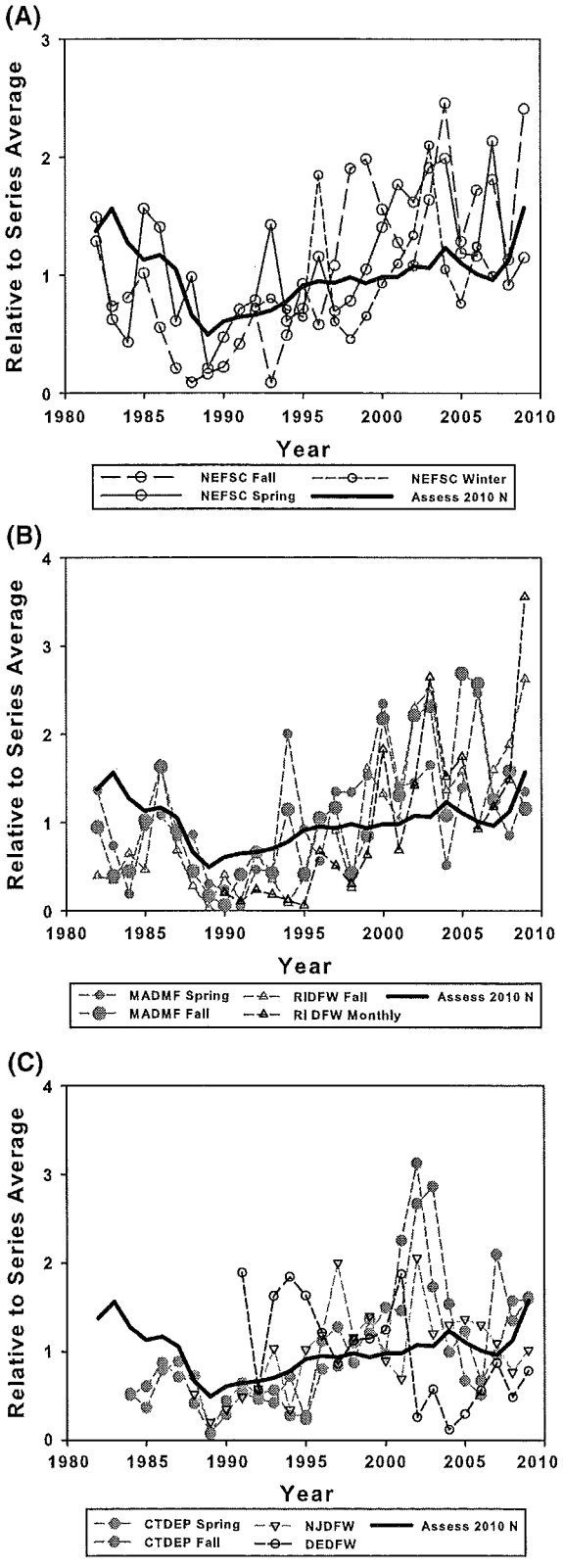


Fig. 8 Retrospective analysis of Recruitment (Stock Numbers; 000s of age 0 fish) from the 2010 assessment update (Terceiro 2010). Note that model age 1 is true age 0



◀**Fig. 9** **a** Comparison of NEFSC survey aggregate numeric indices with 2010 assessment update model (Assess 2010 N) estimates of total numeric abundance (Terceiro 2010). NEFSC Fall, Spring, and Winter refer to the seasonal NEFSC trawl survey index series, here presented aggregated across all ages. All series are scaled to their time series averages. **b** Comparison of MADMF and RIDFW survey aggregate numeric indices with 2010 assessment update model (Assess 2010 N) estimates of total numeric abundance (Terceiro 2010). MADMF Spring and Fall and RIDFW Spring and Monthly refer to the seasonal Massachusetts and Rhode Island state agency trawl survey index series, here presented aggregated across all ages. All series are scaled to their time series averages. **c** Comparison of CTDEP, NJDFW, and DEDFW survey aggregate numeric indices with 2010 assessment update model (Assess 2010 N) estimates of total numeric abundance (Terceiro 2010). CTDEP Spring and Fall, NJDFW, and DEDFW to the seasonal or annual Connecticut, New Jersey, and Delaware state agency trawl survey index series, here presented aggregated across all ages. All series are scaled to their time series averages

since 1990 have been consistent in estimating the relative magnitude (e.g., high, moderate, low) of fishing mortality and stock biomass, despite "internal model" retrospective uncertainty (Table 1; Fig. 10).

Reference points

As noted earlier, one of the alternative modeling efforts in 2001 asserted that FMSY of about 0.9 and SSBMSY of about 25,000 mt (55 million lb) were appropriate reference points for summer flounder. These conclusions—and similar ones in 2006 suggesting that the summer flounder stock had reached its maximum production of recruits, and that "the bar has been set too high" with regard to the definition of Btarget—now appear incorrect, given the recent increases in both SSB and recruitment. Fishing the stock at a high fishing mortality rate to maintain the biomass at the abundance of the late 1990s would have resulted in a current stock size half of that estimated for 2009 (Fig. 5). While the high F strategy could potentially provide higher yield per recruit, the potential negative consequences include a more truncated age structure with less SSB at older ages and about a 60% lower rate of SSB per recruit (Gibson 2001; NEFSC 2008). Although no work has been done specifically for summer flounder, larger and older spawning fish typically produce greater quantities of viable eggs than smaller, younger spawners. A population with an expanded age structure with more "experienced" spawners

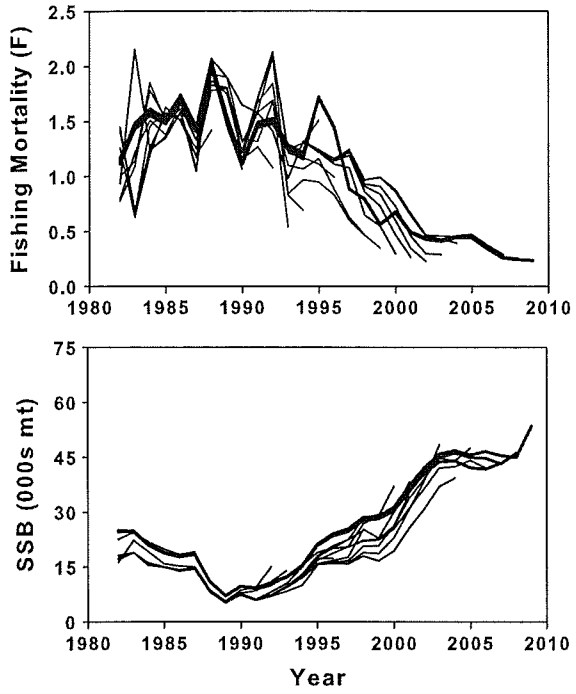


Fig. 10 Historical retrospective pattern in estimates of Fishing Mortality (F) and Spawning Stock Biomass (SSB; 000s metric tons [mt]) from the 1990–2010 summer flounder stock assessments. The 1990–2007 assessments used single fleet VPA models and average M = 0.20 (*thin lines*). The 2008–2010 assessments used multi-fleet ASAP models and average M = 0.25 (*thick lines*)

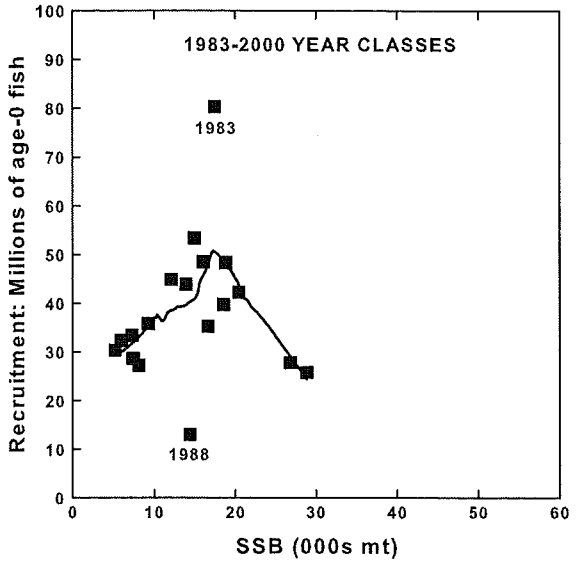


Fig. 11 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for summer flounder from the 2001 assessment (MAFMC, 2001a). Bold line is a lowess smoother with tension = 0.5

therefore has a greater chance of producing large year classes (Hislop 1988; Montelone and Houde 1990; Buckley et al. 1991; Trippel and Nielsen 1992; Chambers and Leggett 1996; Trippel 1998; Murawski et al. 2001; Begg and Marteinsdottir 2003).

A comparison of a series of stock-recruitment plots further illustrates why scientists have yet to develop a clear understanding of the stock-recruitment dynamics for summer flounder. Figure 11 presents the data considered in 2001, when some concluded that the stock was exhibiting over-compensation and should be maintained near (or below) the existing SSB to maximize recruit survivorship (Gibson 2001; Crecco 2001). The curve through the data is a Lowess smoother with tension = 0.5 (Cleveland 1979; Cleveland and Devlin 1988) to highlight the trend. Based solely on this scatterplot of stock-recruitment data, it is perhaps understandable how some scientists in 2001 reached the over-compensation conclusion. Figure 12 shows the stock-recruitment scatterplot considered in 2006, with five more stock-recruit pairs than in the 2001 plot, that prompted one MAFMC member to conclude "... the relationship between the spawning stock biomass size and recruitment [showing] a disturbing trend in recent history of there being a poor—or a negative relationship actually between SSB and recruitment, in that the SSB isn't producing the number of recruits that you would expect under normal circumstances." (MAFMC 2006). This conclusion was shared by other managers and scientists, and lead to the 2006 S&T Peer Review of the assessment and reference points (Terceiro 2006a, b), but ultimately no major changes in either. Based on the 2010 assessment update (Terceiro 2010) the picture of summer flounder stock-recruitment dynamics has now changed to that in Fig. 13. The 2010 assessment update (and accompanying projections) indicated the summer flounder stock was experiencing a 30-year low in exploitation and a 30-year high in stock biomass, and was likely to reach its rebuilding target in 2010 (Terceiro 2010). Further, the 2009 year class—the largest in 30 years—is projected to recruit to the exploitable stock over the next 3 years, providing the potential for further near-term stock growth. It may seem that the question of "How much fish is enough?" has finally been

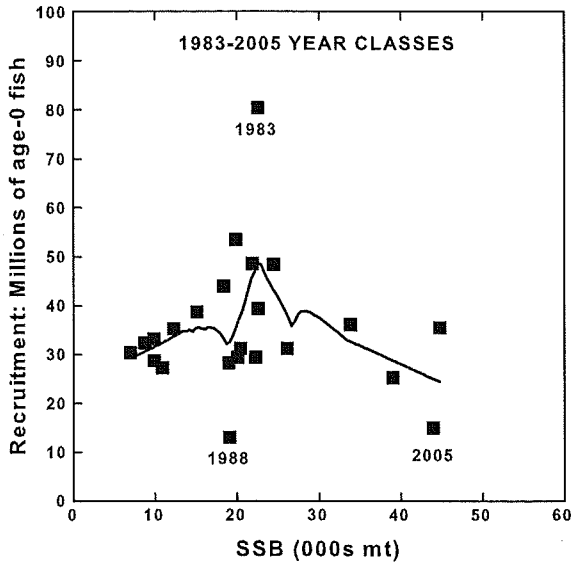


Fig. 12 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for summer flounder from the final 2006 assessment (Terceiro 2006b). Bold line is a lowess smoother with tension = 0.5

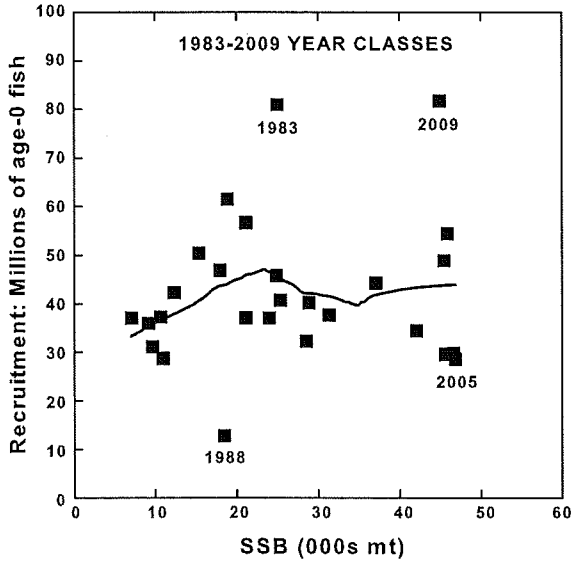


Fig. 13 Spawning stock biomass (SSB; 000s metric tons [mt]) and recruitment (millions of age-0 fish) estimates for summer flounder from the 2010 assessment (Terceiro 2010). *Bold line* is a lowess smoother with tension = 0.5

answered with the attainment of Btarget. However, it is also clear that our understanding of the nature of the summer flounder stock-recruitment relationship and its subsequent impact on reference points, status determination, and allowable landings, will continue to evolve as more data are obtained.

The challenges ahead

During the last decade the science and management of summer flounder markedly improved, but significant challenges lay ahead. From a scientific perspective, future assessments need to: (a) better account for the uncertainty resulting from "internal model" retrospective error, (b) better integrate environmental, ecological, and other non-traditional calibration indices into the modeling framework, and (c) better discern summer flounder stock-recruitment dynamics by considering covariates such as environmental factors and predator/prey abundance. Initiatives are already underway to acquire improved fishery and biological data (e.g., stratified by sex) to allow the assessments to better reflect the true "state of nature."

This paper has chronicled the "angst" involved in rebuilding a fish stock. Events since 2006 have demonstrated that the recreational and commercial fishing industries now have significant influence on the assessment and management of summer flounder. Future management challenges may prove even more daunting than the technical ones, as there will likely be heavy pressure from all fishery user groups to harvest as many fish from the rebuilt stock as permissible. Now that summer flounder stock has been rebuilt, the MAFMC Scientific and Statistical Committee has recommended that the stock be exploited at Ftarget = 0.255 over the long term, which based on current science will provide a median annual total catch of 14,362 mt (32.26 million lb). Fishing at a relatively low F over the last decade has provided the desired increase in stock biomass and, finally, a pay-off in terms of strong recruitment. As a result, a new challenge of "managing success" has arisen, and new science is underway in 2011 to explore the potential effectiveness of alternative management options. The aim of this work is to determine the levels of "risk" to the stock associated with different fishing mortality rates (or catch quotas) to evaluate how large (or small) the "buffer" needs to be between the threshold and target reference points to ensure a sustainable stock and fishery.

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Glossary of acronyms and technical terms

APA	(Adminstrative Procedures Act)—The US federal law that governs the way in which administrative agencies of the government propose and establish regulations; became law in 1946
ASAP	(Age Structured Assessment Program)—An age-structured model that uses forward computations to estimate population sizes given observed fishery catches and survey indices of abundance. ASAP is the model used in the 2010 summer flounder assessment to evaluate stock status
ASMFC	(Atlantic States Marine Fisheries Commission)—The Commission was formed by the 15 Atlantic coast states in 1942 as a deliberative body to coordinate the conservation and management of the states shared near-shore fishery resources—marine, shell, and anadromous—for sustainable use. Member states are Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida. Headquarters are in Arlington, VA
B40%	The long-term average biomass that would be achieved if fishing at a constant fishing mortality rate equal to F40%. B40% is the current proxy for BMSY (expressed in terms of Spawning Stock Biomass as SSBMSY40%) for summer flounder
BMSY	The long-term average biomass that would be achieved if fishing at a constant fishing mortality rate equal to FMSY, i.e., the Btarget
Btarget	A biomass biological reference point used to guide management objectives for achieving a desirable outcome (e.g., BMSY)
Bthreshold	A biomass biological reference point used to guide management objectives for achieving a desirable outcome (e.g., one-half BMSY). Under current management, if biomass falls below the biomass threshold the stock is considered to be overfished
EEZ	(Exclusive Economic Zone)—The ocean zone in which the USfederal government has administrative rights over the exploration and use of marine resources, typically stretching from the seaward edge of each US state's territorial sea (3–12 miles) out to 200 nautical miles from its coast
F40%	The fishing mortality rate at which the spawning stock biomass would be reduced to 40% of the theoretical maximum over the long-term. F40% is sometimes used as a proxy for FMSY (i.e., the Fthreshold) if FMSY cannot be reliably estimated. F40% is the current proxy for FMSY for summer flounder
Fmax	The fishing mortality rate that produces the maximum yield per recruit. Fmax is sometimes used as a proxy for FMSY if FMSY cannot be reliably estimated
FMSY	The fishing mortality rate that produces the maximum sustainable yield. Under current management, the fishing mortality rate threshold (Fthreshold) above which the stock is experiencing overfishing
FMP	(Fishery Management Plan)—The program of management regulations implemented cooperatively for summer flounder by the ASMFC, MAFMC, and USDOC

Frebuild	A fishing mortality rate that results in stock rebuilding to a desired biomass target
Ftarget	A biological reference point used to guide management objectives for achieving a desirable outcome (e.g., some percentage of FMSY)
Fthreshold	The fishing mortality rate above which the stock is experiencing overfishing. Defined as FMSY or its proxy in current management plans
IGFA	(International Game Fish Association)—The recreational fishing industry group that keeps track of sport fishing records for the largest fish caught on rod-and–reel in accordance with their rules. Headquarters are in Ft. Lauderdale, FL
MAFMC	(Mid-Atlantic Fishery Management Council)—The Council is responsible for the management of fisheries in federal waters which occur predominantly off the mid-Atlantic coast. States with voting representation on the Council include New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, and North Carolina. (North Carolina is represented on both the Mid-Atlantic and South Atlantic Fishery Management Councils.) Headquarters are in Dover, DE
MRFSS	(Marine Recreational Fishery Statistical Survey)—A standard method of data collection and statistical estimation initiated by the NMFS in 1981 to produce catch, effort, and participation estimates for marine recreational fisheries
MSA	(Magnuson–Stevens Act)—The Magnuson–Stevens Fishery Conservation and Management Act is the primary law governing marine fisheries management in United States federal waters. The Act was first enacted in 1976 and amended in 1996 and 2006. The Magnuson–Stevens Act aided in the development of the domestic commercial fishing industry by phasing out foreign commercial fishing. To manage the fisheries and promote conservation, the Act created eight regional fishery management councils, including those for New England and the Mid-Atlantic. The 1996 amendments focused rebuilding overfished fisheries, protecting essential fish habitat, and reducing bycatch. The 2006 amendments mandate the use of annual catch limits and accountability measures to end overfishing
MSY	(Maximum Sustainable Yield)—The largest average long-term catch that can be taken from a fish stock. Corresponds to the catch at FMSY or its proxy
NCFA	(North Carolina Fisheries Association)—a commercial fishing industry group
NEFMC	(New England Fishery Management Council)—The Council is responsible for management of fisheries in federal waters which occur predominantly off the New England coast. States with voting representation on the Council include Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut. Headquarters are in Newburyport, MA
NEFSC	(Northeast Fisheries Science Center), a scientific facility of the NMFS, with the primary laboratory located in Woods Hole, MA
NEPA	(The National Environmental Policy Act)—The federal law that requires federal agencies to integrate environmental values into their decision making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions
NMFS	(National Marine Fisheries Service)—headquarters are in Silver Spring, MD

NOAA	(National Oceanographic and Atmospheric Administration)—headquarters are in Silver Spring, MD
NRC	(National Research Council)—The Council functions under the auspices of the National Academy of Sciences (NAS), and is part of a private, nonprofit institution established in 1916 that provides science, technology and health policy advice to the US federal government. The NRC conducted a peer-review of the summer flounder data collection programs and assessment science in 1999, with results published in 2000
NRDC	(National Resources Defense Council)—The Council is an environmental action group currently with 1.3 million members and employees, including more than 350 lawyers, scientists and other professionals
Recruitment, Recruits	The number of young fish that survive from birth to a specific age or grow to a specific size. The specific age or size at which recruitment is measured may correspond to when the young fish become vulnerable to capture in a fishery or when the number of fish in a cohort can be reliably estimated by a stock assessment; also referred to as a "year-class." For summer flounder, these are fish in their first year of life, classified as "age 0." Age 0 summer flounder recruits (e.g., the 1988 year-class) first appear in fishery and survey catches in the fall of the year (1988) following the spawning season in which they were born (the previous fall of 1987 to the previous spring of 1988)
Retrospective pattern	The systematic over- or under-estimation of population parameters such as fishing mortality, stock numbers, or stock biomass, usually most evident in the most recent years of a stock assessment model such as VPA, ASAP, or SS2
SAW	(Stock Assessment Workshop)—The Northeast Regional Stock Assessment Workshop (SAW) is a formal scientific peer-review process for evaluating and presenting stock assessment results for fish stocks in the offshore US waters of the northwest Atlantic to managers and the public, conducted under the auspices of the regional management councils (the ASMFC, MAFMC, and NEFMC) and the NEFSC
SCAA	(Statistical Catch At Age)—The generic term referring to the class of age-structured models that use forward computations to estimate population sizes given observed fishery catches and survey indices of abundance
SDWG	(Southern Demersal Working Group)—The group of state and federal fishery scientists that prepares summer flounder stock assessments for peer review by the SAW, SSC, and other review panels
SS2	(Stock Synthesis 2)—Version 2 of the Stock Synthesis model, an age-structured model that uses forward computations to estimate population sizes given observed fishery catches and survey indices of abundance. SS2 was one of the models considered in the development of the 2008 SAW 47 assessment of summer flounder assessment
SSB	(Spawning Stock Biomass)—The total weight of all sexually mature fish in a stock
SSBMSY	The long-term average Spawning Stock Biomass (SSB) biomass that would be achieved if fishing at a constant fishing mortality rate equal to FMSY or its proxy
SSC	(Scientific and Statistical Committee)—The Advisory Panels to the MAFMC and NEFMC which provide peer review of scientific work

	and advice on appropriate catch levels and other fishery regulations
SSFFF	(Save the Summer Flounder Fishery Fund)—a recreational fishing industry group
TAL	(Total Allowable Landings)—the regulated annual weight removed from the stock as landed fish
TSB	(Total Stock Biomass)—The total weight of all fish in a stock
USDC	United States District Court
USDOC	(United States Department of Commerce)—The parent agency of the NOAA and the NMFS—headquarters are in Washington, DC
VPA	(Virtual Population Analysis)—An age-structured model that uses backward computations to estimate population sizes given observed fishery catches and survey indices of abundance. VPA was one of the models considered in the development of the 2008 SAW 47 assessment of summer flounder assessment

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