Northeast Fisheries Science Center Reference Document 03-06

36th Northeast Regional Stock Assessment Workshop (36th SAW)

Stock Assessment Review Committee (SARC) Consensus Summary of Assessments

March 2003

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02-14 **Report of the 35th Northeast Regional Stock Assessment Workshop (35th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments.** [By Northeast Regional Stock Assessment Workshop No. 35.] September 2002.

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02-16 **Assessment of 20 Northeast Groundfish Stocks through 2001: A Report of the Groundfish Assessment Review Meeting (GARM), Northeast Fisheries Science Center, Woods Hole, Massachusetts, October 8-11, 2002.** [By Groundfish Assessment Review Meeting, Northeast Fisheries Science Center, Woods Hole, Massachusetts, October 8-11, 2002.] October 2002.

03-01 **Manuscript/Abstract/Webpage Preparation, Review, & Dissemination: NEFSC Author's Guide to Policy, Process, and Procedure.** By J.A. Gibson, T.L. Frady, E.L. Kleindinst, and L.S. Garner. January 2003.

03-02 **Stock Assessment of Yellowtail Flounder in the Southern New England - Mid-Atlantic Area.** By S.X. Cadrin. [A report of Northeast Regional Stock Assessment Workshop No. 36.] February 2003.

03-03 **Stock Assessment of Yellowtail Flounder in the Cape Cod - Gulf of Maine Area.** By S.X. Cadrin and J. King. [A report of Northeast Regional Stock Assessment Workshop No. 36.] February 2003.

03-04 **Report of the 36th Northeast Regional Stock Assessment Workshop (36th SAW): Public Review Workshop.** [By Northeast Regional Stock Assessment Workshop No. 36.] February 2003.

03-05 **Description of the 2002 Oceanographic Conditions on the Northeast Continental Shelf.** By M.H. Taylor, C. Bascuñán, and J.P. Manning. March 2003.

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A Report of the 36th Northeast Regional Stock Assessment Workshop

36th Northeast Regional Stock Assessment Workshop (36th SAW)

Stock Assessment Review Committee (SARC) Consensus Summary of Assessments

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

March 2003

Northeast Fisheries Science Center Reference Documents

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TABLE OF CONTENTS

C. NORTHERN SHRIMP

D. STRIPED BASS

MEETING OVERVIEW

The Stock Assessment Review Committee (SARC) meeting of the 36th Northeast Regional Stock Assessment Workshop (36th SAW) was held in the Aquarium Conference Room of the Northeast Fisheries Science Center's Woods Hole Laboratory, Woods Hole, MA December 2-6, 2002. The SARC Chairman was Dr. Andrew Payne, CEFAS, UK (CIE). Members of the SARC included scientists from the NEFSC, the NMFS's Northeast Regional Office, the New England Fishery Management Council (MAFMC), Atlantic States Marine Fisheries Commission (ASMFC), State of Maryland, Canada's Department of Fisheries and Oceans (DFO), and the SEFSC's Beaufort NC laboratory (Table 1). In addition, 39 other persons attended some or all of the meeting (Table 2). The meeting agenda is presented in Table 3.

Table 1. SAW-36th SARC Composition.

Andrew Payne (CEFAS, Lowestoft, UK; CIE), **Chairman**

Northeast Fishery Science Center:
Jon Brodziak
Chris Legault
Richard Pace
Anne Richards

Regional Fishery Management Councils:
Andy Applegate, NEFMC

Atlantic States Marine Fisheries Commission/States:
Laura Lee, ASMFC
Paul Piavis, MD

Other experts:
Jerome Hermsen, NMFS, Gloucester
Heath Stone, DFO, St. Andrews
John Wheeler, DFO, Newfoundland; CIE
Erik Williams, SEFSC, Beaufort

Table 2. List of Participants.

NMFS, Northeast Fisheries Science Center	MAFMC/ASMFC/States/Industry
Almeida, Frank	Carmichael, John - NC DMF
Boreman, John	Caruso, Paul - MA DMF
Burnett, Jay	Correia, Steve - MA DMF
Cadrin, Steve	Gamble, Megan - ASMFC
Col, Laurel	Glenn, Bob - MA DMR
Idoine, Josef	Hunter, Margaret - Maine DMR
Jearld, Ambrose	Kelly, Steve - REMSA
Mayo, Ralph	King, Jeremy - MA DMF
McHugh, Nancy	Kuzirian, Alan - MBL
Moser, Joshua	Lazar, Najih - RI DFW
Murawski, Steve	Lewis, Michael - ASMFC
Nitshcke, Paul	Lovett, Katie - NMFS
O'Brien, Loretta	McNamee, Jason - RI DEM
Serchuk, Fred	Munger, Lydia - ASMFC
Shepherd, Gary	O'Shea, Vincent - ASMFC
Smith, Pie	Quinlan, John - Rutgers IMCS
Smith, Terry	Sharov, Alexei - MD DNR
Sosebee, Katherine	Welch, Stuart - U.S.G.S
Sutherland, Sandra	
Terceiro, Mark	
Thompson, Michele	

Table 3. Agenda of the 36th Northeast Regional Stock Assessment Workshop (SAW-36) Stock Assessment Review Committee (SARC) Meeting

Aquarium Conference Room - NEFSC Woods Hole Laboratory
Woods Hole, Massachusetts
2 - 6 December, 2002

TOPIC	WORKING GROUP & PRESENTER(S)	SARC LEADER	RAPPORTEUR
MONDAY, 2 December (1:00 - 5:00 PM)..			
Opening			
Welcome	Terry Smith, SAW Chairman		P. Smith
Introduction	Andy Payne, SARC Chairman		
Yellowtail flounder (A)	SAW Southern Demersal Working Group		
	S. Cadrin	H. Stone	R. Mayo
TUESDAY, 3 December (8:30 AM - 5:00 PM)..			
SNE/MA winter flounder (B1)	ASMFC winter flounder technical committee		
	M. Terceiro	J. Wheeler	P. Nitschke
Gulf of Maine winter flounder (B2)	ASMFC winter flounder technical committee		
	P. Nitschke	E. Williams	M. Terceiro
Northern shrimp (C)	ASMFC northern shrimp technical committee		
	M. Hunter	L. Lee	R. Glenn
Informal reception (**6:00 PM**) at SWOPE Building (Marine Biological Laboratory)			
WEDNESDAY, 4 December (8:30 AM - 5:00 PM)..			
SNE/MA yellowtail flounder (A1)	SAW Southern Demersal Working Group		
	S. Cadrin	H. Stone	S. Wigley
Cape Cod yellowtail flounder (A2)	SAW Southern Demersal Working Group		
	S. Cadrin	A. Applegate	J. King
Atlantic striped bass (D)	ASMFC striped bass technical committee		
	A. Sharov/ S. Welch	P. Piavis	M. Gamble
THURSDAY, 5 December (8:30 AM - 5:00 PM)..			
Review Advisory Reports and Consensus Summary Sections for the SARC Report			
FRIDAY, 6 December (8:30 AM - 5:00 PM)..			
SARC comments, research recommendations, and 2nd drafts of Advisory Reports			
Other business		P. Smith	

The Process

The Northeast Regional Coordinating Council, which guides the SAW process, is composed of the chief executives of the five partner organizations (NMFS/NEFSC, NMFS/NER, NEFMC, MAFMC, ASMFC). Working groups assemble the data for assessments, decide on methodology, and prepare documents for SARC review. The SARC members have a dual role n panelists are both reviewers of assessments and drafters of management advice. As products of the meeting, the Committee prepares two reports: a summary of the assessments with advice for fishery managers known as the *Advisory Report on Stock Status*; and a more detailed report of the assessment, results, discussions and recommendations known as the *Consensus Summary of Assessments* (this report).

Assessments for SARC review were prepared at meetings listed in Table 4.

Table 4. SAW-36 Working Group meetings and participants.

Working Group and Participants	Stock/Species	Meeting Date
SAW Southern Demersal Subcommittee		
	Yellowtail flounder stock structure	August 29, 2002
Frank Almeida	NEFSC	
Jon Brodziak	NEFSC	
Steve Cadrin	NEFSC	
Hemant Chikarmane	MBL	
Laurel Col	NEFSC	
Alexandra Hangsterfer	MBL	
Jeremy King	MADMF	
Alan Kuzirian	MBL	
Chris Legault	NEFSC	
Ralph Mayo	NEFSC	
Tom Nies	NEFMC	
Loretta O'Brien	NEFSC	
Bill Overholtz	NEFSC	
Paul Rago	NEFSC	
Tim Sheehan	NEFSC	
Vaughn Silva	NEFSC	
Sandy Sutherland	NEFSC	
Mark Terceiro, chair	NEFSC	
Michelle Thompson	NEFSC	
Susan Wigley	NEFSC	

Table 4. (cont.) SAW-36 Working Group meetings and participants.

Working Group and Participants	Stock/Species	Meeting Date
	SNE/MA yellowtail flounder CC/GOM yellowtail flounder	Sept. 30 - October 4, 2002
Steve Cadrin	NEFSC	
Steve Correia	MA DMF	
Jeremy King	MA DMF	
Gary Shepherd	NEFSC	
Kathy Sosebee	NEFSC	
Mark Terceiro, chair	NEFSC	
ASMFC Winter Flounder Technical Committee		
	SNE/MA winter flounder GOM winter flounder	September 24-25, 2002
Jay Burnett	NEFSC	
Steve Cadrin	NEFSC	
Steve Correia	MA DMF, Chair	
Laura Lee	ASMFC, RIDMF	
Chris Legault	NEFSC	
Anne Mooney	NY DEC	
Lydia Munger	ASMFC	
Paul Nitschke	NEFSC	
Sally Sherman	ME DMR	
David Simpson	CT DEP	
Kathy Sosebee	NEFSC	
Mark Terceiro	NEFSC	
Susan Wigley	NEFSC	
ASMFC Northern Shrimp Technical Committee		
	Northern Shrimp	May 15, 2002 September 23-24, 2002
Robert Glenn	MA DMF	
Margaret Hunter, chair	ME DMR	
Josef Idoine	NEFSC	
Clare McBane	NH F&G	

Table 4. (cont.) SAW-36 Working Group meetings and participants.

Working Group and Participants	Stock/Species	Meeting Date
ASMFC Atlantic Striped Bass Tagging. Committee		Linthicum, MD July 23-24, 2002
Robert Beal	ASMFC	
Megan Gamble	ASMFC	
Bob Harris	VIMS	
Desmond Kahn	DE DFW	
Tina McCrobie	USFWS	
Kim McKown	NYS DEC	
Vic Vecchio	NYS DEC	
Beth Versak	MD DNR	
Stuart Welch	USGS, WVU	
ASMFC Striped Bass Technical Committee		Linthicum, MD September 10-12, 2002
Mike Armstrong	MA DMF	
Tom Baum	NJ DFW	
Robert Beal	ASMFC	
John Carmichael	NC DMF	
Vic Crecco	CT DMF	
Megan Gamble	ASMFC	
Mark Gibson	RI DFW	
Doug Grout	NH DFW	
Phil Jones	MD DNR	
Desmond Kahn	DE DFW	
Kim McKown	NYS DEC	
Gary Nelson	MA DMF	
Rob O'Reilly	VRMC	
Alexi Sharov	MD DNR	
Gary Shepherd	NEFSC	
Tom Squiers	ME DMR	

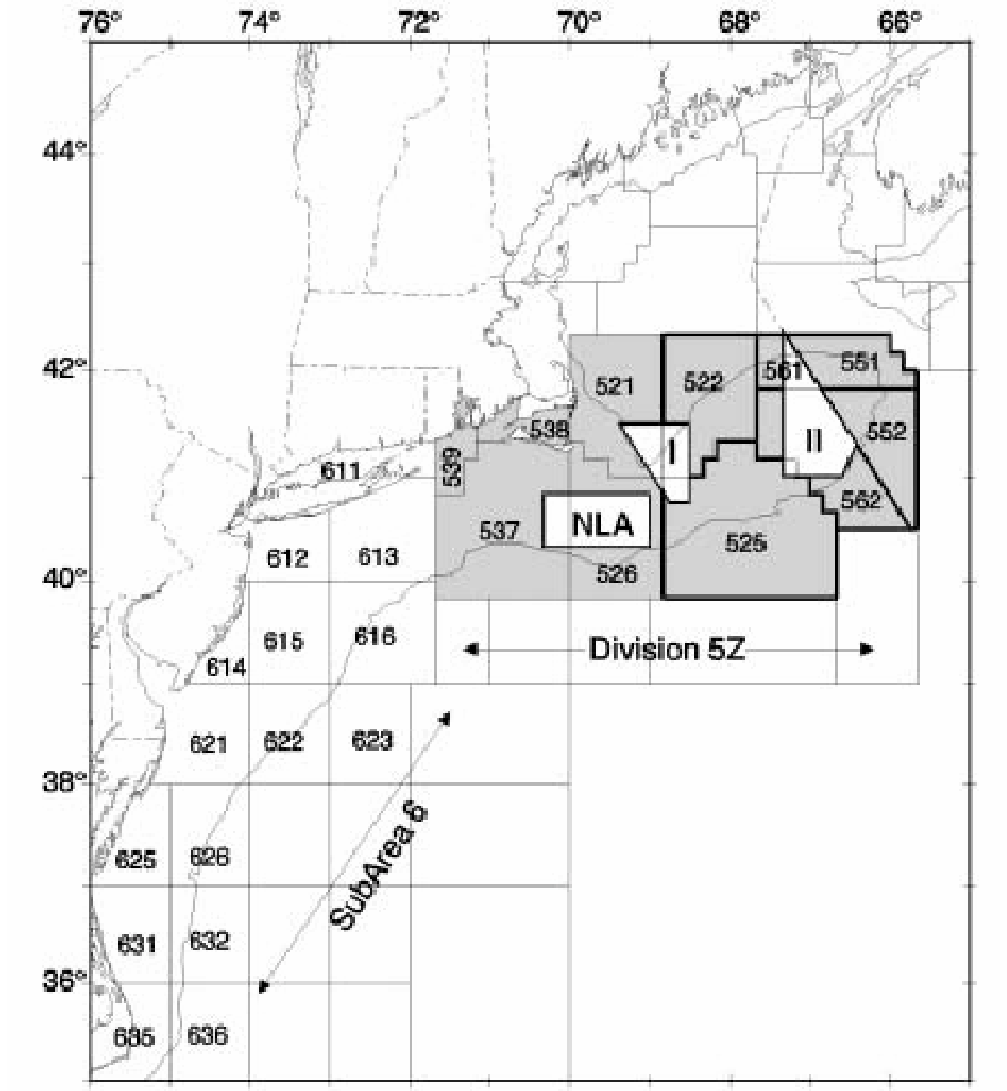
Agenda and Reports

The 36th SARC included presentations on assessments for yellowtail flounder (two stocks), winter flounder (two stocks), and northern shrimp as well as a presentation on assessment methodologies for striped bass. Prior to the presentation and discussion of individual yellowtail flounder stock assessments, the SARC discussed the issue of stock identification for the species. Information was offered by the SAW southern demersal group that led the SARC to conclude that, for assessment purposes, three stocks be classified: Southern New England/Mid-Atlantic (SNE/MA), Georges Bank, and Cape Cod/Gulf of Maine (CC/GOM). Assessments for the SNE/MA and CC/GOM stocks were then reviewed by the panel. The two winter flounder stocks assessed and reviewed by the panel are the Southern New England/Mid-Atlantic stock (SNE/MA) (as previously defined) and the Gulf of Maine stock (previously defined). The GOM winter flounder assessment was the first analytical assessment (VPA via ADAPT) offered for the stock. The winter flounder assessments were prepared by the ASMFC's winter flounder technical committee as was the assessment for northern shrimp. The striped bass information reviewed by the SARC was not an assessment, per se, but rather materials to address a set of questions (Terms of Reference) which related to specific issues of assessment methodology offered by the ASMFC.

SARC documentation includes two reports: one containing the assessments, SARC comments, and research recommendations (the Consensus Summary Report), and another produced in a standard format which includes information on stock status and management advice (Advisory Report). The draft reports were provided to the NEFMC, MAFMC and ASMFC in January. Presentations to the Councils and Commissions took place in January and February 2003 (MAFMC, 23 January, Atlantic City; NEFMC, 29 January, Portsmouth NH; ASMFC, 25 February, Crystal City VA). Following review by the Councils and Commission, the documents are finalized and published in the NEFSC Reference Document series as the *36th SARC Consensus Summary of Assessments* (this report) and the 36th *SAW Public Review Workshop Report* (which includes the final version of the Advisory Report).

A chart of US commercial statistical areas used to report landings in the Northwest Atlantic is presented in Figure 1. A chart showing the sampling strata used in NEFSC bottom trawls surveys is presented in Figure 2.

Figure 1. Statistical areas used for catch monitoring in offshore fisheries in the Northeast United States.



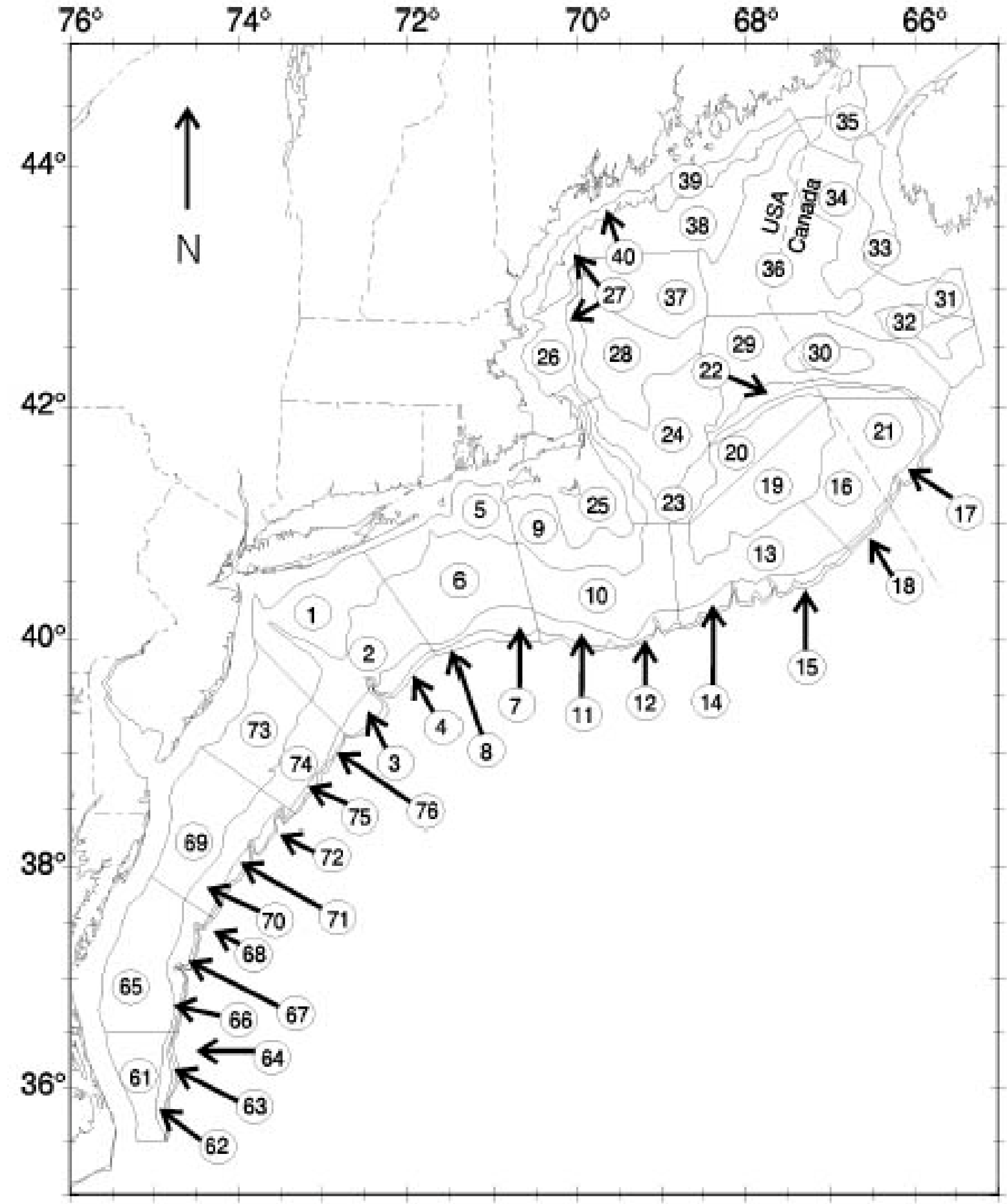


Figure 2. Offshore sampling strata used in NEFSC bottom trawl surveys.

A. YELLOWTAIL FLOUNDER

Stock Structure

The SARC reviewed a summary of available information on stock structure of yellowtail flounder in the Northwest Atlantic, with a focus on resources off the northeastern United States. Following an extensive review of the literature on stock identification, the SARC was presented with a summary of a series of studies covering spatial distribution patterns, geographic variation in growth and maturity, morphometric variation, and larval transport. At present, yellowtail flounder off the northeast coast of the United States are managed as four units: Georges Bank, Cape Cod, Southern New England, and Mid-Atlantic. In addition, the resource is distributed in the western Gulf of Maine, primarily in statistical area 513 adjacent to the Cape Cod management unit. Assessment of the Georges Bank, Southern New England, and Cape Cod stocks are carried out analytically through Virtual Population Analysis (VPA) and/or Biomass Dynamics Models (ASPIC), while the status of the Mid-Atlantic stock is evaluated using research survey index proxies. There has been no analytical assessment of the Gulf of Maine resource.

Most scientific evidence, including tagging studies, growth and maturity rates, and larval transport suggests that yellowtail flounder on Georges Bank are distinct from those in adjacent areas. However, there appears to be a considerable degree of mixing and similarities in biological characteristics between the southern New England and Mid-Atlantic stock units. In the past, the two units were considered to be a single stock, and were apparently split for ICNAF jurisdictional, rather than biological reasons. Although data on stock structure in the Gulf of Maine are sparse, the available information suggests that there is no basis to maintain a distinction between the Cape Cod stock unit and the remaining distribution of the resource in the Gulf of Maine.

The SARC then considered a proposal by the Southern Demersal Working Group to define three stock units: Georges Bank, Southern New England/Mid-Atlantic, and Cape Cod/Gulf of Maine.

Although the literature review and recent studies are comprehensive, there remain several areas of concern. Many conclusions were based on differences in biological characteristics that may simply reflect different environmental regimes in the various locations or changes in exploitation over time. Regardless of the mechanism, differences in growth and maturity are maintained because there is a significant degree of geographic isolation, particularly between the Georges Bank stock and those to the west. However, there are no such physical barriers between the southern New England and Mid-Atlantic areas and there appears to be substantial movement across the existing boundary between the management units for these two stocks.

The relevance of the historical tagging experiments is also an area of concern. The tag returns from these earlier studies were not adjusted for fishing effort, and the tag release sites (often on the boundary of the existing management units) and time at large was not considered in the original analyses by Royce et al. (1959) and Lux (1963) and in the recent review of stock structure. The available information on tagging is also somewhat dated and may not represent current environmental and stock conditions. In the case of the Mid-Atlantic tagging experiment, the number of tag returns was relatively low (n = 64 recaptures off Southern New England), and release sites may not represent the distribution of yellowtail flounder in the Mid Atlantic region, particularly off New Jersey and Delaware.

In all cases, there must be evidence that the proposed stock units are self-sustaining. This may be problematic for the Cape Cod stock unit, whether or not it is combined with the remaining Gulf of Maine area, because there appears to be little evidence of egg and larval production in this area.

The SARC endorsed the conclusions of the Southern Demersal Working Group to conduct assessments of yellowtail flounder based on the following stock units (Figure A1):

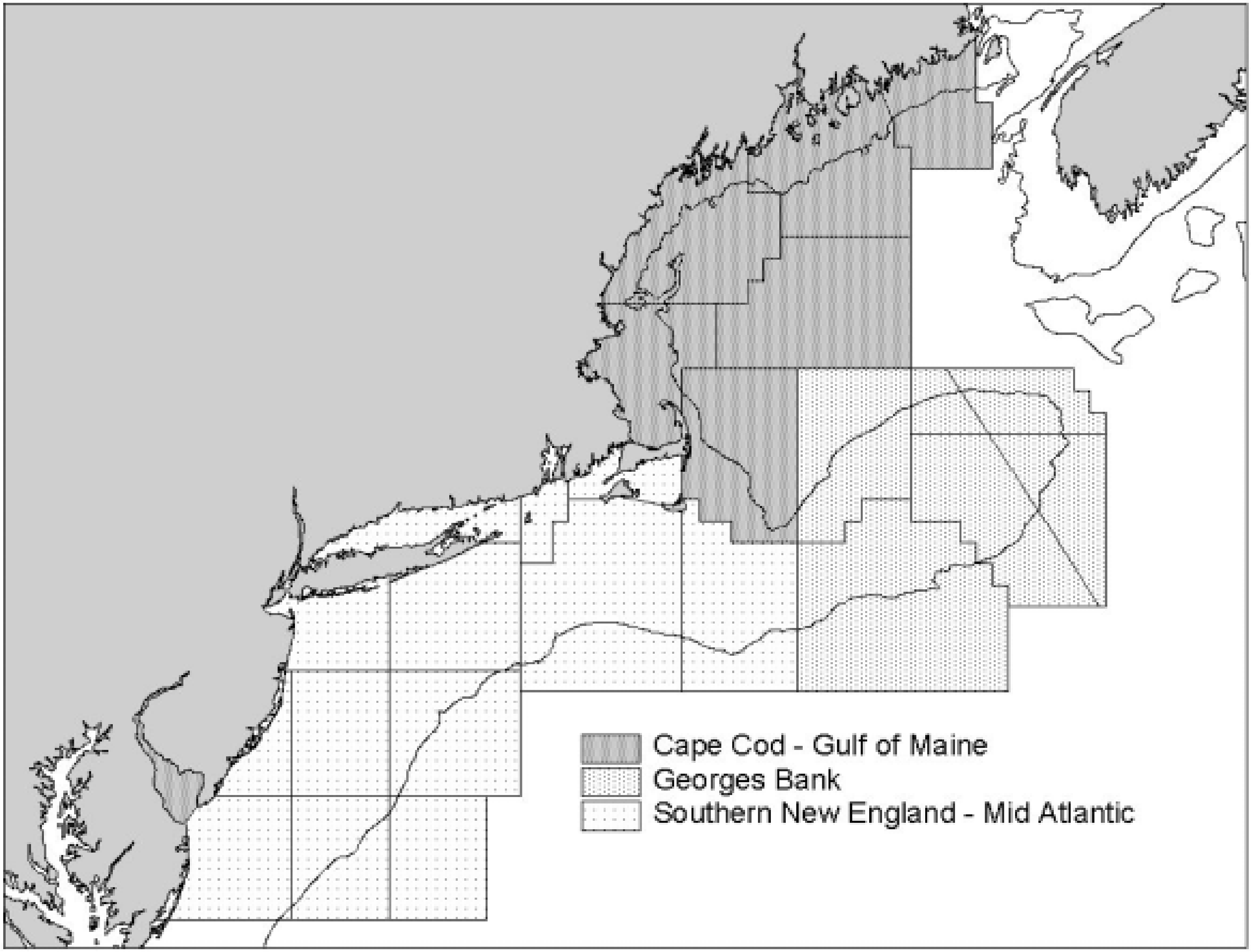
- Georges Bank
- Southern New England/Mid-Atlantic
- Cape Cod/Gulf of Maine.

Research Recommendations to be carried forward.

Further investigation should be carried out to evaluate the degree of mixing between the Georges Bank and Cape Cod stocks of yellowtail flounder.

Several suggestions were made to refine the analysis of stock boundaries, including: 1) evaluating the spatial scale at which data are presented for distribution of life history stages, 2) incorporating information on larval size composition to better delineate possible spawning areas, and 3) performing statistical tests for differences in biological characteristics.

Figure A.1. Revised stock boundaries of yellowtail flounder off the northeastern U.S.



A1. SOUTHERN NEW ENGLAND - MID ATLANTIC YELLOWTAIL FLOUNDER

INTRODUCTION

Yellowtail flounder, *Limanda ferruginea,* inhabit relatively shallow waters (20-100 m) of the northwest Atlantic from Labrador to Chesapeake Bay (Bigelow and Schroeder 1953, Scott and Scott 1988, Collette and Klein-MacPhee 2002). A fishery for yellowtail flounder developed off southern New England in the 1930s, coincident with the increased use of otter trawls, a decline in winter flounder abundance, and demand for food products during World War II (Scott 1954, Royce *et al.* 1959).

The available information on yellowtail flounder stock structure off the northeast U.S. indicates separate stocks on Georges Bank, off Cape Cod, and from southern New England to the Mid-Atlantic Bight. Distributional analyses indicate a relatively continuous distribution from the Mid Atlantic Bight to Nantucket Shoals, a concentration on Georges Bank, and a relatively separate concentration off Cape Cod (Royce *et al.* 1959). Geographic patterns of landings over time suggest that yellowtail resources on Georges Bank on off southern New England are separate harvest stocks (McBride and Brown 1980). Geographic variation indicates that yellowtail off Cape Cod comprise a separate phenotypic stock than resources to the south (Begg et al. 1999). Tagging data indicate less than 3% dispersion from Cape Cod, Georges Bank and southern New England fishing grounds, but substantial movement from the Mid Atlantic to southern New England (Royce et al. 1959, Lux 1963). Descriptive information on early life history stages and circulation patterns suggest that yellowtail spawn in hydrographic retention areas, but there may be some advection of eggs and larvae from Georges Bank and Cape Cod to southern New England and the Mid Atlantic Bight (Sinclair 1988). In conclusion, yellowtail flounder on Georges Bank appear to be a separate harvest stock, yellowtail off Cape Cod can be considered a separate phenotypic stock (with some question on the northern boundary of the stock area), but there is little evidence supporting separate stocks in southern New England and the Mid Atlantic Bight.

<u>Management History</u>

From 1950 to 1977, the International Commission for the Northwest Atlantic Fisheries managed yellowtail flounder resources in southern New England, Georges Bank and the Gulf of Maine (i.e., in ICNAF subarea 5). Gear restrictions and total allowable catch were the primary management strategies of ICNAF, but minimum fish size, fishing effort and closed area and season regulations were also regulated. Minimum trawl mesh size was 114 mm in the 1950s and 1960s. National catch quotas were implemented for southern New England yellowtail flounder from 1971 to 1976, but these were exceeded in most years.

Following the implementation of the Magnuson Fisheries Conservation and Management Act (FCMA) in 1976, U.S. yellowtail resources have been managed by the New England Fisheries Management Council (Table A1.1). Groundfish regulations included minimum cod end mesh size, minimum fish size, seasonal area closures, mandatory reporting, trip limits and annual quotas. Minimum size for yellowtail was increased from 28cm in 1982 to 30cm in 1986 and 33cm in 1989. Minimum mesh size increased from 140 mm in 1991 (diamond and square mesh) to 140mm diamond-152mm square in 1994 and to 165mm in 1999. A large area south of Nantucket Shoals was closed to fishing since December 1994. Scallop dredge vessels were limited to possession of 136kg of yellowtail flounder since 1996, and in 1999 minimum twine top mesh was increased from 203mm to 254mm to reduce yellowtail bycatch.

Assessment History

The first quantitative stock assessment of yellowtail flounder was on the southern New England - Mid Atlantic resource and fishery. Royce et al. (1959) evaluated landings, length and age composition, effort, and tagging data to conclude that fishing mortality was approximately 0.30 in the 1940s. However, retrospective estimates of F during the 1940s were substantially greater (approximately 0.6, Lux 1969). Lux (1964) concluded that the stock was not overfished during the 1950s, but age-based mortality estimates for the 1960s were high (Lux 1967[1], 1969).

Subsequent assessments of yellowtail flounder in the southern New England area excluded Mid-Atlantic catch and survey data, but indicated increasing F and declining stock size in the late 1960s (Brown and Hennemuth 1971a, 1971b; Pentilla and Brown 1973). Starting in 1974, Mid Atlantic and southern New England yellowtail resources were treated as separate assessment and management units, but analyses for each area indicated high mortality and low stock size in the 1970s (Parrack 1974, Sissenwine et al. 1978, McBride and Sissenwine 1979, McBride et al. 1980, Clark et al. 1981). In the early 1980s, there was indication of strong recruitment of yellowtail from surveys and commercial catches in both southern New England and Mid Atlantic areas, but discard rates were high and F exceeded F_{max} in southern New England (McBride and Clark 1983, Clark et al. 1984, NEFC 1986).

Assessment methods used for southern New England yellowtail progressed to a calibrated VPA in the late 1980s. The 1988 assessment indicated high F in the 1970s and early 1980s and a strong 1980 cohort (F=0.60-1.48; NEFC 1989). Later stock assessments showed another dominant cohort spawned in 1987, but F continually increased through the 1980s, and the stock was depleted to record low biomass in the early 1990s (Conser et al. 1991, Rago et al. 1994). The VPA-based assessment of southern New England yellowtail was updated annually from 1997 to 1999, and assessments indicated a reduction in F in the late 1990s, but little rebuilding of stock biomass (NEFSC 1997, 1998; Cadrin 2000). In 2000, an updated VPA was attempted, but was rejected as a basis for management advice because sampling in 1999 was inadequate to estimate catch at age reliably (Cadrin 2001b). Therefore, recent assessments of southern New England yellowtail have been based on projections of observed catch from the 1999 VPA (Cadrin 2001b, NEFSC 2002). An updated assessment of the southern New England yellowtail flounder stock was prepared

[1] Although Lux (1967) is titled, "Landings per unit effort, age composition and total mortality of yellowtail flounder (*Limanda ferruginea*) in subarea 5Z," the southern New England analyses also include catch and effort data from statistical area 6.

concurrently with this assessment for the Groundfish Assessment Review Meeting (Cadrin 2002b).

An analytical assessment of Mid Atlantic yellowtail flounder has not been developed, and management advice has been based on descriptive summaries of landings and survey data. Assessments of the Mid Atlantic yellowtail resource indicated similar trends in catch and survey indices as in southern New England (NEFC 1987, 1988; NEFSC 1991, 1992, 1993; Rago 1995; Overholtz and Cadrin 1998). Based on survey biomass and exploitation ratios, the Mid Atlantic yellowtail resource was 2% of the B_{MSY} proxy, and the exploitation rate greatly exceeded the F_{MSY} proxy (Cadrin 2001a). An updated assessment of the Mid Atlantic yellowtail flounder stock was prepared concurrently with this assessment for the Groundfish Assessment Review Meeting (Cadrin 2002a).

FISHERY DATA

Commercial Landings

Commercial statistics for southern New England yellowtail flounder are from statistical areas 526, 537, 538, and 539, and mid Atlantic yellowtail are from statistical areas 611-623 (Figure A1.1). U.S. commercial landings of yellowtail flounder were derived from dealer weighout reports and canvas data according to historical assessment reports (Royce et al. 1959, Brown and Hennemuth 1971, Sissenwine et al. 1978, McBride et al. 1980, McBride and Clark 1983, NEFC 1986, McBride 1989, Rago et al. 1994). Total Mid Atlantic landings from canvas data were allocated to market category according to annual proportions in the weighout database. Previous to 1994, landings were allocated to statistical area, month, and gear type according to interview data collected by port agents (Burns et al. 1983). For 1994, landings reported by dealers were allocated to stock area using fishing vessel logbook data, by fishing gear, port, and season (Wigley, et al. 1998). For 1995-1997, dealers' reported landings were prorated to stock area using a modified proration that included dealer codes (NEFSC 1998).

Landings generally increased in southern New England during the 1930s and early 1940s and the fishery expanded to the Mid Atlantic in the early 1940s, with landings of 28,000mt in 1942 (Table A1.2, Figure A1.2). Annual landings were around 10,000mt from 1943 to 1948 with approximately 10% from the Mid Atlantic. A domestic industrial fishery developed in the late 1940s. Landings decreased to less than 2,000mt in the mid 1950s. Landings increased in southern New England in the late 1950s and again expanded to the Mid Atlantic in the 1960s. A distant water fishery developed in the 1960s and total annual landings were greater than 20,000mt from 1963 to 1970. The industrial and foreign fisheries were discontinued in the early 1970s. Landings generally decreased since the 1970s, with temporary increases in the early 1980s and early 1990s. Landings in 1995 were a record low 200 mt, and the proportion of landings from the Mid Atlantic generally increased from approximately 10% in the early 1990s to greater than 20% (e.g., in 1997, 70% of landings in the stock area came from the Mid Atlantic). Landings slightly increased to greater than 1,000mt per year since 1999.

A summary of port samples (each consisting of approximately 100 lengths and 1 age sample per cm) are listed in Table A1.3. Landings at age were derived by geographic region, half-year and market category, when possible. Landings at age of southern New England yellowtail flounder are described in previous assessment documents (Conser et al. 1991; Rago et al. 1994; NEFSC 1997, 1998; Cadrin 2000; Cadrin 2002b). Mid Atlantic landings were not sampled in several half-year periods, and age distributions of southern New England landings were assumed for Mid Atlantic landings in those periods by quarter and market category (2nd half of 1975, 2nd half of 1981, 2nd half of 1986, 2nd half of 1987, 2nd half of 1988, 1st half of 1989, 2nd half of 1990), or by half and market category for 2000 and 2001. Landings at age and landed mean weights at age are reported in Table A1.4. In the early 1970s a substantial portion of landings were from older fish (e.g., 17% of 1973 landings were age-6 or older), but the age distribution of landings rapidly truncated, and the portion of age 6+ fish has generally been less than 3% since 1977.

Discarded Catch

Estimates of discards for the southern New England – Mid Atlantic yellowtail fishery for 1963-1969 were derived from interviews with vessel captains; historical discards were approximated by Brown and Hennemuth (1971a) from the 1963-1969 average discard rate (Table A1.5). Discards for 1970-1977 were also based on interview data, however yellowtail interview data were suspect from 1978 to 1982 when trip limits were imposed (McBride et al. 1980, Clark et al. 1981). Discards during 1978-1982 were estimated from observer data when available (Sissenwine et al. 1978), derived directly from field selectivity studies (McBride et al. 1980), or from application of selectivity estimates to survey size frequencies (McBride and Clark 1983). Discards for 1983 were from interview data (Clark et al. 1984). Discards at age from southern New England, 1984-1993 were from a combination of sea sampling, interviews and survey data (Conser et al. 1991, Rago et al. 1994). Discards for 1994-2001 were derived from vessel logbooks (NEFSC 1997, 1998; Cadrin 2000). Updated discard estimates for southern New England are listed in Table A1.5a. Discards of Mid Atlantic yellowtail were from interview data for 1984-1993. Mid Atlantic discards for 1994-2001 were derived from logbook data by gear for all trips that reported discards of any species (NEFSC 1998, Table A1.5b).

Discarded catch accounted for an average of 30% of total catch annually, but appears to have decreased to approximately 10% since 1995. In 1969, discards peaked at 24,000mt, 40% of the total catch that year. A substantial portion of recent discards are from the scallop dredge fishery.

Discards at age were estimated from observer lengths (Table A1.3) and survey ages 1994-2001. Discards at age of southern New England yellowtail flounder are described in previous assessment documents (Conser et al. 1991; Rago et al. 1994; NEFSC 1997, 1998; Cadrin 2000; Cadrin 2002b). Age distribution of discards in southern New England were assumed for Mid Atlantic discards for 1973 to 1993 (Table A1.6). Discards were primarily ages 1 and 2 during from the 1970s through the early 1990s, but shifted to age 2 and 3 in the early 1990s, coincident with regulated mesh size increases.

Estimates of total catch at age reflect the landings at age in that they indicate a relatively wide age distribution in the catch in the early 1970s (e.g., approximately 10% of the catch was age-6 or older from 1973 to 1975; Figure A1.3, Appendix A). Subsequent catch at age was dominated by the 1980 and 1987 cohorts, but few fish older than age-6 contributed to the catch. Mean weights at age of older fish (age 4+) generally increased in the mid 1970s, were relatively light during the mid 1980s, and generally increased in recent years (Figure A1.4). Mean weight of age-1 yellowtail generally decreased in the 1990s, presumably from discards of small yellowtail in the scallop fishery.

ABUNDANCE AND BIOMASS INDICES

Stock Abundance and Biomass Indices

The NEFSC spring and autumn bottom trawl surveys have sampled offshore strata since 1963 and 1968, respectively (Despres et al. 1988). However, the southern–most offshore strata (61-76) were not sampled until 1967. Therefore southern strata were included in the spring survey index, 1968-2002 and the winter survey index 1992-2002 (strata 1, 2, 5, 6, 9, 10, 69, 73, 74; Figure A1.5), but excluded from the fall survey index, 1963-2001 (strata 1, 2, 5, 6, 9, 10). Nearly all yellowtail caught by the survey in the southern New England – Mid Atlantic stock area (99%) are in the spring and winter strata sets. The strata set for the NEFSC scallop survey was determined as all strata that were consistently sampled in the stock area (14, 15, 18, 19, 22-28, 30, 31, 33, 35, and 46).

Indices of abundance and biomass indicate relatively high stock size in the 1960s and early 1970s, followed by a rapid decrease in the mid 1970s (Table A1.6, Figure A1.6). Stock biomass increased temporarily in the early and late 1980s with the recruitment of the strong 1980 and 1987 cohorts. Recent distributions of yellowtail catches in surveys are illustrated in Figure A1.7. The average portion of yellowtail biomass in the Mid Atlantic region has been 45% of the total southern New England – Mid Atlantic yellowtail biomass (Figure A1.8). Age distribution of yellowtail in surveys indicates abundant cohorts in the 1960s and early 1970s, strong year classes in 1980 and 1987, and relatively truncated age structure since the early 1970s (Table A1.7, Figure A1.9).

Correspondence among survey indices was assessed using correlations among normalized observations for the VPA time series 1973-2001 [Ln(x/mean); Table A1.8]. Normalized indices of catch per tow at age are illustrated in Figure A1.10. Correlations among survey series were generally low for the winter survey, particularly for older ages, presumably because it is a short series with little contrast. Correlations between spring and fall survey series were strongest at ages 2-4 (r=0.71-0.82).

MORTALITY AND STOCK SIZE

Virtual Population Analysis

Abundance estimates from virtual population analysis of catch at age of age-1 to age-7+, 1973-2001, were calibrated using an ADAPT algorithm (Gavaris 1988) that estimated age 2-5 survivors in 2002 and survey catchability coefficients (*q*) using nonlinear least squares of survey observation errors. Abundance at age was calibrated with survey indices of abundance: spring survey indices (age-1 to age-7+) and winter indices (age-1 to age-5) were calibrated to January abundance, and fall survey indices (age-1 to age-7+) were calibrated to mean abundance. The instantaneous rate of natural mortality (M) was assumed to be 0.2 based on tag returns (Lux 1969), relationships of Z to effort (Brown and Hennemuth 1971a), and the oldest individual sampled in the stock area (age-14). Although catches of yellowtail older than age-8 are rare in commercial or research catches, the stock has been heavily exploited for seven decades. Maturity at age for southern New England yellowtail flounder was reported by O'Brien et al. (1993) from 1985-1990 NEFSC spring survey samples. Model Residuals are plotted in Figure A1.11.

Results show that the stock was abundant in the early 1970s with a relatively wide age structure (11% of the population in 1973 was age 6 or older), but was quickly truncated by the late 1970s (<2% age 6+ from 1978 to 2001; Table A1.9, Figure A1.12c). Fishing mortality generally increase in the 1970s and 1980s to a peak of 2.3 in 1991 and 1992, averaged 1.6 during the 1990s, and appears to have decreased to 0.68 in 2000 and increased to 0.91 in 2001 (Figure A1.12a). Recruitment was generally strong in the 1970s and moderate during the 1980s, with two exceptional year classes in 1980 and 1987. Recruitment has been low during the 1990s. Spawning biomass was high in the early 1970s, decreased in the late 1970s, and increased briefly in the early and late 1980s with recruitment of the 1980 and 1987 cohorts. Spawning biomass decreased to a record low 622mt in 1994, gradually increased to 2,100mt in 2000, and decreased to 1,900mt in 2001. Retrospective analysis indicates a strong pattern of underestimating F, and overestimating SSB in recent years (Figure A1.13).

Biomass Dynamics

Given the problems in estimating recent catch at age in the southern New England area (Cadrin 2000) an age-aggregated production model (ASPIC, Prager 1994) was fit to total catch and survey biomass indices. Initial trials did not fit the winter survey biomass series, presumably because it is relatively short and does not have much contrast, nor did the model fit the catch rate data from Lux (1969). Alternative analyses that assumed that stock biomass was at the carrying capacity in 1935 had very similar results.

Results of the biomass dynamics model indicate that biomass decreased during the 1960s and early 1970s to about 10% of the biomass estimated for the early 1960s (Figure A1.14). Similar to the age-based analysis, the biomass dynamics model indicates brief periods of rebuilding in the early and late 1980s and a further decrease to extremely low biomass in the mid 1990s. However, the biomass dynamics model indicates a slightly faster rate of rebuilding in recent years than indicated by the age-based analysis.

Biological Reference Points

Yield and biomass per recruit were calculated assuming the observed partial recruitment and mean weight at age for 1994-2001 (Thompson and Bell 1934). Results are reported in Table A1.10 and illustrated in Figure A1.15. Applying the approach used to estimate MSY proxies for southern New England yellowtail (NEFSC 2002), F_{MSY} is approximated as $F_{40\%}$ (0.26). The SSB_{MSY} proxy is 69,500mt, calculated as the product of 40%MSP (1.129 kg spawning biomass) and average long-term recruitment (61.57 million). The average long-term recruitment was derived as the fall survey age-1 index divided by the catchability coefficient estimated by ADAPT (8.08E-5). The MSY proxy is 14,200mt, derived as the product of yield per recruit at $F_{40\%}$ (0.230 kg) and average recruitment.

Alternatively, SSB_{MSY} and MSY were estimated using stochastic long-term projections assuming recent average weights at age and partial recruitment (1994-2001), and the distribution of long term recruitment. Results suggest that at an F of 0.26, the long-term average catch is 13,100mt, and long-term average SSB is 64,500mt (Figure A1.16) .

For comparison, the estimate of B_{MSY} from biomass dynamics analysis is 104,700mt of total biomass, F_{MSY} is 0.19 on total biomass, and MSY is 20,300mt. The Working Group accepted the deterministic estimates of MSY reference points based on consistency with estimates for other groundfish stocks (NEFSC 2002): F_{MSY}=0.26, SSB_{MSY}= 69,500mt and MSY=14,200mt.

Projections

Stochastic age-based projections that assume a 15% reduction in F from 2001 to 2002 and recruitment similar to that experienced in the last decade suggest that the stock cannot rebuild to B_{MSY} by 2009 even if F in 2003-2010 is zero. If the same hindcast recruitment values used to derive the reference points are assumed for projections, there stock is expected to have approximately a 50% chance of rebuilding to SSB_{MSY} by 2009 with an F of 0.08 (Figure A1.17, Appendix A). However, long-term recruitment levels are not likely in the short-term, because SSB is extremely low, and retrospective patterns indicate that projections may be overly optimistic. For comparison, stochastic projections from the biomass dynamics model at status quo F in 2002 and F=0 for 2003-2009 indicate a 25% probability of rebuilding to the ASPIC estimate of B_{MSY} by 2009 (Appendix B).

WORKSHOP DISCUSSION

Working Group Discussion

Stock Structure - The WG reviewed seven working papers/presentations on yellowtail stock structure. With respect to spatiotemporal patterns of abundance, the WG noted that recruitment trends of Cape Cod and southern New England yellowtail indicated possible autocorrelation, as evidenced by a common series of several years of poor recruitment that might be indicative of a common stock. The WG noted that historical tagging data indicate weak movement between the Cape Cod, Georges Bank, and other areas, but strong mixing between Mid Atlantic and southern New England areas, that might be indicative of a common Mid Atlantic-southern New England stock. The WG also noted that the fish from the Mid Atlantic and southern New England have concurrent spawning seasons, comparable lengths of 50% Maturity, and similar growth rates, and that detailed distribution plots indicated that most of the Mid Atlantic fish are found in areas closest to the boundary with the Southern New England stock (i.e., area 613). The WG noted that the Mid Atlantic and Southern New England areas were grouped together prior to the early 1970s, when they were separated to conform with ICNAF reporting conventions. The WG noted limited evidence in the literature to separate Gulf of Maine fish from the Cape Cod stock. The WG supported the major conclusion of working paper A1 that information available from the literature indicates separate yellowtail flounder stocks on Georges Bank, off Cape Cod, and in the Southern New England-Mid Atlantic Bight area.

The WG noted that NEFSC survey stratum 13 (southwestern Georges Bank) appears to be an Aoverlap@ or Atransition@ zone, with peaks in abundance over time that are characteristic of both the Georges Bank and southern New England stocks, and may be inhabited by fish from both stocks during times of abundance. The WG noted that a similar situation may exist in NEFSC stratum 10, adjacent to the Great South Channel. The WG supported the conclusions of working paper A2 that 1) there are two major groups of NEFSC survey strata based on patterns of abundance over time, with a boundary on southwestern Georges Bank, and 2) the current analyses confirm earlier conclusions of separate Aharvest stocks@ on Georges Bank and off southern New England. A correlation analysis of survey and catch data by management area generally confirmed the multivariate analysis by stratum. Survey indices and landings were strongly correlated between southern New England and the mid-Atlantic, not correlated between southern New England and Cape Cod or southern New England and Georges Bank, and moderately correlated between Georges Bank and Cape Cod.

The WG noted that previous investigators (e.g., Lux 1963) found no significant differences in meristics (e.g., fin and ray counts) among U.S. stocks, supporting the current morphometric work. The WG also noted that the results of the morphometric work coincides with the differences in growth noted between U.S. and Newfoundland stocks. The WG supported the working paper A4 conclusion that morphometric variation among U.S. yellowtail flounder groups is not sufficient for accurate classification to stock area.

The WG noted that the number of migrants per generation between the yellowtail stock areas, although probably low, is likely sufficient to prevent detection of significant genetic differences using RAPD-PCR. The WG noted that the expression of phenotypic differences may not be evident in the genome, or Mid Atlantic be very difficult to detect (many different primers may have to be tested to find one that isolates the gene responsible for a given phenotypic expression). The WG supported the conclusion of presentation A6 that, at this time, yellowtail flounder stock differentiation must be based on factors other than genetics.

The WG noted that historical stock area determinations included the mid Atlantic area as a part of the southern New England stock (e.g., Royce et al. 1959, Lux 1969) . Mid

Atlantic landings were excluded from assessments of AICNAF Area 5" yellowtail beginning in the early 1970s (e.g., Brown and Hennemuth 1971), apparently to conform to ICNAF jurisdictions and to respond to the concerns of Mid Atlantic fishermen of being subject to the ICNAF regulatory regime. The Mid Atlantic resource was assessed as a separate stock beginning in the mid 1970s/early 1980s (e.g., Parrack 1974, McBride and Brown 1980).

The current work reviewed by the WG indicates a single homogeneous genetic stock of yellowtail flounder on U.S. fishing grounds. Patterns over time in landings and survey indices suggest two harvest stocks with a boundary between Georges Bank and Southern New England. Differences in life history characteristics suggest two phenotypic stocks with a boundary off Cape Cod. The WG noted that the most important potential Amisalignments@ with respect to current or proposed stock definitions are in areas 521, 525, and 526 (and associated NEFSC survey strata 10, 13 and 25), where fish from adjacent stocks may overlap during times of abundance. However, the WG found no strong evidence in patterns of fishery landings, survey abundance indices, or life history parameters to suggest that revision of the current assignment to stock areas of these particular statistical areas or survey strata is appropriate. The WG concluded that current evidence indicates that three stock areas are appropriate for yellowtail flounder: 1) a Georges Bank stock including fish landed from NEFSC statistical areas 522, 525, 551-552, and 561-562, and associated NEFSC survey strata (i.e., the current stock definition used in U.S. and Canadian assessments), 2) a southern New England – Mid Atlantic stock including fish landed from areas 526, 533-539, 541, and 611-639, and associated NEFSC survey strata, and 3) a Cape Cod – Gulf of Maine stock including fish landed from areas 511-521, and associated NEFSC survey strata. Finally, the WG recommends that assessment scientists explore the potential to classify yellowtail in fishery and survey samples to stock in the Aoverlap/transition@ areas based on age structure characteristics.

<u>Stock Assessment</u>
The Working Group discussed the quality of historical canvas data and questioned if historical catch may be underreported in the Mid Atlantic region or misallocated from the Mid Atlantic to the southern New England region.

The Group examined three criteria for choosing indices of abundance for the VPA calibration: correlation with other indices, partial variance in an initial calibration that included all indices, and residual patterns. During the time series of the winter survey, 1992-2002, few age 6 and 7+ yellowtail were caught and those two indices accounted for a disproportionately large portion of the total model variance. The Working Group excluded those two indices from the calibration, because they were adding noise to the calibration. However, it was noted that the survey is designed to catch flatfish, and the indices may become useful as age structure rebuilds.

The Working Group discussed the recruitment assumptions for projections. Previous studies found significant effects of temperature on survival ratios, but the reference point working group (NEFSC 2002) found no trend in temperatures for the last decade which would suggest a reason why recruitment has been extremely low since 1987. The Group noted that the ASPIC model was more optimistic than the VPA in terms of current status, but was not optimistic in terms of projections. ASPIC projections indicate that biomass does not rebuild to Bmsy in 2009 at F=0. By comparison, age-based projections do not rebuild to target in 2009 at F= 0 unless the whole time series of recruitment values, including the hind-cast estimates are used.

The Working Group adopted the approach of the Reference Point Working Group (NEFSC 2002) for estimating MSY reference point proxies. The Group also noted that mean weights at age seem to show density dependence. Therefore, weights may decrease as the stock rebuilds. The Group also decided to account for sampling problems in recent years by averaging mean weights and partial recruitment from as many years as possible (1994-2001) to represent the current fishery in reference point calculations and projections.

SARC DISCUSSION

The poor sampling of commercial landings in 1999 for the entire area was considered. While there is a systematic problem in collecting a biological sample without knowledge of the statistical area from which it came (e.g. the area fished is acquired from the VTR and not from an interview with the captain at the time of landing), in this situation the lack of samples is due to the 'hit-or-miss' nature of sampling low-volume landings (in 1999 the MA landings were just 240 mt). Throughout the entire time period (1973-2001) 15% of the MA cells did not have samples and SNE samples were used to characterize the catch at age. As SNE samples were applied to MA landings in some years, the SARC suggested evaluating the impact of pooling areas using years where adequate samples exist for both areas.

The SARC noted that the discard ratio used to estimate yellowtail flounder discards in the scallop fishery may not be suitable. As the scallop fishery has had trip limit regulations, the discard/kept ratio may not be as appropriate as an effort-based ratio. However, an effort-based ratio, if applied resource-wide, would overestimate discards in areas where scallop effort and yellowtail distribution do not overlap. It was suggested that an effort-based ratio be applied in the MA area, where scallop effort and yellowtail flounder distributions overlap, and a discard/kept ratio in the SNE area, where these distributions do not overlap as much.

The SARC commented on the declining mean weights at age in the commercial catch in recent years. Mean weights at age from the NEFSC survey would be informative in confirming the commercial trends observed.

The spatial coverage of the NEFSC autumn survey was not consistent over the entire time series; from 1963 to 1967 the southernmost strata used to assess the stock were not sampled. Although the restricted spatial coverage will not impact the VPA because the VPA begins in 1973, other analyses, such as hindcast estimates of recruitment and ASPIC, may be impacted. The SARC evaluated the NEFSC autumn survey indices (with and without strata 69, 73 and 74) and concluded that the trend and magnitude were similar between the two series. The SARC accepted the analyses conducted with the spatially restricted series to gain the benefits of the longer time series.

The SARC discussed the VPA retrospective analysis, which revealed a consistent pattern of underestimating F and overestimating SSB since 1995. It was agreed that the retrospective pattern was a key element to the stock assessment results and that this information should be included in the management advice because the direction of the retrospective pattern changes perspective of stock biomass and fishing mortality from year to year. However, the overfished and overfishing status is not affected by the retrospective bias.

The SARC felt that the YPR-SPR approach was appropriate for estimating biological reference points for this stock. The discussion focused on establishing the most appropriate time series of recruitment. The SARC reviewed SSB_{MSY} and MSY estimates derived from four possible recruitment time series: 1) long-term (1963-2001) average; 2) VPA time-series (1973-2001) average; 3) last ten years (1992-2001) VPA average; and 4) pre-VPA hindcast (1963-1972) average. The average recruitment from the four time series ranged between 6.4 million (last ten years) and 193 million (pre-VPA hindcast) and caused a wide range in the point estimates of SSB_{MSY} and MSY (Figure A1.18). Given the lack of evidence of an ecological regime shift, the SARC concluded that the most credible recruitment time series was the long-term (1963-2001) series. It was also concluded that a range of biological reference points would be useful in providing boundaries about the most credible estimate.

The SARC reviewed a stock-recruitment trajectory plot where estimates from the VPA and the hindcast analysis were represented. It was noted that what appeared to be two outliers in the VPA series would not be considered outliers when the hindcast recruitment estimates were included.

<u>Sources of Uncertainty</u>

- Although sampling improved in 2000 and 2001, estimates of previous catch at age (particularly 1999) may be imprecise due to poor sampling intensity. Therefore, VPA- and age-based projections may also be imprecise. Retrospective patterns may indicate inadequate sampling and misallocation of catch at age.
- Retrospective patterns indicate that VPA estimates of biomass and F are likely to be optimistic. Future VPAs may indicate a lower level of SSB and a higher F for 2001 than reported here.
- Estimates of landings and discard ratios since 1994 are based on preliminary logbook data applied on a pro rata basis, and are subject to change.

<u>Research Recommendations</u>

- Explore the use of effort-based and discard/kept ratios for the scallop fisheries
- Analyze the impacts of applying SNE samples to MA landings for years where adequate samples exists for both areas.
- Consider using a forward projection model that allows for error in catch at age, because of

the extremely poor sampling in 1999 and more flexible assumptions about selectivity.

- o Investigate changes in maturity at age over time.
- o Examine mean weights at age from surveys to confirm trends observed in the commercial mean weights.
- o Incorporate data from the entire stock area for the fall survey calibration index.
- o Improve sea sampling coverage for otter trawl and scallop vessels to allow for better estimation of discards.
- o Increase the sampling frequency of SNE-MA yellowtail flounder during the bottom trawl surveys.
- o Collect adequate numbers of quarterly commercial samples for length and age composition.

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Table A1.1. Management history of southern New England – Mid Atlantic yellowtail flounder.

Year	Comments
1977	FCMA implemented March 1 Groundfish plan adopts quotas for cod, haddock, yellowtail flounder
1982	Interim Groundfish Plan adopted: 11 inch minimum size for yellowtail
	Scallop FMP implemented
1986	Northeast Multispecies FMP adopted: Minimum size for yellowtail flounder: 12 inches Seasonal yellowtail closure, March - May, between 69-30 and 72-30W Closed area I and II continued as spawning closures on GB
1989	Amendment 2: Yellowtail minimum size increased to 13 inches Seasonal large mesh area off Nantucket Shoals to protect cod
1991	Amendment 4: Tightened restrictions on carrying small mesh while in Regulated Mesh Areas Minimum mesh size of 5 1/2 inches in Southern New England yellowtail area
1994	Amendment 5 and emergency regulations: December: NLCA closed year round, including to scallop dredges DAS limits for most vessels West of 72-30W. Mesh determined by mesh requirements of summer flounder fishery (5 1/2 inch diamond or 6 inch square) Established Southern New England RMA, mesh of 5 1/2 inch diamond square, to increase to 5 1/2 inch diamond or 6 inch square in year 2. Area from approximately 69-40W to 72-30 W.
	Scallop Amendment 4: adopted permit moratorium, effort control/DAS program, 5.5 inch twine top minimum, and crew limits
1996	Amendment 7 Extended DAS limits to most vessels Limited possession of groundfish by scallop vessels to 300 pounds of regulated multispecies Established criteria for exempted fisheries Mid-Atlantic regulated mesh area fisheries exempt from bycatch certification
1999	Framework 27: (May 1) Increased square mesh minimum size to 6 1/2 inches in GOM/GB/SNE Regulated mesh areas Framework 29: (June)
	Amendment 9: (November): Revised overfishing definitions Scallop Framework 11: 10 inch minimum twine top mesh
2000	Scallop Framework 13: Scallop vessel closed area access programs with yellowtail bycatch limits
	Adopted management measures for small-mesh multispecies, establishing minimum mesh sizes and trip/possession limits to reduce mortality on silver, red, and offshore hake

Table A1.2. Southern New England–mid Atlantic yellowtail flounder catch (kt).

	Mid-Atlantic			Southern New England				
	U.S.	U.S.	foreign	U.S.	U.S.	industrial	foreign	
year	landings	discards	catch	landings	discards	landings	landings	total
1960	0.0	0.0	0.0	8.3	3.2	0.5	0.0	12.0
1961	0.0	0.0	0.0	12.3	4.7	0.7	0.0	17.7
1962	0.0	0.0	0.0	13.3	5.3	0.2	0.0	18.8
1963	0.0	0.0	0.0	22.3	5.4	0.3	0.2	28.2
1964	1.8	0.0	0.0	19.5	9.5	0.5	0.0	31.3
1965	2.1	0.0	0.0	19.4	7.0	1.0	1.4	30.9
1966	2.2	0.0	0.0	17.6	5.3	2.7	0.7	28.5
1967	5.3	0.0	0.0	15.3	7.7	4.5	2.8	35.6
1968	3.3	0.0	0.0	18.2	6.3	3.9	3.5	35.2
1969	3.9	0.0	0.7	15.6	2.4	4.2	17.6	44.4
1970	4.1	0.0	0.1	15.2	4.5	2.1	2.5	28.5
1971	6.9	0.0	1.0	8.6	2.2	0.4	0.3	19.3
1972	8.8	0.0	0.1	8.5	1.8	0.3	3.0	22.5
1973	4.9	0.2	0.2	7.2	1.5	0.3	0.2	14.5
1974	1.9	0.0	0.0	6.4	8.7	0.0	0.1	17.1
1975	0.6	0.0	0.0	3.2	1.9	0.0	0.0	5.7
1976	0.3	0.0	0.0	1.6	1.6	0.0	0.0	3.4
1977	0.5	0.0	0.0	2.8	1.9	0.0	0.0	5.2
1978	0.8	0.0	0.0	2.3	5.0	0.0	0.0	8.1
1979	0.2	0.0	0.0	5.3	4.4	0.0	0.0	9.9
1980	0.3	0.0	0.0	6.0	1.7	0.0	0.0	8.0
1981	0.7	0.0	0.0	4.7	1.2	0.0	0.0	6.6
1982	0.4	0.0	0.0	10.3	5.0	0.0	0.0	15.8
1983	1.5	0.2	0.0	17.0	3.5	0.0	0.0	22.2
1984	2.2	0.0	0.0	7.9	1.1	0.0	0.0	11.2
1985	0.9	0.0	0.0	2.7	1.2	0.0	0.0	4.8
1986	0.2	0.0	0.0	3.3	1.1	0.0	0.0	4.6
1987	0.2	0.0	0.0	1.6	0.9	0.0	0.0	2.7
1988	0.1	0.0	0.0	0.9	1.8	0.0	0.0	2.8
1989	0.4	0.0	0.0	2.5	5.5	0.0	0.0	8.3
1990	0.2	0.0	0.0	8.0	9.7	0.0	0.0	17.9
1991	0.2	0.0	0.0	3.9	2.3	0.0	0.0	6.4
1992	0.2	0.0	0.0	1.4	1.1	0.0	0.0	2.7
1993	0.2	0.0	0.0	0.5	0.1	0.0	0.0	0.8
1994	0.2	0.1	0.0	0.2	0.1	0.0	0.0	0.6
1995	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.3
1996	0.2	0.0	0.0	0.3	0.1	0.0	0.0	0.5
1997	0.5	0.0	0.0	0.2	0.0	0.0	0.0	0.8
1998	0.2	0.0	0.0	0.4	0.1	0.0	0.0	0.7
1999	0.5	0.0	0.0	0.7	0.1	0.0	0.0	1.3
2000	0.2	0.0	0.0	0.7	0.0	0.0	0.0	1.0
2001	0.2	0.0	0.0	0.8	0.0	0.0	0.0	1.1

Table A1.3. Commercial samples of southern New England – Mid Atlantic yellowtail flounder by geographic region, half-year and market category (values in italics are Mid Atlantic observer lengths).

		Southern New England				Mid Atlantic				
year	half	uncl. lengths	large lengths	small lengths	ages	uncl. lengths	large lengths	small lengths	ages	discard lengths
1969	1	5059	0	0	991	950	0	0	143	0
1969	2	5730	0	0	951	1120	0	0	159	0
1970	1	6313	0	0	2515	1238	0	0	377	0
1970	2	9554	0	0	3149	707	0	0	197	0
1971	1	5421	0	0	2165	1212	0	0	387	0
1971	2	3414	0	0	577	1305	0	0	250	0
1972	1	2817	479	741	1483	1132	252	420	442	0
1972	2	1761	364	515	968	395	0	0	99	0
1973	1	1441	675	777	1085	923	0	0	249	0
1973	2	2757	248	362	1035	1293	0	0	299	0
1974	1	2568	112	319	1296	327	251	741	383	0
1974	2	3767	0	299	1396	498	0	0	149	0
1975	1	767	633	1257	1039	220	345	898	456	0
1975	2	321	100	149	189	0	0	0	0	0
1976	1	412	717	843	824	235	157	0	173	0
1976	2	149	190	192	192	426	0	0	161	0
1977	1	0	707	803	572	520	379	340	497	0
1977	2	162	370	275	339	283	0	0	103	0
1978	1	0	747	1222	680	223	85	0	146	0
1978	2	431	433	472	427	322	0	0	104	0
1979	1	249	444	348	379	451	0	0	164	0
1979	2	2050	377	735	1073	164	0	0	54	0
1980	1	1664	1313	1559	1984	214	90	281	228	0
1980	2	916	365	961	803	129	0	0	52	0
1981	1	888	270	151	530	1155	0	0	465	0
1981	2	377	109	1111	554	0	0	0	0	0
1982	1	1071	608	1374	1108	821	0	0	319	0
1982	2	266	401	3361	1210	139	0	188	101	0
1983	1	205	750	2281	1060	578	90	0	197	0
1983	2	252	601	2411	915	0	0	174	50	0
1984	1	416	558	1469	520	1544	0	1244	532	0
1984	2	0	932	2976	832	469	0	161	120	0
1985	1	138	822	2524	833	842	0	260	235	0
1985	2	443	620	2725	759	172	0	154	60	0
1986	1	422	326	1753	537	380	107	410	269	0
1986	2	299	498	1517	472	0	0	0	0	0
1987	1	0	662	964	391	765	0	0	201	0
1987	2	0	586	1042	347	0	0	0	0	0
1988	1	0	800	1272	536	240	0	0	54	0
1988	2	0	381	692	294	0	0	0	0	0
1989	1	0	759	1274	559	0	0	0	0	432
1989	2	0	504	971	351	316	0	0	75	183
1990	1	0	776	1155	504	*565*	0	0	0	1311
1990	2	0	693	956	389	*0*	0	0	0	0
1991	1	0	619	932	384	*151*	0	0	25	273
1991	2	0	671	1034	434	*456*	0	0	0	209
1992	1	0	524	895	400	*376*	0	0	50	1
1992	2	0	520	660	326	*35*	0	0	0	0
1993	1	0	348	625	265	*45*	0	0	0	7
1993	2	0	72	234	0	*7*	0	0	0	0
1994	1	0	102	133	58	*3*	0	0	0	10
1994	2	0	252	254	128	*0*	94	134	0	7
1995	1	78	234	240	143	*17*	0	0	0	70
1995	2	0	94	146	50	*3*	0	0	0	57
1996	1	0	0	0	0	*21*	0	0	0	255
1996	2	0	469	691	305	*28*	0	0	60	479
1997	1	215	813	803	468	*473*	0	0	78	433
1997	2	78	328	679	238	*67*	91	0	17	253
1998	1	0	283	596	275	*27*	0	0	0	41
1998	2	0	0	127	37	*101*	100	0	0	8
1999	1	262	408	333	154	*281*	77	111	83	61
1999	2	0	0	0	0	0	0	0	0	0
2000	1	114	589	94	170	0	85	0	14	537
2000	2	300	715	598	80	0	0	0	0	26
2001	1	0	263	710	249	0	0	117	48	14
2001	2	222	626	1028	526	0	0	0	114	33

Table A1.4a. Landings at age (thousands) of yellowtail flounder in southern New England.

				Age					
Year	1	2	3	4	5	6	7	8+	Total
1973	28	2570	7169	4630	1716	1517	257	55	17,942
1974	130	1766	3922	5053	2500	950	1021	196	15,538
1975	170	2352	1496	973	1257	549	308	163	7,268
1976	0	1396	898	245	337	391	167	188	3,622
1977	66	2039	3931	392	205	253	123	160	7,169
1978	21	3209	1488	1025	165	34	44	28	6,014
1978	19	4972	8252	1033	428	96	24	0	14,824
1980	119	4557	6324	3619	472	117	19	12	15,239
1981	0	2732	6418	2449	884	128	14	0	12,625
1982	56	17414	12788	1741	404	78	7	0	32,488
1983	57	13823	33242	3347	376	129	35	7	51,016
1984	45	2624	13902	6587	740	244	7	14	24,163
1985	166	3984	1496	1312	774	135	27	4	7,898
1986	39	5926	2882	561	324	119	21	1	9,873
1987	72	1370	2014	803	139	47	8	1	4,454
1988	0	1154	504	407	101	17	6	0	2,189
1989	0	5213	1269	280	41	3	0	0	6,806
1990	0	415	18476	1352	68	5	0	0	20,316
1991	0	253	2230	6606	81	1	17	0	9,188
1992	0	301	896	1687	246	10	3	0	3,143
1993	0	211	361	417	124	4	0	0	1,117
1994	0	15	187	136	120	48	1	0	507
1995	0	154	125	182	18	1	3	0	483
1996	0	224	439	122	15	10	5	1	816
1997	0	33	319	146	14	2	2	1	517
1998	0	300	364	139	25	2	0	0	830
1999	0	9	1231	158	45	11	5	0	1,458
2000	0	420	805	323	12	2	1	1	1,563
2001	0	201	1086	297	83	18	9	0	1,694

Table A1.4b. Landed weight (kg) at age of yellowtail in southern New England.

	Age							
Year	1	2	3	4	5	6	78+	
1973	0.210	0.298	0.381	0.420	0.430	0.506	0.611	-
1974	0.203	0.308	0.359	0.429	0.477	0.476	0.518	-
1975	0.218	0.290	0.385	0.439	0.436	0.469	0.515	-
1976	-	0.303	0.427	0.528	0.533	0.568	0.603	-
1977	0.215	0.284	0.385	0.521	0.529	0.484	0.612	-
1978	0.234	0.296	0.402	0.543	0.710	0.791	0.677	-
1979	0.189	0.301	0.366	0.476	0.590	0.684	0.679	-
1980	0.206	0.281	0.384	0.499	0.690	0.891	1.182	-
1981	0.140	0.262	0.343	0.484	0.619	0.664	0.476	-
1982	0.226	0.263	0.354	0.502	0.661	0.821	0.956	-
1983	0.175	0.262	0.341	0.499	0.671	0.829	0.838	-
1984	0.182	0.239	0.298	0.388	0.497	0.652	0.724	-
1985	0.183	0.264	0.370	0.428	0.541	0.620	0.867	-
1986	0.186	0.285	0.335	0.470	0.598	0.617	0.804	-
1987	0.247	0.268	0.361	0.412	0.542	0.595	0.905	-
1988	-	0.293	0.398	0.501	0.664	0.936	0.937	-
1989	-	0.337	0.389	0.546	0.736	0.959	1.278	-
1990	-	0.327	0.378	0.461	0.800	0.884	0.781	-
1991	-	0.336	0.379	0.426	0.715	1.530	0.599	-
1992	-	0.347	0.386	0.460	0.631	0.802	1.432	-
1993	-	0.358	0.430	0.471	0.645	1.040	1.040	-
1994	-	0.319	0.349	0.416	0.556	0.717	0.876	-
1995	-	0.317	0.410	0.460	0.668	0.883	0.863	-
1996	-	0.363	0.399	0.476	0.602	0.680	0.780	-
1997	-	0.347	0.435	0.494	0.677	0.847	0.926	-
1998	-	0.284	0.399	0.528	0.694	0.790	0.707	-
1999	-	0.334	0.440	0.574	0.763	1.106	1.104	-
2000	-	0.371	0.477	0.604	0.690	0.979	1.040	-
2001	-	0.393	0.441	0.617	0.743	0.919	0.948	-

Table A1.4c. Landings at age (thousands) of yellowtail in the Mid Atlantic.

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1973	0	80	3426	3297	3510	3788	660	8	14,769
1974	0	87	838	2272	1187	648	453	80	5,565
1975	6	340	387	147	340	243	108	81	1,652
1976	0	78	269	82	112	86	63	1	690
1977	2	221	917	115	73	51	44	18	1,441
1978	0	880	669	445	82	27	26	20	2,149
1979	0	142	296	29	10	5	5	1	488
1980	18	217	253	210	40	12	3	4	757
1981	0	284	841	477	227	33	3	5	1,869
1982	0	566	665	114	11	1	0	0	1,357
1983	0	593	3914	237	9	17	2	2	4,773
1984	2	434	5136	1467	138	1	9	0	7,188
1985	0	1046	659	656	335	69	11	0	2,775
1986	1	289	405	74	32	8	0	0	808
1987	4	33	335	123	28	8	1	0	532
1988	0	59	28	99	33	9	0	0	229
1989	0	705	244	51	1	0	0	0	1,001
1990	0	8	446	184	11	0	0	0	649
1991	0	0	113	208	75	33	0	0	429
1992	0	0	115	393	18	4	1	0	532
1993	0	34	71	285	21	0	0	0	411
1994	0	7	79	103	164	77	3	0	432
1995	0	45	14	7	1	2	1	2	73
1996	0	117	105	92	32	5	0	0	353
1997	0	35	751	378	46	3	1	2	1,217
1998	0	96	133	117	46	7	3	0	401
1999	0	18	835	100	44	0	0	0	998
2000	0	74	252	110	3	1	0	0	440
2001		32	200	111	43	14	10	0	409

Table A1.4d. Landed weight (kg) at age of yellowtail in the Mid Atlantic.

	Age							
Year	1	2	3	4	5	6	7	8+
1973	-	0.184	0.267	0.310	0.358	0.382	0.421	0.830
1974	-	0.210	0.311	0.323	0.358	0.364	0.386	0.450
1975	0.218	0.283	0.342	0.385	0.432	0.430	0.478	0.524
1976	-	0.265	0.342	0.409	0.397	0.429	0.404	0.621
1977	0.201	0.268	0.364	0.447	0.469	0.466	0.511	0.553
1978	-	0.241	0.339	0.520	0.566	0.553	0.568	0.605
1979	-	0.249	0.317	0.424	0.586	0.461	0.344	0.830
1980	0.202	0.269	0.373	0.509	0.581	0.712	0.760	0.696
1981	0.140	0.261	0.337	0.421	0.504	0.687	0.473	0.649
1982	-	0.263	0.325	0.458	0.636	0.863	-	-
1983	0.175	0.238	0.315	0.455	0.523	0.707	0.765	0.765
1984	0.144	0.215	0.287	0.387	0.436	0.704	0.614	-
1985	-	0.235	0.355	0.367	0.419	0.494	0.450	-
1986	0.185	0.258	0.305	0.408	0.476	0.563	0.720	-
1987	0.260	0.282	0.303	0.350	0.409	0.536	0.619	-
1988	-	0.303	0.369	0.459	0.449	0.539	-	-
1989	-	0.359	0.458	0.606	0.700	0.882	-	-
1990	-	0.330	0.351	0.386	0.509	-	-	-
1991	-	0.234	0.392	0.426	0.680	0.881	-	-
1992	-	-	0.382	0.459	0.636	0.808	1.048	-
1993	-	0.302	0.431	0.422	0.614	-	-	-
1994	-	0.323	0.362	0.494	0.602	0.715	0.913	-
1995	-	0.222	0.315	0.350	0.494	0.480	0.594	0.769
1996	-	0.378	0.412	0.471	0.580	0.687	-	-
1997	-	0.296	0.416	0.474	0.552	0.952	1.128	1.941
1998	-	0.344	0.457	0.626	0.827	1.007	1.048	-
1999	-	0.360	0.458	0.548	0.563	-	-	-
2000	-	0.371	0.472	0.616	0.931	1.173	1.040	1.040
2001	-	0.366	0.464	0.643	0.817	0.968	1.030	

Table A1.5a. Discard estimates for southern New England yellowtail flounder for 2000 and 2001 from logbook (VTR) data (observer data, OB, also listed for comparison).

2000 logbook data

half year	gear	kept (mt)	disc (mt)	d/k	landings (mt)	discards (mt)
1	trawl	69.0	2.1	0.031	343.9	10.5
	dredge	0.1	3.3	23.102	0.6	13.6
2	trawl	97.7	2.5	0.026	402.6	10.5
	dredge	0.1	3.5	38.696	0.1	2.2
	total					36.8

2000 observer data

half year	gear	kept (mt)	disc (mt)	d/k	trips	discard lengths
1	trawl	0.20	0.21	1.069	2	90
	dredge					0
2	trawl	1.57	0.37	0.237	2	82
	dredge	0.04	0.63	17.859	1	22
	total					194

2001 logbook data

half year	gear	kept (mt)	disc (mt)	d/k	landings (mt)	discards (mt)
1	trawl	162.0	3.9	0.024	602.9	14.5
	dredge	0.1	2.2	40.907	0.0	0.4
2	trawl	42.7	1.3	0.029	225.0	6.6
	dredge	0.0	2.5	280.478	0.1	20.1
	total					41.7

2001 observer data

half year	gear	kept (mt)	disc (mt)	d/k	trips	discard lengths
1	trawl	11.15	0.75	0.067	1	72
	dredge	0.00	0.28		1	0
2	trawl	1.46	0.21	0.142	3	82
	dredge				0	0
	total					154

Table A1.5b. Discard estimates for Mid Atlantic yellowtail flounder, 1994-2001 from logbook (VTR) data (observer data, OB, also listed for comparison).

Trawl Discards		OB	OB	OB	VTR	VTR	VTR		
year	half	kept	discard	d/k	kept	discard	d/k	landings	discards
1994	1	0.054	0.004	0.07	0.292	0.062	0.2127	63.1	13.4
1994	2	0.001	0.024	47.20	0.675	0.043	0.0639	93.3	6.0
1995	1	0.000	0.001		1.436	0.692	0.4817	5.2	2.5
1995	2				2.994	0.170	0.0568	11.1	0.6
1996	1	0.001	0.000	0.00	24.362	1.442	0.0592	83.3	4.9
1996	2	0.000	0.345		22.607	0.815	0.0361	66.0	2.4
1997	1	1.925	0.133	0.07	84.408	3.500	0.0415	451.7	18.7
1997	2	0.000	0.381		9.887	0.714	0.0723	71.3	5.1
1998	1	0.001	0.000	0.00	29.147	2.302	0.0790	117.5	9.3
1998	2	0.018	0.002	0.13	12.033	0.765	0.0636	86.0	5.5
1999	1	0.000	0.009		103.788	4.402	0.0424	409.9	17.4
1999	2				9.022	0.484	0.0536	57.7	3.1
2000	1	0.001	0.030	21.36	46.856	0.968	0.0206	152.8	3.2
2000	2	6.269	0.424	0.07	14.233	0.467	0.0328	65.3	2.1
2001	1	0.079	0.000	0.00	38.375	0.956	0.0249	206.5	5.1
2001	2	0.000	0.003		4.040	0.175	0.0433	27.7	1.2
Dredge Discards									
1994	1	0.045	0.037	0.82	0.320	0.445	1.392	69.1	96.2
1994	2	0.001	0.006	4.57	0.091	0.068	0.747	12.6	9.4
1995	1	0.030	0.245	8.24	0.889	0.494	0.556	3.2	1.8
1995	2	0.014	0.361	25.62	0.439	0.426	0.971	1.6	1.6
1996	1	0.081	0.856	10.54	0.859	0.370	0.430	2.9	1.3
1996	2	0.054	0.674	12.57	0.529	1.150	2.174	1.5	3.4
1997	1	0.211	0.863	4.10	1.179	0.628	0.533	6.3	3.4
1997	2	0.095	0.200	2.11	0.894	0.284	0.317	6.4	2.0
1998	1	0.023	0.103	4.48	1.410	1.281	0.909	5.7	5.2
1998	2	0.000	0.058	144.50	0.839	0.578	0.689	6.0	4.1
1999	1	0.015	0.126	8.37	1.126	0.166	0.147	35.1	5.2
1999	2				0.052	0.009	0.175	0.0	0.0
2000	1	0.000	0.211		0.122	0.227	1.859	2.0	3.8
2000	2	0.000	0.033		0.077	0.261	3.387	0.1	0.4
2001	all	0.079	0.000	0.00	0.062	1.699	27.398	0.9	24.6

Table A1.6a. Discards at age (thousands) of yellowtail flounder in southern New England.

	Age						
Year	1	2	3	4	5	6	7
1973	160	2486	1130	43	0	0	0
1974	728	26568	793	45	0	0	0
1975	8670	1427	1	10	0	0	0
1976	214	5203	14	0	0	0	0
1977	5376	2732	42	0	0	0	0
1978	8677	10102	7	0	0	0	0
1979	185	14253	119	0	0	0	0
1980	869	5441	18	0	0	0	0
1981	38	4013	319	0	0	0	0
1982	113	17716	905	3	0	0	0
1983	2469	4607	5373	17	0	0	0
1984	465	3107	941	74	0	0	0
1985	2064	3031	20	0	0	0	0
1986	423	3754	39	0	0	0	0
1987	1518	2034	19	0	0	0	0
1988	5899	896	4	0	0	0	0
1989	24	14002	1834	131	6	0	0
1990	192	1633	23709	673	11	0	0
1991	445	1354	2820	2883	12	0	0
1992	477	1152	1086	659	33	0	0
1993	13	212	15	9	0	0	0
1994	9	134	35	29	12	2	0
1995	7	94	38	27	12	3	0
1996	21	81	56	29	13	2	0
1997	1	23	32	4	1	0	0
1998	0	88	114	40	9	3	1
1999	3	64	215	22	11	2	0
2000	31	35	29	13	0	0	0
2001	1	35	75	3	2	0	0

Table A1.6b. Discarded weight at age of southern New England yellowtail flounder.

	Age						
Year	1	2	3	4	5	6	7
1973	0.210	0.298	0.381	0.420			
1974	0.203	0.308	0.359	0.429			
1975	0.218	0.290	0.385	0.439			
1976	0.228	0.303	0.427				
1977	0.215	0.284	0.385				
1978	0.234	0.296	0.402				
1979	0.189	0.301	0.366				
1980	0.206	0.281	0.384				
1981	0.140	0.262	0.343				
1982	0.226	0.263	0.354	0.502			
1983	0.175	0.262	0.341	0.499			
1984	0.182	0.239	0.298	0.388			
1985	0.183	0.264	0.370				
1986	0.186	0.285	0.335				
1987	0.247	0.268	0.361				
1988	0.270	0.293	0.398				
1989	0.311	0.337	0.389	0.546	0.736		
1990	0.301	0.327	0.378	0.461	0.800		
1991	0.206	0.248	0.302	0.387	0.413		
1992	0.167	0.308	0.351	0.354	0.344		
1993	0.122	0.358	0.430	0.471			
1994	0.108	0.323	0.349	0.416	0.556	0.358	
1995	0.123	0.317	0.410	0.477	0.668	0.883	
1996	0.147	0.404	0.495	0.424	0.610	0.922	
1997	0.143	0.220	0.325	0.532	0.722		
1998	0.020	0.284	0.399	0.528	0.694	0.790	0.707
1999	0.208	0.272	0.389	0.565	0.767	0.586	1.183
2000	0.020	0.314	0.473	0.572			
2001	0.153	0.327	0.363	0.568	0.528		

Table A1.6c. Discards at age (thousands) of Mid Atlantic yellowtail flounder.

				Age		
Year	1	2	3	4	5	6
1973	32	496	225	9	0	0
1974	3	98	3	0	0	0
1975	64	11	0	0	0	0
1976	0	0	0	0	0	0
1977	69	35	1	0	0	0
1978	0	0	0	0	0	0
1979	1	52	0	0	0	0
1980	0	0	0	0	0	0
1981	0	0	0	0	0	0
1982	0	0	0	0	0	0
1983	142	265	309	1	0	0
1984	5	34	10	1	0	0
1985	9	13	0	0	0	0
1986	0	1	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	1	12	0	0	0
1991	1	3	6	6	0	0
1992	0	0	0	0	0	0
1993	0	0	0	0	0	0
1994	145	592	11	13	13	0
1995	0	15	3	3	0	1
1996	1	5	26	5	0	0
1997	1	11	64	10	0	0
1998	3	27	24	10	1	2
1999	3	15	39	8	3	0
2000	4	38	5	2	0	0
2001	0	7	51	13	2	0

Table A1.6d. Discarded weight at age of Mid Atlantic yellowtail flounder.

	Age					
Year	1	2	3	4	5	6
1973	0.210	0.298	0.381	0.420		
1974	0.203	0.308	0.359	0.429		
1975	0.218	0.290	0.385	0.439		
1976	0.228	0.303	0.427			
1977	0.215	0.284	0.385			
1978	0.234	0.296	0.402			
1979	0.189	0.301	0.366			
1980	0.206	0.281	0.384			
1981	0.140	0.262	0.343			
1982	0.226	0.263	0.354	0.502		
1983	0.175	0.262	0.341	0.499		
1984	0.182	0.239	0.298	0.388		
1985	0.183	0.264	0.370			
1986	0.186	0.285	0.335			
1987	0.247	0.268	0.361			
1988	0.270	0.293	0.398			
1989	0.311	0.337	0.389	0.546	0.736	
1990	0.301	0.327	0.378	0.461	0.800	
1991	0.206	0.248	0.302	0.387	0.413	
1992	0.167	0.308	0.351	0.354	0.344	
1993	0.122	0.358	0.430	0.471		
1994	0.065	0.171	0.348	0.407	0.377	
1995	0.146	0.233	0.318	0.385	0.506	0.507
1996	0.163	0.220	0.347	0.358	0.652	0.810
1997	0.133	0.230	0.347	0.399	0.567	0.876
1998	0.162	0.267	0.389	0.507	0.627	0.499
1999	0.234	0.251	0.399	0.501	0.608	0.899
2000	0.149	0.137	0.447	0.570	0.765	
2001	0.153	0.278	0.385	0.590	0.621	0.765

Table A1.7. NEFSC Survey indices of abundance and biomass of southern New England – Mid Atlantic yellowtail flounder.

Fall Survey

year	age-0	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	sum	kg/tow
1963	0.030	14.778	12.274	9.972	4.944	0.683	0.059	0.082	0.000	0.000	42.822	14.023
1964	0.000	13.900	19.067	3.381	5.356	2.643	0.543	0.036	0.000	0.000	44.925	13.972
1965	0.166	22.272	12.835	4.327	1.489	1.184	0.146	0.000	0.000	0.000	42.418	10.228
1966	0.569	34.899	10.656	2.342	0.902	0.175	0.000	0.000	0.000	0.000	49.542	9.033
1967	0.177	23.579	29.045	12.719	1.212	0.260	0.047	0.124	0.000	0.000	67.164	14.018
1968	0.000	13.882	21.622	24.639	1.571	0.263	0.325	0.069	0.000	0.000	62.370	13.038
1969	0.056	10.440	11.316	33.936	4.454	0.049	0.019	0.019	0.000	0.000	60.288	14.472
1970	0.067	4.414	8.047	29.866	18.927	3.305	0.359	0.047	0.000	0.000	65.032	16.211
1971	0.000	14.540	12.485	6.886	12.452	1.909	0.162	0.123	0.000	0.000	48.556	8.975
1972	0.000	3.245	32.938	33.089	33.080	18.618	2.305	0.101	0.000	0.000	123.376	31.543
1973	0.000	1.779	1.747	4.086	2.318	1.564	0.768	0.162	0.000	0.000	12.422	3.125
1974	0.132	0.695	1.185	0.433	1.640	0.687	0.297	0.146	0.014	0.042	5.271	1.545
1975	0.000	1.533	0.416	0.136	0.217	0.213	0.048	0.070	0.000	0.000	2.634	0.602
1976	0.000	1.964	4.204	0.350	0.046	0.073	0.190	0.220	0.099	0.000	7.147	1.954
1977	0.028	2.289	1.439	0.519	0.044	0.040	0.035	0.065	0.000	0.000	4.459	1.125
1978	0.000	2.080	4.771	0.296	0.236	0.024	0.006	0.048	0.000	0.021	7.481	2.004
1979	0.000	1.493	3.283	1.579	0.241	0.026	0.026	0.000	0.000	0.000	6.646	1.818
1980	0.000	1.153	2.908	0.757	0.313	0.000	0.000	0.000	0.000	0.000	5.130	1.354
1981	0.000	9.511	9.498	1.251	0.198	0.103	0.037	0.000	0.000	0.000	20.597	4.046
1982	0.000	2.040	17.794	4.392	0.535	0.215	0.000	0.000	0.000	0.000	24.976	5.706
1983	0.000	1.920	11.278	5.593	0.458	0.038	0.000	0.026	0.000	0.000	19.314	4.490
1984	0.000	1.444	1.275	1.529	0.334	0.000	0.000	0.000	0.000	0.000	4.582	1.033
1985	0.000	0.869	0.375	0.134	0.080	0.000	0.000	0.000	0.000	0.000	1.458	0.298
1986	0.000	0.606	1.826	0.523	0.123	0.025	0.000	0.000	0.000	0.000	3.104	0.754
1987	0.073	1.067	0.451	0.359	0.030	0.024	0.000	0.024	0.000	0.000	2.028	0.401
1988	0.000	4.370	0.310	0.141	0.156	0.021	0.034	0.000	0.000	0.000	5.032	0.510
1989	0.000	0.198	10.492	1.370	0.072	0.000	0.000	0.000	0.000	0.000	12.132	2.359
1990	0.000	0.539	1.847	3.117	0.194	0.000	0.000	0.000	0.000	0.000	5.696	1.305
1991	0.000	0.588	0.243	1.516	0.367	0.000	0.000	0.000	0.000	0.000	2.713	0.755
1992	0.000	0.168	0.024	0.072	0.285	0.000	0.000	0.000	0.000	0.000	0.548	0.147
1993	0.000	0.332	0.028	0.130	0.104	0.000	0.000	0.000	0.000	0.000	0.594	0.116
1994	0.000	0.732	0.448	0.107	0.129	0.066	0.025	0.000	0.000	0.000	1.507	0.308
1995	0.000	0.139	0.645	0.257	0.115	0.000	0.000	0.025	0.028	0.000	1.209	0.304
1996	0.000	0.448	0.161	0.320	0.000	0.000	0.000	0.000	0.000	0.000	0.929	0.208
1997	0.000	0.822	0.519	1.459	0.271	0.024	0.000	0.000	0.000	0.000	3.095	0.851
1998	0.023	0.890	1.620	0.124	0.049	0.000	0.023	0.000	0.000	0.000	2.728	0.655
1999	0.000	1.238	0.392	0.279	0.028	0.028	0.000	0.000	0.000	0.000	1.964	0.468
2000	0.000	0.049	1.669	0.303	0.171	0.000	0.000	0.023	0.000	0.000	2.215	0.718
2001	0.000	0.390	0.611	0.158	0.071	0.000	0.000	0.000	0.000	0.000	1.231	0.419

Table A1.7 cont.

Spring Survey

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	age-9	age-10	age-11	sum	kg/tow
1968	1.014	29.910	38.854	13.103	1.076	0.040	0.184	0.000	0.000	0.000	0.000	84.181	18.645
1969	2.941	18.796	29.464	14.069	1.599	0.147	0.048	0.000	0.000	0.000	0.000	67.064	14.311
1970	1.045	7.311	18.942	16.237	3.518	0.656	0.123	0.005	0.022	0.000	0.000	47.860	12.066
1971	0.447	7.616	8.124	20.765	3.713	0.371	0.004	0.000	0.000	0.004	0.000	41.043	9.552
1972	0.196	12.355	11.201	5.986	9.887	2.394	0.303	0.000	0.000	0.000	0.000	42.321	10.815
1973	0.838	5.467	14.753	8.335	6.432	7.987	0.852	0.230	0.083	0.000	0.000	44.977	12.115
1974	0.511	2.188	2.607	5.016	2.891	1.154	1.291	0.145	0.027	0.000	0.000	15.830	4.918
1975	0.358	1.171	0.406	0.665	0.709	0.531	0.156	0.197	0.000	0.000	0.000	4.193	1.307
1976	0.016	4.182	0.536	0.256	0.245	0.338	0.096	0.031	0.000	0.000	0.000	5.699	1.666
1977	1.618	1.557	2.758	0.242	0.154	0.189	0.093	0.080	0.006	0.046	0.000	6.743	1.963
1978	2.681	10.302	1.791	0.778	0.253	0.126	0.123	0.158	0.010	0.000	0.000	16.221	3.513
1979	1.002	2.967	1.601	0.255	0.124	0.018	0.018	0.014	0.000	0.000	0.012	6.009	1.318
1980	0.683	6.353	4.298	2.684	0.261	0.070	0.005	0.009	0.015	0.001	0.005	14.384	4.830
1981	0.810	18.598	4.817	2.502	0.580	0.113	0.000	0.000	0.000	0.000	0.000	27.420	6.930
1982	0.149	17.329	5.610	1.406	0.467	0.135	0.017	0.000	0.000	0.000	0.000	25.114	5.865
1983	0.016	5.329	8.803	0.598	0.191	0.000	0.000	0.000	0.000	0.000	0.000	14.938	4.097
1984	0.038	0.453	0.902	2.110	0.354	0.262	0.000	0.000	0.000	0.000	0.000	4.119	1.302
1985	0.267	1.613	0.406	0.480	0.714	0.135	0.019	0.000	0.000	0.000	0.000	3.634	0.948
1986	0.016	2.893	0.916	0.237	0.124	0.016	0.000	0.000	0.000	0.000	0.000	4.201	1.052
1987	0.000	0.086	0.701	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.954	0.319
1988	0.285	0.357	0.125	0.174	0.294	0.029	0.000	0.000	0.000	0.000	0.000	1.263	0.378
1989	0.162	11.211	0.537	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.022	2.090
1990	0.090	0.485	15.349	2.194	0.079	0.000	0.000	0.000	0.000	0.000	0.000	18.197	5.064
1991	0.228	0.611	2.509	4.156	0.539	0.060	0.000	0.000	0.000	0.000	0.000	8.103	2.508
1992	0.036	0.051	0.571	1.597	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.255	0.794
1993	0.016	0.253	0.112	0.441	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.894	0.341
1994	0.016	0.269	0.016	0.000	0.068	0.019	0.000	0.000	0.000	0.000	0.000	0.389	0.136
1995	0.016	1.169	0.068	0.092	0.019	0.037	0.000	0.016	0.016	0.000	0.000	1.433	0.329
1996	0.000	0.398	1.303	0.566	0.072	0.000	0.000	0.000	0.000	0.000	0.000	2.339	0.747
1997	0.053	0.885	1.144	0.327	0.067	0.000	0.000	0.000	0.000	0.000	0.000	2.475	0.789
1998	0.068	3.016	0.386	0.161	0.036	0.021	0.000	0.000	0.000	0.000	0.000	3.688	0.848
1999	0.036	0.651	1.930	0.349	0.074	0.000	0.023	0.000	0.000	0.000	0.000	3.062	1.138
2000	0.019	1.245	1.006	0.559	0.043	0.000	0.000	0.000	0.000	0.000	0.000	2.873	0.990
2001	0.000	0.069	1.158	0.240	0.082	0.023	0.000	0.000	0.000	0.000	0.000	1.572	0.657
2002	0.049	1.191	0.235	0.200	0.067	0.000	0.000	0.000	0.000	0.000	0.000	1.742	0.510

Table A1.7 continued.
Winter Survey

year	age-1	age-2	age-3	age-4	age-5	age-6	age-7	age-8	sum	kg/tow
1992	0.011	1.619	3.477	8.063	0.959	0.000	0.000	0.000	14.129	5.264
1993	0.596	1.924	1.057	2.487	0.292	0.000	0.000	0.000	6.357	2.118
1994	0.366	8.654	0.742	1.654	0.966	0.353	0.118	0.000	12.854	3.924
1995	0.090	10.681	2.698	0.597	0.253	0.185	0.016	0.000	14.519	3.464
1996	0.041	1.285	8.235	0.851	0.140	0.065	0.015	0.015	10.648	3.346
1997	0.156	2.380	9.785	2.958	0.529	0.000	0.038	0.000	15.846	5.720
1998	0.118	7.841	1.596	1.158	0.112	0.000	0.018	0.000	10.843	2.780
1999	0.243	2.909	10.176	0.777	0.311	0.056	0.023	0.000	14.494	5.226
2000	0.109	4.917	3.006	1.160	0.073	0.100	0.000	0.000	9.364	3.025
2001	0.028	0.895	8.542	1.615	0.254	0.096	0.046	0.000	11.475	4.786
2002	0.012	2.735	2.578	2.047	0.100	0.020	0.000	0.000	7.492	2.589

Scallop Survey

year	all	age-1
1982	3.123	0.362
1983	0.858	0.255
1984	0.309	0.180
1985	0.577	0.465
1986	0.199	0.015
1987	0.150	0.054
1988	7.482	7.359
1989	3.774	0.579
1990	0.370	0.158
1991	0.230	0.151
1992	0.169	0.108
1993	0.192	0.170
1994	0.732	0.573
1995	0.507	0.072
1996	38.479	0.120
1997	0.886	0.736
1998	0.567	0.253
1999	0.456	0.357
2000	0.432	0.082
2001	0.106	0.063
2002	0.152	0.020

Table A1.8. Correlation among abundance indices by age.

Age 1	Fall	Spring	Winter	Scallop
Fall	1.00			
Spring	0.45	1.00		
Winter	0.25	0.00	1.00	
Scallop	0.49	0.40	0.47	1.00

Age 2	Fall	Spring	Winter
Fall	1.00		
Spring	0.82	1.00	
Winter	0.45	0.65	1.00

Age 3	Fall	Spring	Winter
Fall	1.00		
Spring	0.71	1.00	
Winter	0.45	0.86	1.00

Age 4	Fall	Spring	Winter
Fall	1.00		
Spring	0.74	1.00	
Winter	0.46	0.57	1.00

Age 5	Fall	Spring	Winter
Fall	1.00		
Spring	0.36	1.00	
Winter	-0.46	0.54	1.00

Age 6	Fall	Spring	Winter
Fall	1.00		
Spring	0.57	1.00	
Winter	-0.49	-0.55	1.00

Age 7+	Fall	Spring	Winter
Fall	1.00		
Spring	-0.18	1.00	
Winter	-0.07	-0.31	1.00

Table A1.9c. Results of virtual population analysis of southern New England – Mid Atlantic yellowtail flounder.

Abundance (thousands)								
	age-1	age-2	age-3	age-4	age-5	age-6	age-7+	sum
1973	43532	17681	27907	16078	8927	11005	2006	127136
1974	10627	35442	9380	12035	5945	2580	2769	78778
1975	31562	7921	3212	2653	3185	1531	1256	51320
1976	14634	17779	2749	925	1149	1162	1009	39407
1977	50316	11788	8514	1182	462	535	596	73393
1978	54165	36207	5103	2545	509	126	243	98898
1979	32034	36476	16803	2220	754	193	57	88537
1980	44493	26042	12293	5915	856	221	64	89884
1981	138470	35518	12078	4097	1378	238	32	191811
1982	64223	113335	22719	3032	707	123	11	204150
1983	16726	52429	60492	5609	801	203	62	136322
1984	19164	11280	25473	10766	1334	308	36	68361
1985	20993	15223	3625	2767	1459	298	60	44425
1986	7315	15161	5158	1000	485	191	32	29342
1987	15044	5570	3392	1213	244	75	13	25551
1988	124008	10875	1450	634	155	49	11	137182
1989	17769	96192	6995	702	61	6	0	121725
1990	8083	14526	60731	2699	157	7	0	86203
1991	3934	6444	10032	11136	211	47	23	31827
1992	2267	2817	3819	3537	338	21	6	12805
1993	2041	1425	992	1229	417	8	0	6112
1994	2953	1660	753	407	363	210	7	6353
1995	3392	2278	682	334	79	18	20	6803
1996	1988	2771	1586	395	75	37	13	6865
1997	5951	1608	1882	732	98	8	9	10288
1998	3377	4871	1223	486	113	25	7	10102
1999	5753	2762	3525	427	121	19	7	12614
2000	1889	4705	2166	786	89	6	4	9645
2001	3060	1515	3339	786	239	59	35	9033
2002	---	2504	991	1455	260	79	31	---
average	25854	19827	10635	3259	1032	646	281	62582

Table A1.9b.

Fishing Mortality

	age-1	age-2	age-3	age-4	age-5	age-6	age-7+	ages 4-6
1973	0.01	0.43	0.64	0.79	1.04	0.76	0.76	0.86
1974	0.09	2.20	1.06	1.13	1.16	1.15	1.15	1.15
1975	0.37	0.86	1.04	0.64	0.81	0.85	0.85	0.77
1976	0.02	0.54	0.64	0.50	0.57	0.60	0.60	0.56
1977	0.13	0.64	1.01	0.64	1.10	0.99	0.99	0.91
1978	0.20	0.57	0.63	1.02	0.77	0.76	0.76	0.85
1979	0.01	0.89	0.84	0.75	1.03	0.86	0.86	0.88
1980	0.03	0.57	0.90	1.26	1.08	1.04	1.04	1.13
1981	0.00	0.25	1.18	1.56	2.22	1.38	1.38	1.72
1982	0.00	0.43	1.20	1.13	1.05	1.24	1.24	1.14
1983	0.19	0.52	1.53	1.24	0.76	1.58	1.58	1.19
1984	0.03	0.94	2.02	1.80	1.30	2.12	2.12	1.74
1985	0.13	0.88	1.09	1.54	1.83	1.41	1.41	1.59
1986	0.07	1.30	1.25	1.21	1.67	1.33	1.33	1.40
1987	0.12	1.15	1.48	1.86	1.41	1.66	1.66	1.64
1988	0.05	0.24	0.53	2.13	3.06	0.89	0.89	2.03
1989	0.00	0.26	0.75	1.30	1.99	0.82	0.82	1.37
1990	0.03	0.17	1.50	2.35	1.00	1.62	1.62	1.66
1991	0.13	0.32	0.84	3.29	2.13	1.60	1.60	2.34
1992	0.26	0.84	0.93	1.94	3.55	1.40	1.40	2.30
1993	0.01	0.44	0.69	1.02	0.48	0.81	0.81	0.77
1994	0.06	0.69	0.61	1.44	2.82	1.10	1.10	1.79
1995	0.00	0.16	0.34	1.29	0.57	0.58	0.58	0.81
1996	0.01	0.19	0.57	1.19	2.11	0.71	0.71	1.34
1997	0.00	0.07	1.15	1.67	1.19	1.33	1.33	1.40
1998	0.00	0.12	0.85	1.19	1.58	1.00	1.00	1.26
1999	0.00	0.04	1.30	1.37	2.84	1.40	1.40	1.87
2000	0.02	0.14	0.81	0.99	0.21	0.85	0.85	0.68
2001	0.00	0.22	0.63	0.91	0.91	0.91	0.91	0.91
average	0.07	0.55	0.97	1.35	1.46	1.13	1.13	1.31

Table A1.9c.

Spawning Biomass (mt)

	age-1	age-2	age-3	age-4	age-5	age-6	age-7+	sum
1973	1091	2974	6704	3983	2033	3082	652	20519
1974	248	2970	1912	2739	1483	633	758	10743
1975	704	1090	705	809	910	452	414	5084
1976	396	2933	773	345	417	451	414	5729
1977	1226	1742	1922	420	138	157	216	5821
1978	1397	5701	1354	822	225	58	104	9661
1979	722	5164	3879	709	267	84	23	10848
1980	1085	3932	2927	1612	342	115	42	10055
1981	2318	5716	2276	934	300	82	8	11634
1982	1734	16980	4388	869	278	56	6	24311
1983	323	7496	9789	1529	359	79	25	19600
1984	412	1233	2920	1816	348	76	5	6810
1985	436	1866	758	547	315	88	21	4031
1986	158	1707	915	257	131	62	13	3243
1987	422	630	583	208	65	20	5	1933
1988	3916	1962	416	118	24	25	7	6468
1989	661	19864	1816	208	18	4	0	22571
1990	288	3013	11096	424	73	3	0	14897
1991	92	1005	2146	1075	54	20	6	4398
1992	41	426	859	630	43	8	4	2011
1993	30	286	288	333	201	5	0	1143
1994	23	172	185	91	59	87	3	620
1995	50	433	214	82	38	9	10	836
1996	35	651	460	103	17	18	7	1291
1997	100	306	435	161	32	4	6	1044
1998	65	926	318	154	41	13	4	1521
1999	152	536	815	125	23	10	4	1665
2000	8	1062	661	290	57	4	3	2085
2001	56	355	1014	308	115	35	22	1905
average	627	3211	2156	748	290	198	96	7327

Table A1.10. Yield and spawning biomass per recruit of southern New England – Mid Atlantic yellowtail flounder.

```
  The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
   PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
            ----------------------------------------
            Run Date: 17- 9-2002;  Time: 09:41:39.27
SNE-MA YELLOWTAIL FLOUNDER - 1994-2001 INPUT

Proportion of F before spawning:  .4167
Proportion of M before spawning:  .4167
Natural Mortality is Constant at:  .200
Initial age is:  1; Last age is:  8
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> snemayt.dat
------------------------------------------------------------
Age-specific Input data for Yield per Recruit Analysis
------------------------------------------------------------
 Age | Fish Mort  Nat Mort | Proportion | Average Weights
     |  Pattern    Pattern |   Mature   |  Catch   Stock
------------------------------------------------------------
  1  |   .0100     1.0000  |    .1300   |   .131    .131
  2  |   .1700     1.0000  |    .7400   |   .310    .310
  3  |   .6400     1.0000  |    .9800   |   .418    .418
  4  |  1.0000     1.0000  |   1.0000   |   .525    .525
  5  |  1.0000     1.0000  |   1.0000   |   .671    .671
  6  |  1.0000     1.0000  |   1.0000   |   .869    .869
  7  |  1.0000     1.0000  |   1.0000   |   .940    .940
  8+ |  1.0000     1.0000  |   1.0000   |  1.026   1.026

------------------------------------------------------------
Summary of Yield per Recruit Analysis for:
SNE-MA YELLOWTAIL FLOUNDER - 1994-2001 INPUT

 Slope of the Yield/Recruit Curve at F=0.00: -->    2.5485
   F level at slope=1/10 of the above slope (F0.1): ----->    .246
     Yield/Recruit corresponding to F0.1: ----->     .2265
   F level to produce Maximum Yield/Recruit (Fmax): ----->    .739
     Yield/Recruit corresponding to Fmax: ----->     .2581
   F level at 40 % of Max Spawning Potential (F40): ----->    .261
     SSB/Recruit corresponding to F40: -------->    1.1288
```

Table A1.10 continued.

Listing of Yield per Recruit Results for:
SNE-MA YELLOWTAIL FLOUNDER - 1994-2001 INPUT

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	3.2532	4.0669	2.8223	100.00
	.100	.21897	.15373	4.4270	2.2137	2.9720	1.8000	63.78
	.200	.33004	.21222	3.8766	1.7151	2.4167	1.3144	46.57
F0.1	.246	.36506	.22653	3.7037	1.5648	2.2416	1.1691	41.42
F40%	.261	.37497	.23015	3.6548	1.5231	2.1921	1.1288	40.00
	.300	.39788	.23774	3.5420	1.4281	2.0776	1.0374	36.76
	.400	.44405	.24951	3.3154	1.2441	1.8470	.8612	30.51
	.500	.47780	.25494	3.1508	1.1173	1.6786	.7405	26.24
	.600	.50373	.25727	3.0249	1.0251	1.5492	.6531	23.14
	.700	.52444	.25804	2.9249	.9552	1.4461	.5872	20.80
Fmax	.739	.53153	.25809	2.8908	.9321	1.4108	.5654	20.03
	.800	.54146	.25801	2.8432	.9005	1.3615	.5357	18.98
	.900	.55578	.25759	2.7747	.8565	1.2904	.4943	17.51
	1.000	.56805	.25698	2.7164	.8203	1.2297	.4603	16.31
	1.100	.57874	.25630	2.6658	.7899	1.1769	.4318	15.30
	1.200	.58817	.25559	2.6214	.7640	1.1304	.4075	14.44
	1.300	.59657	.25490	2.5819	.7416	1.0891	.3865	13.69
	1.400	.60414	.25424	2.5465	.7219	1.0521	.3682	13.04
	1.500	.61100	.25361	2.5145	.7046	1.0185	.3519	12.47
	1.600	.61728	.25301	2.4854	.6891	.9880	.3374	11.96
	1.700	.62305	.25245	2.4586	.6752	.9600	.3244	11.49
	1.800	.62838	.25191	2.4340	.6625	.9342	.3126	11.08
	1.900	.63334	.25140	2.4112	.6510	.9103	.3018	10.69
	2.000	.63796	.25091	2.3899	.6404	.8880	.2920	10.34

Figure A1.1. Statistical areas for southern New England – Mid Atlantic yellowtail flounder.

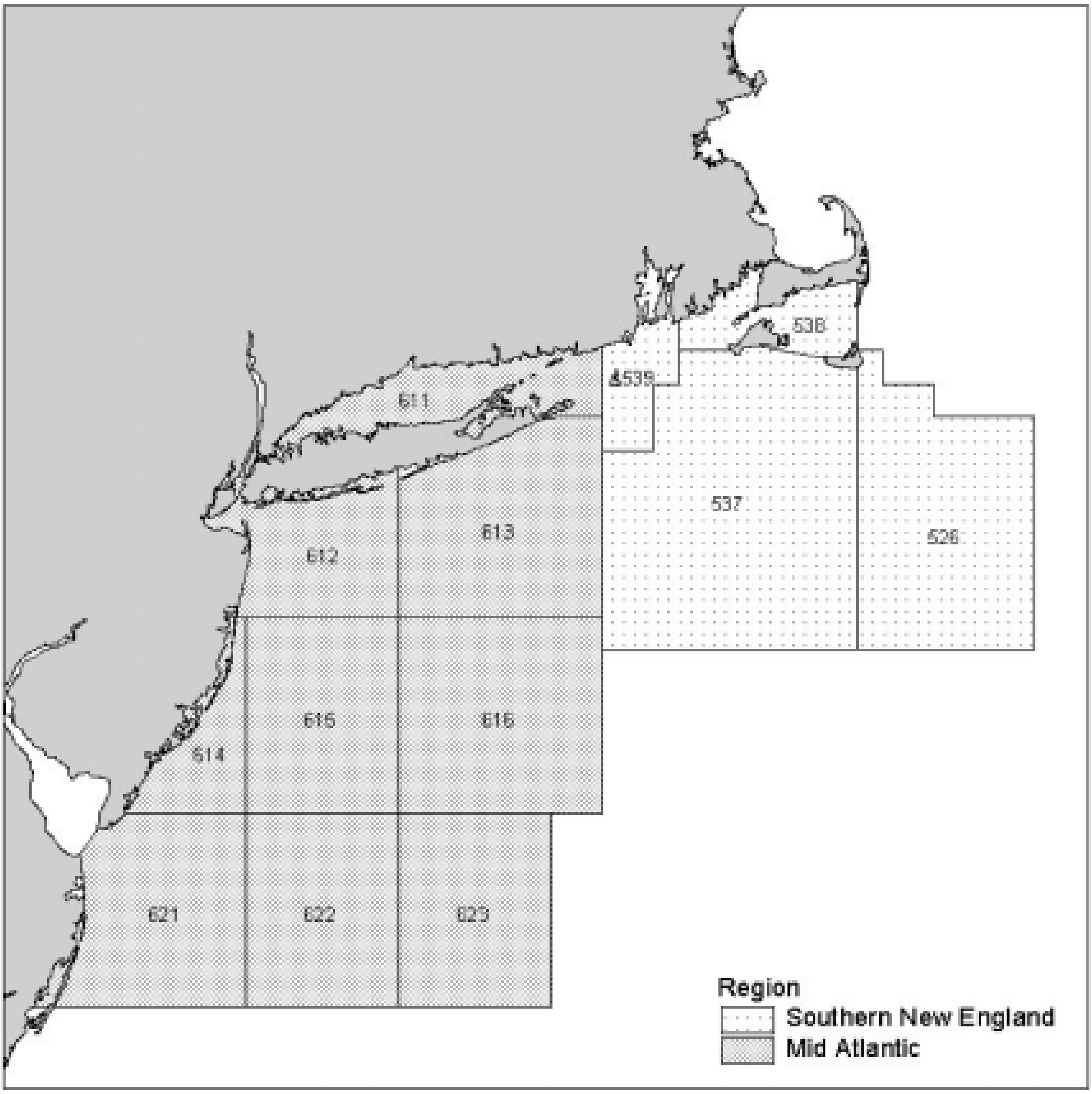


Figure A1.2. Catch of southern New England- Mid Atlantic yellowtail flounder.

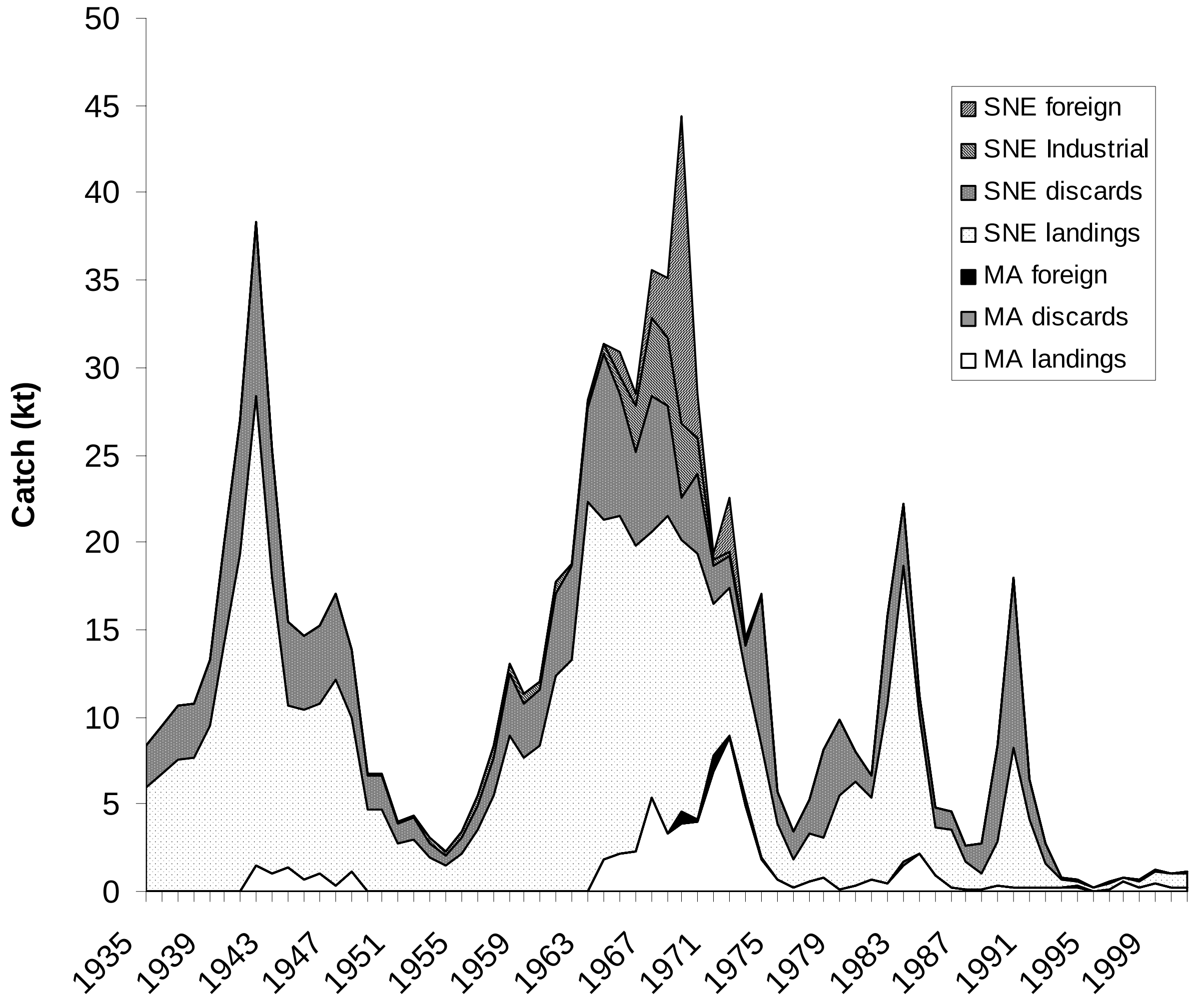


Figure A1.3. Total catch at age of southern New England – Mid Atlantic yellowtail flounder (size of circle indicates relative magnitude).

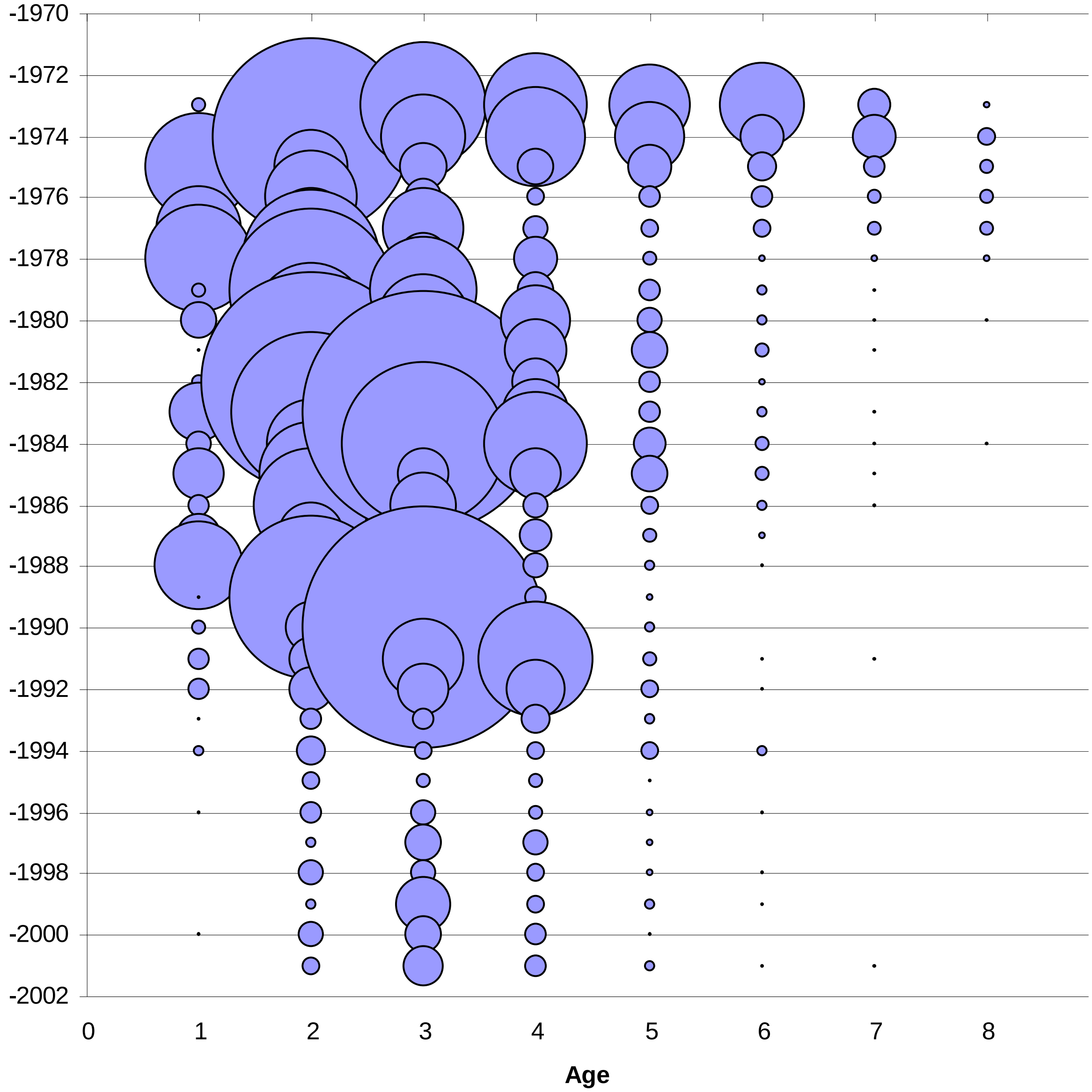


Figure A1.4. Mean weight at age of yellowtail flounder in the catch.

Figure A1.5. Survey strata for southern New England – Mid Atlantic yellowtail flounder.

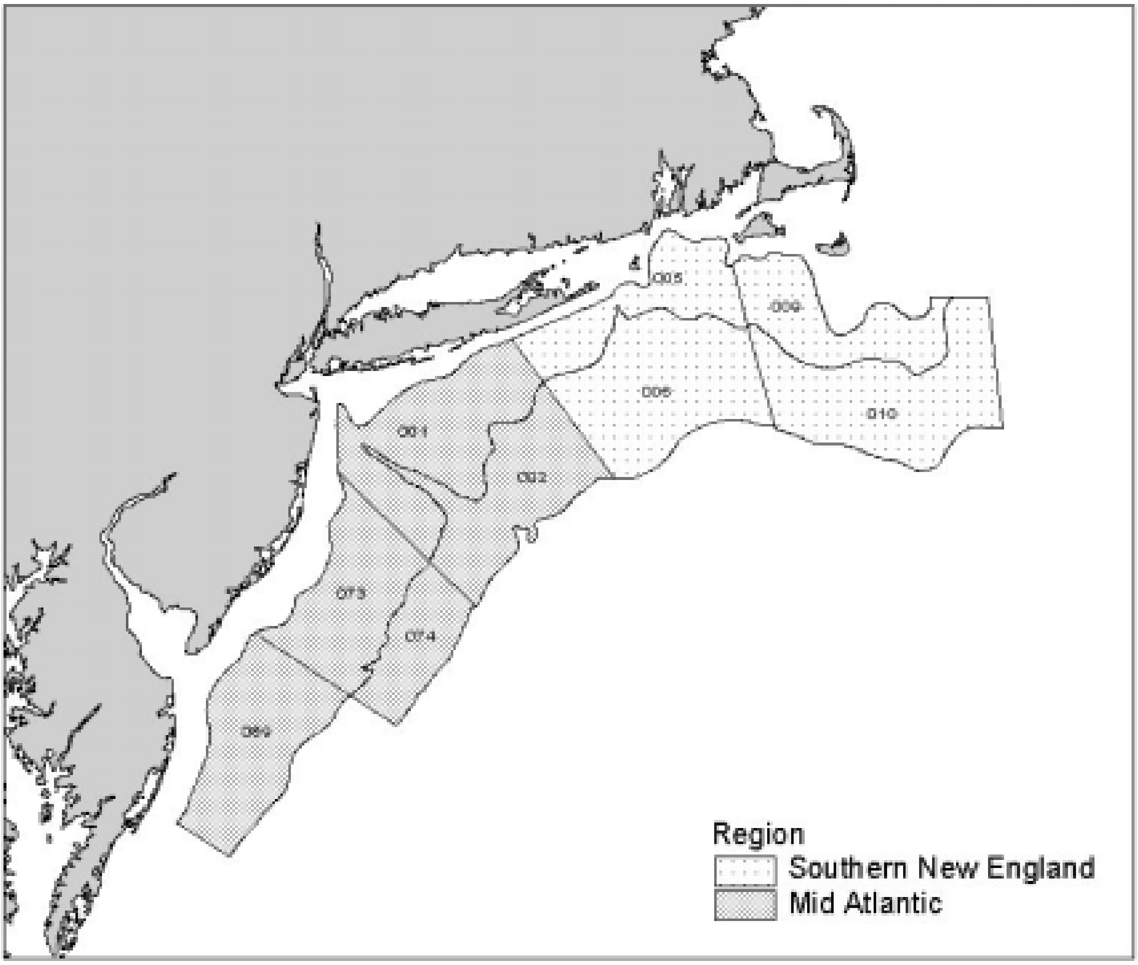


Figure A1.6. Survey indices of southern New England – Mid Atlantic yellowtail flounder biomass.

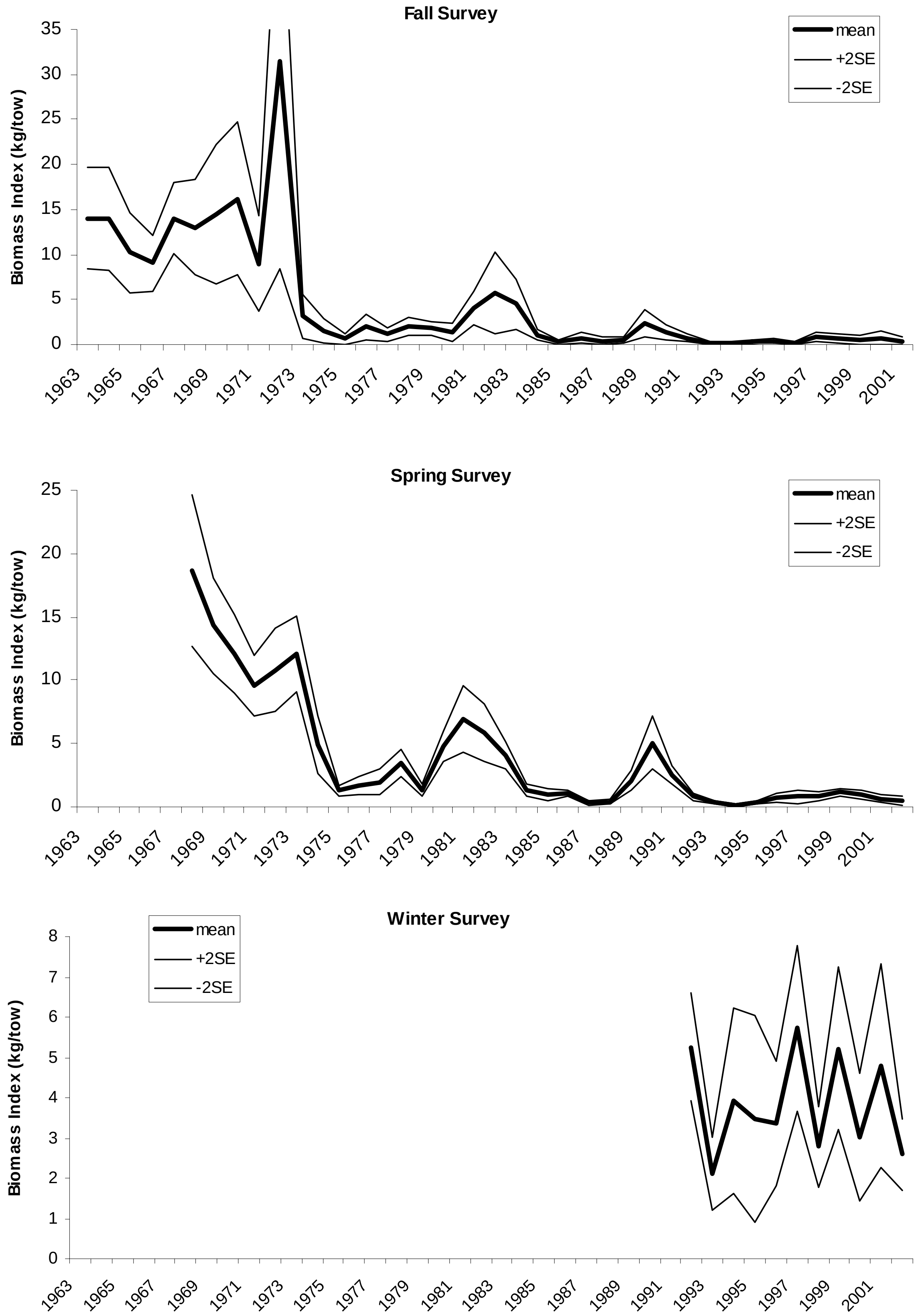


Figure A1.7a. Distribution of yellowtail flounder in recent NEFSC surveys.

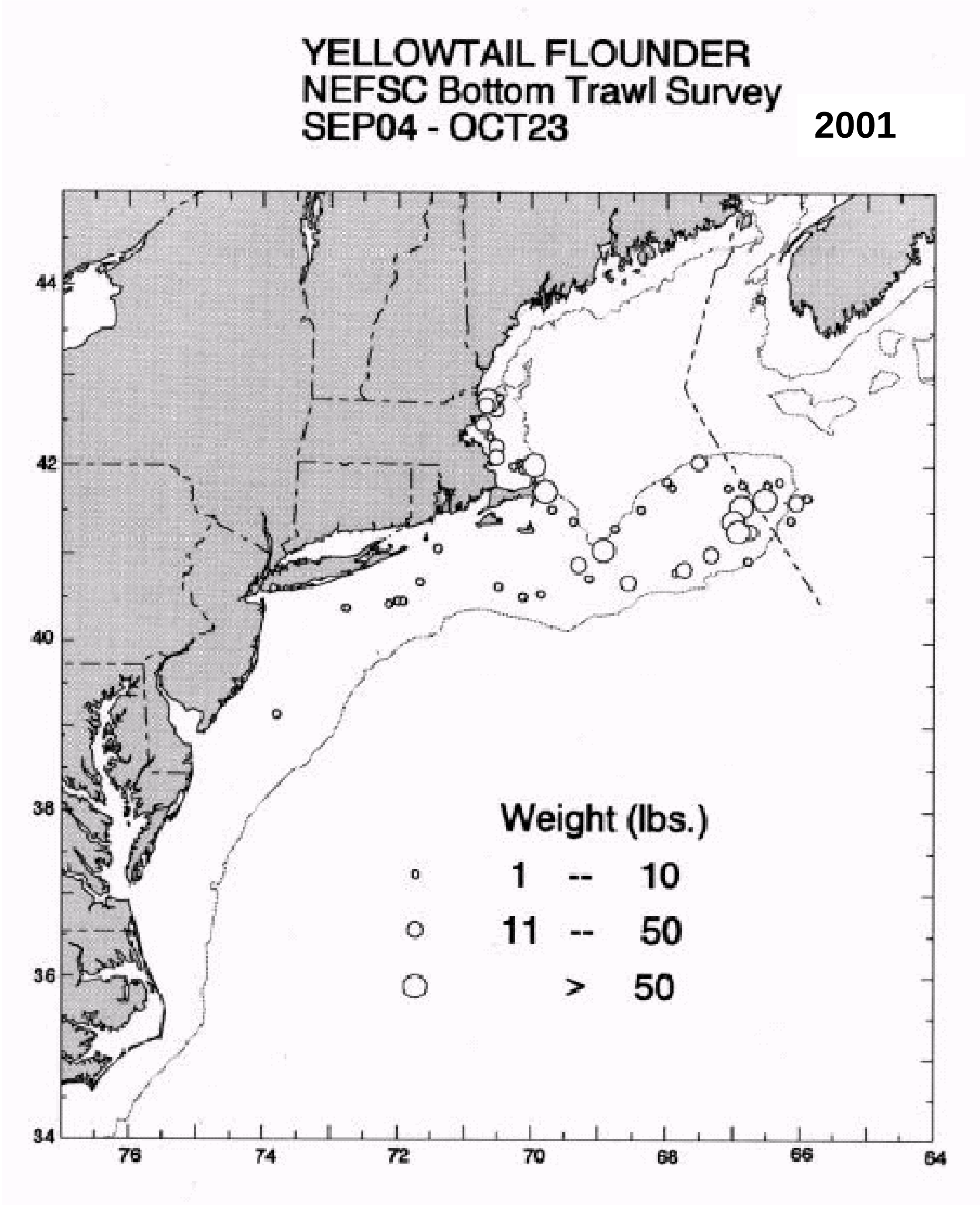
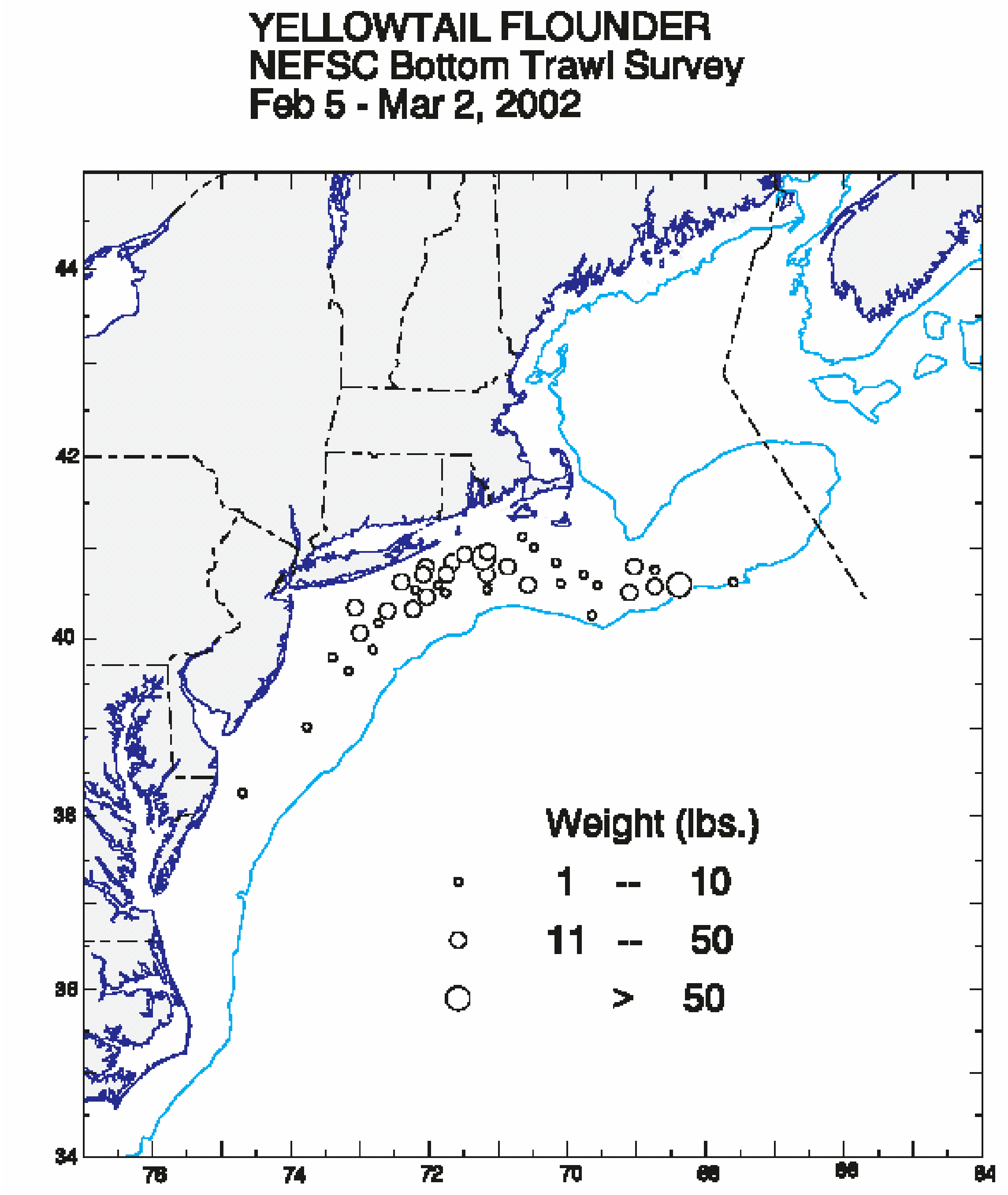


Figure A1.7b.



YELLOWTAIL FLOUNDER
NEFSC Bottom Trawl Survey
Feb 5 - Mar 2, 2002
44
42
40
38
36
34
76
74
72
70
68
66
64
Weight (lbs.)
1 -- 10
11 -- 50
> 50

Figure A1.7c.

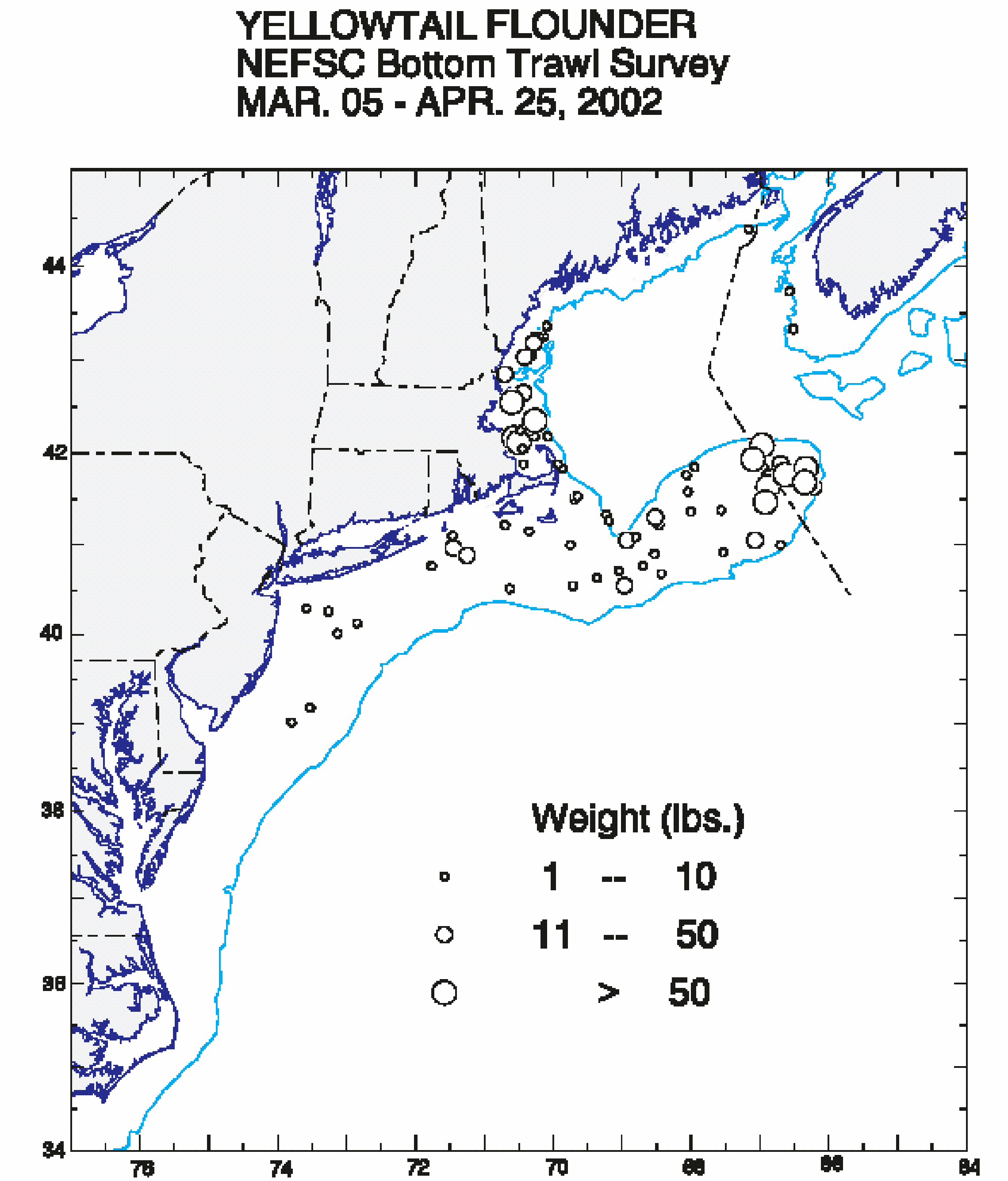

YELLOWTAIL FLOUNDER
NEFSC Bottom Trawl Survey
MAR. 05 - APR. 25, 2002
Weight (lbs.)
1 -- 10
11 -- 50
> 50
44
42
40
38
36
34
76
74
72
70
68
66
64

Figure A1.8. Area-swept biomass of southern New England – Mid Atlantic yellowtail flounder, by geographic region.

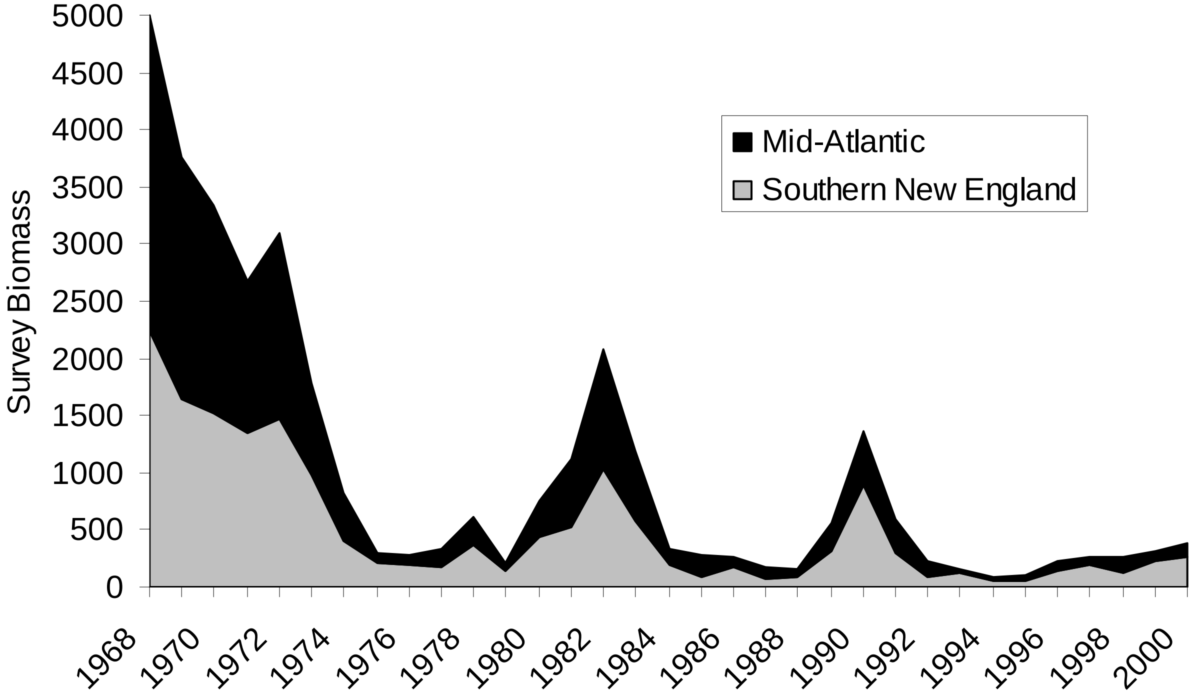


Figure A1.9a. Age distribution of southern New England – Mid Atlantic yellowtail flounder from NEFSC surveys (circle size indicates relative abundance).

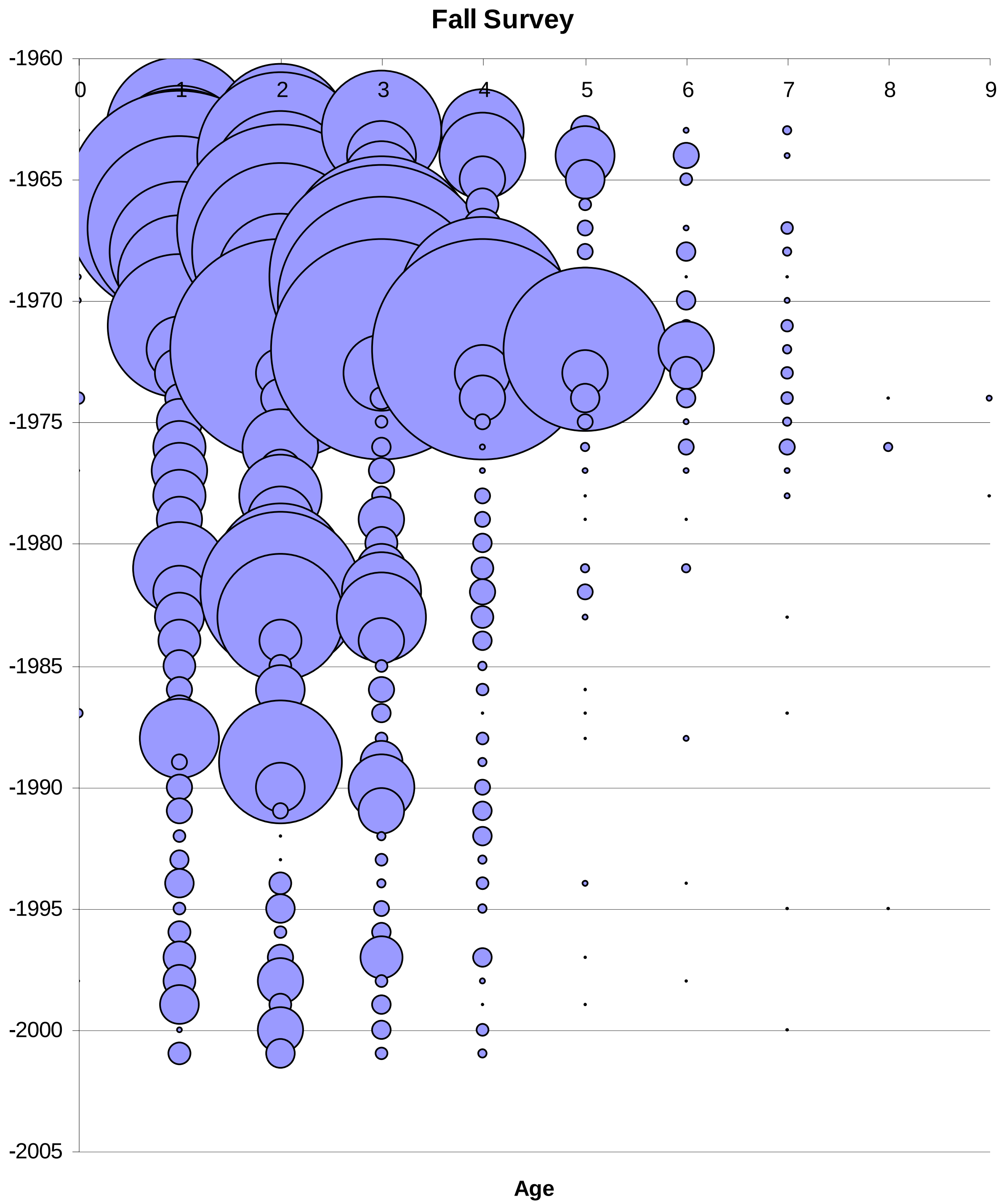


Figure A1.9b.

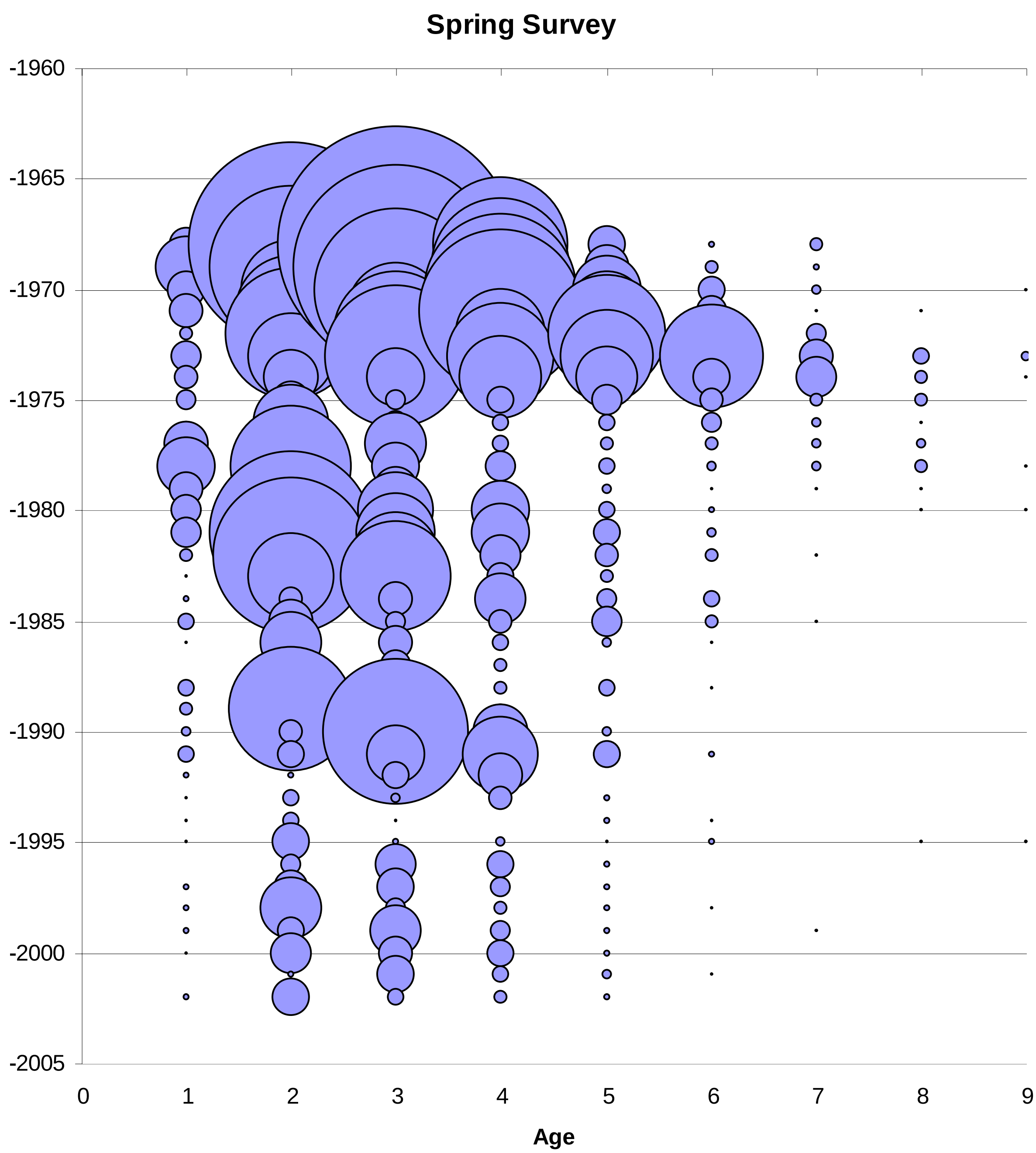
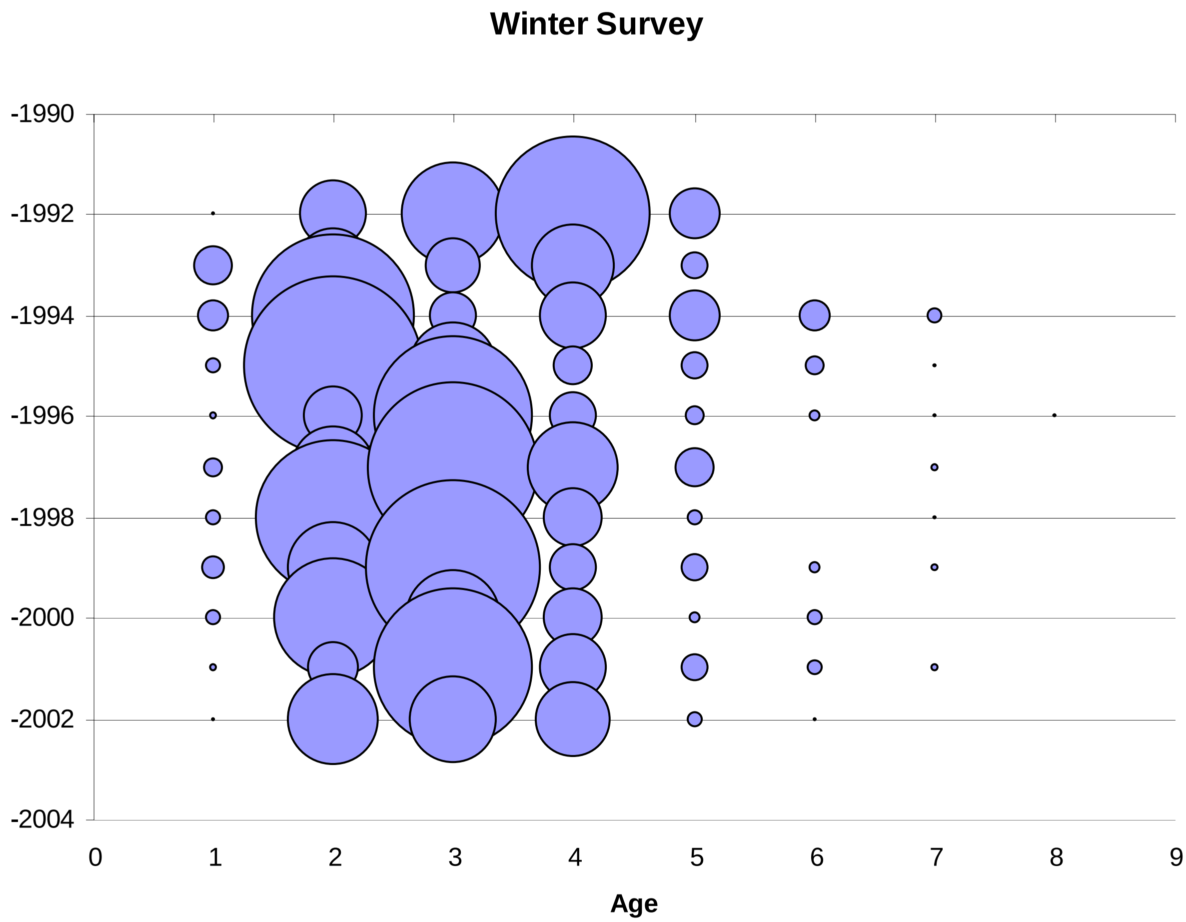

Spring Survey
-1960
-1965
-1970
-1975
-1980
-1985
-1990
-1995
-2000
-2005
0
1
2
3
4
5
6
7
8
9
Age

Figure A1.9c.



Winter Survey
-1990
-1992
-1994
-1996
-1998
-2000
-2002
-2004
0
1
2
3
4
5
6
7
8
9
Age

Figure A1.10a. Normalized indices of abundance of southern New England – Mid Atlantic yellowtail flounder, by age.

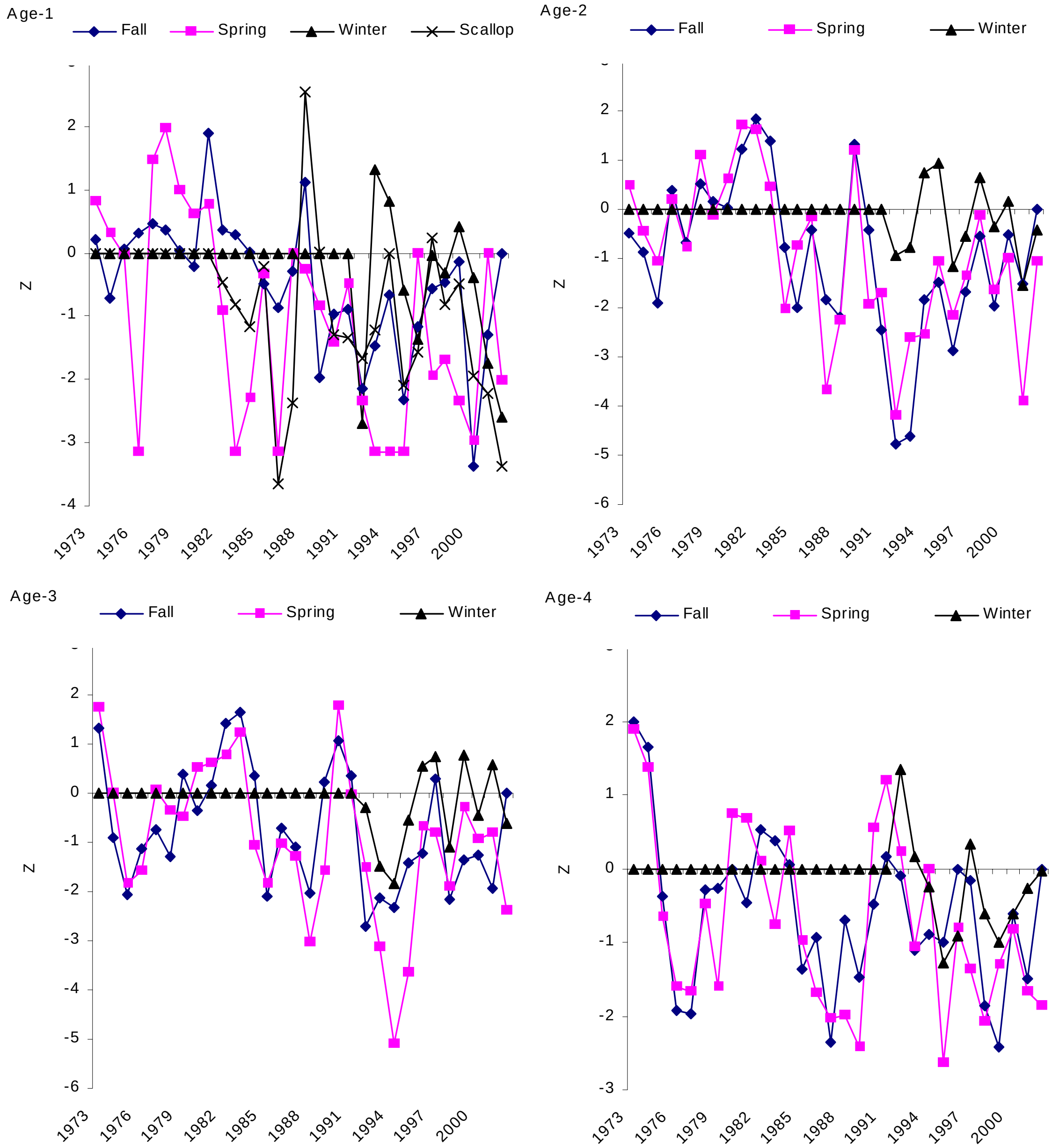


Figure A1.10b.

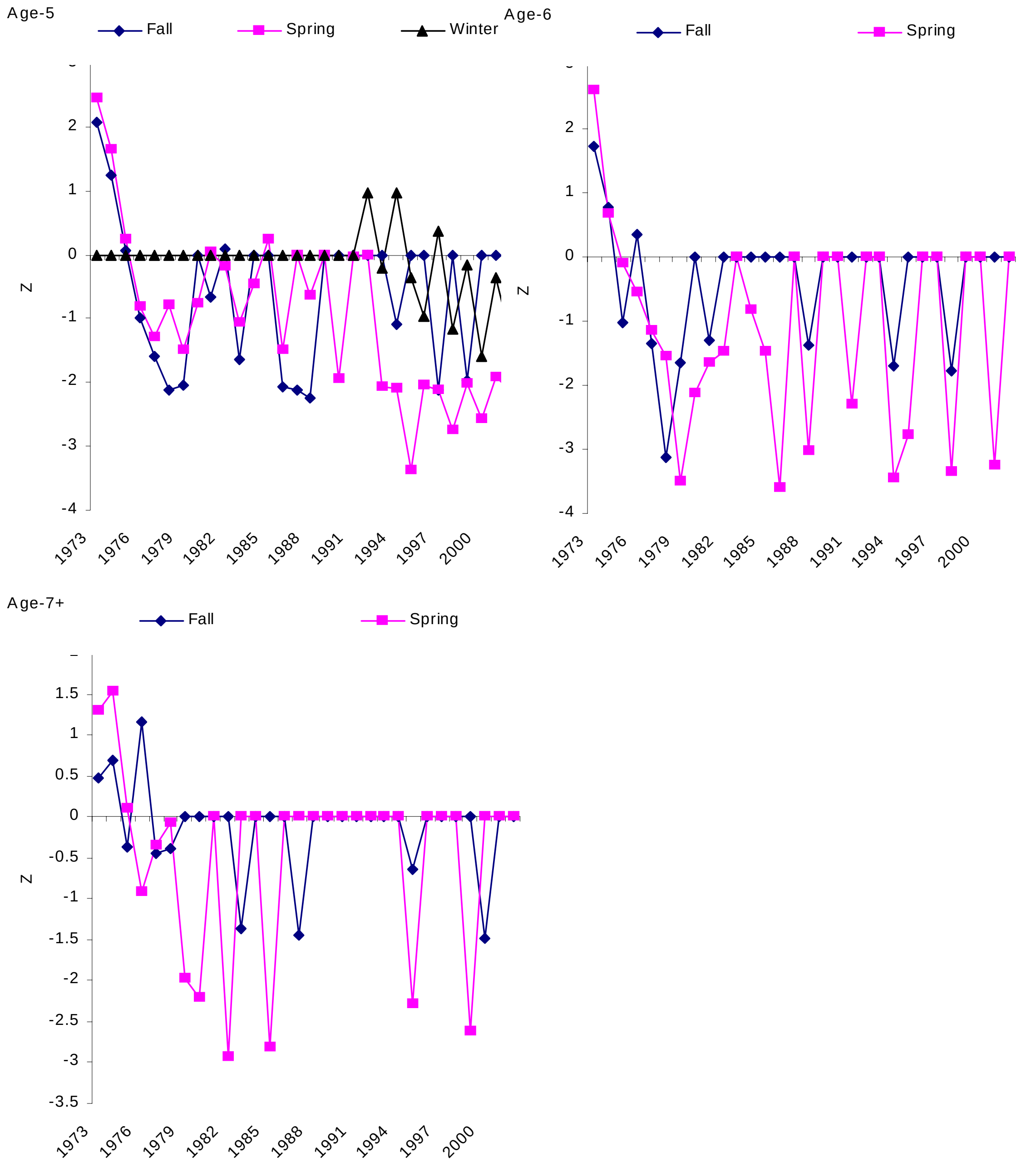


Figure A1.11a. Calibration residuals from southern New England – Mid Atlantic yellowtail flounder ADAPT analysis.

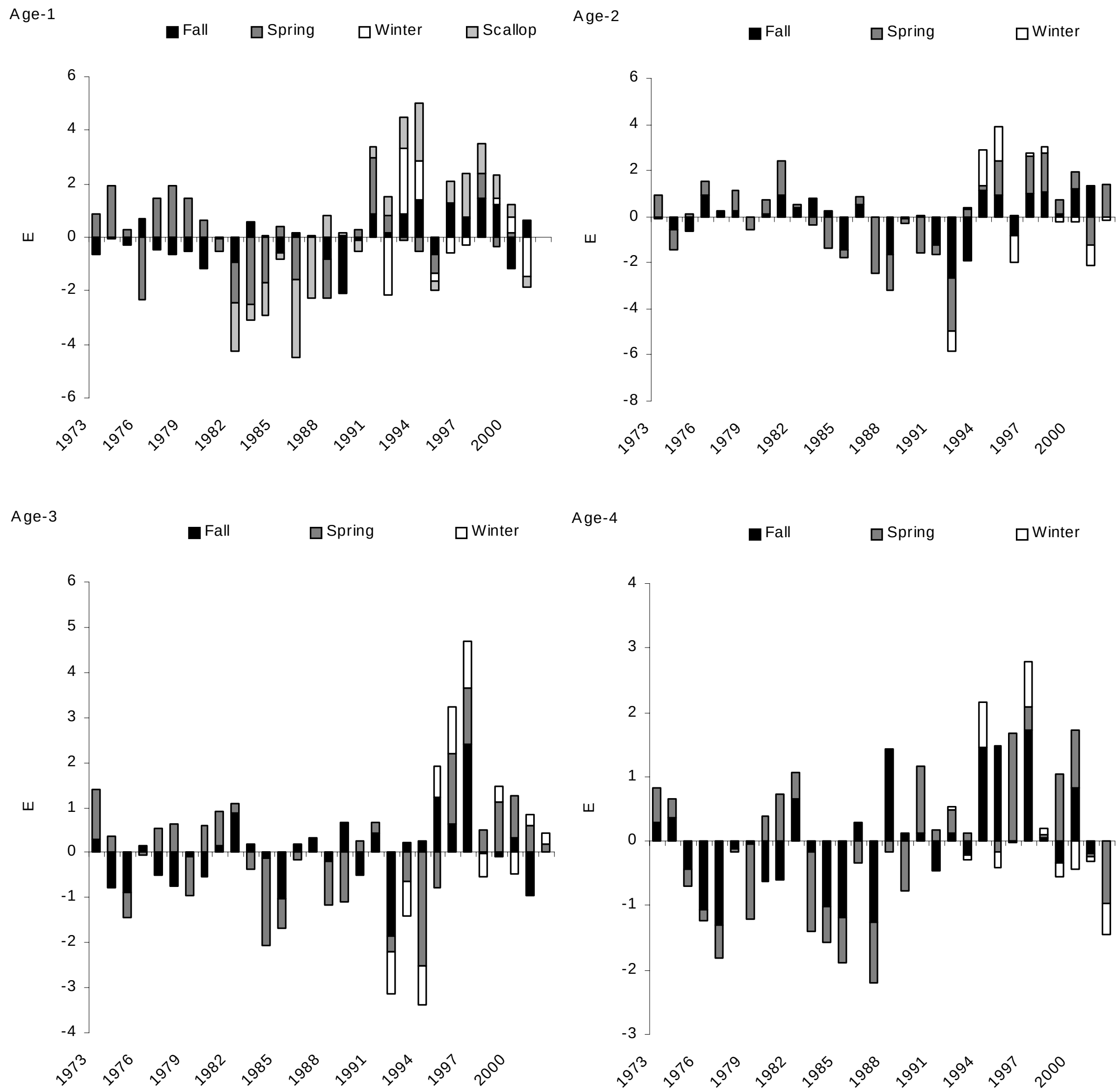
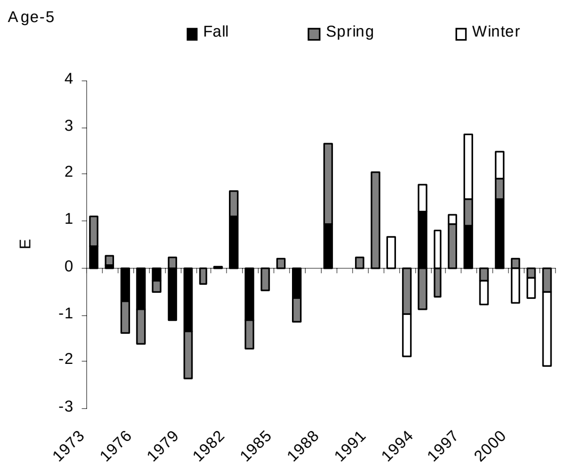
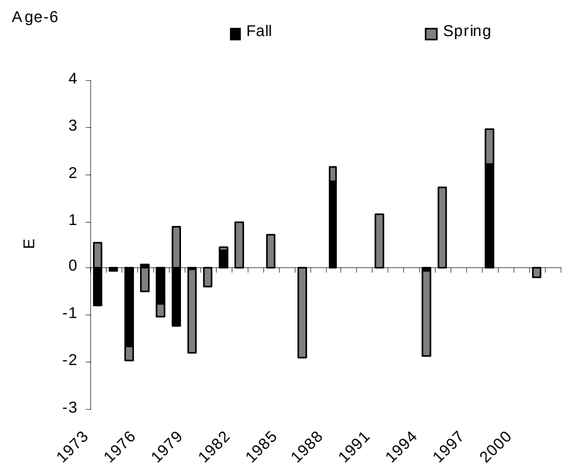


Figure A1.11b.





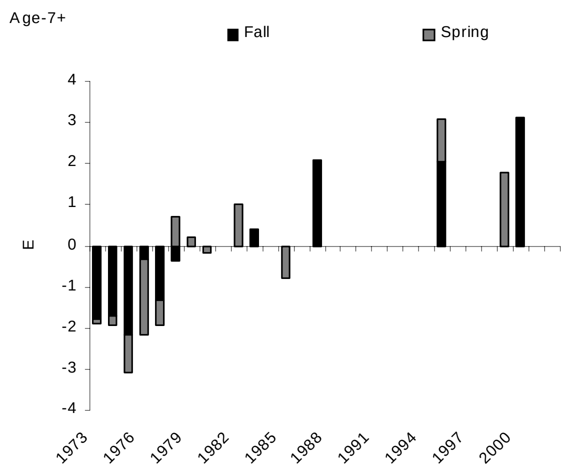


Figure A1.12a. VPA results for southern New England – Mid Atlantic yellowtail flounder.

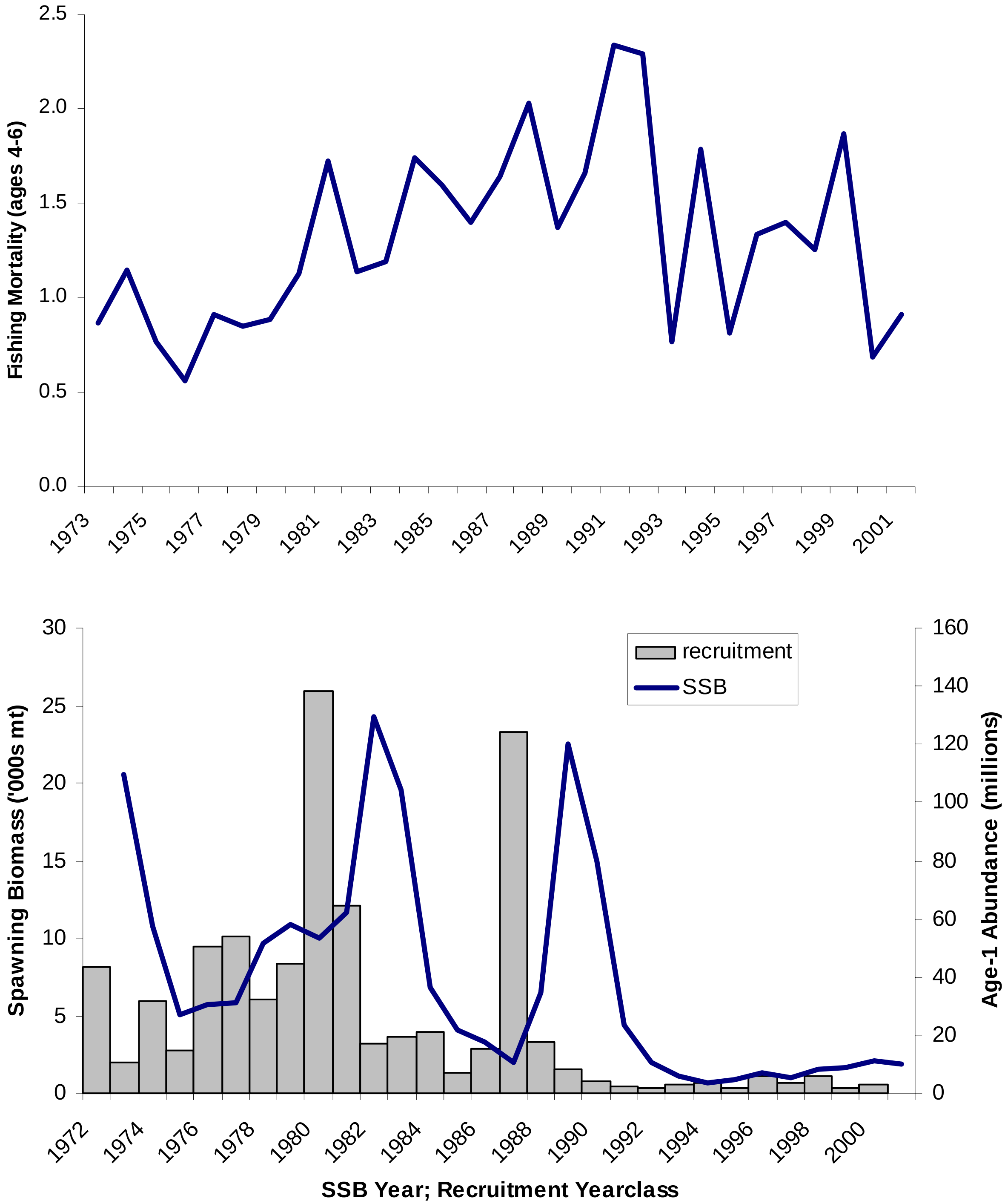


Figure A1.12b. Spawning stock and recruitment of southern New England – Mid Atlantic yellowtail flounder (points labeled by yearclass).

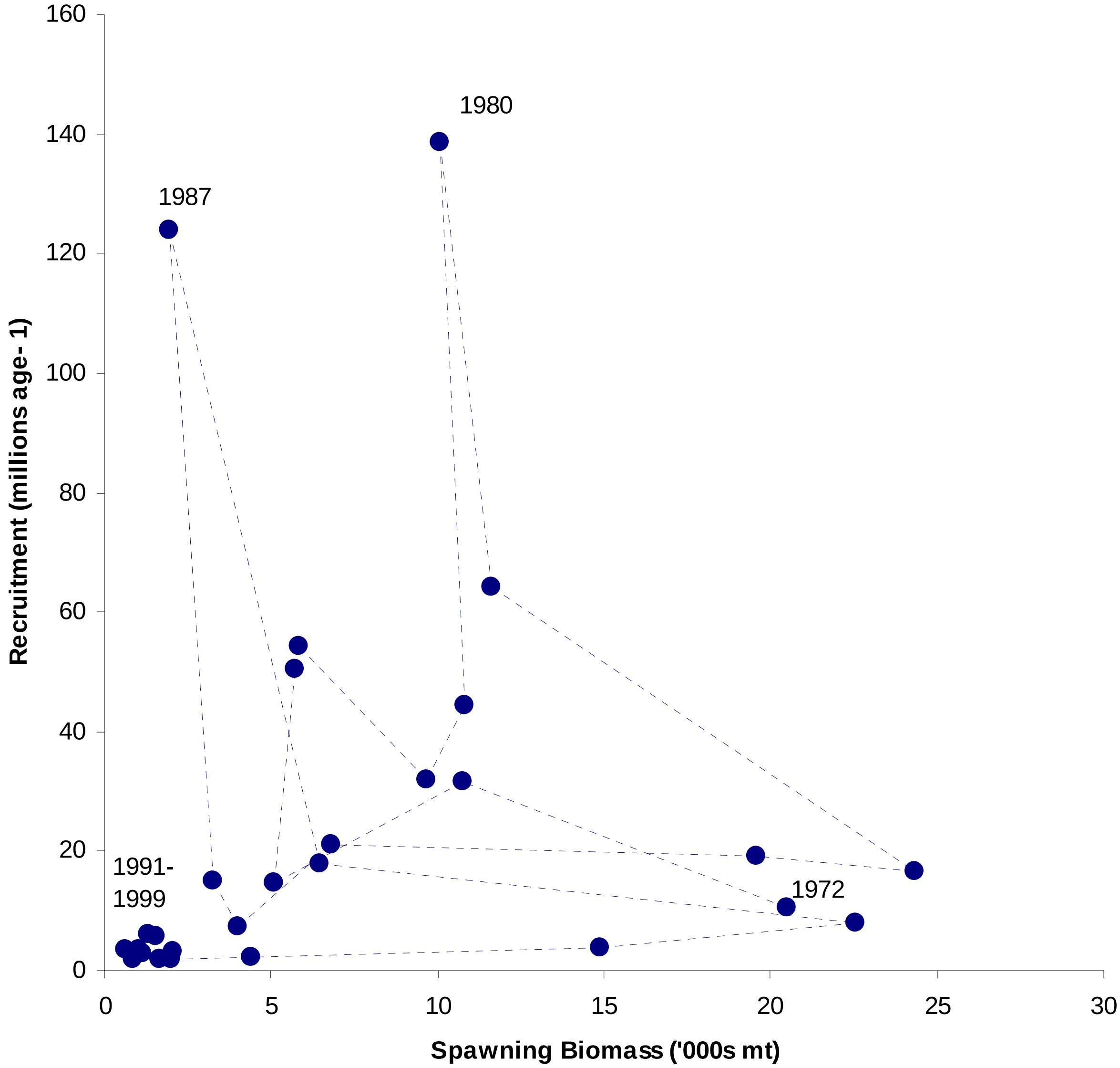


Figure A1.12c. Abundance at age of southern New England – Mid Atlantic yellowtail flounder.

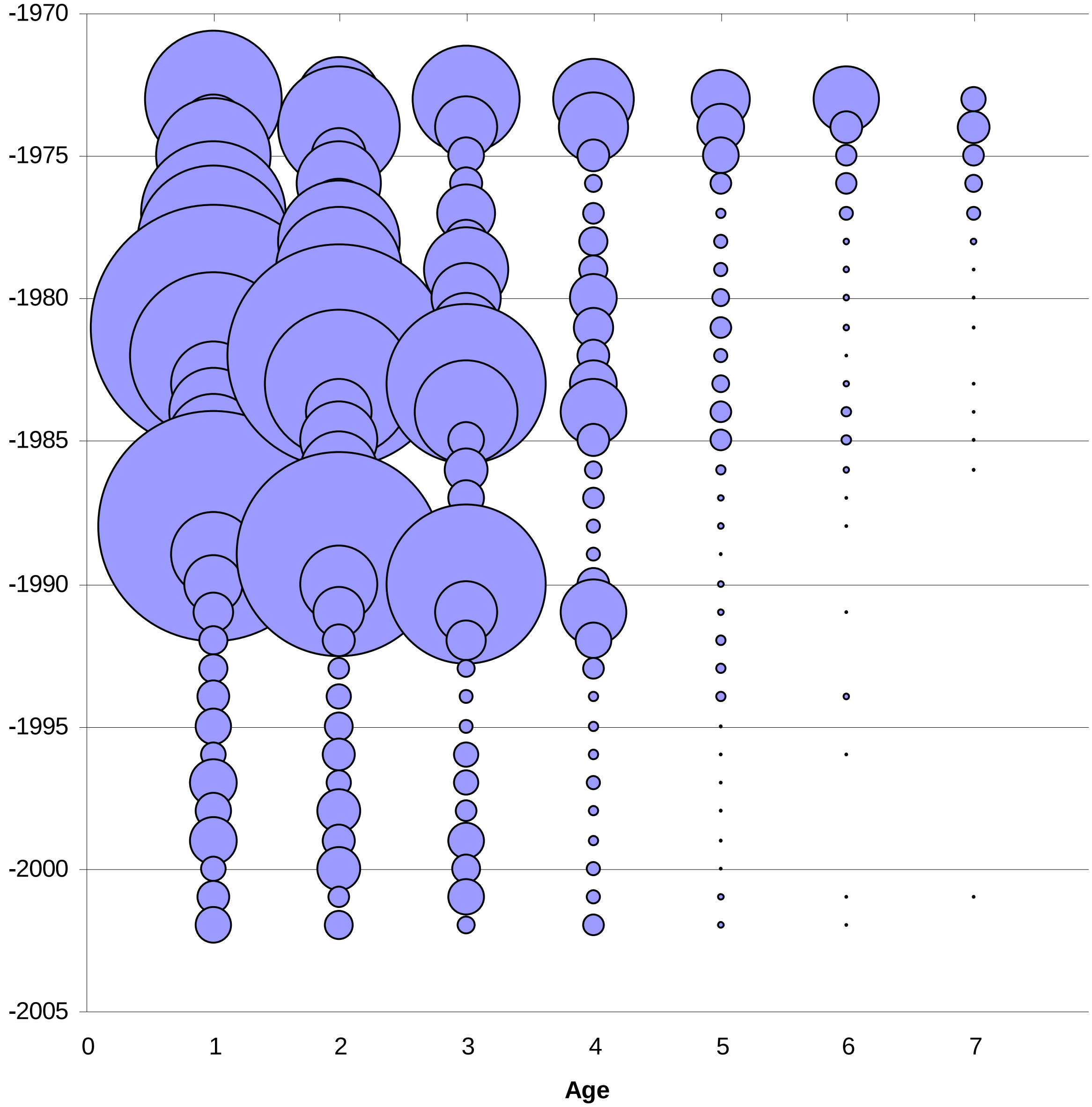


Figure A1.13. Retrospective analysis of the southern New England – Mid Atlantic yellowtail flounder VPA.

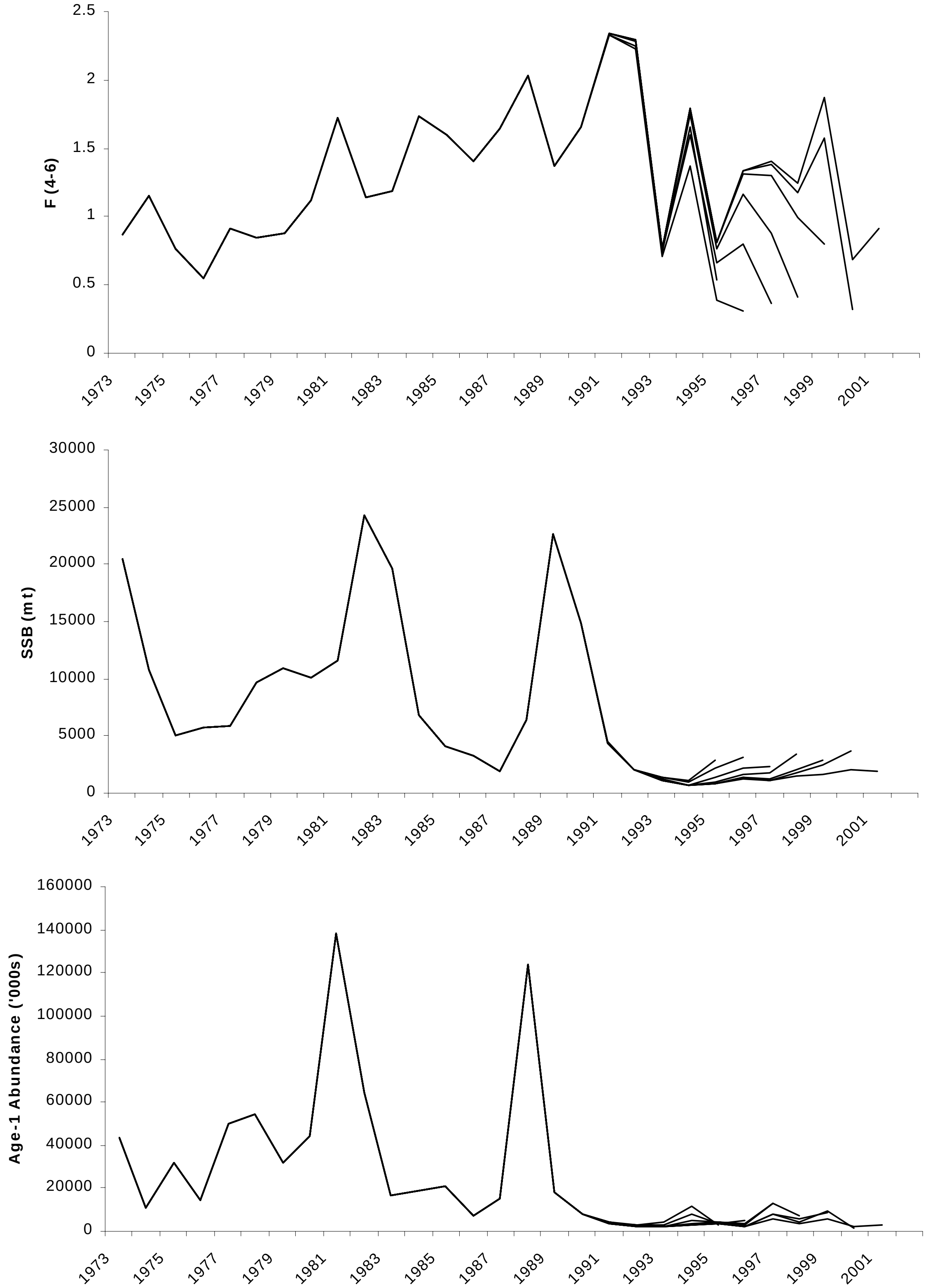
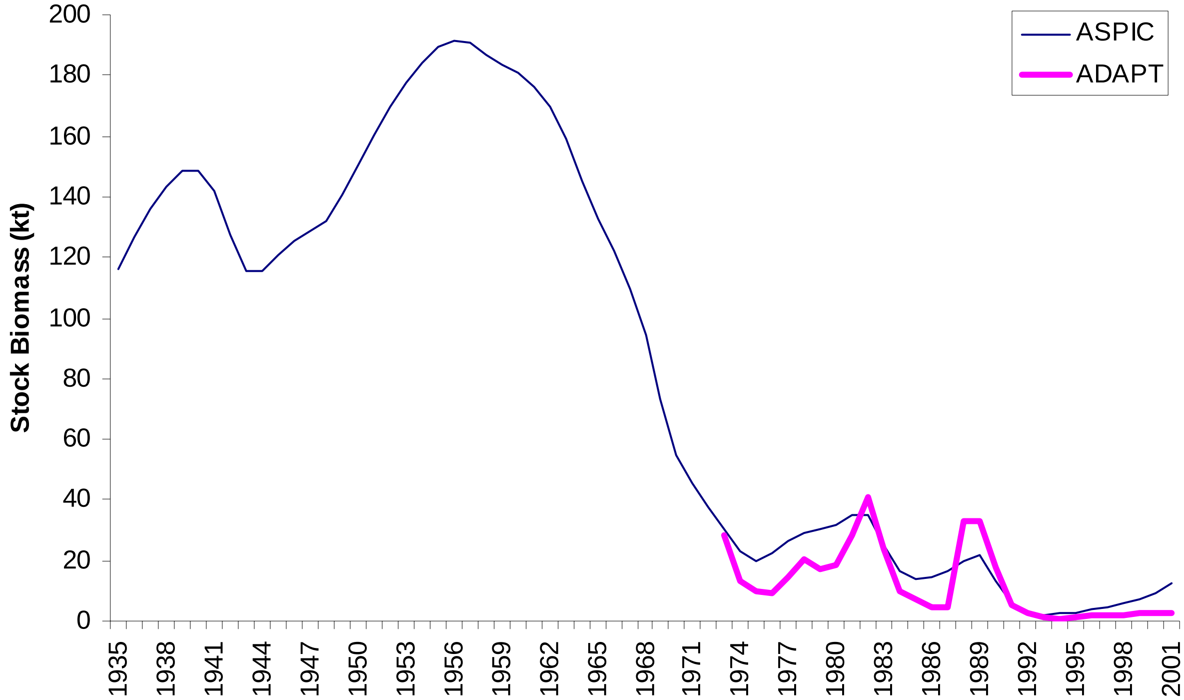


Figure A1.14. Results from biomass dynamics model (ASPIC) of southern New England – Mid Atlantic yellowtail flounder, with age-based estimates (ADAPT) for comparison.



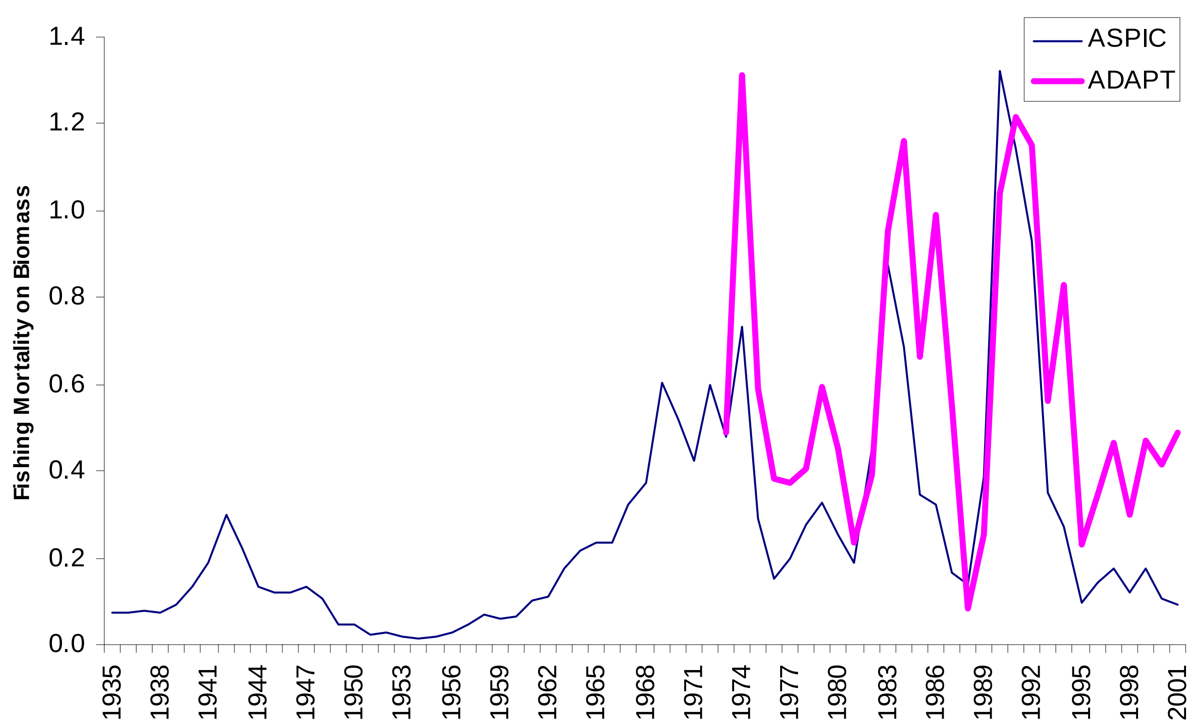


Figure A1.15. Yield and biomass per recruit of southern New England – Mid Atlantic yellowtail flounder.

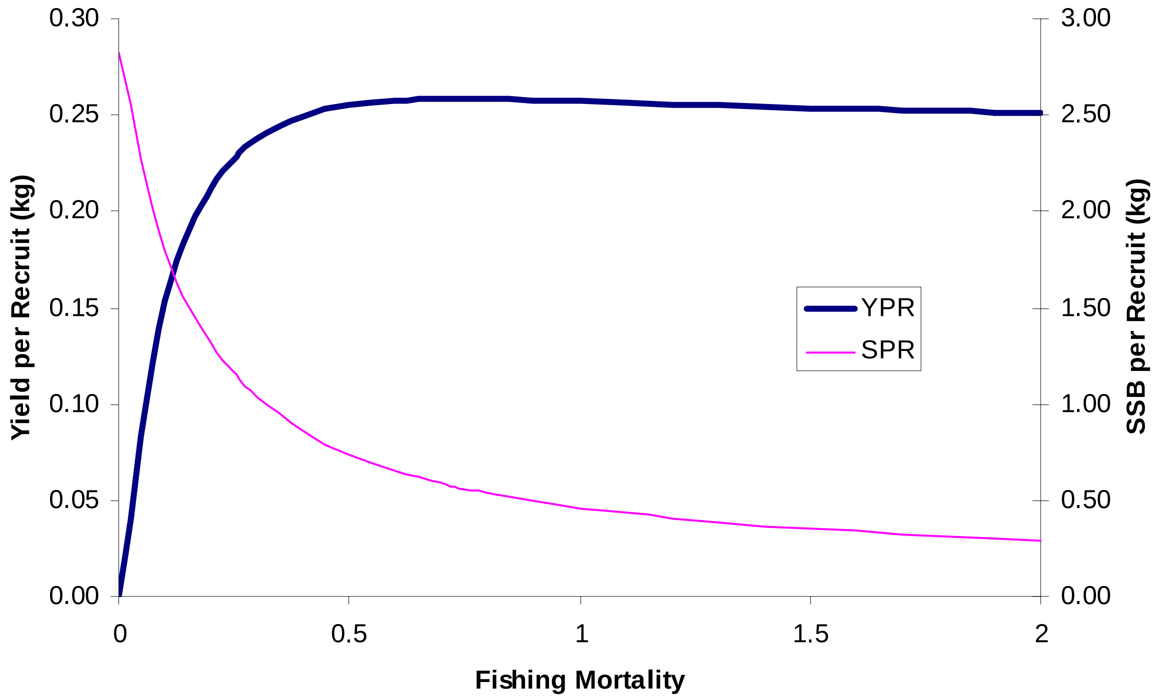


Figure A1.16. Stochastic projection of southern New England – Mid Atlantic yellowtail flounder spawning biomass (top panel) and landings (bottom panel) at F=0.26, assuming long-term recruitment (dotted lines indicate 90% confidence limits, and the dashed horizontal line indicates SSB_{MSY}).

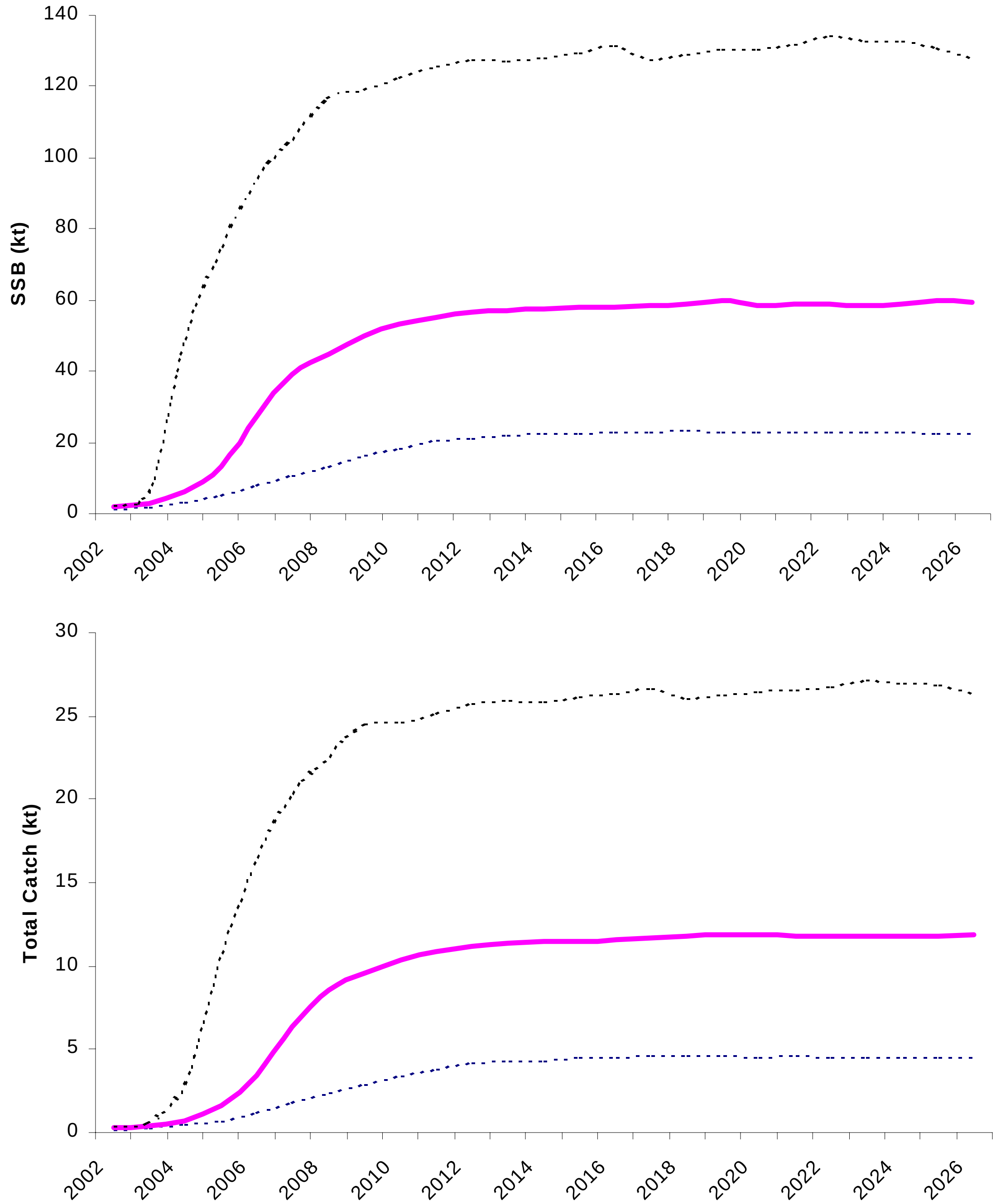


Figure A1.17. Stochastic projection of southern New England – Mid Atlantic yellowtail flounder spawning biomass (top panel) and landings (bottom panel) at a 2002 F of 0.77 and 2003-2009 F of 0.08, assuming long-term recruitment (dotted lines indicate 90% confidence limits, and the dashed horizontal line indicates SSB_{MSY}).

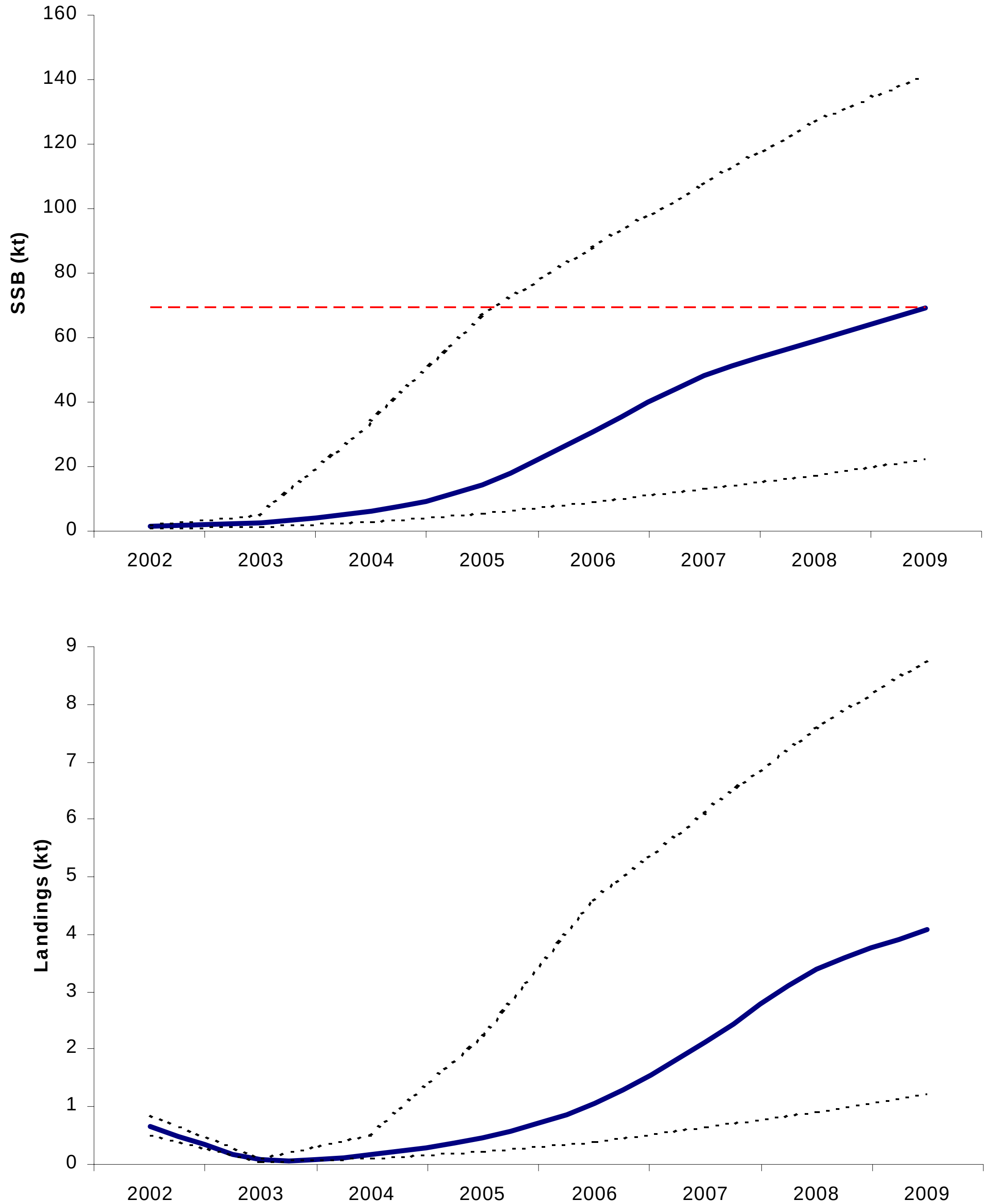
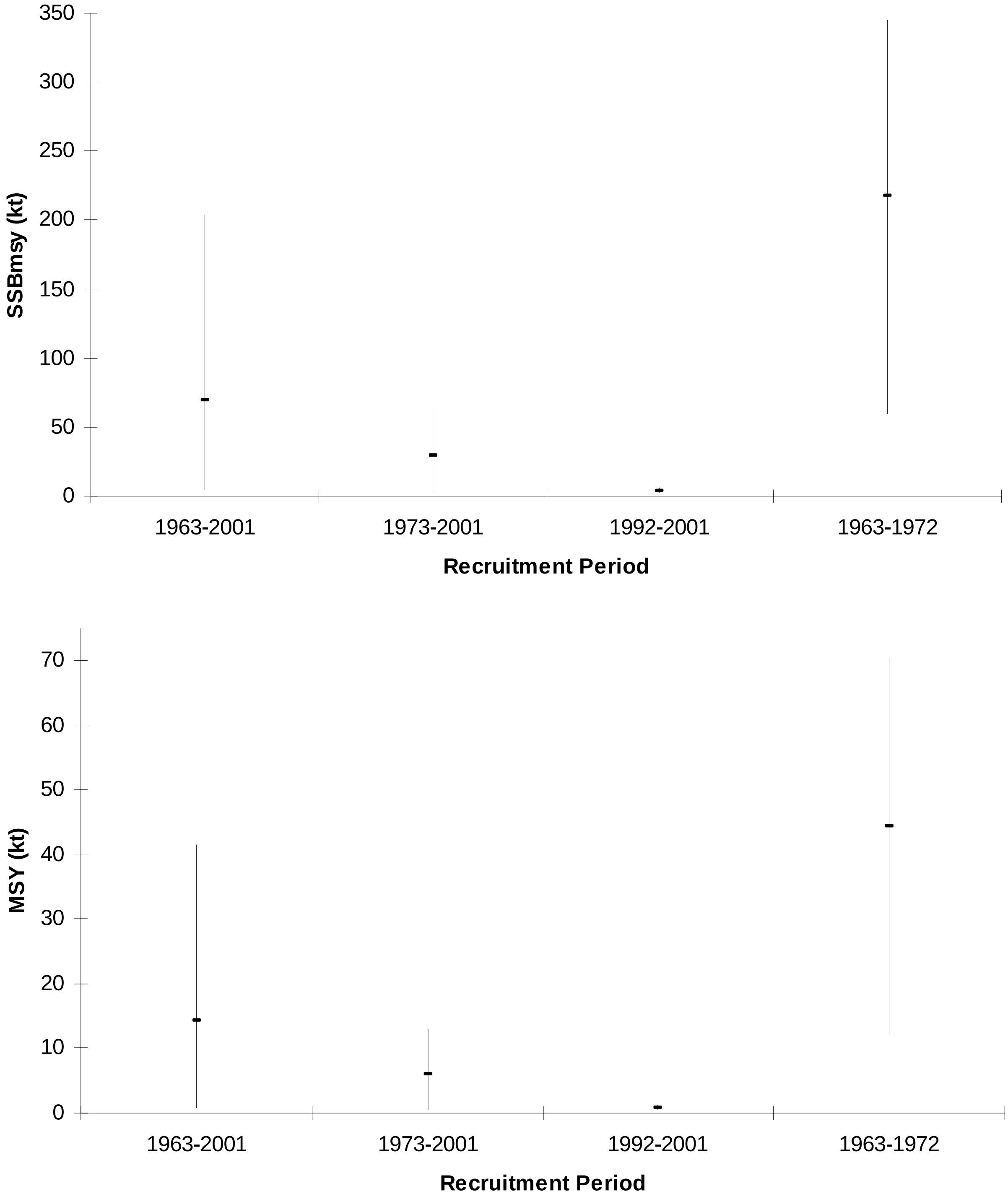


Figure A.1.18. Sensitivity analysis of MSY reference proxies for southern New England-Mid Atlantic yellowtail flounder, assuming different periods of recruitment (with 80% confidence intervals).



A2. CAPE COD – GULF OF MAINE YELLOWTAIL FLOUNDER

INTRODUCTION

Yellowtail flounder, *Limanda ferruginea,* inhabit the continental shelf of the northwest Atlantic from Labrador to Chesapeake Bay (Bigelow and Schroeder 1953, Collette and Klein-MacPhee 2002). Off the U.S. coast, commercially important concentrations are found on Georges Bank, off southern New England, and off Cape Cod (statistical areas 514 and 521; Figure A2.1). Cape Cod yellowtail inhabit shallow water (10-60 m) relative to offshore yellowtail stocks (Lux 1964). Spawning occurs during spring and summer, peaking in late May. Larvae are pelagic for a month or more, then develop demersal form and settle to the bottom. Yellowtail flounder on the Cape Cod grounds generally mature at age-3 (O'Brien et al. 1993) and grow to 58 cm total length.

A New England fishery for yellowtail flounder developed in the 1930s, coincident with a decline in winter flounder abundance, and the fishery expanded from southern New England to Georges bank and the Cape Cod grounds in the late 1930s and early 1940s (Royce et al. 1959, Lux 1964). On the Cape Cod grounds, yellowtail are generally caught in multi-species groundfish fisheries (principally by otter trawls) from late fall to spring, with some landings by gillnets in the winter and spring, but may also be specifically targeted in certain seasons (Royce et al. 1959).

Historically, landings from the Cape Cod grounds were a small portion of the total U.S. yellowtail landings. However, during the collapse of Georges Bank and southern New England stocks in the early 1990s (NEFSC 1994), the Cape Cod stock was the most productive of the U.S. yellowtail stocks (Overholtz and Cadrin 1998).

The available information on yellowtail flounder stock structure off the northeast U.S. indicates separate stocks on Georges Bank, off Cape Cod, and from southern New England to the Mid-Atlantic Bight. Distributional analyses indicate a relatively continuous distribution from the Mid Atlantic Bight to Nantucket Shoals, a concentration on Georges Bank, and a relatively separate concentration off Cape Cod (Royce et al. 1959). Geographic variation indicates that yellowtail off Cape Cod comprise a separate phenotypic stock than resources to the south (Begg et al. 1999). Tagging data indicate low dispersion from Cape Cod, Georges Bank and southern New England fishing grounds (Royce et al. 1959, Lux 1963). Descriptive information on early life history stages and circulation patterns suggest that yellowtail spawn in hydrographic retention areas, but there may be some advection of eggs and larvae from Georges Bank and Cape Cod to southern New England and the Mid Atlantic Bight (Sinclair 1988). In summary, yellowtail on the Cape Cod grounds can be considered a separate phenotypic stock (with some question on the northern boundary of the stock area). There is little evidence supporting separate stocks on the Cape Cod grounds and in the northern Gulf of Maine.

Management History

Over the past 25 years, the fishery for yellowtail flounder in federal waters has been managed under several regimes. From 1971 to 1976, national quotas were allocated by the International Commission for Northwest Atlantic Fisheries. From 1977 to 1982, the New England Fishery Management Council Atlantic Groundfish Fishery Management Plan established optimum yield thresholds for yellowtail west of 69^{o} longitude (which included Cape Cod and southern New England yellowtail stocks) and imposed minimum mesh size, spawning closures, and trip limits (Table A2.1). In 1982, the Council adopted an Interim Groundfish Plan, which established a minimum size limit of 28 cm (11 in) and a minimum mesh size of 130 mm (5 1/8"; with exemptions). In 1983, the minimum mesh size was increased to 140 mm (5.5"; with exemptions) In 1986, the Council's Multispecies Fishery Management Plan increased the minimum legal size to 30 cm (12 in) and imposed seasonal area closures. Amendment #4 to the Plan further increased the minimum legal size to 33 cm (13 in) in 1989. In 1993, finfish exclusion devices were required in the northern shrimp fishery to reduce groundfish bycatch. Amendments #5, #6, and #7 (1994-1996), limited days at sea, closed areas year-round, further increased minimum mesh size to 142 mm (6 in diamond or square; with fewer exemptions), imposed trip limits for groundfish bycatch in the sea scallop fishery, and prohibited small-mesh fisheries from landing groundfish. Framework #25 was an annual adjustment to the Multispecies Plan which prohibited bottom trawling in two areas of yellowtail habitat on the Cape Cod grounds in 1998: Massachusetts Bay was closed in March, and the waters off Cape Ann were closed in April. Other sections of the western Gulf of Maine were closed in May and June. The 'western Gulf of Maine closure' is too deep to protect yellowtail flounder. Amendment #9 was adopted in 1998 to revise the overfishing definition according to Sustainable Fisheries Act requirements. In 1999, minimum twine top mesh of scallop dredges was increased from 203mm to 254mm to reduce yellowtail bycatch.

The portion of the Cape Cod yellowtail stock found within the Massachusetts territorial sea is managed by the Massachusetts Division of Marine Fisheries under a suite of management measures. Since 1931, many coastal areas have been closed to bottom trawling year-round (e.g. Winthrop Head to Gloucester), or seasonally (e.g. Boston to Provincetown and Gloucester to New Hampshire). The state has had a succession of more stringent size limits beginning with a 11" minimum size in 1982. The size limit increased to 12" in 1986 and then to 13" in 1988. In 1986, 5" mesh codends were required for trawling within the 20 fathom contour in waters north of Cape Cod. In 1986, a winter flounder spawning closure to trawling and gillnetting extending approximately one to two miles from shore was established in waters from the New Hampshire border to Provincetown from February 1 to April 30 (extended to May 31 in 1990). In 1989, small mesh trawling was restricted to permitted fisheries targeting specific species. In 1991, minimum mesh size throughout the net was increased to 5 1/2" north and east of Cape Cod. Since November 1, 1992 a year-round night closure to mobile gear has abbreviated fishing effort by curtailing "trip fishing". Beginning in 1993, a Coastal Access Permit was required to fish mobile gear. The mesh size was increased again in 1994 to 6". A moratorium on new applicants for this permit was enacted in 1994 stemming an increase in effort into state waters. In 1995, the size limit for vessels fishing mobile gear was reduced from 90' registered length to 72' length over all. From 1995-1999, small mesh trawling in state waters north of Cape Cod was limited to an experimental whiting fishery with drastic ground gear modifications for bycatch reduction, prohibitions on groundfish retention and intensive sea sampling. Scallop dredge fisheries have been limited to 10' combined maximum dredge width since 1990. Gillnet fisheries in Massachusetts have a permit moratorium, 2400' maximum net length, 6" minimum mesh size and seasonally closed areas.

Assessment History

Yellowtail resources on the Cape Cod fishing grounds and in the northern Gulf of Maine have been assessed and managed separately. The Cape Cod yellowtail resource was initially assessed by descriptive summaries of catch, effort, catch samples, survey indices, yield per recruit modeling, and estimates of total mortality rate (Z) from survey and commercial age samples. The stock was more stable than the Georges Bank or southern New England stocks from the 1940s to the 1960s, based on patterns of landings and commercial catch rates (Royce et al. 1959, Lux 1964). However in the early 1970s, effort began to increase, and catch rates began to decline (Parrack 1974). Estimates of fishing mortality rate (F) during the 1970s were at or above the estimated level of maximum yield per recruit (Howe 1975). Although yield remained stable relative to offshore stocks, catch rates were at the lowest levels observed by the late 1970s (Sissenwine et al. 1978). For a brief period in the mid 1970s, the stock appeared to be stable (McBride and Sissenwine 1979). However, by the late 1970s, peak catches produced high mortality rates, the age structure appeared to be truncated, and catch rates continued to decrease (McBride et al. 1980, McBride and Sissenwine 1980, Clark et al. 1981). Despite some indications of good recruitment in early 1980s (McBride and Clark 1983, Clark et al. 1984), landings and relative abundance generally decreased in the 1980s (NEFC 1986). The 1987 year class was dominant and contributed to some rebuilding, however, the most recent descriptive assessment of Cape Cod yellowtail concluded that the stock was overexploited (Rago 1994). An age-based assessment indicated that F was high (>0.7) from 1985 to 1997 and biomass was much less than B_{MSY} (Cadrin et al. 1999). Updated assessments in 1999 and 2000 each indicated a reduction in F in the last year of the assessment (Cadrin and King 2000, Cadrin 2001), but the revised estimate of 1998 F remained high (1.0, Cadrin 2001). An updated assessment of the Cape Cod yellowtail flounder stock was prepared concurrently with this assessment for the Groundfish Assessment Review Meeting (Cadrin and King 2002).

Yellowtail flounder in the northern Gulf of Maine have not been analytically assessed. Royce et al. (1959) compiled yellowtail landings statistics for the scattered shoals in the northern Gulf of Maine in the 1940s, and Lux (1964) updated landings statistics through 1961. McBride and Sissenwine (1980) reported a substantial increase in yellowtail flounder landings from the northern Gulf of Maine during the 1970s, and described the sparse survey information available for yellowtail in the northern Gulf of Maine. This assessment combines catch and survey information from the Cape Cod grounds and the northern Gulf of Maine for a single-stock analysis.

FISHERY DATA

Commercial Landings

Commercial statistics for Cape Cod yellowtail flounder are from statistical areas 514 and 521, and northern Gulf of Maine yellowtail are from statistical areas 511, 512, 513 and 515 (Figure A2.1). U.S. commercial landings of yellowtail flounder were derived from dealer weighout reports and canvas data according to historical assessment reports (Royce et al. 1959, Lux 1964, Sissenwine et al. 1978, McBride et al. 1980, McBride and Clark 1983, NEFC 1986). Previous to 1994, landings were allocated to statistical area, month, and gear type according to interview data collected by port agents (Burns et al. 1983). For 1994, landings reported by dealers were allocated to stock area using fishing vessel logbook data, by fishing gear, port, and season (Wigley, et al. 1998). For 1995-1997, dealers' reported landings were prorated to stock area using a modified proration that included dealer codes (NEFSC 1998).

Annual landings generally increased from less than 1,000mt in the mid 1930s to a peak of 5,600mt in 1980 (Table A2.2, Figure A2.2). Landings decreased to approximately 1,200mt per year in the late 1980s, but peaked again in 1990 at 3,200mt with recruitment of the strong 1987 yearclass. Landings decreased to 800mt in 1993 and remained low through the 1990s, but rapidly increased to greater than 2,400mt in 2000 and 2001.

Landings at age of Cape Cod yellowtail flounder are described in Cadrin et al. (1999), Cadrin and King (2000, 2002) and Cadrin (2001), and sample sizes are reported in Table A2.3. Very few port samples are available for the northern Gulf of Maine yellowtail fishery (six samples from 1969, 1976, 1983, 1987, 1988 and 1991), and all market categories were not sampled in any year. Therefore, the age distribution of Cape Cod yellowtail landings, by half and market category, were assumed for northern Gulf of Maine landings. Landings at age, by region, are listed in Table A2.4.

Discarded Catch

Discards were estimated using discard to kept observations from 1989-2001 sea sampling for the trawl and gillnet fisheries and discard per effort for the shrimp and scallop fisheries as described in Cadrin et al. (1999). Discards at age of Cape Cod yellowtail flounder for 1985-1997 are described in Cadrin et al. (1999), and for 1998-2001 by Cadrin and King 2002 (Table A2.5a). Discards for the northern Gulf of Maine averaged 38% of Gulf of Maine yellowtail landings, primarily from the trawl fishery and the shrimp fishery prior to the Nordmore grate requirement in 1993 (Table A2.5b). Discards for 1985-1988 were approximated by assuming a 38% annual discard ratio.

Discards at age of Cape Cod yellowtail flounder are described in Cadrin et al. (1999) and Cadrin and King (2002; Table A2.6a). Discards at age for yellowtail in the northern Gulf of Maine were estimated using length observations from sea sampling (Table A2.6b; using pooled-year samples by half and gear for unsampled discards) and survey age-length keys for 1989-2001, by half-year. The proportion discard at age from the Cape Cod grounds were assumed for 1985-1988 discards in the northern Gulf of Maine. Total catch at age is dominated by age-3 and indicates a strong 1987 yearclass (Appendix A,

Figure A2.3). Mean weight at age of catch was relatively stable from 1985 to 1996, but has increased for ages 2+ in recent years (Figure A2.4).

ABUNDANCE AND BIOMASS INDICES

<u>Stock Abundance and Biomass Indices</u>

NEFSC survey strata for the Cape Cod grounds are offshore strata 25-27 and inshore strata 56-66 and strata for the northern Gulf of Maine are offshore strata 39 and 40 (Figure A2.5). The NEFSC spring and autumn bottom trawl surveys have sampled offshore strata since 1963 and 1968, respectively (Despres et al. 1988). However, sampling of inshore strata north of Cape Cod began in 1977. Yellowtail are consistently sampled in offshore stratum 27 by the spring survey, but were only caught in 4 years since 1963 by the fall survey. Therefore, the spring index includes offshore stratum 27, but the fall survey does not.

Survey biomass indices are somewhat noisy, but generally indicate high biomass in the late 1970s and early 1980s, a decline in the 1980s and a rapid increase in the late 1990s (Figure A2.6). The rapid increases in fall 1999 or spring 2000 do not appear to result from strong recruitment, because catches of all ages increased. Large survey catches were distributed throughout Cape Cod and Massachusetts Bays, Stellwagen Bank and Jeffreys Ledge (Figure A2.7).

The portion of survey biomass from northern Gulf of Maine is variable, but averages 11% throughout the survey time series (Figure A2.8). There appears to have been low abundance of yellowtail in the northern Gulf of Maine during the late 1960s, early 1970s, and middle 1980s. Age distribution of survey catches are potted in Figure A2.9 and listed in Table A2.8.

Correspondence among survey indices was assessed using correlations among normalized observations [Ln(x/mean); Table A2.7]. Correlations among survey series were weak to moderate with strongest correlations among indices for ages 2-4 (r=0.12 to 0.69). Normalized indices of catch per tow at age are illustrated in Figure A2.10.

MORTALITY AND STOCK SIZE

<u>Virtual Population Analysis</u>

Estimates of abundance from virtual population analysis of catch at age-1 to age-5+, 1985-2001, were calibrated using an ADAPT algorithm (Gavaris 1988) that estimated age 2-4 survivors in 2002 and survey catchability coefficients (q) using nonlinear least squares of survey observation errors. Abundance at age was calibrated with survey indices of abundance: spring and winter survey indices (age-1 to age-5+) were calibrated to January abundance, and fall survey indices (age-1 to age-4+) were calibrated to abundance for January of the next year. The instantaneous rate of natural mortality (M) was assumed to be 0.2 based on tag returns (Lux 1969), relationships of Z to effort

(Brown and Hennemuth 1971), and the oldest individual sampled in the stock area (age-14). Although catches of yellowtail older than age-8 are rare in commercial or research catches, the stock has been heavily exploited for seven decades. Maturity at age for Cape Cod yellowtail flounder was reported by O'Brien et al. (1993) from 1985-1990 NEFSC spring survey samples. Model Residuals are plotted in Figure A2.11.

Results indicate that F on ages 3+ decreased from a peak of 1.3 in 1988 to 0.28 in 1993, then increased to an annual average of 0.61 from 1995 to 2000 and was 0.75 in 2001 (Table A2.9, Figure A2.12). With the exception of the strong 1987 year class (29 million at age-1), recruitment has been stable, averaging 10 million at age 1. However, early indications are that the 2000 yearclass is well below average. Spawning biomass averaged 1,000mt during the late 1980s increased to a peak of 3,800mt in 1991 as the 1987 cohort matured, decreased to 1,600mt in 1998, and gradually increased to 3,200 mt in 2001. Retrospective analysis indicates a pattern of underestimating F, and overestimating SSB in the last five years (Figure A2.13).

Bootstrap analysis indicates that abundance estimates in 2002 were estimated with moderate precision (CVs=0.26-0.51). The 80% confidence limit for 2001 F is 0.59-0.95, and the 80% confidence limit for 2001 SSB is 2,500-4,000mt.

Biological Reference Points

Yield and biomass per recruit were calculated assuming the observed partial recruitment and mean weight at age for 1994-2001 (Thompson and Bell 1934). Results are reported in Table A2.10 and shown in Figure A2.14. A comparison of recently observed age distributions with the age distribution expected at $F_{40\%}$ shows a relative truncation in current age structure (Figure A2.15). Applying the approach used to estimate MSY proxies for Cape Cod yellowtail (NEFSC 2002), F_{MSY} is approximated as $F_{40\%MSP}$ (0.17). The SSB_{MSY} proxy is 12,600mt, calculated as the product of 40%MSP (1.192kg spawning biomass) and average recruitment (10.5 million). The MSY proxy is 2,300mt, derived as the product of yield per recruit at $F_{40\%MSP}$ (0.213kg) and average recruitment.

Projections

Stochastic projections at 85% of status quo F in 2002 and F=0.03 for 2003-2009 there is a 50% probability of rebuilding to SSB_{MSY} by 2009 (Appendix A, Figure A2.16). However, retrospective patterns indicate that projections may be optimistic.

WORKING GROUP DISCUSSION

Stock Structure

The WG reviewed seven working papers/presentations on yellowtail stock structure. With respect to spatiotemporal patterns of abundance, the WG noted that recruitment trends of Cape Cod and southern New England yellowtail indicated possible autocorrelation, as evidenced by a common series of several years of poor recruitment that might be indicative of a common stock. The WG noted that historical tagging data indicate weak movement between the Cape Cod, Georges Bank, and other areas, but strong mixing between Mid Atlantic and southern New England areas, that might be indicative of a common Mid Atlantic-southern New England stock. The WG noted limited evidence in the literature to separate Gulf of Maine fish from the Cape Cod stock. The WG supported the major conclusion of working paper A1 that information available from the literature indicates separate yellowtail flounder stocks on Georges Bank, off Cape Cod, and in the Southern New England-Mid Atlantic Bight area.

The Working Group reviewed the evidence available in the scientific literature for different assumptions about yellowtail flounder stock structure based on 1) geographic distribution of the fish and fishing patterns, 2) geographic variation of genetics, life history patterns, recruitment, and morphology, 3) movements and migration of ichthyoplankton and juvenile/adult fish, and 4) previous Amulti-approach@ assessments which considered many of these factors in developing stock structure assumptions for assessment. Geographic analyses indicate a relatively continuous distribution of yellowtail flounder from the Mid Atlantic Bight to Nantucket Shoals, a concentration on Georges Bank, and a relatively separate concentration off Cape Cod. Geographic variation in life history parameters indicates that yellowtail off Cape Cod comprise a separate phenotypic stock than resources to the south. Historical tagging data indicate less than 3% dispersion from Cape Cod, Georges Bank and southern New England fishing grounds. Descriptive information on early life history stages and circulation patterns suggest that yellowtail spawn in hydrographic retention areas, but that there may be some advection of eggs and larvae from Georges Bank and Cape Cod to Southern New England and the Mid Atlantic Bight.

The Working Group reviewed spatiotemporal patterns in the abundance of yellowtail for evidence of stock structure. The overwhelming pattern indicated by cluster analysis was a difference between northern and southern survey strata, with southern strata having peaks of abundance in the early and late 1980s and northern strata having a general increase abundance increasing in northern strata during the 1990s and having no trend in southern strata. The boundary between the two major clusters is between southwestern Georges Bank and Nantucket Shoals, particularly the southwestern part, where survey catches reflect both southern and northern peaks in abundance. The WG noted that the GIS and multivariate analyses did not provide strong evidence for separation of the CC and GOM stocks. The WG supported the major conclusions that 1) there are two major groups of NEFSC survey strata based on patterns of abundance over time, with a boundary on southwestern GB (northern: GOM, CC, and GB areas; southern: MA and SNE areas), and 2) the current analyses confirm earlier conclusions of separate Aharvest stocks@ on GB and off SNE. Correlation analysis of survey data generally confirmed the multivariate analysis by stratum. Survey indices and landings were strongly correlated between southern New England and the mid-Atlantic, not correlated between southern New England and Cape Cod or southern New England and Georges bank, and moderately correlated between Georges Bank and Cape Cod.

The Working Group reviewed geographic variation in growth and maturity of yellowtail as the basis for stock structure assumptions, using spatial and multivariate statistical analyses. A nineteen-year time series of NEFSC survey observations was analyzed to investigate patterns of variation in nine life history variables (male mean length at ages 2-4, female mean length at ages 2-4, male maturity at age-2, and female maturity at ages 2 and 3) among survey strata. Life history characters are strongly correlated and vary significantly among stock areas as well as 5-year time periods. The major pattern of variance was faster growth and maturation in southern stocks (GB, SNE, and MA) and slower growth and maturation in northern stocks (Scotian Shelf and CC). Life history characters are generally homogeneous within the southern areas and within the northern areas, with some intermediate observations in the CC area. One survey stratum east of Cape Cod was identified that had life history observations that were consistently more similar to observations in SNE than to other observations in the Cape Cod area. The WG supported the major conclusion that geographic patterns of variation in size at age and proportion mature at age indicate two phenotypic stocks of yellowtail flounder off the northeastern United States, with a boundary east of Cape Cod.

The Working Group reviewed information on morphometric (fish body measurement) variation of yellowtail flounder as the basis for stock structure assumptions, using image analysis and multivariate statistical analysis. Significant morphometric variation was found between sexes of yellowtail flounder and among eight geographic areas, from the Grand Bank to the Mid-Atlantic Bight. Yellowtail sampled off Newfoundland had relatively shorter bodies than those from south of Nova Scotia. Extrinsic classification accuracy of males and females to the correct Canadian area was 71-95%, but was lower for areas off the northeastern United States (43-76%). Females had relatively deeper abdomens and larger heads than males.

The WG noted that previous investigators (e.g., Lux 1963) found no significant differences in meristics (e.g., fin and ray counts) among U.S. stocks, supporting the current morphometric work. The WG also noted that the results of the morphometric work coincides with the differences in growth noted between U.S. and Newfoundland stocks. The WG supported the conclusion that morphometric variation among U.S. yellowtail flounder groups is not sufficient for accurate classification to stock area.

The Working Group reviewed an exploratory analysis of patterns of yellowtail larval drift for evidence of stock structure. Changes in the geographic distribution of yellowtail flounder eggs and larvae over the course of the spawning season suggest broad-scale larval drift. Evidence of similar distributional changes from the location of the spawners to that of the eggs, however, is confounded by limitations in survey timing. The WG supported the conclusion of working paper A4 that qualitative spatial analyses indicate a general southwesterly movement of yellowtail flounder larvae along the continental shelf of the northeastern United States.

The Working Group reviewed genetic analyses that attempted to find evidence for yellowtail flounder stock structure. The objective of this work is to define stocks based on genetic markers, using methods (RAPD-PCR) which can resolve DNA Afingerprints@ from the sampled muscle tissue of individual fish. Frequency patterns of DNA Abanding@ are obtained which are examined for differences between fish from the MA, SNE, GB, CC, and GOM stocks. Results for two DNA primers, which provided 28 characteristic bands, provided no evidence of extensive population structure for yellowtail flounder sampled from the MA to GOM areas. Future work will attempt to use other methods, such as the examination of nuclear and/or mitochondrial DNA, to look for differences among groups of yellowtail flounder.

The WG noted that the number of migrants per generation between the yellowtail stock areas, although probably low, is likely sufficient to prevent detection of significant genetic differences using RAPD-PCR. The WG noted that the expression of phenotypic differences may not be evident in the genome, or may be very difficult to detect (many different primers may have to be tested to find one that isolates the gene responsible for a given phenotypic expression). The WG supported the conclusion of presentation A6 that, at this time, yellowtail flounder stock differentiation must be based on factors other than genetics.

The current work reviewed by the WG indicates no genetic difference among yellowtail flounder on U.S. fishing grounds. Patterns over time in landings and survey indices suggest two harvest stocks with a boundary between Georges Bank and Southern New England. Differences in life history characteristics suggest two phenotypic stocks with a boundary off Cape Cod. The WG noted that the most important potential Amisalignments@ with respect to current or proposed stock definitions are in areas 521, 525, and 526 (and associated NEFSC survey strata 10, 13 and 25), where fish from adjacent stocks may overlap during times of abundance. However, the WG found no strong evidence in patterns of fishery landings, survey abundance indices, or life history parameters to suggest that revision of the current assignment to stock areas of these particular statistical areas or survey strata is appropriate. Further, the WG did not find significant justification for the inclusion of fish caught in area 4 (i.e., Canadian landings) to the CC-GOM stock. The WG concluded that current evidence indicates that three stock areas are appropriate for yellowtail flounder: 1) a GB stock including fish landed from NEFSC statistical areas 522, 525, 551-552, and 561-562, and associated NEFSC survey strata (i.e., the current stock definition used in U.S. and Canadian assessments), 2) a SNE-MA stock including fish landed from areas 526, 533-539, 541, and 611-639, and associated NEFSC survey strata, and 3) a CC-GOM stock including fish landed from areas 511-521, and associated NEFSC survey strata. Finally, the WG recommends that assessment scientists explore the potential to classify yellowtail in fishery and survey samples to stock in the Aoverlap/transition@ areas based on age structure characteristics.

Stock Assessment

The Working group discussed the sharp increase in catch and survey indices from 1999 to 2001. The Group speculated that rolling closures may have increased both survey and fishery catchability. Surrounding closures may have redirected effort onto Stellwagen Bank. The Group noted that sharp increases also occurred in historic landings (Figure A2.2).

The Working Group noted that sampling improved since last assessment, with samples in each market category and season. The mean weight at ages 3-5 increased in the catch.

The Group considered the possibility that mean weights were poorly estimated in early part of time series when sampling coverage was poor. Therefore, the Group agreed that as many years as possible should be included to derive the mean weights and partial recruitment at age for reference point estimation and projections.

The Working group agreed to revise the calibration configuration from previous assessments by including all age 5 and 6+ indices. The change was made to reduce the substantial positive bias in the age-5 abundance estimate when those indices were excluded.

The Working Group was concerned that projections may not be reliable because of retrospective error. They noted that retrospective inconsistencies are worst for older ages, but could not determine if the source of the errors was in the catch data or assumptions such as M or F on the oldest age. Although estimates from the assessment are imprecise and perhaps biased, the Group concluded that F is high. The truncated age structure in the surveys and catch confirm that mortality is high.

Despite the high F, stock size appears to be increasing. However, the same impression was given by recent assessments, only to have stock size estimates decrease when the assessments were updated. The Group noted that the problems in the assessment may result from the relatively short time series of catch at age and little contrast in the data.

The Group investigated the possibility that older fish are moving from the fishing and survey areas, giving the false impression of high mortality. Size distributions from the longest time series of survey data (fall survey, offshore strata 25, 26, 39 and 40; Figure A2.17) show that larger fish were sampled in the assessment strata in the 1960s, but recent length distributions are considerably smaller. More large fish were also sampled in the earliest years of the Massachusetts survey (Figure A2.18). The Gulf of Maine summer survey, which sampled the inshore strata of the western Gulf of Maine (1977-1981, inshore strata 68-90; Figure A2.19) caught a similar size distribution of yellowtail as the assessment strata. Survey catches in the central and eastern Gulf of Maine also caught a similar size distribution of yellowtail as the assessment strata (Figure A2.20), but inconsistently and at much lower densities than those in the assessment strata (e.g., since 1963, yellowtail were only caught twice in stratum 28, six surveys in stratum 29, six surveys in stratum 37 and once in stratum 38). Therefore, the assessment strata appear to reflect the size distribution throughout the Gulf of Maine, and no large yellowtail were sampled anywhere in the Gulf of Maine in recent years.

SARC DISCUSSION

The original ADAPT run used age 1-6+ catch at age formulation and exhibited a severe retrospective pattern for SSB and F. A comparison of ADAPT retrospective patterns from Cape Cod-Gulf of Maine and Cape Cod only exhibited little difference. The low numbers of age 5 in the catch and surveys did not appear to be sufficient to reliably estimate F on age 5. The GARM noted that the high F seems inconsistent with level or increasing SSB and increasing survey indices. A lot of discussion centered on how this could be possible, without a consensus regarding cause. It was suggested that the high F means that the tuning is actually only working on the oldest age group. Similarly, the estimated catchabilities increase without reaching an asymptote with increasing age. Also, the SARC observed that $F_{(4\text{-}5)}$ may not be a good estimator of F on the population since a large portion of the catch is age-3

As a result, an alternate ADAPT run which truncated the catch at age to age-5^+ was considered. Estimation of abundance for the truncated catch at age required that age 3 be considered fully recruited for calculation of F on the oldest true age. The alternate Adapt run reduced the magnitude of the retrospective patterns for fully recruited F and spawning biomass. The results revealed a high sensitivity to the calibration change. The fully recruited F decreased while spawning stock biomass increased.

Including a flat-topped selectivity pattern at age 3+ could mask high F's at true fully recruited ages. The original formulation, which estimated F on age 3, suggested that age 3 yellowtail were partially recruited. A comparison of observed length distribution at age-3 and length selectivity at various mesh sizes indicated only partial retention of age-3 yellowtail. However, mesh selectivity is only one component of fishery selectivity and other factors, such as temporal-spatial elements of the fishery, also influence fishery selectivity. In addition, the mean weights of a plus group at age-5 and older may be difficult to characterize because they continue to grow substantially after age 5.

Age determination does not seem to be a problem with this stock, especially for the young ages in the catch. However, the sampling of catch could be causing a problem, particularly in the Gulf of Maine. The lack of contrast in the VPA time series may lead to imprecise estimate of survey catchability. The time series begins in 1985 due to few commercial samples prior to 1985.

The possibility of contributions from the Georges Bank and/or Southern New England stocks of yellowtail flounder to the Cape Cod-Gulf of Maine stock was discussed in terms of both adult movement and recruitment impacts. Given the relative sizes of the stocks, especially the Georges Bank and Cape Cod stocks, any transfer among stocks could overwhelm the signal from Cape Cod.

The revised ADAPT formulation, which uses average fully recruited F on ages 3 and 4 required re-estimating yield per recruit and biological reference points. Several concerns about including the partially recruited age 3 in the average of fully recruited F were raised. However, the YPR and biological reference points were re-estimated using age 3 as fully recruited in order to be consistent with the revised Adapt configuration.

An examination of stock-recruit observations for Cape Cod-Gulf of Maine yellowtail and fishing mortality rates at various levels of replacement suggests that the stock can replace itself at F greater than $F_{40\%}$ (i.e.$F_{med} > F_{40\%\ MSP}$) and $F_{40\%}$ may be a conservative proxy for $F_{MSY.}$ However, extrapolating recruitment at high stock sizes from the VPA time series may overestimate productivity of the stock at higher SSB. The stock recruitment relationship is similar to the Georges Bank stock prior to recovery, in that most stock recruitment points were above the $F_{40\%}$ replacement line. This suggests that a short-term perspective of the stock recruitment relationship may not represent the potential productivity of the Cape Cod-Gulf of Maine stock. The SARC concluded that there is currently no justification for changing the$F_{40\%}$ reference point.

Sources of Uncertainty

- Very few length samples were available from the relatively small Gulf of Maine catch.
- There was an apparent increase in survey availability in Fall 1999 and Spring 2000 surveys. These recent observations have a large influence on the ADAPT calibration.
- Relative yearclass strengths are not tracked well over time by the surveys, indicating that survey availability has been variable throughout the time series.
- Spawning stock biomass calculations are based on a constant maturity at age assumption. Changes in maturity at age have not been investigated.
- The degree of mixing between Cape Cod-Gulf of Maine yellowtail and adjacent stocks is not precisely known. Substantial mixing may confound population estimates.
- Estimation of the very small 2000 year class may change in future assessments. Previous estimates of recruitment in the most recent year have changed substantially as assessments were updated.
- Lack of contrast in the recruitment time series limits the perception of $SSB_{MSY.}$

Research Recommendations

- Tagging studies should be planned to examine movements and to independently estimate F. Early tagging studies may have been conducted during different temperature regimes.
- Commercial length and age samples from the Gulf of Maine region are needed.
- The use of parametric models to estimate MSY based reference points should be explored.
- Consider using a forward-projection statistical catch at age model.
- Incorporate the State of Maine inshore survey data in the assessment.
- Alternative indices of abundance should be explored, such as industry surveys, study fleets, and a flatfish survey.
- Increase observer sampling on the exempted whiting fishery, particularly to confirm low bycatch observations for the recently required raised footrope.
- Sample inshore NEFSC survey strata more consistently.
- Continue investigation of geographic patterns in sex ratios and maturity at age. Evaluate possible revisions of survey sampling and data processing protocol to obtain abundance indices by sex.
- Evaluate information on dimorphic growth rates.
- Explore stock identification techniques for additional information on stock boundaries and rates of movement among stock areas.
- Unique gear codes for small-mesh fisheries (similar to negear=058 or gearcode='OTS' for shrimp trawls) would greatly benefit estimation of discards.

- Continue processing archived age samples from MADMF surveys to eliminate using NEFSC age keys as noted and process NEFSC observer age samples.
- Revise historical small-mesh discard estimates so that the shrimp and whiting fisheries are treated separately.
- Investigate information available on discard mortality of yellowtail flounder.
- Explore post-stratification of survey data in NEFSC stratum 24 and inshore strata.

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Table A2.1. Summary of management of Cape Cod-Gulf of Maine yellowtail flounder.

Year	**Comments**
1977	FCMA implemented March 1 Groundfish plan adopts quotas for cod, haddock, yellowtail flounder
1982	Interim Groundfish Plan adopted: Georges Bank and Gulf of Maine minimum mesh size of 5 1/8 inches, increasing to 5 1/2 inches in 1983 11 inch minimum size for yellowtail Scallop FMP implemented
1986	Northeast Multispecies FMP adopted: Minimum size for yellowtail flounder: 12 inches Minimum mesh size in GB/GOM: 5 1/2 inch cod end (no minimum size in SNE/MA) Seasonal yellowtail closure, March - May, between 69-30 and 72-30W Small mesh fisheries in GOM/GB area only restricted to specific seasons with limits on landings (not catch) of groundfish and inshore area of GOM
1989	Amendment 2: Yellowtail minimum size increased to 13 inches
1991	Amendment 4: Tightened restrictions on carrying small mesh while in Regulated Mesh Areas Mandated use of selective gear in shrimp fishery, leading to implementation of the Nordmore grate in 1993
1994	Amendment 5 and emergency regulations: DAS limits for most vessels West of 72-30W. Mesh determined by mesh requirements of summer flounder fishery (5 1/2 inch diamond or 6 inch square) GOM/GB mesh of 6 inches (diamond or square) Eliminated seasonal restrictions on small mesh fisheries in Small Mesh Exemption Area of inshore GOM Adopted Nordmore grate requirement into FMP Scallop Amendment 4: adopted permit moratorium, effort control/DAS program, 5.5 inch twine top minimum, and crew limits
1996	Amendment 7 Extended DAS limits to most vessels Limited possession of groundfish by scallop vessels to 300 pounds of regulated multispecies Established criteria for exempted fisheries Established exempted whiting fisheries in GOM/GB in three areas (Small Mesh Areas I and II in inshore GOM, Cultivator Shoals area on GB)
1999	Framework 27: (May 1) Increased square mesh minimum size to 6 1/2 inches in GOM/GB/SNE Regulated mesh areas Framework 29: (June)
	Amendment 9: (November): Revised overfishing definitions
	Scallop Framework 11 mandates 8 inch twine top, authorizes scallop access program for Closed Area II, with yellowtail flounder bycatch limits
	Scallop Framework 13: Scallop vessel closed area access programs with yellowtail bycatch limits
2000	Adopted management measures for small-mesh multispecies, establishing minimum mesh sizes and trip/possession limits to reduce mortality on silver, red, and offshore hake Framework 35: Established exempted whiting fishery in upper Cape Cod Bay using raised footrope trawl

Table A2.2. Cape Cod – Gulf of Maine yellowtail flounder catch.

	Cape Cod Landings	Cape Cod Discards	Gulf of Maine Landings	Gulf of Maine Discards	Total
1960	1,500	500	39	---	2,039
1961	1,800	600	22	---	2,422
1962	1,900	600	0	---	2,500
1963	3,600	1,000	0	---	4,600
1964	1,851	600	6	---	2,457
1965	1,498	500	8	---	2,006
1966	1,808	300	26	---	2,135
1967	1,542	800	50	---	2,391
1968	1,569	600	13	---	2,181
1969	1,346	300	75	---	1,722
1970	1,185	400	125	---	1,710
1971	1,662	700	56	---	2,418
1972	1,364	300	156	---	1,821
1973	1,662	0	63	---	1,724
1974	2,054	200	104	---	2,358
1975	2,027	0	194	---	2,220
1976	3,587	100	258	---	3,945
1977	3,469	0	252	---	3,722
1978	3,683	400	388	---	4,471
1979	4,163	500	276	---	4,939
1980	5,106	600	461	---	6,167
1981	3,149	600	425	---	4,174
1982	3,150	400	486	---	4,035
1983	1,884	300	324	---	2,509
1984	1,121	20	244	---	1,385
1985	967	77	205	77	1,326
1986	1,041	305	164	62	1,572
1987	1,159	198	194	73	1,624
1988	1,085	283	190	72	1,630
1989	909	390	209	47	1,555
1990	2,984	1,141	238	98	4,461
1991	1,472	405	265	110	2,251
1992	828	637	203	78	1,746
1993	628	90	158	31	907
1994	978	192	321	89	1,580
1995	1,207	233	124	111	1,674
1996	1,064	182	108	51	1,405
1997	1,040	257	74	20	1,392
1998	1,169	259	73	39	1,540
1999	1,089	107	121	40	1,357
2000	2,279	163	133	33	2,609
2001	2,362	447	143	35	2,988

Table A2.3. Samples of Cape Cod yellowtail flounder.

Year	half	trips	unclass. lengths	small lengths	large lengths	ages
1985	1	5	109	304	196	292
	2	12	0	825	543	357
1986	1	4	0	608	206	217
	2	6	0	321	172	240
1987	1	6	0	300	352	353
	2	5	0	284	269	207
1988	1	6	0	477	267	286
	2	5	0	291	364	252
1989	1	6	10	261	314	305
	2	4	97	262	173	200
1990	1	8	536	532	374	339
	2	6	636	429	276	137
1991	1	8	811	501	332	610
	2	7	109	531	242	277
1992	1	4	707	126	254	339
	2	7	136	262	457	268
1993	1	3	170	145	182	177
	2	3	273	244	74	114
1994	1	4	100	261	170	273
	2	3	0	106	144	149
1995	1	4	39	276	201	196
	2	6	998	392	275	157
1996	1	1	2560	0	87	196
	2	12	118	495	640	485
1997	1	7	343	388	483	556
	2	17	317	996	869	634
1998	1	7	4781	0	508	195
	2	6	165	0	600	165
1999	1	4	2501	278	60	49
	2	4	1024	268	116	57
2000	1	46	521	723	2775	903
	2	15	0	566	1057	395
2001	1	8	3502	251	570	192
	2	16	1950	393	774	436

Table A2.4a. Landings at age of Cape Cod yellowtail flounder.

Landings at age (thousands)				age					
	1	2	3	4	5	6	7	8+	sum
1985	5	738	700	522	268	89	3	7	2,332
1986	0	1,998	579	223	32	6	0	1	2,838
1987	0	609	1,786	268	100	29	12	5	2,808
1988	1	802	1,043	625	172	36	0	0	2,679
1989	0	726	989	231	31	3	2	2	1,986
1990	0	692	6,191	416	32	16	7	3	7,357
1991	0	311	903	1,455	249	33	27	1	2,978
1992	0	338	807	514	150	6	5	1	1,821
1993	0	25	684	573	90	24	15	7	1,418
1994	0	87	1,023	650	236	65	38	9	2,109
1995	0	233	1,730	808	152	78	5	0	3,006
1996	0	150	1,097	798	287	11	5	2	2,349
1997	0	481	1,086	702	160	13	0	1	2,443
1998	0	257	1,681	472	141	41	3	0	2,595
1999	0	328	1,134	646	106	43	1	0	2,258
2000	0	942	2,625	1,152	138	18	13	3	4,891
2001	0	807	2,933	1,058	152	24	13	1	4,987
mean	0	518	1,429	594	147	33	8	3	2,732

Landed weight at age (kg)				age				
	1	2	3	4	5	6	7	8+
1985	0.19	0.32	0.37	0.49	0.60	0.73	1.20	1.39
1986		0.32	0.46	0.57	0.73	0.90	---	1.40
1987		0.31	0.42	0.55	0.65	0.81	1.03	1.18
1988	0.11	0.31	0.37	0.53	0.70	0.85	---	---
1989		0.38	0.45	0.65	0.92	1.41	1.24	1.24
1990		0.31	0.41	0.56	0.82	0.90	0.99	1.17
1991		0.35	0.39	0.54	0.74	0.99	1.06	1.01
1992		0.32	0.41	0.53	0.61	0.73	1.53	1.91
1993		0.31	0.38	0.43	0.74	0.95	1.01	1.17
1994		0.29	0.38	0.50	0.62	0.68	1.04	1.11
1995		0.35	0.36	0.43	0.61	0.78	1.11	---
1996		0.32	0.42	0.50	0.53	0.91	1.19	1.18
1997		0.39	0.41	0.47	0.57	0.78	1.30	1.31
1998		0.33	0.41	0.55	0.63	1.00	1.62	---
1999		0.36	0.45	0.56	0.58	0.88	1.62	---
2000		0.38	0.44	0.56	0.61	0.82	0.87	1.12
2001		0.38	0.44	0.59	0.74	1.07	0.92	1.93
mean	0.15	0.33	0.41	0.52	0.67	0.89	1.23	1.28

Table A2.4b. Landings at age of northern Gulf of Maine yellowtail flounder.

Landings at age (thousands)			age						
year	1	2	3	4	5	6	7	8+	sum
1985	1	138	139	112	61	20	1	1	474
1986	0	235	116	49	8	1	0	0	409
1987	0	75	315	41	17	5	2	1	456
1988	0	115	239	119	27	5	0	0	505
1989	0	112	295	55	6	1	0	0	469
1990	0	26	472	56	3	2	0	0	559
1991	0	50	162	263	43	6	7	0	531
1992	0	72	223	130	38	1	1	0	465
1993	0	9	184	150	20	5	3	1	372
1994	0	42	344	200	74	36	11	1	708
1995	0	20	196	90	15	7	0	0	329
1996	0	7	83	93	39	2	1	0	225
1997	0	12	78	66	13	0	0	0	169
1998	0	12	106	31	8	3	0	0	160
1999	0	28	119	85	12	7	0	0	251
2000	0	62	163	70	4	0	0	0	299
2001	0	35	153	100	15	5	0	0	307
mean	0	62	199	101	24	6	2	0	393

Landed weight at age (kg)			age					
year	1	2	3	4	5	6	7	8+
1985	0.19	0.31	0.37	0.49	0.60	0.72	1.17	1.39
1986		0.32	0.46	0.58	0.74	0.93		1.40
1987		0.31	0.41	0.56	0.67	0.86	1.10	1.25
1988	0.11	0.29	0.33	0.48	0.64	0.76		
1989		0.37	0.41	0.69	0.95	1.41	1.24	1.24
1990		0.31	0.41	0.54	0.90	0.99	0.99	1.79
1991		0.34	0.37	0.54	0.76	0.95	1.07	1.53
1992		0.32	0.40	0.50	0.58	0.80	1.49	1.89
1993		0.31	0.38	0.42	0.72	0.94	1.00	1.14
1994		0.28	0.38	0.49	0.60	0.67	1.04	1.12
1995		0.32	0.34	0.40	0.60	0.80	1.18	
1996		0.31	0.43	0.50	0.53	0.91	1.19	1.19
1997		0.38	0.40	0.47	0.56	0.93	1.30	1.30
1998		0.33	0.41	0.54	0.63	1.00	1.62	
1999		0.35	0.42	0.58	0.58	0.85	1.62	
2000		0.37	0.42	0.55	0.59	0.97	0.87	1.06
2001		0.35	0.41	0.56	0.57	0.69	1.62	
mean	0.15	0.33	0.40	0.52	0.66	0.89	1.23	1.36

Table A2.5a. Discard estimates for Cape Cod yellowtail flounder, by fishery.

Large-mesh Trawl Fishery

year	half	observed kept (mt)	discard (mt)	d/k	total landings	discards (mt)	discard lengths
1998	1	0.1551	0.0095	0.061	355	21.8	6
	2	0.1810	0.0230	0.127	426	54.1	7
1999	1	0.0091	0.0014	0.150	282	42.3	48
	2	2.2226	0.0945	0.043	564	24.0	0
2000	1	10.6743	0.4195	0.039	871	34.2	608
	2	1.1785	0.0431	0.037	1079	39.4	45
2001	1	5.9789	0.6183	0.103	789	81.6	42
	2	6.3832	1.6209	0.254	1311	332.8	890

Gillnet Fishery

year	half	observed kept (mt)	discard (mt)	d/k	total landings	discards (mt)	
1998	1	33.6627	0.5355	0.016	360	5.7	5101
	2	1.1959	0.0290	0.024	23	0.5	159
1999	1	16.6555	0.3622	0.022	207	4.5	521
	2	3.3086	0.0174	0.005	36	0.2	5
2000	1	29.5608	0.4748	0.016	295	4.7	426
	2	0.1919	0.0095	0.050	32	1.6	3
2001	1	13.1767	0.1202	0.009	223	2.0	63
	2	1.2431	0.0095	0.008	35	0.3	0

Small-mesh Trawl Fishery

year	half	observed effort (d)	discard (mt)	mt/d	total effort	discards (mt)	
1998	1	0.0000	0.0000	0.046 *	74	3.4	0
	2	0.0000	0.0000	0.046 *	308	14.0	0
1999	1	0.0000	0.0000	0.046 *	39	1.8	0
	2	0.4583	0.0209	0.046	214	9.7	0
2000	1	0.0000	0.0000	0.009 *	27	0.2	0
	2	9.0417	0.0794	0.009	201	1.8	0
2001	1	0.8125	0.0123	0.015	51	0.8	0
	2	1.0792	0.0014	0.001	121	0.2	0

Scallop Dredge Fishery

year	half	observed effort (d)	discard (mt)	mt/d	total effort	discards (mt)	
1998	1	0.6250	0.0302	0.048	1019	49.2	19
	2	7.0833	0.5643	0.080	1379	109.8	296
1999	1	2.7917	0.0372	0.013	1092	14.6	23
	2	6.7500	0.0445	0.007	1478	9.7	11
2000	1	0.0000	0.0000	0.045 *	772	34.6	0
	2	0.0000	0.0000	0.045 *	1045	46.8	0
2001	1	0.2583	0.0116	0.045	284	12.7	0
	2	0.0000	0.0000	0.045 *	384	17.2	0

* assumed from adjacent cell

Table A2.5b. Discard estimates for the northern Gulf of Maine yellowtail flounder, by fishery.

Trawl Fishery

year	half	observed kept	observed discard	d/k	landings	discards	discard lengths
1989	1	0.097	0.010	0.103	121	12	26
	2	0.029	0.005	0.186	45	8	0
1990	1	0.034	0.010	0.294	117	34	8
	2	0.007	0.002	0.265	80	21	0
1991	1	0.273	0.063	0.231	152	35	10
	2	0.122	0.047	0.387	86	33	0
1992	1	0.196	0.055	0.282	129	36	0
	2	0.720	0.017	0.024	56	1	0
1993	1	0.036	0.002	0.050	71	4	0
	2	0.681	0.082	0.120	72	9	2
1994	1	0.000	0.000	0.235	220	52	0
	2	0.000	0.000	0.501	55	28	0
1995	1	0.014	0.006	0.454	70	32	5
	2	0.002	0.006	2.478	26	63	14
1996	1	0.013	0.004	0.311	82	26	11
	2	0.000	0.060	0.501	13	7	147
1997	1	0.003	0.001	0.185	46	9	1
	2	0.000	0.000	0.501	10	5	0
1998	1	0.038	0.012	0.314	45	14	38
	2	0.000	0.000	0.501	17	8	0
1999	1	0.000	0.000	0.235	69	16	0
	2	0.000	0.000	0.501	23	12	0
2000	1	0.660	0.079	0.119	78	9	102
	2	0.186	0.066	0.353	44	15	27
2001	1	0.158	0.039	0.247	103	25	190
	2	0.206	0.041	0.199	32	6	64

Table A2.5b, continued.

Shrimp Fishery

year	half	observed effort	observed discard	d/e	effort	discards	discard lengths
1989	1	11	0.017	0.002	8200	13	18
	2	4	0.014	0.004	1361	5	8
1990	1	19	0.067	0.004	8647	31	83
	2	2	0.003	0.002	1111	2	0
1991	1	35	0.171	0.005	7402	36	222
	2	5	0.020	0.004	566	2	0
1992	1	62	0.322	0.005	7413	39	175
	2	3	0.002	0.001	385	0	2
1993	1	45	0.127	0.003	5666	16	394
	2	1	0.003	0.003	492	1	0
1994	1	35	0.047	0.001	4777	6	86
	2	4	0.010	0.002	1213	3	70
1995	1	34	0.052	0.002	8494	13	212
	2	6	0.008	0.001	1971	3	29
1996	1	13	0.020	0.002	9656	15	88
	2	2	0.004	0.002	2135	4	14
1997	1	6	0.003	0.000	9648	4	9
	2	0	0.000	0.002	1086	3	0
1998	1	0	0.000	0.002	6295	15	0
	2	0	0.000	0.002	311	1	0
1999	1	0	0.000	0.002	3811	9	0
	2	0	0.000	0.002	0	0	0
2000	1	0	0.000	0.002	3382	8	0
	2	0	0.000	0.002	0	0	0
2001	1	2	0.002	0.001	2963	3	0
	2	0	0.000	0.002	0	0	0

Table A2.5b, continued.

Gillnet Fishery

year	half	observed kept	observed discard	d/k	landings	discards	discard lengths
1989	1	0.000	0.000	0.323	25	8	0
	2	0.013	0.004	0.323	2	1	0
1990	1	0.049	0.012	0.249	29	7	0
	2	0.004	0.012	2.878	1	3	0
1991	1	0.074	0.011	0.147	12	2	1
	2	0.069	0.075	1.099	1	1	3
1992	1	0.968	0.095	0.098	11	1	40
	2	0.065	0.026	0.403	1	0	7
1993	1	1.292	0.098	0.076	13	1	31
	2	0.010	0.003	0.308	1	0	1
1994	1	0.662	0.005	0.007	44	0	4
	2	0.222	0.003	0.011	2	0	1
1995	1	2.794	0.015	0.005	27	0	36
	2	0.083	0.001	0.008	1	0	1
1996	1	2.775	0.004	0.001	11	0	3
	2	0.055	0.001	0.026	0	0	1
1997	1	7.112	0.008	0.001	17	0	7
	2	0.067	0.000	0.000	1	0	0
1998	1	0.031	0.002	0.075	11	1	0
	2	0.003	0.000	0.000	0	0	0
1999	1	0.076	0.000	0.000	23	0	0
	2	0.003	0.002	0.500	6	3	0
2000	1	0.267	0.000	0.000	10	0	2
	2	0.002	0.000	0.000	1	0	0
2001	1	0.047	0.007	0.145	6	1	0
	2	0.003	0.000	0.000	2	0	0

Table A2.6a. Discards at age of Cape Cod yellowtail flounder.

Discards at age (thousands)				age		
	1	2	3	4	5	6
1985	340	184	34	0	0	0
1986	79	1,657	75	26	0	0
1987	14	877	168	0	0	0
1988	360	1,328	177	0	0	0
1989	114	1,405	396	1	0	0
1990	81	2,047	2,501	19	0	0
1991	460	895	561	100	7	0
1992	1,688	3,543	731	29	3	0
1993	138	324	173	30	0	0
1994	60	383	279	49	4	1
1995	453	469	652	50	2	0
1996	7	397	327	94	11	0
1997	1	399	351	117	22	1
1998	56	393	420	46	11	0
1999	11	153	188	22	3	3
2000	3	81	219	76	15	4
2001	19	837	700	26	3	1
mean	228	904	468	40	5	1

Discarded weight at age (kg)				age		
	1	2	3	4	5	6
1985	0.13	0.15	0.15			
1986	0.10	0.17	0.19	0.18		
1987	0.06	0.19	0.19			
1988	0.12	0.15	0.20			
1989	0.13	0.21	0.25	0.36		
1990	0.08	0.24	0.27	0.33		
1991	0.12	0.19	0.27	0.37	0.54	
1992	0.05	0.11	0.22	0.31	0.36	
1993	0.09	0.15	0.27	0.33	0.63	
1994	0.08	0.20	0.29	0.32	0.38	0.34
1995	0.07	0.16	0.23	0.33	0.48	
1996	0.04	0.15	0.28	0.36	0.50	
1997	0.03	0.21	0.29	0.39	0.54	0.65
1998	0.03	0.23	0.33	0.37	0.46	0.59
1999	0.03	0.25	0.29	0.45	0.48	0.99
2000	0.03	0.29	0.38	0.57	0.61	0.80
2001	0.03	0.26	0.30	0.46	0.80	1.13
mean	0.07	0.19	0.26	0.37	0.53	0.75

Table A2.6b. Discards at age of northern Gulf of Maine yellowtail flounder.

Discards at age (thousands)	age							
	1	2	3	4	5	6	7	sum
1985	341	185	34	0	0	0	0	560
1986	16	336	15	5	0	0	0	372
1987	5	324	62	0	0	0	0	391
1988	91	336	45	0	0	0	0	472
1989	4	53	132	10	0	0	0	199
1990	3	134	236	2	0	0	0	375
1991	5	116	139	134	0	0	0	394
1992	21	26	200	58	0	0	0	305
1993	21	67	33	43	0	0	0	164
1994	15	22	7	132	53	41	30	300
1995	5	29	175	120	70	0	0	400
1996	0	38	84	92	2	0	0	216
1997	2	20	58	4	0	0	0	84
1998	52	46	92	14	3	0	0	207
1999	6	55	108	17	1	0	0	187
2000	7	58	52	12	0	0	0	130
2001	1	26	26	78	4	0	0	134
mean	35	110	88	43	8	2	2	288

Discarded weight at age (kg)	age						
	1	2	3	4	5	6	7
1985	0.13	0.15	0.15				
1986	0.10	0.17	0.19	0.18			
1987	0.06	0.19	0.19				
1988	0.12	0.15	0.20				
1989	0.13	0.21	0.24	0.39			
1990	0.09	0.20	0.29	0.41			
1991	0.08	0.22	0.28	0.32			
1992	0.06	0.11	0.27	0.32			
1993	0.08	0.12	0.25	0.30			
1994	0.09	0.12	0.18	0.27	0.31	0.36	0.54
1995	0.04	0.14	0.25	0.32	0.34		
1996		0.10	0.25	0.28	0.43		
1997	0.12	0.09	0.30	0.35			
1998	0.06	0.15	0.26	0.31	0.27		
1999	0.19	0.13	0.24	0.32	0.49		
2000	0.06	0.14	0.33	0.49	0.30		
2001	0.07	0.19	0.23	0.29	0.37		
mean	0.09	0.15	0.24	0.33	0.36	0.36	0.54

Table A2.7a. Indices of Cape Cod – Gulf of Maine yellowtail flounder abundance at age and biomass.

MADMF Spring Survey					age					
	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	2.71	20.69	11.82	1.60	0.63	0.54	0.10	0.13	38.22	10.16
1979	2.63	22.58	13.85	3.68	0.86	0.00	0.17	0.00	43.77	11.38
1980	2.68	17.62	10.10	2.30	0.15	0.00	0.00	0.00	32.85	10.03
1981	5.61	58.83	9.00	2.26	1.59	0.27	0.00	0.00	77.56	16.35
1982	0.69	17.06	17.04	4.45	0.94	0.06	0.04	0.00	40.28	12.85
1983	3.13	8.50	11.51	4.28	0.04	0.17	0.03	0.00	27.66	9.00
1984	0.43	18.13	7.56	2.29	0.85	0.00	0.00	0.00	29.26	7.37
1985	1.97	8.27	7.15	1.52	0.59	0.39	0.05	0.05	19.99	5.21
1986	1.73	15.39	1.74	0.24	0.21	0.04	0.00	0.00	19.36	4.52
1987	2.53	4.95	5.31	0.97	0.27	0.11	0.08	0.00	14.22	3.67
1988	3.10	14.46	2.52	0.60	0.05	0.02	0.00	0.00	20.74	3.83
1989	0.67	22.26	3.18	1.08	0.06	0.00	0.00	0.00	27.25	4.73
1990	0.63	11.77	15.57	0.63	0.14	0.01	0.02	0.01	28.77	6.60
1991	0.06	5.34	3.31	2.15	0.48	0.12	0.05	0.00	11.50	3.32
1992	1.30	11.03	9.71	2.38	1.45	0.03	0.03	0.00	25.94	6.54
1993	0.63	7.99	6.31	1.94	0.23	0.06	0.20	0.03	17.38	4.60
1994	2.67	24.02	7.53	1.49	0.33	0.12	0.00	0.00	36.15	6.23
1995	7.51	14.64	24.96	2.88	1.20	0.02	0.02	0.00	51.22	10.38
1996	1.17	18.03	14.70	6.78	1.74	0.00	0.04	0.00	42.46	9.25
1997	0.52	16.94	12.22	4.04	0.54	0.00	0.00	0.00	34.26	7.55
1998	0.55	4.96	13.50	1.25	0.19	0.02	0.00	0.00	20.46	5.17
1999	0.10	6.34	10.90	1.28	0.08	0.00	0.00	0.00	18.70	5.08
2000	0.83	21.92	33.29	11.28	1.30	0.52	0.00	0.00	69.14	20.37
2001	0.22	10.21	38.20	10.39	1.68	0.00	0.00	0.00	60.71	19.34
2002	0.36	1.29	13.84	5.34	0.26	0.17	0.00	0.00	21.27	7.43
mean	1.78	15.33	12.19	3.08	0.63	0.11	0.03	0.01	33.16	8.44

Table A2.7b.

MADMF Fall Survey					age						
	0	1	2	3	4	5	6	7	8+	sum	kg/tow
1978	0.04	7.13	7.74	1.45	0.11	0.00	0.01	0.00	0.00	16.48	2.80
1979	0.03	24.11	22.82	1.78	0.06	0.00	0.00	0.00	0.00	48.80	7.33
1980	0.03	26.54	12.38	2.70	0.35	0.00	0.00	0.00	0.00	42.00	5.90
1981	0.00	2.93	6.54	1.54	0.23	0.17	0.00	0.00	0.00	11.41	2.76
1982	0.00	9.58	3.36	5.54	0.30	0.08	0.00	0.00	0.00	18.86	4.20
1983	0.00	9.68	6.68	1.60	0.13	0.00	0.00	0.00	0.00	18.09	3.39
1984	0.04	1.91	3.00	0.86	0.39	0.10	0.02	0.00	0.04	6.37	1.18
1985	0.04	5.70	1.63	1.03	0.00	0.00	0.00	0.00	0.02	8.42	1.17
1986	0.01	2.60	4.95	0.20	0.03	0.01	0.00	0.00	0.00	7.80	1.36
1987	0.44	5.85	2.30	0.49	0.07	0.02	0.00	0.00	0.00	9.17	1.09
1988	0.00	8.96	11.24	2.27	0.15	0.00	0.00	0.00	0.00	22.62	3.71
1989	0.00	2.64	5.22	0.96	0.10	0.00	0.00	0.00	0.00	8.92	1.52
1990	0.00	5.20	11.93	4.84	0.01	0.00	0.00	0.00	0.00	21.98	4.16
1991	0.00	3.76	5.14	5.03	0.86	0.00	0.00	0.00	0.00	14.78	3.23
1992	0.20	7.18	3.62	2.08	0.47	0.20	0.00	0.00	0.00	13.75	2.00
1993	0.00	8.39	7.29	5.80	1.43	0.00	0.00	0.00	0.00	22.91	3.99
1994	0.00	2.36	11.79	1.79	0.15	0.00	0.00	0.00	0.00	16.09	3.27
1995	0.00	8.38	15.16	5.85	0.00	0.00	0.00	0.00	0.00	29.40	5.75
1996	0.01	1.87	3.94	2.18	0.17	0.00	0.00	0.00	0.00	8.17	1.56
1997	0.00	1.01	7.38	1.14	0.16	0.10	0.00	0.00	0.00	9.79	2.10
1998	0.00	7.05	6.74	2.25	0.00	0.00	0.00	0.00	0.00	16.05	2.68
1999	0.15	4.73	11.94	4.10	0.65	0.08	0.00	0.00	0.00	21.66	4.71
2000	0.00	1.36	8.25	3.53	0.22	0.10	0.00	0.03	0.00	13.48	3.46
2001	0.00	0.57	8.06	4.23	0.14	0.00	0.00	0.00	0.00	13.00	3.55
mean	0.04	6.65	7.88	2.63	0.26	0.04	0.00	0.00	0.00	17.50	3.20

Table A2.7c.

NMFS Spring Survey

year	1	2	3	4	5	6	7	8+	sum	kg/tow
1977	0.775	0.329	0.185	0.049	0.093	0.000	0.000	0.000	1.431	0.566
1978	0.000	0.057	0.247	0.036	0.088	0.000	0.000	0.000	0.427	0.209
1979	0.228	0.315	0.748	0.770	0.068	0.021	0.000	0.019	2.169	0.795
1980	0.000	4.150	2.189	0.828	0.167	0.000	0.000	0.000	7.334	2.426
1981	0.041	2.921	2.198	1.143	0.584	0.473	0.179	0.000	7.538	2.468
1982	0.016	1.195	3.009	1.519	0.416	0.232	0.219	0.099	6.705	2.814
1983	1.190	3.203	2.093	1.298	0.092	0.064	0.000	0.000	7.939	2.340
1984	0.039	1.020	0.606	0.394	0.257	0.023	0.032	0.069	2.440	0.809
1985	0.047	0.806	0.865	0.205	0.123	0.043	0.000	0.000	2.089	0.615
1986	0.024	1.786	0.198	0.137	0.100	0.000	0.000	0.000	2.245	0.470
1987	0.062	1.599	2.356	0.637	0.538	0.570	0.611	0.304	6.676	2.971
1988	0.896	3.781	0.922	0.513	0.268	0.097	0.057	0.000	6.533	1.077
1989	0.177	2.179	1.442	0.372	0.274	0.038	0.038	0.038	4.559	0.863
1990	2.285	6.144	0.210	0.000	0.099	0.000	0.000	0.000	8.739	1.948
1991	0.421	3.554	2.834	1.049	0.222	0.000	0.047	0.000	8.128	1.783
1992	0.155	0.915	1.835	0.498	0.018	0.000	0.000	0.000	3.421	0.764
1993	0.064	0.656	1.045	0.563	0.000	0.000	0.000	0.000	2.327	0.501
1994	0.347	2.631	1.578	0.951	0.593	0.208	0.000	0.000	6.308	1.201
1995	0.182	1.040	3.978	2.991	0.432	0.048	0.000	0.000	8.670	2.036
1996	0.015	0.547	1.430	2.009	0.335	0.000	0.000	0.000	4.336	1.108
1997	0.021	0.934	2.025	1.545	0.288	0.000	0.000	0.000	4.813	1.311
1998	0.000	0.748	2.934	0.887	0.144	0.000	0.000	0.000	4.712	1.155
1999	0.018	0.848	3.633	1.853	0.332	0.147	0.000	0.000	6.831	1.977
2000	0.238	3.931	17.630	5.837	0.953	0.715	0.000	0.000	29.305	9.506
2001	0.000	1.201	4.878	1.030	0.216	0.000	0.000	0.000	7.324	2.292
2002	0.015	1.568	7.092	3.271	0.213	0.026	0.000	0.026	12.211	4.554
average	0.279	1.848	2.622	1.169	0.266	0.104	0.046	0.021	6.354	1.868

Table A2.7d.

NMFS Fall Survey

year	1	2	3	4	5	6	7	8+	sum	kg/tow
1977	4.882	9.330	4.987	0.788	0.197	0.053	0.062	0.123	20.421	7.526
1978	0.354	3.540	2.383	0.152	0.168	0.015	0.015	0.015	6.642	2.047
1979	4.003	4.072	1.227	0.306	0.075	0.016	0.000	0.000	9.698	2.596
1980	10.534	8.937	4.115	1.556	0.340	0.000	0.037	0.000	25.518	6.557
1981	1.596	4.965	1.330	0.532	0.266	0.177	0.000	0.000	8.866	1.881
1982	0.572	2.743	2.593	0.313	0.379	0.000	0.000	0.000	6.599	2.056
1983	0.285	0.546	0.312	0.020	0.000	0.000	0.000	0.000	1.162	0.264
1984	0.320	1.124	0.443	0.763	0.546	0.151	0.075	0.075	3.497	1.380
1985	4.609	1.778	1.352	0.068	0.068	0.068	0.000	0.000	7.943	1.583
1986	1.308	3.613	0.297	0.019	0.019	0.000	0.000	0.000	5.257	0.970
1987	0.564	1.357	0.476	0.057	0.049	0.000	0.000	0.000	2.503	0.556
1988	3.128	4.587	0.443	0.134	0.000	0.000	0.000	0.000	8.292	1.126
1989	1.657	5.338	2.008	0.417	0.146	0.066	0.000	0.000	9.631	2.202
1990	3.500	6.201	2.874	0.046	0.010	0.000	0.000	0.000	12.630	2.345
1991	1.840	1.643	1.639	0.332	0.000	0.000	0.000	0.000	5.453	1.202
1992	2.537	2.758	1.878	0.948	0.183	0.142	0.000	0.000	8.447	1.932
1993	4.445	4.507	0.601	0.099	0.000	0.000	0.000	0.000	9.652	1.106
1994	2.472	7.368	2.596	0.824	0.354	0.000	0.000	0.000	13.615	2.701
1995	0.516	0.713	1.068	0.297	0.171	0.000	0.000	0.000	2.765	0.783
1996	1.058	2.907	4.928	1.179	0.133	0.000	0.000	0.000	10.205	2.614
1997	1.049	2.440	2.945	1.223	0.670	0.115	0.000	0.000	8.441	2.277
1998	1.022	2.984	1.197	0.986	0.234	0.000	0.000	0.000	6.422	1.637
1999	4.147	8.090	5.532	1.697	0.698	0.027	0.000	0.000	20.191	5.983
2000	0.955	6.729	4.455	0.260	0.000	0.000	0.000	0.000	12.399	3.472
2001	0.117	3.835	2.231	0.114	0.019	0.000	0.000	0.000	6.316	1.889
average	2.299	4.084	2.156	0.525	0.189	0.033	0.008	0.009	9.303	2.347

Table A2.8. Correlation among indices of abundance at age for Cape Cod – Gulf of Maine yellowtail flounder.

Age-1	MASS_F	MASS_S	NMFS_S
MASS_F	1.00		
MASS_S	0.07	1.00	
NMFS_S	0.48	-0.10	1.00

Age-2	MASS_F	MASS_S	NMFS_F	NMFS_S
MASS_F	1.00			
MASS_S	0.33	1.00		
NMFS_F	0.17	0.59	1.00	
NMFS_S	0.16	0.59	0.63	1.00

Age-3	MASS_F	MASS_S	NMFS_F	NMFS_S
MASS_F	1.00			
MASS_S	0.45	1.00		
NMFS_F	0.58	0.37	1.00	
NMFS_S	0.64	0.45	0.54	1.00

Age-4	MASS_F	MASS_S	NMFS_F	NMFS_S
MASS_F	1.00			
MASS_S	0.56	1.00		
NMFS_F	0.69	0.56	1.00	
NMFS_S	0.43	0.48	0.63	1.00

Age-5	MASS_F	MASS_S	NMFS_F	NMFS_S
MASS_F	1.00			
MASS_S	0.00	1.00		
NMFS_F	-0.04	0.28	1.00	
NMFS_S	-0.08	0.50	0.24	1.00

Age-6+	MASS_F	MASS_S	NMFS_F	NMFS_S
MASS_F	1.00			
MASS_S	0.10	1.00		
NMFS_F	-0.01	0.04	1.00	
NMFS_S	-0.44	0.52	0.27	1.00

Table A2.9. Results of virtual population analysis of Cape Cod – Gulf of Maine yellowtail flounder.

Abundance (thousands)

	age-1	age-2	age-3	age-4	age-5+	sum
1985	12302	3195	1696	1168	814	19175
1986	6030	9451	1489	568	88	17626
1987	8083	4851	3915	509	273	17631
1988	28844	6601	2266	1096	345	39152
1989	11325	23207	3068	495	75	38170
1990	11634	9166	16922	872	111	38705
1991	13071	9449	4883	5349	1008	33760
1992	9639	10281	6495	2401	668	29484
1993	10404	6346	4817	3543	731	25841
1994	7177	8375	4811	2972	1710	25045
1995	6380	5808	6372	2443	745	21748
1996	9625	4809	4076	2725	898	22133
1997	8590	7874	3402	1896	442	22204
1998	10724	7031	5621	1361	504	25241
1999	13439	8682	5117	2522	575	30335
2000	10047	10988	6598	2788	411	30832
2001	1939	8218	7961	2634	447	21199
2002	---	1569	5185	3069	1188	---
average	10544	8106	5261	2134	613	26958

Fishing Mortality

	age-1	age-2	age-3	age-4	age-5+	age 3-4
1985	0.06	0.56	0.89	0.92	0.92	0.90
1986	0.02	0.68	0.87	0.90	0.90	0.88
1987	0.00	0.56	1.07	1.11	1.11	1.07
1988	0.02	0.57	1.32	1.39	1.39	1.34
1989	0.01	0.12	1.06	1.09	1.09	1.06
1990	0.01	0.43	0.95	0.98	0.98	0.95
1991	0.04	0.17	0.51	0.52	0.52	0.52
1992	0.22	0.56	0.41	0.41	0.41	0.41
1993	0.02	0.08	0.28	0.28	0.28	0.28
1994	0.01	0.07	0.48	0.48	0.48	0.48
1995	0.08	0.15	0.65	0.66	0.66	0.65
1996	0.00	0.15	0.57	0.57	0.57	0.57
1997	0.00	0.14	0.72	0.73	0.73	0.72
1998	0.01	0.12	0.60	0.61	0.61	0.60
1999	0.00	0.07	0.41	0.41	0.41	0.41
2000	0.00	0.12	0.72	0.73	0.73	0.72
2001	0.01	0.26	0.75	0.75	0.75	0.75
average	0.03	0.28	0.72	0.74	0.74	0.73

Table A2.9 continued.

Spawning Stock Biomass (mt)

	age-1	age-2	age-3	age-4	age-5+	sum
1985	0	50	313	359	332	1055
1986	0	131	332	191	43	696
1987	0	65	728	162	115	1070
1988	0	81	331	294	128	834
1989	0	439	559	188	44	1230
1990	0	141	3138	293	60	3633
1991	0	155	1000	2063	591	3810
1992	0	78	1308	931	331	2648
1993	0	72	1149	1216	490	2926
1994	0	132	1087	1028	836	3083
1995	0	88	1159	700	312	2260
1996	0	63	912	928	364	2267
1997	0	164	715	592	177	1647
1998	0	128	1272	514	255	2169
1999	0	192	1319	1095	303	2909
2000	0	277	1567	1058	184	3087
2001	0	174	1777	992	234	3177
average	0	143	1098	741	282	2265

Table A2.10. Yield and biomass per recruit of Cape Cod – Gulf of Maine yellowtail flounder.

```
   The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
    PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
             ----------------------------------------
             Run Date:  4-12-2002;  Time: 14:49:47.35
 CC_GOM YELLOWTAIL FLOUNDER - 1994-2001 INPUT

 Proportion of F before spawning:  .4167
 Proportion of M before spawning:  .4167
 Natural Mortality is Constant at:  .200
 Initial age is:  1; Last age is:  8
 Last age is a PLUS group;
 Original age-specific PRs, Mats, and Mean Wts from file:
 ==> CCGOMYT.DAT
------------------------------------------------------------
 Age-specific Input data for Yield per Recruit Analysis
------------------------------------------------------------
  Age | Fish Mort  Nat Mort | Proportion | Average Weights
      |  Pattern    Pattern |   Mature   |  Catch   Stock
------------------------------------------------------------
   1  |   .0200     1.0000  |    .0000   |   .043    .043
   2  |   .2200     1.0000  |    .0800   |   .273    .273
   3  |   .9800     1.0000  |    .8100   |   .387    .387
   4  |  1.0000     1.0000  |   1.0000   |   .501    .501
   5  |  1.0000     1.0000  |   1.0000   |   .588    .588
   6  |  1.0000     1.0000  |   1.0000   |   .845    .845
   7  |  1.0000     1.0000  |   1.0000   |  1.176   1.176
   8+ |  1.0000     1.0000  |   1.0000   |  1.328   1.328

------------------------------------------------------------
 Summary of Yield per Recruit Analysis for:
 CC_GOM YELLOWTAIL FLOUNDER - 1994-2001 INPUT

  Slope of the Yield/Recruit Curve at F=0.00: -->    3.0044
    F level at slope=1/10 of the above slope (F0.1): ----->    .195
      Yield/Recruit corresponding to F0.1: ----->     .2205
    F level to produce Maximum Yield/Recruit (Fmax): ----->    .437
      Yield/Recruit corresponding to Fmax: ----->     .2432
    F level at 40 % of Max Spawning Potential (F40): ----->    .174
      SSB/Recruit corresponding to F40: -------->    1.1917
```

Table A2.10 cont.

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	3.5367	3.3453	2.9798	100.00
	.100	.23532	.16955	4.3458	2.1815	2.1818	1.6643	55.85
F0.1	.195	.34935	.22052	3.7809	1.5853	1.6236	1.0959	36.78
F40%	.174	.32915	.21343	3.8808	1.6866	1.7221	1.1917	39.99
	.200	.35385	.22197	3.7586	1.5630	1.6017	1.0748	36.07
	.300	.42566	.23872	3.4049	1.2250	1.2549	.7584	25.45
	.400	.47407	.24300	3.1678	1.0191	1.0246	.5688	19.09
Fmax	.437	.48838	.24322	3.0981	.9623	.9573	.5172	17.36
	.500	.50912	.24277	2.9975	.8838	.8607	.4462	14.97
	.600	.53579	.24102	2.8687	.7896	.7383	.3622	12.15
	.700	.55687	.23890	2.7677	.7210	.6436	.3018	10.13
	.800	.57404	.23682	2.6861	.6691	.5682	.2567	8.62
	.900	.58834	.23493	2.6186	.6286	.5067	.2221	7.45
	1.000	.60050	.23325	2.5617	.5962	.4557	.1947	6.53
	1.100	.61099	.23175	2.5128	.5696	.4128	.1725	5.79
	1.200	.62018	.23041	2.4704	.5473	.3762	.1543	5.18
	1.300	.62832	.22919	2.4330	.5284	.3446	.1390	4.67
	1.400	.63560	.22807	2.3998	.5120	.3171	.1261	4.23
	1.500	.64217	.22702	2.3699	.4977	.2929	.1150	3.86
	1.600	.64814	.22604	2.3429	.4851	.2715	.1054	3.54
	1.700	.65361	.22511	2.3182	.4738	.2525	.0970	3.25
	1.800	.65865	.22422	2.2956	.4636	.2355	.0895	3.00
	1.900	.66332	.22337	2.2746	.4544	.2201	.0830	2.78
	2.000	.66766	.22254	2.2552	.4459	.2063	.0771	2.59

Figure A2.1. Statistical areas for Cape Cod – Gulf of Maine yellowtail flounder.

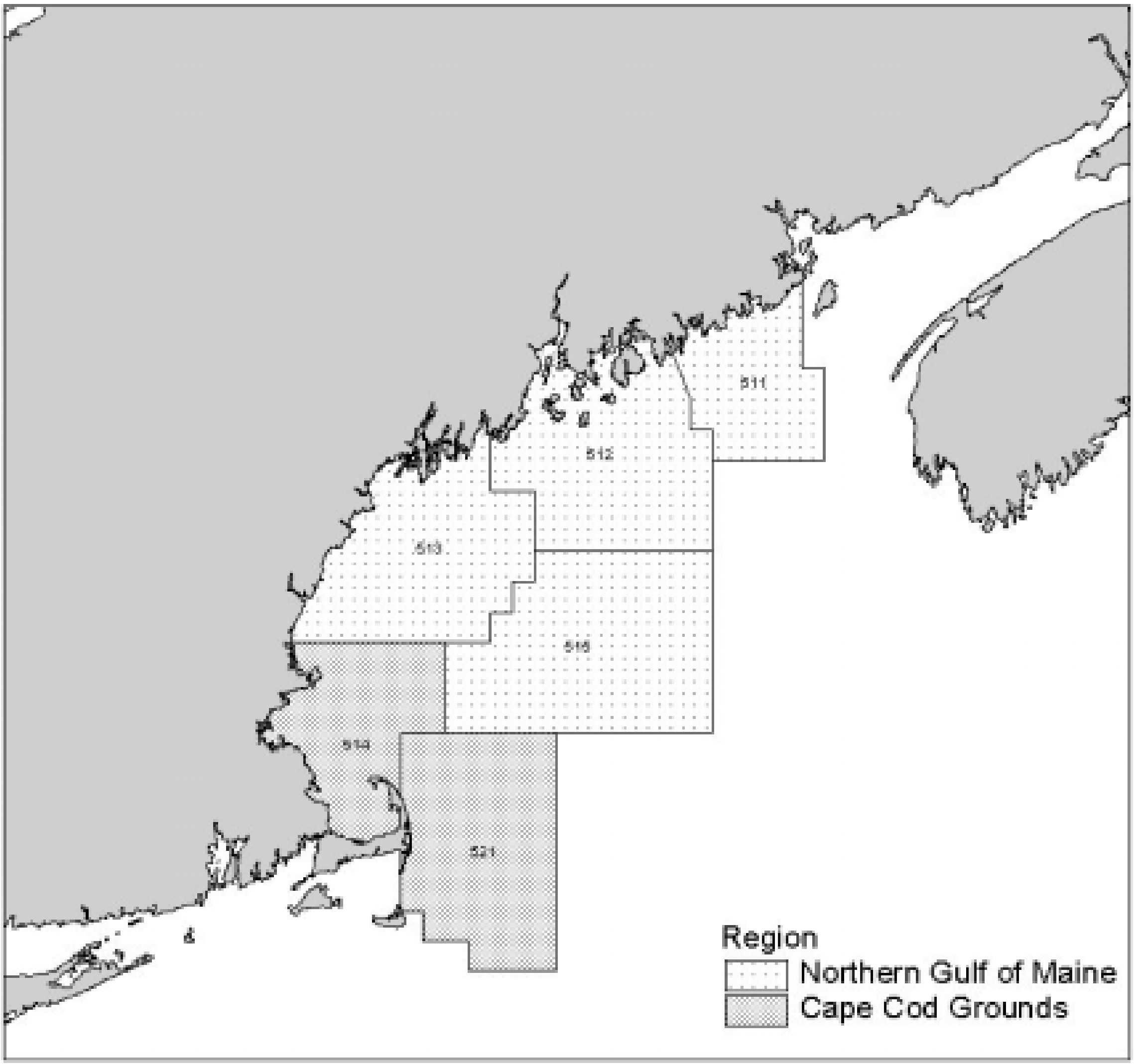


Figure A2.2. Cape Cod – Gulf of Maine yellowtail flounder catch.

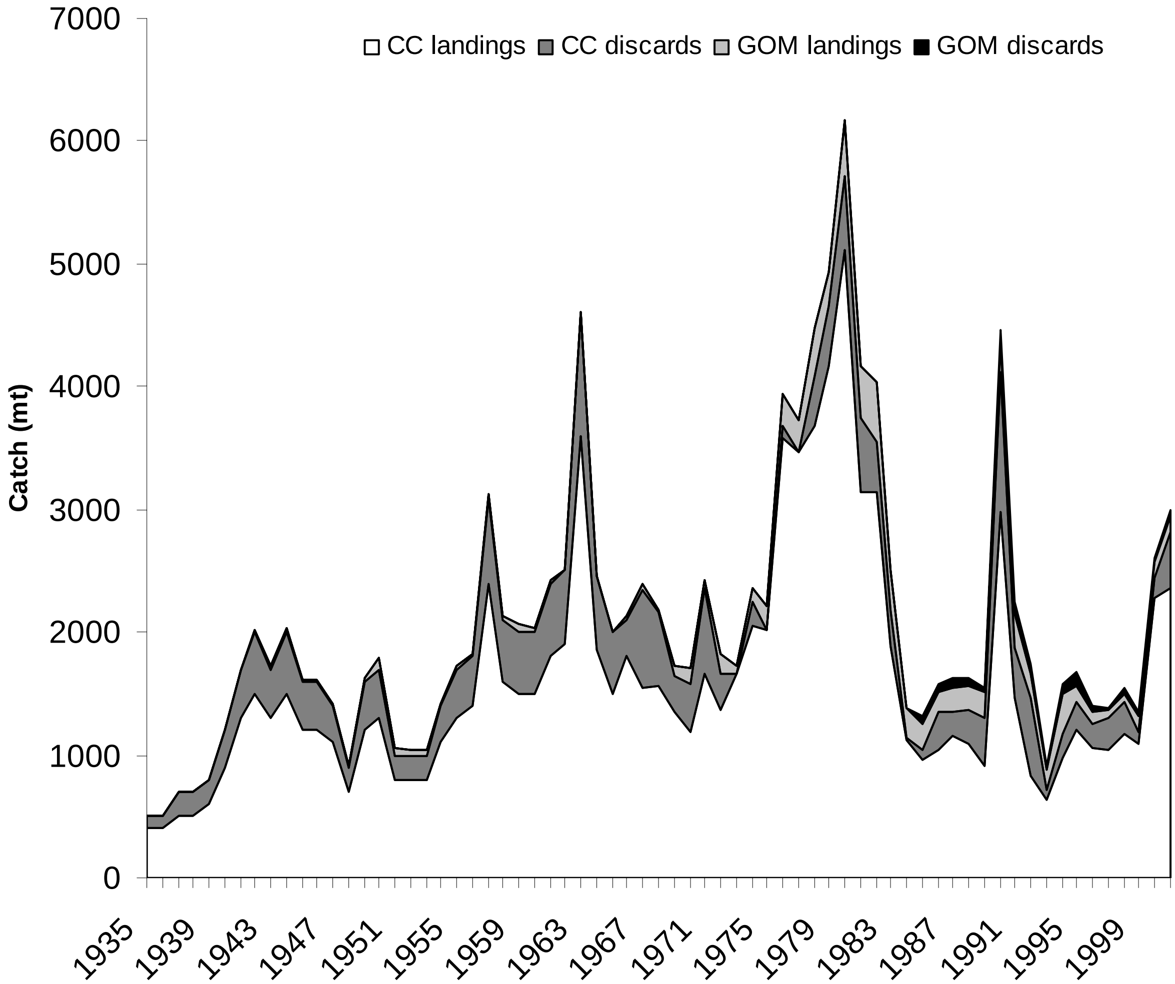


Figure A2.3. Total catch at age of Cape Cod – Gulf of Maine yellowtail flounder.

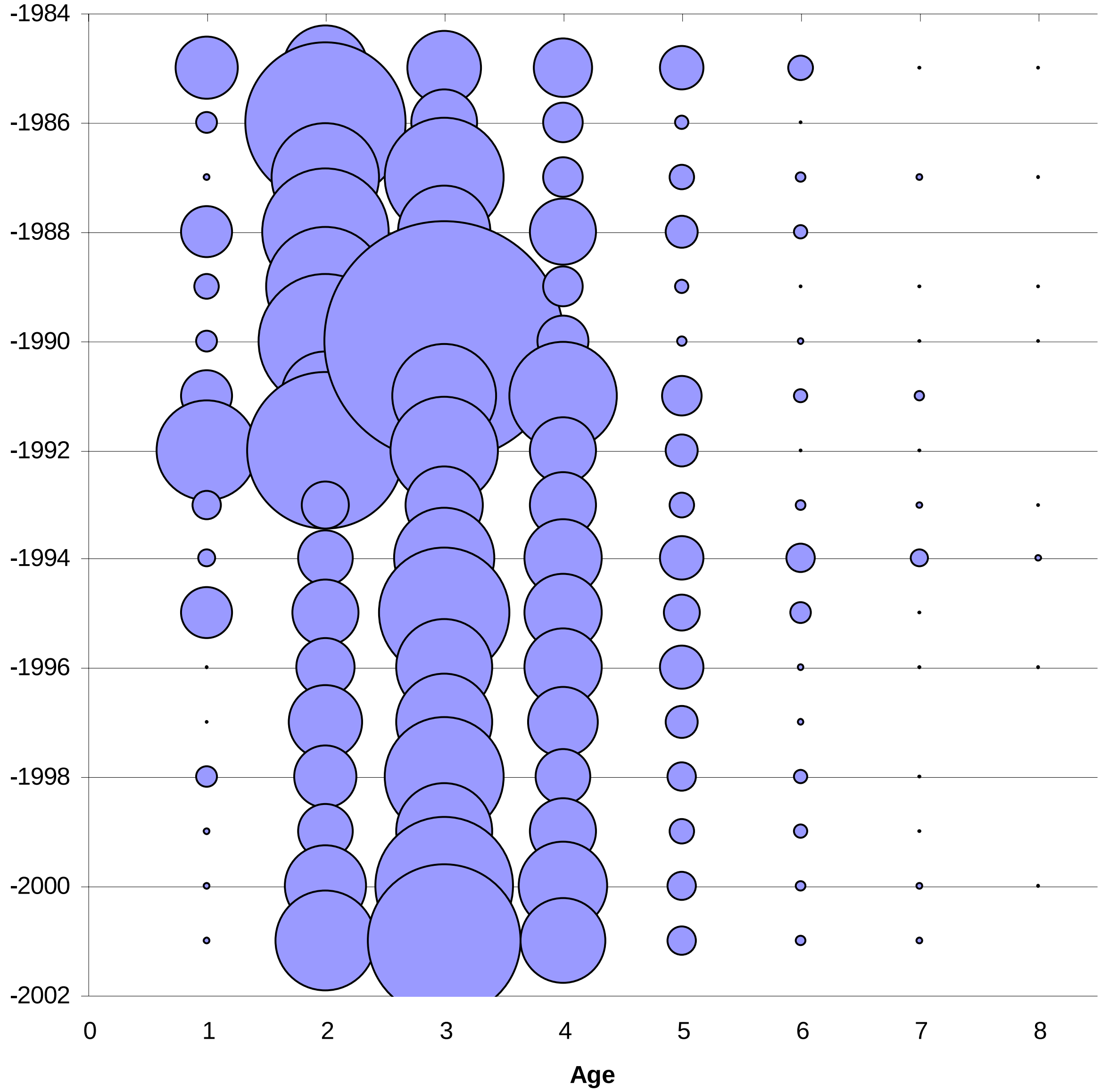


Figure A2.4. Mean weight at age of Cape Cod – Gulf of Maine yellowtail flounder catch.

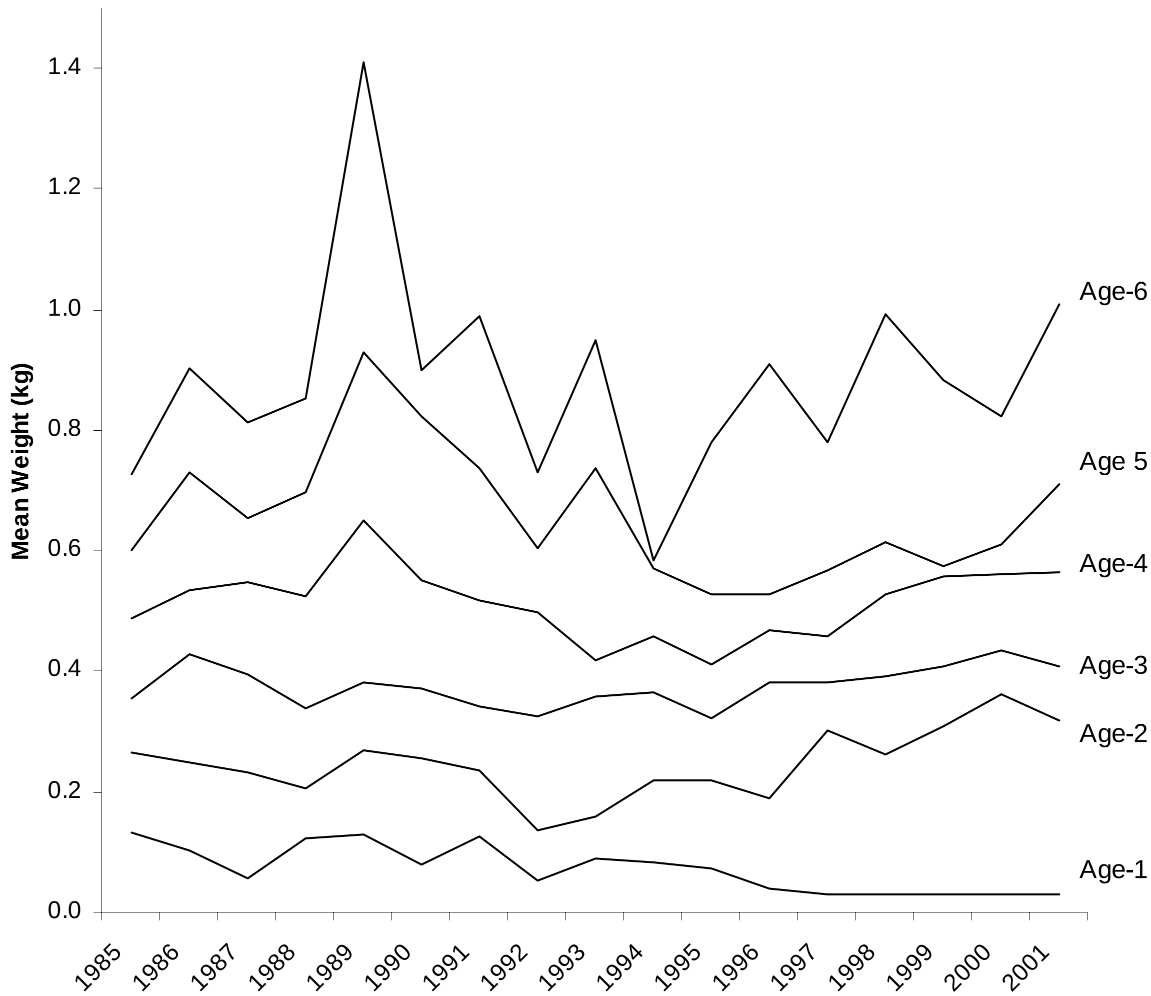


Figure A2.5. NEFSC survey strata used for Cape Cod – Gulf of Maine yellowtail flounder.

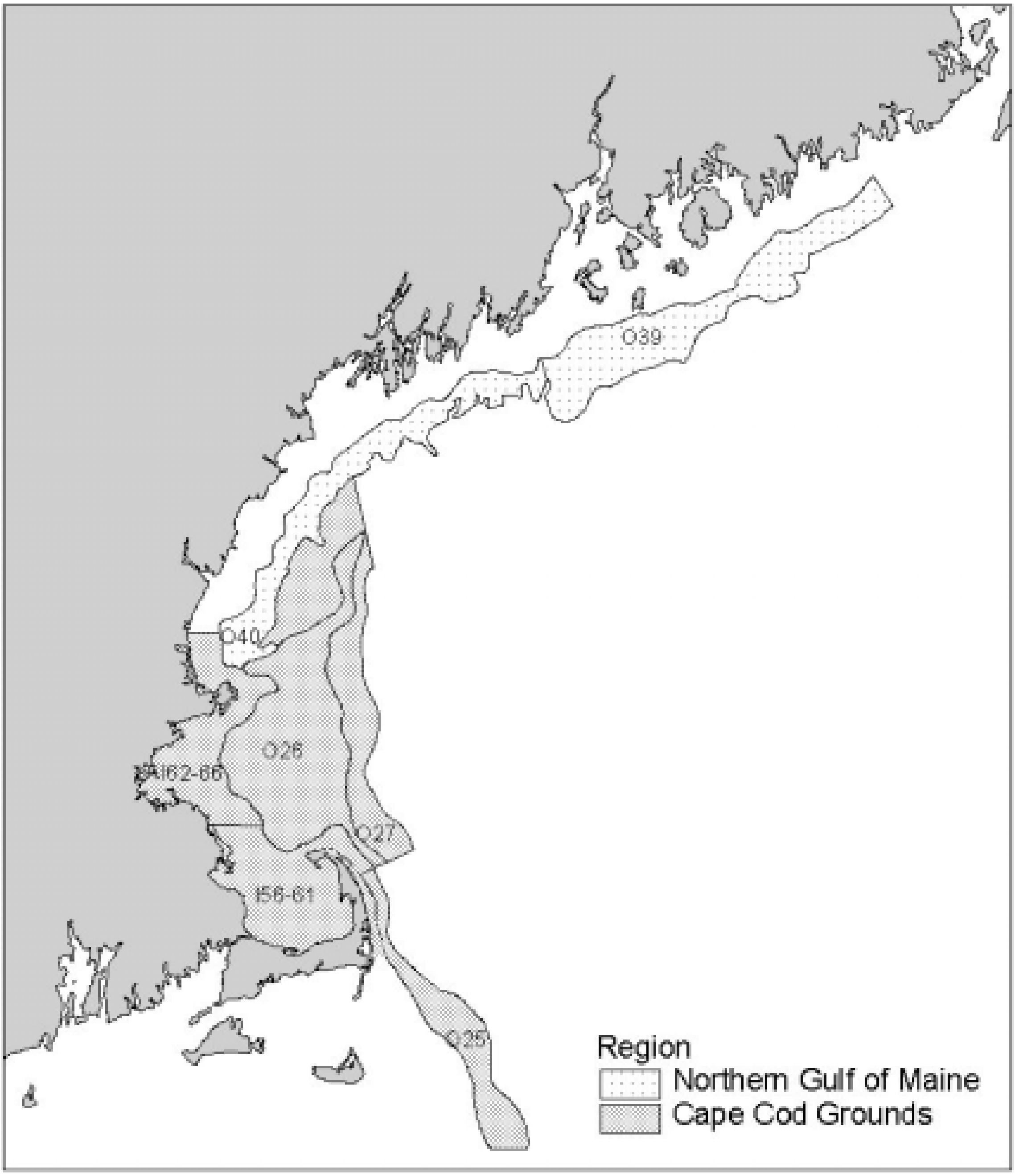


Figure A2.6a. Survey indices of Cape Cod – Gulf of Maine yellowtail flounder biomass.

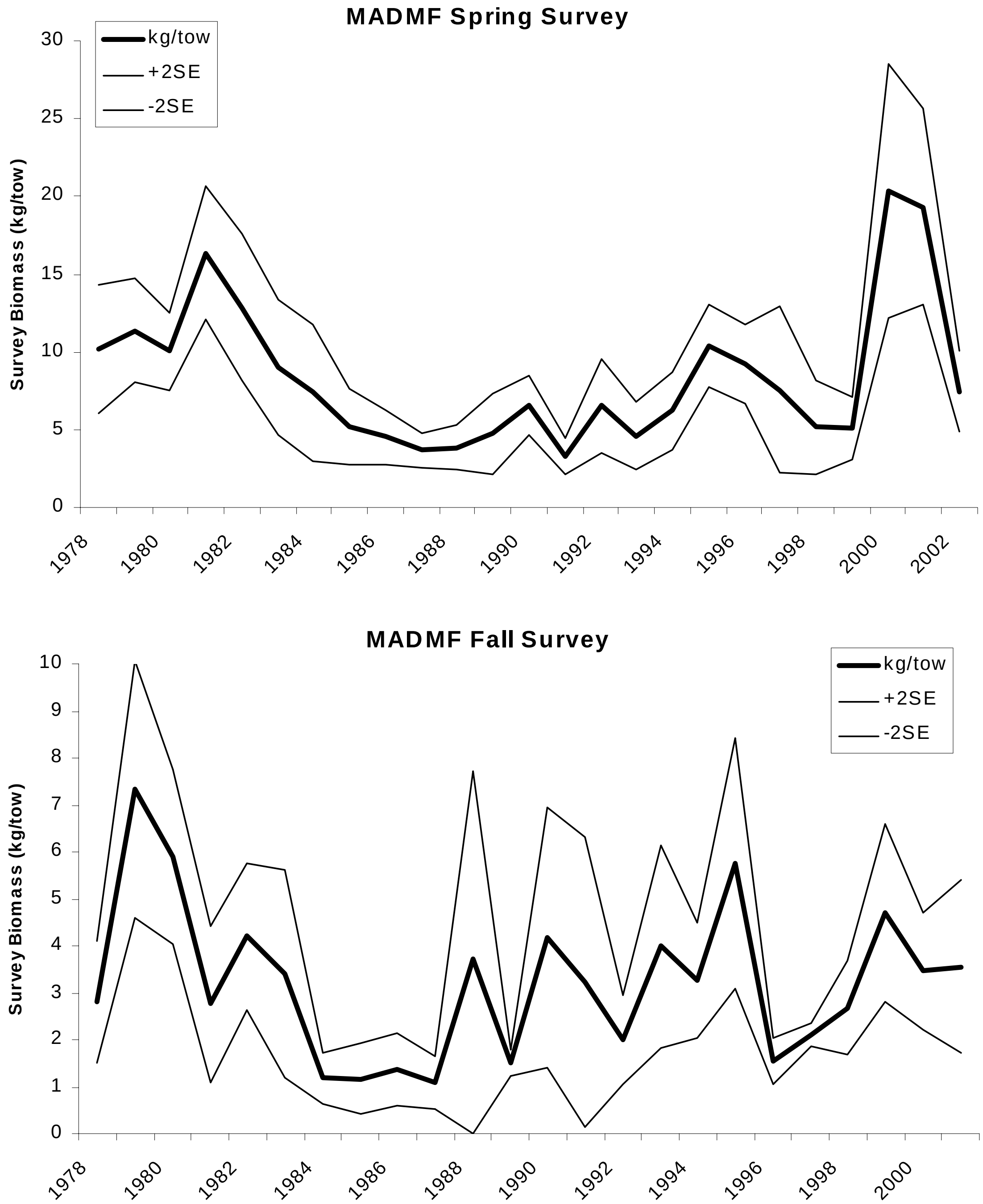
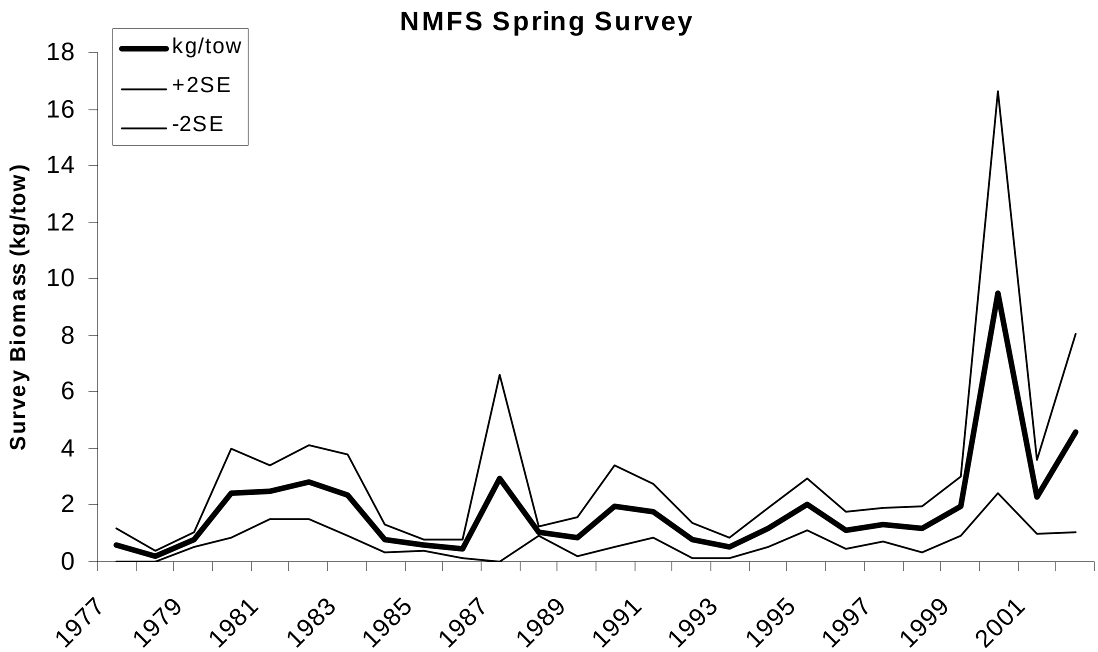


Figure A2.6b.


NMFS Spring Survey
kg/tow
+2SE
-2SE
Survey Biomass (kg/tow)
18
16
14
12
10
8
6
4
2
0
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001

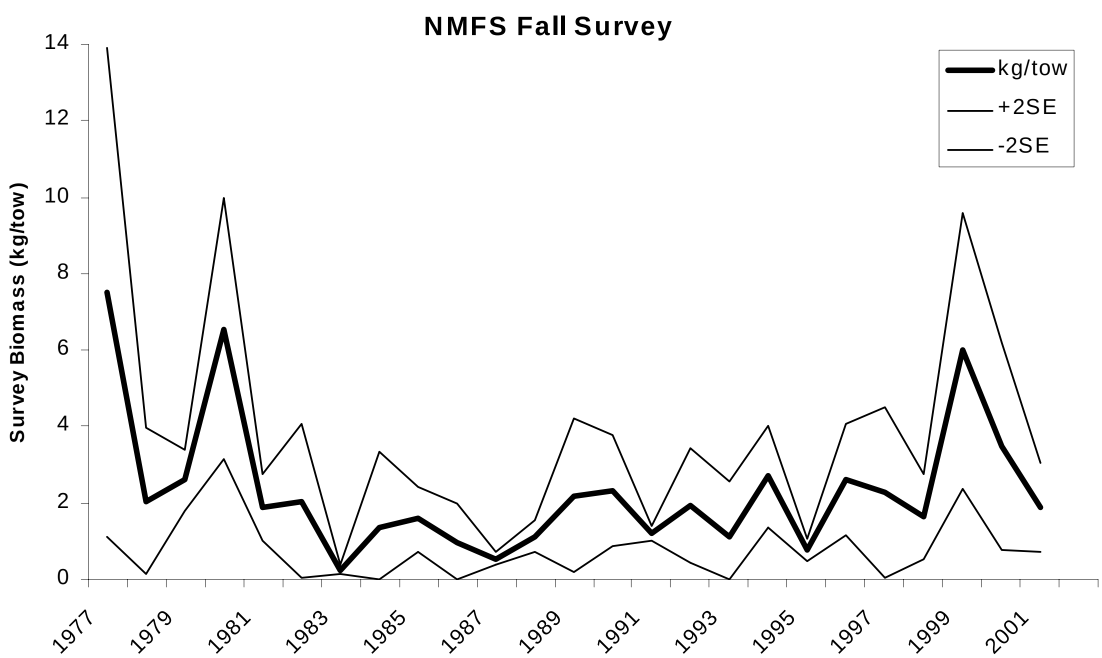

NMFS Fall Survey
kg/tow
+2SE
-2SE
Survey Biomass (kg/tow)
14
12
10
8
6
4
2
0
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001

Figure A2.7a. Distribution of yellowtail flounder from recent surveys.

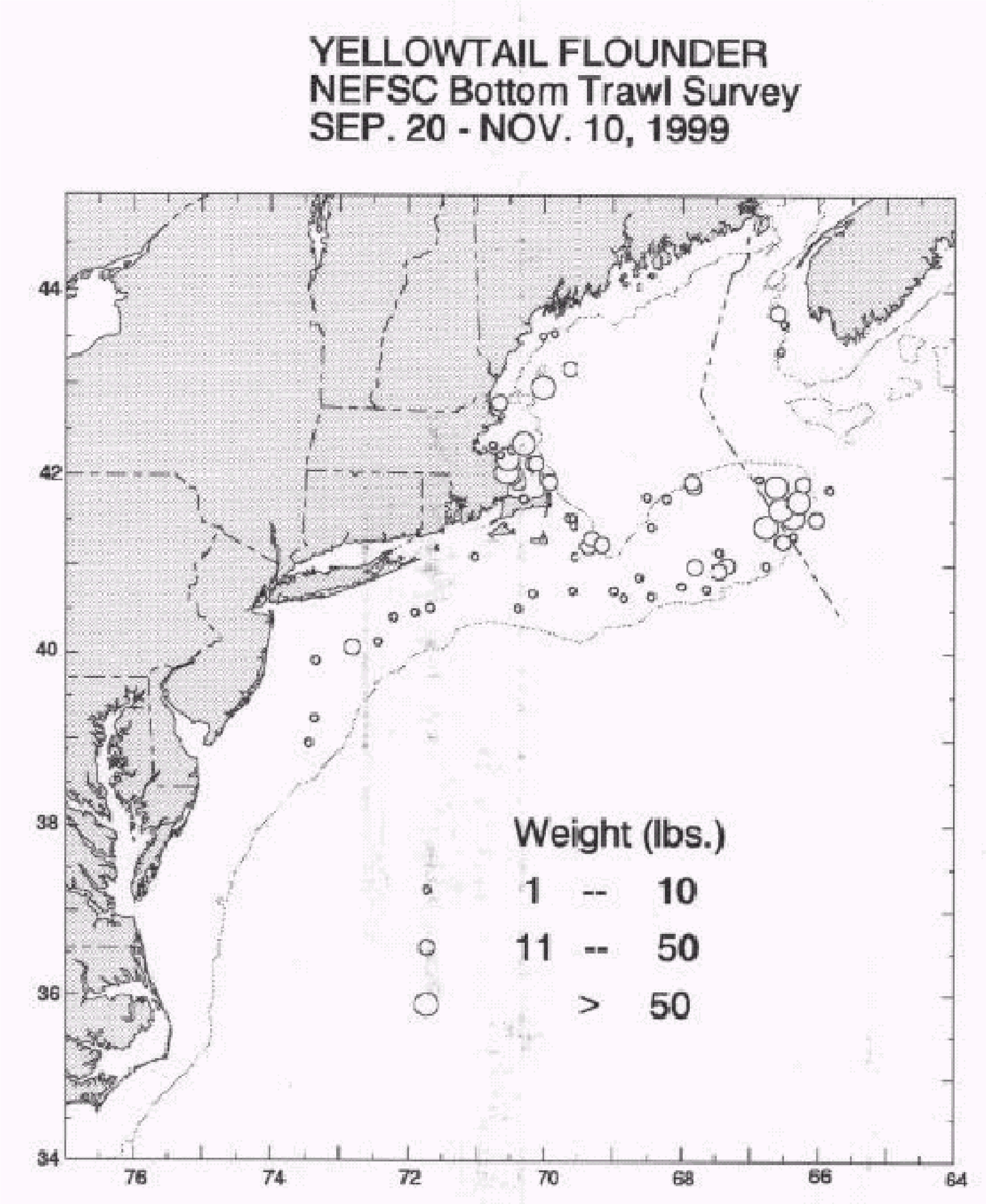


Figure A2.7b.

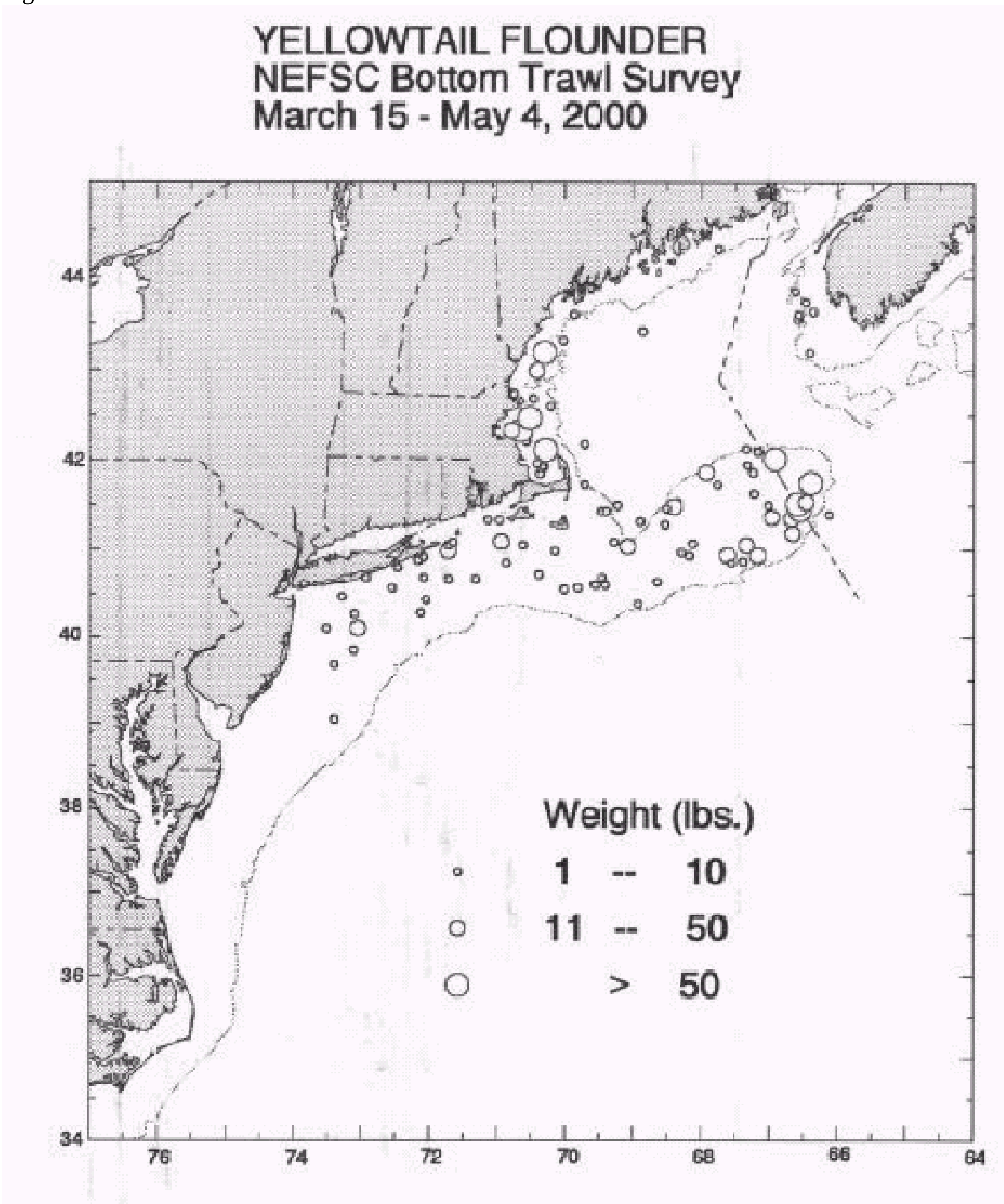

YELLOWTAIL FLOUNDER
NEFSC Bottom Trawl Survey
March 15 - May 4, 2000
Weight (lbs.)
1 -- 10
11 -- 50
> 50
44
42
40
38
36
34
76
74
72
70
68
66
64

Figure A2.8. Geographic distribution of area-swept biomass of Cape Cod – Gulf of Maine yellowtail flounder from the NEFSC fall survey (offshore strata only).

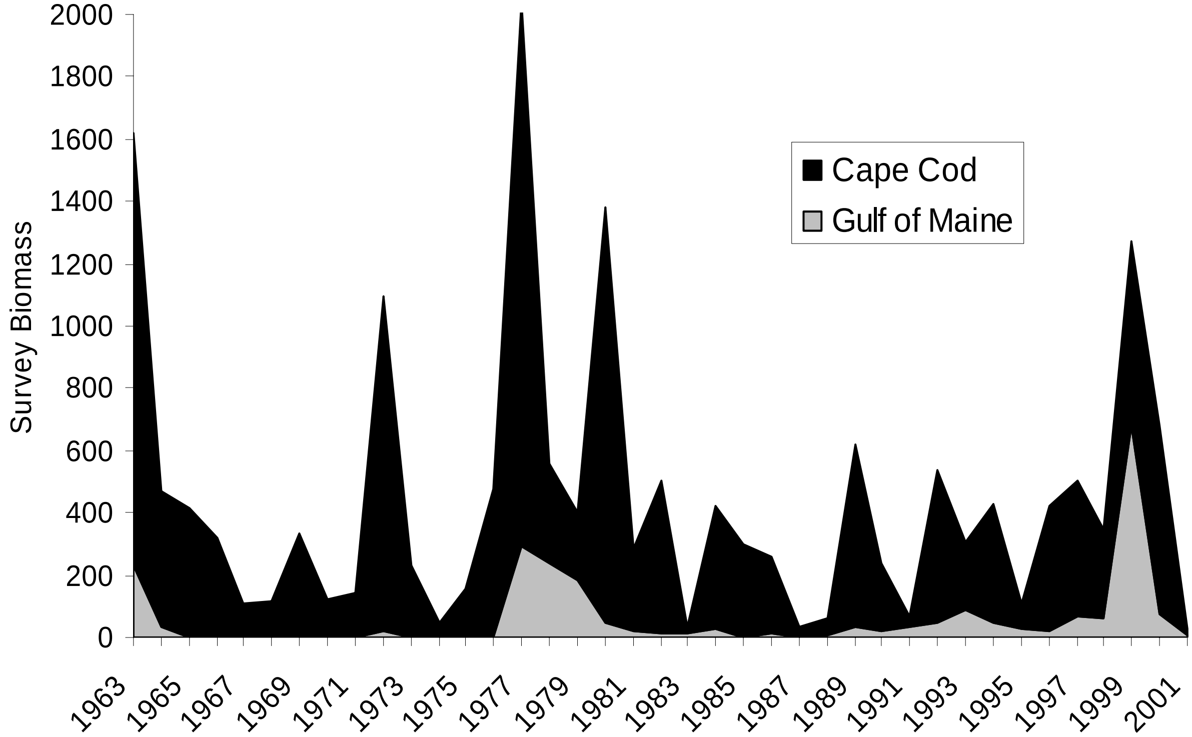


Figure A2.9a. Survey age distributions of Cape Cod – Gulf of Maine yellowtail flounder.

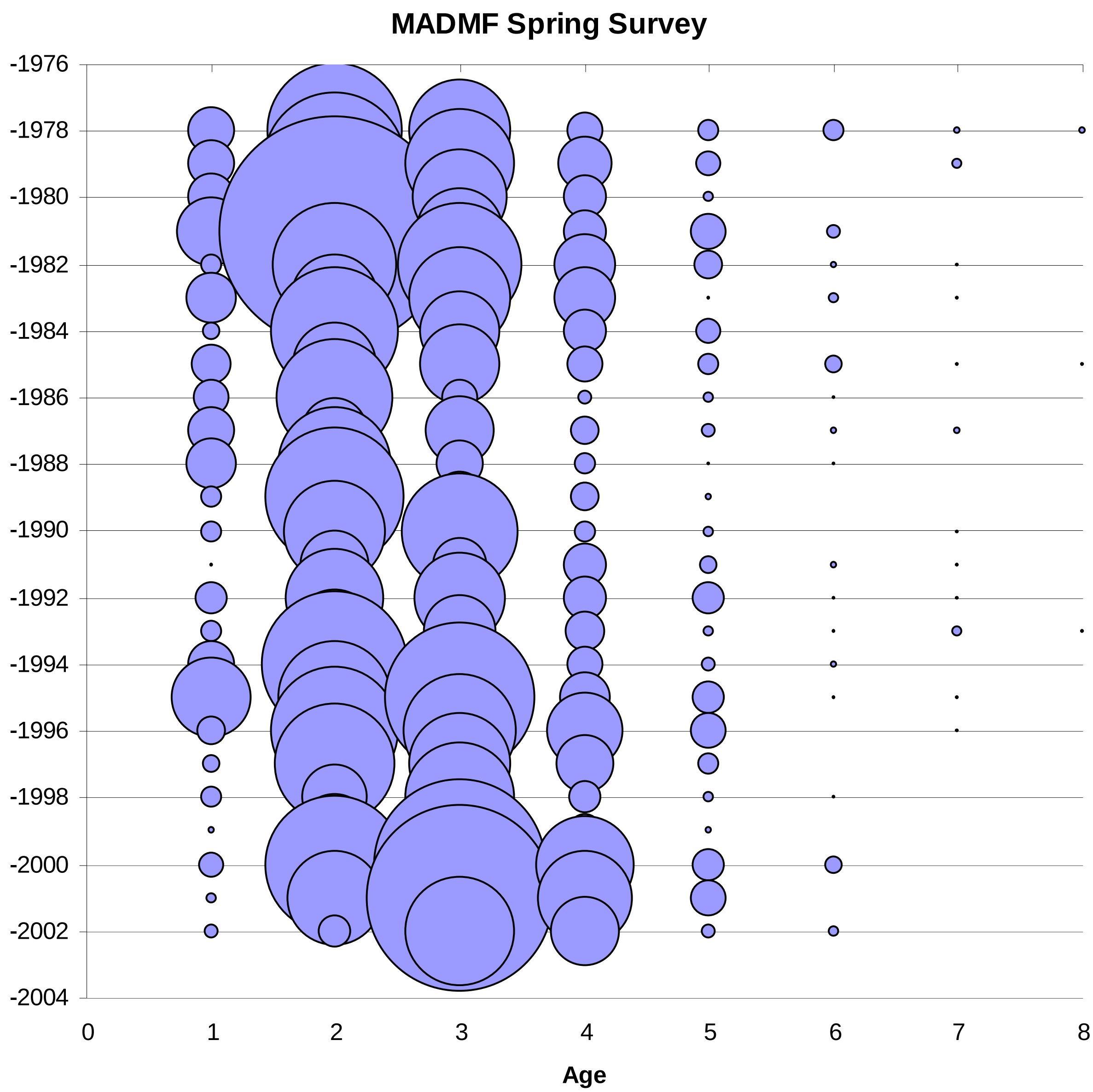


Figure A2.9b.

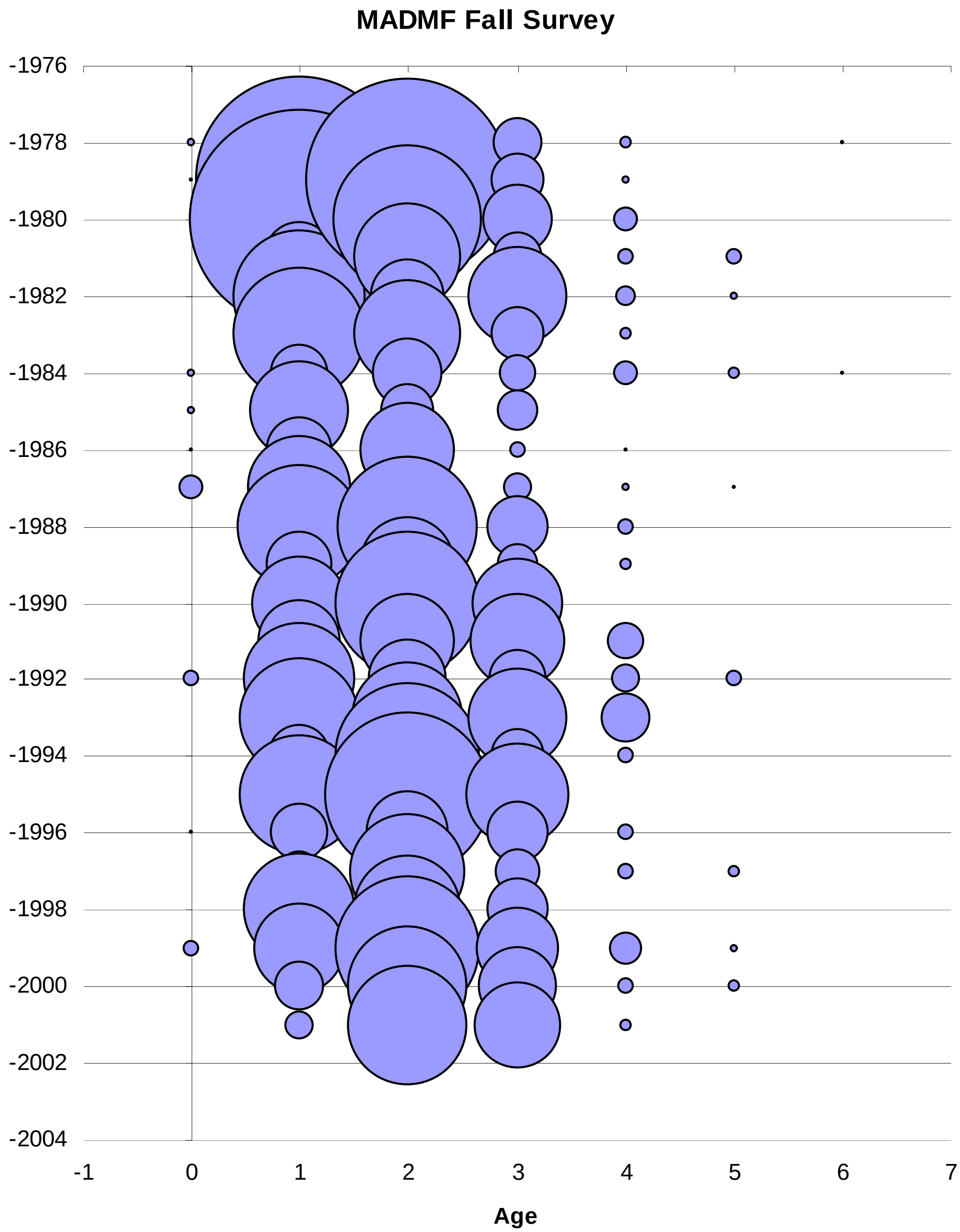

MADMF Fall Survey
-1976
-1978
-1980
-1982
-1984
-1986
-1988
-1990
-1992
-1994
-1996
-1998
-2000
-2002
-2004
-1
0
1
2
3
4
5
6
7
Age

Figure A2.9c.

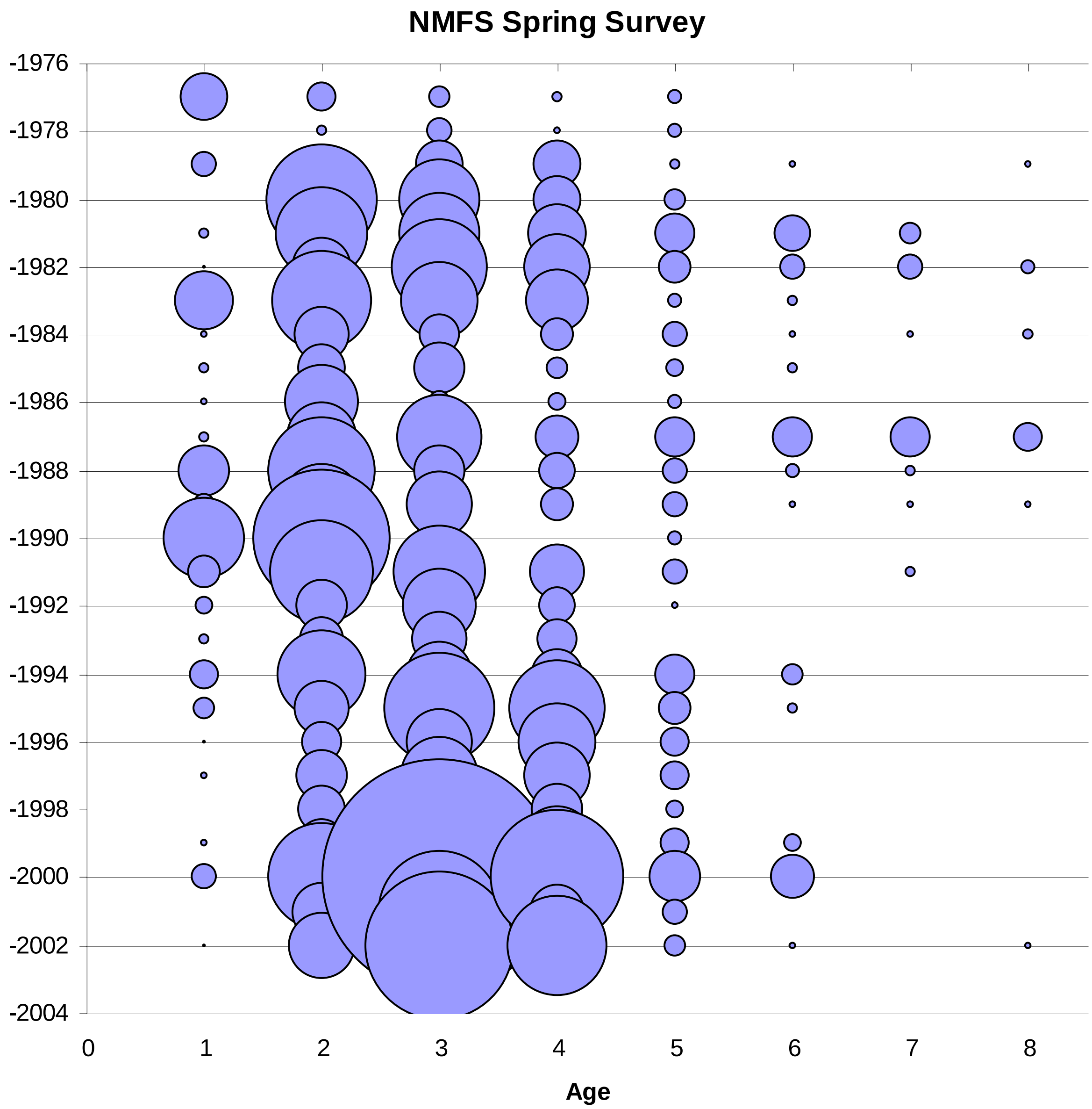

NMFS Spring Survey
-1976
-1978
-1980
-1982
-1984
-1986
-1988
-1990
-1992
-1994
-1996
-1998
-2000
-2002
-2004
0
1
2
3
4
5
6
7
8
Age

Figure A2.9d.

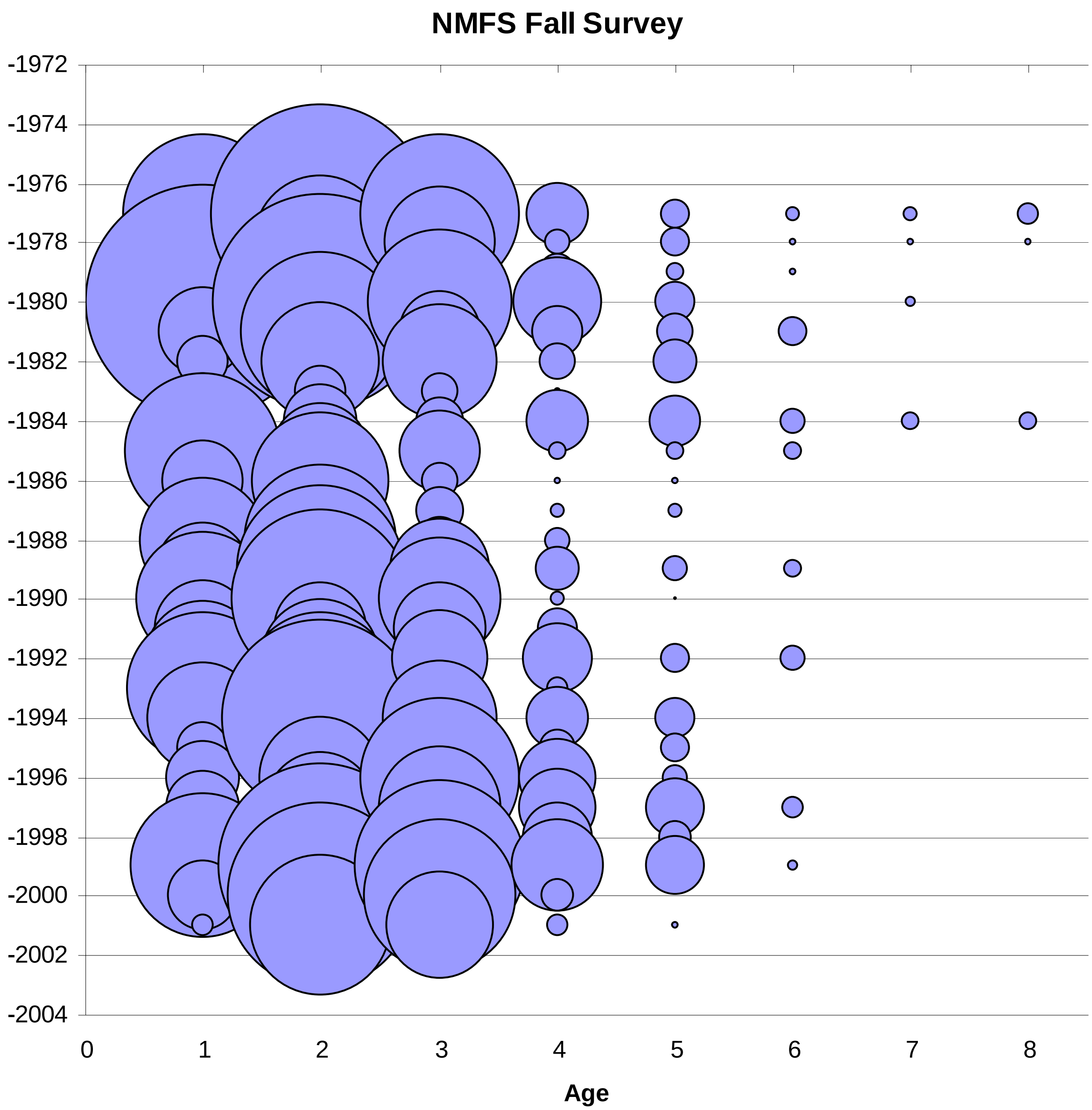

NMFS Fall Survey
-1972
-1974
-1976
-1978
-1980
-1982
-1984
-1986
-1988
-1990
-1992
-1994
-1996
-1998
-2000
-2002
-2004
0
1
2
3
4
5
6
7
8
Age

Figure A2.10. Normalized indices of abundance of Cape Cod – Gulf of Maine yellowtail flounder.

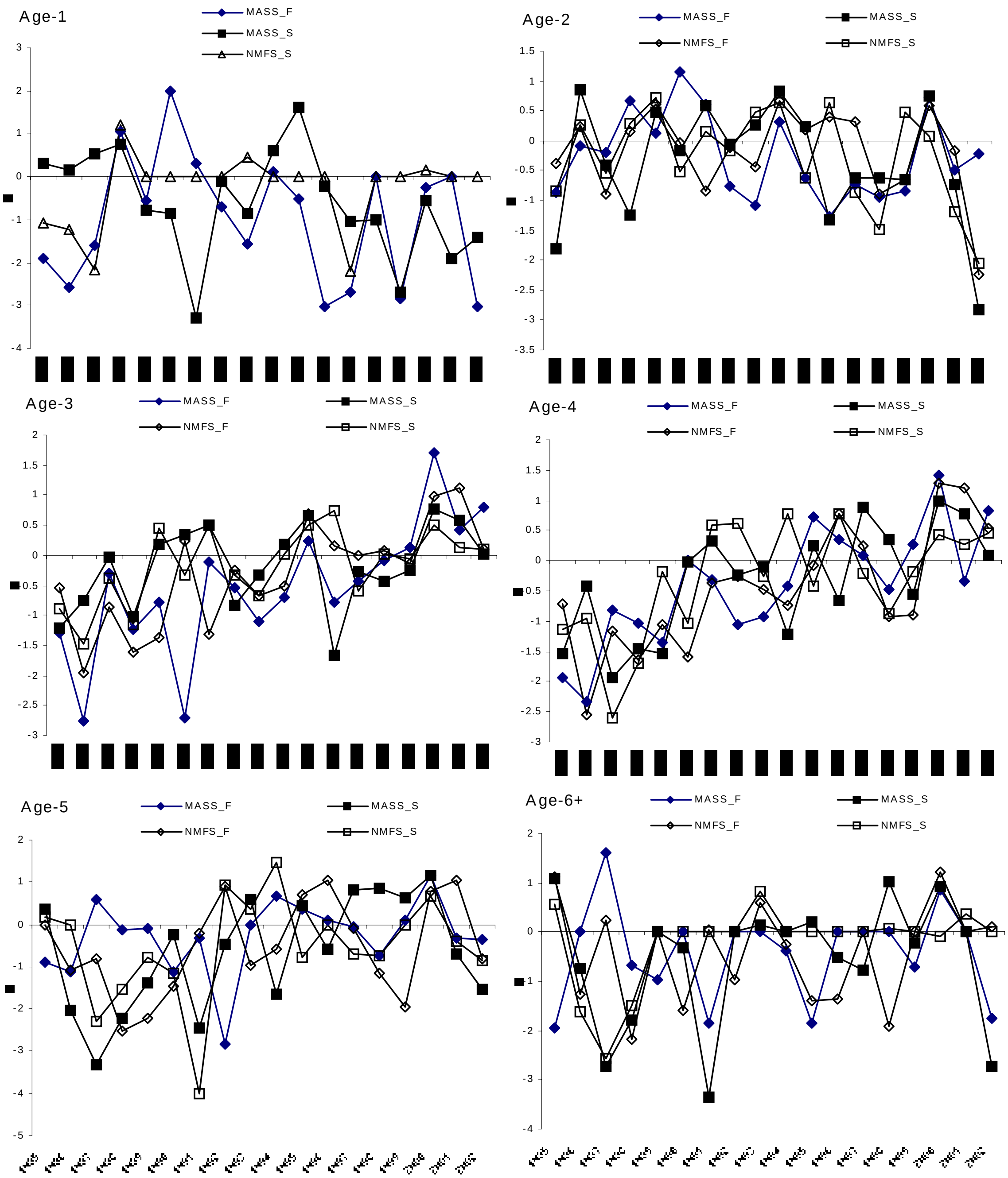


Figure A2.11. Residuals of the Cape Cod – Gulf of Maine yellowtail flounder ADAPT calibration.

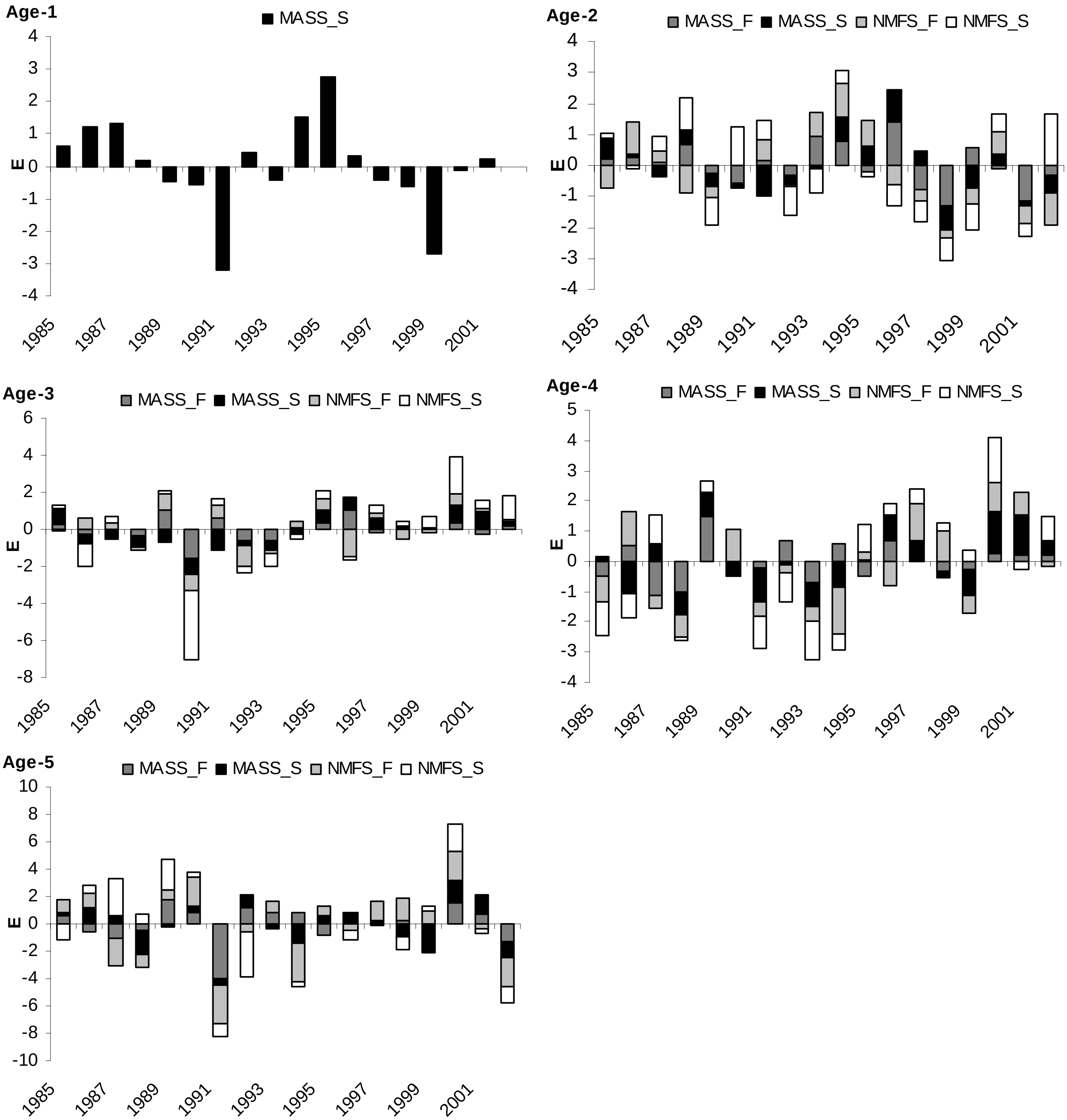


Figure A2.12. Results of the Cape Cod – Gulf of Maine VPA.

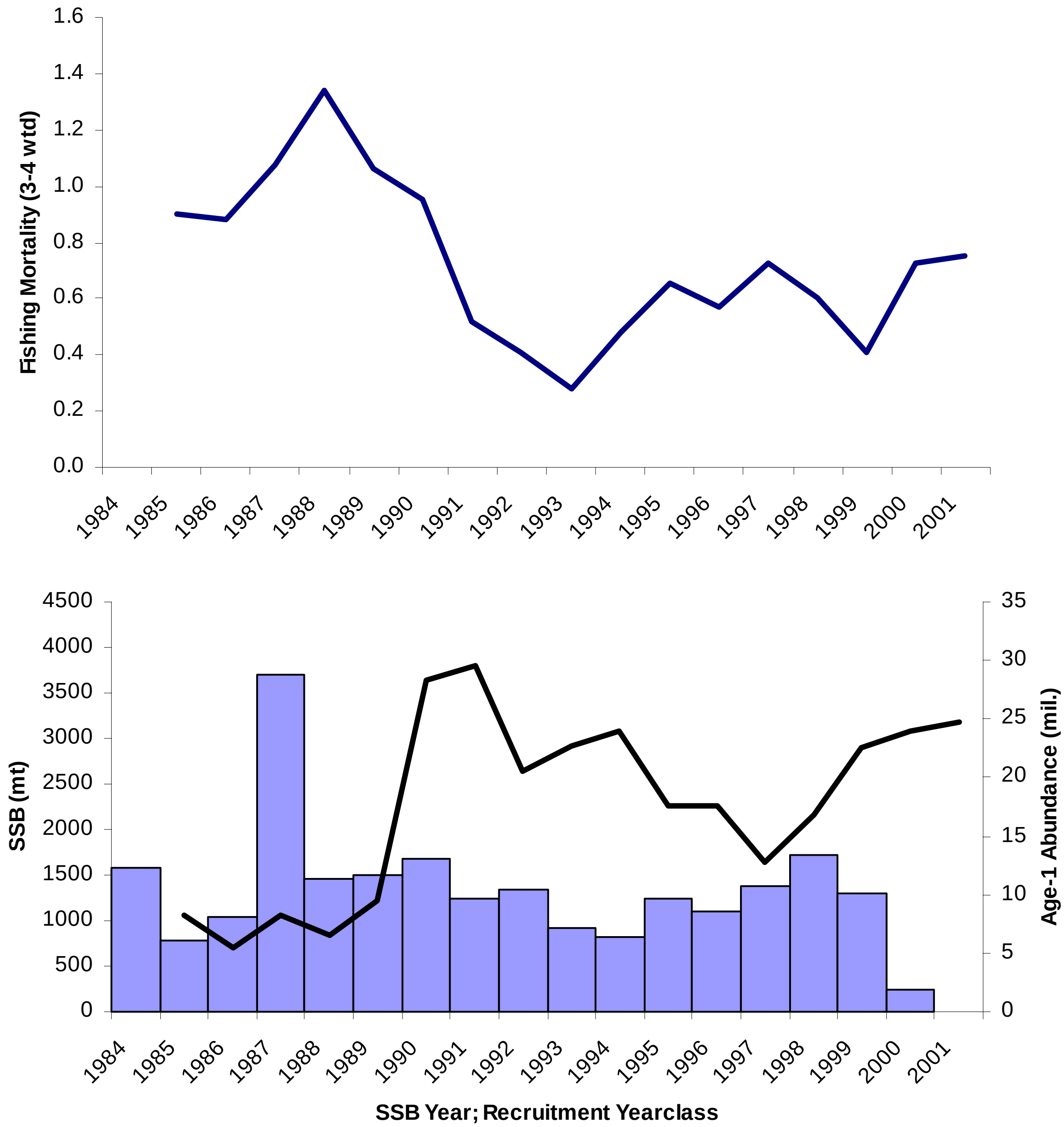


Figure A2.12b. Stock and recruitment of Cape Cod – Gulf of Maine yellowtail flounder (extreme points labeled by yearclass).

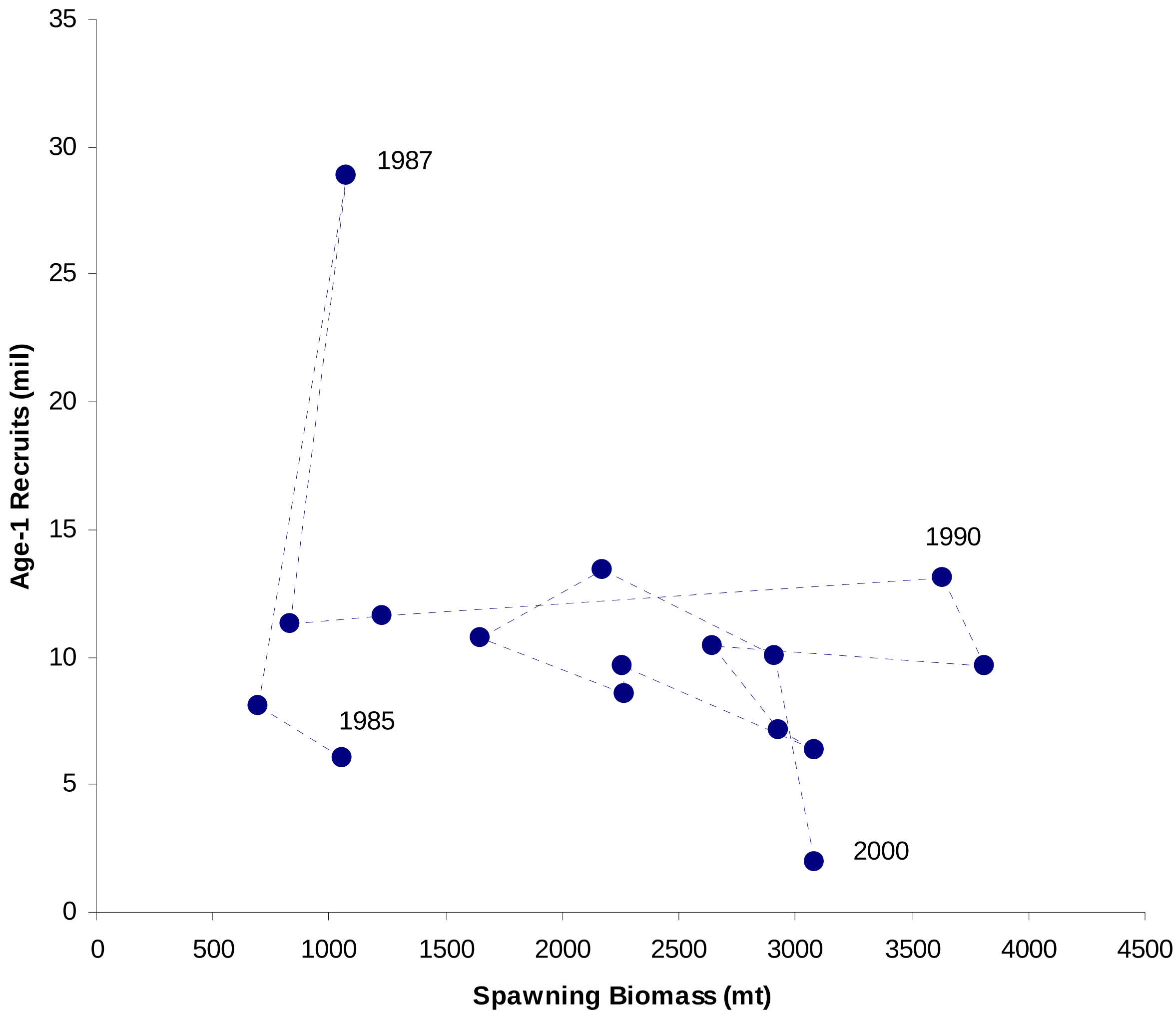


Figure A2.12c. Abundance at age of Cape Cod – Gulf of Maine yellowtail flounder.

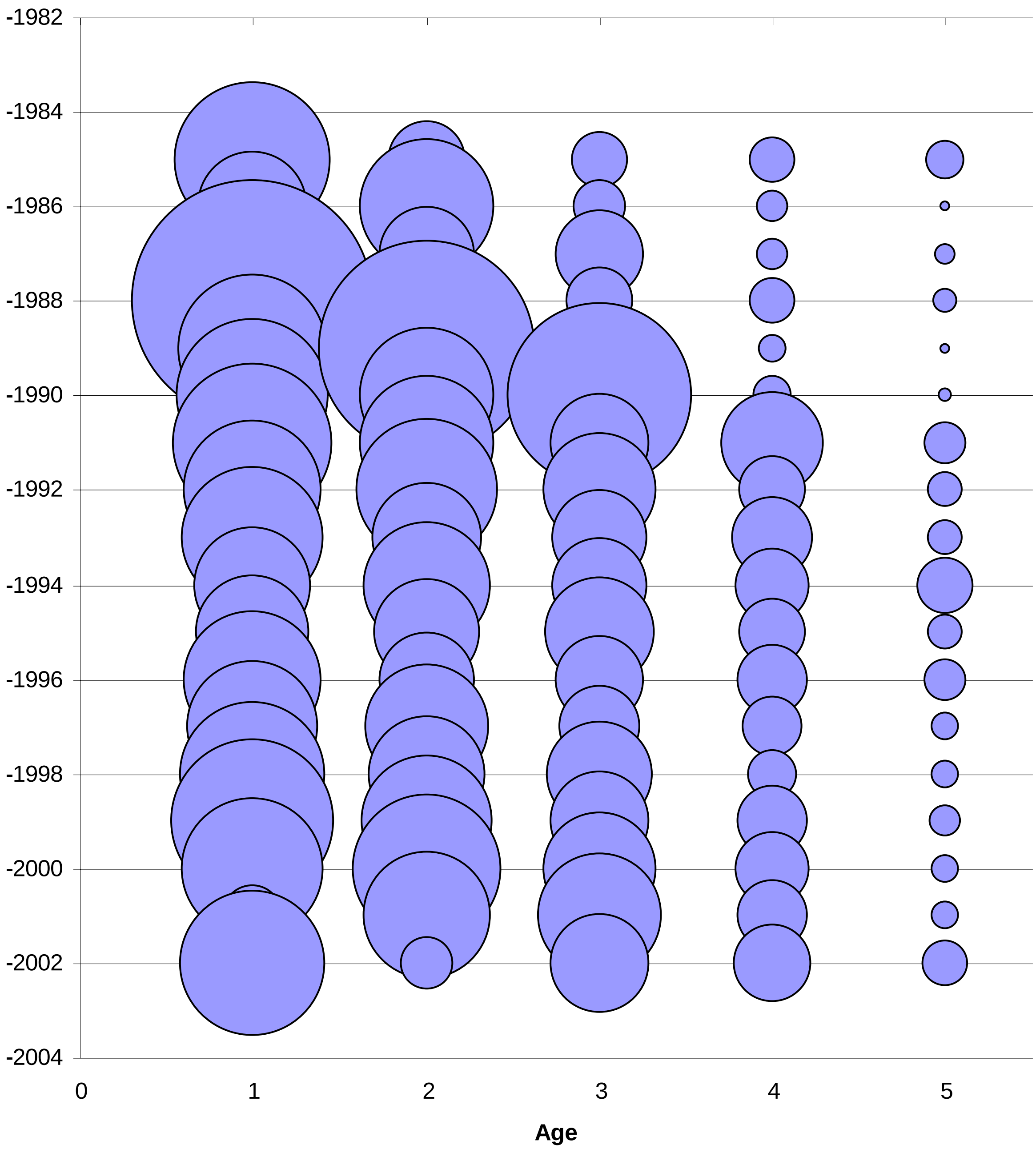


Figure A2.13. Retrospective analysis of the Cape Cod – Gulf of Maine yellowtail flounder VPA.

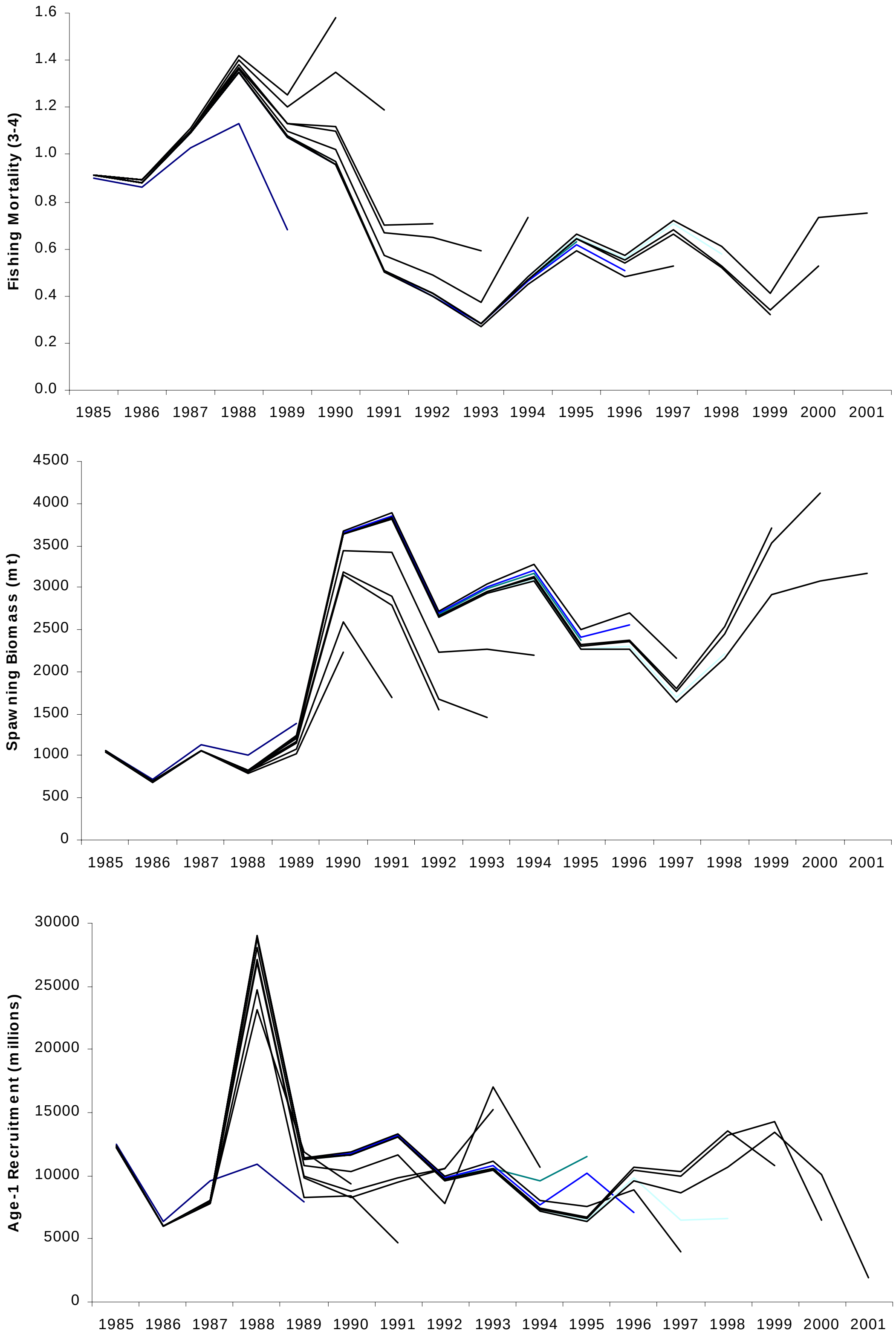


Figure A2.14. Yield and spawning biomass per recruit of Cape Cod – Gulf of Maine yellowtail flounder.

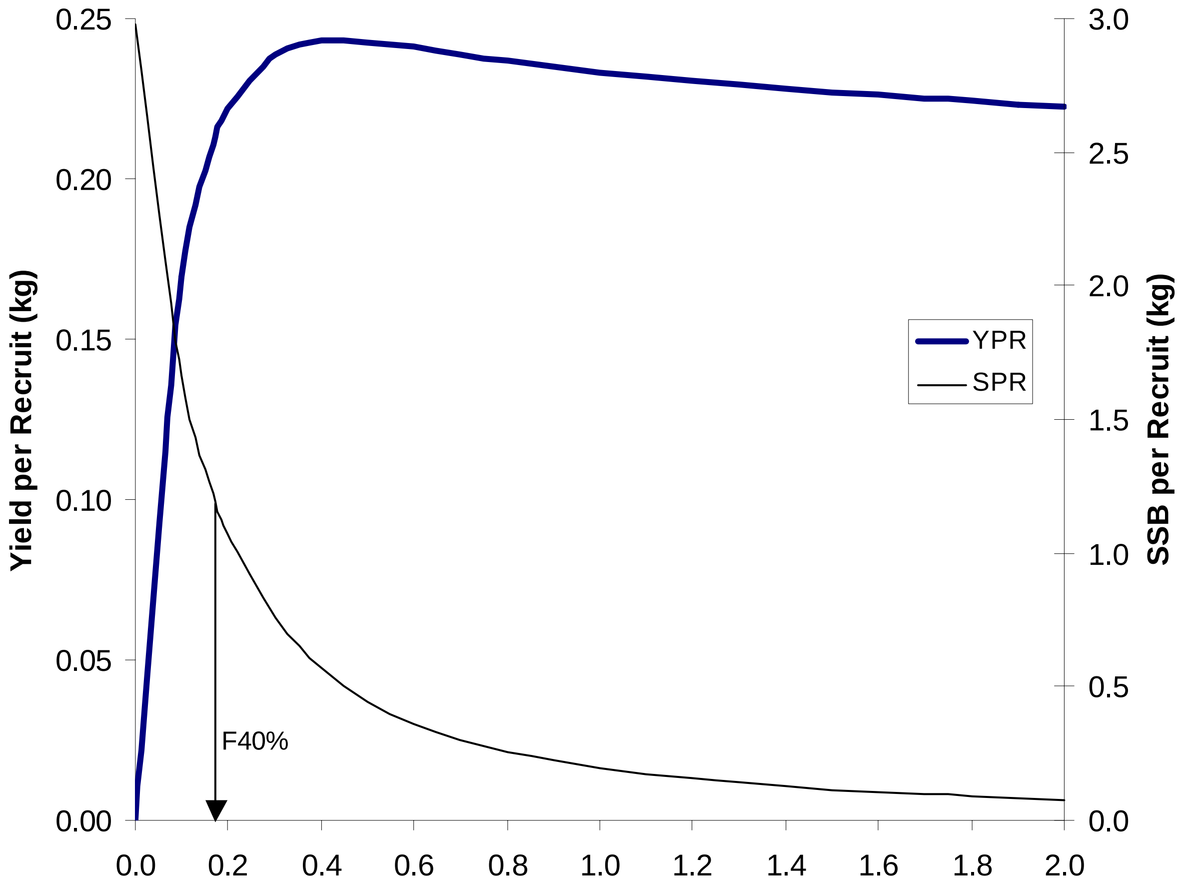


Figure A2.15. Observed and expected age distribution of spawning biomass at $F_{40\%}$ for Cape Cod-Gulf of Maine yellowtail flounder.

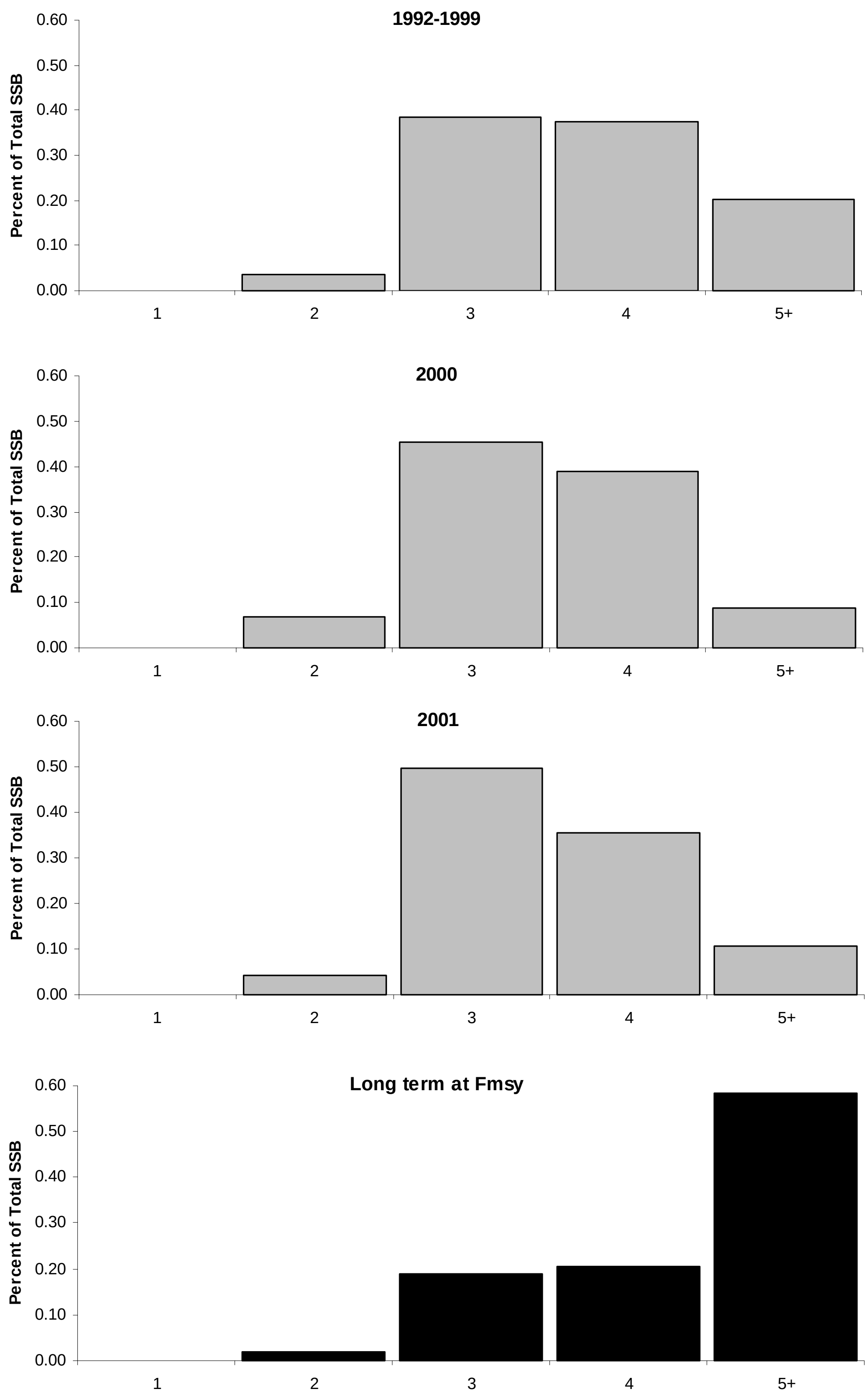
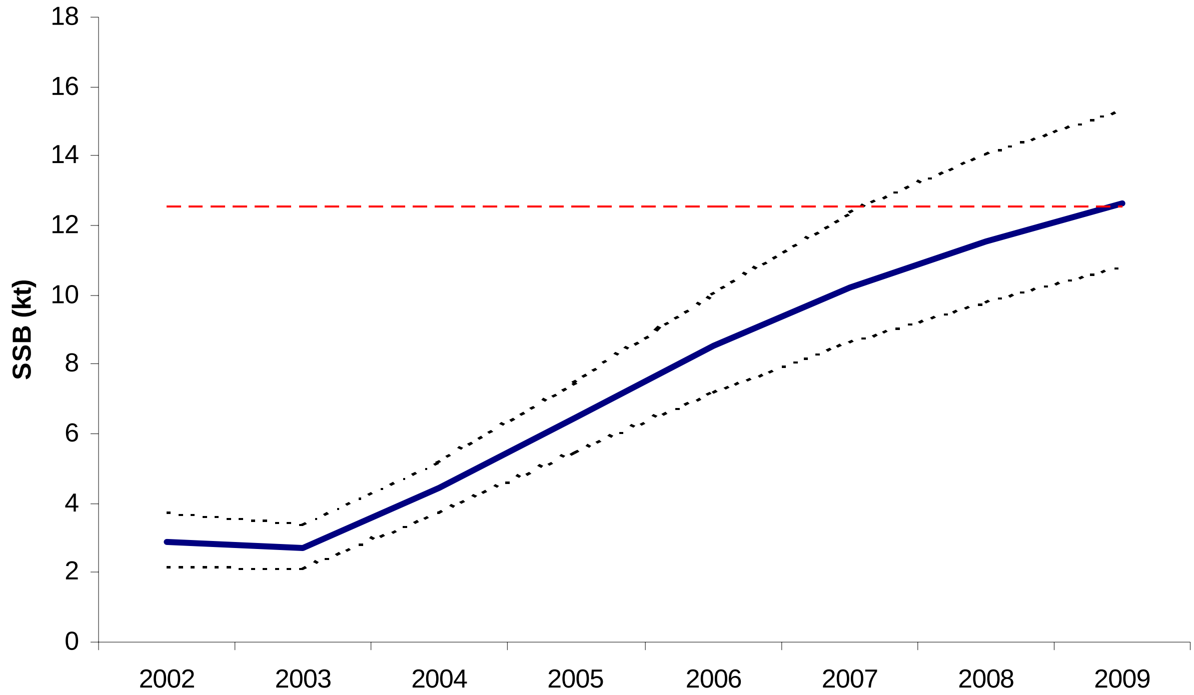


Figure A2.16. Stochastic projection of Cape Cod- Gulf of Maine yellowtail flounder spawning biomass (upper panel) and landings (lower panel) at 2002 F = 0.64 and 2003-2009 F=0.03; dotted lines indicate 90% confidence limits and the horizontal dashed line indicates SSB_{MSY}).



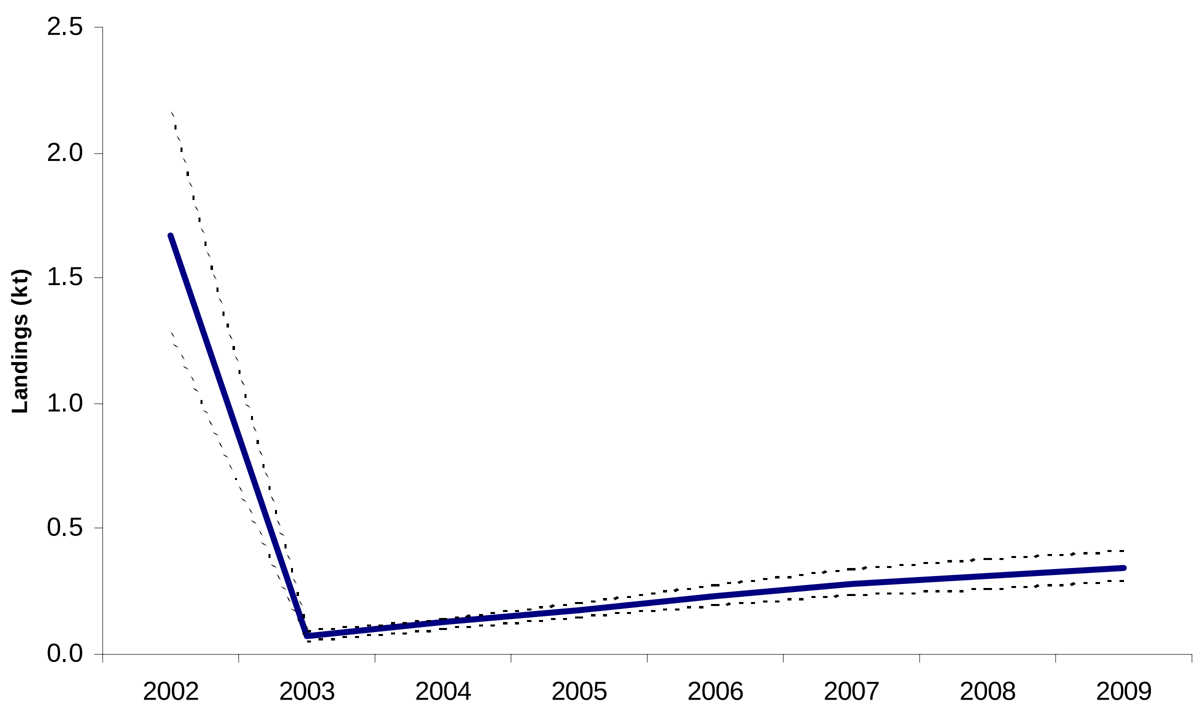


Figure A2.17. Length distribution of Cape Cod – Gulf of Maine yellowtail flounder by decade, from offshore survey strata 25, 27, 39 and 40.

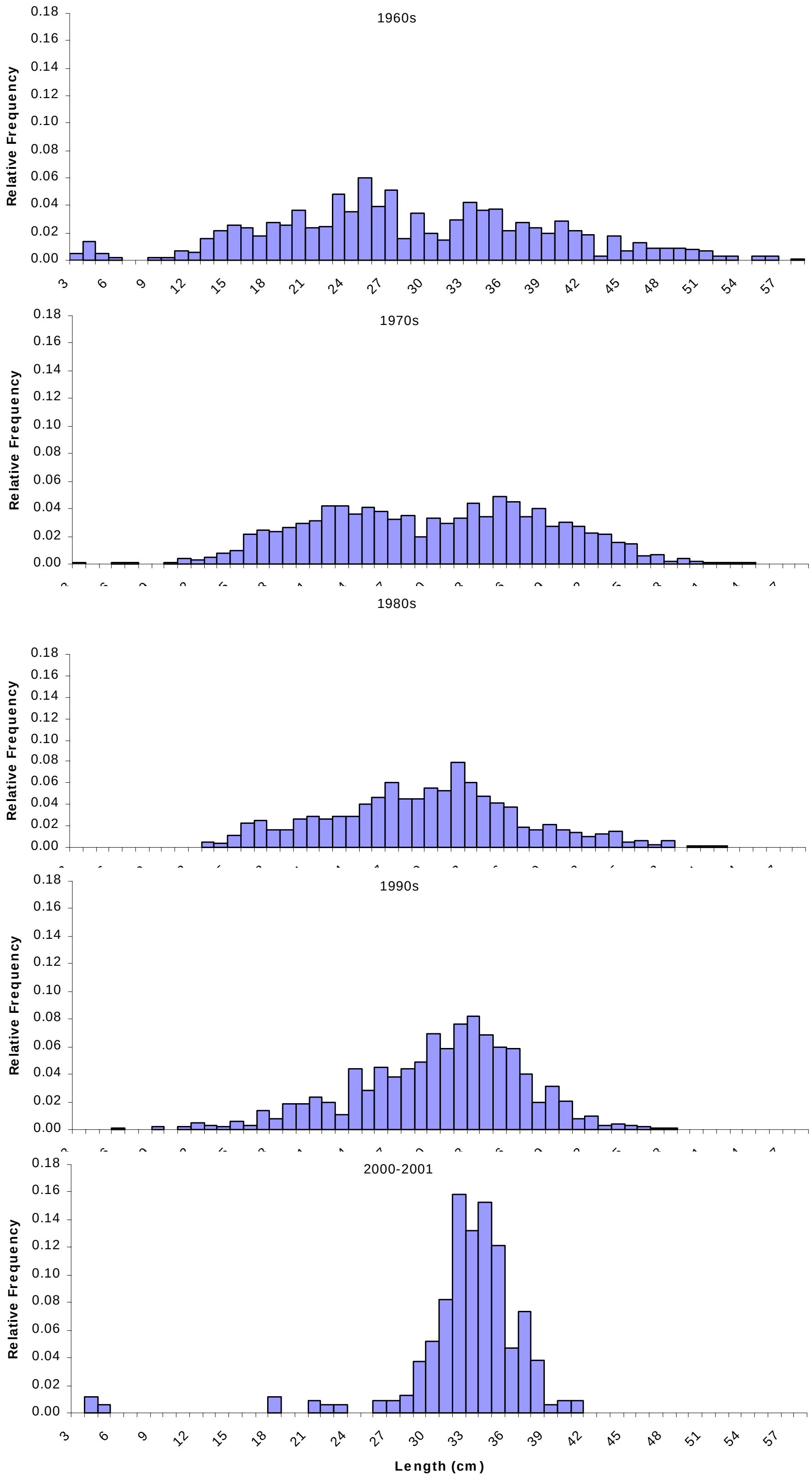


Figure A2.18a. Length distribution of Cape Cod – Gulf of Maine yellowtail flounder by decade, from the Massachusetts spring survey.

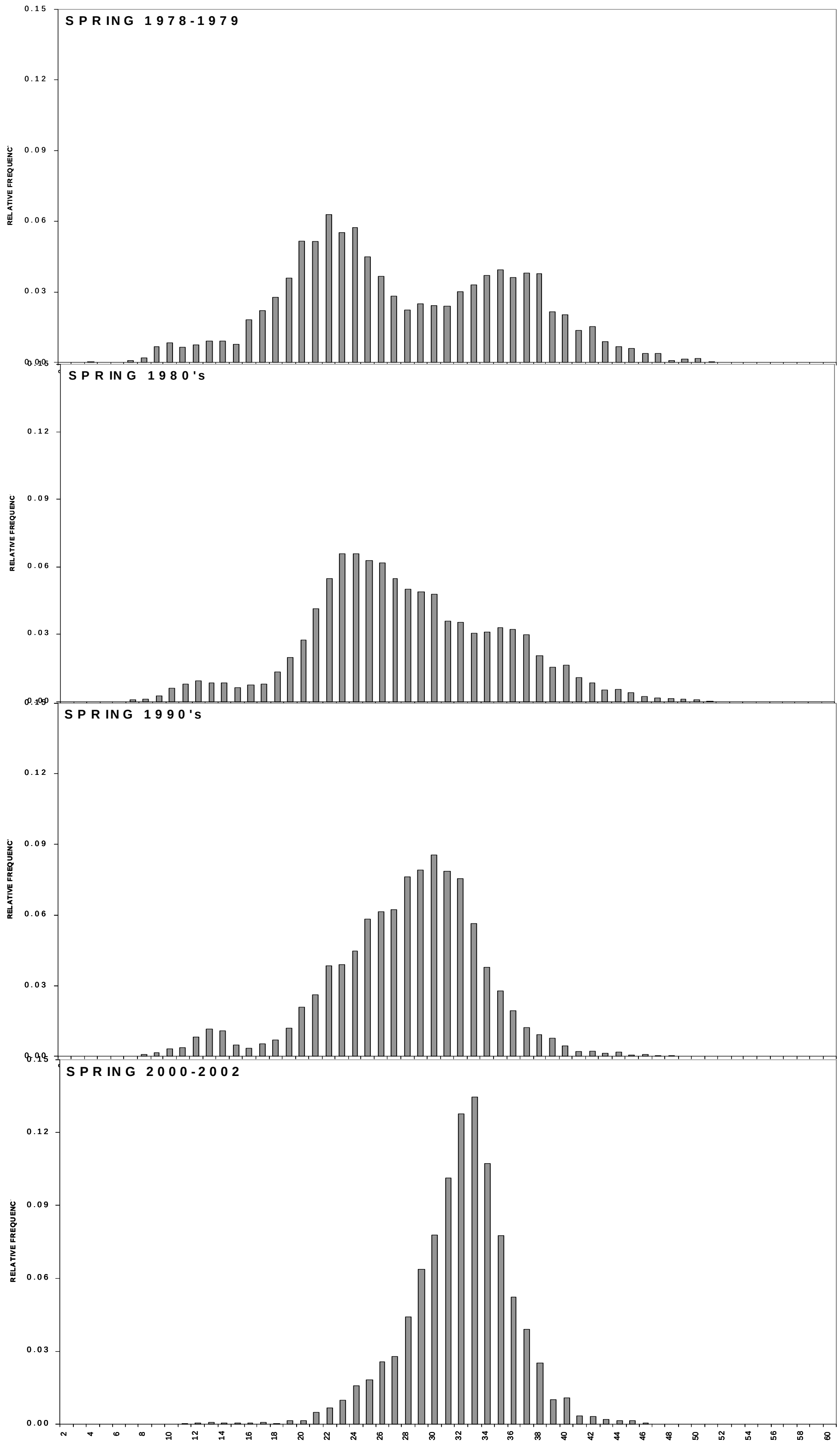


Figure A2.18b. Length distribution of Cape Cod – Gulf of Maine yellowtail flounder by decade, from the Massachusetts fall survey.

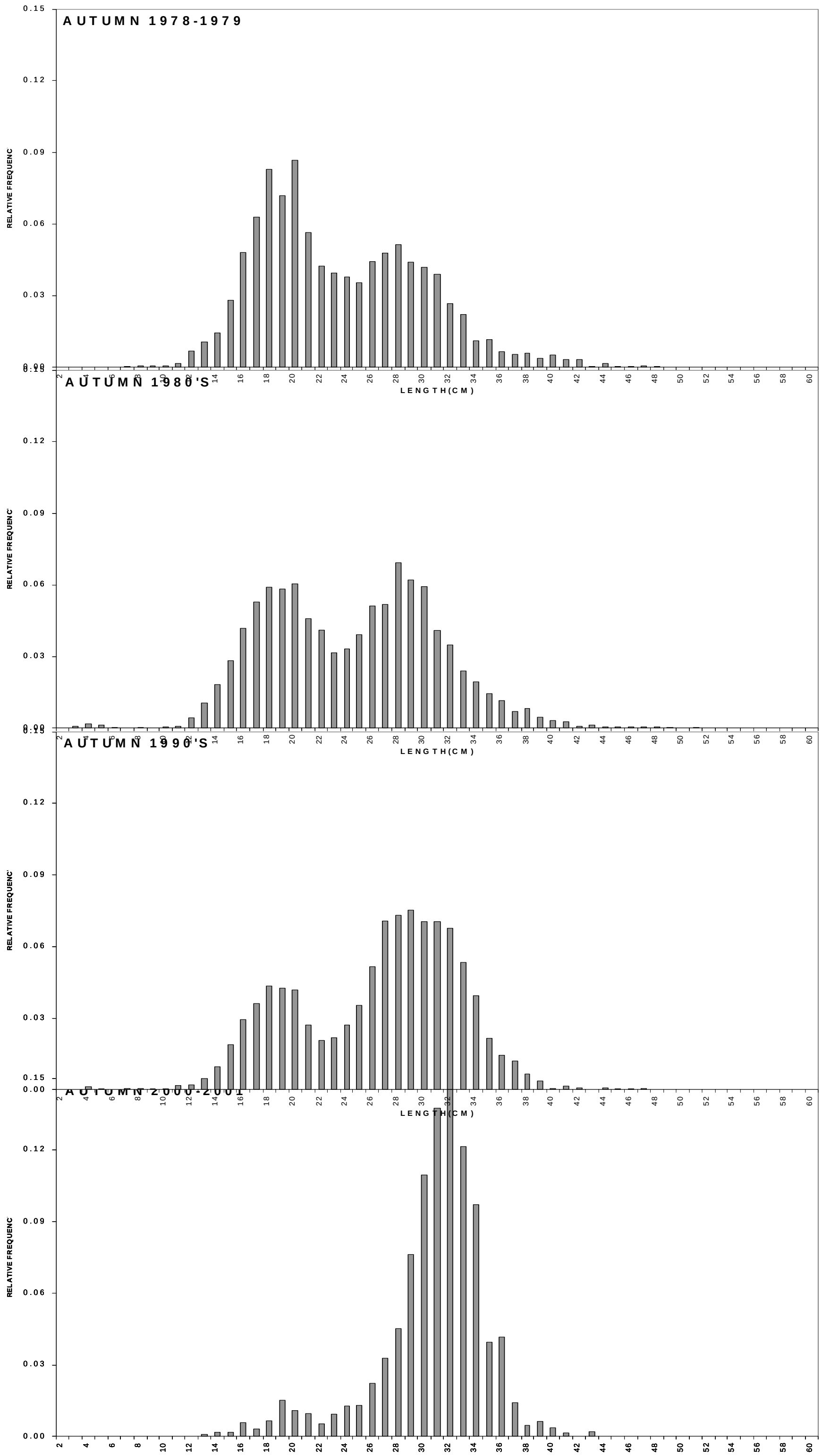


Figure A2.19. Size distribution of yellowtail flounder sampled from the inshore Gulf of Maine (NEFSC summer surveys, 1978-1981).

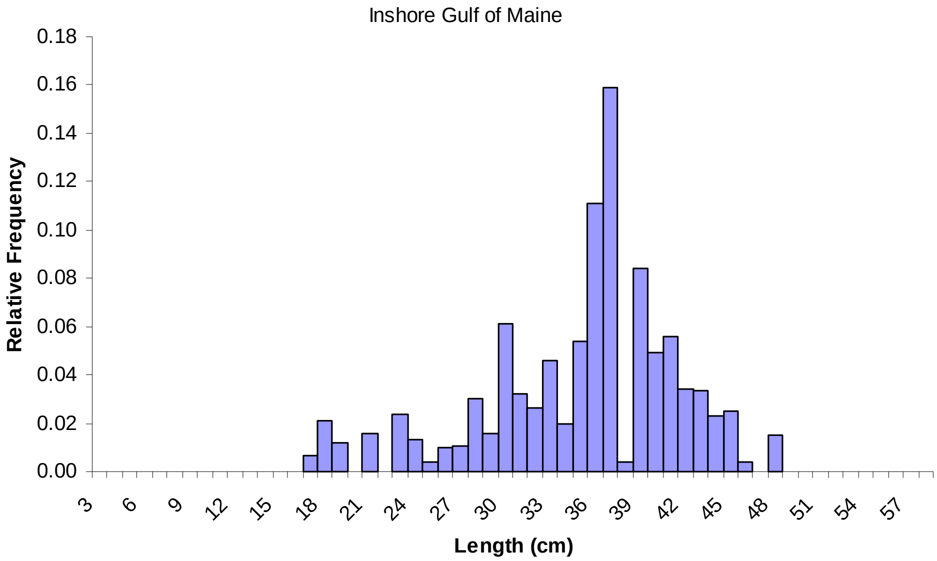
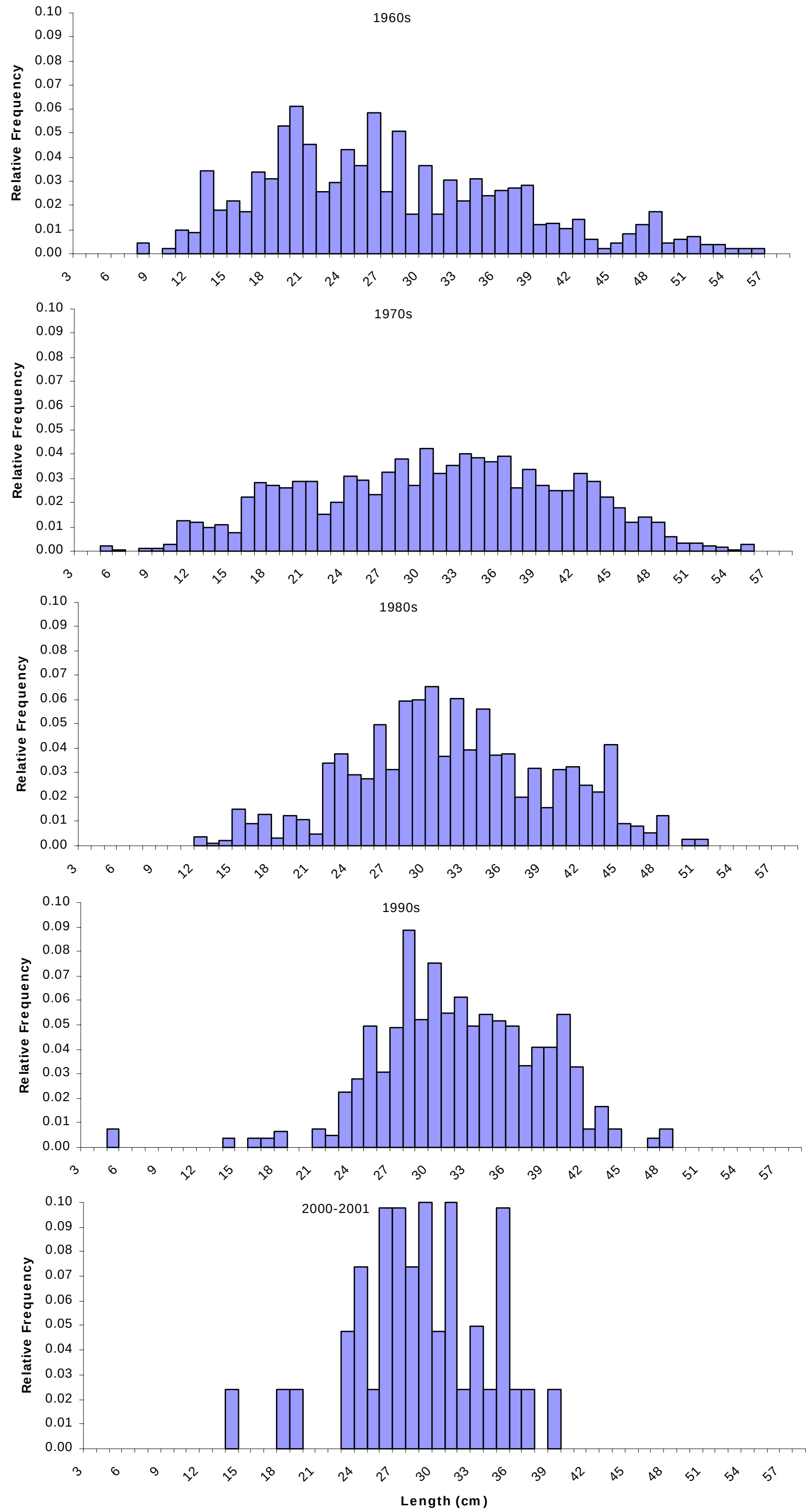


Figure A2.20. Size distribution of yellowtail flounder sampled from the NEFSC survey in the central and eastern Gulf of Maine, by decade.



B1. SOUTHERN NEW ENGLAND/MID-ATLANTIC (SNE/MA) WINTER FLOUNDER

TERMS OF REFERENCE

The following terms of reference were addressed for the Southern New England/Mid Atlantic (SNE/MA) stock complex of winter flounder:

1) Update the status of SNE/MA winter flounder stock through 2001 providing estimates of fully recruited fishing mortality rate, biomass weighted fishing mortality rate, stock size, mean biomass, spawning stock biomass, and recruitment as appropriate. Characterize uncertainty in SSB and fishing mortality rates.

2) Provide short-term (2003) and medium term projections (2009) of catch and biomass (mean biomass, SSB) under status quo F, and ASMFC's $F_{40\%}$ target, and NEFMC's F_{MSY}.

3) Develop research recommendations for improving the assessment of SNE/MA winter flounder.

4) Comment on and revise, where necessary, the ASMFC and the NEFMC overfishing definitions for this stock. (Note: Currently ASMFC and the NEFMC have different overfishing definitions. The ASMFC Board had recommended that the Winter Flounder Technical Committee develop a single overfishing definition for this stock).

INTRODUCTION

The current assessment of the SNE/MA stock complex of winter flounder is an update of the previous assessment completed in 1998 at SARC 28 (NEFSC 1999). The SARC 28 assessment included catch through 1997, research survey abundance indices through 1998, catch at age analyzed by Virtual Population Analysis (VPA) for 1981-1997, and biological reference points based on a production model conditioned on VPA results. The SARC 28 assessment concluded that the stock complex was fully exploited and at a medium level of biomass. Total biomass in 1997 was estimated to be 17,900 mt, spawning stock biomass was estimated to be 8,600 mt, and the fully recruited fishing mortality rate was estimated to be F = 0.31. Subsequent to the SARC 28 assessment, the status of SNE/MA winter flounder has been evaluated annually by projection methods to provide advice to the New England Fishery Management Council (NEFMC). The last such status update was provided in 2001, and projected total biomass to be 25,300 mt, spawning stock biomass to be 13,800 mt, and fully recruited F = 0.29, in 1999 (NEFSC 2001). The current assessment updates landings and discard estimates, research survey abundance indices, and assessment models through 2001-2002, as applicable.

Winter flounder (*Pleuronectes americanus*) is a demersal flatfish species commonly found in estuaries and on the continental shelf. The species is distributed between the Gulf of St. Lawrence and North Carolina, although it is not abundant south of Delaware Bay. Within the SNE/MA stock complex, winter flounder undergo migrations from estuaries, where spawning occurs in the late winter and spring, to offshore shelf areas of less than 60 fathoms. Winter flounder reach a maximum size of around 2.25 kg (5 pounds) and 65 cm, with the exception of Georges Bank where growth rate is higher and fish may reach a maximum weight up to 3.6 kg (8 pounds; Bigelow and Schroeder 1953).

Current fishery management is coordinated by the Atlantic States Marine Fisheries Commission (ASMFC) in state waters and the NEFMC in federal waters. Winter flounder fisheries in state waters have been managed by Interstate Agreement under the auspices of the ASMFC Fishery Management Plan (FMP) for Inshore Stocks of Winter Flounder since approval in May, 1992. The plan includes states from Delaware to Maine, with Delaware granted *de minimus* status (habitat regulations applicable but fishery management not required). The Plan's goal is to rebuild spawning stock abundance and achieve a fishing mortality-based management target of $F_{40\%}$ (fishing rate that preserves 40% of the maximum spawning potential of the stock) in three steps: $F_{25\%}$ in 1993-1994, $F_{30\%}$ in 1995-1998, and $F_{40\%}$ in 1999 and later years through implementation of compatible, state-specific regulations. Coastal states from New Jersey to New Hampshire have promulgated a broad suite of indirect catch and effort controls. State agencies have set or increased minimum size limits for recreationally and commercially landed flounder (10-12 inches and 12 inches, respectively); enacted limited recreational closures and bag limits; and instituted seasonal, areal, or state-wide commercial landings/gear restrictions. Minimum codend mesh regulations have been promulgated in directed winter flounder fisheries: 5 inch for NJ and NY, 5.5 inch for CT, 5 inch for RI, and 6 inch for MA.

Winter flounder in the Exclusive Economic Zone (EEZ) are managed under the Northeast Multispecies Fishery FMP developed by the NEFMC. The principle catch of winter flounder in the EEZ has recently occurred as bycatch in directed trawl fisheries for Atlantic cod, haddock, and yellowtail flounder. The management unit encompasses the multispecies finfish fishery that operates from eastern Maine through Southern New England (72°30'). At least one offshore stock, on Georges Bank, has been identified. The FMP extends authority over vessels permitted under the FMP even while fishing in state waters if federal regulations are more restrictive than the state regulations.

The Multispecies FMP was implemented in September, 1986, imposing a codend minimum mesh size of 5.5 inches (previously 5.1 inches) in the large-mesh regulatory area of Georges Bank and the offshore portion of Gulf of Maine. There were closed areas and seasons for haddock and yellowtail flounder. In the western Gulf of Maine, vessels were required to enroll in an Exempted Fisheries Program in order to target small-mesh species such as shrimp, dogfish, or whiting. The bycatch restrictions specified area and season and limited groundfish bycatch to 25% of trip and 10% for the reporting period. In southern New England waters, the groundfish bycatch on vessels fishing with small mesh was not limited in any way. There was a 11 inch minimum size for winter flounder which corresponded with the length at first capture (near zero percent retention) for 5.5 inch diamond mesh. Although the Multispecies FMP was amended four times by 1991, it was widely recognized that many stocks, including winter flounder, were being overfished.

Time-specific stock rebuilding schedules were a part of Multispecies FMP Amendment 5 which took effect in May, 1994. The rebuilding target for winter flounder, a so-called "large-mesh" species, was $F_{20\%}$ within 10 years. Along with a moratorium on issuance of additional vessel permits, the cornerstone of Amendment 5 was an effort reduction program that required "large-mesh" groundfish vessels to limit days at sea, which would be reduced each year. There was an exemption from effort reduction requirements for groundfishing vessels less than 45 feet in length and for "day boats" (from 2:1 layover day ratio requirement). Draggers retaining more than the "possession limit" of groundfish (10%, by weight, up to 500 lbs) were required to fish with either 5.5 inch diamond or square mesh in Southern New England or 6 inch throughout the net in the regulated mesh area of Georges Bank/ Gulf of Maine, respectively. The possession limit was allowed when using small mesh within the western Gulf of Maine (except Jeffreys Ledge and Stellwagon Bank) and in Southern New England. Vessels fishing in the EEZ west of 72° 30' (the longitude of Shinnecock Inlet, NY) were required to abide by 5.5 inch diamond or 6 inch square codend mesh size restrictions consistent with the Summer Flounder FMP. The minimum landed size of winter flounder increased to 12 inches, appropriate for the increased mesh size in order to reduce discards. There were many additional rules including time/area closures for sink gillnet vessels, seasonal netting closures of prime fishing areas on Georges Bank (Areas I and II), and on Nantucket Shoals to protect juvenile yellowtail flounder.

At the end of 1994, the NEFMC reacted to collapsed stocks of Atlantic cod, haddock, and yellowtail flounder on Georges Bank by recommending a number of emergency actions to tighten existing regulations reducing fishing mortality. Prime fishing areas on Georges Bank (Areas I & II), and the Nantucket Lightship Area were closed. The NEFMC also addressed expected re-direction of fishing effort into Gulf of Maine and Southern New England while, at the same time, developing Amendment 7 to the Multispecies FMP. Under Amendment 7, days-at-sea controls were extended, and any fishing by an EEZ-permitted vessel required use of not less than 6 inch diamond or square mesh in Southern New England east of 72° 30'. Framework 27 in 1999 increased the square mesh minimum size to 6.5 inches in the Gulf of Maine, Georges Bank, and Southern New England mesh areas. Amendment 9 revised the overfishing definitions for New England groundfish, and new overfishing definitions for SNE/MA winter flounder were recommended by SARC 28 (NEFSC 1999).

STOCK STRUCTURE

Although stock groups consist of an assemblage of adjacent estuarine spawning units, the ASMFC FMP originally defined three coastal management units based on similar growth, maturity and seasonal movement patterns: Gulf of Maine, Southern New England and Mid-Atlantic. Boundaries for a total of four winter flounder stock units as originally defined in the ASMFC management plan (Howell et al., 1992) were:

Gulf of Maine: Coastal Maine, New Hampshire, and Massachusetts north of Cape Cod

Southern New England: Coastal Massachusetts east and south of Cape Cod, including Nantucket Sound, Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, Rhode Island coastal ponds and eastern Long Island Sound to the Connecticut River, including Fishers Island Sound, NY.

Mid-Atlantic: Long Island Sound west of the Connecticut River to Montauk Point, NY, including Gardiners and Peconic Bays, coastal Long Island, NY, coastal New Jersey and Delaware.

Georges Bank

In the current and three previous assessments (e.g., NEFSC 1996, ASMFC 1998, NEFSC 1999) the Southern New England and Mid-Atlantic units have been combined into a single stock complex for assessment purposes. A review of tagging studies for winter flounder (Howell 1996) indicates dispersion (and hence mixing) has occurred between the previously defined Southern New England and Mid-Atlantic units. Howell (1996) noted that differences in growth and maturity among samples from Southern New England to the Mid-Atlantic may reflect discrete sampling along a gradient of changing growth and maturity rates over the range of a stock complex. Differences in growth rates within the Mid-Atlantic unit were observed to be greater than differences between Mid-Atlantic and Southern New England units (Howell, 1996). In offshore waters, the length structure of winter flounder caught in NEFSC research surveys is similar from Southern New England to New Jersey. Most commercial landings are obtained in these offshore regions (greater than 3 miles from shore).

<u>Stock Boundaries and associated Statistical Areas</u>
The Gulf of Maine stock complex extends along the coast of eastern Maine to Provincetown, MA, corresponding to NEFSC commercial fishery statistical division 51. Recreational landings from Maine, New Hampshire and northern Massachusetts (northern half of Barnstable County and north to New Hampshire border) are associated with this stock complex.

The Southern New England/Mid-Atlantic stock complex extends from the coastal shelf east of Provincetown, MA southward along the Great South Channel (separating Nantucket Shoals and Georges Bank) to the southern geographic limits of winter flounder. NEFSC commercial fishery statistical areas within this boundary are 521 and 526, and statistical divisions 53, 61, 62, and 63. The corresponding recreational areas are southern Massachusetts (the southern half of Barnstable County; Dukes, Nantucket and Bristol counties), Rhode Island, Connecticut, New York, New

Jersey, Delaware, Maryland and Virginia. NEFSC survey strata included for this stock extend from the waters of outer Cape Cod to the south and west.

The Georges Bank stock extends eastward of the Great South Channel, including statistical areas 522, 525, and 551-562.

FISHERY DATA

Landings

After reaching an historical peak of 11,977 metric tons (mt) in 1966, then declining through the 1970s, total U.S. commercial landings again peaked at 11,176 mt in 1981, and then steadily declined to a record low of 2,159 mt in 1994. Landings have increased since 1994 to 4,448 mt in 2001 (Table B1.1, Figure B1.1). During 1989-1996, an average of 43% of commercial landings were taken from statistical area 521, 13% from area 526, 13% from area 537, and 11% from area 539, with the remaining landings (20%) obtained from area 538 and divisions 61-62 (Table B1. 2). Since 1993, a larger percentage of the commercial landings has been taken from area 521. An unusually high proportion of the commercial landings for the stock complex was reported from NEFSC statistical area 521 in 1997 and 2001, with 62% in 1997 and 56% in 2001. When considered along with the distribution of survey catches, this factor indicates that the commercial fishery is focused on winter flounder along the western side of the Great South Channel. The primary gear in the fishery is the otter trawl which accounts for an average of 95% of landings since 1989. Scallop dredges account for 4%, with handlines, pound nets, fyke nets, and gill nets each accounting for about 1% of total landings.

Recreational landings reached a peak in 1984 of 5,772 mt but declined substantially thereafter (Table B1.3, Figure B1.1). Landings have been less than 1,000 mt since 1991, with the lowest estimated landings in 1998 of 290 mt. Landings in 2001 from the Southern New England/Mid Atlantic stock complex were 552 mt. The principal mode of fishing is private/rental boats, with most recreational landings occurring during January to June.

Sampling Intensity

Length samples of winter flounder are available from both the commercial and recreational landings. In the commercial fishery, annual sampling intensity varied from 63 to 264 mt landed per 100 lengths measured during 1981-1997 (Table B1.4). Overall sampling intensity was 90 mt per 100 lengths in 1998, 75 mt per 100 lengths in 1999, 59 mt per 100 lengths in 2000, and 71 mt per 100 lengths in 2001 (Table B1.5). In the recreational fishery, annual sampling intensity varied from 36 to 231 mt landed per 100 lengths measured during 1981-1997 (Table B1.6). Overall sampling intensity was 47 mt per 100 lengths in 1998, 81 mt per 100 lengths in 1999, 519 mt per 100 lengths in 2000, and 109 mt per 100 lengths in 2001 (Table B1.7).

Landed Age Compositions

Commercial fishery

In the SARC 21 assessment (NEFSC 1996), numbers at age were estimated for 1985-1993 for commercial landings, recreational landings, commercial discards, and recreational discards. Quarterly or half-year commercial age-length samples were applied to corresponding commercial market category landings at length. Unsampled unclassified landings and landings not represented in the weighout database (i.e., state canvas landings) were assumed to have the same age composition as the initial weighout commercial landings at age. Landings at lengths with no associated age data within the quarter were assigned ages based on age at length from adjacent quarters. A comparison was undertaken among age data collected from inshore regions (where the recreational fishery is prosecuted), to determine if all age data were comparable within the stock complex. Data for ages 3-5 from New Jersey, Connecticut, Massachusetts and NEFSC were compared for 1993-1994. Distributions of length at age from New Jersey and Connecticut were similar, while distributions of length at age from Massachusetts lacked smaller fish at age (Howell 1996).

In the ASMFC 1998 assessment (ASMFC 1998), the Technical Committee attempted to update the catch at age matrix for VPA for 1994-1996. Two key market categories of commercial landings were found to lack port samples: medium fish in the second half of 1995 and large fish in the first half of 1996. In addition, several market categories were poorly sampled: medium fish in the first and second half-year of 1996, and large fish in the second half of 1995. The Technical Committee concluded then that the port sampling was insufficient to characterize the length and age frequency of the commercial landings for 1995-1996, and elected to use a non-age dependent model (ASPIC) to assess the stock complex (ASMFC 1998).

In the SARC 28 assessment (NEFSC 1999), commercial fishery port samples for 1995 and 1996 were supplemented with commercial fishery sea sample length data for the second half of 1995 and 1996, to continue the catch at age series. For the second half-year of 1995, 2,979 sea sample lengths (unclassified by market category) were used in place of the available 702 port sample lengths to construct an unclassified length frequency for the second half-year of 1995 landings. For the first half-year of 1996, 55 sea sample lengths were combined with 752 port sample lengths to create an unclassified frequency of 807 lengths for the first-half year of 1996 landings. Also, archived NEFSC research survey and commercial fishery age samples were aged, allowing extension of the NEFSC survey catch at age series back to 1980 and of the fishery catch at age matrix back to 1981 (Table B1.4). Since 1997, port sampling has been adequate to develop the commercial fishery landings at age on a half-year, market category basis across all statistical areas (Tables B1.5 and B1.10).

Recreational fishery

Recreational landings at length were estimated seasonally (January-June and July-December) and geographically. Landings were divided into two geographic regions; 1) Massachusetts and Rhode Island (SNE) and 2) Connecticut and south (MA). For the 1981-1984 period, NEFSC spring age-length keys were used to age both area length frequencies. For 1985-1996, MADMF survey age-length keys were applied to MA-RI data while CTDEP age-length keys were applied to CT-south data, with the exception of 1993 landings which used a combined NJ/CT age-length key. Since 1997, NEFSC spring and fall keys have been used to age all length frequencies (Tables B1.6, B1.7, and B1.10). For the 1998-1999 recreational catch at age, sample lengths were applied to catch numbers on an annual basis for the two regions, due to low samples size. For the 2000-2001 recreational catch at age, sample lengths were applied to catch numbers on an annual basis for the regions combined, due to low sample sizes in the SNE region (Table B1.7).

<u>Discard estimates and age compositions</u>

Commercial fishery

In the SARC 21 assessment (NEFSC 1996), the Working Group and the SARC concluded that there were too few Fishery Observer sampled trips in which winter flounder were caught to adequately characterize the overall ratio of discards to landings in the commercial fishery. The Fishery Observer sample length frequency data, however, were judged adequate to help characterize the proportion discarded at length. In the SARC 21 assessment, commercial discards for 1985 to 1993 were estimated from length frequency data from NEFSC and the Massachusetts Division of Marine Fisheries (MADMF) bottom trawl surveys, commercial port sampling of landings at length and Fishery Observer sampling of landings and discard at length. The method follows an approach described by Mayo et al. (1992). The year was divided into half year periods. Survey length frequency data (MADMF survey in spring and NEFSC in fall) were smoothed using a three point moving average, then filtered through a mesh selection ogive (Simpson 1989) for 4.5 inch mesh (1984-1989), 5 inch mesh (1990-1992, fall 1993) or 5.5 inch mesh (spring, 1993). The 5.5 inch mesh selection curve was calculated using the 5 inch curve adjusted to an L_{50} for 5.5 inch mesh. The choice of mesh sizes was based on sizes used in the yellowtail assessment for southern New England (Rago et al. 1994) and comparison to length frequencies of commercial landings. The mesh filtering process resulted in a survey length frequency of retained winter flounder. A logistic regression was used to model the percent discarded at length from 1989-1992 sea sampling data, and the resulting percentages at length were applied to the survey numbers at length data to produce the survey-based equivalent of commercial kept and discarded winter flounder. The 1989-1992 average percentage discard at length was applied to 1985-1988. The survey numbers per tow at length "kept" were then regressed against commercial (weighout) numbers landed at length. The linear relationship was calculated for those lengths common to both length frequencies and fitted with an intercept of zero. The slope of the regression provided a conversion factor to re-scale the survey "discard" numbers per tow at length to equivalent commercial numbers at length. The resulting vector of number of fish discarded at length was multiplied by a discard mortality rate of 50% (as averaged in Howell et al., 1992) to produce the vector of fish discarded dead at length per half year. The number of dead discards at length was adjusted by the ratio of weighout landings to total commercial landings and summed across seasons and lengths (and corresponding weight at length) to produce the annual total number and weight of commercial fishery discards for 1985-1993 (Tables B1.10-11, Figure B1.1). In the SARC 28 assessment (NEFSC 1999), this same method using the 4.5 inch mesh ogive and 1989-1992 average discard percentage at length was used to estimate commercial fishery discards for 1981-1984. NEFSC spring and fall survey age-length keys were applied to convert discard length frequencies to age.

During ASMFC Winter Flounder Technical Committee meetings since 1995, the group has considered the SARC 21 survey length-mesh selection method, NEFSC Fishery Observer data (OB), and NER Vessel Trip Report (VTR) data as sources of information to use in the estimation of commercial fishery discards, with a focus on the latter two sources. The Committee examined the characteristics of both the Fishery Observer and VTR discard data (number of trip samples, frequency distributions of discards to landings ratio per trip, mean and variance of annual half-year discards to landings ratio), and concluded that the VTR mean discard to landed ratio aggregated over all trips in annual half-year season strata (January to June, July to December) provided the most reliable data from which to estimate commercial fishery discards. VTR trawl gear fishery discards to landings ratios on a half-year basis (January to June; July to December) were applied to corresponding commercial fishery landings (all gears) to estimate discards in weight (Table B1.8, Figure B1.1). The Fishery Observer length frequency samples were judged adequate to directly characterize the proportion discarded at length (Table B1.9). The sample proportion at length, converted to weight, was used to convert the discard estimate in weight to numbers at length. As in the SARC 28 assessment (NEFSC 1999), the resulting number of fish discarded at length was multiplied by a discard mortality rate of 50% (as averaged in Howell et al., 1992) to produce the number of fish discarded dead at length. For 1998, discard estimates at length were made by half-year; for 1999-2001, samples length were applied on an annual basis due to low sample sizes (Table B1.9). NEFSC Spring and Fall survey age-length keys were used to convert the discard length frequency to age (Table B1.10).

Recreational fishery

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked in 1984-1985 at 0.7 million fish Discards have since declined reaching a low in 1999 of 62,000 fish. In 2001, 81,000 fish were estimated to have been discarded (Table B1.3). In the SARC 21 assessment (NEFSC 1996), recreational discards for 1985-1993 were assumed to have the same average weight per fish as spring commercial discards, providing estimates of the total weight of recreational discards ranging from 15 mt in 1992 to 230 mt in 1985. Estimates of recreational discard at age for 1985-1993 were developed using state survey length and age data in a manner similar to that for the commercial discard estimates (Tables B1.10-11; see Gibson (1996) for complete description of computation of 1985-1993 recreational discard numbers at length and age).

The SARC was unable to apply the 1985-1993 method to the 1994-1997 or 1981-1984 periods for the SARC 28 assessment, due to data availability problems (NEFSC 1999). Instead, for 1994-1997, the average proportion at age in the 1991-1993 recreational discard was used to apportion the recreational fishery estimate of discard in numbers to length and age. These discards at age were assumed to have the same mean weight as the landed portion at the same ages, and so this method probably slightly overestimates the discard in weight. For 1981-1984, before implementation of the 12 inch (30 cm) minimum landing size in most states (which encompasses fish up to age 3), it was assumed that all recreational discard would be age 1 and age 2 fish, and so the discard was allocated to ages 1 and 2 in the same relative proportion as those in the landings, and assumed to have the same mean weight at age. SARC 28 (NEFSC 1999) concluded that since the magnitude of the recreational discard is relatively small compared to the total landings and commercial discards, error in estimation of recreational discard at age due to different methods over the time series and/or error is allocation among ages 1 and 2 would have a minimal effect in terms of estimation of population sizes in the VPA.

Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 1998-2001, the recreational discard has been assumed to have the same length frequency as the landed portion of the catch below 12 inches, and so is still predominantly ages 1, 2, and 3 fish. As with the recreational landings, sample lengths were applied to catch numbers on an annual basis for the two regions for 1998-1999, and on an annual basis for the regions combined for 2000-2001. The recreational discard for 1998-2001 is aged using NEFSC survey spring and fall keys (Table B1.10).

Mean Weights at Age in the Catch

Mean weights at age were determined for the landings and discards in the commercial and recreational fisheries. Length frequencies (cm) for each component were converted to weight (kg) using length-weight equations derived from NEFSC survey samples:

Spring surveys: $wt = 0.00000997 * length^{3.055236}$

Fall surveys: $wt = 0.00000925 * length^{3.095188}$

The equations from the spring and fall surveys were applied to catches during the corresponding time periods. The annual mean weights at age from the commercial and recreational fisheries were used in the virtual population analysis and yield per recruit calculations.

Total Catch

Estimates of the total catch of winter flounder during 1981-2001 are presented in Table B1.11. These estimates include commercial and recreational landings and discards. The total catch during this period has varied from a high of 15,788 mt (34.6 million fish) in 1984 to a low of 3,095 mt (3.6 million fish) in 1994. The total catch has increased since 1995 to 5,102 mt (9.0 million fish) in 2001 (Table B1.11, Figure B1.1). Total catch and mean weights at age as aggregated for input to the VPA (ages 1-7+) are presented in Tables B1.12-13, and Figures B1.2-3.

RESEARCH SURVEY ABUNDANCE AND BIOMASS INDICES

State and federal surveys were evaluated as fishery independent indices of winter flounder abundance and biomass. Survey methods (with the exception of Rhode Island and the young-of-year surveys) are reviewed in the proceedings of a 1989 trawl survey workshop sponsored by the ASMFC (Azarovitz et al., 1989).

NEFSC

Mean weight and number per tow abundance indices were determined from fall (1963-2001) and spring (1968-2002) NEFSC bottom trawl surveys. Indices from the spring and fall surveys were based on tows in offshore strata 1-12, 25, and 69-76 and inshore strata 1-29 and 45-56. Spring indices prior to 1973 and fall indices prior to 1972 do not include inshore strata. In addition, offshore surveys from 1963-1966 were not conducted south of Hudson Canyon.

A new series of NEFSC winter trawl surveys was begun in February 1992 specifically to provide improved indices of abundance for flatfish, including winter flounder. A modified 36 Yankee trawl is used in the winter survey that differs from the standard trawl employed during the spring and fall surveys in that 1) long trawl sweeps (wires) are added before the trawl doors, to better herd fish to the mouth of the net, and 2) the large rollers used on the standard gear are absent, and only a chain "tickler" and small spacing "cookies" are present on the footrope. This gear is intended to better target flatfish than the gear used in the spring and fall surveys. The geographical coverage of the winter survey is more limited than the spring and fall surveys, due to time limitations and the use of the flatfish net. Inshore strata and offshore deep strata are irregularly sampled, strata east of the Great South Channel are irregularly sampled, and the Gulf of Maine has never been sampled. For winter flounder, the winter survey indices include offshore strata 1-2, 5-6, 9-10, 69, and 73; generally the offshore between 27 to 110 meters depth (15 to 60 fathoms).

Mean weight per tow and number per tow indices for the spring, fall, and winter time series are presented in Table B1.14. Indices dropped from the beginning of the time series in the 1960s to a low point in the early to mid- 1970s, then rose to a peak by the early 1980s. Following several years of high indices, abundance once again declined to below the low levels of the 1970s. NEFSC survey indices reached near- or record low levels for the time series in the late 1980s-1990s. Indices from the three survey series generally increased during 1993-1998/1999, but have since declined (Figure B1.4).

Massachusetts

The Massachusetts Division of Marine Fisheries (MADMF) spring survey from 1978-2001 was used to characterize the abundance of winter flounder. Survey areas from east and south of Cape Cod were used in the analysis (strata 11-21). The MADMF mean number per tow indices steadily declined from a high value of 53.79 in 1979 to a low of 10.66 in 1991, and then increased to 30-40 fish per tow during 1995-1998, before falling again to 16.00 in 2001. Mean weight per tow indices have varied in a similar manner over the time series, ranging from 15-20 kg/tow in the early 1980s to about 5 kg/tow during 2000-2001 (Tables B1.15-16, Figure B1.4).

The MADMF also conducts an annual juvenile winter flounder seine survey during June. The survey has been conducted since 1975 in coastal ponds and estuaries. The index has shown a general decline in production, with a high of 0.60 fish per haul in 1977 to a low of 0.07 fish per haul in 1993. The 1997 value was 0.39 fish per haul, and has since declined to 0.10 in 2002 (Table B1.17, Figure B1.5).

Rhode Island

The Rhode Island Division of Fish and Wildlife (RIDFW) conducts a number of research surveys in Narragansett Bay and Rhode Island coastal waters. A seasonal trawl survey was initiated in 1979 to monitor finfish stocks in Narragansett Bay, Rhode Island Sound and Block Island Sound. The survey employs a stratified random design and collects length, weight, and abundance information. Survey results are expressed as un-weighted catch per tow (Tables B1.15-16). Spring survey indices from 1979-2001 showed a steady decline from high values during 1979-1981 (12-13 kg per tow, 63-88 fish per tow) to a low of 0.22 kg per tow and 2.92 fish per tow in 1993. Spring indices increased to 5.83 kg per tow and 31.78 fish per tow in 1995, before declining again to 3.56 kg per tow and 12.49 fish per tow in 2001 (Figure B1. 4). Fall survey indices show simliar trends, with peak abundance and biomass during the early and mid 1980s, a decline to low values in the mid-1990s, some rebound during 1995-1997, and a recent decline (Tables B1.15-16).

A juvenile finfish beach seine survey, conducted from June to October since 1986, takes monthly samples at 17 fixed stations in Narragansett Bay. This seine survey provides an index of young-of-year winter flounder. The index shows a great deal of annual variability, although in recent years there have been consistently high levels of recruitment. The index of the 2000 year class is the highest of the time series (Table B1.17, Figure B1.5).

Connecticut

The Connecticut Department of Environmental Protection (CTDEP) Long Island Sound Trawl Survey (1984-present) uses a stratified-random design to sample Connecticut and New York waters of the Sound from Groton to Norwalk. Forty sites are sampled monthly (Apr-June, Sept-Oct) across three sediment (mud, sand , transitional) and four depth intervals (<30 ft, 30-60 ft, 60-90 ft, 90+ft). A 14 m otter trawl with 51 mm codend is towed for 30 min at 3.5 kts from a 15.2 m research vessel.

Winter flounder abundance indices are based on April and May sampling. Winter flounder are counted and measured from each tow. Since 1992 composite biomass (0.1kg) has also been recorded from each tow. Otoliths are collected for aging each spring. Aging samples are stratified by month, area (east/west) and size. Subsamples of 5-7 fish per centimeter are collected from fish up to 36 cm and all fish over 36 cm are retained for aging. Aged fish are measured and weighed in the lab and gonad condition is recorded. Gonad weights were also recorded in some years. In recent years approximately 800 flounder have been aged annually. Otoliths are generally aged whole, however larger fish and difficult bones are sectioned for reading. Indices at age are calculated as a proportion of the overall index. Age length keys are applied by area (east-west) and year where possible and any remaining unaged fish are aged using a pooled area/year key as necessary.

CTDEP indices exhibited several years of high values between 1988 and 1991, declined to a minimum in 1995, and have since increased to about one-half the time series average during 2000-2002 (Tables B1.15-16, Figure B1.4). A separate young of the year survey index shows above average recruitment during 1994-1996, and below average recruitement since. The 2001 year class index is the smallest of the time series (Table B1.17, Figure B1.5).

New York

The New York Department of Environmental Conservation (NYDEC) has conducted a small-mesh trawl survey in Peconic Bay since 1985. Winter flounder indices for ages 0 and 1 were evaluated for trends in winter flounder abundance (Tables B1.16-17, Figure B1.5). Young of the year indices have increased in recent years from 0.7 in 1985 to the 1993 index of 4.7 and 1996 index of 3.80. The 1992 index indicated the strongest recent year class with an index of 11.4. The corresponding age 1 indices also indicated strong 1992, 1993, and 1996 year classes.

New Jersey

The New Jersey Division of Fish, Game and Wildlife (NJDFW) has conducted a bottom trawl survey in near-shore ocean waters of the state since 1989, and in inshore waters in the Shark and Manasquan Rivers since 1995. Ocean survey samples are collected via a stratified random bottom trawl survey. Surveys are usually conducted in January, April, June, August, and October. Inshore samples are collected via a random station trawl survey in the main channel of the Shark and Manasquan Rivers. Sampling is conducted in March, April and May and results are pooled to calculate mean number per tow indices. Aging of NJDFW samples started in 1993. During both surveys, a sub-sample of fish are aged(fish are aged from April ocean survey only). Age/length keys are constructed, and all lengths are transformed to ages by applying all lengths to the age/length keys. Number at each age are divided by the number of tows to derive catch at age per tow.

Ocean survey indices (mean number per tow in April) tended to decline between 1989 and 1993, and have been quite variable since 1994, with a time series low in 1996, increasing to above the time series mean in 2002 (Tables B1.15-16, Figures B1.4-5). River survey indices exhibit no trend over the short time series (Table B1.16, Figure B1.5).

Delaware

The Delaware Division of Fish and Game (DEDFG) conducts monthly surveys from April to October using a 16 ft. semi-balloon otter trawl with a 0.5 inch stretch mesh liner. An index of young-of-year winter flounder was developed from stations sampled within Indian River and Rehoboth Bays. The re-transformed annual geometric means, presented in Table B1.17, indicate variable annual recruitment with a large year class in 1990. The 1994 index indicates above average recruitment (Table B1.17, Figure B1.5).

ESTIMATES OF MORTALITY AND STOCK SIZE

Natural Mortality and Maturity

Instantaneous natural mortality (M) for winter flounder was assumed to be 0.20 and constant across ages. Commercial catch at age included fish to age 14, under conditions of relatively high fishing mortality. If M = 0.25, less than 5% of the population would reach age 12 under conditions of no fishing mortality. Therefore, the SARC judged that M = 0.20, which represents a maximum age of 15, was representative of the stock complex throughout its range.

In the SARC 28 review of the SNE/MA winter flounder stock assessment (NEFSC 1999), the SARC recommended re-examination of the maturity schedule used in the yield per recruit (YPR) and virtual population analyses (VPA) to incorporate any recent research results. The SARC 28 and previous assessments used the maturity schedule as published in O'Brien et al. (1993) for winter flounder south of Cape Cod, based on data from the MADMF spring trawl survey for strata 11-21 (state waters east of Cape Cod, Nantucket sound, Vineyard Sound, and Buzzards Bay) sampled during 1985-1989 (n = 301 males, n = 398 females). Those data provided estimates of lengths and ages of 50% maturity of 29.0 cm and 3.3 yr for males, and 27.6 cm and 3.0 yr for females, and the following estimated proportions mature at age. The female schedule (with the proportion at age 2 rounded down to 0.00) was used in the SARC 28 assessment YPR and VPA (NEFSC 1999).

Age	1	2	3	4	5	6	7+
Males	0.00	0.04	0.32	0.83	0.98	1.00	1.00
Females	0.00	0.06	0.53	0.95	1.00	1.00	1.00

In response to the SARC 28 recommendation, the SARC has examined NEFSC spring trawl survey data over the 1981-2001 period in an attempt to better characterize the maturity characteristics of the SNE/MA winter flounder stock complex. Data from the NEFSC survey included those judged in the SARC 28 assessment to comprise the SNE/MA complex from Delaware Bay to Nantucket Shoals: NEFSC offshore strata 1-12, 25 and 69-76, and inshore strata 1-29, 45-46. Note that this is a much larger geographic area than that included in the MADMF survey data used in O'Brien et al. (1993). Data were analyzed in 5-6 year blocks (1981-1985, 1986-1990, 1991-1995, and 1996-2001) and for the entire time period (1981-2001), for each sex and combined sexes. Observed proportions mature at age were tabulated, and from those data maturity ogives at length and age were calculated to provide estimated proportions mature at age.

In general, the NEFSC maturity data indicated earlier maturity than the MADMF data, with L50% values ranging from 22-25 cm, rather than from 28-29 cm, and with ~50% maturity for age 2 fish, rather than ~50% maturity for age 3 fish. To investigate the apparent inconsistency between the MADMF and NEFSC maturity data, the SARC compared the two data sets over the same time periods (1985-1989, 1990-1995, 1996-2001) for common/adjacent survey strata (MADMF strata 11-12; NEFSC inshore strata 50-56 and offshore strata 10-12 and 25). Note that the MAMDF data now have about 160 observations for the 1985-1989 period that were added subsequent to the O'Brien et al. (1993) work. For comparable time periods and geographic areas, the NEFSC maturity data still consistently indicated a smaller size and younger age of 50% maturity than the MADMF data. NEFSC L50% and A50% values range from 22-26 cm and about 2.0 yr, while the MADMF values range from 27-30 cm and about 3.0 yr. The difference in values from this comparison was not as large as for the full NEFSC data set extending southward to Delaware Bay, which incorporates components of the stock complex that mature at smaller sizes and younger ages. However, the difference is still nearly a full age class difference at 50% maturity.

Given that both length and age vary in the same direction, it seems unlikely that the differences could be attributed to aging differences between the two data sets. Since the MADMF and NEFSC geographic areas in this comparison do not match exactly, the difference in maturity rates may be due to the extension of the NEFSC strata to somewhat deeper waters inhabited by fish that mature at a smaller size and younger age (inclusion of fish in offshore strata were necessary for sufficient sample size). Alternatively, for the size range of fish in question (20 to 30 cm length), it may be that immature and mature fish are segregated by area, with mature fish in that size interval tending to occupy inshore areas during the spring, with immature fish tending to remain offshore. Finally, there may be differences in the accuracy and consistency of interpretation of maturity stage between MADMF and NEFSC survey staff.

The SARC considered these data and analyses and the possible causes for the noted inconsistencies, and concluded that more detailed spatial and temporal analyses are needed before revisions to the maturity schedule can be adopted. Therefore, the maturity at age schedule used in the SARC 28 assessment (see above) has been retained for this assessment.

<u>Total Mortality from Mark and Recapture Data</u>

Total mortality in two components of the stock were evaluated using recent tag and recapture data. Northeast Utilities Co. marked and recaptured winter flounder in eastern Long Island Sound from 1983-1998 and the RIDFW has conducted winter flounder tagging programs in Narragansett Bay from 1986-1990 and again from 1996-1998. Mortality estimates were made by maximum likelihood methods using the Brownie class of survivorship models (Brownie et al. 1985). Average estimates of fishing mortality for Long Island Sound averaged 0.59 from 1984-1988 and 0.77 from 1989-1993, and 0.65 from 1993-1996. Fishing mortality in 1996 was estimated to be 0.56. Narragansett Bay estimates of fishing mortality ranged from 0.81 to 1.92 and averaged 1.19 from 1986 to 1989. The most recent tag releases in Narragansett Bay indicate that F had dropped to 0.37 in 1996-1997.

<u>Virtual Population Analysis</u>

Tuning

The Virtual Population Analysis (VPA) was tuned (calibrated) using the NEFSC Woods Hole Fisheries Assessment Compilation Toolbox (FACT) version 1.50 of the ADAPT VPA (Conser and Powers 1990). Abundance indices at age (Tables B1.18-25) were available from several bottom trawl surveys: NEFSC spring bottom trawl ages 1-7+, NEFSC fall ages 1-5 (advanced to tune January 1 abundance of ages 2-6), NEFSC winter ages 1-5, MADMF spring ages 1-7+, RIDFW fall seine age 0 (advanced to tune age-1), RIDFW spring ages 1-7+, CTDEP spring ages 1-7+, NYDEC age 0 (advanced to tune age-1) and age-1, MADMF summer seine index of age-0 (advanced to tune age-1), DEDFG juvenile trawl survey age-0 (advanced to tune age-1), NJDFW Ocean trawl survey ages 1-7+, and NJDFW River trawl survey ages 1-7+. The indices from the NEFSC winter trawl survey, NYDEC, and NJDFW were included in the VPA tuning for the first time. Survey indices were selected for inclusion in VPA tuning based on consideration of the partial variance in a VPA trial run including all indices, residual error patterns from the various trail runs, and on the significance of the correlation among indices and with VPA abundance estimates from the trial run including all indices.

The SARC considered eight different configurations of tuning indices. In general, tuning indices were excluded if they exhibited high partial variance (indicating a lack of fit within the VPA model) and low correlation with other indices with similar spatial and temporal characteristics and with the VPA estimates of 2002 stock size. Run W36ALL was the initial trial including all indices. Run W36_28 used the same suite of indices as that selected for the SARC 28 VPA (NEFSC 1999), and therefore did not include new indices available from the NEFSC Winter trawl survey, the NYDEC indices, or the two NJDFW index series. Run W36_1 excluded eight indices with high partial variance within the VPA and low correlation with other indices and/or the VPA estimates of stock size, resulting in improvements both in overall fit (Mean Square Residual (MSR) reduced by 14%) and in the precision of the stock size estimates, relative to the W36ALL configuration. Run W36_2 dropped an additional seven indices from the W36_1 configuration, resulting in further improvements in fit (21% improvement over run W36_1) and precision. This was the run adopted as final by the SARC, and is the basis for all further analyses (Table B1.26).

Run W36_3 dropped an additional two indices (from W36_2) to exam the trade-off between overall model fit (MSR) and the precision of the 2002 stock size estimates as degrees of freedom were further reduced. The SARC concluded that the improvement of run W36_3 in overall fit (7%) was balanced by the decrease in precision at ages 6 and 7+, and so retained run W36_2 as final. Two additional runs excluded all state agency indices (W36NEC) and excluded all NEFSC indices (W36STATE). The W36NEC exhibited a better fit than the W36_2 run, but much lower precision of the 2002 stock size estimates, reflecting the fewer degrees of freedom available. The W36STATE run exhibited the poorest fit of the eight considered, along with the lowest precision of the 2002 stock sizes at ages 4 and older. Run W36_28 provided results intermediate to those from the W36_2 and W36STATE runs. Finally, run W36_2IR was the same as run W36_2, but incorporated the iterative re-weighting option of the VPA tuning, which in a second step of tuning gives more influence to indices that fit best within the analysis (tuning weight in inverse proportion to initial fitted variance). The W36_2IR results were very similar to those of runs W36_2 and W36_3 (Figure B1.6).

Stock size estimates for 2002 in the final W36_2 calibration were moderately precise (initial coefficients of variation ranged from 0.21 at age-3 to 0.38 at age-1). Nearly all surveys had years in which all observations deviated from predicted values in the same direction. For example, most surveys exhibited blocks of negative residuals during the late 1980s, and then blocks of positive residuals during the mid to late 1990s, when residuals for all ages are summed within year and survey series. Residuals by age exhibit a similar pattern of blocking, and a tendency for blocks of positive residuals at younger ages during the mid-1990s to move to older ages later in the VPA time series. This pattern of residuals (i.e., overestimation of stock size by the surveys during the mid-to late 1990s) is reflective of the retrospective pattern of VPA estimates evident for terminal years 1995-1999 (see the following Retrospective Analysis section). The correlation analysis of tuning indices also indicated that there are strong year effects in survey indices, due to annual distribution patterns or local recruitment events. However, in concert, the SARC concluded that the surveys appear to provide geographically balanced tuning.

Exploitation Pattern

The exploitation pattern has been variable from year to year, but with the exception of 1996-1997, age-4 fish have been 80%-100% recruited since 1993 (Table B1.26). The SARC noted a recent tendency for partial recruitment at age to decrease substantially at ages 5 and 6 in the terminal year, but further noted that the retrospective analysis indicates that this tendency does not persist, with the expected, flat-topped partial recruitment pattern becoming evident as the VPA converges. For this reason, the average exploitation pattern to be used in yield per recruit analysis and stock projections was calculated as the geometric mean fishing mortality rates for 1998-2000, normalized to age 4. The resulting pattern indicates 1% recruitment at age-1, 27% at age-2 and 75% at age-3. For purposes of yield per recruit and stock projections, full (100%) recruitment was assumed at ages 4 and older. For consistency with the partial recruitment averages, mean weights at age in the landings, discards, and spawning stock biomass were also averaged over 1998-2000.

Fishing Mortality, Spawning Stock Biomass, and Recruitment

During 1981-1993, fishing mortality (fully recruited F, ages 4-5) has varied between 0.4 (1982) and 1.4 (1988), and was as high as 1.2 as recently as 1997. Fishing mortality has been in the range of 0.5-0.6 during 1999-2001 (Table B1.26, Figure B1.7). Accounting for the uncertainty of the 2001 estimate, there is an 80% probability that F in 1997 was between 0.44 and 0.58 (Figure B1.8).

SSB declined from 14,800 mt in 1983 to a record low of 2,700 mt in 1994. SSB has increased since 1994 to 7,600 mt in 2001 (Table B1.26, Figure B1.9). Accounting for the uncertainty of the 2001 estimate, there is an 80% probability that SSB in 2001 was between 6,800 mt and 8,400 mt (Figure B1.8). Recruitment declined from 62.9 million age-1 fish in 1981 to 7.8 million in 1992. Recruitment then averaged 14.7 million fish during 1993-2001, below the VPA time series average of 23.9 million. The 2001 year class is estimated to be the smallest in 22 years, at only 5.7 million fish (Table B1.26, Figure B1.9).

Retrospective analysis
A retrospective analysis of the VPA was conducted back to a terminal catch year of 1997. The VPA exhibits a retrospective pattern of underestimation of F and overestimation of SSB during the late 1990s. The most likely cause of this pattern is a combination of factors including under-reporting of the landings, mis-classification of the landings by stock area, and underestimation of the discards. For 1995-1999, retrospective fishing mortality rates underestimate the current values by an average of 128%, ranging from 232% for 1997 to 44% for 1995. The pattern reversed for 2000 (i.e., F was overestimated), and fishing mortality appears to have been overestimated for 2000 by 7%. The retrospective pattern for spawning stock biomass has been a tendency for overestimation since 1991. The overestimation of SSB averaged 76% from 1995-1999, and was largest for the 1997 and 1998 terminal years (115% and 98% overestimation). The retrospective estimation of age-1 recruits indicated a tendency for overestimation during 1993-2000, with recruitment apparently underestimated for 2001 (2000 year class; Table B1.26, Figure B1.10).

Precision of Stock Size, F, and SSB estimates
The precision of the 2002 stock size, fishing mortality at age in 2001, and SSB estimates from VPA was evaluated using bootstrap techniques (Efron 1982). Five hundred bootstrap iterations were realized in which errors (differences between predicted and observed survey values) were resampled. Estimates of precision and bias are presented in Table B1.27. Bootstrap estimates of stock size at age indicate low bias (<6%) for ages 1-7+ and bootstrap standard errors provide stock size CVs ranging from 18% at age 3 to 34% at age 1.

Bootstrapped estimates of spawning stock biomass indicate a CV of 9%, with low bias (bootstrap mean estimate of spawning stock biomass of 7,705 mt compared with VPA estimate of 7,643 mt; Table B1.27). There is an 80% probability that spawning stock in 2001 was between 6,800 mt and 8,400 mt (Figure B1.8).

The bootstrap estimates of standard error associated with fishing mortality rates at age indicate good precision. Coefficients of variation for F estimates ranged from 16% at age 3 to 21% at ages 1, 6 and 7+ (Table B1.27). There is an 80% probability that fully recruited F for ages 4-5 in 2001 was between 0.44 and 0.58 (Figure B1.8).

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit; Stock-recruitment model
NEFSC (2002) re-estimated the biological reference points for SNE/MA winter flounder in 2002 using yield and SSB per recruit (Thompson and Bell 1936) and Beverton-Holt stock-recruitment models (Beverton and Holt 1957, Brodziak et al. 2001, Mace and Doonan 1988) based on the SARC 28 assessment (NEFSC 1999). The yield and SSB per recruit analyses indicate that $F_{40\%}$ =

0.21 and F0.1 = 0.25 (Figure B1.11). The parametric stock-recruitment model indicated that MSY = 10,600 mt, F_{msy} = 0.32, and SSB_{msy} = 30,100 mt (Figure B1.12).

Biological reference points estimated in NEFSC (2002) were updated by the SARC with the partial recruitment pattern and mean weights at age for 1998-2000 (as noted earlier, the 2001 estimates were not included in the averages due to the retrospective variability of the partial recruitment pattern in the terminal year of the VPA). Given the stability of the input data to these analyses and the consistency of the results with the previous work, the SARC elected to retain the NEFSC (2002) estimates of biological reference points for this assessment. The SARC recommends that these parametric stock-recruitment model reference points be adopted as the basis for the ASMFC and NEFMC FMP overfishing definitions.

PROJECTIONS FOR 2002-2013

Stochastic projections were made based on 500 bootstrapped VPA realizations of stock size in numbers at age in 2002. The stochastic forecasts only incorporate uncertainty in 2002 stock sizes due to survey variability, assume current discard to landings proportions, and are not adjusted for the retrospective pattern in VPA stock size estimates. Partial recruitment to the fishery and percentage discarded were estimated as the geometric mean of VPA estimates for 1998-2000. The 2001 estimates were not included in the averages due to the retrospective variability of the partial recruitment pattern in the terminal year of the VPA. For consistency with the partial recruitment averages, mean weights at age in the stock, landings, and discards were similarly estimated as the weighted (by number landed) geometric mean weight at age from 1998-2000. Age-1 recruitment levels in 2003 and later years are estimated from the stochastic, parametric stock-recruitment relationship estimated in NEFSC (2002). Projections were made through 2013 to respond both to the ASMFC terms of reference and more recent NEFMC Plan Development Team requirements.

If F in 2002 is assumed to be 15% less than F in 2001 (F2002 = 0.43), due to the impact of management measures implemented in response to court orders during 2002, then landings are expected to be about 3,000 mt in 2002. At this reduced F, spawning stock biomass is projected to fall to 5,900 mt in 2002. Given F = 0.43 in 2002, a fishing mortality rate of Freb = 0.24 will be necessary to rebuild the spawning stock to 30,100 mt by 2013 with 50% probability (Table B1.28, Figure B1.13).

POTENTIAL SENSITIVITY OF VPA ESTIMATES TO HYPOTHETICAL NEFSC SURVEY ADJUSTMENTS

Acting on the advice of industry members, NEFSC staff inspected the trawl cables (warp) on the NOAA Ship Albatross IV' s sampling equipment on September 3, 2002. It was determined that the marks on the cable attaching scientific survey gear to the vessel were not at true 50 m length intervals they are intended to indicate. The marks are used by the vessel crew to determine how much cable is deployed. The cable was most recently replaced in February 2000, and used in eight bottom trawl surveys, beginning with Winter 2000 and ending with Spring 2002.

Therefore, it is likely that at times more cable was deployed on one side of the NEFSC trawl survey net than on the other. This is a matter of inches at shorter lengths, and more pronounced as more cable is deployed. For example, with 100 m (328 ft) of cable deployed, just under 1 inch more cable was out on one side; at 300 m (984 ft) the difference was just under 6 ft. Of all tows made in the surveys, 75% deploy 300 m of cable or less. As a result, the NEFSC trawl survey gear may have fished differently during the Winter 2000 through Spring 2002 survey compared to prior surveys, and the data collected (catch per tow, for example) may have been influenced in a way that should be accounted for.

During September 24-27, 2002, video and net sensor equipment were used in experimental tows to both directly and numerically document net performance. Individuals from the region's commercial industry and the fishery management councils were part of the scientific crew during these observations. During October 2-3, 2002, a workshop was convened to examine the data collected and produce a report. The workshop was open to the public, with invited members to include scientists familiar with fishery survey practices, commercial fishermen and gear providers, the region's fishery management councils. As of this writing, the workshop was in progress, and was expected to produce a report detailing correction factors that can then be used in adjusting the NEFRSC survey indices used in this assessment, if needed.

In the interim, to examine the potential sensitivity of the SNE/MA winter flounder VPA to such corrections, hypothetical adjustments have been applied to the NEFSC winter, spring, and fall survey indices used in the SNE/MA winter flounder VPA. NEFSC indices from the Winter 2000 through Spring 2002 surveys were increased by 10%, 25%, and 100% to explore a range of the potential positive adjustments to the indices that might be necessary to account for reduced catch efficiency of the NEFSC survey gear during those surveys. The effect is nearly linear, with F in 2001 ranging from 0.51 for the baseline, W36_2 VPA to 0.36 for the VPA with all NEFSC survey indices increased by 100% (doubled); SSB in 2001 ranged from 7,600 mt for the baseline to 11,300 mt for NEFSC indices increased 100%. In all cases, the fishing mortality rate remained above Fmsy, and SSB remained below one-half Bmsy (Figure B1.14).

CONCLUSIONS

The Southern New England/Mid-Atlantic winter flounder stock complex is overfished and overfishing is occurring (Figure B1.15). Fully recruited fishing mortality in 2001 was 0.51 (exploitation rate = 37%), about 60% above Fmsy =0.32. The current VPA indicates there is an 80% chance that the 2001 F was between 0.44 and 0.58. Spawning stock biomass was estimated to be 7,600 mt in 2001, about 25% of SSBmsy = 30,100 mt. There is an 80% chance that the spawning stock biomass was between 6,800 mt and 8,400 mt in 2001.

The current assessment provides a much more pessimistic evaluation of stock status than the SARC 28 assessment in 1998 (NEFSC 1999). This is mainly due to the retrospective pattern of underestimating F and overestimating SSB in the current VPA. However, while the SNE/MA winter flounder VPA provides uncertain estimates of current F and SSB, it provides a better determination of stock status than reliance on survey indices alone. Managers should recognize that given the estimation uncertainty in the assessment, current fishing mortality rates are likely much higher than the 2001 estimate of 0.51, potentially by nearly 100%. Current SSB may in turn be substantially overestimated.

Spawning stock biomass declined substantially from 13,000-14,000 mt during the early 1980s to 2,700 mt during 1994-1996. SSB has increased since the mid 1990s to about 7,600 mt in 2001 due to reduced fishing mortality rates since 1997. Recruitment to the stock has been below average since 1989, and early indications are that the 2001 year class is the smallest in 22 years. Forecasts indicate that it will be necessary to reduce the fishing mortality rate to Freb = 0.24 in 2003 and later years to rebuild to spawning stock to the target (SSBmsy = 30,100 mt) by 2013 with 50% probability.

The SARC elected to retain the NEFSC (2002) estimates of biological reference points for SNE/MA winter flounder for this assessment. The SARC recommends that these parametric stock-recruitment model reference points be adopted as the basis for the ASMFC and NEFMC FMP overfishing definitions. These reference points are a technical improvement over the ASMFC's yield per recruit reference points, as they include the estimates of Bmsy, MSY, and Fmsy required by the Sustainable Fisheries Act of 1996.

SARC COMMENTS

The SARC noted that while three of the major research recommendations from the SARC 28 assessment had been addressed, three more dealing mainly with the estimates of fishery discards remain unresolved, and should be addressed before the next assessment. The SARC discussed the use of surveys with different recent trends for tuning the VPA. A VPA run using only NEFSC surveys produced a more optimistic view of stock status than a run using only State indices. It was noted that the different trends among State surveys are likely tracking real trends in different portions of the stock complex. Therefore, combining the indices on a spatial scale or weighting them by survey area before tuning the VPA should be explored. The SARC reviewed a run using iterative re-weighting of the indices, which provided results very similar to the final, accepted VPA.

The SARC discussed the process of selecting indices used to tune the VPA, because the current VPA includes three new tuning series for ages 1-7+ (NEFSC winter, NJDFW river, and NJDFW ocean) and two more recruitment indices (NYDEC) not available for the SARC 28 assessment. The SARC reviewed a VPA run using the same suite of indices as in the last assessment (SARC 28) to determine how the addition of the new series had influenced the VPA results. That run provided results similar to the final VPA. An examination of the utility of a randomization test on survey indices for determining the influence of the indices on VPA results could be informative.

The SARC noted that the current assessment provides a much more pessimistic evaluation of stock status than the SARC 28 assessment in 1998 (NEFSC 1999). This is mainly due to the retrospective pattern of underestimating F and overestimating SSB in the current VPA. It was noted that an increase in the catchability of the survey could produce the observed retrospective pattern. However, there was no reason to suspect an increase in the catchability of the NEFSC and State research surveys used in the VPA tuning. The mis-classification of landings by stock area could also be a cause of the retrospective pattern. However, the SARC noted a similar retrospective pattern in the Gulf of Maine winter flounder assessment, suggesting that significant SNE-MA landings had not been mis-classified into the Gulf of Maine stock area. An underestimation of the discarded proportion of the catch could also produce the observed retrospective pattern. The use of VTR data in estimating commercial fishery discards is a source of uncertainty. Possible significant discarding in the commercial scallop dredge fishery was noted, but current data provide generally small (less than the trawl fishery) and extremely variable estimates of winter flounder discards in the dredge fishery. Finally, the observed retrospective pattern might be caused by under-reporting or underestimation of the commercial or recreational landings. Given the retrospective pattern, the utility of the current SNE-MA winter flounder VPA was evaluated. The SARC concluded that, while the SNE-MA winter flounder VPA provides uncertain estimates of current F and SSB, it still provides the best available determination of stock status.

As one illustration of the possible magnitude of potential missing catch, the SARC noted that it would take roughly a trebling of the catch during the period 1996-1998 to significantly reduce the magnitude of the retrospective pattern in fishing mortality. The SARC noted that retrospective patterns are evident in several of the New England groundfish stock assessments (e.g. GOM winter flounder, SNE-MA, CC/GOM, and GB yellowtail flounder, GB and GOM cod, and witch flounder). Investigation to determine a common cause for this pattern should be pursued. Alternative assessment methods for dealing with retrospective patterns, such as statistical catch at age models, should be explored.

SOURCES OF UNCERTAINTY

1) Stock-specific landings data for 1994 and later are derived by proration from Vessel Trip Report data and are considered provisional.

2) Length frequency sampling intensity of the commercial and recreational fishery landings has been low in some recent years, and likely increases the uncertainty of the estimated landings at age.

3) Commercial fishery discard estimates are based on rates provided by fishers in the Vessel Trip Reports, owing to inadequate Fishery Observer sampling.

4) The SNE-MA winter flounder VPA exhibits a retrospective pattern of underestimating F and overestimating SSB during the late 1990s, increasing the uncertainty of current estimates of F and SSB.

RESEARCH RECOMMENDATIONS

New

1) Evaluate the maturity at age of fish sampled in the NEFSC fall and winter surveys.

2) Consider fieldwork to record ovary weights along with maturity stage data from 20-30 cm fish in the NEFSC and State agency surveys for 1-2 years to help resolve age/size at maturity differences between State and NEFSC surveys.

3) Conduct periodic maturity staging workshops involving State and NEFSC trawl survey staff.

4) Examine sources of the differences between NEFSC, MA and CT survey maturity (validity of evidence for smaller size or younger age at 50% maturity in the NEFSC data). Compare NEFSC inshore against offshore strata for differences in maturity. Compare confidence intervals for maturity ogives. Calculate annual ogives and investigate for progression of maturity changes over time. Examine maturity data from NEFSC strata on Nantucket Shoals and near George’s Bank separately from more inshore areas. Consider methods for combining maturity data from different survey programs.

5) Increase the intensity of commercial fishery discard length sampling.

6) Consider post-stratification of NEFSC survey offshore stratum 23, to facilitate inclusion of survey catches from this stratum (east of Cape Cod) in the SNE-MA winter flounder assessment.

7) Incorporate State samples (e.g. NY DEC Party Boat Survey and CT DEP Volunteer Angler Survey) in the estimation of recreational fishery landings and discards, if possible.

8) Attempt use of a forward projection (statistical catch at age model) in the next assessment.

Old: Pending

1) Continue to consider the effects of catch-and-release components of recreational fishery on discard at age (i.e., develop mortality estimates from the American Littoral Society tagging database, if feasible).

2) Compare commercial fishery discard estimates from the Mayo survey/mesh algorithm with those from VTR data for comparable time periods.

3) Maintain or increase sampling levels (currently supported by individual state funding) and collect age information from MRFSS samples.

4) Examine the implications of anthropogenic mortalities caused by pollution and power plant entrainment in estimating yield per recruit, if feasible.

5) Examine the implications of stock mixing from data from Great South Channel region.

6) Expand sea sampling for estimation of commercial discards.

7) Revise the recreational fishery discard estimates by applying a consistent method across all years, if feasible (i.e., the Gibson 1996 method).

Old: Work In Progress

1) Re-examine the maturity ogive to incorporate any recent research results.

2) Explore the feasibility of stratification of the commercial fishery discard estimation by fishery (e.g., mesh, gear, area).

Old: Completed

1) Further examine the comparability of age-length keys from different areas within the stock. Current comparisons are based on two years and three ages. Conduct an age structure exchange between NEFSC, CT DEP, and MADMF, to ensure consistency in ageing protocol.

2) Age the archived MA DMF survey age samples for 1978-1989.

3) Compile NEFSC Winter Survey abundance indices for winter flounder and evaluate their utility.

4) Evaluate the utility of MADMF sea sample data for winter flounder in estimating commercial fishery discards.

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Table B1.1. Winter flounder commercial landings (metric tons) for Southern New England/Mid-Atlantic stock complex area (U.S. statistical reporting areas 521, 526, divisions 53, 61-63) as reported by NEFSC weighout, state bulletin and general canvas data.

Year	Metric Tons
1964	7,474
1965	8,678
1966	11,977
1967	9,478
1968	7,070
1969	8,107
1970	8,603
1971	7,367
1972	5,190
1973	5,573
1974	4,259
1975	3,982
1976	3,265
1977	4,413
1978	6,327
1979	6,543
1980	10,627
1981	11,176
1982	9,438
1983	8,659
1984	8,882
1985	7,052
1986	4,929
1987	5,172
1988	4,312
1989	3,670
1990	4,232
1991	4,823
1992	3,816
1993	3,010
1994	2,159
1995	2,634
1996	2,781
1997	3,441
1998	3,208
1999	3,444
2000	3,783
2001	4,448

Table B1.2. Distribution of commercial landings (percentage of annual total) of winter flounder from Southern New England/Mid-Atlantic stock complex area by U.S. statistical reporting area.

	Area								
Year	521	526	537	538	539	611	612	613	614-622
1989	33.2	10.8	18.9	7.0	12.1	7.1	5.5	4.2	1.2
1990	45.2	16.8	6.1	4.9	9.5	11.1	4.1	2.0	0.1
1991	46.4	14.7	10.8	1.7	13.7	5.7	3.6	2.9	0.4
1992	37.0	12.5	17.4	2.4	9.4	10.1	4.5	3.4	3.4
1993	46.6	10.0	10.8	2.4	8.2	7.7	4.2	8.0	2.1
1994	41.8	13.3	3.3	0.1	17.6	10.3	6.5	3.1	3.3
1995	43.3	9.1	6.7	1.6	15.7	10.8	9.3	2.1	1.4
1996	47.3	12.0	10.8	1.4	12.3	11.0	2.5	2.4	0.3
1997	62.8	3.1	7.5	1.5	12.3	8.5	2.0	2.1	0.2
1998	49.5	12.4	7.6	0.6	15.2	9.9	1.8	2.4	0.6
1999	48.7	12.3	6.9	0.4	13.2	8.2	6.4	2.4	1.5
2000	44.1	7.4	10.7	0.8	15.1	8.5	7.2	4.8	1.4
2001	55.8	7.2	7.4	0.1	9.7	7.7	7.4	3.1	1.6

Table B1.3. Estimated number (N, 000's) and weight (mt) of winter flounder caught, landed, and discarded in the recreational fishery, Southern New England/Mid-Atlantic stock complex.

Year	Catch N (A+B1+B2)	Landed N (A+B1)	Released N (B2)	15% Release Mortality	Landings (A+B1; mt)
1981	11,006	8,089	2,916	437	3,050
1982	10,665	8,392	2,273	341	2,457
1983	11,010	8,365	2,645	397	2,524
1984	17,723	12,756	4,967	745	5,772
1985	18,056	13,297	4,759	714	5,198
1986	9,368	6,995	2,374	356	2,940
1987	9,213	6,900	2,313	347	3,141
1988	10,134	7,358	2,775	416	3,423
1989	5,919	3,682	2,236	335	1,802
1990	3,827	2,486	1,340	201	1,063
1991	4,325	2,795	1,530	230	1,214
1992	1,360	806	555	83	393
1993	2,211	1,180	1,031	155	543
1994	1,829	1,209	620	93	598
1995	1,850	1,390	461	69	661
1996	2,679	1,554	1,125	169	689
1997	1,901	1,207	694	104	621
1998	1,008	584	425	64	290
1999	1,071	658	412	62	320
2000	2,043	1,346	697	105	831
2001	1,441	901	540	81	552

Table B1.4. Winter flounder commercial fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1981-1997. Landings are in metric tons.

Year	Landings	Lengths measured	Metric tons per 100 lengths
1981	11,176	4,230	264
1982	9,438	5,796	163
1983	8,659	5,601	155
1984	8,882	3,697	240
1985	7,052	6,407	110
1986	4,929	5,120	96
1987	5,172	5,271	98
1988	4,312	4,208	102
1989	3,670	3,525	104
1990	4,232	4,088	104
1991	4,823	3,058	158
1992	3,816	4,163	92
1993	3,010	2,354	128
1994	2,159	2,593	83
1995	2,634	4,153	63
1996	2,781	2,019	138
1997	3,441	4,005	86

Table B1.5. Winter flounder commercial fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1998-2001. Landings are in metric tons.

1998		Market Category				
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	162	105	767	205	1239
Port	Jul-Dec	780	794	558	210	2342
Total lengths used		942	899	1325	415	3581
Landings		644	1453	438	673	3208
Metric tons per 100 lengths		68	162	33	162	90

1999		Market Category				
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	978	334	502	522	2336
Port	Jul-Dec	1403	464	105	299	2271
Total lengths used		2381	798	607	821	4607
Landings		838	1566	290	750	3444
Metric tons per 100 lengths		35	196	48	91	75

2000		Market Category				
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	808	377	1868	126	3179
Port	Jul-Dec	845	565	1025	839	3274
Total lengths used		1653	942	2893	965	6453
Landings		848	451	1670	815	3784
Metric tons per 100 lengths		51	48	58	84	59

Table B1.5 continued.

2001		Market Category				
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	557	510	1067	636	2770
Port	Jul-Dec	203	387	1234	1661	3485
Total lengths used		760	897	2301	2297	6255
Landings		908	1101	1475	962	4446
Metric tons per 100 lengths		119	123	64	42	71

Table B1.6. Winter flounder recreational fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1981-1997. Landings are in metric tons.

Year	Landings	Lengths measured	Metric tons per 100 lengths
1981	3,050	1,725	177
1982	2,457	1,971	125
1983	2,524	2,587	98
1984	5,772	3,123	185
1985	5,198	2,357	221
1986	2,940	2,237	131
1987	3,141	1,360	231
1988	3,423	1,944	176
1989	1,802	2,810	64
1990	1,063	2,548	42
1991	1,214	1,755	69
1992	393	1,083	36
1993	543	1,288	42
1994	598	948	63
1995	661	767	86
1996	689	936	74
1997	621	752	83

Table B1.7. Winter flounder recreational fishery sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1998-2001. SNE = MA & RI; MA = CT and states south. Landings are in metric tons.

Season/area	1998	1999	2000	2001
Jan-Jun/SNE	105	77	7	80
Jan-Jun/MA	405	256	105	387
Jul-Dec/SNE	85	48	0	3
Jul-Dec/MA	21	14	48	38
Total lengths	616	395	160	508
Landings (A+B1.)	290	320	831	552
Metric tons per 100 Lengths	47	81	519	109

Table B1.8. Winter flounder NEFSC Domestic Fishery Observer Program (OB) and NER Vessel Trip Report (VTR) data: number of OB trips with landed winter flounder (to estimate discards to landings ratio), OB discards to landings ratio, number of VTR trips with winter flounder landings that discarded any species, and VTR discards to landings ratio. VTR data available for 1994 and subsequent years.

Year	Half-year	OB trips	OB ratio	VTR Trips	VTR ratio
1989	Jan-Jun	22	0.235		
	Jul-Dec	28	0.299		
1990	Jan-Jun	21	0.069		
	Jul-Dec	18	0.227		
1991	Jan-Jun	46	0.579		
	Jul-Dec	42	0.283		
1992	Jan-Jun	17	0.021		
	Jul-Dec	21	0.076		
1993	Jan-Jun	11	0.299		
	Jul-Dec	22	0.32		
1994	Jan-Jun	13	0.304	1519	0.241
	Jul-Dec	12	2.84	1488	0.091
1995	Jan-Jun	20	0.044	1484	0.072
	Jul-Dec	36	0.289	764	0.028
1996	Jan-Jun	18	0.358	1002	0.088
	Jul-Dec	38	0.115	576	0.05
1997	Jan-Jun	27	0.175	2138	0.145
	Jul-Dec	18	0.021	1766	0.16

Table B1.8 continued.

Year	Half-year	OB trips	OB ratio	VTR Trips	VTR ratio
1998	Jan-Jun	6	0.306	2114	0.265
	Jul-Dec	18	0.437	1424	0.292
1999	Jan-Jun	13	11.842	2570	0.102
	Jul-Dec	7	0.005	1554	0.238
2000	Jan-Jun	20	0.095	2104	0.16
	Jul-Dec	21	0.042	1586	0.043
2001	Jan-Jun	27	0.04	2508	0.061
	Jul-Dec	22	0.069	2016	0.025

Table B1.9. Winter flounder commercial fishery discard sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1994-2001. Discard estimates (before impact of 50% mortality rate) are in metric tons.

Season	1994	1995	1996	1997
Jan-Jun	111	73	358	412
Jul-Dec	196	646	245	556
Total lengths	307	719	603	968
Discard Estimate (before mortality)	608	242	346	534
Metric tons per 100 Lengths	198	34	57	55

Season	1998	1999	2000	2001
Jan-Jun	170	354	353	135
Jul-Dec	604	13	128	0
Total lengths	774	367	481	135
Discard Estimate (before mortality)	911	659	296	167
Metric tons per 100 Lengths	118	180	62	124

Table B1.10. Winter flounder catch at age (number in 000s) for the Southern New England/Mid-Atlantic stock complex.

Commercial Landings	Age												
Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1981	194	7154	9740	2750	606	178	42	32	0	0	9	0	0
1982	54	6897	8496	2715	488	187	78	59	21	17	7	7	0
1983	6	2795	7114	3957	1322	584	269	91	34	70	6	29	35
1984	0	4518	6367	3197	1503	768	355	158	67	86	27	33	37
1985	27	3936	5688	3052	1014	326	104	32	17	7	5	2	0
1986	0	2122	4187	2206	551	271	84	27	6	3	1	2	0
1987	0	2488	5465	1895	465	122	40	20	14	12	2	0	0
1988	0	2241	3929	1607	412	122	37	24	3	2	1	0	0
1989	0	1542	4057	1747	431	58	34	13	5	1	0	0	0
1990	0	1003	3977	1757	315	95	37	16	0	3	0	0	0
1991	0	1406	4756	2239	447	143	48	16	5	1	1	0	0
1992	0	484	3416	2127	574	111	32	11	3	0	0	0	0
1993	13	885	2516	1377	361	102	71	7	0	0	2	0	1
1994	0	629	804	401	90	14	10	0	0	0	0	0	0
1995	0	73	1537	587	95	24	5	0	0	0	0	0	0
1996	0	606	1146	470	122	17	11	0	0	0	0	0	0
1997	0	1418	2574	1370	356	70	28	12	5	1	0	0	0
1998	0	1021	3057	1483	450	83	60	63	7	0	0	0	0
1999	0	2009	3347	1538	386	59	11	6	0	0	0	0	0
2000	0	1073	2801	1942	592	135	35	12	0	0	0	0	0
2001	0	1727	3263	1851	620	148	53	23	2	3	0	0	0

Table B1.10 continued

Commercial Discards Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13
1981	322	2514	2186	101	0	0	0	0	0	0	0	0	0
1982	43	2817	1219	192	0	0	0	0	0	0	0	0	0
1983	260	2479	2000	467	45	0	0	0	0	0	0	0	0
1984	159	2102	1502	166	6	1	0	0	0	0	0	0	0
1985	22	1504	2516	442	43	4	0	0	0	0	0	0	0
1986	78	2220	2389	205	10	0	0	0	0	0	0	0	0
1987	11	1600	1755	170	9	0	0	0	0	0	0	0	0
1988	6	887	2540	276	20	0	0	0	0	0	0	0	0
1989	315	2724	2131	555	33	2	1	0	0	0	0	0	0
1990	16	781	1433	322	14	0	1	0	0	0	0	0	0
1991	17	1238	1205	227	12	1	0	0	0	0	0	0	0
1992	15	845	787	150	14	1	0	0	0	0	0	0	0
1993	201	849	467	57	6	0	0	0	0	0	0	0	0
1994	44	204	88	8	0	0	0	0	0	0	0	0	0
1995	15	47	41	4	0	0	0	0	0	0	0	0	0
1996	11	64	66	7	1	0	0	0	0	0	0	0	0
1997	373	580	210	31	6	0	0	0	0	0	0	0	0
1998	43	972	407	78	3	0	0	0	0	0	0	0	0
1999	63	583	314	54	23	22	15	0	0	0	0	0	0
2000	68	218	199	34	8	1	6	0	0	0	0	0	0
2001	11	127	111	33	3	0	0	0	0	0	0	0	0

Table B1.10 continued.

Recreational Landings Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13
1981	776	4054	2426	742	59	4	28	0	0	0	0	0	0
1982	457	4235	2716	823	122	26	13	0	0	0	0	0	0
1983	289	1630	4194	1702	427	112	11	0	0	0	0	0	0
1984	294	4258	6224	1565	267	107	41	0	0	0	0	0	0
1985	219	1585	4270	2558	1895	1513	878	0	335	44	0	0	0
1986	106	1765	2432	1797	491	171	81	77	51	8	17	0	0
1987	16	926	1736	1023	2229	633	82	115	64	77	0	0	0
1988	21	534	2858	2078	775	857	128	51	37	20	0	0	0
1989	99	739	944	1200	385	161	91	36	16	8	3	1	0
1990	7	189	814	851	439	101	52	20	3	3	0	2	5
1991	13	232	1122	879	399	107	38	0	1	0	3	0	0
1992	3	123	235	303	85	50	7	0	0	0	0	0	0
1993	31	233	321	289	218	54	20	10	4	2	0	0	0
1994	5	203	240	303	220	149	89	0	0	0	0	0	0
1995	0	30	268	298	321	267	206	0	0	0	0	0	0
1996	0	106	200	630	220	240	157	0	0	0	0	0	0
1997	1	82	497	410	178	36	0	0	0	0	0	0	0
1998	2	89	191	235	58	7	1	0	0	0	0	0	0
1999	1	101	340	151	49	16	0	0	0	0	0	0	0
2000	0	113	440	472	262	44	14	0	0	0	0	0	0
2001	1	84	267	303	168	62	16	0	0	0	0	0	0

Table B1.10 continued.

Recreational Discards Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13
1981	70	367	0	0	0	0	0	0	0	0	0	0	0
1982	33	308	0	0	0	0	0	0	0	0	0	0	0
1983	62	337	0	0	0	0	0	0	0	0	0	0	0
1984	48	697	0	0	0	0	0	0	0	0	0	0	0
1985	9	340	363	2	0	0	0	0	0	0	0	0	0
1986	32	222	93	9	0	0	0	0	0	0	0	0	0
1987	47	254	43	3	1	0	0	0	0	0	0	0	0
1988	57	279	76	3	0	0	0	0	0	0	0	0	0
1989	49	240	45	1	0	0	0	0	0	0	0	0	0
1990	12	136	51	2	0	0	0	0	0	0	0	0	0
1991	22	151	56	0	0	0	0	0	0	0	0	0	0
1992	7	51	19	1	0	0	0	0	0	0	0	0	0
1993	29	95	26	4	0	0	0	0	0	0	0	0	0
1994	12	60	21	0	0	0	0	0	0	0	0	0	0
1995	9	45	15	0	0	0	0	0	0	0	0	0	0
1996	21	110	37	0	0	0	0	0	0	0	0	0	0
1997	11	55	19	0	0	0	0	0	0	0	0	0	0
1998	5	49	8	1	0	0	0	0	0	0	0	0	0
1999	2	53	6	1	0	0	0	0	0	0	0	0	0
2000	0	38	60	7	0	0	0	0	0	0	0	0	0
2001	1	49	27	5	0	0	0	0	0	0	0	0	0

Table B1.10 continued.

Total Catch Year	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	Total
1981	1362	14089	14352	3593	665	182	70	32	0	0	9	0	0	34354
1982	587	14257	12421	3730	610	213	91	59	21	17	7	7	0	32020
1983	617	7241	13308	6126	1794	696	280	91	34	70	6	29	35	30327
1984	501	11575	14093	4928	1776	876	396	158	67	86	27	33	37	34553
1985	277	7366	12836	6054	2953	1843	982	32	352	52	5	2	0	32753
1986	215	6327	9102	4216	1053	442	165	104	57	10	19	2	0	21712
1987	73	5268	8999	3091	2703	755	122	135	78	89	2	0	0	21315
1988	84	3941	9402	3964	1207	979	165	75	39	22	1	0	0	19880
1989	463	5246	7176	3503	849	222	126	49	21	9	3	1	0	17668
1990	36	2109	6275	2931	767	196	89	36	4	5	0	2	5	12455
1991	53	3027	7140	3344	858	251	87	16	6	1	4	0	0	14788
1992	25	1503	4457	2581	674	162	38	11	3	0	0	0	0	9455
1993	274	2062	3329	1728	585	157	91	17	4	2	2	0	1	8251
1994	61	1097	1152	713	311	162	99	0	0	0	0	0	0	3595
1995	24	195	1862	889	415	291	211	0	0	0	0	0	0	3887
1996	32	886	1450	1107	343	258	168	0	0	0	0	0	0	4244
1997	385	2135	3300	1811	540	106	28	12	5	1	0	0	0	8323
1998	50	2132	3663	1797	511	90	61	63	7	0	0	0	0	8374
1999	66	2746	4008	1744	458	97	26	6	0	0	0	0	0	9150
2000	69	1442	3500	2455	862	180	55	12	0	0	0	0	0	8575
2001	13	1987	3668	2191	790	211	69	23	2	3	0	0	0	8957

Table B1.11. Total winter flounder recreational and commercial catch for the Southern New England/Mid-Atlantic stock complex in weight (mt) and numbers (000s).

Year	Commercial Landings		Commercial Discards		Recreational Landings		Recreational Discards		Total Catch		% Discards/Total	
	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s
1981	11,176	20,705	1,343	5,123	3,050	8,089	88	437	15,657	34,354	9.1	16.2
1982	9,438	19,016	1,149	4,271	2,457	8,392	66	341	13,110	32,020	9.3	14.4
1983	8,659	16,312	1,311	5,251	2,524	8,365	125	399	12,619	30,327	11.4	18.6
1984	8,882	17,116	986	3,936	5,772	12,756	148	745	15,788	34,553	7.2	13.5
1985	7,052	14,211	1,534	4,531	5,198	13,297	230	714	14,014	32,753	12.6	16.0
1986	4,929	9,460	1,273	4,902	2,940	6,994	66	356	9,208	21,712	14.5	24.2
1987	5,172	10,524	950	3,545	3,141	6,899	61	347	9,324	21,315	10.8	18.3
1988	4,312	8,377	904	3,728	3,423	7,359	69	416	8,708	19,880	11.2	20.8
1989	3,670	7,888	1,404	5,761	1,802	3,684	49	335	6,925	17,668	21.0	34.5
1990	4,232	7,202	673	2,567	1,063	2,485	31	201	5,999	12,455	11.7	22.2
1991	4,823	9,063	784	2,701	1,214	2,794	51	230	6,872	14,788	12.2	19.8
1992	3,816	6,759	511	1,811	393	802	15	83	4,735	9,455	11.1	20.0
1993	3,010	5,336	457	1,580	543	1,180	31	155	4,041	8,251	12.1	21.0
1994	2,159	1,948	304	344	598	1,210	34	93	3,095	3,595	10.9	12.2
1995	2,634	2,321	121	107	661	1,390	23	69	3,439	3,887	4.2	4.5
1996	2,781	2,372	173	149	689	1,555	64	168	3,707	4,244	6.4	7.5
1997	3,441	5,834	267	1,200	618	1,204	26	85	4,352	8,323	6.7	15.4

Table B1.11 continued.

Year	Commercial Landings		Commercial Discards		Recreational Landings		Recreational Discards		Total Catch		% Discards/Total	
	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s	mt	000s
1998	3,208	6,224	456	1,503	290	584	13	64	3,967	8,375	11.8	18.7
1999	3,444	7,356	329	1,074	320	658	14	62	4,107	9,150	8.4	12.4
2000	3,783	6,590	148	534	831	1,346	30	105	4,792	8,575	3.7	7.5
2001	4,448	7,690	83	285	552	901	19	81	5,102	8,957	2.0	4.1

Table B1.12. Total fishery catch at age used as input to Virtual Population Analysis (VPA) for the Southern New England/Mid-Atlantic winter flounder stock complex.

Year	Age						
	1	2	3	4	5	6	7+
1981	1362	14089	14352	3593	665	182	111
1982	587	14257	12421	3730	610	213	202
1983	617	7241	13308	6126	1794	696	545
1984	501	11575	14093	4928	1776	876	804
1985	277	7366	12836	6054	2953	1843	1424
1986	215	6327	9102	4216	1053	442	357
1987	73	5268	8999	3091	2703	755	426
1988	84	3941	9402	3964	1207	979	303
1989	463	5246	7176	3503	849	222	209
1990	36	2109	6275	2931	767	196	141
1991	53	3027	7140	3344	858	251	115
1992	25	1503	4457	2581	674	162	53
1993	274	2062	3329	1728	585	157	116
1994	61	1097	1152	713	311	162	99
1995	24	195	1862	889	415	291	211
1996	32	886	1450	1107	343	258	168
1997	385	2135	3300	1811	540	106	46
1998	50	2132	3663	1797	511	90	131
1999	66	2746	4008	1744	458	97	32
2000	69	1442	3500	2455	862	180	67
2001	13	1987	3668	2191	790	211	97

Table B1.13. Total fishery mean weights at age used as input to Virtual Population Analysis (VPA) for the Southern New England/Mid-Atlantic winter flounder stock complex.

Year	Age						
	1	2	3	4	5	6	7+
1981	0.130	0.276	0.478	0.802	1.065	1.243	1.202
1982	0.090	0.261	0.438	0.694	1.048	1.253	1.837
1983	0.195	0.237	0.353	0.516	0.774	1.046	1.552
1984	0.146	0.258	0.366	0.542	0.693	0.913	1.282
1985	0.111	0.282	0.364	0.482	0.522	0.467	0.613
1986	0.129	0.292	0.398	0.480	0.685	0.879	0.961
1987	0.046	0.287	0.384	0.551	0.475	0.564	0.853
1988	0.039	0.279	0.351	0.508	0.634	0.517	0.827
1989	0.118	0.258	0.378	0.508	0.660	0.716	1.073
1990	0.082	0.295	0.394	0.525	0.672	0.808	0.990
1991	0.093	0.317	0.420	0.534	0.603	0.823	1.168
1992	0.079	0.287	0.427	0.599	0.802	0.945	1.395
1993	0.169	0.334	0.460	0.592	0.689	0.878	1.167
1994	0.156	0.347	0.448	0.597	0.741	0.692	0.818
1995	0.167	0.323	0.449	0.578	0.714	0.763	0.780
1996	0.193	0.407	0.507	0.569	0.705	0.826	0.853
1997	0.093	0.369	0.510	0.659	0.806	1.071	1.511
1998	0.202	0.332	0.438	0.580	0.665	0.892	1.241
1999	0.079	0.314	0.435	0.562	0.782	0.951	1.317
2000	0.100	0.396	0.484	0.613	0.738	0.915	1.144
2001	0.102	0.419	0.506	0.636	0.796	1.053	1.259

Table B1.14. Winter flounder NEFSC survey index stratified mean number and mean weight (kg) per tow for the Southern New England- Mid-Atlantic stock complex. Spring and fall strata set (offshore 1-12, 25, 69-76 ; inshore 1-29, 45-56); winter strata set (offshore 1-2, 5-6,9-10,69,73).

	Spring				Fall			
Year	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)
1963					8.554	33.2	3.284	41.4
1964					13.673	22.1	4.894	19.4
1965					15.537	32.5	4.435	28.7
1966					9.843	31.5	3.275	27.3
1967					9.109	20.6	2.745	18.7
1968	2.444	26.7	0.734	37.2	8.105	21	2.19	18.7
1969	5.64	34.3	3.414	53.7	6.841	34.9	1.939	29.7
1970	2.729	30.9	1.326	35.6	5.11	36.1	2.375	47.8
1971	2.035	32.9	0.756	36.2	3.861	17.5	1.231	19.1
1972	1.865	28.1	0.656	32.1	7.687	39.4	3.053	44.6
1973	7.458	19.9	2.013	20.6	2.691	26.9	0.775	25.8
1974	3.362	21.9	1.043	19.3	2.032	31.1	0.822	29.4
1975	1.135	22.6	0.354	20.8	2.196	20.3	0.688	22.1
1976	3.085	16.3	0.804	17.2	2.376	32.2	1.251	42.9
1977	4.209	17.2	1.189	18.6	4.722	22.5	1.735	25.2
1978	6.695	11.1	1.758	13.3	3.743	17.6	1.43	22.6
1979	2.966	16.8	1.069	25	10.058	18.4	2.606	15.4
1980	15.25	17.5	3.551	13.6	9.964	31	3.216	29.5
1981	18.234	20.9	4.762	16.9	10.206	20.3	3.11	19.9
1982	6.986	20.1	1.918	15.8	4.927	22.8	1.683	25.9
1983	6.262	18.4	2.469	28	8.757	37.6	2.69	31.7
1984	5.524	19	2.072	28.4	2.681	21.1	0.887	21
1985	5.36	17.4	1.983	16.5	2.727	21.5	0.991	21.5
1986	2.266	23.9	0.766	23.4	1.538	21.9	0.487	19.1
1987	1.763	21.3	0.568	17.9	1.167	28.9	0.419	37.8
1988	2.126	19.6	0.73	19.3	1.246	22.4	0.53	27.5
1989	2.485	33.5	0.582	29.6	1.435	40.7	0.341	30.4
1990	1.992	36.8	0.472	33.1	1.979	29.6	0.546	25.8
1991	2.473	15.6	0.692	14.7	1.95	23.6	0.708	25.6

Table B1.14 continued.

	Spring				Fall				Winter			
Year	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)	Number	N(CV)	Weight	W(CV)
1992	1.579	23.4	0.435	22.1	2.963	32.4	0.829	31.8	3.68	27.3	0.928	26
1993	0.961	19.1	0.219	14.8	1.382	25	0.392	25.9	2.59	29.4	0.456	21.5
1994	1.51	26.4	0.329	21.9	4.134	24.8	1.482	27.3	3.797	30.8	1.183	35.5
1995	2.097	23.4	0.592	19.1	2.253	20.7	0.626	17.3	2.221	26.1	0.697	29.1
1996	1.517	14.3	0.428	15.2	3.186	39.8	1.063	45.3	3.778	28.4	0.734	25.2
1997	1.436	22.1	0.399	20	7.893	32.6	2.583	26.7	3.906	19.7	1.043	21.6
1998	2.774	20.6	0.845	22.1	6.597	13.6	2.232	9.9	7.169	21.6	1.83	24.1
1999	4.171	16.2	1.245	16.4	3.596	17	1.549	16.5	10.328	31.8	3.1	32.3
2000	3.172	26.6	1.123	31.9	6.168	25.5	2.143	26.2	5.571	32.9	1.525	29.5
2001	1.568	14.3	0.581	13.3	4.877	28.1	2.03	28.5	3.096	31.6	0.873	29
2002	2.043	15.7	0.782	16.3					2.901	27.7	1.188	38.3

NOTE: 1968-1972 spring index does not include inshore strata ; 1963-1971 fall index does not include inshore strata. All indices calculated with trawl door conversion factors where appropriate. Winter trawl survey began in 1992.

Table B1.15. SNE/MA winter flounder mean weight per tow for annual state surveys.

Year	MADMF Spring	RIDFW Spring	RIDFW Fall	CTDEP	NJDFW Ocean (April)
1978	18.12				
1979	18.17	7.72	7.24		
1980	15.18	13.57	4.88		
1981	15.77	12.13	2.12		
1982	14.82	5.23	1.30		
1983	19.67	9.52	2.28		
1984	14.68	8.43	3.38	15.68	
1985	11.60	5.93	3.01	13.82	
1986	10.36	6.47	3.12	10.33	
1987	9.57	8.14	2.25	11.76	
1988	6.64	6.02	1.45	18.29	
1989	8.46	3.09	0.79	22.62	5.86
1990	5.38	3.07	0.71	29.02	4.78
1991	2.91	7.38	0.18	24.59	5.32
1992	7.99	0.95	0.42	12.29	2.48
1993	8.16	0.22	0.50	10.26	3.87
1994	12.59	1.67	0.33	12.20	3.25
1995	7.98	6.04	0.89	7.72	8.06
1996	9.78	4.45	0.91	20.41	3.73
1997	10.02	4.57	0.64	15.53	6.52
1998	7.99	5.00	0.32	14.66	4.17
1999	4.44	3.66	0.57	10.29	6.83
2000	6.52	4.52	0.56	12.63	5.24
2001	3.73	3.56	0.28	14.02	6.36
2002				10.90	8.80
Mean	10.44	5.71	1.66	15.11	5.38

Table B1.16. Winter flounder mean number per tow for annual state surveys.

Year	MADMF Spring	RIDFW Spring	RIDFW Fall	CTDEP	NYDEC (Age-1)	NJDFW Ocean (April)	NJDFW Rivers (March-May)
1978	51.62						
1979	53.78	83.76					
1980	38.94	63.10					
1981	46.12	87.97	25.21				
1982	40.23	31.39	18.55				
1983	56.84	58.97	17.29				
1984	37.36	41.64	19.02	111.96			
1985	38.38	34.97	21.44	83.05	1.96		
1986	36.27	41.02	31.28	63.64			
1987	37.85	56.21	20.90	79.92	1.64		
1988	27.91	34.44	10.64	153.08	1.32		
1989	24.41	20.88	7.17	150.08	3.01	25.60	
1990	25.86	20.33	8.83	226.17	1.79	17.47	
1991	10.66	41.95	1.77	156.06	3.38	22.17	
1992	28.83	4.40	10.60	75.09	1.11	9.88	
1993	46.96	2.92	6.65	69.60	5.42	20.13	
1994	48.55	10.25	2.21	101.60	3.16	14.16	
1995	37.84	32.19	7.00	62.62	1.72	30.04	3.00
1996	30.18	20.67	7.79	129.82	1.32	9.60	3.30
1997	39.31	22.28	5.48	78.79	3.15	36.24	3.60
1998	34.63	19.22	2.02	82.21	3.80	18.05	4.90
1999	25.11	13.45	2.80	50.05	3.25	17.84	3.20
2000	26.23	16.32	2.58	49.74	1.56	10.13	2.60
2001	16.00	12.49	2.10	55.80	5.52	13.83	2.90
2002				43.74		22.72	
Mean	35.83	33.51	11.02	95.95	2.69	19.13	3.36

Table B1.17. State survey indices (stratified mean number per tow or haul) for young-of-year winter flounder in Southern New England/Mid-Atlantic stock complex.

Year	MADMF Seine	RIDFW Seine	CTDEP	NYDEC	DEDFG
1975	0.30				
1976	0.32				
1977	0.60				
1978	0.34				
1979	0.49				
1980	0.40				
1981	0.32				
1982	0.37				
1983	0.23				
1984	0.32				
1985	0.34			0.75	
1986	0.32	29.00			0.17
1987	0.27	11.60		0.97	0.09
1988	0.18	8.90	15.50	0.69	0.02
1989	0.42	18.90	1.90	1.67	0.29
1990	0.33	22.10	3.10	2.71	0.63
1991	0.27	12.00	5.80	2.57	0.03
1992	0.29	33.20	13.70	11.49	0.27
1993	0.07	5.50	6.00	4.73	0.04
1994	0.15	2.60	16.60	2.44	0.31
1995	0.16	5.30	12.50	0.91	0.10
1996	0.22	2.80	19.20	3.80	0.04
1997	0.39	4.40	7.47	4.42	
1998	0.16	2.50	9.38	3.11	
1999	0.19	14.60	8.70	7.49	
2000	0.33	52.90	4.30	0.90	
2001	0.21	12.90	1.30	2.31	
2002	0.10				
Mean	0.27	14.95	8.96	3.19	0.18

Table B1.18. NEFSC Spring survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-12, 5, 69-76; inshore 1-29, 45-56).

	Age									
Year	1	2	3	4	5	6	7	8	9+	Total
1980	2.19	8.21	4.15	0.51	0.15	0.04				15.25
1981	2.00	8.08	6.89	0.95	0.26	0.02	0.03			18.23
1982	1.16	3.20	1.56	0.74	0.21	0.09	0.02	0.01		6.99
1983	0.58	0.97	2.14	1.23	0.81	0.37	0.08	0.08		6.26
1984	0.22	1.36	2.18	0.85	0.46	0.29	0.07	0.06	0.03	5.52
1985	0.41	1.21	2.16	0.72	0.51	0.20	0.14	0.01		5.36
1986	0.10	0.49	1.16	0.31	0.15	0.05	0.01			2.27
1987	0.14	0.54	0.70	0.28	0.06	0.02		0.01	0.01	1.76
1988	0.09	0.48	0.99	0.37	0.16	0.02	0.02			2.13
1989	0.14	0.95	0.90	0.34	0.11	0.02	0.02	0.01		2.49
1990	0.23	0.49	0.89	0.28	0.05	0.04	0.01			1.99
1991	0.14	0.60	1.22	0.41	0.05	0.02	0.02	0.01		2.47
1992	0.14	0.39	0.62	0.36	0.05	0.02				1.58
1993	0.14	0.35	0.26	0.12	0.07	0.01	0.01			0.96
1994	0.16	0.74	0.43	0.11	0.04	0.02	0.01			1.51
1995	0.22	0.75	0.87	0.22	0.03		0.01			2.10
1996	0.07	0.54	0.66	0.17	0.06	0.01	0.01			1.52
1997	0.13	0.50	0.56	0.18	0.06	0.01				1.44
1998	0.33	1.21	0.72	0.37	0.13	0.01				2.77
1999	0.41	1.89	1.35	0.36	0.11	0.04	0.01			4.17
2000	0.28	0.70	1.19	0.65	0.27	0.07	0.01			3.17
2001	0.17	0.26	0.47	0.44	0.20	0.02	0.01			1.57
2002	0.11	0.60	0.56	0.38	0.23	0.11	0.04		0.01	2.04
Mean	0.42	1.50	1.42	0.45	0.18	0.07	0.03	0.03	0.02	4.07

Table B1.19. NEFSC Fall survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-12, 5, 69-76; inshore 1-29, 45-56).

	Age									
Year	0	1	2	3	4	5	6	7	8+	Total
1980	0.40	1.76	4.62	2.74	0.44	0.01	0.01			9.98
1981	0.01	2.06	5.05	2.30	0.31	0.06	0.08	0.03		9.90
1982	0.01	0.76	2.21	1.34	0.47	0.12	0.02			4.93
1983		1.63	3.82	2.06	0.62	0.35	0.11	0.07	0.10	8.76
1984		0.17	1.04	1.17	0.26	0.03	0.01			2.68
1985		0.16	1.18	0.99	0.30	0.09	0.01			2.73
1986		0.23	0.90	0.36	0.03	0.01		0.01		1.54
1987		0.03	0.64	0.36	0.12	0.02				1.17
1988		0.03	0.30	0.64	0.22	0.04	0.01	0.01		1.25
1989		0.28	0.83	0.26	0.05	0.01	0.01			1.44
1990		0.08	0.89	0.85	0.15	0.01				1.98
1991		0.07	1.02	0.73	0.12	0.01				1.95
1992		0.13	1.74	0.79	0.26	0.03	0.01			2.96
1993		0.43	0.52	0.35	0.08					1.38
1994		0.45	2.23	1.08	0.30	0.04	0.03			4.13
1995		0.58	0.93	0.63	0.09	0.01	0.01			2.25
1996		0.61	1.40	0.80	0.31	0.06	0.01			3.19
1997		1.48	3.58	2.20	0.55	0.08				7.89
1998		1.39	2.83	1.91	0.41	0.05	0.01			6.60
1999		0.43	0.95	1.46	0.54	0.18	0.04			3.60
2000		0.90	2.30	2.02	0.71	0.22	0.01	0.01		6.17
2001		0.49	1.79	1.61	0.63	0.30	0.02	0.04		4.88
2002										
Mean		0.64	1.85	1.21	0.32	0.08	0.03	0.03	0.10	4.26

Table B1.20. NEFSC Winter survey: stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set: offshore 1-2, 5-6, 9-10,69, 73).

	Age								
Year	1	2	3	4	5	6	7	8+	Total
1992	0.73	0.86	1.09	0.73	0.24	0.02	0.02		3.68
1993	0.56	1.16	0.54	0.18	0.12	0.02	0.01		2.59
1994	0.36	1.16	1.76	0.25	0.28				3.80
1995	0.04	0.75	1.26	0.17					2.22
1996	1.01	0.87	1.55	0.32	0.02				3.78
1997	0.43	1.49	1.32	0.54	0.13				3.91
1998	0.42	3.52	1.95	0.96	0.32				7.17
1999	0.84	5.94	2.23	0.96	0.20	0.16			10.33
2000	0.23	2.82	2.12	0.24	0.16				5.57
2001	1.04	0.55	0.70	0.54	0.22	0.05			3.10
2002	0.08	1.34	0.74	0.15	0.21	0.06	0.21	0.11	2.90
Mean	0.52	1.86	1.39	0.46	0.19	0.06	0.08	0.11	4.46

Table B1.21. MADMF spring trawl survey mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex.

					Age					
Year	1	2	3	4	5	6	7	8	9+	Total
1978	9.93	9.73	15.74	9.33	3.15	1.09	1.33	0.51	0.81	51.62
1979	4.63	12.92	21.14	8.90	2.93	1.00	0.95	0.46	0.85	53.78
1980	1.63	8.21	14.50	9.13	3.01	0.96	0.79	0.28	0.43	38.94
1981	8.35	8.75	13.17	9.38	3.68	1.16	0.75	0.32	0.56	46.12
1982	3.22	11.13	12.36	8.62	2.61	1.05	0.67	0.15	0.42	40.23
1983	1.68	14.84	17.42	13.87	4.08	2.31	1.18	0.56	0.90	56.84
1984	1.17	9.34	11.62	10.06	3.32	1.22	0.48	0.01	0.14	37.36
1985	2.96	9.53	16.09	6.30	2.44	0.73	0.24	0.02	0.07	38.38
1986	3.23	6.81	19.13	5.64	0.82	0.12	0.18	0.16	0.18	36.27
1987	9.29	7.44	11.68	6.46	2.02	0.43	0.35	0.08	0.10	37.85
1988	3.21	7.22	14.45	2.41	0.34	0.08	0.17	0.00	0.03	27.91
1989	2.09	5.41	11.39	4.52	0.96	0.28	0.27	0.12	0.37	25.41
1990	4.22	10.66	7.60	2.90	0.32	0.05	0.10		0.01	25.86
1991	1.64	2.79	4.68	1.15	0.23	0.12	0.02		0.03	10.66
1992	7.93	7.55	6.68	4.16	1.64	0.59	0.07	0.08	0.13	28.83
1993	14.17	17.56	11.70	2.71	0.62	0.14	0.02	0.04		46.96
1994	11.48	16.12	14.65	4.66	0.61	0.58	0.37	0.05	0.03	48.55
1995	13.82	12.05	8.17	1.92	0.60	0.80	0.28	0.14	0.06	37.84
1996	4.81	9.73	7.61	2.84	1.99	1.45	0.84	0.29	0.62	30.18
1997	10.34	10.06	10.38	4.26	1.32	1.01	0.49	0.75	0.70	39.31
1998	8.17	12.59	6.92	3.51	1.46	1.22	0.41	0.31	0.04	34.63
1999	9.23	7.91	5.59	1.79	0.20	0.23	0.13	0.03		25.11
2000	6.62	8.94	6.95	1.69	1.05	0.48	0.22	0.25	0.03	26.23
2001	5.21	5.17	2.46	2.03	0.63	0.19	0.14	0.13	0.04	16.00
Mean	6.21	9.69	11.34	5.34	1.67	0.72	0.44	0.22	0.30	35.87

Table B1.22. CTDEP spring survey for winter flounder in the Southern New England/Mid Atlantic stock complex.

	Age													
Year	0	1	2	3	4	5	6	7	8	9	10	11	12	Total
1984	-	8.21	44.50	31.47	20.83	4.23	1.23	0.67	0.74	0.04	0.01	0.03	0.00	111.96
1985	-	4.10	28.28	32.57	14.13	2.33	0.83	0.45	0.19	0.11	0.04	0.02	0.00	83.05
1986	-	6.69	25.91	15.62	12.27	2.04	0.50	0.25	0.24	0.09	0.01	0.02	0.00	63.64
1987	-	7.32	44.69	14.56	5.05	6.55	1.29	0.11	0.24	0.11	0.00	0.00	0.00	79.92
1988	15.50	14.49	71.87	39.10	8.60	1.82	1.45	0.17	0.04	0.02	0.02	0.00	0.00	153.08
1989	1.90	13.57	78.42	41.23	10.85	2.84	0.98	0.13	0.09	0.06	0.01	0.00	0.00	150.08
1990	3.10	11.31	131.52	64.97	8.97	4.08	1.96	0.19	0.05	0.00	0.02	0.00	0.00	226.17
1991	5.80	8.66	66.88	60.41	9.31	4.05	0.80	0.13	0.01	0.00	0.00	0.01	0.00	156.06
1992	13.70	6.80	31.32	12.78	8.98	1.10	0.36	0.05	0.00	0.00	0.00	0.00	0.00	75.09
1993	6.00	19.11	19.87	15.46	4.81	3.24	0.79	0.15	0.12	0.04	0.01	0.00	0.00	69.60
1994	16.60	9.54	64.06	5.90	3.06	1.15	0.50	0.17	0.06	0.01	0.01	0.00	0.00	101.06
1995	12.50	14.35	23.69	9.77	1.36	0.63	0.20	0.08	0.02	0.02	0.00	0.00	0.00	62.62
1996	19.20	11.46	59.07	24.17	14.41	0.98	0.29	0.13	0.06	0.04	0.01	0.00	0.00	129.82
1997	7.47	12.53	25.53	19.41	9.45	3.76	0.51	0.07	0.03	0.01	0.01	0.01	0.00	78.79
1998	9.28	11.30	32.48	12.18	12.60	3.09	1.05	0.15	0.01	0.07	0.00	0.00	0.00	82.21
1999	8.70	6.53	12.42	11.29	6.09	3.21	1.13	0.61	0.04	0.01	0.02	0.00	0.00	50.05
2000	4.30	7.11	16.66	8.40	7.70	3.44	1.53	0.31	0.26	0.01	0.01	0.00	0.01	49.74
2001	1.30	8.37	19.65	10.87	8.06	5.46	1.26	0.70	0.04	0.09	0.00	0.00	0.00	55.80
2002														0.00
Mean	8.95	10.08	44.27	23.90	9.25	3.00	0.93	0.25	0.12	0.04	0.01	0.01	0.00	100.81

Table B1.23. RIDFW spring survey for winter flounder in the Southern New England-Mid Atlantic stock complex.

	Age							
Year	1	2	3	4	5	6	7+	Total
1981	13.55	32.2	32.99	6.07	1.85	0.79	0.48	87.93
1982	10.59	10.28	6.24	3.21	0.74	0.12	0.14	31.32
1983	16.75	18.51	11.63	7.61	1.9	0.84	0.25	57.49
1984	3.31	21.97	10.46	4.17	1.19	0.3	0.08	41.48
1985	3.77	13.42	14.19	2.44	0.81	0.07	0.04	34.74
1986	9.65	14.16	12.5	3.79	0.57	0.04	0.08	40.79
1987	12.44	20.56	17.09	4.24	0.91	0.14	0.09	55.47
1988	7.33	12.05	10.97	2.94	0.36	0	0.02	33.67
1989	6.67	6.32	5.55	1.58	0.32	0.1	0.03	20.57
1990	5.73	7.63	4.51	2.09	0.19	0.03	0.05	20.23
1991	12.48	14.67	11.29	2.14	0.48	0.22	0.02	41.30
1992	1.19	1.36	1.13	0.51	0.18	0.03	0	4.40
1993	2.35	0.26	0.18	0.05	0.01	0	0	2.85
1994	2.87	4.74	1.9	0.59	0.08	0.02	0.01	10.21
1995	8.33	9.53	11.22	2.03	0.43	0.45	0.2	32.19
1996	2.11	6.45	4.07	1.42	0.53	0.25	0.11	14.94
1997	4.47	7.79	7.42	1.69	0.45	0.25	0.18	22.25
1998	1.5	4.16	8.43	3.87	0.7	0.46	0.11	19.23
1999	1.61	4.07	5.45	1.84	0.16	0.16	0.13	13.42
2000	2.99	4.91	6.09	1.32	0.65	0.20	0.12	16.28
2001	2.11	4.23	2.89	2.53	0.57	0.04	0.08	12.45
Mean	6.28	10.44	8.87	2.67	0.62	0.21	0.11	29.20

Table B1.24. NJDFW Ocean survey (April) for winter flounder in the Southern New England/Mid-Atlantic stock complex. Lengths for 2002 aged with the 2001 age-length key.

	Age							
Year	1	2	3	4	5	6	7+	Total
1993	5.1	6.5	2.5	2.4	1.7	0.4	0.57	19.17
1994	3.7	4.2	3.9	1.4	0.4	0.3	0.16	14.06
1995	8	10.1	8.6	2.4	0.9	0.3	0.11	30.41
1996	0.6	2.9	2.6	1.9	0.9	0.3	0.2	9.40
1997	16.6	5.4	6.1	6	1.5	0.3	0.12	36.02
1998	4.5	3.9	4.8	3.3	1.2	0.4	0.1	18.20
1999	2.40	2.20	5.90	3.10	2.90	0.70	0.59	17.79
2000	0.70	0.30	2.10	3.30	2.00	0.90	0.80	10.10
2001	3.90	0.60	1.30	2.70	3.80	0.70	0.83	13.83
2002	7.56	3.67	3.30	3.00	3.67	0.76	0.77	22.73
Mean	5.06	4.01	4.20	2.94	1.70	0.48	0.39	18.78

Table B1.25. NJDFW Rivers survey (March-May) for winter flounder in the Southern New England/Mid Atlantic stock complex.

	Age							
Year	1	2	3	4	5	6	7+	Total
1995	0.6	0.3	1.4	0.4	0.1	0.01	0.01	2.82
1996	0.3	0.9	0.7	0.7	0.2	0.1	0.15	3.05
1997	1.1	0.4	0.9	0.4	0.4	0.1	0.05	3.35
1998	1.9	0.9	0.4	0.7	0.2	0.1	0.05	4.25
1999	0.20	0.50	1.40	0.50	0.40	0.10	0.13	3.23
2000	0.40	0.20	0.40	0.80	0.20	0.10	0.01	2.11
2001	1.40	0.30	0.20	0.40	0.40	0.10	0.04	2.84
Mean	0.84	0.50	0.77	0.56	0.27	0.09	0.06	3.09

Table B1.26. Virtual Population Analysis for SNE/MA winter flounder, 1981-2001.

```
Fisheries Assessment Toolbox  SNE/MA Winter Flounder  Run Number W36_2  9/25/2002   1:11:40 PM
FACT Version 1.5.0
SNE/MA Winter Flounder  1981 - 2002
Input Parameters and Options Selected
---------------------------------------
Natural mortality is a matrix below
Oldest age (not in the plus group) is  6
For all years prior to the terminal year ( 21 ), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  6 : 4 5 6
This method for estimating F on the oldest age is generally used when a
flat-topped partial recruitment curve is thought to be characteristic of the stock.
 Stock size of the  7 + group is then calculated using
the following method:  CATCH EQUATION
 Partial recruitment estimate for  2002
 1             0.01
 2             0.2
 3             0.6
 4             1
 5             1
 6             1

 The Indices that will be used in this run are:
 1            NEC_S1
 2            NEC_S2
 3            NEC_S3
 4            NEC_S4
 5            NEC_S5
 6            NEC_S6
 7            NEC_S7
 8            NEC_F2
 9            NEC_F3
 10           NEC_F4
 11           NEC_W1
 12           NEC_W2
 13           NEC_W3
 14           NEC_W4
 15           NEC_W5
 16           MA_S2
 17           MA_S3
 18           MA_S4
 19           MA_S5
 20           RI_S1
 21           RI_S2
 22           RI_S3
 23           RI_S4
 24           CT_S1
 25           CT_S2
 26           CT_S3
 27           CT_S4
 28           CT_S5
 29           CT_S6
 30           CT_S7
 31           MA_YOY1
 32           CT_YOY1
 33           NY_PB1.1
 34           NJ_O3
 35           NJ_O4
 36           NJ_O5
 37           NJ_O6
 38           NJ_O7
 39           NJ_R1
 40           NJ_R2
 41           NJ_R3
 42           NJ_R4
 43           NJ_R5
```

Table B1.26 continued.

STOCK NUMBERS (Jan 1) in thousands

	1981	1982	1983	1984	1985	1986	1987
1	62859	52020	56503	35617	34615	32795	25973
2	52566	50232	42060	45703	28708	28090	26656
3	27768	30289	28226	27884	26945	16839	17273
4	7146	9748	13560	11068	10077	10446	5551
5	1468	2600	4606	5559	4603	2773	4738
6	363	600	1577	2148	2944	1096	1317
7	218	564	1219	1949	2228	876	730
1+	152388	146054	147751	129927	110120	92914	82238

	1988	1989	1990	1991	1992	1993	1994
1	26726	23113	17366	11355	7808	8844	8315
2	21199	21806	18504	14185	9249	6370	6993
3	17057	13790	13106	13242	8875	6212	3350
4	6000	5458	4798	5053	4381	3233	2074
5	1748	1325	1299	1276	1111	1251	1084
6	1433	339	317	369	268	300	495
7	433	312	223	165	86	218	300
1+	74596	66142	55613	45645	31778	26429	22611

	1995	1996	1997	1998	1999	2000	2001
1	12647	17632	21154	18793	13372	12710	19011
2	6753	10333	14407	16971	15341	10889	10343
3	4733	5352	7658	9864	11966	10076	7610
4	1700	2190	3070	3284	4761	6170	5082
5	1053	588	791	875	1063	2320	2830
6	606	487	171	159	254	456	1120
7	433	312	73	228	83	168	512
1+	27925	36893	47324	50174	46840	42788	46509

	2002
1	5665
2	15553
3	6671
4	2912
5	2179
6	1602
7	1057
1+	35639

Table B1.26 continued.

FISHING MORTALITY

	1981	1982	1983	1984	1985	1986	1987
1	0.02	0.01	0.01	0.02	0.01	0.01	0.00
2	0.35	0.38	0.21	0.33	0.33	0.29	0.25
3	0.85	0.60	0.74	0.82	0.75	0.91	0.86
4	0.81	0.55	0.69	0.68	1.09	0.59	0.96
5	0.69	0.30	0.56	0.44	1.23	0.54	1.00
6	0.81	0.50	0.67	0.60	1.18	0.59	1.00
7	0.81	0.50	0.67	0.60	1.18	0.59	1.00

	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.02	0.00	0.01	0.00	0.03	0.01
2	0.23	0.31	0.13	0.27	0.20	0.44	0.19
3	0.94	0.86	0.75	0.91	0.81	0.90	0.48
4	1.31	1.24	1.12	1.31	1.05	0.89	0.48
5	1.44	1.23	1.06	1.36	1.11	0.73	0.38
6	1.41	1.29	1.15	1.39	1.10	0.86	0.45
7	1.41	1.29	1.15	1.39	1.10	0.86	0.45

	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.02	0.00	0.01	0.01	0.00
2	0.03	0.10	0.18	0.15	0.22	0.16	0.24
3	0.57	0.36	0.65	0.53	0.46	0.48	0.76
4	0.86	0.82	1.06	0.93	0.52	0.58	0.65
5	0.57	1.04	1.40	1.04	0.65	0.53	0.37
6	0.76	0.88	1.16	0.98	0.55	0.57	0.23
7	0.76	0.88	1.16	0.98	0.55	0.57	0.23

Average F for 4,5

	1981	1982	1983	1984	1985	1986	1987
4,5	0.75	0.42	0.63	0.56	1.16	0.57	0.98

	1988	1989	1990	1991	1992	1993	1994
4,5	1.38	1.23	1.09	1.34	1.08	0.81	0.43

	1995	1996	1997	1998	1999	2000	2001
4,5	0.72	0.93	1.23	0.98	0.58	0.55	0.51

Biomass Weighted F

1981	1982	1983	1984	1985	1986	1987
0.47	0.42	0.38	0.47	0.61	0.44	0.58

1988	1989	1990	1991	1992	1993	1994
0.67	0.56	0.48	0.68	0.64	0.60	0.28

1995	1996	1997	1998	1999	2000	2001
0.30	0.23	0.42	0.31	0.36	0.37	0.39

Table B1.26 continued.

BACK-CALCULATED PARTIAL RECRUITMENT

	1981	1982	1983	1984	1985	1986	1987
1	0.03	0.02	0.02	0.02	0.01	0.01	0.00
2	0.41	0.62	0.29	0.40	0.27	0.31	0.25
3	1.00	1.00	1.00	1.00	0.61	1.00	0.85
4	0.96	0.91	0.94	0.83	0.88	0.65	0.95
5	0.82	0.50	0.76	0.53	1.00	0.60	0.99
6	0.95	0.82	0.91	0.73	0.95	0.65	1.00
7	0.95	0.82	0.91	0.73	0.95	0.65	1.00

	1988	1989	1990	1991	1992	1993	1994
1	0.00	0.02	0.00	0.00	0.00	0.04	0.02
2	0.16	0.24	0.12	0.19	0.18	0.49	0.40
3	0.65	0.66	0.65	0.65	0.73	1.00	1.00
4	0.91	0.96	0.98	0.95	0.95	1.00	1.00
5	1.00	0.95	0.92	0.98	1.00	0.81	0.80
6	0.98	1.00	1.00	1.00	0.99	0.96	0.94
7	0.98	1.00	1.00	1.00	0.99	0.96	0.94

	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.01	0.00	0.01	0.01	0.00
2	0.04	0.10	0.13	0.14	0.34	0.27	0.31
3	0.66	0.34	0.46	0.51	0.71	0.84	1.00
4	1.00	0.79	0.75	0.89	0.80	1.00	0.85
5	0.66	1.00	1.00	1.00	1.00	0.91	0.48
6	0.88	0.85	0.83	0.94	0.85	0.99	0.31
7	0.88	0.85	0.83	0.94	0.85	0.99	0.31

MEAN BIOMASS (using catch mean weights at age)

	1981	1982	1983	1984	1985	1986	1987
1	7320	4218	9928	4678	3468	3821	1081
2	11153	9965	8174	9159	6274	6496	6171
3	8228	9117	6470	6403	6338	4048	4094
4	3606	4760	4630	3994	2728	3465	1813
5	1033	2144	2494	2851	1276	1340	1313
6	284	541	1102	1350	747	666	432
7	165	745	1264	1720	742	582	362
1+	31790	31490	34061	30156	21572	20418	15266

	1988	1989	1990	1991	1992	1993	1994
1	943	2445	1289	955	558	1332	1171
2	4807	4409	4639	3590	2190	1570	2009
3	3573	3219	3329	3364	2386	1735	1090
4	1573	1472	1396	1390	1496	1164	899
5	544	465	497	390	497	562	609
6	369	126	140	152	142	162	252
7	178	174	121	97	67	157	180
1+	11987	12310	11412	9937	7335	6682	6210

	1995	1996	1997	1998	1999	2000	2001
1	1912	3081	1766	3436	955	1149	1757
2	1946	3634	4425	4755	3933	3624	3508
3	1482	2082	2635	3068	3806	3532	2475
4	605	782	1152	1142	1908	2627	2180
5	524	238	318	334	561	1216	1718
6	298	246	100	84	170	290	957
7	218	163	60	166	77	134	523
1+	6984	10225	10456	12985	11410	12571	13118

Table B1.26 continued.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1981	1982	1983	1984	1985	1986	1987
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	4739	4757	3771	3557	3615	2395	2482
4	3893	4592	5119	3855	3106	3541	1958
5	1205	2157	2899	2927	1838	1374	1779
6	341	603	1387	1540	1272	634	644
7	214	900	1590	2129	1037	718	489
1+	10393	13009	14766	14008	10869	8662	7353

	1988	1989	1990	1991	1992	1993	1994
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	2282	1923	1831	1980	1414	960	600
4	1863	1642	1556	1627	1626	1242	902
5	744	576	590	526	559	667	639
6	516	169	177	200	156	203	300
7	260	248	169	140	93	206	215
1+	5663	4559	4323	4474	3848	3278	2656

	1995	1996	1997	1998	1999	2000	2001
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	849	1028	1563	1817	2128	1756	2579
4	665	857	1311	1354	1990	2548	2103
5	589	293	389	452	563	1251	1692
6	376	301	113	107	170	296	715
7	279	214	84	224	73	169	553
1+	2759	2693	3459	3954	4923	6021	7643

Table B1.26 continued.

Fishing Mortality
Terminal Year

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1997	0.75	0.42	0.63	0.56	1.16	0.57	0.98	1.37	1.23	1.08	1.31	1.02	0.71	0.34	0.50	0.47	0.37				
1998	0.75	0.42	0.63	0.56	1.16	0.57	0.98	1.38	1.23	1.09	1.33	1.05	0.76	0.38	0.60	0.65	0.54	0.32			
1999	0.75	0.42	0.63	0.56	1.16	0.57	0.98	1.38	1.23	1.09	1.33	1.07	0.79	0.41	0.65	0.76	0.77	0.38	0.36		
2000	0.75	0.42	0.63	0.56	1.16	0.57	0.98	1.38	1.23	1.09	1.34	1.08	0.81	0.42	0.71	0.89	1.10	0.74	0.39	0.59	
2001	0.75	0.42	0.63	0.56	1.16	0.57	0.98	1.38	1.23	1.09	1.34	1.08	0.81	0.43	0.72	0.93	1.23	0.98	0.58	0.55	0.51

Spawning Stock Biomass
Terminal Year

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1997	10393	13009	14767	14009	10869	8663	7354	5666	4566	4343	4548	4038	3670	3273	3849	4826	7444				
1998	10393	13009	14766	14008	10869	8662	7354	5664	4562	4331	4505	3929	3445	2919	3220	3833	6041	7845			
1999	10393	13009	14766	14008	10869	8662	7354	5664	4561	4327	4488	3887	3355	2783	2969	3357	5233	6245	7280		
2000	10393	13009	14766	14008	10869	8662	7354	5663	4560	4323	4477	3856	3295	2681	2807	2781	3971	4866	5537	6897	
2001	10393	13009	14766	14008	10869	8662	7353	5663	4559	4323	4474	3848	3278	2656	2759	2693	3459	3954	4923	6021	7643

Population Numbers Age: 1
Terminal Year

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1997	62859	52021	56504	35618	34618	32804	26001	26802	23425	17857	12277	8527	11725	13557	19744	19471	31502	21889			
1998	62859	52021	56504	35617	34617	32799	25985	26759	23243	17580	11733	8140	9992	12293	17810	18933	27084	31936	31205		
1999	62859	52021	56504	35617	34616	32797	25979	26743	23169	17482	11501	8036	9204	11387	16304	17649	22197	21574	17992	15496	
2000	62859	52020	56503	35617	34616	32795	25975	26729	23127	17384	11400	7826	8998	8449	15177	17596	20214	19212	13851	13085	15615
2001	62859	52020	56503	35617	34615	32795	25973	26726	23113	17366	11355	7808	8844	8315	12647	17632	21154	18793	13372	12710	19011

Table B1.27. VPA Bootstrap results: precision of estimates.

The number of bootstraps: 500

Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 1	5665	5960	1905	0.34
N 2	15553	15895	3191	0.21
N 3	6671	6691	1176	0.18
N 4	2912	2938	648	0.22
N 5	2179	2208	504	0.23
N 6	1602	1631	369	0.23
N 7	726	736	159	0.22

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 1	294	85	5.20	5371	0.354683	3746	8342
N 2	342	143	2.20	15211	0.209761	11856	19828
N 3	21	53	0.31	6650	0.176795	5097	8050
N 4	26	29	0.90	2886	0.224561	2114	3811
N 5	29	23	1.35	2149	0.234726	1611	2910
N 6	28	16	1.78	1574	0.234188	1158	2114
N 7	10	07	1.42	715	0.221624	534	937

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0008	0.0008	0.0002	0.21
Age 2	0.2386	0.2440	0.0395	0.17
Age 3	0.7607	0.7755	0.1236	0.16
Age 4	0.6471	0.6599	0.1136	0.18
Age 5	0.3689	0.3773	0.0754	0.20
Age 6	0.2336	0.2397	0.0491	0.21
Age 7	0.2336	0.2397	0.0491	0.21

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.0000137	0.0000070	1.815	0.0007423	0.21	0.0006	0.0010
Age 2	0.0053697	0.0017644	2.250	0.2332777	0.17	0.2014	0.3004
Age 3	0.0147454	0.0055258	1.938	0.7459918	0.17	0.6241	0.9413
Age 4	0.0128214	0.0050816	1.981	0.6342562	0.18	0.5193	0.8015
Age 5	0.0084273	0.0033716	2.285	0.3604493	0.21	0.2905	0.4802
Age 6	0.0061558	0.0021967	2.635	0.2274158	0.22	0.1853	0.3045
Age 7	0.0061558	0.0021967	2.635	0.2274158	0.22	0.1853	0.3045

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
7642.6469	7705.3234	658.0444	0.09

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
62.68	29.43	0.82	7579.97	0.09	6777.3392	8444.6451

Table B1.28. Input parameters and stochastic projection results for winter flounder in the Southern New England/Mid-Atlantic stock complex. Starting stock sizes for ages 1 and older on January 1, 2002 are as estimated by SARC 36 VPA, and are not adjusted for the retrospective pattern. Age-1 recruitment levels in 2003 and later years are estimated from a parametric stock-recruitment relationship estimated in NEFSC (2002). Fishing mortality was apportioned among landings and discard based on the proportion landed at age during 1998-2000. Mean weights at age (kg; spawning stock, mean stock biomass, landings, and discards) are weighted (by fishery) geometric means of 1998-2000 values. Proportion of F, M before spawning = 0.20 (spawning peak on 1 March).

Age	Stock Size on 1 Jan 2002 (000s)	Fishing Mortality Pattern	Proportion Landed	Proportion Mature	Mean Weights Spawning Stock	Mean Weights Landings	Mean Weights Discards
1	5688	0.02	0.02	0	0.07	0.325	0.116
2	15592	0.27	0.7	0	0.196	0.383	0.242
3	6712	0.75	0.91	0.53	0.387	0.465	0.317
4	2908	1	0.97	0.95	0.52	0.59	0.417
5	2170	1	0.97	1	0.637	0.725	0.868
6	1612	1	0.97	1	0.793	0.916	0.853
7+	1064	1	0.97	1	1.144	1.125	1.402

F2002 is assumed 0.85*F2001 (15% decrease in F from 2001 to 2002); F during 2003-2013 as indicated; Forecast Medians (50% probability level)

2002				2003 ‘000 Metric tons				2013				
F	Land	Disc	SSB	F	Land	Disc	SSB	F	Land	Disc	SSB	P (%) SSB > 30.1 kmt
0.43	3.0	0.2	5.9	Fsq=0.43	3.3	0.1	7.0	Fsq=0.43	8.0	0.5	16.4	0%
				Fmsy=0.32	2.6	0.2	7.2	Fmsy=0.32	8.3	0.5	23.3	6%
				Freb=0.24	2.0	0.1	7.3	Freb=0.24	8.1	0.4	30.1	50%

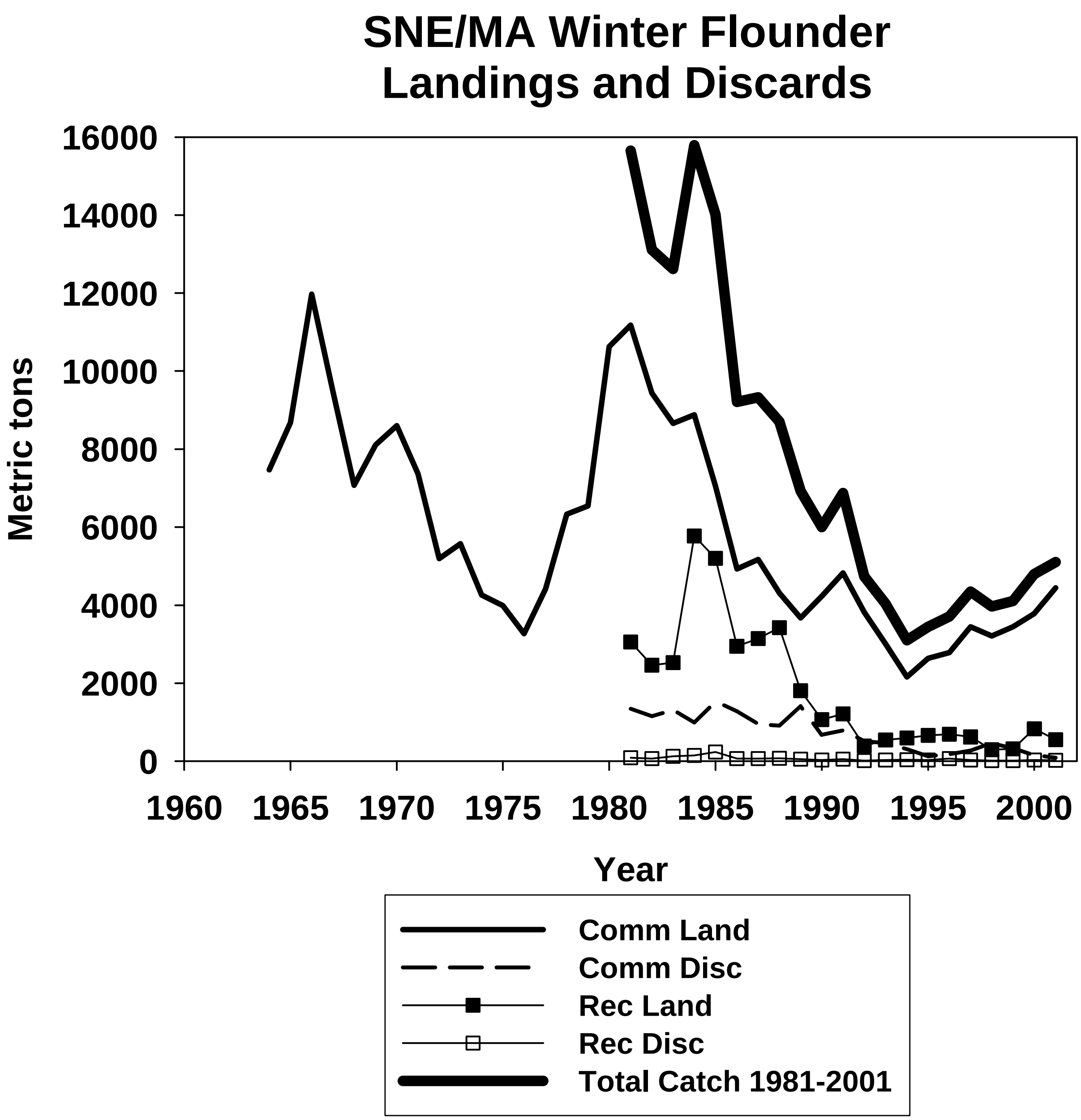

Figure B1.1. Commercial landings (1964-2001), commercial discards (1981-2001) recreational landings (1981-2001), recreational discards (1981-2001) and total fishery catch (198-2001) for the SNE/MA winter flounder stock complex.

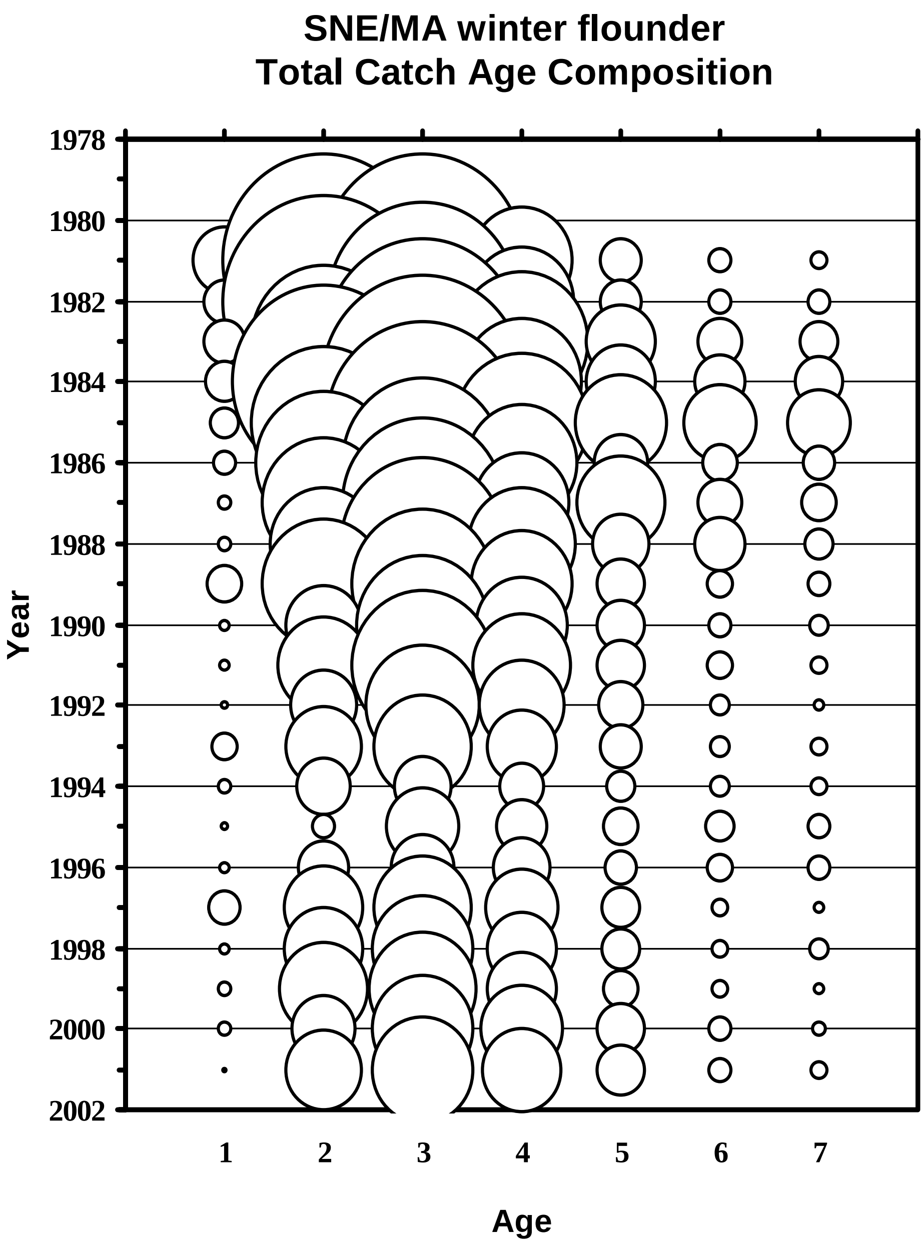

Figure B1.2. Total catch age composition: 1981-2001

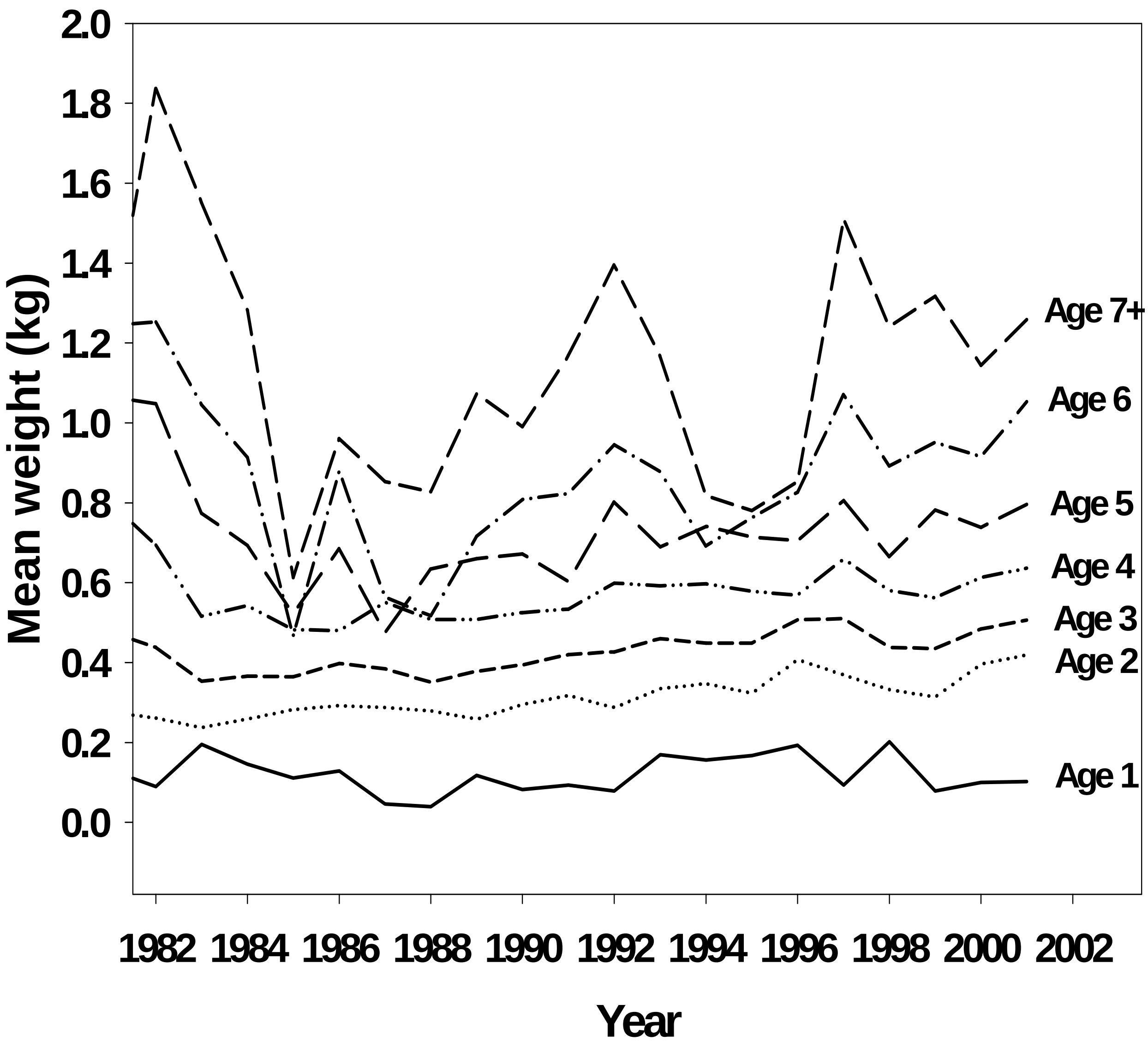

Figure B1.3. Trends in mean weight at age in the total catch of SNE/MA winter flounder.

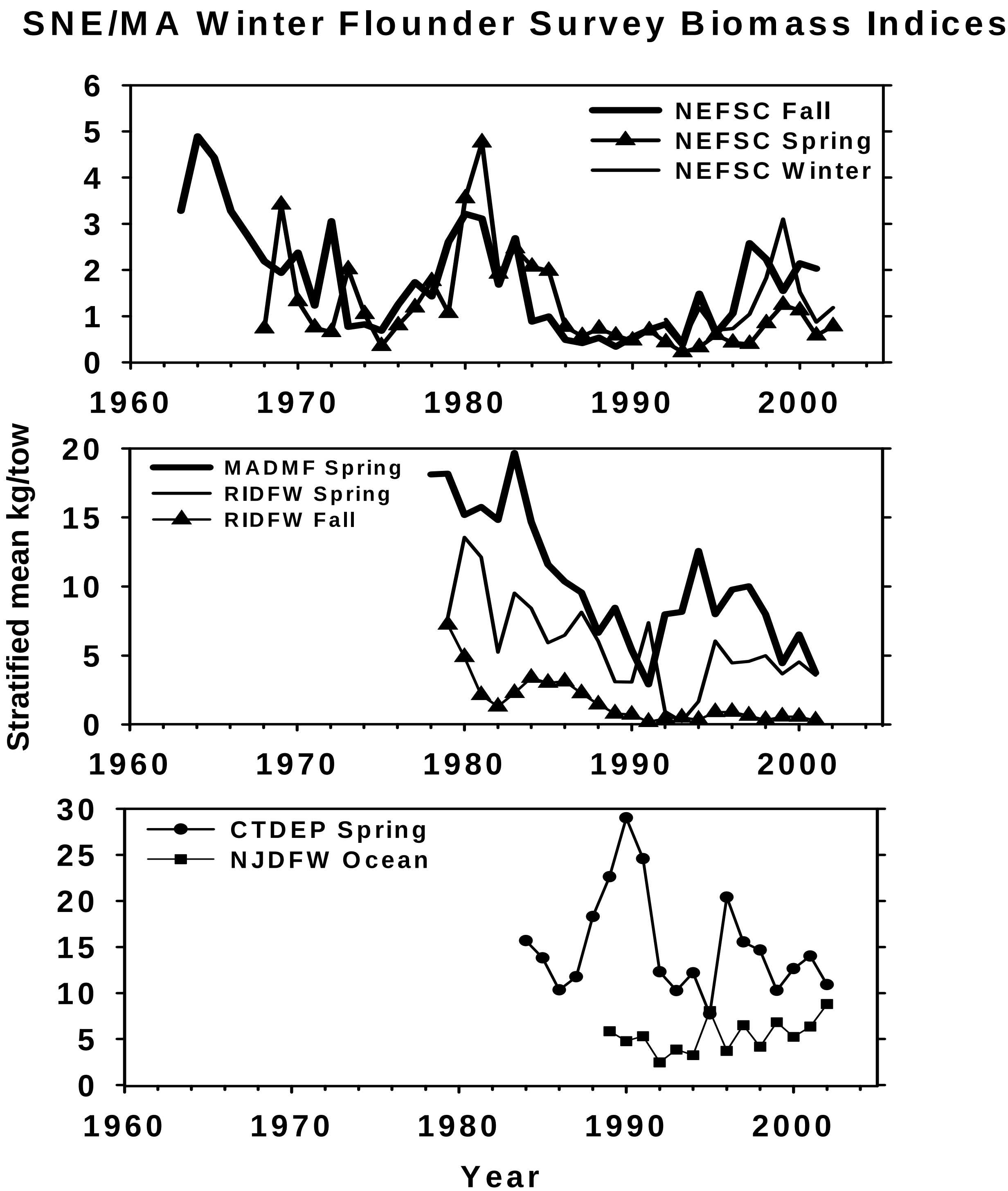

Figure B1.4. Trends in research survey biomass indices for SNE/MA winter flounder.

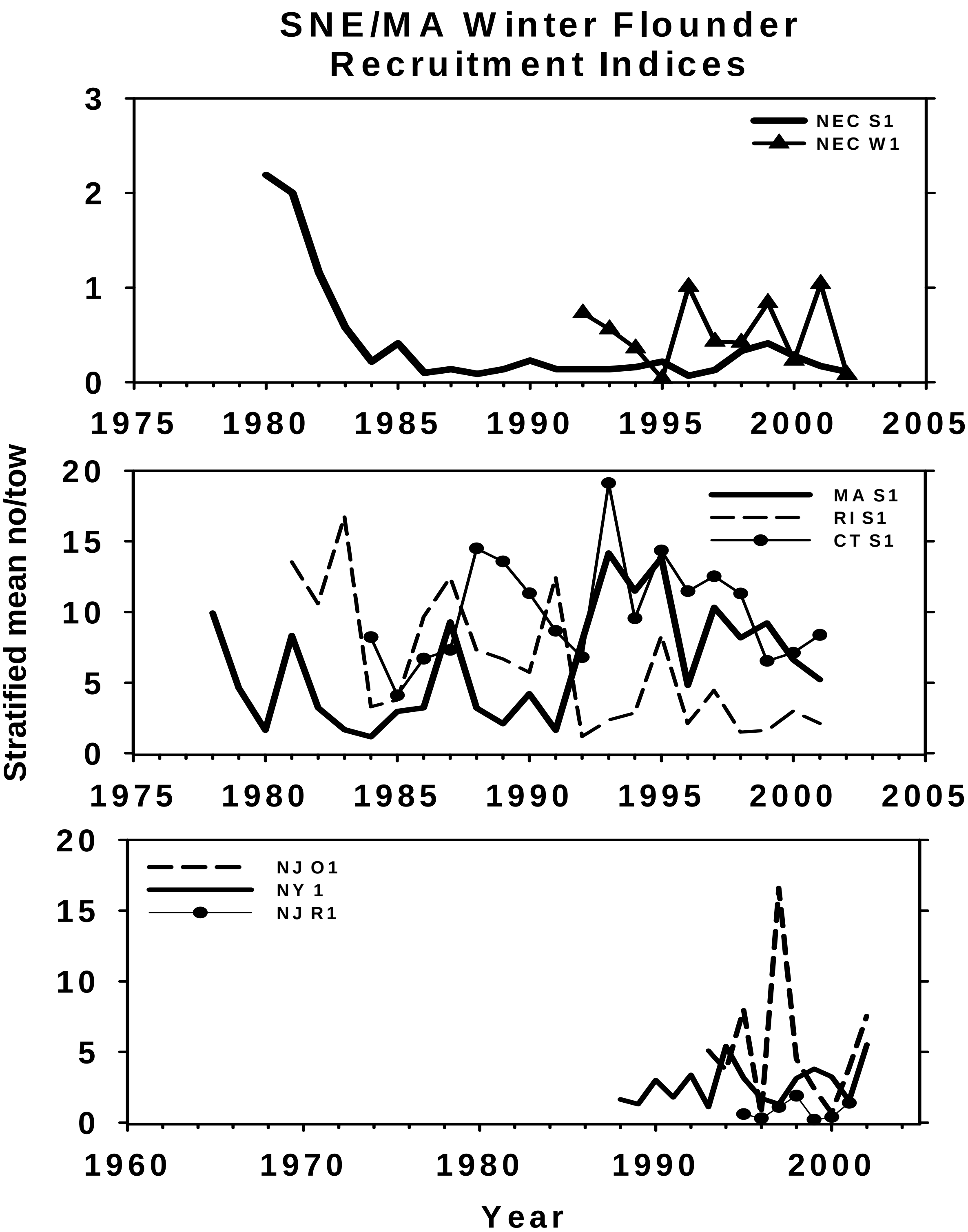

Figure B1.5. Trends in survey recruitment indices for SNE/MA winter flounder. Includes spring survey age-1 indices and fall YOY indices advanced one year

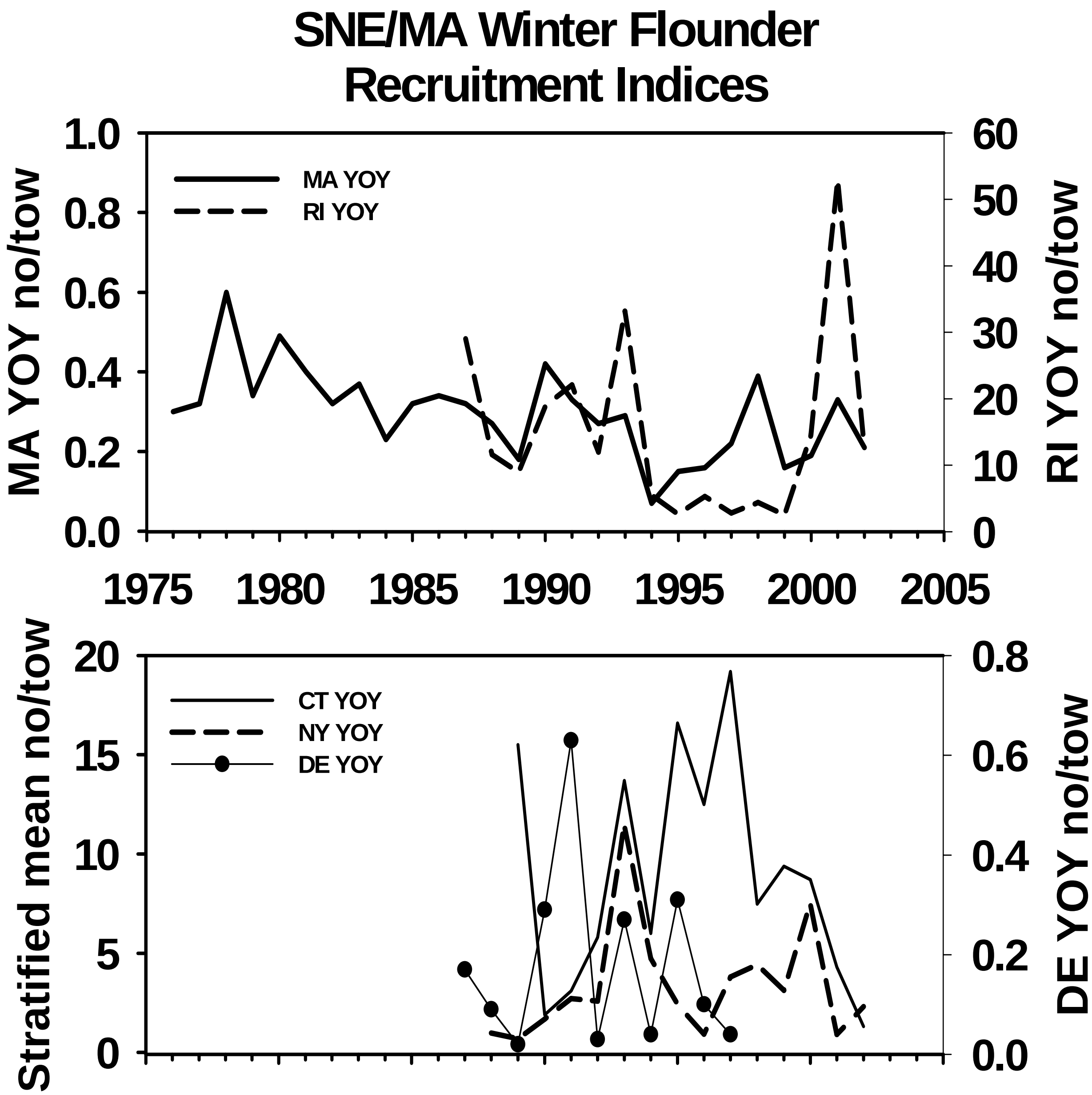

Figure B1.5 continued.

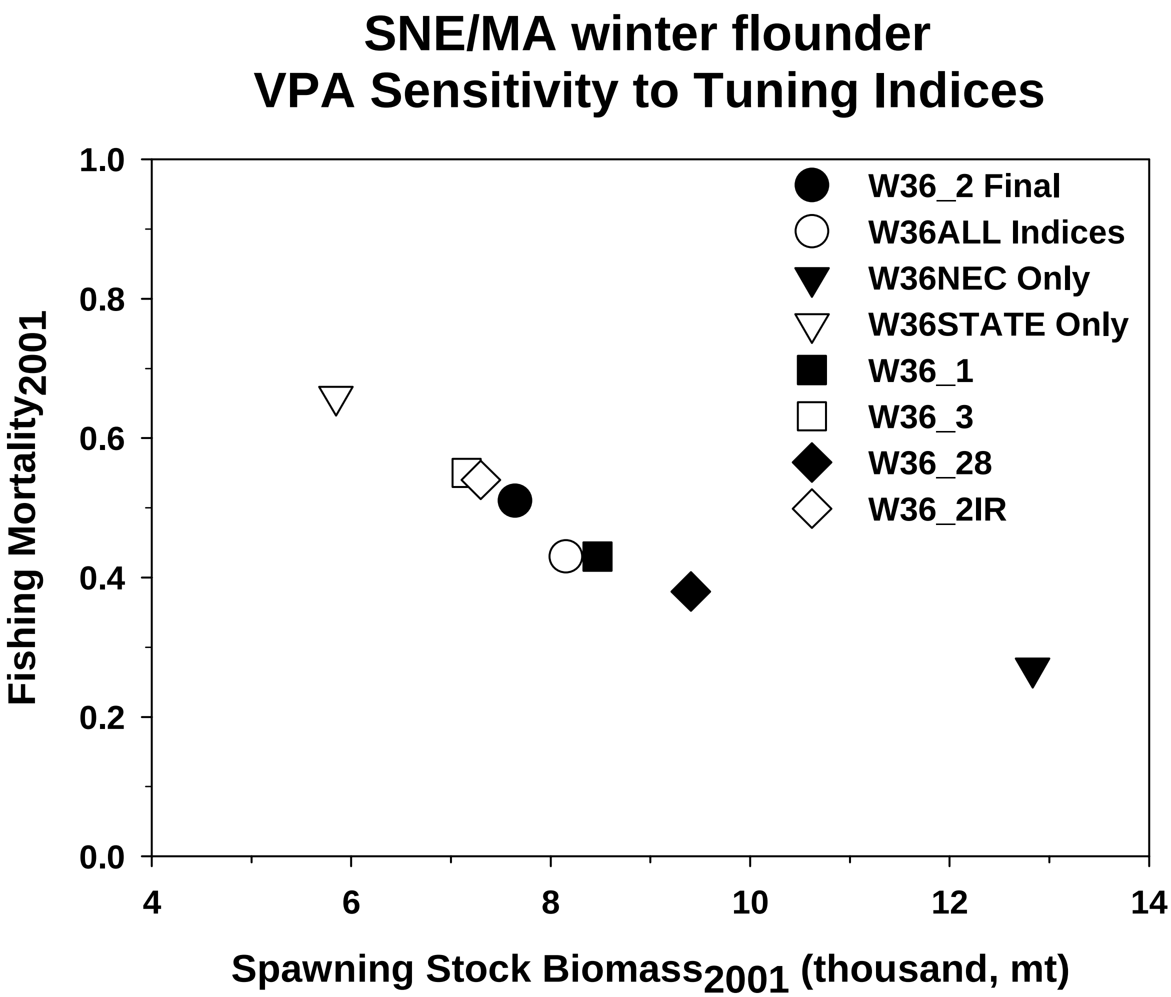

Figure B1.6. Sensitivity of the SARC 36 VPA for SNE/MA winter flounder to alternative combination of survey tuning indices. Run W36_2 was selected as the final run.

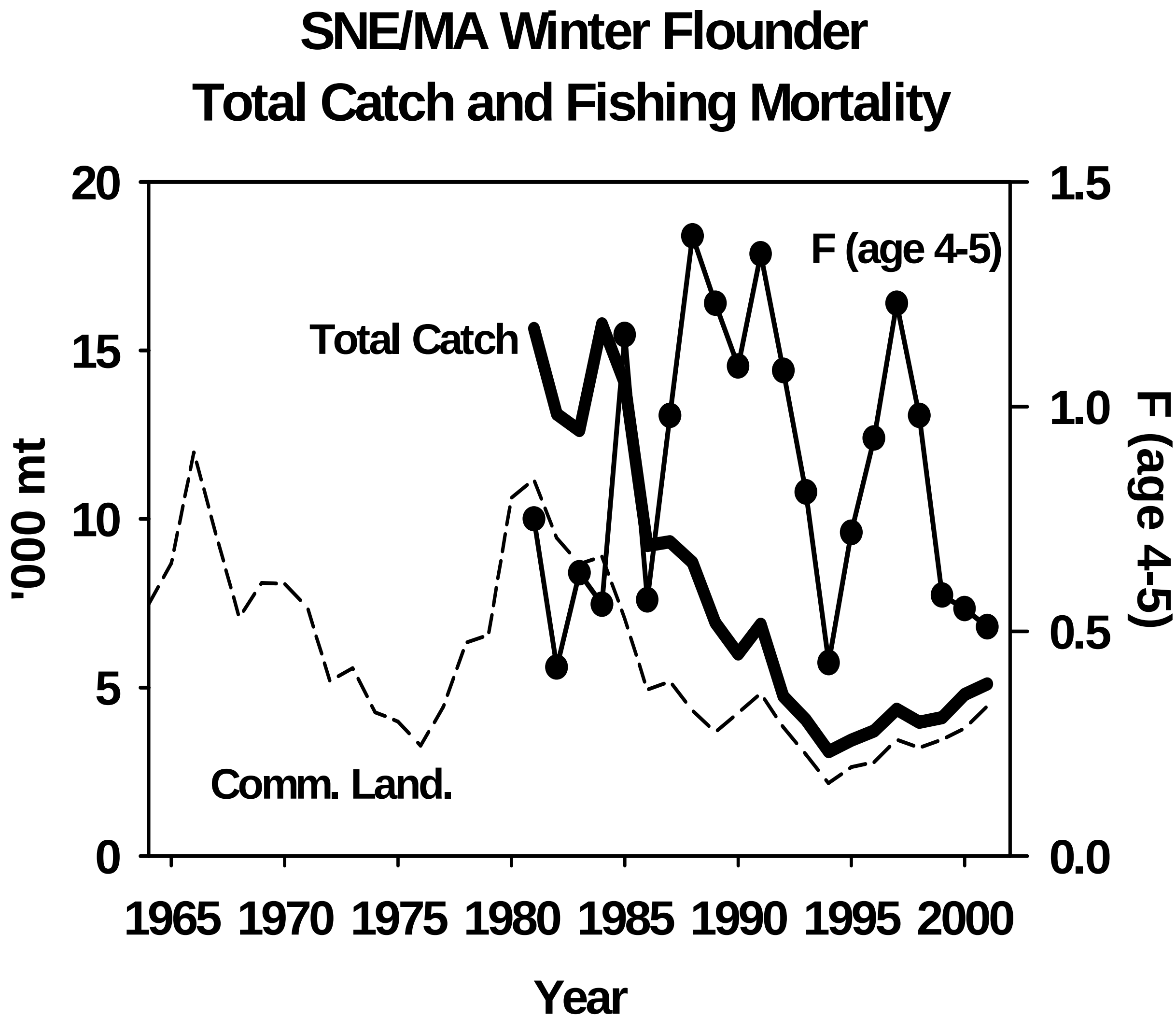

Figure B1.7. Total catch (landings and discards, '000 mt), commercial landings('000 mt), and fishing mortality rate (F, ages 4-5, unweighted) for SNE/MA winter flounder.

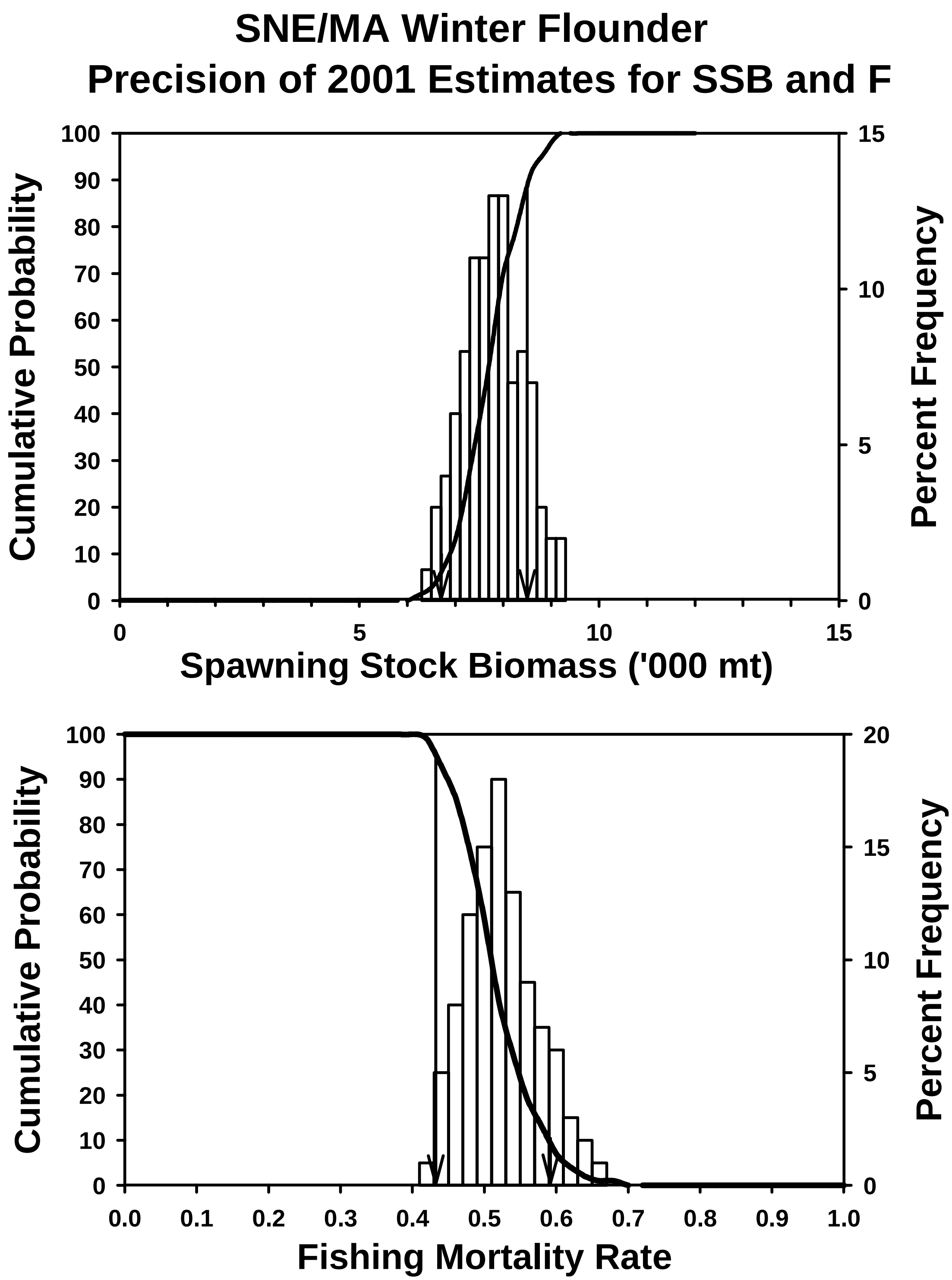

Figure B1.8. Precision of estimates of spawning stock biomass (ages 3-7+, '000 mt) and fishing mortality rate (F, ages 4-5, unweighted) in 2001 for SNE/MA winter flounder. Vertical bars display the range of the bootstrap estimates and the probability of individual values in the range. The solid curve gives the probability of SSB that is less or fishing mortality that is greater than any value along the X axis.

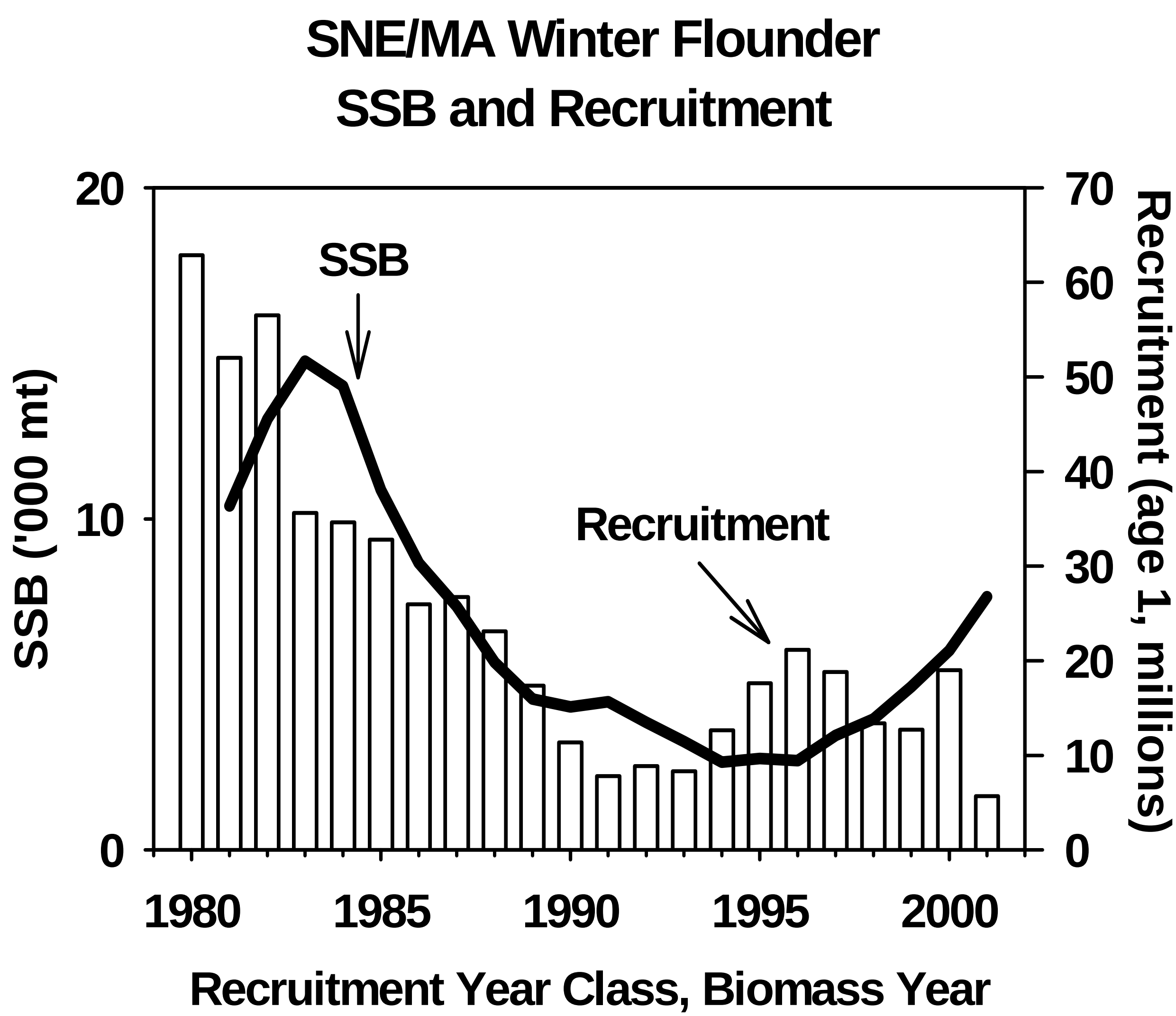

Figure B1.9. Spawning stock biomass (SSB, ages 3-7+, '000 mt) and recruitment (millions of fish at age-1) for SNE/MA winter flounder.

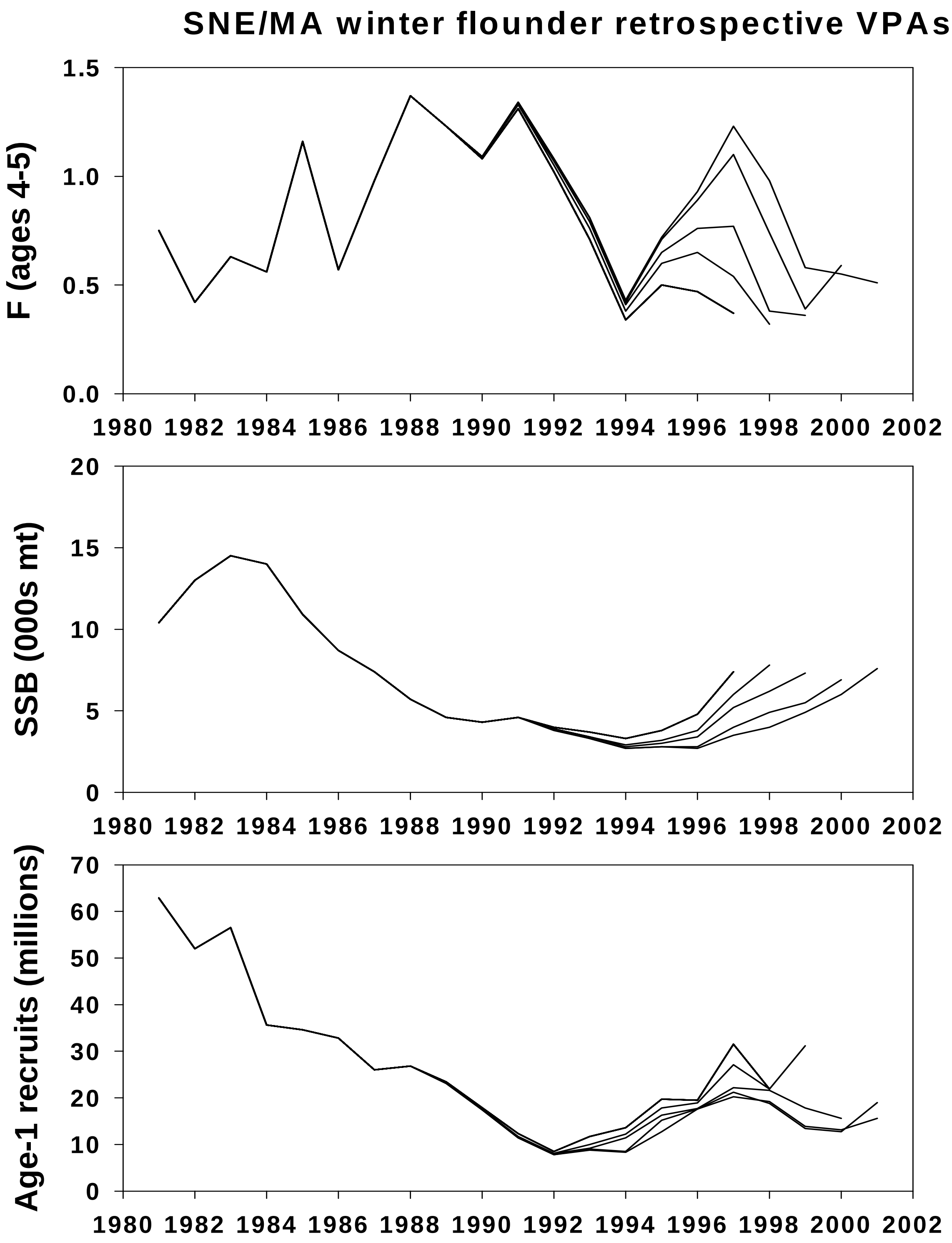

Figure B1.10. Retrospective VPAs for SNE/MA winter flounder.

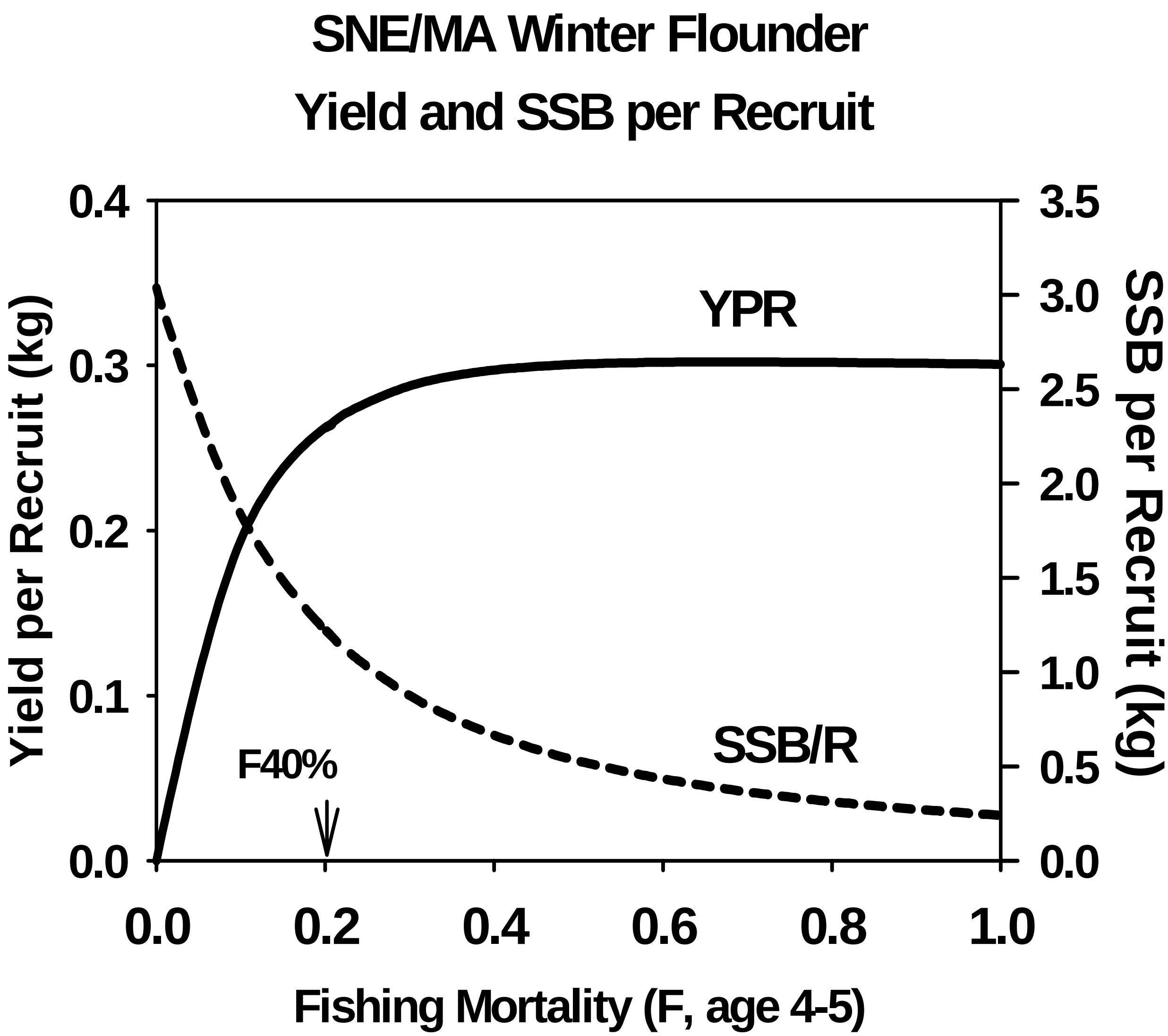

Figure B1.11. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) for SNE/MA winter flounder.

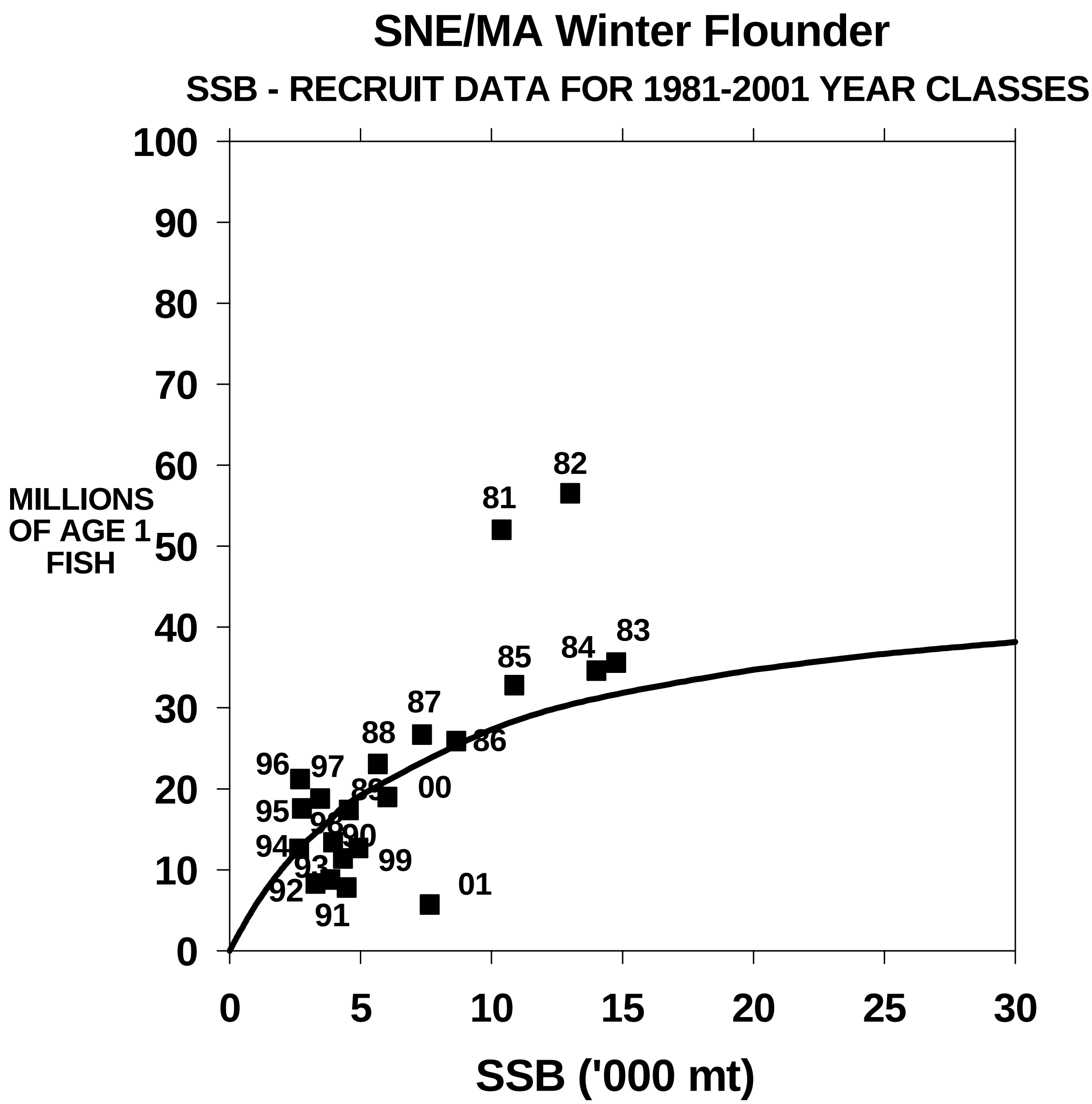

Figure B1.12. SNE/MA winter flounder SARC 36 VPA SSB and recruit data for the 1981-2001 year classes. Curved line is the S-R function estimated by NEFSC (2002).

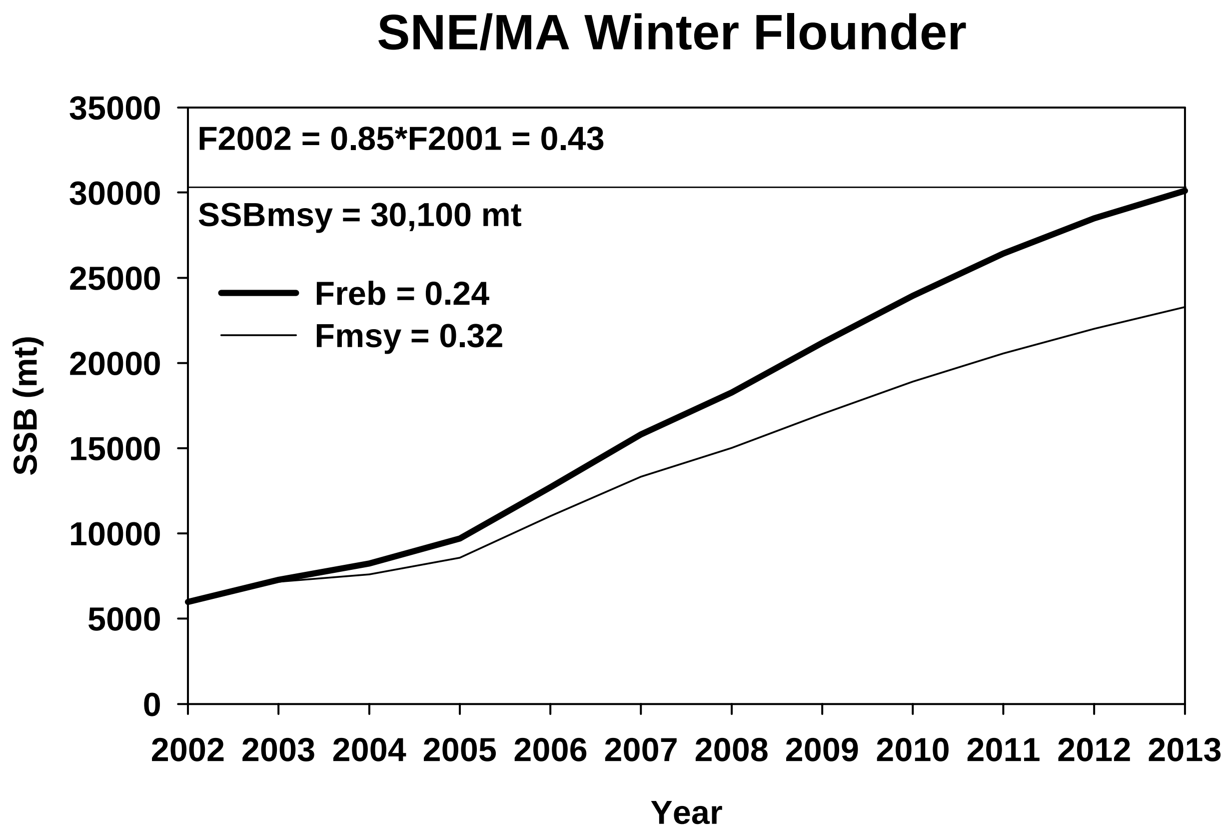

Figure B1.13. Median (50% probability) of forecast spawning stock biomass (SSB, mt) for SNE/MA winter flounder under Fmsy and Frebuild fishing mortality rates during 2003-2013. Assumes F2002 = 0.85*F2001 = 0.43.

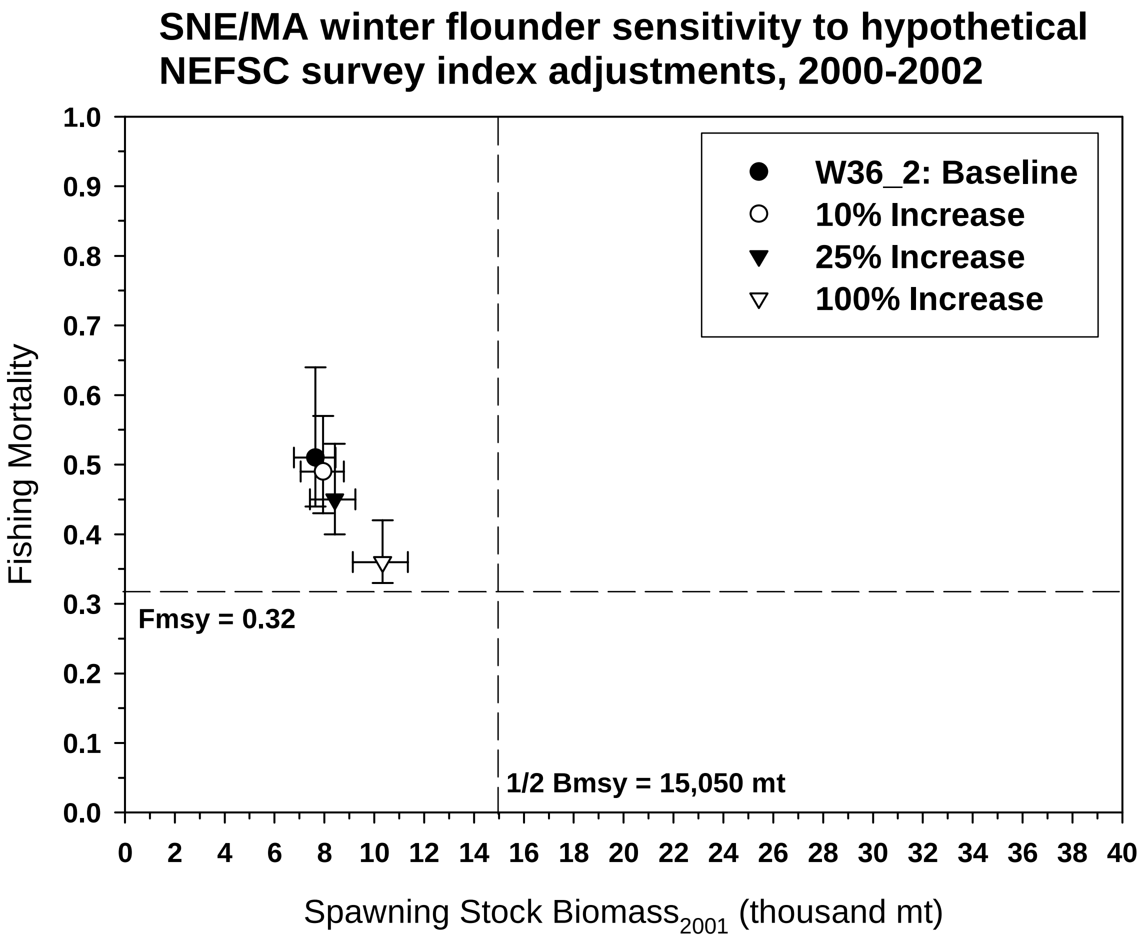

Figure B1.14. SNE/MA winter flounder VPA sensitivity to hypothetical NEFSC winter, spring, and fall survey index adjustments.

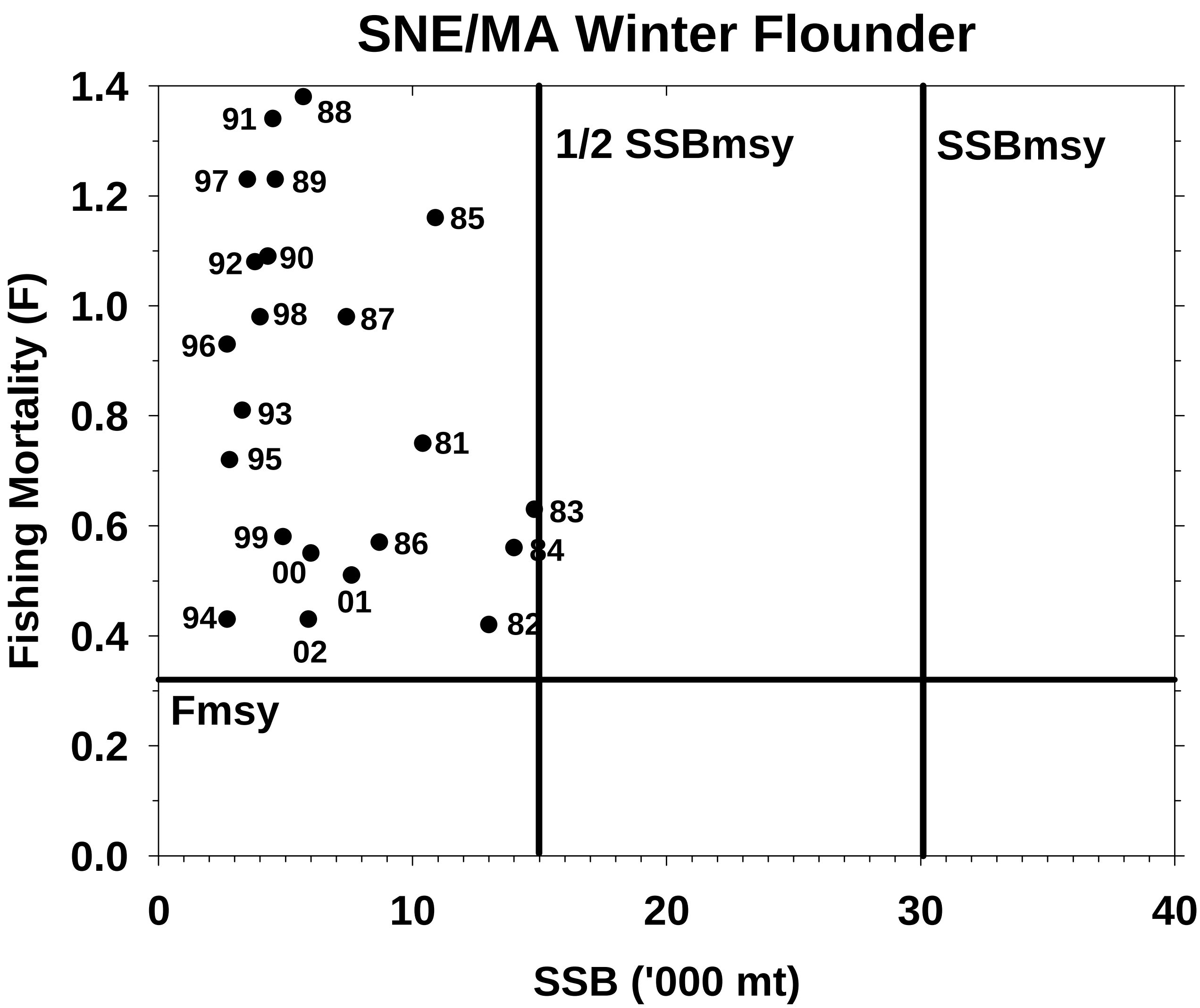

Figure B1.15. SSB and F for SNE/MA winter flounder. NEFSC (2002) biological reference points (Fmsy = 0.32, SSBmsy = 30,100 mt) are also shown.

B2. GULF OF MAINE (GOM) WINTER FLOUNDER

TERMS OF REFERENCE

The following terms of reference were addressed for Gulf of Maine winter flounder stock:

1) Characterize status of GM winter flounder using the analytical tools that are most appropriate for available data. These may include sequential population analysis, surplus production, survey indices and relative exploitation indices, or length based models.

2) Where possible provide best estimates of exploitation rates (fishing mortality, relative exploitation), mean biomass, spawning stock biomass and characterize uncertainty associated with these estimates.

3) Develop yield per recruit and biological reference points.

4) Where possible, provide short-term and medium term projections of catch and stock size under status quo F and various proposed target fishing mortality rates (F20%, F25%, F30%, F40%, F0.01, Fmax, Fmsy) as appropriate.

5) Develop and recommend an overfishing definition for Gulf of Maine winter flounder that meets the standards of the Sustainable Fishery Act.

6) Develop research recommendations for improving assessment of winter flounder.

INTRODUCTION

The last assessment for Gulf of Maine winter flounder was an index based assessment reviewed at SARC 21 (NEFSC 1996). Low indices and the absence of large fish in the survey led SARC 21 to conclude that the stock was overexploited in the mid 1990s. The current benchmark assessment is based on a Virtual Population Analysis (VPA) with commercial/recreational landings and discard estimates from 1982-2001 and research survey abundance indices from 1982-2002.

Winter flounder (*Pleuronectes americanus*) is a demersal flatfish species commonly found in estuaries and on the continental shelf. The species is distributed between the Gulf of St. Lawrence and North Carolina, although it is not abundant south of Delaware Bay. Within the Gulf of Maine, winter flounder undergo migrations from estuaries, where spawning occurs in the late winter and spring, to offshore shelf areas of less than 60 fathoms. Winter flounder reach a maximum size of around 2.25 kg (5 pounds) and 65 cm, with the exception of Georges Bank where growth rate is higher and fish may reach a maximum weight up to 3.6 kg (8 pounds; Bigelow and Schroeder 1953).

Current fishery management is coordinated by the ASMFC in state waters and the NEFMC in federal waters. Winter flounder fisheries in state waters have been managed by Interstate Agreement under the auspices of the ASMFC Fishery Management Plan (FMP) for Inshore Stocks of Winter Flounder since approval in May, 1992. The plan includes states from Delaware to Maine, with Delaware granted *de minimus* status (habitat regulations applicable but fishery management not required). The Plan's goal is to rebuild spawning stock abundance and achieve a fishing mortality-based management target of $F_{40\%}$ (fishing rate that preserves 40% of the maximum spawning potential of the stock) in three steps: $F_{25\%}$ in 1993-1994, $F_{30\%}$ in 1995-1998, and $F_{40\%}$ in 1999 and later years through implementation of compatible, state-specific regulations.

Coastal states from New Jersey to New Hampshire have promulgated a broad suite of indirect catch and effort controls. State agencies have set or increased minimum size limits for recreationally and commercially landed flounder (10-12 in and 12 in, respectively); enacted limited recreational closures and bag limits; and instituted seasonal, areal, or state-wide commercial landings/gear restrictions. Minimum codend mesh regulations have been promulgated in directed winter flounder fisheries: 6 in MA. New Hampshire prohibits the use of mobile gear in state waters with the exception of small mesh trawling in the shrimp fishery.

Winter flounder in the Exclusive Economic Zone (EEZ) are managed under the Northeast Multispecies Fishery FMP developed by the NEFMC. The principle catch of winter flounder in the EEZ has recently occurred as bycatch in directed trawl fisheries for Atlantic cod, haddock, and yellowtail flounder. The management unit encompasses the multispecies finfish fishery that operates from eastern Maine through Southern New England (72° 30'). At least one offshore stock, on Georges Bank, has been identified. The FMP extends authority over vessels permitted under the FMP even while fishing in state waters if federal regulations are more restrictive than the state regulations.

The Multispecies FMP was implemented in September, 1986, imposing a codend minimum mesh size of 5.5 in (previously 5.1 in) in the large-mesh regulatory area of Georges Bank and the offshore portion of Gulf of Maine. There were closed areas and seasons for haddock and yellowtail flounder. In the western Gulf of Maine, vessels were required to enroll in an Exempted Fisheries Program in order to target small-mesh species such as shrimp, dogfish, or whiting. The bycatch restrictions specified area and season and limited groundfish bycatch to 25% of trip and 10% for the reporting period. In southern New England waters, the groundfish bycatch on vessels fishing with small mesh was not limited in any way. There was a 11 in minimum size for winter flounder which corresponded with the length at first capture (near zero percent retention) for 5.5 in diamond mesh. Although the Multispecies FMP was amended four times by 1991, it was widely recognized that many stocks, including winter flounder, were being overfished.

Time-specific stock rebuilding schedules were a part of Multispecies FMP Amendment 5 which took effect in May, 1994. The rebuilding target for winter flounder, a so-called "large-mesh" species, was $F_{20\%}$ within 10 years. Along with a moratorium on issuance of additional vessel permits, the cornerstone of Amendment 5 was an effort reduction program that required "large-mesh" groundfish vessels to limit days at sea, which would be reduced each year. There was an exemption from effort reduction requirements for groundfishing vessels less than 45 feet in length and for "day boats" (from 2:1 layover day ratio requirement). Draggers retaining more than the "possession limit" of groundfish (10%, by weight, up to 500 lbs) were required to fish with either 5.5 in diamond or square mesh in Southern New England or 6 in throughout the net in the regulated mesh area of Georges Bank/ Gulf of Maine, respectively. The possession limit was allowed when using small mesh within the western Gulf of Maine (except Jeffreys Ledge and Stellwagon Bank) and in Southern New England. Vessels fishing in the EEZ west of 72° 30' (the longitude of Shinnecock Inlet, NY) were required to abide by 5.5 in diamond or 6 in square codend mesh size restrictions consistent with the Summer Flounder FMP. The minimum landed size of winter flounder increased to 12 in, appropriate for the increased mesh size in order to reduce discards. There were many additional rules including time/area closures for sink gillnet vessels, seasonal netting closures of prime fishing areas on Georges Bank (Areas I and II), and on Nantucket Shoals to protect juvenile yellowtail flounder.

At the end of 1994, the NEFMC reacted to collapsed stocks of Atlantic cod, haddock, and yellowtail flounder on Georges Bank by recommending a number of emergency actions to tighten existing regulations reducing fishing mortality. Prime fishing areas on Georges Bank (Areas I & II), and the Nantucket Lightship Area were closed. The NEFMC also addressed expected re-direction of fishing effort into Gulf of Maine and Southern New England while, at the same time, developing Amendment 7 to the Multispecies FMP. Under Amendment 7, days-at-sea controls were extended, and any fishing by an EEZ-permitted vessel required use of not less than 6 in diamond or square mesh in Southern New England east of 72° 30'. Framework 27 in 1999 increased the square mesh minimum size to 6.5 in in the Gulf of Maine, Georges Bank, and Southern New England mesh areas. Amendment 9 revised the overfishing definitions for New England groundfish, and new overfishing definitions for SNE/MA winter flounder were recommended by SARC 28 (NEFSC 1999).

STOCK STRUCTURE

Although stock groups consist of an assemblage of adjacent estuarine spawning units, the ASMFC FMP originally defined three coastal management units based on similar growth, maturity and seasonal movement patterns: Gulf of Maine, Southern New England and the Mid-Atlantic. Boundaries for a total of four winter flounder stock units as originally defined in the ASMFC management plan (Howell et al., 1992) were:

Gulf of Maine: Coastal Maine, New Hampshire, and Massachusetts north of Cape Cod

Southern New England: Coastal Massachusetts east and south of Cape Cod, including Nantucket Sound, Vineyard Sound, Buzzards Bay, Narragansett Bay, Block Island Sound, Rhode Island Sound, Rhode Island coastal ponds and eastern Long Island Sound to the Connecticut River, including Fishers Island Sound, NY.

Mid-Atlantic: Long Island Sound west of the Connecticut River to Montauk Point, NY, including Gardiners and Peconic Bays, coastal Long Island, NY, coastal New Jersey and Delaware.

Georges Bank

In the current and previous assessments (e.g., NEFSC 1996, ASMFC 1998, NEFSC 1999) the Southern New England and Mid-Atlantic units have been combined into a single stock complex for assessment purposes. A review of tagging studies for winter flounder (Howell 1996) indicates dispersion (and hence mixing) has occurred between previously defined Southern New England and Mid-Atlantic units. Howell (1996) noted that differences in growth and maturity among samples from Southern New England to the Mid-Atlantic may reflect discrete sampling along a gradient of changing growth and maturity rates over the range of a stock complex. Differences in growth rates within the Mid-Atlantic units were observed to be greater than differences between Mid-Atlantic and Southern New England units (Howell, 1996). In offshore waters, the length structure of winter flounder caught in NEFSC research surveys is similar from Southern New England to New Jersey. Most commercial landings are obtained in these offshore regions (greater than 3 miles from shore).

Stock Boundaries and associated Statistical Areas

The Gulf of Maine stock complex extends along the coast of eastern Maine to Provincetown, MA, corresponding to NEFSC commercial fishery statistical division 51 (Figure B2.1). Recreational landings from Maine, New Hampshire and northern Massachusetts (northern half of Barnstable County and north to New Hampshire border) are associated with this stock complex.

The Southern New England/Mid-Atlantic stock complex extends from the coastal shelf east of Provincetown, MA southward along the Great South Channel (separating Nantucket Shoals and Georges Bank) to the southern geographic limits of winter flounder. NEFSC commercial fishery statistical areas within this boundary are 521 and 526, and statistical divisions 53, 61, 62, and 63. The corresponding recreational areas are southern Massachusetts (the southern half of Barnstable County; Dukes, Nantucket and Bristol counties), Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland and Virginia. NEFSC survey strata included for this stock extend from the waters of outer Cape Cod to the south and west.

The Georges Bank stock extends eastward of the Great South Channel, including statistical areas 522, 525, and 551-562.

FISHERY DATA

Landings

Commercial landings from 1964-1981 was taken directly from the SARC 21 assessment (NEFSC 1996). Landings from 1981-1993 was estimated from the weighout data and landings from 1994-2001 comes from a proration of dealer and vessel trip report (VTR) data (Table B2.1).

Commercial landings were near 1,000 mt from 1964 to the mid 1970s. Thereafter commercial landings increased to a peaked of 2,793 mt in 1982, and then steadily declined to a record low of 253 mt in 1999. Landings have remained near 500 mt since 1999 (Table B2.1, Figure B2.2). Otter trawl was the primary gear use during 1964-1985; > 95% of the landings (Table B2.2, Figure B2.2). Since 1985 the proportion of landings coming from gillnets has increased, and has averaged 25% since 1990. Over 95% of the landings came from Massachusetts since 1997 (Table B2.3, Figure B2.3). The proportion of winter flounder commercial landings taken in Maine has decrease from an average of 25 percent of the landings in the early 1980s to less than 5% of the landings from 1995-2001. Over 90% of the commercial landings came from statistical area 514 since 1996 (Table B2.4, Figure B2.4). Commercial landings are taken relatively constant over the year (Table B2.5, Figure B2.5). There has been a decrease in the proportion of the landings in the large market category in the last few years (Table B2.6, Figure B2.6).

Recreational landings reached a peak in 1981 of 2,554 mt but declined substantially thereafter (Table B2.7, Figure B2.7). Landings have been less than 100 mt since 1995, with the lowest estimated landings in 1998 of 30 mt. Landings in 2001 for the Gulf of Maine winter flounder were 43 mt. The proportion of recreational landings from Maine has decreased similarly to the commercial landings (Tables B2.8-9). The proportion of recreational landings taken by halfyear has fluctuated from 1981 to 2001 (Tables B2.10-11).

Landed Age Compositions

Commercial fishery

Length samples of winter flounder are available from both the commercial and recreational landings. In the commercial fishery, annual sampling intensity varied from 4 to 310 mt landed per sample during 1982-2001. Overall sampling intensity was adequate, however temporal and market category coverage in some years was poor (Table B2.12). Samples were pooled to halfyear when possible. In 1982 mediums were pooled with unclassified by halfyear; in 1985 and 1995 smalls were pooled with mediums; the large sample from 1998 was also used to characterize 1999; and the 2001 large samples were used to characterize the 1999 large market category. Sampling coverage may have been poor but length frequency samples appeared relatively constant over time and there was a substantial amount of overlap between market categories which helped justify the pooling used in the assessment. Length data from the obsever data was used to supplement length data of unclassified fish. The large number of lengths sampled in the observer data for gillnet trips were used to characterize the gillnet proportion of the landings from 1990-2001 (Table B2.13). There has been a slight shift in the commercial catch at length to larger fish since 1982. The total amount of fish aged in the commercial landings varied from 130 to 1,182 ages (Table B2.14).

Recreational fishery

Recreational landings at length were estimated seasonally (January-June and July-December) from 1982-2001 using the Marine Recreational Fisheries Statistics Survey (MRFSS). Recreational length sampling intensity varied from poorly sampled years in the beginning of the time series (1982-1987 average of 375 mt per 100 lengths) to relatively good sampling from the late 1980s to early 1990s (1988-1997 average of 109 mt per 100 lengths), and more recently

(1998-2001) the sampling intensity has decreased to an average of 179 mt per 100 lengths. Combined Massachusetts Division of Marine Fisheries (MADMF) spring and NEFSC spring surveys and the NEFSC fall survey were used to age recreational length frequencies by halfyear from 1982-2001.

Discard estimates and age compositions

Commercial fishery

Discards were estimated for the large mesh otter trawl (1982-2001), gillnet (1986-2001), and northern shrimp fishery (1982-2001; Table B2.15). Discard data for the small mesh trawl fishery was judged inadequate for estimating discards (Tables B2.15-16). Discard rates in the small mesh trawl fishery were assumed to be the same as for large mesh trawls and to have the same size distribution.

The survey culling ogive method was used in estimating both the discard magnitude and discard proportion at length for the large mesh trawl fishery on a yearly basis from 1982-1993 (Mayo et al. 1992). VTR data was used to estimate the discard magnitude from 1994-2001, and the survey method used to estimate only the discard proportion at length for these years (Table B2.17). Survey length frequency data (MADMF survey spring and fall) were smoothed using a three point moving average, then filtered through a mesh selection ogive (Simpson 1989) for 5 in mesh (1982), 5.5 in mesh (1983-1993), and a 6 in mesh (1994-2001). The 5.5 and 6 in mesh selection curve were calculated using the 5 inch curve adjusted to an L_{50} for 5.5 and 6 in mesh respectively. The choice of mesh sizes was based on sizes used in the American Plaice assessment for the Gulf of Maine (O'Brien and Esteves 2001). The mesh filtering process resulted in a survey length frequency of retained winter flounder. A logistic regression was used to model the percent discarded at length (culling ogive) from 1989-2000 observer data (Figures B2.8-9), and the resulting percentages at length were applied to the survey numbers at length data to produce the survey-based equivalent of commercial kept and discarded winter flounder. The 1989-1993 average percentage discard at length was applied to 1982-1993. The 1995-2000 average percentage discard at length was applied to 1994-2001. The survey numbers per tow at length "kept" were then regressed against commercial numbers landed at length. The linear relationship was calculated for those lengths common to both length frequencies and fitted with an intercept of zero. The slope of the regression provided a conversion factor to re-scale the survey "discard" numbers per tow at length to equivalent commercial numbers at length. The resulting vector of number of fish discarded at length was multiplied by a discard mortality rate of 50% (as averaged in Howell et al., 1992) to produce the vector of fish discarded dead at length per year. The number of dead discards at length was summed across lengths (and corresponding weight at length) to produce the annual total number and weight of commercial fishery discards for 1982-1993. NEFSC combined spring and fall survey age-length keys were applied to convert discard length frequencies to age.

The ASMFC Winter Flounder Technical Committee has considered NEFSC Fishery Observer data (OB), and NER Vessel Trip Report (VTR) data as sources of information to use in the estimation of commercial fishery discards (Tables B2.15-18). The Committee examined the characteristics of both the Fishery Observer and VTR discard data (number of trips/tows sampled, frequency distributions of discards to landings ratio per trip, mean and variance of annual/half-year discards to landings ratios), and concluded that the VTR sum discard to landed ratio aggregated over all trips provided the most reliable data from which to estimate large mesh trawl discards. VTR large mesh trawl gear discards to landings ratios were applied to the total commercial trawl fishery landings to estimate discards in weight from 1994 to 2001. The Fishery Observer length frequency samples were judged inadequate to characterize the proportion discarded at length for the trawl fishery and the length proportion from the survey method (described above) was used to characterize the size distribution of discarded fish (Table B2.16).

Fishery Observer discarded to landing ratios (annual total discards for all trips to annual total landings for all trips) were used for estimating gillnet discard rates, and observer discarded to days fished ratios (shrimp season total discards for all trips to total shrimp fishery days fished for all trips) were used for estimating shrimp discards, since landings of winter flounder in the shrimp fishery is prohibited (Table B2.18). Estimated annual total days fished in the shrimp fishery was calculated as in Wigley et al. 1999. Discard estimates in the shrimp fishery were based on a shrimp fishery season (December-April). The shrimp season catch at age was then adjusted to the appropriate calendar year and age using the proportion of calendar year landings. The average ratio for shrimp discards from 1989 to 1992 (before Nordmore grate requirement) was used for years (1982-1988) when observer data were not available. The 1989-1993 average gillnet ratios were used for 1986 to 1988.

The observer length frequency samples for gillnet and the northern shrimp fishery were used to characterize the proportion discarded at length. Total lengths from shrimp fishery observer discard data from 1989-1992 were used to characterize years 1982-1988 and total lengths from 1993-1997 were used for years 1998 to 2001. Total gillnet lengths from 1990-1993 were used to characterize years 1986 to 1989. Gillnet lengths in 1990 and 1992 were used to supplement lengths in 1991. The sample proportion at length, converted to weight, was used to convert the discard estimate in weight to numbers at length. As in the southern New England stock (NEFSC 1999), the resulting number of fish discarded at length was multiplied by a discard mortality rate of 50% (as averaged in Howell et al., 1992) to produce the number of fish discarded dead at length for all estimated commercial discard sources. Ages were determined using NEFSC/MADMF spring and NEFSC fall survey age-length keys.

Recreational fishery

A discard mortality of 15% was assumed for recreational discards (B2 category from MRFSS data), as assumed in Howell et al. (1992). Discard losses peaked in 1982 at 140,000 fish. Discards have since declined reaching a low in 1999 of 7,000 fish. In 2001, 15,000 fish were estimated to have been discarded (Table B2.7, Figure B2.7). Since 1997, irregular sampling of the recreational fisheries by state fisheries agencies has indicated that the discard is usually of fish below the minimum landing size of 12 inches (30 cm). For 1982-2001, the recreational discard has been assumed to have the same length frequency as the catch in the MADMF survey below the legal size and above an assumed hookable fish size (13 cm). When a size limit did not exist from 1982-1984 it was assumed that all fish discard were below 23 cm based on some length frequency information of discarded fish from the American Littoral Society tagging data. The recreational discard for 1982-2001 is aged using NEFSC/MADMF spring and NEFSC fall survey age-length keys.

Mean Weights at Age in the Catch

Mean weights at age were determined for the landings and discards in the commercial and recreational fisheries (Figure B2.10). Length frequencies (cm) for each component were converted to weight (kg) using length-weight equations derived from NEFSC survey samples:

Spring surveys: $wt = 0.00000997 * length^{3.055236}$
Fall surveys: $wt = 0.00000925 * length^{3.095188}$

The equations from the spring and fall surveys were applied to catches during the corresponding time periods. The annual mean weights at age from the commercial and recreational fisheries were used in the virtual population analysis and yield per recruit calculations.

Total Catch

Estimates of the individual catch and mean weights at age components which made up the total catch are present in Tables B2.19 through B2.30 and Figure B2.11. The total catch during this period has varied from a high of 5,034 mt (14.2 million fish) in 1982 to a low of 300 mt (0.6 million fish) in 1999 (Tables B2.31-32). The total catch estimates include commercial and recreational landings and discards (Figure B2.12). Total catch and mean weights at age as aggregated for input to the VPA (ages 1-8+) are presented in Tables B2.33 and B2.34 (Figure B2.13). A summary of how the catch at age is was constructed can be seen in Table B2.35.

RESEARCH SURVEY ABUNDANCE AND BIOMASS INDICES

Research surveys

Mean weight and number per tow abundance indices were determined from spring (1979-2002) and fall (1979-2002) NEFSC and MADMF bottom trawl surveys (Table B2.36). Winter flounder are not found in the central Gulf of Maine and these strata (24, 28, 29, 37, and 36) were dropped from the index (Figures B2.14-15). Indices from the NEFSC spring and fall surveys were based on tows in offshore strata 26, 27, 38 to 40 and inshore strata 58 to 61, 65, and 66 (Figures B2.16-19). A longer spring (1968-2002) and fall (1963-2002) NEFSC survey index was also calculated which was limited to just offshore strata (26,27,38,39,40) since inshore strata were not sampled prior to 1979 in the Gulf of Maine (Figures B2.18-19). All MADMF strata sampled north of Cape Cod (25-36) were included in the index (Figures B2.20-21).

Survey trends by individual strata in the NEFSC survey suggests a decreasing trend in the northern part of the stock off the coast of Maine and an increasing trend in the southern stock component off Massachusetts which mirrors the trend seen in the landings by state and statistical area (Figures B2.16-17). Higher catches of winter flounder are seen in the MADMF survey with individual strata following similar trends. All of the indices generally dropped from the beginning of the time series in the early 1980s to a low point in the early to mid- 1990s, then increase slightly in the late 1990s (Table B2.36). All of the indices generally show increases during 1998 and 1999. Similar trends were seen between the inshore/offshore index and the index limited to just the offshore strata regardless of the increased variability in the offshore series due to less fish inhabiting the deeper waters of the offshore strata (Figures B2.18-19).

The Seabrook Nuclear Power Plant in New Hampshire has conducted a monthly bottom trawl survey at 3 fixed stations in Southern New Hampshire since 1975. Four replicate tows using a shrimp trawl were made at each station once per month from 1975-1983. Sampling changed to two replicate tows twice per month in 1985. Length data was collected from 1985-2001 with the exception of 1993. The monthly survey was broken down to a spring and fall survey. The Fall survey index was not used for tunning due to a lack of sampling in more recent years at one of the three stations because of the presence of lobster gear. In addition, appropriate age data in the fall does not exist for aging the smaller fish caught in this survey. MADMF spring survey ages were used to age the Seabrook spring index. This survey also shows an increase in the number of fish in the late 1990s (Figure B2.22).

MADMF catches a larger proportion of smaller fish than the NEFSC surveys. Survey numbers at age is summarized in Tables B2.37 through B2.41. No MADMF age data are currently available for the fall survey or for 2002 in the Spring. The NEFSC age data was used to age missing ages in the MADMF survey.

ESTIMATES OF MORTALITY AND STOCK SIZE

Natural Mortality

Instantaneous natural mortality (M) for winter flounder was assumed to be 0.20 and constant across ages as in the SNE winter flounder stock. Commercial catch at age included fish to age 13, under conditions of relatively high fishing mortality. If M = 0.25, less than 5% of the population would reach age 12 under conditions of no fishing mortality. Therefore, the SARC felt that M = 0.2, which represents a maximum age of 15, was representative of the stock.

Maturity

The VPA assessment uses the maturity schedule as published in O'Brien et al. (1993) for winter flounder north of Cape Cod, based on data from the MADMF spring trawl survey for strata 25-36 (state waters east and north of Boston and Cape Cod Bay) sampled during 1985-1989 (n = 215 males, n = 320 females). Those data provided estimates of lengths and ages of 50% maturity of 27.6 cm and 3.3 yr for males, and 29.7 cm and 3.5 yr for females, and estimated proportions mature at age as follows:

Age	1	2	3	4	5	6	7+
Males	0.00	0.04	0.34	0.87	0.99	1.00	1.00
Females	0.00	0.01	0.16	0.86	0.99	1.00	1.00

The female schedule (with the proportion at age 2 rounded down to 0.00 and the proportion at age 5 rounded up to 1.00) was used in the present VPA and YPR assessment.

The SARC has examined NEFSC spring trawl survey data over the 1981-2001 period in an attempt to better characterize the maturity characteristics of the Gulf of Maine winter flounder. Data were analyzed in 5-6 year blocks (1981-1985, 1986-1990, 1991-1995, and 1996-2001) and for the entire time period (1981-2001), for each sex and combined sexes (Tables B2.42-43). Observed proportions mature at age were tabulated, and from those data maturity ogives at length and age were calculated to provide estimated proportions mature at age.

In general, the NEFSC maturity data for the sexes combined indicated earlier maturity than the MADMF data, with L50% values ranging from 21-24 cm, rather than from 28-29 cm, and with 50% maturity for age 2.5 fish, rather than 50% maturity for age 3.3 fish (Table B2.42). To investigate the apparent inconsistency between the MADMF and NEFSC maturity data, the SARC compared the two data sets over the same time periods (1981-1985, 1986-1990, 1991-1995, 1996-2001, and 1981-2001) and area of survey coverage (MADMF strata 25-36; NEFSC inshore strata 58-66). For comparable time periods and geographic areas, the NEFSC maturity data still consistently indicated a smaller size and younger age of 50% maturity than the MADMF data. NEFSC L50% and A50% values range from 21-25 cm and about 2.5 yr, while the MADMF values range from 28-29 cm and about 3.3 yr (Table B2.44, Figure B2.23). The difference is still nearly a full age class difference at 50% maturity. These results are very similar to the differences seen between the MADMF and NEFSC surveys for the southern New England winter flounder stock.

Given that both length and age vary in the same direction, it seems unlikely that the differences could be attributed to aging differences between the two data sets. The comparison of MADMF and NEFSC maturity estimates over the same time period and location suggests the observed difference is not due to immature and mature fish in the 20 - 30 cm size-class being segregated by area e.g., mature fish in that size interval tending to occupy inshore areas during the spring with immature fish tending to remain offshore. The difference between MADMF and NEFSC surveys is consistent over time. The differences may be due to differences in interpretation of maturity stage for fish sizes between 20-30 cm between MADMF and NEFSC survey staff.

The SARC considered these data and analyses and the possible causes for the noted inconsistencies, and concluded that more detailed spatial and temporal analyses and/or a maturity workshop on the interpretation of maturity stages is needed before revisions to the maturity schedule can be adopted. Therefore, the maturity at age schedule published by O'Brien et al. 1993 was used for this assessment.

Virtual Population Analysis

Tuning

The Virtual Population Analysis (VPA) was tuned (calibrated) using the NEFSC Woods Hole Fisheries Assessment Compilation Toolbox (FACT) version 1.50 of the ADAPT VPA (Conser and Powers 1990). Abundance indices at age were available from several research surveys: NEFSC spring bottom trawl ages 1-8+, NEFSC fall ages 1-8+ (advanced to tune January 1 abundance of ages 2-8+), 1-5, Massachusetts spring ages 1-8+, Massachusetts fall ages 0-8+ (advanced to tune January 1 abundance of ages 1-8+), and Seabrook spring trawl survey ages 1-8+. Survey indices were selected for inclusion in VPA tuning based on consideration of the partial variance in a VPA trial run including all indices, residual error patterns from the various trail runs, and on the significance of the correlation among indices and with VPA abundance estimates from the trail run including all indices. A conditional non-parametric bootstrap procedure (Efron 1982) was used to evaluate the precision of fishing mortality and spawning stock biomass. A retrospective analysis was performed for terminal year fishing mortality, spawning stock biomass, and age 1 recruitment.

VPA diagnostics

The SARC considered 6 different configurations of tuning indices with the catch at age estimated to 8+ from 1982 to 2001. Run GOMWFS36_ALL was the initial trial including all indices. The results of the VPA were not sensitivity to the method used in estimating large mesh discards i.e. using the survey method only or using the survey method and vtr data to estimate discards (run GOMWFS36_survey). In addition, VPA result were not sensitivity to excluding all discards from the catch at age (GOMWFS36_no_dis). In general, tuning indices were excluded if they exhibited high partial variance (indicating a lack of fit within the VPA model) and low correlation with other indices with similar spatial and temporal characteristics and with the VPA estimates of stock size.

Run GOMWFS36_2 excluded six indices with high partial variance within the VPA and low correlation with other indices and/or the VPA estimates of stock size, resulting in improvements both in overall fit (Mean Square Residual (MSR) reduced by 25%) and in the precision of the stock size estimates. Run GOMWFS36_3 dropped an additional five indices from the GOMWFS36_2 configuration, resulting in some improvements in fit but this run also resulted in a decrease in the precision around age-1 stock numbers at age. Run GOMWFS36_no_age1 has the same survey indices as GOMWFS36_3, but did not estimate stock size at age 1, and provided virtually the same results. Therefore, GOMWFS36 _2 was the run adopted as final by the SARC, and is the basis for all further analyses (Table B2.45).

Fishing Mortality, Spawning Stock Biomass, and Recruitment

During 1982-1995, fishing mortality (fully recruited F, ages 5-6) has varied between 0.5 (1983) and 1.9 (1995). Fishing mortality has declined to a range of 0.06-0.14 during 1999-2001 (Figure B2.24). Accounting for the uncertainty of the 2001 estimate, there is an 80% probability that F in 2001 was between 0.12 and 0.16 (Table B2.46, Figure B2.25). Spawning stock biomass (SSB) declined from 4,790 mt in 1982 to a record low of 666 mt in 1995. SSB has increased since 1995 to 5,866 mt in 2001 (Figure B2.26). Accounting for the uncertainty of the 2001 estimate, there is an 80% probability that SSB in 2001 was between 5,203 mt and 6,581 mt (Figure B2.25). Recruitment declined continuously from 11.8 million age-1 fish in 1982 to 3.2 million in 1993. Recruitment then averaged 7.8 million fish during 1995-2002 (Figure B2.26).

Retrospective analysis
A retrospective analysis of the VPA was conducted back to a terminal catch year of 1995 (Table B2.45b, Figure B2.27). The Gulf of Maine winter flounder VPA does exhibit a retrospective pattern in F from 1993 to 1998. Retrospective fishing mortality rates underestimate the current values by an average of 56% from 1993-1998. The most likely cause of this pattern is a combination of factors including under-reporting of the landings, mis-classification of the landings by stock area, and underestimation of the discards. There is a tendency for an overestimation of SSB during the late 1990s. For 1993-1998, retrospective SSB levels overestimate current values by an average of 92%.

Precision of Stock Size, F, and SSB estimates
The precision of the 2002 stock size, fishing mortality at age in 2001, and SSB estimates from VPA was evaluated using bootstrap techniques (Efron 1982). Five hundred bootstrap iterations were realized in which errors (differences between predicted and observed survey values) were resampled. Bootstrap estimates of stock size at age indicate a bias of less than 5% for age 1-2 and a bias less than 4% for ages 3-8+. Bootstrap standard errors provide stock size CVs ranging from 16% at age 7 to 48% at age 1 (Table B2.46).

Bootstrapped estimates of spawning stock biomass indicate a CV of 9%, with low bias (bootstrap mean estimate of spawning stock biomass of 5,945 mt compared with VPA estimate of 5,866 mt). There is an 80% probability that spawning stock in 2001 was between 5,203 mt and 6,581 mt (Figure B2.25).

The bootstrap estimates of standard error associated with fishing mortality rates at age indicate good precision. Coefficients of variation for F estimates ranged from 16% at age 7 to 37% at ages 1. There is an 80% probability that fully recruited F for ages 5-6 in 2001 was between 0.12 and 0.16 (Figure B2.25).

BIOLOGICAL REFERENCE POINTS

The ASMFC Winter Flounder Technical Committee followed the parametric modeling approach done for SNE winter flounder by the NEFSC Working Group on the Re-Evaluation of Biological Reference Points for New England Groundfish (RPWG; NEFSC 2002) in estimating biological reference points for Gulf of Maine winter flounder. The RPWG (NEFSC 2002) estimated biological reference points using yield and SSB per recruit (Thompson and Bell 1934) and Beverton-Holt/Ricker stock-recruitment models (Beverton and Holt 1957, Brodziak et al. 2001, Mace and Doonan 1988).

Yield and Spawning Stock Biomass per Recruit

The yield and SSB per recruit analyses was estimated by the Technical Committee for Gulf of Maine winter flounder. Natural mortality was assumed to be 0.2. The proportion mature was taken from O'Brien et. al (1993). The average partial recruitment pattern form 1999-2001 was used for ages 1 to 4. Full recruitment was assumed for 5 and older. The average catch weight from 1999-2001 was used for ages 1 to 7 and the Rivard weights were used for the stock weights for ages 1 to 7. An estimated von bertalanffy model for female Gulf of Maine winter flounder using MADMF data from Witherell and Burnett (1993) was used to estimate catch and stock weights for ages 8 to 15. The von Bertalanffy model for females was used since survey data indicates a skewed sex ratio for older ages. The yield and SSB per recruit analyses indicate that $F_{40\%}$ and $F_{0.1}$ = 0.26 (Table B2.47, Figure B2.28). F_{max} was estimated to be 0.69.

Empirical Nonparametric approach

If $F_{40\%}$ is assumed to be an adequate proxy for Fmsy, then the fishing mortality threshold is 0.26. This fishing mortality rate produces 0.8333 kg of spawning stock biomass per recruit and 0.1977 kg of yield per recruit (including discards). Since the VPA estimates of recruitment does not increase greatly with increasing spawning stock size, the mean of the time-series of recruitments (1982-2001) is assumed to be representative of recruitment levels expected at maximum sustainable yield (MSY). Thus, recruitment of 6.705 million fish results in an estimate of 5,587 mt of spawning stock biomass (SSBmsy proxy) and 1,326 mt of MSY.

Parametric Model Approach

Maximum likelihood fits of the 10 parametric stock-recruitment models to the Gulf of Maine winter flounder VPA estimates for 1982-2001 are listed below (Table B2.48). The model acronyms are: BH = Beverton-Holt, ABH = Beverton-Holt with autoregressive errors, PBH = Beverton-Holt with steepness prior, PABH = Beverton-Holt with steepness prior and autoregressive errors, PRBH = Beverton-Holt with recruitment prior, PRABH = Beverton-Holt with recruitment prior and autoregressive errors, RK = Ricker, ARK = Ricker with autoregressive errors, PRK = Ricker with slope at the origin prior, PARK = Ricker with slope at the origin prior and autoregressive errors. The six hierarchical criteria are applied to each of the models to determine the set of candidate models (NEFSC 2002).

1. Parameter estimates must not lie on the boundary of their feasible range of values.
2. The estimate of MSY lies within the range of observed landings.
3. The estimate of S_{msy} is not substantially greater than the nonparametric proxy estimate.
4. The estimate of F_{msy} is not substantially greater than the value of F_{max}.
5. The dominant frequencies for the autoregressive parameter, if applicable, lie within the range of one-half of the length of the stock-recruitment time series.
6. The estimate of recruitment at S_{max}, the maximum spawning stock size proxy input to the stock-recruitment model, is consistent with the value of recruitment used to compute the nonparametric proxy estimate of S_{msy}.

The fifth criterion is not satisfied by the ABH, PABH, PRABH, ARK, and PARK models. The RK, and ARK models do not satisfy criterion 4. The stock-recruitment data does not support overcompensatory effects at SSB predicted by the PRK model (Ricker model with slope at the origin prior). The three remaining models are BH, PBH, and PRBH. All three models estimated a high steepness parameter. The AIC assigns the greastest probability to the BH model (Figure B2.29). However similar point estimates of MSY, F_{msy}, and S_{msy} are estimated by all three models. The standardized residual plot of the fit of the BH model to the stock-recruitment data shows that the standardized residuals generally lie within $\pm$ two standard deviations of zero.

The SARC selected the parametric Berverton-Holt (BH) model for estimating biological reference points for Gulf of Maine winter flounder; MSY = 1,543 mt, F_{msy} = 0.43, SSB_{msy} = 4,104 mt. The SARC concluded that the high steepness estimates from the Beverton-Holt models were within the feasible biological range and therefore estimating F_{msy} using the (BH) parametric approach was preferred over assuming $F_{msy} = F_{40\%}$ in the empirical nonparametric approach. The high steepness estimate also likely resulted in similar estimates of SSB_{msy} between the empirical and parametric approach.

PROJECTIONS FOR 2002-20012

Stochastic projections were made based on 500 bootstrapped VPA realizations of stock size in numbers at age in 2002. The stochastic forecasts only incorporate uncertainty in 2002 stock sizes due to survey variability and assume current discard to landings proportions. Partial recruitment to the fishery and percentage discarded were estimated as the mean of VPA estimates for 1999-2001. For consistency with the partial recruitment averages, mean weights at age in the stock, landings, and discards were similarly estimated as the weighted (by number landed) geometric mean weight at age from 1999-2001.

Parametric approach

Assuming F in 2002 will be equal to F in 2001 (F2002 = 0.14), landings are expected to be about 961 mt in 2002. At this status quo F, spawning stock biomass is projected to continue to increase to 7,623 mt in 2002. If fishing mortality rate is increased to F_{msy} = 0.43 in 2003 spawning stock will decrease to 4,258 mt by 2013 with 50% probability which is slightly above the B_{msy} = 4,104 mt estimate (Table B2.49).

If F in 2002 is assumed to be 15% less than F in 2001 (F2002 = 0.12), due to the impact of management measures implemented in response to court orders during 2002, then landings are expected to be about 831 mt in 2002. At this reduced F, spawning stock biomass is projected to continue to increase to 7,655 mt in 2002. If fishing mortality rate is increased to F_{msy} = 0.43 in 2003 spawning stock will decrease to 4,260 mt by 2013 with 50% probability which is slightly above the B_{msy} = 4,104 mt estimate (Table B2.49, Figure B2.30).

CONCLUSIONS

The Gulf of Maine winter flounder stock is not overfished and overfishing is not occurring (Figure B2.31). Fully recruited fishing mortality in 2001 was 0.14 (exploitation rate = 12%), about 67% below F_{msy} = 0.43. There is an 80% chance that the 2001 F was between 0.12 and

0.16. Spawning stock biomass was estimated to be 5,900 mt in 2001, about 44% above B_{msy} = 4,100 mt. There is an 80% chance that the spawning stock biomass was between 5,200 mt and 6,600 mt in 2001.

Spawning stock biomass declined substantially from 4,800 mt in 1982 to700 mt in 1995, but has increased to about 5,900 mt in 2001 due to reduced fishing mortality rates since 1996. Recruitment to the stock has been near or above average since 1995.

For 1993-1998 retrospective fishing mortality rates underestimate the current values by an average of 56%. The most likely cause of this pattern is a combination of factors including under-reporting of the landings, mis-classification of the landings by stock area, and underestimation of the discards. For 1993-1998, retrospective SSB levels overestimate current values by an average of 92%. While the GOM winter flounder VPA provides uncertain estimates of current F and SSB, it provides a better determination of stock status than reliance on survey indices alone. However, recent spatial distribution of both commercial landings and survey catches indicates that most of the recent stock rebuilding has taken place off the Massachusetts coast, with little evidence of rebuilding off the Maine coast.

Biological reference points for Gulf of Maine winter flounder were estimated using empirical, non-parametric and parametric stock-recruit modeling approaches. The yield and SSB per recruit analyses indicate that $F_{40\%}$ = $F_{0.1}$ = 0.26 and F_{max} = 0.69. A parametric Beverton-Holt stock-recruitment model estimated values of F_{msy} = 0.43, B_{msy} = 4,100, and MSY = 1,500 mt. The SARC recommends that the parametric model reference points be adopted as the basis for the ASMFC and NEFMC FMP overfishing definitions.

SARC COMMENTS

The SARC noted that a single survey length-weight relationship has been used for SNE-MA, GOM and GB winter flounder stocks, and suggested stock-specific parameters be explored in the next assessment.

The VPA indicates substantial rebuilding of the stock since 1995. The stock status of GOM winter flounder is somewhat unique among GOM groundfish stocks, as it is currently at a relatively high stock biomass and apparently subject to relatively low fishing mortality. The recent spatial distribution of commercial landings and survey catches indicates that most of the recent stock rebuilding has taken place off the Massachusetts coast, with little evidence of rebuilding off the Maine coast. This situation may be attributed to the restrictive regulations imposed in recent years in the areas where much of the current biomass is concentrated (e.g. area closures and gear and vessel restrictions in statistical areas 513 and 514).

The GOM winter flounder VPA, like the SNE-MA analysis, exhibits a retrospective pattern of underestimating fishing mortality (averaging 56%) and overestimating SSB (averaging 92%) during the period 1993-1998. The observed retrospective pattern is likely caused by under-reporting or under-estimating the catch. The SARC concluded that, while the GOM winter flounder VPA provides uncertain estimates of current F and SSB, it provides a better determination of stock status than would reliance on survey indices alone.

As this is a new, benchmark analytical assessment for GOM winter flounder, biological reference points based on the analytical results have been estimated for the first time. The SARC discussed options for the analyses to be used as the basis for defining overfishing. It was noted that the ASMFC Winter Flounder Technical Committee preferred the empirical non-parametric approach, based on concerns over the relatively high stock resilience (i.e. relatively high estimates of the model steepness parameter, and therefore the estimated F_{MSY}) of the stock inferred from the stock-recruitment models. The SARC agreed with the Technical Committee's conclusion to reject the Ricker stock-recruitment model estimates of reference points, based on: 1) the lack of evidence of population dynamics (e.g. cannibalism, high degree of spatial interference among adults and recruits) that would justify a high degree of density-dependent compensation in recruitment; and 2) the lack of VPA or hindcast stock-recruitment estimates at biomass levels where there might be such compensation. The SARC concluded that the Beverton-Holt stock-recruitment model provided reasonable reference points for the stock, and recommended that they be adopted as the basis for the ASMFC and NEFSC FMP overfishing definitions.

SOURCES OF UNCERTAINTY

1) Stock-specific landings data for 1994 and later are derived by proration from Vessel Trip Report data and are considered provisional.

2) The lack of a long time series of survey coverage in inshore New Hampshire and Maine waters, where winter flounder are abundant, is a source of uncertainty. The small number of survey tows in inshore Massachusetts strata in the NEFSC survey results in uncertainty in the index.

3) Length frequency sampling intensity of the commercial and recreational fishery landings has been low in some recent years, and likely increases the uncertainty of the estimated landings at age.

4) Observer sampling intensity of the commercial trawl fishery has been low. Shrimp fishery discard sampling has been discontinued in recent years. Commercial fishery discard estimates are based on rates provided by fishers in the Vessel Trip Reports, owing to inadequate Fishery Observer sampling.

5) Scales and otoliths collected by the MADMF fall survey are not aged. In addition, the MADMF 2002 spring survey scales and otoliths were not aged, which likely resulted in an underestimation of the high incoming recruitment evident from the length frequency distributions in the Fall 2000 and Spring 2002 surveys.

6) Differences in the age at maturity between the MADMF and NEFSC spring surveys are a source of uncertainty.

7) The Gulf of Maine winter flounder VPA exhibits a retrospective pattern of underestimating F from 1993 to 1998 and overestimating SSB during the late 1990s.

RESEARCH RECOMMENDATIONS

New

1) The MADMF fall survey does collect winter flounder otoliths and scales, so ageing such material should be undertaken.

2) Increase the number of tows and/or consistently sample inshore strata in the NEFSC bottom trawl survey.

3) Increase MRFSS length sampling intensity in the recreational fishery.

4) Increase temporal and market category coverage of length sampling in the commercial landings.

5) Increase the intensity of observer sampling especially with small- and large-mesh trawl gear.

6) Examine the sources of discrepancy between NEFSC and MA survey maturity estimates.

7) Initiate periodic maturity staging workshops, involving State and NEFSC trawl survey staff.

8) Incorporate the results from the MEDMR research trawl survey (begun in 2001) into the assessment as they become available.

9) Investigate derivation of stock-specific parameters for the next assessment.

10) Attempt use of a forward projection (statistical catch at age model) in the next assessment.

Old

1) Examine the implications of anthropogenic mortalities caused by pollution and power plant entrainment in estimating yield per recruit, if feasible.

2) Examine growth variations within the Gulf of Maine, using results from the Gulf of Maine Biological Sampling Survey (1993-1994).

3) Further examine the stock boundaries to determine if Bay of Fundy winter flounder should be included in the Gulf of Maine stock complex.

Old: completed

1) Process archived age samples from NEFSC surveys and commercial landings, and develop an analytical age based assessment.

2) Estimate biological reference points for Gulf of Maine winter flounder.

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Table B2.1. Winter flounder commercial landings (metric tons) for the Gulf of Maine stock (U.S. statistical reporting areas 512 to 515). Landings from 1964-1981 is taken directly from SARC 21, 1982-1993 is re-estimated from the wodets, data and 1994-2001 is estimated using prorated dealer and VTR data.

Year	metric tons
1964	1,081
1965	665
1966	785
1967	803
1968	864
1969	975
1970	1,092
1971	1,113
1972	1,085
1973	1,080
1974	885
1975	1,181
1976	1,465
1977	2,161
1978	2,194
1979	2,021
1980	2,437
1981	2,406
1982	2,793
1983	2,096
1984	1,699
1985	1,582
1986	1,188
1987	1,140
1988	1,250
1989	1,253
1990	1,116
1991	1,008
1992	825
1993	611
1994	552
1995	796
1996	600
1997	618
1998	637
1999	253
2000	382
2001	571

Table B2.2. Percent commercial landings by gear for Gulf of Maine winter flounder.

Year	otter trawl	shrimp trawl	gillnet	other
1964	96%		1%	3%
1965	95%	-	2%	3%
1966	98%	-	1%	2%
1967	99%	-	-	1%
1968	98%	-	-	2%
1969	99%	-	-	1%
1970	99%	-	1%	-
1971	95%	-	4%	1%
1972	95%	-	4%	1%
1973	97%	-	2%	-
1974	95%	-	5%	-
1975	92%	4%	1%	3%
1976	87%	2%	6%	5%
1977	93%	1%	3%	3%
1978	89%	-	3%	9%
1979	94%	-	1%	5%
1980	95%	-	1%	4%
1981	92%	3%	1%	3%
1982	89%	5%	2%	4%
1983	87%	7%	3%	4%
1984	85%	8%	2%	6%
1985	91%	4%	1%	4%
1986	77%	6%	14%	4%
1987	74%	8%	12%	5%
1988	81%	5%	13%	1%
1989	80%	5%	11%	4%
1990	77%	2%	19%	2%
1991	86%	2%	9%	2%
1992	77%	2%	19%	2%
1993	75%	-	23%	2%
1994	78%	-	21%	1%
1995	66%	-	32%	3%
1996	72%	-	27%	1%
1997	72%	-	27%	1%
1998	73%	-	27%	1%
1999	65%	-	33%	1%
2000	73%	-	26%	1%
2001	77%	-	22%	1%

Table B2.3. Percent commercial landings by state for Gulf of Maine winter flounder.

Year	ME	NH	MA	RI
1964	3%	-	97%	-
1965	7%	-	93%	-
1966	6%	-	94%	-
1967	6%	-	94%	-
1968	3%	-	97%	-
1969	4%	-	96%	-
1970	13%	-	87%	-
1971	6%	-	93%	1%
1972	12%	-	88%	-
1973	9%	-	91%	-
1974	13%	-	87%	-
1975	20%	-	80%	-
1976	12%	-	88%	-
1977	9%	-	91%	-
1978	14%	-	86%	-
1979	21%	-	79%	-
1980	23%	-	77%	-
1981	27%	2%	71%	-
1982	32%	4%	64%	-
1983	31%	4%	65%	-
1984	23%	6%	71%	-
1985	21%	5%	74%	1%
1986	22%	4%	73%	-
1987	19%	8%	72%	1%
1988	22%	9%	69%	-
1989	18%	9%	72%	-
1990	14%	7%	78%	-
1991	16%	7%	76%	-
1992	14%	7%	79%	-
1993	8%	6%	86%	-
1994	5%	7%	88%	-
1995	3%	4%	93%	-
1996	1%	5%	94%	-
1997	3%	2%	95%	-
1998	1%	2%	97%	-
1999	-	3%	97%	-
2000	-	4%	95%	1%
2001	1%	3%	96%	-

Table B2.4. Percent commercial landings by statistical area for Gulf of Maine winter flounder.

Year	511	512	513	514	515
1964	-	2%	1%	96%	-
1965	-	1%	6%	92%	1%
1966	-	2%	7%	90%	-
1967	-	1%	6%	94%	-
1968	-	2%	1%	97%	-
1969	-	1%	4%	95%	-
1970	-	1%	12%	87%	-
1971	-	1%	6%	93%	-
1972	-	1%	12%	87%	-
1973	-	1%	8%	91%	-
1974	-	2%	11%	87%	-
1975	1%	2%	18%	79%	-
1976	-	1%	13%	86%	-
1977	-	2%	9%	89%	-
1978	-	3%	13%	83%	-
1979	2%	4%	18%	77%	-
1980	1%	3%	20%	76%	1%
1981	-	3%	27%	69%	1%
1982	3%	5%	27%	62%	2%
1983	2%	4%	29%	64%	1%
1984	1%	3%	27%	68%	1%
1985	4%	2%	21%	70%	2%
1986	4%	5%	26%	64%	2%
1987	2%	3%	25%	69%	1%
1988	4%	6%	22%	67%	1%
1989	1%	5%	24%	69%	2%
1990	4%	3%	21%	71%	1%
1991	2%	1%	23%	68%	5%
1992	1%	3%	21%	73%	3%
1993	1%	-	17%	81%	2%
1994	-	2%	14%	81%	2%
1995	2%	9%	8%	80%	1%
1996	-	-	9%	90%	1%
1997	-	-	9%	90%	1%
1998	-	-	4%	96%	-
1999	-	-	3%	94%	2%
2000	1%	-	5%	94%	-
2001	-	-	4%	95%	-

Table B2.5. Percent commercial landings by quarter for Gulf of Maine winter flounder.

year	1	2	3	4
1964	21%	31%	22%	27%
1965	22%	27%	11%	40%
1966	21%	23%	8%	48%
1967	15%	35%	8%	42%
1968	12%	39%	17%	32%
1969	23%	37%	15%	26%
1970	19%	40%	11%	30%
1971	25%	33%	19%	22%
1972	23%	34%	18%	25%
1973	24%	27%	16%	33%
1974	22%	30%	7%	41%
1975	18%	25%	17%	40%
1976	22%	18%	18%	42%
1977	24%	19%	13%	44%
1978	21%	32%	12%	35%
1979	13%	28%	17%	42%
1980	17%	30%	16%	37%
1981	23%	28%	14%	34%
1982	24%	28%	9%	38%
1983	28%	31%	12%	30%
1984	29%	27%	8%	36%
1985	26%	31%	10%	33%
1986	33%	32%	7%	29%
1987	29%	34%	7%	30%
1988	30%	29%	7%	34%
1989	27%	39%	8%	27%
1990	27%	38%	10%	26%
1991	26%	32%	9%	32%
1992	26%	36%	7%	32%
1993	18%	37%	11%	34%
1994	13%	38%	11%	38%
1995	22%	38%	15%	25%
1996	20%	38%	10%	32%
1997	18%	34%	16%	31%
1998	16%	44%	13%	28%
1999	13%	44%	17%	25%
2000	15%	39%	17%	29%
2001	9%	41%	17%	32%

Table B2.6. Percent commercial landings by market category for Gulf of Maine winter flounder.

year	unclassified	small	medium	large
1964	77%	-	-	23%
1965	66%	-	-	34%
1966	68%	-	-	32%
1967	78%	-	-	22%
1968	70%	-	-	30%
1969	71%	-	-	29%
1970	75%	-	-	25%
1971	71%	-	-	29%
1972	64%	-	-	36%
1973	-	40%	-	60%
1974	-	38%	-	62%
1975	-	31%	-	69%
1976	-	42%	-	58%
1977	-	53%	-	47%
1978	-	50%	-	50%
1979	-	51%	-	49%
1980	-	49%	-	50%
1981	3%	47%	-	50%
1982	12%	41%	2%	44%
1983	15%	48%	3%	35%
1984	15%	46%	7%	33%
1985	11%	41%	17%	31%
1986	17%	39%	16%	29%
1987	22%	36%	20%	23%
1988	19%	42%	17%	22%
1989	20%	35%	20%	25%
1990	22%	34%	15%	29%
1991	15%	34%	22%	29%
1992	16%	33%	23%	29%
1993	14%	32%	29%	25%
1994	14%	33%	28%	26%
1995	12%	46%	18%	25%
1996	10%	56%	17%	18%
1997	10%	46%	25%	20%
1998	29%	44%	18%	9%
1999	42%	32%	18%	7%
2000	36%	41%	14%	9%
2001	36%	30%	28%	6%

Table B2.7. Estimated number (000's) and weight (mt) of winter flounder caught, landed, and discarded in the recreational fishery, Gulf of Maine stock.

	Numbers (000's)				Metric Tons
Year	Catch A+B1+B2	Landed A+B1	Released B2	15 % Release Mortality	Landed A+B2
1981	6,200	5,433	767	115	2,554
1982	8,207	7,274	933	140	1,876
1983	2,169	1,988	181	27	868
1984	2,477	2,285	191	29	1,300
1985	3,694	3,220	474	71	1,896
1986	946	691	255	38	523
1987	3,070	2,391	679	102	1,809
1988	953	841	111	17	345
1989	1,971	1,678	294	44	620
1990	786	652	134	20	370
1991	213	154	59	9	91
1992	186	137	48	7	90
1993	396	249	147	22	140
1994	232	145	87	13	83
1995	150	82	68	10	39
1996	184	98	86	13	56
1997	192	64	129	19	43
1998	109	65	44	7	30
1999	115	67	48	7	34
2000	177	75	102	15	42
2001	172	72	100	15	43

Table B2.8. Gulf of Maine winter flounder recreational landings (mt) by state.

Year	ME	NH	MA	total
1981	45	55	2,455	2,554
1982	2	20	1,855	1,876
1983	11	36	821	868
1984	5	68	1,227	1,300
1985	4	28	1,864	1,896
1986	112	21	390	523
1987	1	12	1,796	1,809
1988	0	15	329	345
1989	197	20	402	620
1990	265	5	100	370
1991	23	0	68	91
1992	16	13	61	90
1993	37	9	94	140
1994	2	12	68	83
1995	0	4	35	39
1996	0	5	51	56
1997	17	6	20	43
1998	1	12	18	30
1999	0	6	27	34
2000	0	4	37	42
2001	1	7	36	43

Table B2.9. Percent Gulf of Maine winter flounder recreational landings (mt) by state.

Year	ME	NH	MA
1981	2%	2%	96%
1982	0%	1%	99%
1983	1%	4%	95%
1984	0%	5%	94%
1985	0%	1%	98%
1986	21%	4%	75%
1987	0%	1%	99%
1988	0%	4%	95%
1989	32%	3%	65%
1990	72%	1%	27%
1991	25%	0%	75%
1992	18%	14%	67%
1993	27%	6%	67%
1994	3%	15%	82%
1995	0%	11%	89%
1996	0%	9%	91%
1997	40%	13%	46%
1998	2%	38%	60%
1999	0%	19%	81%
2000	0%	10%	90%
2001	1%	15%	83%

Table B2.10. Gulf of Maine winter flounder recreational landing (mt) by halfyear.

Year	halfyear 1	halfyear 2	total
1981	1,407	1,148	2,554
1982	517	1,359	1,876
1983	455	413	868
1984	599	701	1,300
1985	1,742	154	1,896
1986	485	39	523
1987	415	1,393	1,809
1988	211	134	345
1989	127	493	620
1990	52	318	370
1991	39	52	91
1992	24	66	90
1993	50	91	140
1994	38	45	83
1995	27	13	39
1996	39	17	56
1997	32	11	43
1998	15	15	30
1999	23	11	34
2000	14	28	42
2001	26	17	43

Table B2.11. Percent Gulf of Maine winter flounder recreational landing by halfyear.

year	halfyear 1	halfyear 2
1981	55%	45%
1982	28%	72%
1983	52%	48%
1984	46%	54%
1985	92%	8%
1986	93%	7%
1987	23%	77%
1988	61%	39%
1989	20%	80%
1990	14%	86%
1991	43%	57%
1992	27%	73%
1993	36%	64%
1994	46%	54%
1995	68%	32%
1996	69%	31%
1997	74%	26%
1998	50%	50%
1999	67%	33%
2000	33%	67%
2001	60%	40%

Table B2.12. Number of lengths, samples, and metric tons per sample for Gulf of Maine winter flounder. Number of samples and calculations of metric tons per samples does not include observer data or gillnet landings from 1990-2001. * = redistributed according to market category and halfyear proportions. Bold are lengths from observer trawl data.

		Number of lengths.						Number of samples					mt/samples				
year	Qtr	lg	sm	med	un	total		lg	sm	Med	un	total	lg	sm	med	un	total
1982	1				296		1				3						
	2	102	101		159		2	1	1		1		838	453		46	
	3	84	81		106		3	1	1		1						
	4					929	4					9	396	691		231	310
1983	1	80		99			1	1		1							
	2	300	100		407		2	3	1		4		120	510		53	
	3	108	388				3	1	3								
	4	107	956		106	2651	4	1	8		1	24	125	44	64	95	87
1984	1	201	209				1	2	2								
	2	237	294		221		2	3	2		2		74	95			
	3		123				3		1								
	4	126	690	100		2201	4	1	5	1		19	189	67	114	124	89
1985	1	273	565				1	3	3								
	2	392	170				2	3	2				54				
	3	105					3	1									
	4	116			80	1701	4	1			1	14	87		182	176	113
1986	1				266		1				3						
	2	237	109	109			2	3	1	1				242	126	48	
	3		111	86			3		1	1							
	4		389	107	89	1503	4		5	1	1	17	113	37	31	56	70
1987	1				113		1				1						
	2						2										
	3		95				3		1								
	4	47	156	272		683	4	1	2	3		8	257	137	75	249	143
1988	1		258	311			1		3	3							
	2	102		395*			2	1		4*				108	23		
	3						3										
	4		169	107*		1342	4		2	1*		14	340	164	96		89
1989	1				100		1				1						
	2	113		91	**134**		2	1		1					168		
	3		95	120	**32**		3		1	1							
	4			100		785	4			1		6	313	435	42	254	209
1990	1	328	301				1	3	4								
	2				102		2				1		64	48			
	3						3										
	4	117	197	97		1142	4	1	2	1		12	83	90	138	118	75

Table B2.12 Continued.

Number of lengths.

Year	qtr	lg	sm	med	un	total
1991	1	100	51	105	101	
	2	88	203	100	**42**	
	3		95			
	4	236	254			1375
1992	1	110			**107**	
	2	136	100	93		
	3					
	4	57	74	253		930
1993	1	100				
	2			288		
	3		55		**91**	
	4	80		157	**51**	822
1994	1					
	2		71	92	102	
	3					
	4	94		235		594
1995	1	101		175	**63**	
	2			299		
	3			414		
	4				**609**	1661
1996	1		77			
	2		231			
	3		355	252		
	4	84	440	86	**112**	1637
1997	1		204			
	2		127	75*		
	3		220	218		
	4	307	502	56*		1709
1998	1		148	79		
	2		151	201*		
	3		583			
	4	69	163	110*		1504
		↑				
1999	1			104		
	2			171		
	3		28			
	4		52		**408**	763

Number of samples

Year	qtr	lg	sm	med	un	total
1991	1	1	1	1	1	
	2	1	2	1		
	3		1			
	4	3	3			15
1992	1	1				
	2	2	1	1		
	3					
	4	1	1	3		10
1993	1	1				
	2			3		
	3		1			
	4	1		2		8
1994	1					
	2		1	1	1	
	3					
	4	1		3		7
1995	1	1		2		
	2			3		
	3			4		
	4					10
1996	1		1			
	2		2			
	3		2	3		
	4	1	5	1		15
1997	1		2			
	2		2	1*		
	3		2	3		
	4	4	8	1*		23
1998	1		2	1		
	2		3	2*		
	3		7			
	4	1	2	1*		19
		↑				
1999	1			1		
	2			2		
	3		1			
	4		1			5

mt/samples

Year	qtr	lg	sm	med	un	total
1991	1					
	2	92	72			
	3					
	4	32	47	95	115	65
1992	1					
	2	47	119	84		
	3					
	4	75	134	19		67
1993	1					
	2	83		16		
	3					
	4	47	177	30		59
1994	1					
	2			75		
	3					
	4	112	143	15	60	62
1995	1					
	2			37		
	3					
	4	134		42		55
1996	1					
	2		44			
	3					
	4	80	16	18		29
1997	1					
	2		28	66		
	3					
	4	25	11	14		19
1998	1					
	2		34	29		
	3					
	4	65	14	30		25
1999	1					
	2					
	3					
	4		26	10		34

Table B2.12. Continued.

		Number of lengths.						Number of samples					mt/samples				
year	qtr	lg	sm	med	un	total		lg	sm	med	un	total	lg	sm	med	un	total
2000	1		866	143	**480**		1		12	2							
	2		3441	51	**554**		2		45	1				1			
	3		102		**50**		3		2								
	4		114		**26**	5827	4		2			64		12	13		4
2001	1			187	**172**		1			2							
	2	99	157	189	**630**		2	1	2	3				37	10		
	3		100	52	**399**		3		1	1							
	4		154	198	**1307**	3644	4		2	2		14	26	21	24		32

Table B2.13. Number of kept observer lengths, trips, and gillnet metric tons landed per 100 lengths sampled for Gulf of Maine winter flounder.

Year	half	lengths	trips	gillnet landings (mt)	mt/100 lengths
1990	1	539	90	184	
	2	78	1	29	
		617	91	214	35
1991	1	126	6	81	
	2	30	8	13	
		156	14	94	60
1992	1	1950	39	134	
	2	172	25	26	
		2122	64	160	8
1993	1	2004	63	96	
	2	375	20	42	
		2379	83	138	6
1994	1	330	22	101	
	2	206	10	15	
		536	32	115	21
1995	1	1116	20	217	
	2	306	23	35	
		1422	43	253	18
1996	1	1275	26	146	
	2	118	17	19	
		1393	43	164	12
1997	1	793	18	139	
	2	42	4	27	
		835	22	166	20
1998	1	1162	19	141	
	2	431	8	32	
		1593	27	173	11
1999	1	747	5	78	
	2	526	12	7	
		1273	17	85	7
2000	1	911	8	85	
	2	261	4	15	
		1172	12	100	9
2001	1	862	15	94	
	2	42	2	32	
		904	17	126	14

Table B2.14. Gulf of Maine winter flounder numbers of fish aged.

	NEFSC			MA DMF	
Year	Commercial landings	Spring	Fall	Spring	Fall
1982	483	68	94	133	
1983	1182	150	104	159	
1984	908	63	150	139	
1985	318	135	160	97	
1986	344	84	62	57	
1987	130	118	67	125	
1988	249	127	68	104	7
1989	148	60	88	320	
1990	241	122	111	224	
1991	262	174	179	333	
1992	270	144	148	362	
1993	183	91	107	172	
1994	139	122	134	253	149
1995	248	170	55	213	221
1996	246	97	181	324	
1997	295	103	189	286	
1998	341	122	75	135	
1999	149	171	194	146	
2000	883	176	216	160	
2001	246	154	118	166	

Table B2.15. Gulf of Maine winter flounder discard ratios and number of trips/tows in the observer and VTR data for the large mesh, small mesh and gillnet fishery.

		Large Mesh Otter Trawl					Small Mesh Otter Trawl					Gillnet				
Year	Half-year	# trips	#tows	SS ratio	VTR trips	VTR ratio	# trips	#tows	SS ratio	VTR trips	VTR ratio	# trips	#tows	SS ratio	VTR trips	VTR ratio
1989	Jan-Jun	15	44	0.130			2	3	0.200							
	Jul-Dec	7	16	0.071			10	25	0.290			26	62	**0.084**		
1990	Jan-Jun	5	6	0.167								50	164	**0.166**		
	Jul-Dec	6	14	0.287			2	3	0.333			33	63	**0.223**		
1991	Jan-Jun	8	25	0.072			4	14	0.029			73	164	**0.164**		
	Jul-Dec	23	103	0.055			8	18	1.152			321	618	**0.142**		
1992	Jan-Jun	21	48	0.098			1	1	0.000			257	617	**0.130**		
	Jul-Dec	6	22	0.039			3	11	0.068			224	397	**0.114**		
1993	Jan-Jun	1	1	0.600								196	576	**0.150**		
	Jul-Dec	4	12	0.080			3	10	0.153			97	198	**0.107**		
1994	Jan-Jun	1	1	0.000	445	**0.053**				23	0.151	43	101	**0.174**	249	0.229
	Jul-Dec				1422	**0.062**				524	0.092	15	35	**0.103**	648	0.091
1995	Jan-Jun	4	15	1.101	2417	**0.048**				229	0.217	18	54	**0.285**	907	0.150
	Jul-Dec	3	52	0.011	1149	**0.037**	22	57		123	0.322	19	52	**0.201**	548	0.388
1996	Jan-Jun	2	5	0.068	2196	**0.044**	1	1		60	0.254	17	62	**0.128**	589	0.159
	Jul-Dec	2	19	0.013	1227	**0.035**	26	93	3.344	219	1.807	18	39	**0.066**	364	0.553
1997	Jan-Jun	3	13	0.231	1700	**0.034**	1	4	0.218	22	0.064	18	56	**0.245**	470	0.112
	Jul-Dec				887	**0.023**				149	0.136	10	22	**0.272**	291	0.087
1998	Jan-Jun	5	16	0.233	1809	**0.046**				17	0.046	27	87	**0.109**	543	0.144
	Jul-Dec				939	**0.030**				129	0.024	35	66	**0.049**	329	0.117
1999	Jan-Jun				942	**0.038**				15	0.034	14	41	**0.141**	285	0.136
	Jul-Dec	15	35	0.015	1148	**0.038**	13	35		123	0.516	23	60	**0.100**	359	0.090
2000	Jan-Jun	35	78	0.041	1240	**0.060**	7	10	0.123	28	0.192	27	74	**0.137**	378	0.094
	Jul-Dec	6	8	0.000	1418	**0.032**	6	13	0.170	52	0.165	18	39	**0.098**	472	0.088
2001	Jan-Jun	27	61	0.100	1289	**0.029**				3	0.054	13	27	**0.061**	340	0.095
	Jul-Dec	51	129	0.037	1272	**0.045**	2	3	0.000	88	0.052	9	21	**0.101**	523	0.107

Table B2.16. Gulf of Maine winter flounder discard lengths from observer data. MADMF observer length data in the small mesh otter trawl was also added to the table (6 tows, 2 trips, and 213 lengths in 1994; 55 tows, 20 trips, and 891 lengths in 1999; 20 tows, 8 trips, and 637 lengths in 2000).

		large-mesh trawl			small mesh otter trawl			shrimp fishery			gillnet		
YEAR		H1	H2		H1	H2		H1	H2		H1	H2	
1989	tows	13		13		7	7	12	2	14		1	1
	trips	9		9		4	4	6	1	7		1	1
	lengths	116		116		239	239	347	79	426		2	2
1990	tows			0			0	3		3	20	1	21
	trips			0			0	3		3	10	1	11
	lengths			0			0	126		126	313	18	331
1991	tows	1		1			0	32		32	3	2	5
	trips	1		1			0	15		15	3	1	4
	lengths	9		9			0	1144		1144	20	2	22
1992	tows		1	1			0	72		72	39	9	48
	trips		1	1			0	24		24	30	7	37
	lengths		18	18			0	1026		1026	352	32	384
1993	tows		2	2		3	3	132	2	134	35	20	55
	trips		2	2		2	2	53	1	54	20	14	34
	lengths		12	12		43	43	1685	2	1687	400	38	438
1994	tows			0		6	6	106	3	109	18	4	22
	trips			0		2	2	49	3	52	10	3	13
	lengths			0		213	213	1002	5	1007	136	6	142
1995	tows	2	9	11		21	21	85	13	98	23	12	35
	trips	1	2	3		12	12	45	7	52	14	8	22
	lengths	28	18	46		264	264	1118	34	1152	377	38	415
1996	tows		2	2	1	59	60	36	6	42	16	2	18
	trips		1	1	1	21	22	17	3	20	7	2	9
	lengths		5	5	1	250	251	197	105	302	89	2	91
1997	tows	1		1			0	13		13	9		9
	trips	1		1			0	7		7	3		3
	lengths	2		2			0	155		155	67		67
1998	tows			0			0			0	17	2	19
	trips			0			0			0	9	2	11
	lengths			0			0			0	70	5	75
1999	tows			0		71	71			0	10	15	25
	trips			0		30	30			0	5	7	12
	lengths			0		1195	1195			0	163	53	216
2000	tows	5		5	3	21	24			0	11	1	12
	trips	3		3	3	9	12			0	6	1	7
	lengths	90		90	9	640	649			0	219	1	220
2001	tows	1	9	10			0			0	5		5
	trips	1	4	5			0			0	3		3
	lengths	8	184	192			0			0	42		42

Table B2.17. Discard ratios and estimated discards (mt) for large mesh trawl VTR data and gillnet observer data. A 50% mortality rate was applied to the total discard estimate. Discard estimates using the survey method for otter trawl is also shown for comparison. Gillnet ratio from 1986-1988 is the average from 1989-1993.

year	large mesh trawl vtr ratio	vtr trawl discards (mt)	survey trawl discards (mt)	observer Gillnet ratio	gillnet discards (mt)
1982	-	-	343	-	-
1983	-	-	112	-	-
1984	-	-	67	-	-
1985	-	-	93	-	-
1986	-	-	63	*0.136*	11
1987	-	-	81	*0.136*	9
1988	-	-	106	*0.136*	11
1989	-	-	86	0.084	6
1990	-	-	81	0.173	18
1991	-	-	84	0.152	7
1992	-	-	56	0.129	10
1993	-	-	11	0.144	10
1994	0.061	13	65	0.165	9
1995	0.043	11	100	0.257	32
1996	0.040	8	72	0.119	10
1997	0.028	6	62	0.247	20
1998	0.038	9	53	0.100	8
1999	0.038	3	13	0.127	5
2000	0.041	6	19	0.133	7
2001	0.036	8	39	0.065	4

Table B2.18. Gulf of Maine winter flounder estimated discard ratios in the shrimp fishery (total discard kg / total days fished estimated from NEFSC and MA Observer data by shrimp season). Ratio for 1982-1988 is the average ratio from 1989-1992. Total shrimp fishery days fished estimated by Wigley et al 1999 and estimated discards are also shown. A 50% mortality is used for estimating dead discards. Dotted line indicates the introduction of the Nordmore grate.

Year	trips	tows	ratio	Shrimp df	discard wt (mt)	dead discards (mt)
1982			*22.225*	970.1	22	11
1983			*22.225*	1156.9	26	13
1984			*22.225*	1754.0	39	19
1985			*22.225*	2081.4	46	23
1986			*22.225*	2395.1	53	27
1987			*22.225*	3708.2	82	41
1988			*22.225*	2815.2	63	31
1989	12	24	13.361	2839.5	38	19
1990	25	53	24.070	3204.6	77	39
1991	38	94	27.720	2587.7	72	36
1992	72	225	23.749	2313.3	55	27
1993	63	178	10.730	1902.2	20	10
1994	63	183	7.320	1982.3	15	7
1995	58	136	7.382	3375.7	25	12
1996	40	92	6.290	3242.9	20	10
1997	21	55	12.511	3661.2	46	23
1998	3	6	10.559	2204.0	23	12
1999	4	5	5.645	1217.4	7	3
2000	4	10	10.927	792.9	9	4
2001	3	6	9.749	672.8	7	3

Table B2.19. Gulf of Maine winter flounder commercial numbers (000's) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982		550	2,025	1,288	733	482	181	22					
1983	5	366	1,026	1,311	632	282	109	68	21	13	7	2	1
1984		599	1,512	982	384	235	152	76	44	7			1
1985		25	573	1,164	759	263	82	64	26	5	5		
1986		310	629	512	303	199	58	28	12	4	1		
1987		283	821	422	356	141	25	35	2	0			
1988		327	745	725	217	94	49	46	5	1			
1989		37	840	733	602	102	8	7					
1990		102	478	690	446	145	43	11	5	2			
1991		175	735	519	191	104	45	28	1				
1992		188	609	511	174	57	20	7	2				
1993	2	105	605	545	77	46	4						
1994		4	386	557	130	31	7						
1995		8	267	680	456	162	21	14	2				
1996		107	693	347	61	11	1	2	1				
1997		93	512	455	105	27	4	2					
1998		25	217	458	321	105	34	4	1				
1999			49	158	143	59	19	5	4				
2000		1	57	212	173	50	14	7		1			
2001		2	27	287	390	175	63	26	6	3			

Table B2.20. Gulf of Maine winter flounder commercial weight (kg) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982		0.351	0.454	0.502	0.617	0.817	0.901	1.087	1.330				
1983	0.293	0.281	0.403	0.528	0.667	0.814	0.970	1.062	1.238	1.415	1.467	1.224	1.422
1984		0.294	0.301	0.392	0.550	0.763	0.971	1.124	1.124	1.275			1.578
1985		0.307	0.366	0.449	0.572	0.802	1.020	1.121	1.183	1.071	1.462		
1986		0.412	0.470	0.534	0.699	0.842	0.940	1.231	1.387	0.479	2.996		
1987		0.380	0.437	0.586	0.650	0.843	1.107	1.272	1.684				
1988		0.510	0.524	0.530	0.669	0.620	0.976	1.082	1.132	2.338	1.619		
1989		0.286	0.434	0.542	0.592	1.034	1.155	1.264					
1990		0.435	0.482	0.541	0.646	0.780	1.039	1.261	1.214	1.310			
1991		0.393	0.487	0.626	0.624	0.725	0.741	0.896	1.810				
1992		0.364	0.447	0.569	0.653	0.787	1.075	1.461	1.745				
1993	0.125	0.336	0.396	0.457	0.701	0.607	1.331						
1994		0.274	0.402	0.489	0.669	0.829	1.324	1.558					
1995		0.305	0.369	0.437	0.552	0.653	1.030	1.181	1.447	2.572			
1996		0.387	0.451	0.546	0.634	0.915	1.452	1.694	2.177	2.663			
1997		0.412	0.451	0.540	0.701	0.847	0.998	1.479					
1998		0.371	0.426	0.482	0.598	0.750	0.991	1.709	2.149	2.459			
1999			0.431	0.503	0.564	0.735	0.962	1.102	1.236	2.941			
2000		0.449	0.400	0.480	0.560	0.711	0.930	1.178	1.467	1.555			
2001		0.175	0.373	0.468	0.546	0.693	0.869	0.953	1.215	1.562			

Table B2.21. Gulf of Maine winter flounder recreational numbers (000's) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	40	1,546	2,526	2,180	669	135	95	22	38	6	5	7	3
1983	89	381	654	488	224	80	49	12	4		6		
1984	12	166	423	847	468	112	159	50	37		10		
1985		112	762	875	1,163	136	136	37					
1986		18	102	301	56	154	44	18					
1987		28	805	739	436	170	113	37	52	9			
1988	2	10	103	320	142	153	75	30	3			3	
1989		124	469	729	172	110	43	21	7	2			
1990		111	228	236	37	25	5	5	3	2	1		
1991		9	31	47	34	12	9	7	3	1			
1992		10	29	50	26	9	5	1	3	3			
1993		21	54	79	66	20	5		3				
1994		4	32	55	30	13	7	5					
1995		2	22	27	19	8	3	2					
1996			17	40	17	11	7	5		1			
1997			8	20	18	5	5	5	3	1			
1998		2	19	32	8	4							
1999			8	23	17	11	4	5	1				
2000			10	23	26	11	4		1	1			
2001			8	22	16	14	12						

Table B2.22. Gulf of Maine winter flounder recreational mean weights (kg) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	0.109	0.197	0.339	0.479	0.571	0.746	1.025	1.522	1.929	2.801	3.431	3.963	5.187
1983	0.131	0.258	0.331	0.444	0.578	0.730	0.893	0.959	1.395		1.365		
1984	0.098	0.256	0.349	0.419	0.539	0.594	0.745	1.073	0.932		1.784		
1985		0.196	0.293	0.456	0.592	0.823	0.872	1.047					
1986		0.201	0.312	0.497	0.563	0.776	1.090	1.187					
1987		0.138	0.417	0.510	0.724	0.871	1.062	1.195	1.252	1.784			
1988	0.098	0.254	0.372	0.464	0.620	0.838	1.053	1.359	1.600	0.000		0.976	
1989		0.277	0.432	0.630	0.762	0.981	1.179	1.298	1.781	1.547	0.000		
1990		0.268	0.425	0.644	0.642	0.770	0.678	1.317	1.078	1.257	1.199		
1991		0.360	0.375	0.460	0.569	0.708	0.916	0.993	1.307	0.616			
1992		0.224	0.358	0.466	0.636	0.886	1.013	1.199	1.576	1.365			
1993		0.282	0.381	0.482	0.626	0.848	0.997		1.453				
1994		0.275	0.386	0.477	0.558	0.701	0.908	1.009					
1995		0.284	0.393	0.446	0.552	0.621	0.644	0.872					
1996		0.317	0.398	0.434	0.516	0.616	0.766	0.958	0.000	1.744			
1997		0.271	0.428	0.426	0.471	0.545	0.619	0.690	0.765	0.869			
1998		0.293	0.325	0.419	0.572	0.753							
1999			0.383	0.446	0.520	0.595	0.666	0.922	0.669				
2000			0.449	0.496	0.529	0.567	0.668	0.616	0.983	1.047			
2001			0.347	0.405	0.521	0.640	0.689						

Table B2.23. Gulf of Maine winter flounder recreational discards (000's) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	25	105	9										
1983	17	7	3										
1984	5	14	10										
1985	12	30	28	1									
1986	20	13	4	1									
1987	29	39	32	2									
1988	3	6	7	1									
1989	13	23	7	1									
1990	3	14	4										
1991	2	4	3	1									
1992	3	2	1										
1993	5	12	4	1									
1994	2	7	3	1									
1995	2	4	3	1									
1996	3	5	3	1									
1997	2	9	6	2									
1998	2	3	2										
1999	2	3	2	1									
2000	4	6	4	2									
2001	3	4	5	3	1								

Table B2.24. Gulf of Maine winter flounder recreational discards (kg) at age.

Year	1	2	3	3	4	5	6	7	8	9	11	12	13
1982	0.041	0.084	0.116										
1983	0.071	0.087	0.128										
1984	0.072	0.072	0.117										
1985	0.041	0.083	0.171	0.210									
1986	0.078	0.161	0.209	0.258	0.295								
1987	0.043	0.088	0.216	0.307									
1988	0.059	0.120	0.177	0.279									
1989	0.055	0.158	0.228	0.285	0.325								
1990	0.043	0.123	0.199	0.259	0.325								
1991	0.055	0.108	0.210	0.288	0.325								
1992	0.048	0.132	0.236	0.277	0.307								
1993	0.048	0.108	0.184	0.286	0.293								
1994	0.059	0.111	0.201	0.251	0.299								
1995	0.055	0.127	0.207	0.239	0.325								
1996	0.046	0.117	0.217	0.268	0.271								
1997	0.042	0.092	0.170	0.247	0.287								
1998	0.037	0.114	0.190	0.269	0.325								
1999	0.051	0.103	0.207	0.245	0.314								
2000	0.074	0.158	0.211	0.272	0.297								
2001	0.042	0.098	0.208	0.261	0.285								

Table B2.25. Gulf of Maine winter flounder commercial large mesh trawl discards (000's) at age using vtr ratios.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	40	642	697	18									
1983	18	124	249	36									
1984	3	87	97	59	3								
1985	4	59	196	77	3								
1986	1	77	143	23	9								
1987	1	20	236	49	1								
1988	3	61	233	107	3	1							
1989	2	118	105	71	19	6							
1990	1	86	162	49	17								
1991	5	70	147	89	5								
1992	2	56	105	45	8								
1993	1	14	20	9	2								
1994	1	10	22	13	4								
1995	1	5	21	14	1								
1996	2	7	12	8	1								
1997		5	9	6	2								
1998		7	14	9	3								
1999		2	5	3	1								
2000	0	3	7	5	3	1							
2001		2	8	10	4	2							

Table B2.26. Gulf of Maine winter flounder commercial large mesh trawl discards weight (kg) at age using vtr ratios.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	0.095	0.212	0.282	0.368	0.560	0.640	0.943	1.259	1.625	2.284			
1983	0.122	0.247	0.264	0.370	0.514	0.458	0.648	1.252			1.422		
1984	0.091	0.223	0.278	0.322	0.350	0.595	0.699	0.954	1.014				
1985	0.114	0.221	0.273	0.318	0.414	0.595	0.761	1.093	1.713				
1986	0.038	0.182	0.275	0.317	0.301	0.508	0.815	1.014	1.422				
1987	0.045	0.125	0.260	0.324	0.424	0.699	1.038	1.362	1.612				
1988	0.068	0.210	0.249	0.314	0.388	0.410	0.768	1.029	1.432	1.619			
1989	0.056	0.229	0.280	0.289	0.351	0.336	0.594	1.249	0.000				
1990	0.040	0.216	0.254	0.300	0.353	0.468	0.949	1.178	0.949	1.248			
1991	0.101	0.220	0.264	0.305	0.379	0.411	0.589	0.876	1.349	1.746			
1992	0.067	0.202	0.264	0.315	0.332	0.419	0.824	1.258	1.617				
1993	0.069	0.202	0.243	0.306	0.348	0.494	0.751	1.377	1.533				
1994	0.060	0.160	0.255	0.320	0.345	0.518	0.956						
1995	0.045	0.152	0.249	0.319	0.390	0.499	0.249	1.351	1.515				
1996	0.077	0.214	0.286	0.333	0.359	0.507	0.642	1.176					
1997	0.046	0.174	0.277	0.312	0.346	0.514	0.538	0.751					
1998	0.030	0.146	0.261	0.328	0.363	0.542	0.890	1.106					
1999	0.061	0.157	0.280	0.339	0.395	0.481	1.033	1.195	1.457				
2000	0.094	0.205	0.270	0.309	0.367	0.382	0.468		0.878	1.105			
2001	0.038	0.159	0.292	0.329	0.354	0.368	0.527	0.592	0.813	1.333			

Table B2.27. Gulf of Maine winter flounder gillnet discards (000's) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1986		3	26	9	3								
1987			27	6									
1988			27	13									
1989			14	7									
1990		1	39	28	2								
1991		2	17	7	1								
1992		3	28	6									
1993		1	25	10	1								
1994		1	22	11	2								
1995		6	37	23	12	5	3	1					
1996		2	21	10	2								
1997		1	26	30	13								
1998		3	14	8	2		1						
1999			2	2	1	2	1	1					
2000		1	8	7	4	1							
2001			4	5	2	1							

Table B2.28. Gulf of Maine winter flounder gillnet discard weight (kg) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1986		0.182	0.276	0.294	0.274	0.593							
1987		0.154	0.265	0.306	0.503	0.693							
1988		0.106	0.261	0.292	0.476	0.543							
1989		0.122	0.259	0.295	0.363	0.346	0.693						
1990		0.143	0.249	0.278	0.338								
1991		0.200	0.269	0.298	0.341								
1992		0.196	0.283	0.311	0.360	0.409							
1993		0.174	0.264	0.287	0.307	0.631							
1994		0.172	0.246	0.295	0.313	0.538							
1995	0.112	0.246	0.285	0.358	0.546	0.636	0.600	0.824					
1996		0.207	0.268	0.286	0.309	0.793	0.812						
1997		0.222	0.265	0.299	0.333								
1998		0.172	0.232	0.305	0.475	0.568	0.761	0.693					
1999		0.184	0.277	0.372	0.540	0.684	0.793	0.786	1.132	1.484			
2000		0.185	0.260	0.296	0.363	0.403	0.607	0.837	0.789				
2001			0.267	0.315	0.323	0.401	0.812		0.812	0.812			

Table B2.29. Gulf of Maine winter flounder commercial shrimp fishery discards (000's) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	13	65	16	1									
1983	17	62	37	4									
1984	15	83	55	19	1								
1985	39	94	57	7									
1986	62	137	32	8	2								
1987	48	182	110	7									
1988	44	103	101	13									
1989	42	136	45	4									
1990	35	53	86	33	7								
1991	36	145	62	12	1								
1992	46	177	30	3									
1993	38	67	17	4	1								
1994	30	73	11	1									
1995	41	70	19	4									
1996	52	52	13	5	1								
1997	34	171	44	7									
1998	41	61	16	3	1								
1999	16	18	4	1									
2000	19	22	11	2	1								
2001	17	16	5	2									

Table B2.30. Gulf of Maine winter flounder shrimp fishery weight (kg) at age.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	0.025	0.093	0.212	0.341	0.429								
1983	0.023	0.074	0.183	0.322	0.505	0.400		0.522					
1984	0.016	0.067	0.151	0.273	0.357	0.502	0.453						
1985	0.034	0.094	0.188	0.293	0.470	0.000							
1986	0.035	0.107	0.234	0.308	0.316	0.469							
1987	0.028	0.081	0.197	0.343	0.470	0.519							
1988	0.028	0.078	0.170	0.291	0.400	0.353							
1989	0.029	0.079	0.191	0.277	0.393								
1990	0.039	0.093	0.201	0.316	0.397	0.442							
1991	0.040	0.106	0.208	0.297	0.336	0.460							
1992	0.028	0.097	0.217	0.296	0.361	0.076							
1993	0.025	0.064	0.187	0.295	0.427	0.621	0.953						
1994	0.026	0.066	0.145	0.286	0.413	0.603	0.767						
1995	0.042	0.091	0.186	0.224	0.579	0.426	0.221	0.795					
1996	0.029	0.084	0.214	0.299	0.277	0.377							
1997	0.043	0.076	0.155	0.245	0.329	0.117	0.170						
1998	0.037	0.088	0.162	0.299	0.440	0.568	0.687	0.974					
1999	0.033	0.078	0.196	0.219	0.400	0.569	0.866	0.810	0.933				
2000	0.031	0.065	0.122	0.258	0.355	0.424	0.633	0.937	0.943				
2001	0.032	0.068	0.163	0.240	0.300	0.431	0.683	0.931	0.751	0.920			

Table B2.31. Gulf of Maine winter flounder composition of the catch by number.

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1982	7,274	5,282	140	0	1,397	96	14,188
1983	1,988	3,842	27	0	428	120	6,406
1984	2,285	3,992	29	0	249	174	6,729
1985	3,220	2,965	71	0	340	197	6,793
1986	691	2,055	38	41	253	240	3,318
1987	2,391	2,086	102	34	308	346	5,266
1988	841	2,210	17	40	406	262	3,775
1989	1,678	2,329	44	21	321	227	4,620
1990	652	1,922	20	70	315	214	3,193
1991	154	1,799	9	26	315	257	2,559
1992	137	1,567	7	36	216	256	2,220
1993	249	1,384	22	36	45	127	1,863
1994	145	1,116	13	36	49	116	1,475
1995	82	1,609	10	85	42	134	1,963
1996	98	1,224	13	35	31	123	1,524
1997	64	1,198	19	70	23	257	1,630
1998	65	1,166	7	29	33	123	1,423
1999	67	437	7	9	11	39	571
2000	75	516	15	22	20	54	701
2001	72	980	15	13	26	41	1,146

Table B2.32. Gulf of Maine winter flounder composition of the catch by weight (mt).

	Landings		Discards				
year	recreational	commercial	recreational	gillnet	lg mesh	shrimp	Total
1982	1,876	2,793	11		343	11	5,034
1983	868	2,096	2		112	13	3,091
1984	1,300	1,699	2		67	19	3,089
1985	1,896	1,582	8		93	23	3,602
1986	523	1,188	5	11	63	27	1,817
1987	1,809	1,140	12	9	81	41	3,091
1988	345	1,250	2	11	106	31	1,745
1989	620	1,253	6	6	86	19	1,989
1990	370	1,116	3	18	81	39	1,626
1991	91	1,008	1	7	84	36	1,227
1992	90	825	1	10	56	27	1,009
1993	140	611	3	10	11	10	785
1994	83	552	2	9	13	7	666
1995	39	796	1	32	11	12	892
1996	56	600	2	10	8	10	686
1997	43	618	2	20	6	23	712
1998	30	637	1	8	9	12	697
1999	34	253	1	5	3	3	300
2000	42	382	2	7	6	4	443
2001	43	571	2	4	8	3	632

Table B2.33. Gulf of Maine winter flounder total catch at age (000's).

Year	1	2	3	4	5	6	7	8+
1982	118	2,909	5,274	3,487	1,402	617	276	104
1983	146	941	1,970	1,839	857	362	158	133
1984	36	949	2,097	1,907	856	348	312	225
1985	54	320	1,617	2,124	1,925	398	218	136
1986	83	557	936	852	373	353	102	62
1987	78	553	2,031	1,224	794	311	138	136
1988	52	507	1,215	1,179	361	248	123	89
1989	56	439	1,480	1,545	793	218	51	38
1990	39	366	997	1,037	509	170	48	29
1991	43	405	995	674	232	116	55	40
1992	52	436	802	615	208	67	24	16
1993	46	220	725	647	147	66	9	3
1994	33	98	477	638	166	44	14	5
1995	43	95	367	749	488	174	27	18
1996	57	174	758	413	83	23	8	9
1997	37	279	605	519	139	32	9	11
1998	44	100	283	511	335	109	36	5
1999	18	23	70	188	162	71	24	16
2000	23	33	97	251	206	62	18	11
2001	20	24	58	329	412	192	76	35

Table B2.34. Gulf of Maine winter flounder mean weight at age (kg).

Year	1	2	3	4	5	6	7	8+
1982	0.081	0.223	0.375	0.487	0.595	0.802	0.943	2.037
1983	0.115	0.252	0.357	0.502	0.644	0.795	0.946	1.164
1984	0.059	0.257	0.305	0.400	0.543	0.708	0.855	1.115
1985	0.041	0.169	0.311	0.447	0.584	0.809	0.927	1.122
1986	0.045	0.291	0.408	0.510	0.664	0.813	1.005	1.221
1987	0.034	0.240	0.390	0.527	0.690	0.858	1.070	1.284
1988	0.034	0.376	0.421	0.487	0.648	0.753	1.022	1.204
1989	0.036	0.197	0.412	0.570	0.623	0.989	1.175	1.397
1990	0.040	0.271	0.398	0.538	0.631	0.778	1.003	1.247
1991	0.048	0.256	0.429	0.563	0.609	0.722	0.771	0.965
1992	0.031	0.229	0.405	0.539	0.638	0.799	1.064	1.468
1993	0.031	0.226	0.380	0.454	0.658	0.680	1.148	1.453
1994	0.029	0.096	0.379	0.481	0.637	0.790	1.128	1.052
1995	0.043	0.127	0.345	0.431	0.552	0.651	0.929	1.186
1996	0.029	0.279	0.437	0.520	0.593	0.768	0.851	1.381
1997	0.043	0.191	0.415	0.514	0.630	0.802	0.798	0.859
1998	0.036	0.170	0.384	0.471	0.594	0.749	0.984	1.814
1999	0.035	0.088	0.391	0.490	0.559	0.713	0.907	1.062
2000	0.039	0.108	0.345	0.470	0.549	0.676	0.869	1.187
2001	0.033	0.090	0.317	0.454	0.542	0.685	0.840	1.055

Table B2.35. Gulf of Maine winter flounder catch at age construction summary.

Catch at age component	years	halfyear	length data	age data
Trawl and other commercial landings	82-01	mix	commercial and observer (unclassified)	commercial
gillnet commercial Landings	90-01	whole year	observer (kept)	commercial
recreational Landings	82-01	halfyear	MRFSS	combine NEFSC and MA DMF ages by halfyear
recreational Discards	82-01	halfyear	spr & fall MA DMF	combine NEFSC and MA DMF ages by halfyear
Large mesh trawl discards (survey)	82-93	whole year	survey method (spr & fall MA DMF)	combine NEFSC spr & fall survey
Large mesh trawl discards (vtr/survey)	94-01	whole year	survey method (spr & fall MA DMF)	combine NEFSC spr & fall survey
gillnet discards	86-01	whole year	observer (discards)	combine spr NEFSC and MA DMF ages
shrimp discards	82-01	shrimp season	observer (discards)	combine spr NEFSC and MA DMF ages

Table B2.36. NEFSC and MADMF stratified mean survey indices of abundance for Gulf of Maine winter flounder. NEFSC indices use offshore strata (26,27,38-40) and inshore strata (58-61,65,66). NEFSC indices are calculated with trawl door conversion factors where appropriate. MADMF uses strata 25-36.

	NEFSC spring		NEFSC fall		MADMF spring		MADMF fall	
year	number	weight	number	weight	number	weight	number	weight
1978					86.805	18.373	43.360	9.887
1979	9.063	3.218	6.003	2.602	64.952	14.407	119.506	28.978
1980	11.284	4.447	13.141	6.553	66.231	17.494	74.684	15.940
1981	13.051	3.946	4.179	3.029	100.569	28.370	47.342	13.228
1982	7.670	3.022	4.201	1.924	60.719	14.687	106.053	23.635
1983	12.367	5.653	10.304	3.519	108.508	27.233	88.143	15.772
1984	5.155	1.979	7.732	3.106	66.271	15.977	35.956	10.817
1985	3.469	1.418	7.638	2.324	48.651	13.594	44.564	7.381
1986	2.343	0.998	2.502	0.938	62.356	14.724	41.914	6.603
1987	5.609	1.503	1.605	0.488	83.171	17.648	50.426	7.227
1988	6.897	1.649	3.000	1.031	52.733	10.617	33.063	7.173
1989	3.717	1.316	6.402	2.013	63.595	13.317	33.983	7.462
1990	5.415	2.252	3.527	1.177	74.131	12.966	67.874	13.452
1991	4.517	1.436	7.035	1.467	49.265	11.587	88.777	15.473
1992	3.933	1.160	10.447	3.096	74.146	13.938	77.350	13.471
1993	1.556	0.353	7.559	1.859	80.133	12.390	92.476	14.996
1994	3.481	0.891	4.870	1.319	71.710	10.036	67.351	13.560
1995	12.185	3.149	4.765	1.446	87.848	14.560	84.768	17.250
1996	2.736	0.732	10.099	3.116	77.249	12.823	74.295	13.031
1997	2.806	0.664	10.008	2.950	95.918	14.796	74.347	14.316
1998	2.001	0.528	3.218	0.987	91.466	15.756	93.889	14.934
1999	6.510	1.982	10.921	3.269	77.941	14.198	117.648	22.672
2000	10.383	2.885	12.705	5.065	169.291	35.453	101.633	25.693
2001	5.242	1.666	8.786	3.131	90.153	23.891	80.978	18.367
2002	12.066	3.693	10.691	4.003	87.376	21.404		

Table B2.37. NEFSC spring stratified mean number per tow at age for Gulf of Maine winter flounder (offshore strata 26,27,38-40 and inshore 58-61,65,66).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total
1980		0.10	3.28	4.73	1.79	0.96	0.31	0.06	0.05							11.28
1981		1.05	5.36	2.05	3.14	0.92	0.39	0.09	0.04							13.05
1982		0.16	1.92	3.40	0.85	1.00	0.11	0.06	0.10		0.03					7.67
1983		0.42	0.88	3.65	3.06	1.88	1.00	1.21	0.23	0.02		0.02				12.37
1984		0.23	1.13	1.37	1.17	0.61	0.08	0.35	0.03	0.16		0.02				5.15
1985		0.01	0.53	1.41	0.65	0.57	0.10	0.14	0.04		0.01					3.47
1986		0.03	0.75	0.42	0.58	0.14	0.31	0.10	0.02							2.34
1987		0.19	1.58	2.65	0.61	0.23	0.14	0.12	0.05	0.03						5.61
1988		0.65	1.36	3.04	1.42	0.26	0.11	0.03	0.03							6.90
1989		0.06	0.49	1.39	1.13	0.31	0.13	0.10	0.11							3.72
1990		0.04	0.61	1.63	1.54	0.78	0.34	0.04	0.17	0.14	0.14					5.42
1991		0.09	1.26	1.52	1.01	0.47	0.10	0.04	0.01	0.01	0.01					4.52
1992		0.31	1.16	1.01	0.96	0.34	0.10	0.03	0.01	0.01						3.93
1993		0.01	0.53	0.59	0.28	0.11	0.02	0.01								1.56
1994		0.02	1.00	1.28	0.78	0.29	0.08	0.01	0.01							3.48
1995		0.59	2.89	5.45	2.20	0.68	0.20	0.14	0.02							12.19
1996		0.05	0.59	1.05	0.74	0.23	0.06	0.01								2.74
1997		0.04	0.69	0.81	0.71	0.41	0.09	0.04	0.01							2.81
1998		0.10	0.59	0.60	0.48	0.21	0.01			0.01						2.00
1999		0.31	1.17	2.28	1.68	0.71	0.36									6.51
2000		0.16	1.50	3.76	2.41	1.56	0.75	0.17		0.04	0.02					10.38
2001		0.07	0.52	1.41	1.49	0.83	0.60	0.22	0.09	0.02						5.24
2002		0.20	1.59	2.98	3.57	2.29	0.92	0.34	0.11	0.07						12.07

Table B2.38. NEFSC fall stratified mean number per tow at age for Gulf of Maine winter flounder (offshore strata 26,27,38-40 and inshore 58-61,65,66).

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total
1980		0.57	4.36	5.34	1.85	0.74	0.18			0.05		0.05				13.14
1981		0.07	0.71	1.76	0.78	0.12	0.37	0.08	0.12	0.08			0.41		0.04	4.18
1982		0.30	1.21	1.68	0.40	0.32	0.08	0.21								4.20
1983		2.14	3.60	3.12	1.01	0.27	0.11	0.07								10.30
1984		0.45	2.34	1.67	2.17	0.59	0.22	0.17	0.11							7.73
1985		1.30	2.74	1.92	1.15	0.33	0.10	0.10								7.64
1986		0.02	0.73	1.15	0.49	0.05	0.02	0.01	0.02							2.50
1987		0.08	0.46	0.84	0.19	0.03				0.01						1.61
1988		0.49	0.96	0.60	0.71	0.15	0.06	0.03								3.00
1989		0.46	3.60	1.42	0.77	0.08	0.07			0.01						6.40
1990		0.10	1.86	1.09	0.41	0.04	0.02	0.02								3.53
1991	0.03	2.60	2.83	1.09	0.39	0.03	0.05	0.03								7.04
1992		1.92	3.70	2.40	1.63	0.75	0.01	0.03								10.45
1993		1.66	3.16	1.82	0.69	0.23	0.01									7.56
1994		0.43	2.32	1.29	0.65	0.12	0.03	0.03								4.87
1995		0.47	1.83	1.51	0.63	0.19	0.14									4.77
1996	0.01	1.77	2.37	2.57	2.63	0.60	0.13	0.01								10.10
1997		0.41	4.32	3.19	1.47	0.57	0.03									10.01
1998		0.19	0.92	1.13	0.78	0.14	0.06									3.22
1999		0.81	2.77	3.65	2.85	0.68	0.15	0.01								10.92
2000		0.62	2.03	4.00	3.54	1.41	0.96	0.15								12.70
2001		0.36	1.66	2.59	2.80	0.96	0.36	0.04	0.01							8.79

Table B2.39. MADMF spring stratified mean number per tow at age for Gulf of Maine winter flounder (strata 25-36).

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total
1982		7.51	30.59	8.96	8.80	2.57	0.90	1.33	0.02	0.04						60.72
1983	0.07	14.01	32.31	30.65	18.11	8.82	2.36	1.02	0.84	0.28					0.02	108.51
1984		5.80	26.27	16.96	11.65	3.94	0.38	0.83	0.08	0.31		0.04				66.27
1985		9.47	7.29	15.34	11.28	3.57	1.39	0.25	0.03	0.03						48.65
1986		9.35	19.78	20.97	10.29	1.22	0.46	0.06	0.04	0.19						62.36
1987		16.93	18.71	32.69	11.54	0.72	1.74	0.33	0.02	0.49						83.17
1988	0.08	7.47	15.76	18.87	9.37	0.61	0.38	0.00	0.04	0.10				0.05		52.73
1989		9.15	23.03	17.39	9.10	3.72	0.71	0.13	0.23	0.15						63.59
1990		14.31	18.33	27.47	10.04	2.04	1.35	0.39	0.08	0.08	0.02	0.04				74.13
1991		4.82	19.21	13.00	7.84	3.17	0.50	0.24	0.17	0.11	0.15	0.04				49.27
1992		19.96	32.12	12.31	6.70	1.97	0.69	0.16	0.07	0.08	0.07					74.15
1993		17.86	37.10	15.09	6.46	2.03	1.09	0.34	0.02	0.11	0.04					80.13
1994		14.33	36.11	15.44	4.66	0.79	0.12	0.17	0.08		0.02					71.71
1995	0.06	20.76	36.25	22.59	6.02	1.33	0.54	0.15	0.11	0.02	0.02					87.85
1996		14.96	34.59	17.79	7.04	1.88	0.73	0.19	0.08							77.25
1997		15.04	39.94	22.78	10.72	5.34	1.08	0.58	0.26	0.09	0.06	0.03				95.92
1998		10.23	32.61	29.11	13.26	4.12	1.15	0.81	0.17							91.47
1999		14.31	25.96	21.79	9.02	4.66	1.14	0.57	0.44	0.05						77.94
2000		28.67	69.85	33.39	18.16	11.00	5.83	1.79	0.37	0.22						169.29
2001		14.37	11.22	29.56	19.47	7.23	4.79	2.34	0.68	0.33	0.16					90.15
2002		9.59	23.85	19.60	19.52	7.59	4.97	1.64	0.25	0.27	0.09					87.38

Table B2.40. MADMF fall stratified mean number per tow at age for Gulf of Maine winter flounder (strata 25-36).

year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	total
1980	0.13	27.26	31.13	14.18	1.54	0.38	0.01	0.04								74.68
1981	0.13	13.05	21.14	11.46	1.31	0.02	0.19	0.04								47.34
1982	0.44	42.30	39.70	19.00	3.62	0.63	0.30	0.04	0.02							106.05
1983	0.00	49.19	23.26	11.70	2.80	1.11	0.07	0.01								88.14
1984	0.06	8.29	11.63	6.41	6.89	1.80	0.59	0.25	0.02							35.96
1985	0.28	22.32	12.36	6.14	2.66	0.54	0.21	0.05								44.56
1986	0.23	16.68	14.78	8.44	1.46	0.24	0.00	0.04	0.04							41.91
1987	0.50	17.29	19.40	11.68	1.34	0.10	0.11	0.02								50.43
1988	0.16	11.96	12.69	3.87	3.09	0.80	0.34	0.11	0.04							33.06
1989		12.17	14.59	5.29	1.41	0.31	0.19	0.03								33.98
1990		8.35	45.03	11.72	2.54	0.18	0.03	0.03								67.87
1991	2.41	40.54	23.35	16.65	4.92	0.58	0.22	0.12								88.78
1992	0.65	38.61	18.43	10.65	5.87	2.58	0.11	0.44								77.35
1993	0.32	34.29	38.90	13.55	3.82	1.37	0.17	0.06								92.48
1994	0.12	17.93	28.24	14.66	5.00	1.08	0.14	0.14	0.05							67.35
1995	0.29	29.32	30.17	17.27	6.04	0.91	0.49	0.22	0.05							84.77
1996	1.01	33.45	16.23	13.19	8.53	1.51	0.37									74.30
1997	0.47	20.04	29.06	17.89	5.25	1.54	0.10									74.35
1998	0.34	38.17	28.88	16.86	7.30	1.71	0.63									93.89
1999	1.17	30.34	42.82	23.00	15.01	4.10	1.15	0.06								117.65
2000	0.30	25.54	30.64	23.79	13.65	4.34	2.43	0.94								101.63
2001	0.20	27.85	17.67	14.22	14.96	4.13	1.71	0.22	0.01							80.98

Table B2.41. Seabrook spring mean number per tow at age for Gulf of Maine winter flounder.

year	1	2	3	4	5	6	7	8	9	10	11	total
1985	1.16	0.49	0.40	0.21	0.08	0.04	0.02					2.39
1986	1.65	1.06	0.52	0.23	0.06	0.01						3.53
1987	1.60	1.47	1.08	0.15	0.01	0.08	0.03		0.01			4.43
1988	0.88	1.18	1.52	0.31	0.02	0.02						3.92
1989	3.73	1.30	1.35	0.37	0.06	0.03	0.01					6.85
1990	1.63	1.06	0.93	0.40	0.08	0.02					0.01	4.14
1991	2.66	1.19	1.19	0.37	0.12	0.02						5.55
1992	0.58	1.00	0.34	0.16	0.02							2.11
1993												
1994	0.81	1.16	0.32	0.05								2.33
1995	0.97	0.97	0.38	0.09	0.02	0.01						2.44
1996	1.38	1.35	0.63	0.11	0.03	0.01						3.51
1997	0.94	1.29	0.59	0.21	0.08	0.02	0.01	0.01				3.15
1998	1.39	2.62	1.67	0.56	0.17	0.04	0.01	0.01	0.02			6.50
1999	3.13	3.94	2.49	0.39	0.12	0.02	0.01	0.03				10.14
2000	3.32	6.72	1.53	0.38	0.23	0.10	0.03	0.01	0.01			12.31
2001	2.74	0.97	1.76	0.32	0.06	0.03	0.02					5.91

Table B2.42. Age and length at 50% maturity for Gulf of Maine winter flounder in the spring NEFSC, MADMF, and combined surveys with the sexes combined.

	NEFSC			MADMF			Both		
time period	total N	L50	A50	total N	L50	A50	total N	L50	A50
81-85	456	23.7	2.5	479	29.1	3.5	935	26.6	2.9
86-90	510	21.3	2.3	763	28.5	3.4	1,273	25.4	3.0
91-95	700	24.2	2.8	1,312	28.4	3.2	2,012	26.8	3.0
96-01	823	22.8	2.6	1,212	27.7	3.3	2,035	25.3	3.0
81-01	2,489	23.1	2.6	3,766	28.3	3.3	6,255	26.0	3.0

Table B2.43. Age at 50% maturity by sex and sexes combined for Gulf of Maine winter flounder in the Spring NEFSC, MADMF, and combined surveys.

		NEFSC		MADMF		Both	
time period	sex	total N	A50	total N	A50	total N	A50
81-01	male	948	2.5	1,406	3.3	2,354	2.9
	female	1,601	2.6	2,533	3.4	4,134	3.1
	Combined	2,489	2.6	3,766	3.3	6,255	3.0

Table B2.44. Comparison of length and age at 50% maturity for Gulf of Maine winter flounder in the spring NEFSC and MADMF surveys with the sexes combined. NEFSC data was limited to inshore Gulf of Maine Massachusetts strata (58-66) which overlap with the MADMF survey (25-36).

	NEFSC			MADMF		
time period	total N	L50	A50	total N	L50	A50
81-85	209	24.0	2.4	479	29.1	3.5
86-90	248	21.0	2.1	763	28.5	3.4
91-95	493	25.0	2.8	1,312	28.4	3.2
96-01	577	23.0	2.5	1,212	27.7	3.3
81-01	1,527	23.5	2.5	3,766	28.3	3.3

Table B2.45. Virtual Population Analysis for Gulf of Maine winter flounder, 1982-2001.

```
Fisheries Assessment Toolbox  gom wf total catch  Run Number  1   12/3/2002   12:55:40 PM
FACT Version 1.5.0
gom wf total catch  1982 - 2002
Input Parameters and Options Selected
---------------------------------------
Natural mortality is a matrix below
Oldest age (not in the plus group) is  7
For all years prior to the terminal year ( 20 ), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  7 : 5 6 7
This method for estimating F on the oldest age is generally used when a
flat-topped partial recruitment curve is thought to be characteristic of the stock.
F for age  8 + is then calculated from the following
ratios of F[age 8 +] to F[age 7 ]
          1982              1
          1983              1
          1984              1
          1985              1
          1986              1
          1987              1
          1988              1
          1989              1
          1990              1
          1991              1
          1992              1
          1993              1
          1994              1
          1995              1
          1996              1
          1997              1
          1998              1
          1999              1
          2000              1
          2001              1
Stock size of the  8 + group is then calculated using
the following method:  CATCH EQUATION
 Partial recruitment estimate for  2002
 1             0.02
 2             0.04
 3             0.15
 4             0.57
 5             1
 6             1
 7             1
 The Indices that will be used in this run are:
 1            NEC_S11
 2            NEC_S22
 3            NEC_S33
 4            NEC_S44
 5            NEC_S55
 6            NEC_S66
 7            NEC_S77
 8            NEC_S88
 9            NEC_F23
 10           NEC_F34
 11           NEC_F45
 12           NEC_F56
 13           NEC_F67
 14           MA_S11
 15           MA_S22
 16           MA_S33
 17           MA_S44
 18           MA_S55
 19           MA_S66
 20           MA_S77
 21           MA_S88
 22           MA_F01
 23           MA_F12
 24           MA_F23
 25           MA_F34
 26           MA_F45
 27           SEA_S11
 28           SEA_S22
 29           SEA_S33
 30           SEA_S44
 31           SEA_S55
 32           SEA_S66
 33           SEA_S77
```

Table B2.45. Continued.

STOCK NUMBERS (Jan 1) in thousands

	1982	1983	1984	1985	1986	1987	1988
1	11761	8778	6269	9277	7686	6125	4482
2	14415	9522	7055	5100	7547	6218	4944
3	11100	9170	6945	4917	3886	5675	4590
4	6207	4316	5725	3788	2563	2334	2808
5	3058	1927	1869	2962	1180	1327	804
6	1177	1235	802	756	683	628	368
7	571	405	683	342	259	240	233
8	212	337	486	209	156	232	166
1+	48500	35690	29834	27351	23959	22779	18395

	1989	1990	1991	1992	1993	1994	1995
1	4043	4242	4542	3322	3240	4519	7503
2	3622	3259	3438	3680	2673	2611	3670
3	3589	2569	2337	2448	2618	1989	2049
4	2659	1599	1201	1013	1279	1488	1197
5	1232	779	371	373	273	461	641
6	331	291	177	94	117	91	228
7	77	74	85	40	16	36	34
8	56	44	60	26	05	13	22
1+	15610	12857	12211	10996	10221	11208	15343

	1996	1997	1998	1999	2000	2001	2002
1	7588	7249	8967	10080	7474	7391	6274
2	6104	6161	5902	7301	8237	6099	6033
3	2919	4840	4792	4742	5957	6714	4971
4	1345	1704	3415	3667	3819	4789	5444
5	302	728	925	2334	2832	2899	3624
6	83	172	470	454	1764	2132	2001
7	29	47	112	286	308	1388	1572
8	32	57	15	190	188	638	1558
1+	18402	20958	24598	29055	30578	32050	31477

Table B2.45. Continued.

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.02	0.01	0.01	0.01	0.01	0.01
2	0.25	0.12	0.16	0.07	0.09	0.10	0.12
3	0.74	0.27	0.41	0.45	0.31	0.50	0.35
4	0.97	0.64	0.46	0.97	0.46	0.87	0.62
5	0.71	0.68	0.71	1.27	0.43	1.08	0.69
6	0.87	0.39	0.65	0.87	0.85	0.79	1.36
7	0.76	0.56	0.70	1.22	0.57	1.01	0.88
8	0.76	0.56	0.70	1.22	0.57	1.01	0.88

	1989	1990	1991	1992	1993	1994	1995
1	0.02	0.01	0.01	0.02	0.02	0.01	0.01
2	0.14	0.13	0.14	0.14	0.10	0.04	0.03
3	0.61	0.56	0.64	0.45	0.37	0.31	0.22
4	1.03	1.26	0.97	1.11	0.82	0.64	1.18
5	1.24	1.28	1.17	0.96	0.90	0.51	1.84
6	1.30	1.03	1.29	1.56	0.97	0.77	1.87
7	1.31	1.26	1.26	1.09	0.95	0.55	2.03
8	1.31	1.26	1.26	1.09	0.95	0.55	2.03

	1996	1997	1998	1999	2000	2001
1	0.01	0.01	0.01	0.00	0.00	0.00
2	0.03	0.05	0.02	0.00	0.00	0.00
3	0.34	0.15	0.07	0.02	0.02	0.01
4	0.41	0.41	0.18	0.06	0.08	0.08
5	0.36	0.24	0.51	0.08	0.08	0.17
6	0.37	0.23	0.30	0.19	0.04	0.10
7	0.37	0.24	0.44	0.10	0.07	0.06
8	0.37	0.24	0.44	0.10	0.07	0.06

5,6
Average F for 5,6

	1982	1983	1984	1985	1986	1987	1988
5,6	0.79	0.53	0.68	1.07	0.64	0.94	1.02

	1989	1990	1991	1992	1993	1994	1995
5,6	1.27	1.16	1.23	1.26	0.94	0.64	1.85

	1996	1997	1998	1999	2000	2001
5,6	0.36	0.23	0.40	0.13	0.06	0.14

Biomass Weighted F

1982	1983	1984	1985	1986	1987	1988
0.60	0.33	0.42	0.70	0.30	0.55	0.40

1989	1990	1991	1992	1993	1994	1995
0.74	0.64	0.54	0.49	0.41	0.39	0.51

1996	1997	1998	1999	2000	2001
0.20	0.17	0.14	0.05	0.05	0.07

Table B2.45. Continued.

BACKCALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988
1	0.01	0.03	0.01	0.01	0.01	0.01	0.01
2	0.26	0.17	0.23	0.06	0.10	0.10	0.09
3	0.77	0.40	0.58	0.36	0.37	0.47	0.25
4	1.00	0.94	0.65	0.76	0.54	0.80	0.46
5	0.73	1.00	1.00	1.00	0.51	1.00	0.50
6	0.89	0.58	0.93	0.69	1.00	0.73	1.00
7	0.79	0.83	1.00	0.96	0.68	0.93	0.64
8	0.79	0.83	1.00	0.96	0.68	0.93	0.64

	1989	1990	1991	1992	1993	1994	1995
1	0.01	0.01	0.01	0.01	0.02	0.01	0.00
2	0.11	0.10	0.11	0.09	0.10	0.06	0.01
3	0.46	0.44	0.49	0.29	0.38	0.40	0.11
4	0.78	0.98	0.75	0.71	0.84	0.83	0.58
5	0.95	1.00	0.91	0.62	0.93	0.66	0.91
6	0.99	0.81	1.00	1.00	1.00	1.00	0.92
7	1.00	0.98	0.98	0.70	0.98	0.72	1.00
8	1.00	0.98	0.98	0.70	0.98	0.72	1.00

	1996	1997	1998	1999	2000	2001
1	0.02	0.01	0.01	0.01	0.04	0.02
2	0.08	0.13	0.04	0.02	0.05	0.03
3	0.82	0.36	0.13	0.09	0.22	0.06
4	1.00	1.00	0.35	0.31	0.90	0.46
5	0.87	0.58	1.00	0.42	1.00	1.00
6	0.88	0.56	0.58	1.00	0.47	0.61
7	0.88	0.58	0.86	0.51	0.80	0.37
8	0.88	0.58	0.86	0.51	0.80	0.37

MEAN BIOMASS (using catch mean weights at age)

	1982	1983	1984	1985	1986	1987	1988
1	859	907	334	344	312	188	137
2	2586	2058	1522	755	1911	1287	1591
3	2693	2611	1588	1124	1242	1589	1489
4	1782	1468	1677	1000	958	757	932
5	1196	826	668	907	581	516	346
6	581	741	382	375	344	342	140
7	345	268	385	169	181	149	146
8	277	275	357	125	132	173	122
1+	10319	9153	6914	4798	5662	5000	4903

	1989	1990	1991	1992	1993	1994	1995
1	131	153	197	93	90	118	292
2	604	751	746	714	523	223	417
3	1014	716	680	729	760	591	577
4	873	452	399	304	364	484	280
5	407	256	123	141	109	211	151
6	170	130	67	35	47	46	63
7	47	39	34	24	11	29	13
8	41	29	31	22	05	10	11
1+	3285	2527	2275	2062	1909	1710	1802

	1996	1997	1998	1999	2000	2001	
1	199	282	292	320	264	221	
2	1520	1041	901	581	805	496	
3	986	1696	1615	1667	1847	1920	
4	523	656	1338	1584	1569	1898	
5	137	371	393	1138	1354	1313	
6	49	112	278	268	1060	1259	
7	19	31	82	225	235	1026	
8	34	40	21	175	196	592	
1+	3466	4228	4918	5957	7328	8724	00

Table B2.45. Continued.

SSB AT THE START OF THE SPAWNING SEASON -MALES AND FEMALES (MT) (using SSB mean weights)

	1982	1983	1984	1985	1986	1987	1988
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	454	368	265	189	144	257	204
4	1685	1307	1578	898	744	714	857
5	1255	867	778	991	549	571	376
6	665	733	437	383	362	370	180
7	390	292	449	194	193	165	167
8	339	325	433	164	157	220	153
1+	4790	3890	3941	2820	2149	2298	1936

	1989	1990	1991	1992	1993	1994	1995
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	185	95	103	107	107	82	54
4	824	450	365	302	366	444	295
5	474	323	151	167	124	208	198
6	183	149	82	42	58	51	87
7	50	51	46	25	12	26	17
8	54	38	40	28	06	11	15
1+	1769	1106	787	672	672	823	666

	1996	1997	1998	1999	2000	2001
1	00	00	00	00	00	00
2	00	00	00	00	00	00
3	96	241	194	185	157	189
4	421	596	1180	1283	1315	1521
5	133	373	428	1116	1369	1335
6	47	107	285	268	1022	1211
7	19	33	85	219	227	980
8	39	44	24	188	208	630
1+	754	1395	2197	3260	4298	5866

Table B2.45b. VPA retrospective analysis for Gulf of Maine winter flounder.

Fishing Mortality

Terminal year

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1995	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.26	1.14	1.17	1.05	0.59	0.29	0.72						
1996	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.15	1.22	1.21	0.85	0.52	1.05	0.07					
1997	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.15	1.22	1.22	0.87	0.55	1.19	0.14	0.09				
1998	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.16	1.22	1.23	0.88	0.56	1.27	0.16	0.09	0.23			
1999	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.16	1.23	1.25	0.91	0.6	1.54	0.23	0.13	0.21	0.09		
2000	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.16	1.23	1.25	0.93	0.63	1.73	0.30	0.19	0.27	0.08	0.06	
2001	0.79	0.53	0.68	1.07	0.64	0.94	1.02	1.27	1.16	1.23	1.26	0.94	0.64	1.85	0.36	0.23	0.40	0.13	0.06	0.14

Spawning Stock Biomass

Terminal year

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1995	4790	3890	3941	2821	2150	2299	1939	1776	1121	831	804	910	1283	1759						
1996	4790	3890	3941	2820	2149	2298	1937	1770	1108	795	695	735	1080	1373	2108					
1997	4790	3890	3941	2820	2149	2298	1937	1770	1108	794	690	722	957	1046	1510	2530				
1998	4790	3890	3941	2820	2149	2298	1936	1770	1108	793	688	715	934	1008	1417	2274	2956			
1999	4790	3890	3941	2820	2149	2298	1936	1769	1106	789	678	688	868	799	1137	2082	2799	4038		
2000	4790	3890	3941	2820	2149	2298	1936	1769	1106	788	674	678	839	719	873	1753	2616	3601	4808	
2001	4790	3890	3941	2820	2149	2298	1936	1769	1106	787	672	672	823	666	754	1395	2197	3260	4298	5866

Population Numbers Age1:

Terminal year

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1995	11762	8779	6271	9285	7698	6150	4556	4377	4717	5296	6200	6700	6302	8273	6222						
1996	11761	8778	6269	9278	7688	6129	4496	4096	4336	5330	5327	6547	6324	7084	6987	6895					
1997	11761	8778	6269	9278	7688	6127	4499	4067	4390	4811	4419	4909	6072	7098	7490	7043	7090				
1998	11761	8778	6269	9278	7688	6127	4497	4061	4380	4723	4402	4662	5446	6768	7060	7347	8617	11412			
1999	11761	8778	6269	9277	7687	6126	4487	4052	4283	4657	3598	4474	5794	7011	7774	7883	9687	13335	16197		
2000	11761	8778	6269	9277	7686	6125	4484	4045	4262	4567	3482	3425	5692	7749	7257	7352	9106	10817	8113	6990	
2001	11761	8778	6269	9277	7686	6125	4482	4043	4242	4542	3322	3240	4519	7503	7588	7249	8967	10080	7474	7391	6274

Table B2.46. VPA Bootstrap results: precision of estimates.

The number of bootstraps: 500

Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
N 1	6274	6578	2984	0.48
N 2	6033	6313	1951	0.32
N 3	4971	5148	1277	0.26
N 4	5444	5544	1043	0.19
N 5	3624	3711	674	0.19
N 6	2001	2043	394	0.20
N 7	1572	1576	273	0.17
N 8	1068	1077	170	0.16

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 1	304	133	4.85	5969	0.499901	3546	11460
N 2	280	87	4.65	5752	0.339112	3677	8478
N 3	177	57	3.56	4794	0.266440	3559	6826
N 4	100	47	1.83	5344	0.195187	4245	6919
N 5	88	30	2.42	3536	0.190486	2818	4483
N 6	42	18	2.11	1959	0.201157	1523	2548
N 7	04	12	0.27	1568	0.173815	1286	1984
N 8	10	08	0.90	1058	0.160299	874	1312

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0030	0.0032	0.0011	0.37
Age 2	0.0044	0.0045	0.0011	0.25
Age 3	0.0096	0.0097	0.0018	0.19
Age 4	0.0790	0.0795	0.0139	0.18
Age 5	0.1708	0.1730	0.0311	0.18
Age 6	0.1048	0.1074	0.0180	0.17
Age 7	0.0624	0.0633	0.0098	0.16
Age 8	0.0624	0.0633	0.0098	0.16

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 1	0.0001690	0.0000491	5.641	0.0028262	0.39	0.0021	0.0048
Age 2	0.0001079	0.0000490	2.477	0.0042508	0.26	0.0032	0.0061
Age 3	0.0001559	0.0000812	1.625	0.0094377	0.19	0.0075	0.0122
Age 4	0.0005479	0.0006197	0.694	0.0784051	0.18	0.0640	0.0998
Age 5	0.0021128	0.0013886	1.237	0.1687286	0.18	0.1359	0.2178
Age 6	0.0025929	0.0008055	2.474	0.1022216	0.18	0.0836	0.1266
Age 7	0.0009146	0.0004373	1.465	0.0614994	0.16	0.0506	0.0752
Age 8	0.0009146	0.0004373	1.465	0.0614994	0.16	0.0506	0.0752

Bootstrap Output Variable: Mean Biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
8723.9106	8873.3264	775.7433	0.09

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
149.4158	34.6923	1.71	8574.4947	0.09	7730.5482	9603.4137

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
5865.7415	5945.3298	554.7207	0.09

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
79.59	24.81	1.36	5786.15	0.10	5203.0726	6580.6435

Table B2.47. Yield Per Recruit analysis for Gulf of Maine winter flounder.

```
 The NEFC Yield and Stock Size per Recruit Program - PDBYPRC
  PC Ver.2.0 [Method of Thompson and Bell (1934)] 1-Jan-1999
           --------------------------------------
           Run Date:  3-10-2002;  Time: 12:05:35.00
 gulf of Maine Winter Flounder - 1999-01 PR, Mean Weights at Age from
 ____________________________________________________________________
 Proportion of F before spawning: 0.2500
 Proportion of M before spawning: 0.2500
 Natural Mortality is Constant at: 0.200
 Initial age is:  1; Last age is: 15
 Last age is a TRUE Age;
 Original age-specific PRs, Mats, and Mean Wts from file:
 ==> C:\Program Files\FACT\wv\ypr\gomwfy3.dat
------------------------------------------------------------
 Age-specific Input data for Yield per Recruit Analysis
------------------------------------------------------------
  Age | Fish Mort  Nat Mort | Proportion | Average Weights
      |  Pattern    Pattern |   Mature   |  Catch   Stock
------------------------------------------------------------
   1  |  0.0300     1.0000  |   0.0000   |  0.036   0.021
   2  |  0.0400     1.0000  |   0.0000   |  0.095   0.059
   3  |  0.1300     1.0000  |   0.1600   |  0.351   0.206
   4  |  0.5700     1.0000  |   0.8600   |  0.471   0.420
   5  |  1.0000     1.0000  |   1.0000   |  0.550   0.512
   6  |  1.0000     1.0000  |   1.0000   |  0.691   0.626
   7  |  1.0000     1.0000  |   1.0000   |  0.872   0.788
   8  |  1.0000     1.0000  |   1.0000   |  0.993   0.993
   9  |  1.0000     1.0000  |   1.0000   |  1.091   1.091
  10  |  1.0000     1.0000  |   1.0000   |  1.171   1.171
  11  |  1.0000     1.0000  |   1.0000   |  1.234   1.234
  12  |  1.0000     1.0000  |   1.0000   |  1.284   1.284
  13  |  1.0000     1.0000  |   1.0000   |  1.323   1.323
  14  |  1.0000     1.0000  |   1.0000   |  1.353   1.353
  15  |  1.0000     1.0000  |   1.0000   |  1.377   1.377

------------------------------------------------------------
 Summary of Yield per Recruit Analysis:
 ____________________________________________________________________
  Slope of the Yield/Recruit Curve at F=0.00: -->    2.0105
    F level at slope=1/10 of the above slope (F0.1): ----->          0.258
      Yield/Recruit corresponding to F0.1: ----->    0.1970
    F level to produce Maximum Yield/Recruit (Fmax): ----->          0.687
      Yield/Recruit corresponding to Fmax: ----->    0.2201
    F level at 40 % of Max Spawning Potential (F40): ----->   0.261
      SSB/Recruit corresponding to F40: -------->    0.8333
 ____________________________________________________________________
1
 Listing of Yield per Recruit Results for:
 ----------------------------------------------------------------------------
      FMORT   TOTCTHN  TOTCTHW  TOTSTKN  TOTSTKW  SPNSTKN  SPNSTKW    % MSP
 ----------------------------------------------------------------------------
       0.00   0.00000  0.00000   5.2420   2.4078   2.6476   2.0834   100.00
       0.10   0.17406  0.12996   4.5658   1.6980   1.9691   1.3773    66.11
       0.20   0.26851  0.18214   4.1562   1.3009   1.5634   0.9877    47.41
 F0.1  0.26   0.30487  0.19700   3.9894   1.1500   1.4000   0.8411    40.37
 F40%  0.26   0.30682  0.19770   3.9802   1.1419   1.3911   0.8333    40.00
       0.30   0.32662  0.20421   3.8874   1.0616   1.3007   0.7557    36.27
       0.40   0.36623  0.21387   3.6983   0.9070   1.1185   0.6074    29.16
       0.50   0.39537  0.21807   3.5575   0.8010   0.9848   0.5067    24.32
       0.60   0.41803  0.21972   3.4476   0.7243   0.8823   0.4345    20.85
 Fmax  0.69   0.43413  0.22009   3.3697   0.6733   0.8108   0.3869    18.57
       0.70   0.43638  0.22010   3.3588   0.6664   0.8009   0.3805    18.26
       0.80   0.45170  0.21982   3.2847   0.6211   0.7343   0.3387    16.26
       0.90   0.46481  0.21920   3.2215   0.5846   0.6787   0.3053    14.66
       1.00   0.47624  0.21839   3.1666   0.5544   0.6314   0.2781    13.35
       1.10   0.48637  0.21747   3.1180   0.5288   0.5905   0.2553    12.25
       1.20   0.49545  0.21650   3.0745   0.5069   0.5547   0.2359    11.32
       1.30   0.50368  0.21549   3.0352   0.4878   0.5230   0.2193    10.52
       1.40   0.51121  0.21446   2.9992   0.4708   0.4947   0.2047     9.83
       1.50   0.51816  0.21343   2.9660   0.4557   0.4693   0.1919     9.21
       1.60   0.52462  0.21238   2.9352   0.4421   0.4463   0.1805     8.67
       1.70   0.53064  0.21134   2.9065   0.4297   0.4253   0.1703     8.18
       1.80   0.53630  0.21029   2.8795   0.4183   0.4060   0.1611     7.73
       1.90   0.54163  0.20924   2.8541   0.4078   0.3883   0.1527     7.33
       2.00   0.54668  0.20819   2.8300   0.3981   0.3719   0.1451     6.96
 ----------------------------------------------------------------------------
```

Table B2.48. Stock-recruitment model comparison for Gulf of Maine winter flounder.

	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior	Prior
	1	0	1	0	1	0	0	0	0	0
	BH	ABH	PBH	PABH	PRBH	PRABH	RK	ARK	PRK	PARK
Posterior Probability	0.36	0.00	0.32	0.00	0.31	0.00	0.00	0.00	0.00	0.00
Odds Ratio for Most Likely Model	1.00		1.12		1.16					
Normalized Likelihood	0.363	0.000	0.323	0.000	0.313	0.000	0.000	0.000	0.000	0.000
Model AIC Ratio	1.160	0	1.033	0	1.000	0	0	0	0	0

	BH	**ABH**	**PBH**	**PABH**	**PRBH**	**PRABH**	**RK**	**ARK**	**PRK**	**PARK**
Number_of_data_points	20	20	20	20	20	20	20	20	20	20
Number_of_parameters	3	4	3	4	3	4	3	4	3	4
Fit_negloglikelihood	41.146	33.566	41.263	33.724	41.295	33.732	43.534	34.926	52.285	37.530
Penalty_steepness	0	0	-0.810	-1.087	0	0	0	0	0	0
Penalty_slope	0	0	0	0	0	0	0	0	3.160	-0.774
Penalty_unfished_R	0	0	0	0	2.085	1.809	0	0	0	0
Negative_loglikelihood	41.146	33.566	40.452	32.637	43.380	35.541	43.534	34.926	55.445	36.756
Bias-corrected_AIC	89.792	77.799	90.025	78.115	90.090	78.130	94.568	80.519	112.070	85.726
Diagnostic Comments	**Most likely parametric model**	Power spectrum dominant frequency exceeds 1/2 time series length		Power spectrum dominant frequency exceeds 1/2 time series length		Power spectrum dominant frequency exceeds 1/2 time series length	Fmsy>> Fmax	Fmsy>> Fmax	no stock recruit data at SSB where density dependence is predicted	Power spectrum dominant frequency exceeds 1/2 time series length

Table B2.48. Continued.

Parameter Point_Estimate	BH	ABH	PBH	PABH	PRBH	PRABH	RK	ARK	PRK	PARK
MSY	1.543	1.587	1.596	1.623	1.640	1.771	1.753	1.836	2.153	0.568
FMSY	0.430	0.415	0.405	0.380	0.410	0.395	0.745	0.705	0.375	0.240
SMSY	4.104	4.359	4.484	4.830	4.554	5.087	2.871	3.154	6.485	2.594
Alpha	7.706	8.051	8.167	8.579	8.365	9.161	2.043	1.982	1.296	0.828
expected_alpha	8.084	8.422	8.574	8.998	8.783	9.612	2.171	2.097	1.500	1.431
Beta	0.387	0.473	0.516	0.698	0.516	0.636	-0.359	-0.323	-0.134	-0.281
Steepness	0.923	0.911	0.905	0.881	0.907	0.896				
R_at_input_SMAX	7.302	7.542	7.606	7.800	7.791	8.398	4.388	5.310	10.032	2.233
expected_R_at_input_SMAX	7.661	7.889	7.985	8.182	8.180	8.811	4.663	5.618	11.611	3.862
unfished_S	18.138	18.883	19.118	19.925	19.594	21.389	8.144	8.863	16.247	6.058
unfished_R	7.544	7.855	7.952	8.288	8.150	8.897	3.387	3.686	6.758	2.520
Sigma	0.310	0.300	0.312	0.309	0.312	0.310	0.349	0.336	0.541	1.047
Phi		0.720		0.734		0.736		0.749		0.973
Sigmaw		0.208		0.210		0.210		0.222		0.240
last_residual_R		-1.177		-1.392		-1.991		-0.141		3.699
last_logresidual_R		-0.172		-0.200		-0.276		-0.022		0.890
expected_lognormal_error_term	1.049	1.046	1.050	1.049	1.050	1.049	1.063	1.058	1.157	1.729
prior_mean_steepness			0.80	0.80						
prior_se_steepness			0.09	0.09						
prior_mean_slope									0.79	0.79
prior_se_slope									0.18	0.18
prior_mean_unfished_R					10.09	10.09				
prior_se_unfished_R					2.06	2.06				

Table B2.49. Input parameters and stochastic projection results for Gulf of Maine winter flounder using recruitment predicted from the Beverton-Holt stock-recruitment model and an estimated Fmsy = 0.43.

Age	Stock Size on 1 Jan 2002 (000s)	Fishing Mortality Pattern	Proportion Landed	Proportion mature	Mean Weights Spawning Stock	Mean Weights Landings	Mean Weights Discards
1	6274	0.030	0.000	0.000	0.021	0.000	0.036
2	6033	0.040	0.040	0.000	0.059	0.000	0.089
3	4971	0.130	0.710	0.160	0.203	0.399	0.229
4	5444	0.570	0.940	0.860	0.419	0.480	0.306
5	3624	1.000	0.980	1.000	0.512	0.553	0.389
6	2001	1.000	0.980	1.000	0.626	0.696	0.468
7	1572	1.000	0.990	1.000	0.788	0.875	0.694
8+	1558	1.000	0.990	1.000	1.100	1.105	0.867

F2002 is assumed equal to F2001; F during 2003-2013 = F_{msy} = 0.43.

Forecast Medians (50% probability level)

000s Metric tons

2002				2003				2013			
F	Land	Disc	SSB	F	Land	Disc	SSB	F	Land	Disc	SSB
0.14	0.9	<0.1	7.6	Fmsy=0.43	2.9	0.1	7.8	Fmsy=0.43	1.5	0.1	4.3

F2002 is assumed 0.85*F2001 (15% decrease in F from 2001 to 2002); F during 2003-2013 = F_{msy} = 0.43.

Forecast Medians (50% probability level)

000s Metric tons

2002				2003				2013			
F	Land	Disc	SSB	F	Land	Disc	SSB	F	Land	Disc	SSB
0.12	0.8	<0.1	7.7	Fmsy=0.43	2.9	0.1	7.9	Fmsy=0.43	1.6	0.1	4.3

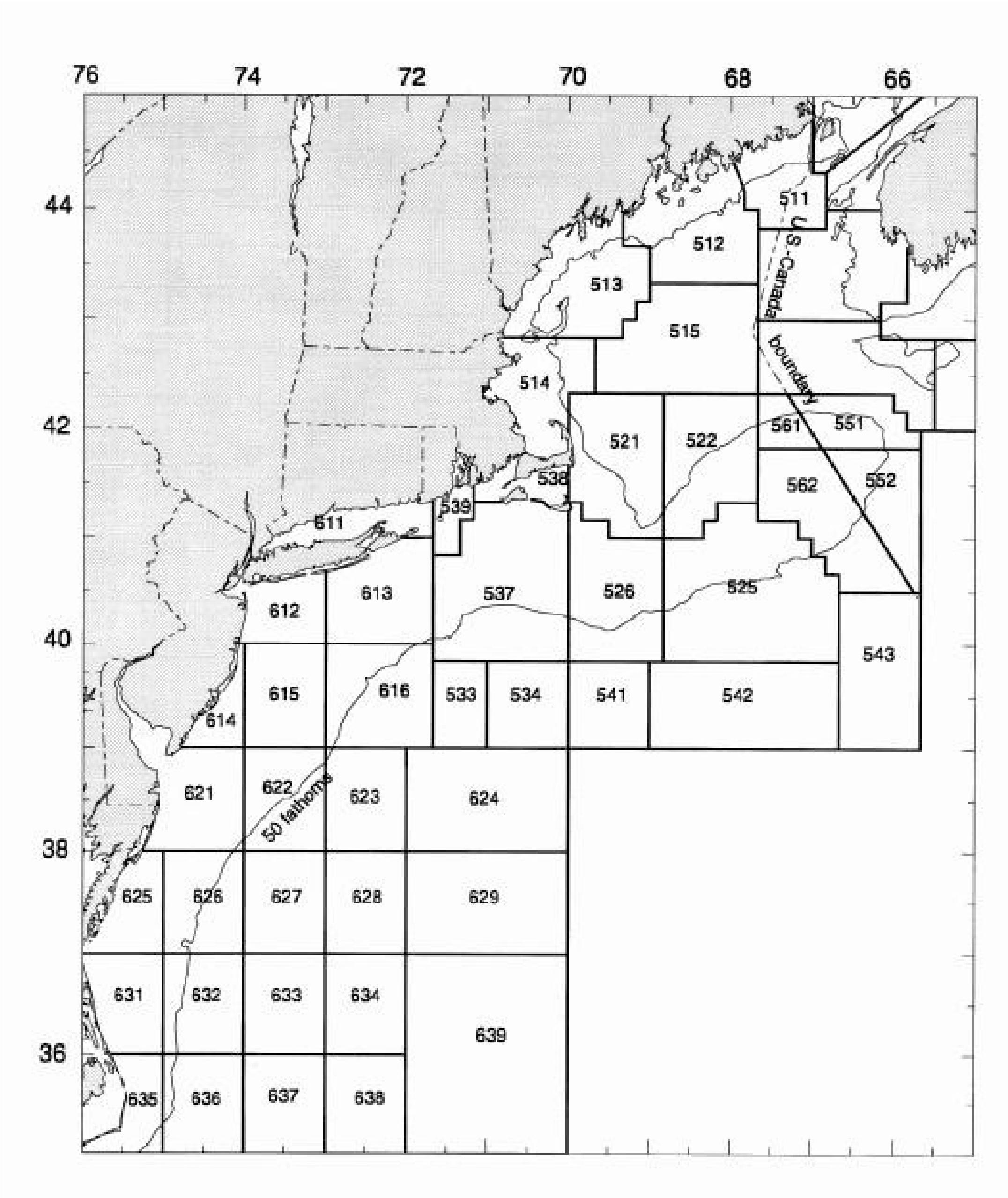

Figure B2.1. Statistical areas for reporting landings in the northwest Atlantic ocean.

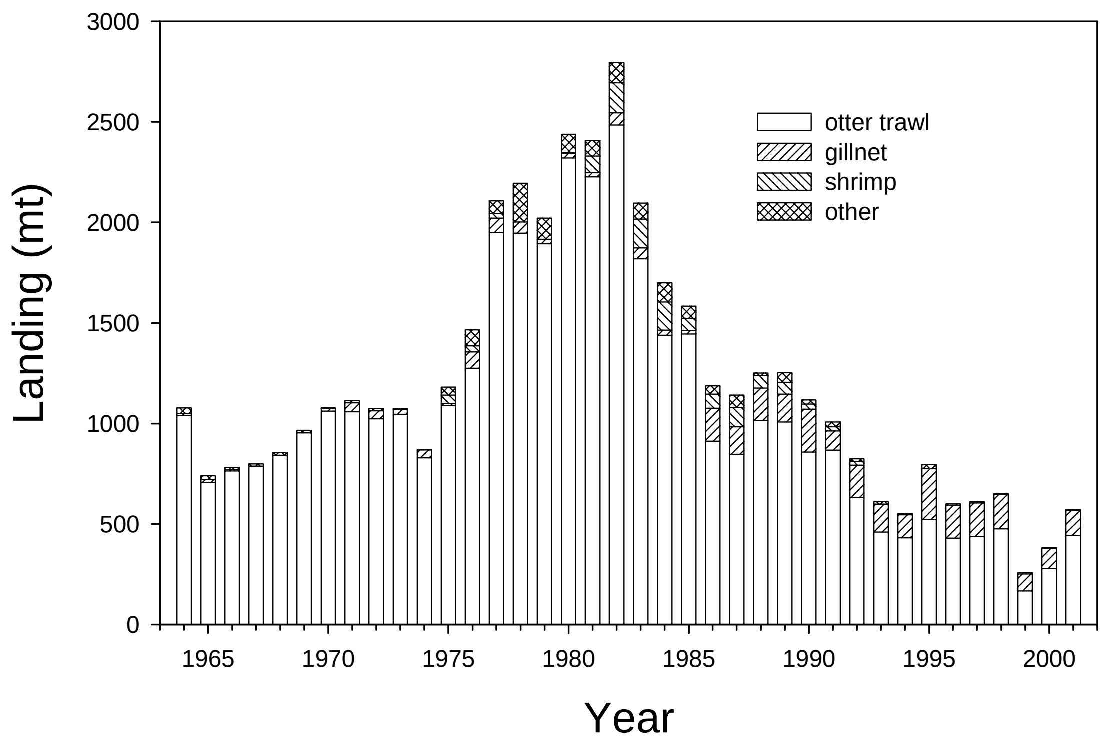

Figure B2.2. Gulf of Maine winter flounder commercial landings by gear from 1964-2001.

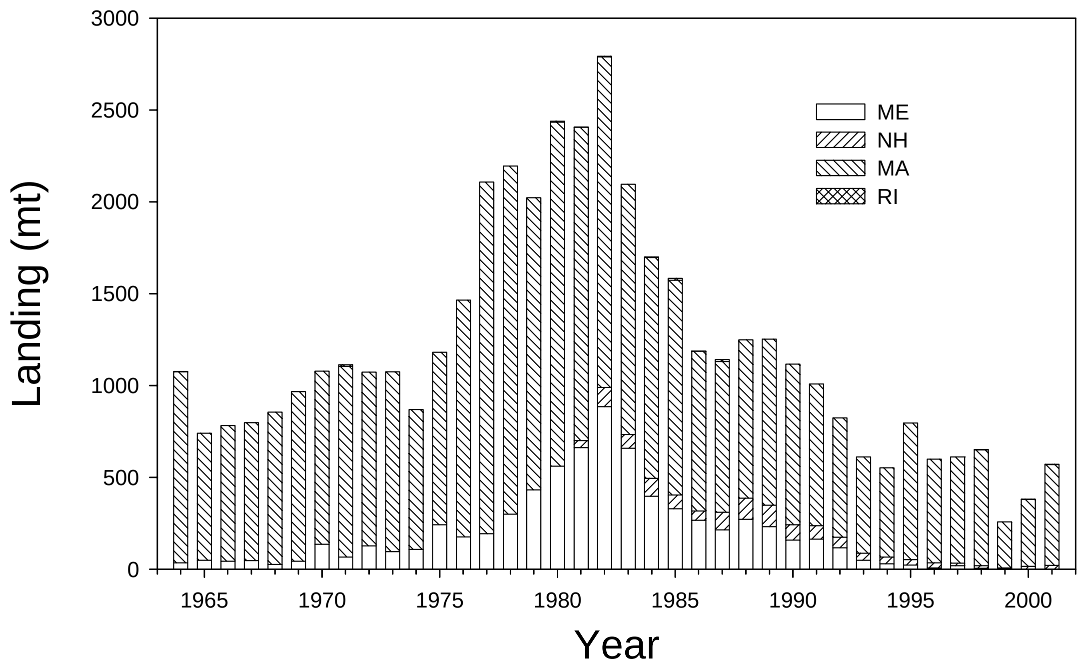

Figure B2.3. Gulf of Maine winter flounder commercial landings by state from 1964-2001.

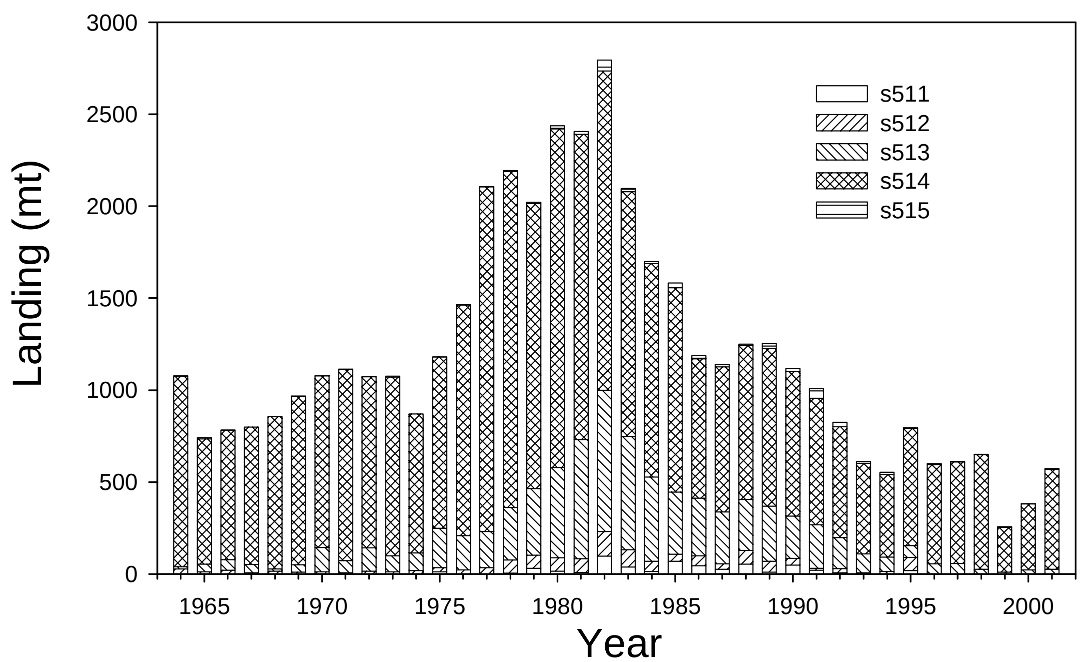

Figure B2.4. Gulf of Maine winter flounder commercial landings by statistical area from 1964-2001.

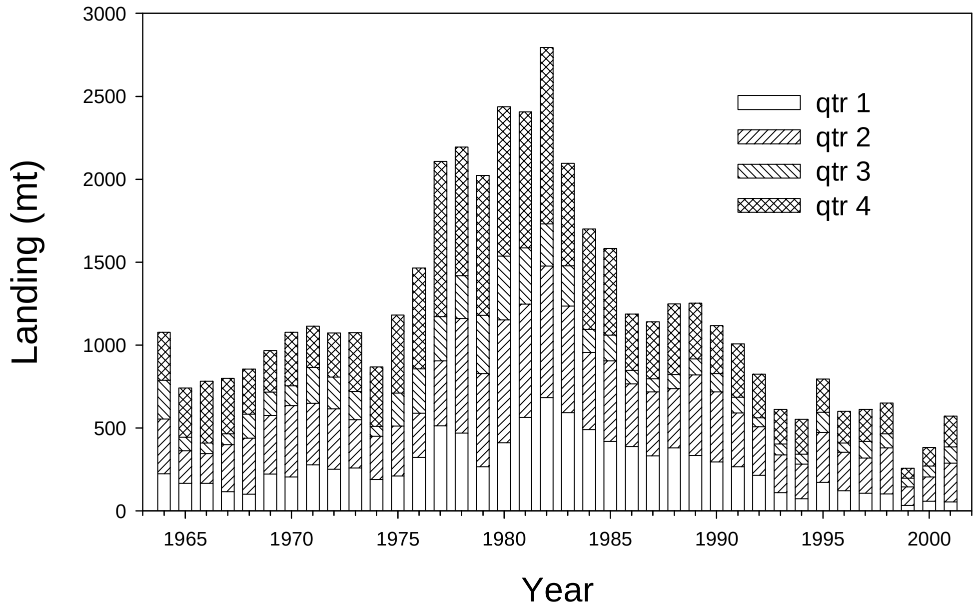

Figure B2.5. Gulf of Maine winter flounder commercial landings by quarter from 1964-2001.

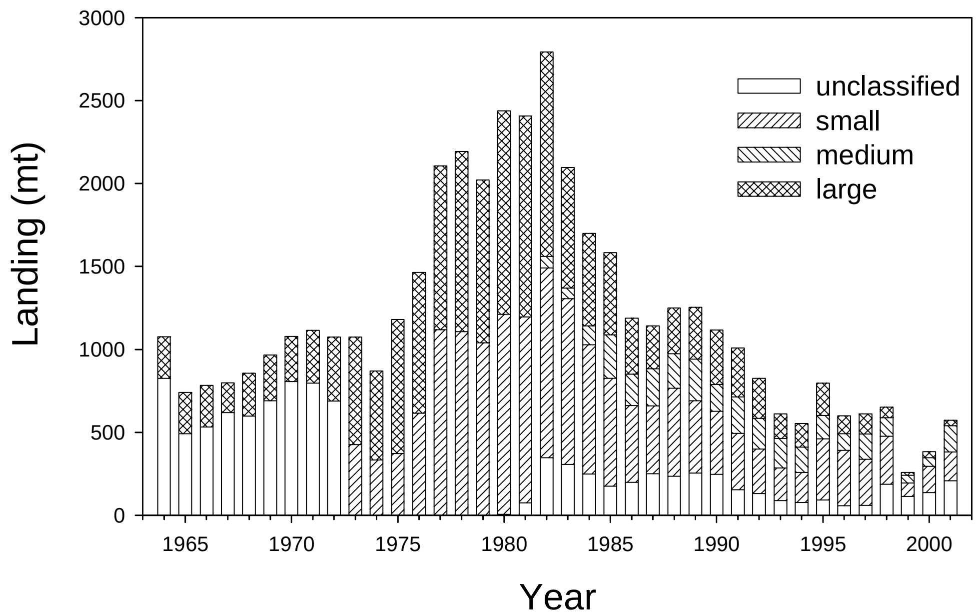

Figure B2.6. Gulf of Maine winter flounder commercial landings by market category from 1964-2001.

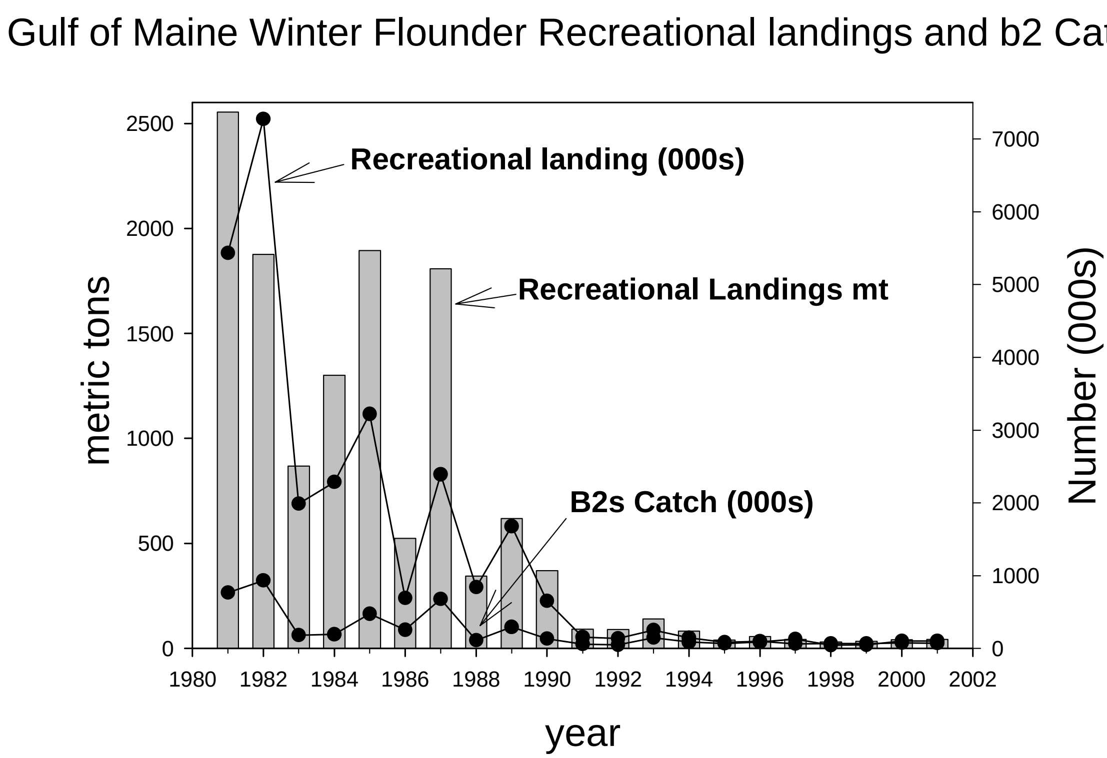

Figure B2.7. Recreational landings in numbers and metric tons for Gulf of Maine winter flounder. B2 catch in numbers is also shown.

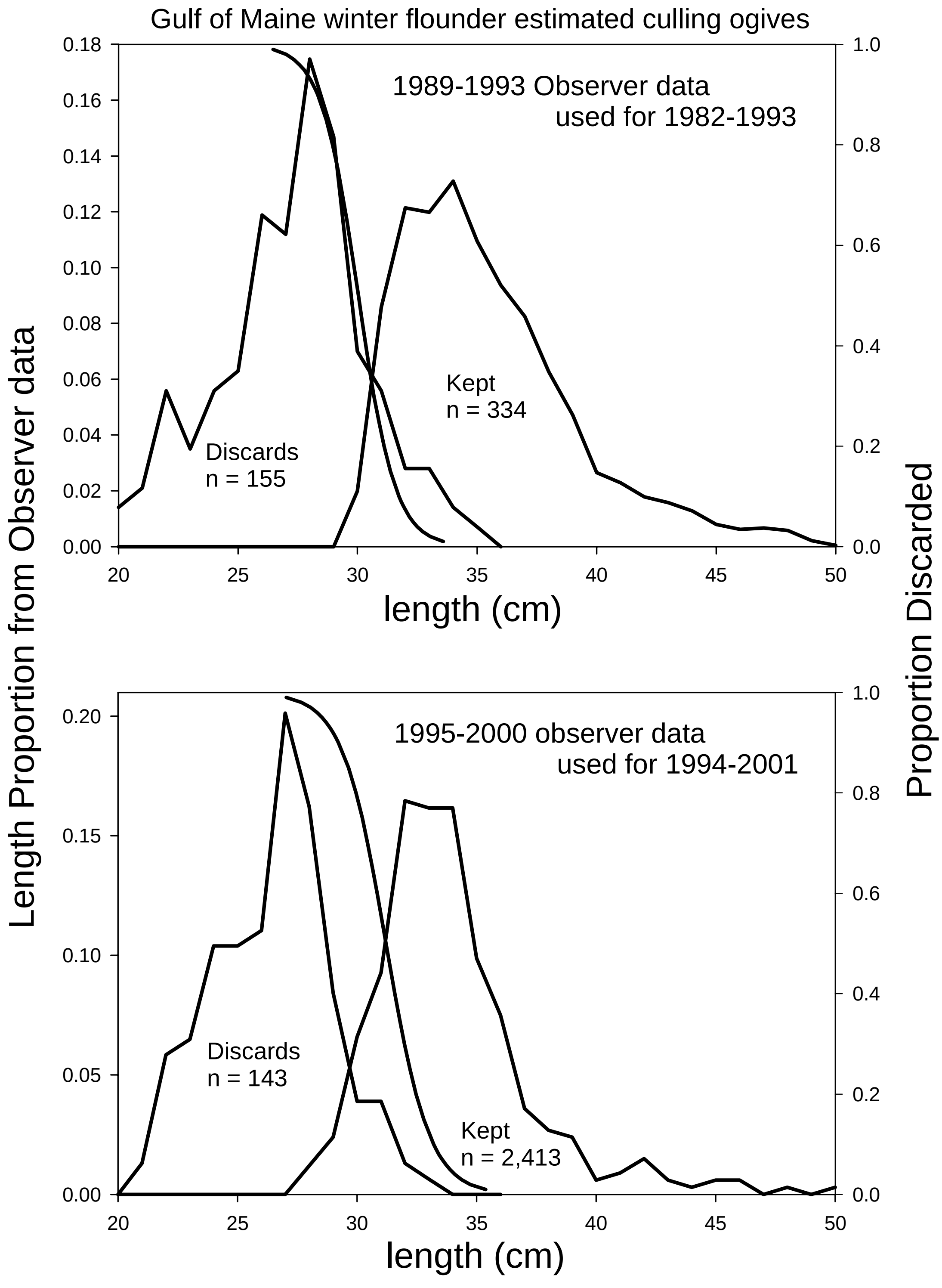

Figure B2.8. Gulf of Maine winter flounder estimated culling ogive from Observer data for estimating trawl discards in the survey method.

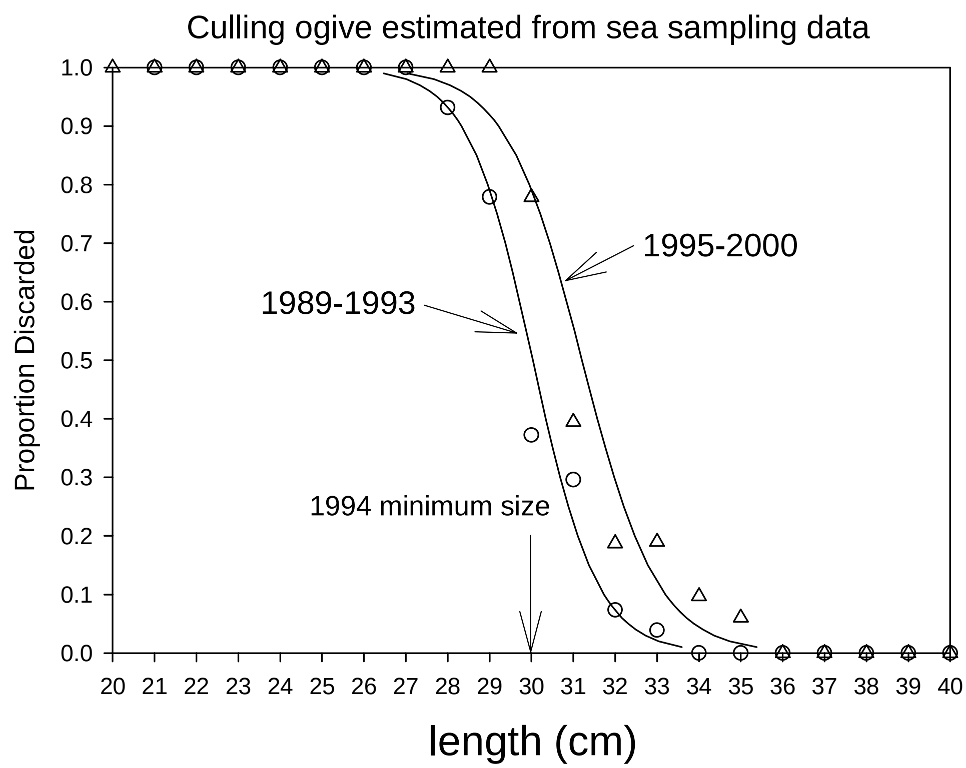

Figure B2.9. Gulf of Maine winter flounder estimated culling ogive. Observer data from 1989-1993 was used to estimate an ogive used for years 1982-1993. Observer data from 1995-2000 was used to estimate an ogive used for years 1994-2001.

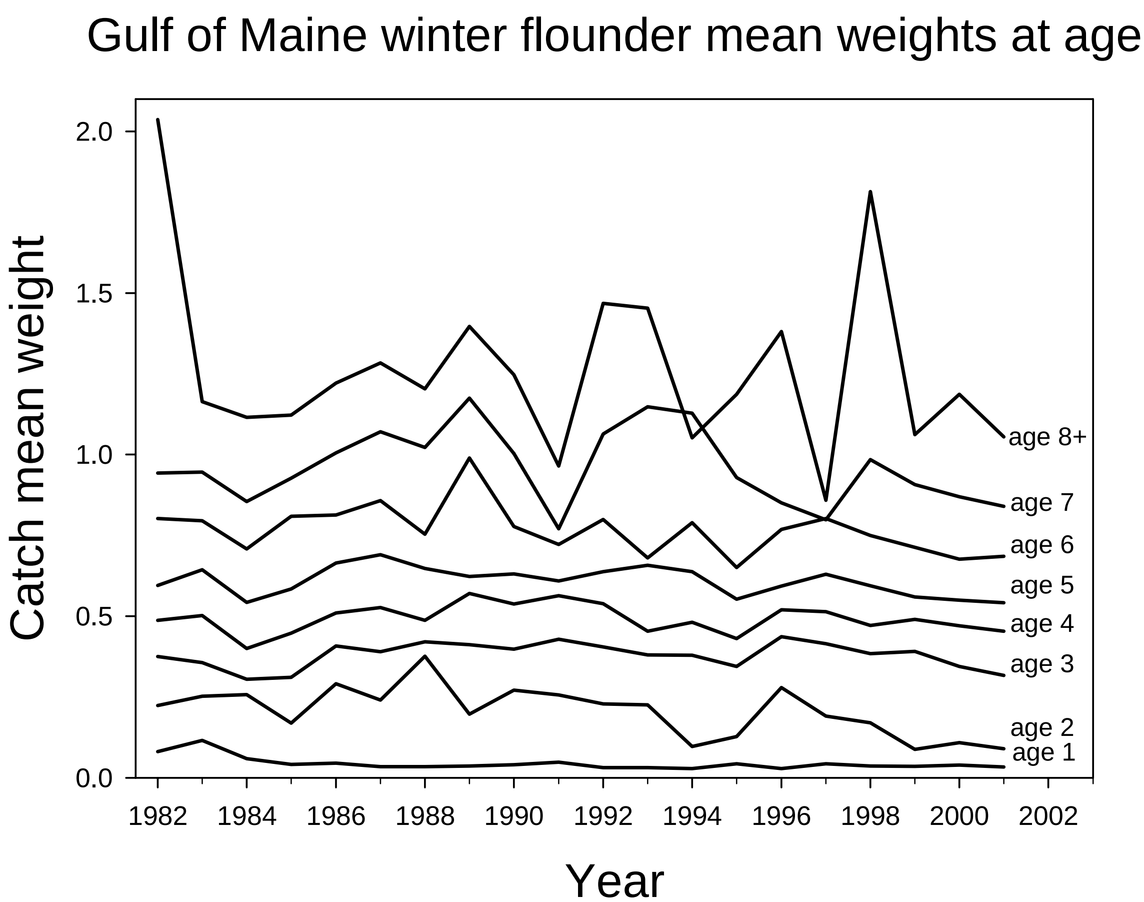

Figure B2.10. Gulf of Maine winter flounder VPA mean weights at age.

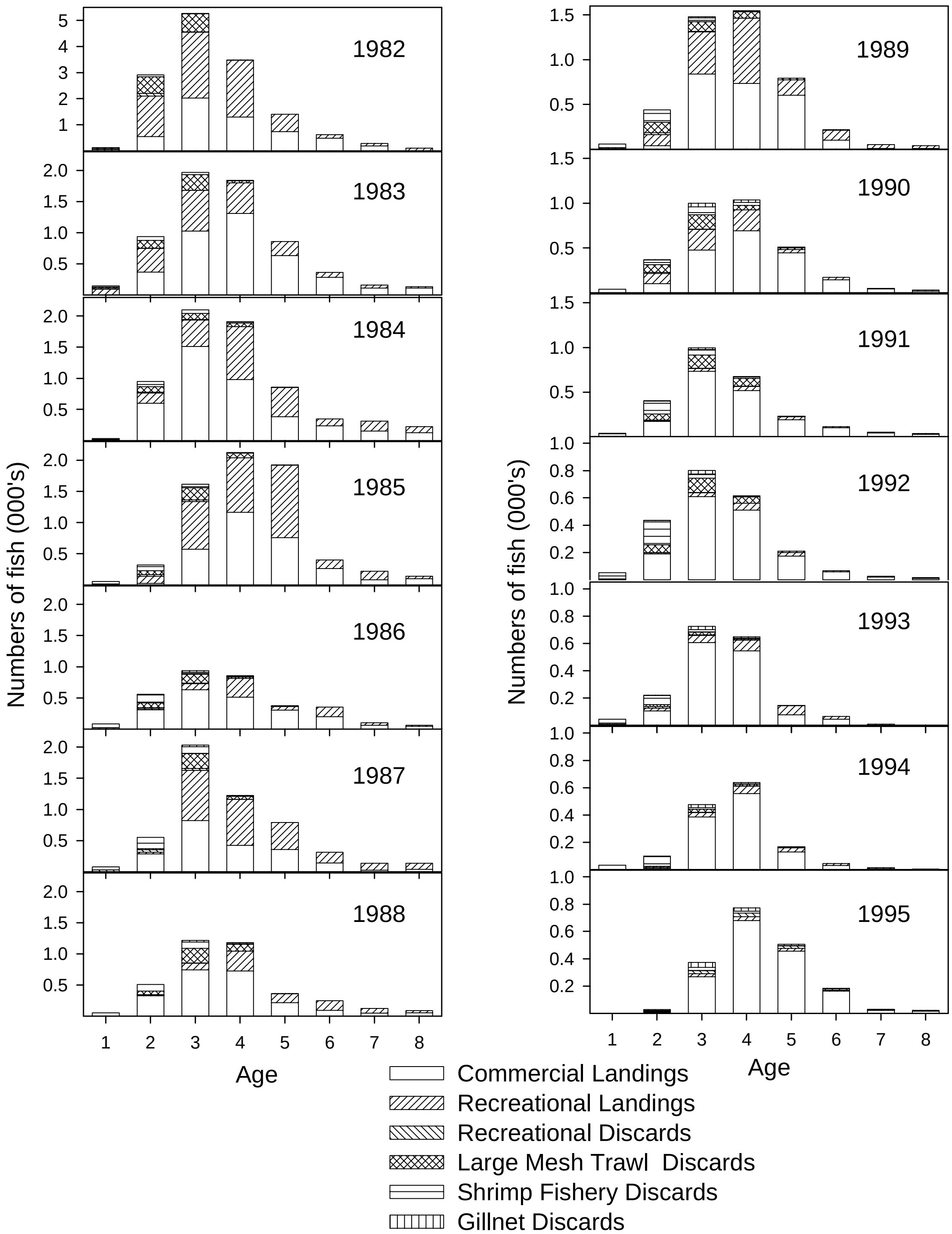

Figure B2.11. Gulf of Maine winter flounder catch at age composition in numbers from 1982-2001.

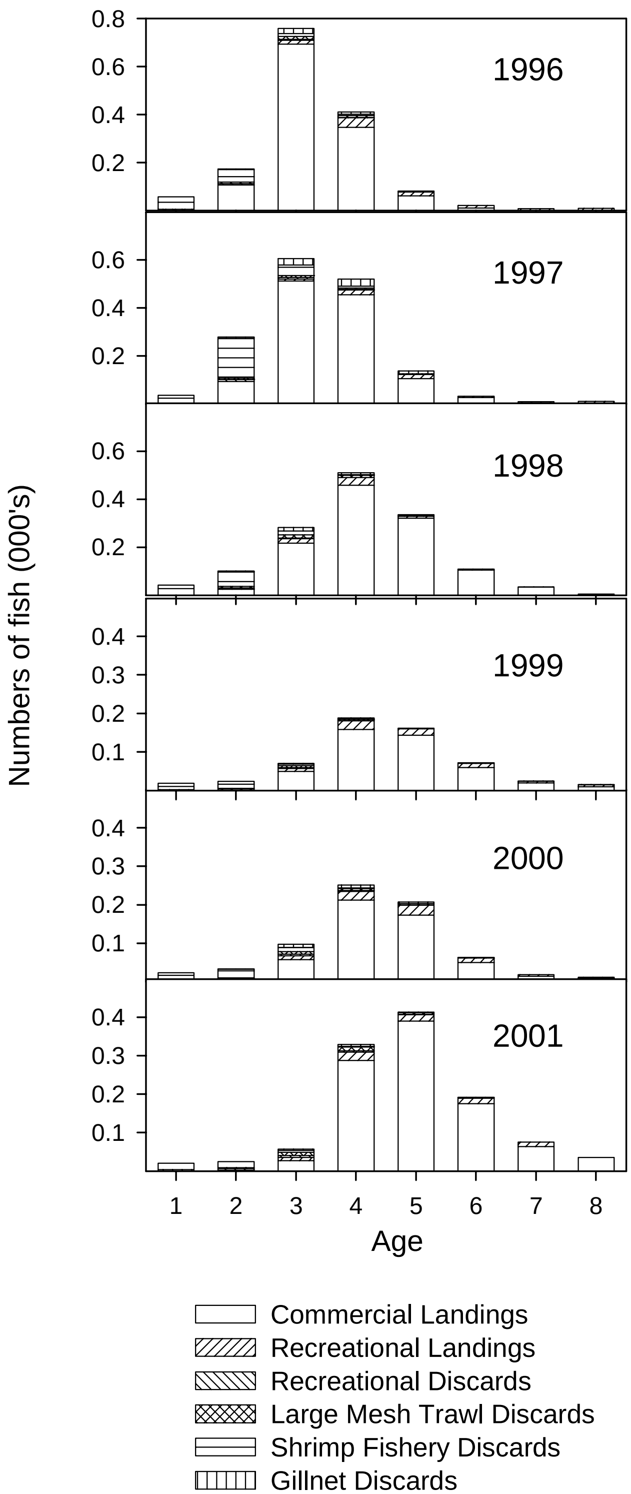

Figure B2.11. Continued.

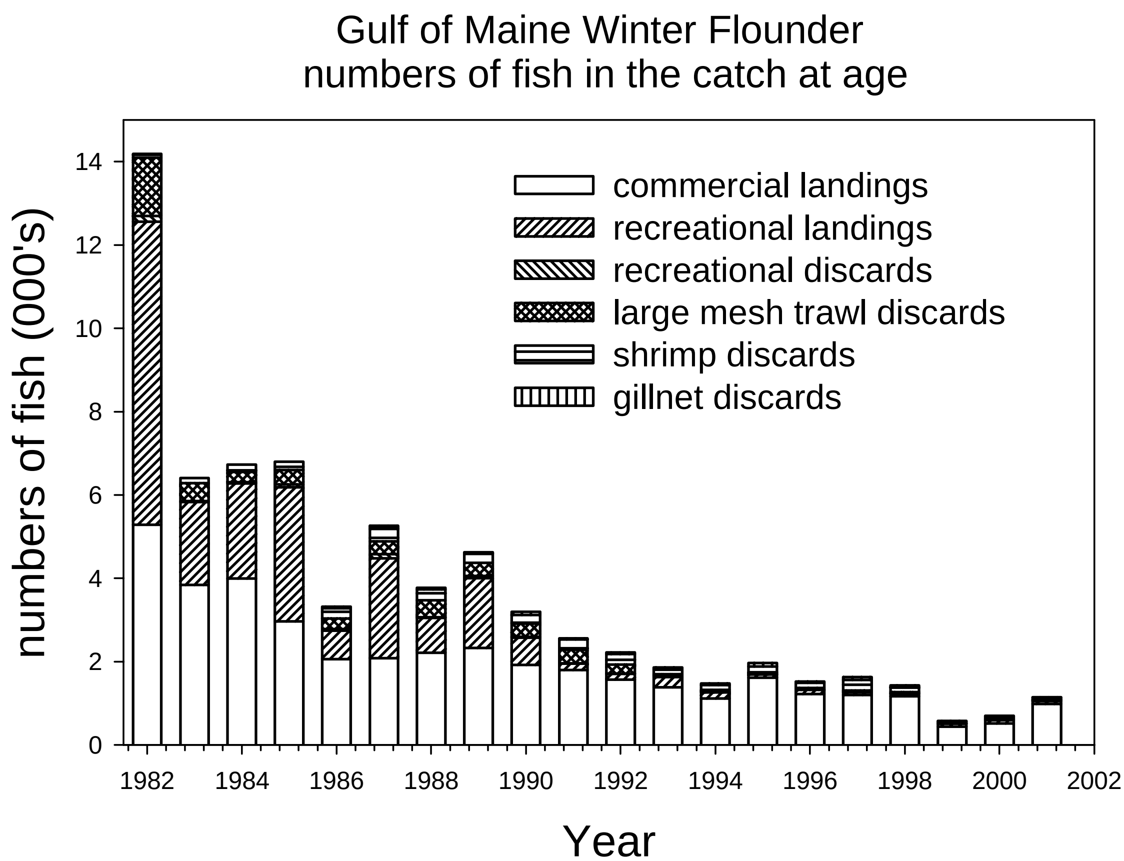

Figure B2.12. Gulf of Maine winter flounder catch composition in numbers

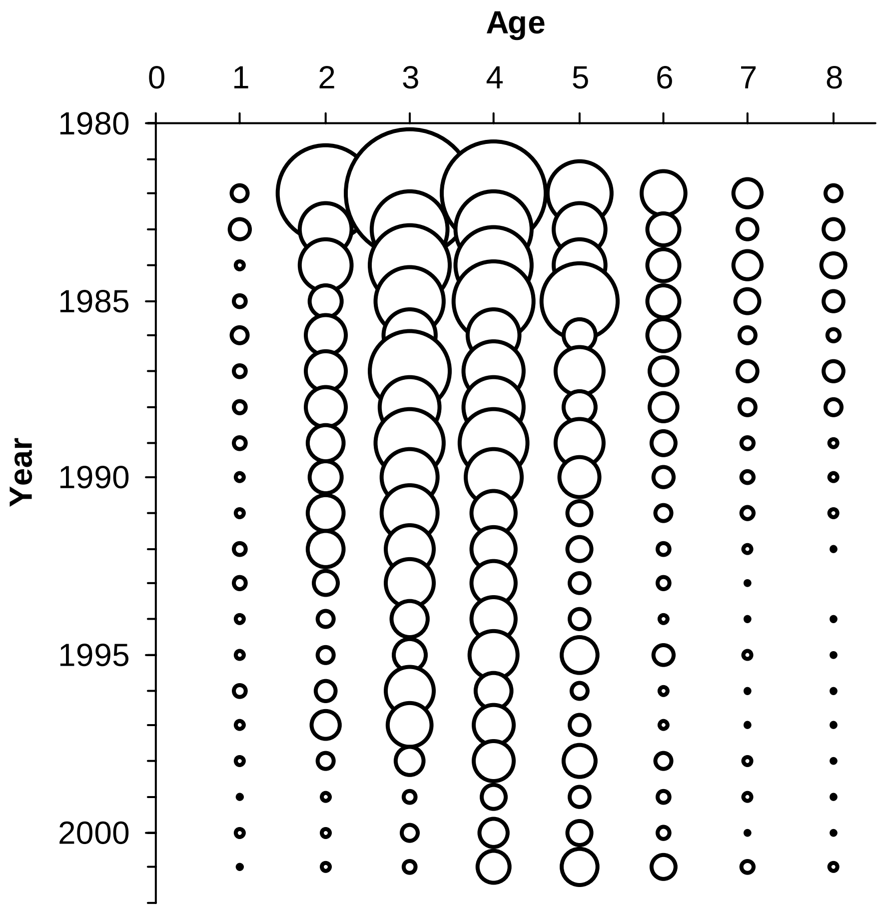

Figure B2.13. Total Gulf of Maine winter flounder catch at age.

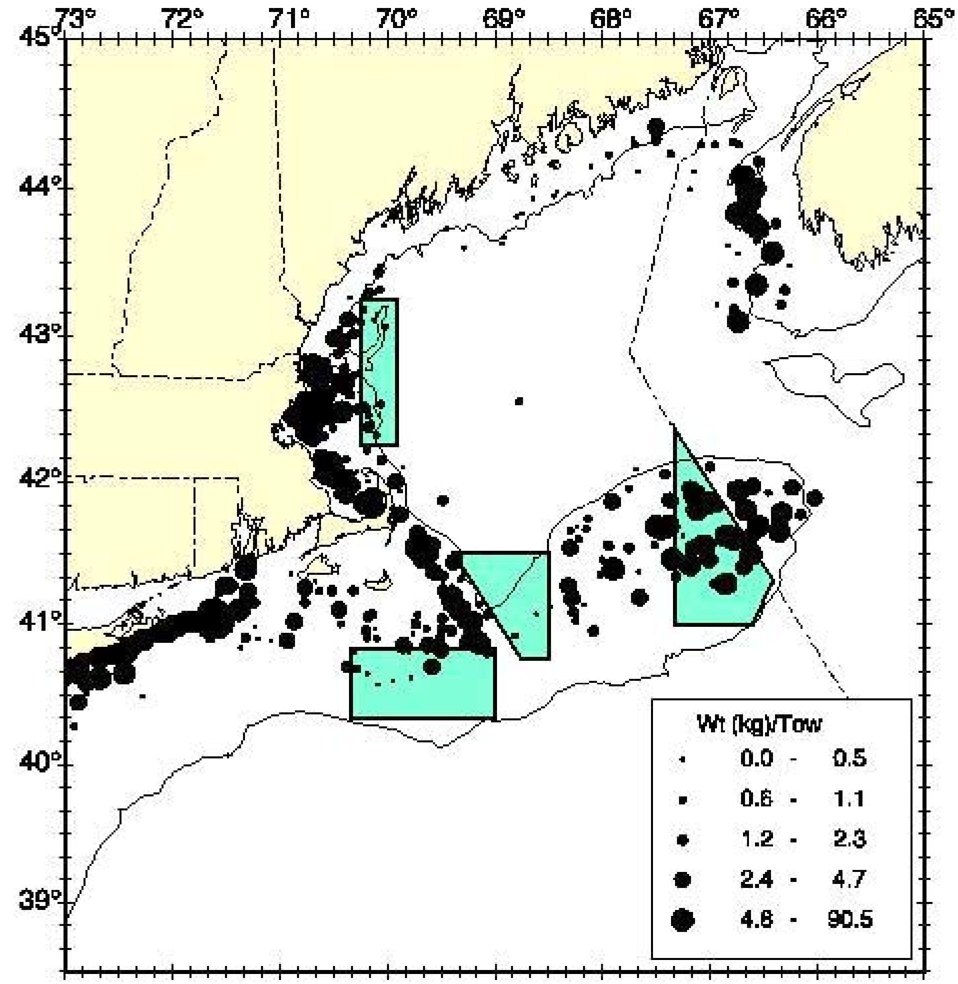

Figure B2.14. Distribution of winter flounder during the NEFSC spring bottom trawl surveys from 1995-1999.

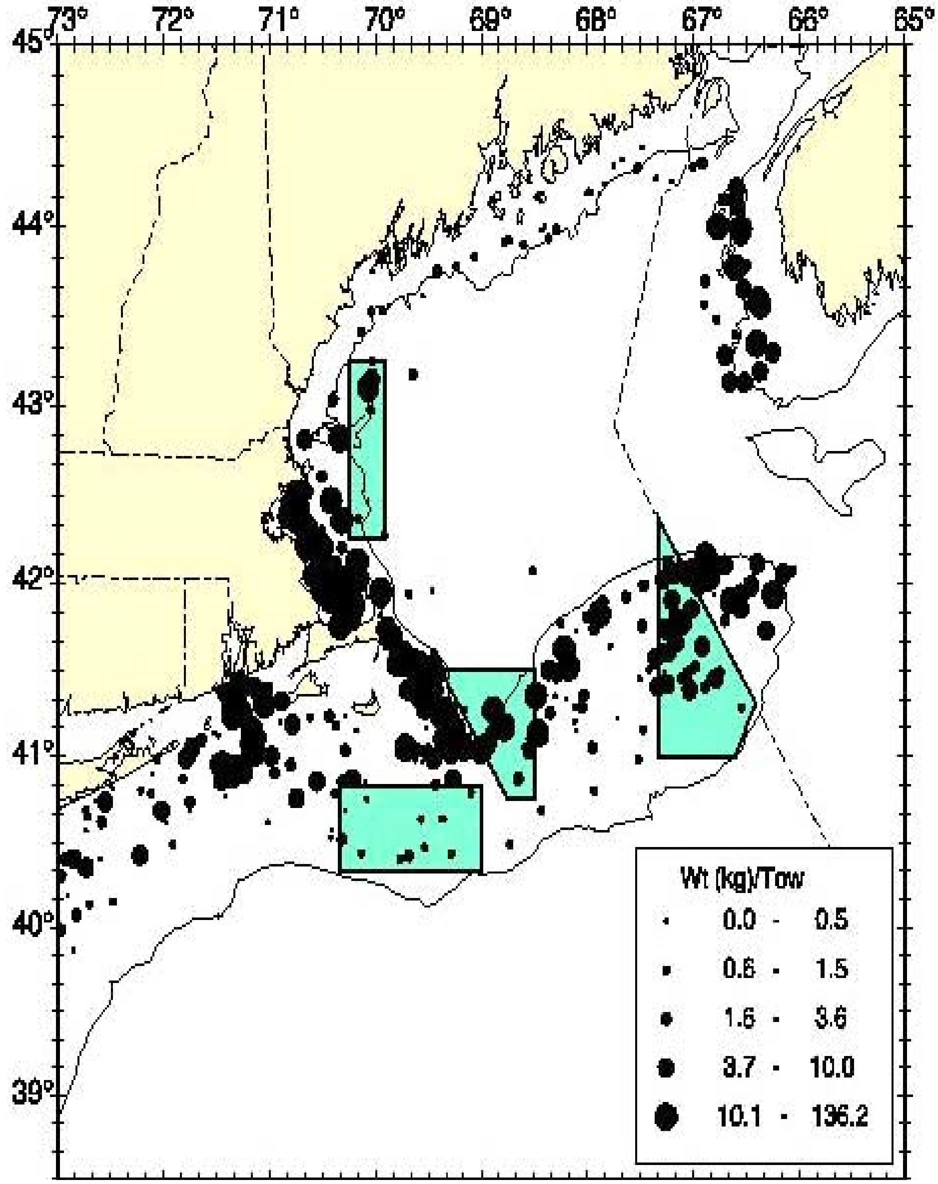

Figure B2.15. Distribution of winter flounder during the NEFSC fall bottom trawl surveys from 1995-1999.

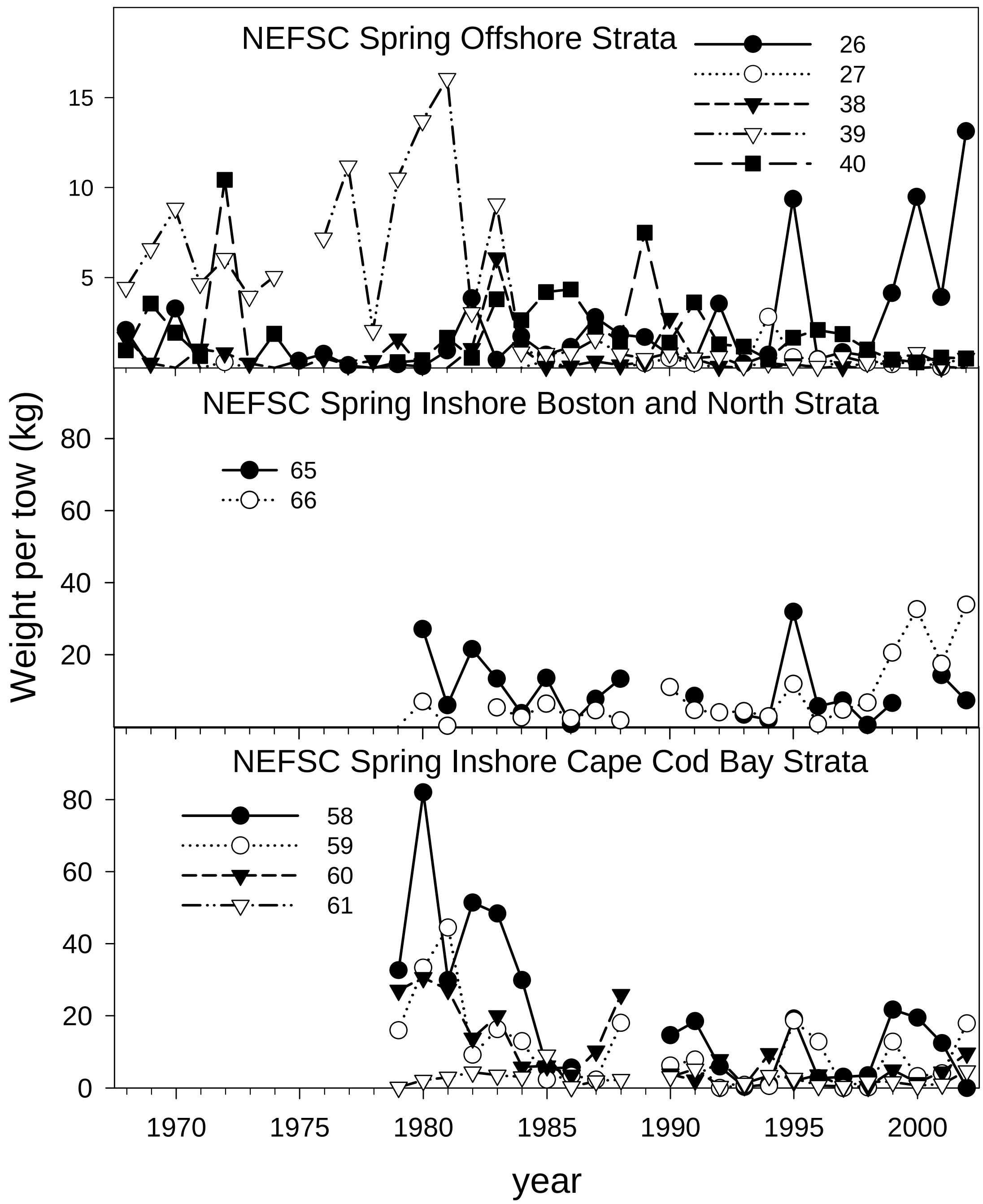

Figure B2.16. NEFCS spring Gulf of Maine winter flounder weight per tow trends among strata.

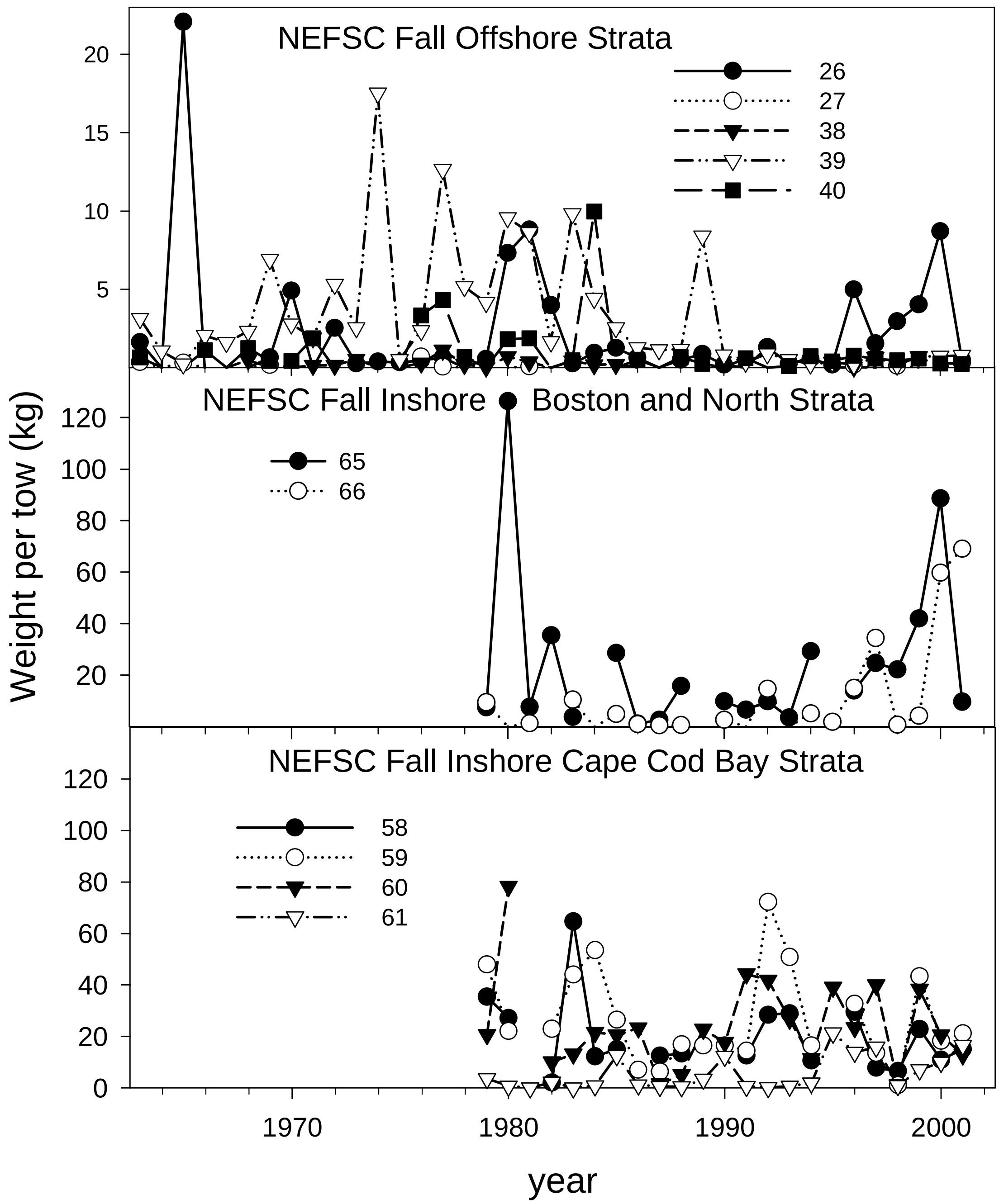

Figure B2.17. NEFCS fall Gulf of Maine winter flounder weight per tow trends among strata.

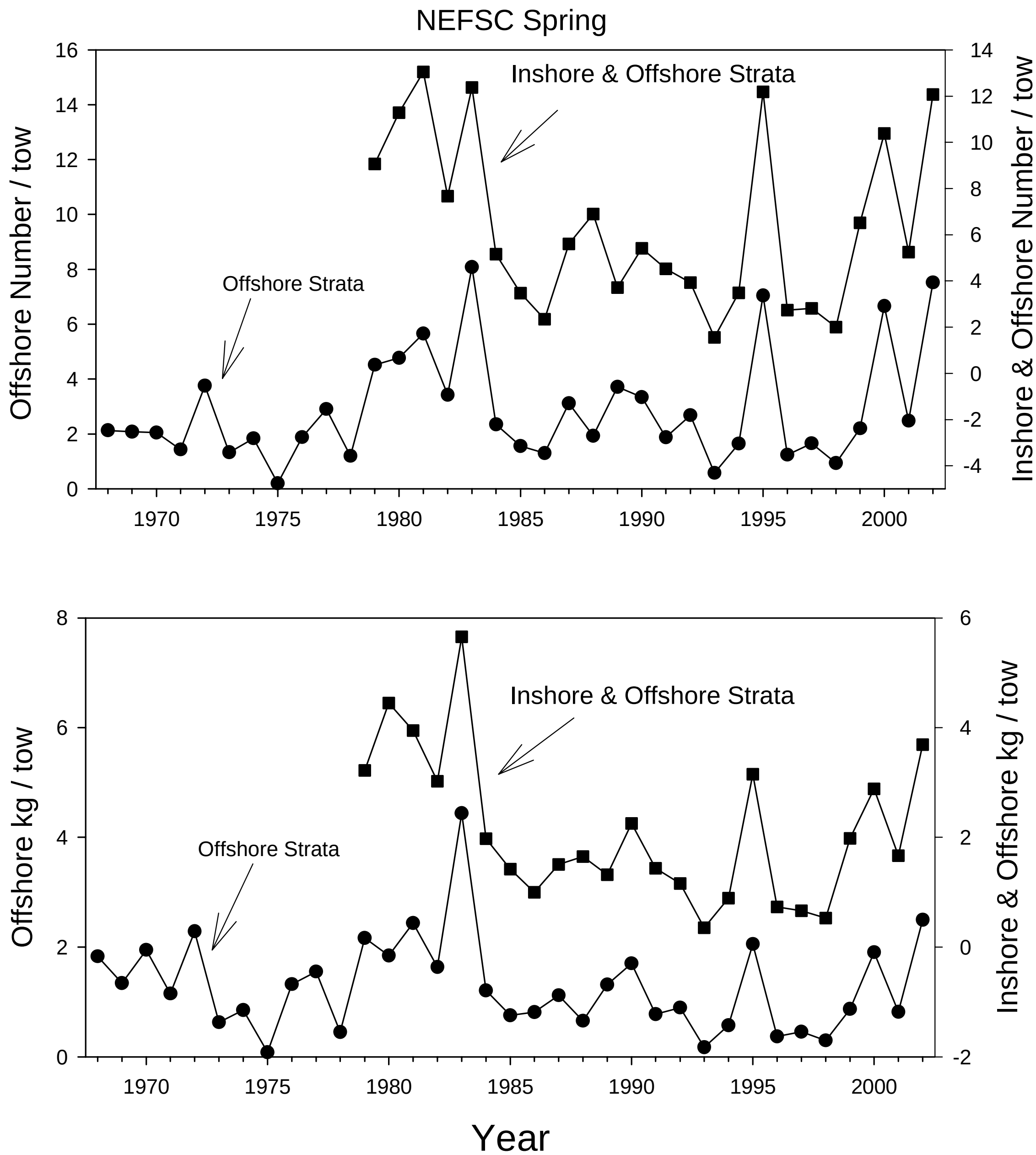

Figure B2.18. NEFSC spring offshore and inshore/offshore survey stratified mean number and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate.

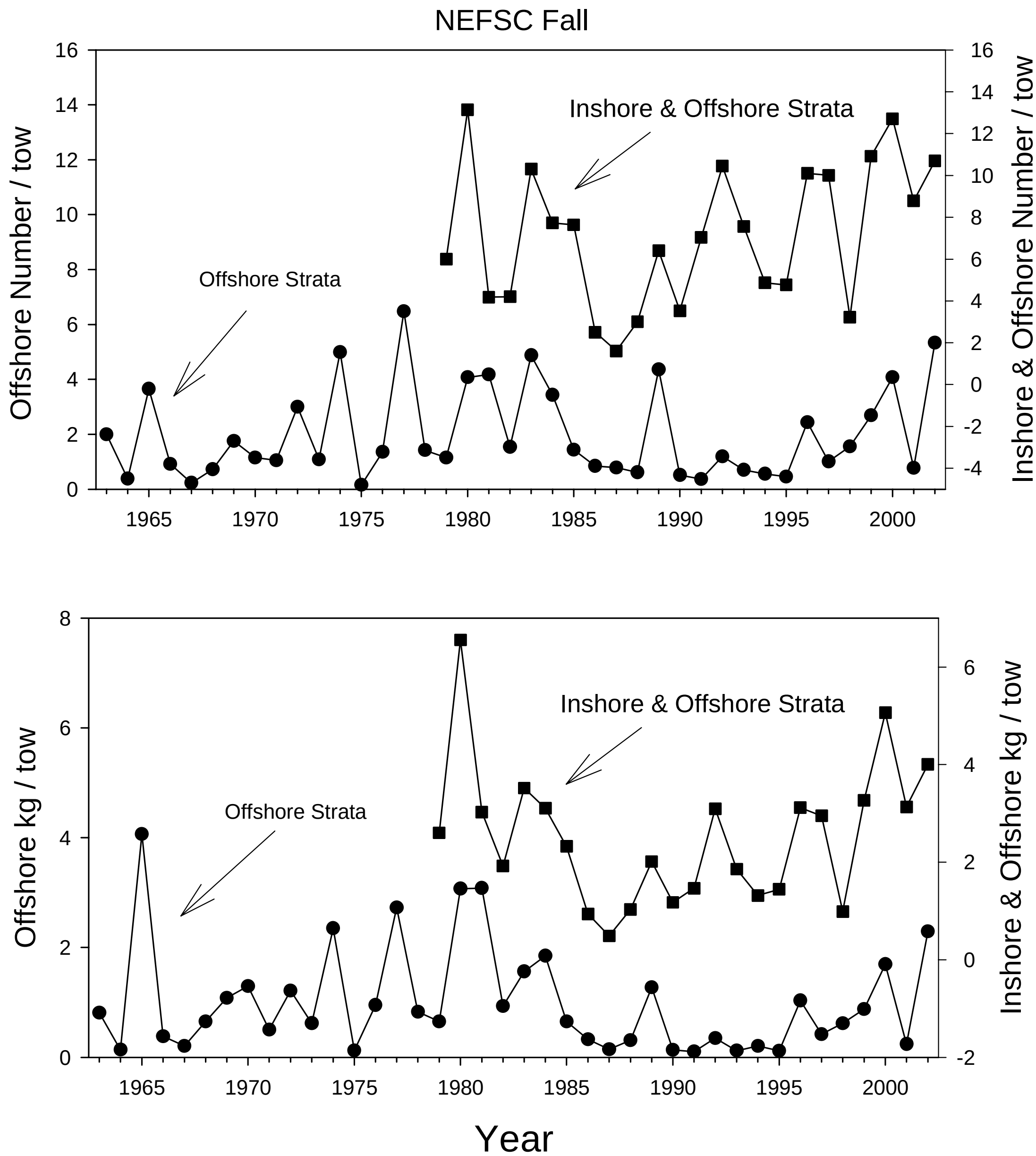

Figure B2.19. NEFSC Fall offshore and inshore/offshore survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder. Trawl door conversion factors are use where appropriate. Data for 2002 is preliminary.

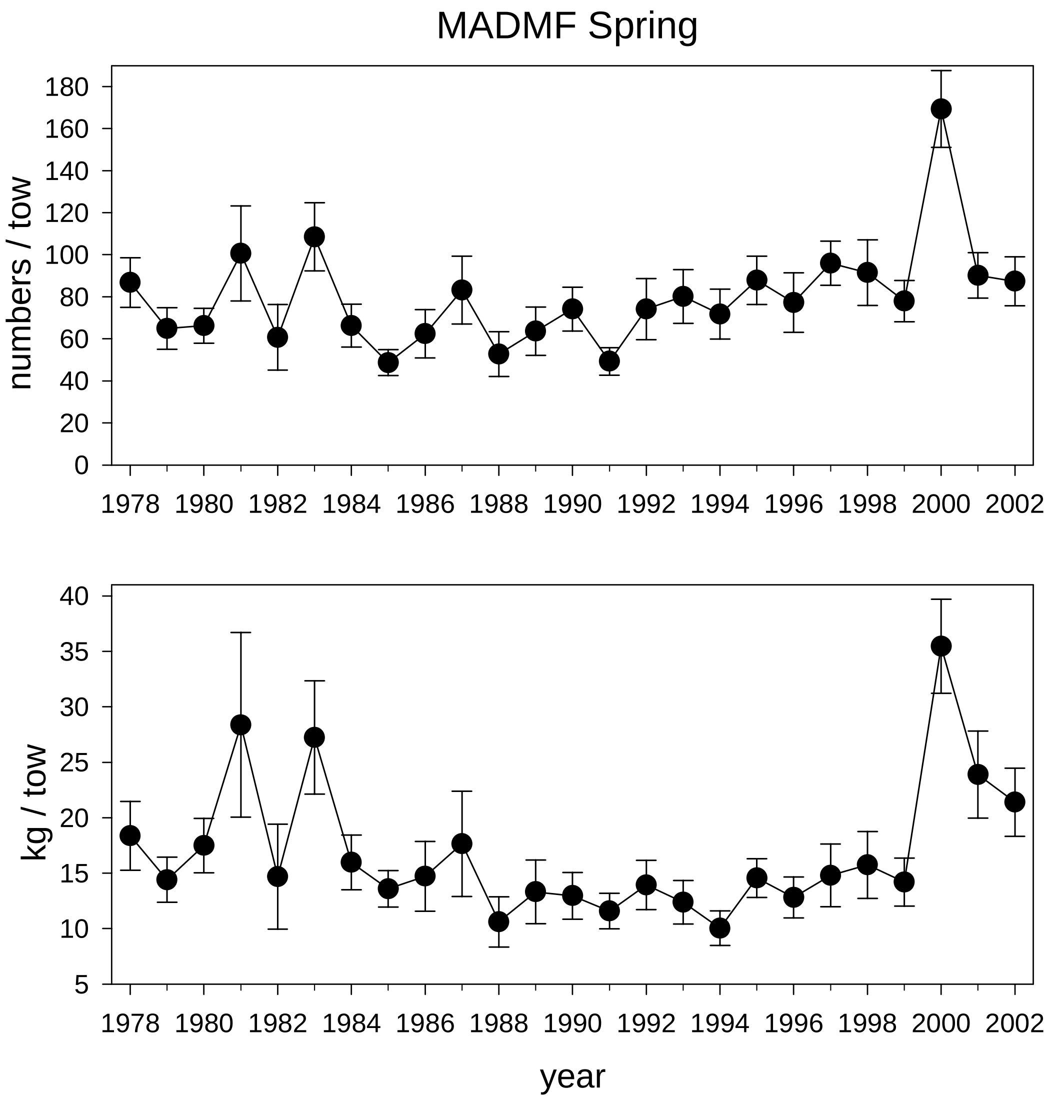

Figure B2.20. Massachusetts Division of Marine Fisheries (MADMF) spring survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

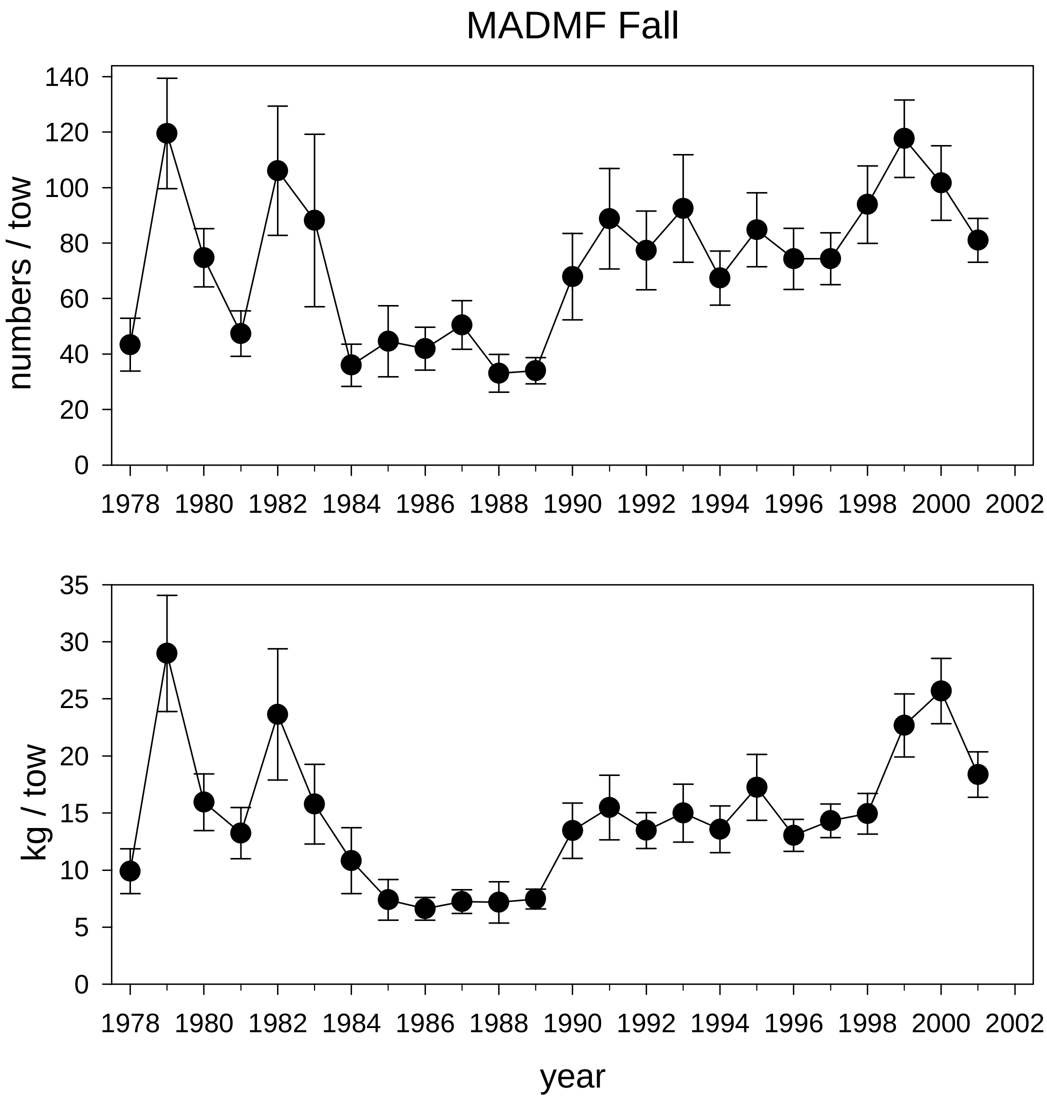

Figure B2.21. Massachusetts Division of Marine Fisheries (MDMF) fall survey stratified mean numbers and mean weight (kg) per tow for Gulf of Maine winter flounder.

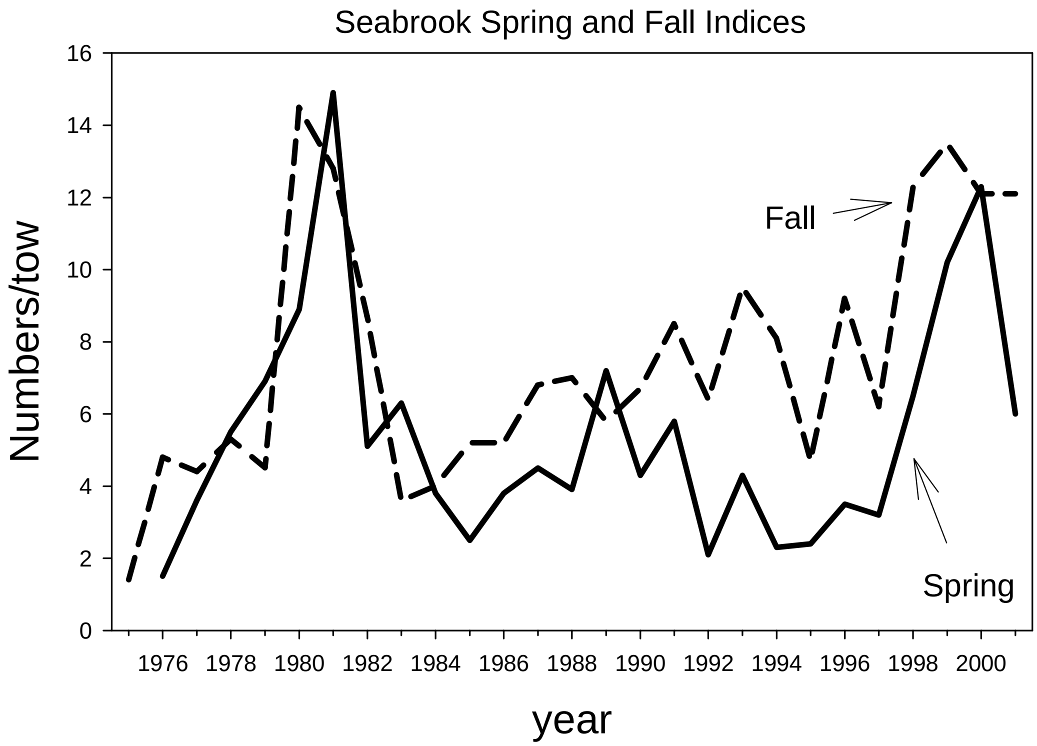

Figure B2.22. Seabrook Nuclear Power Plant in New Hampshire spring and fall survey mean numbers per tow for Gulf of Maine winter flounder. No length data exists from 1975 to 1984 and 1993.

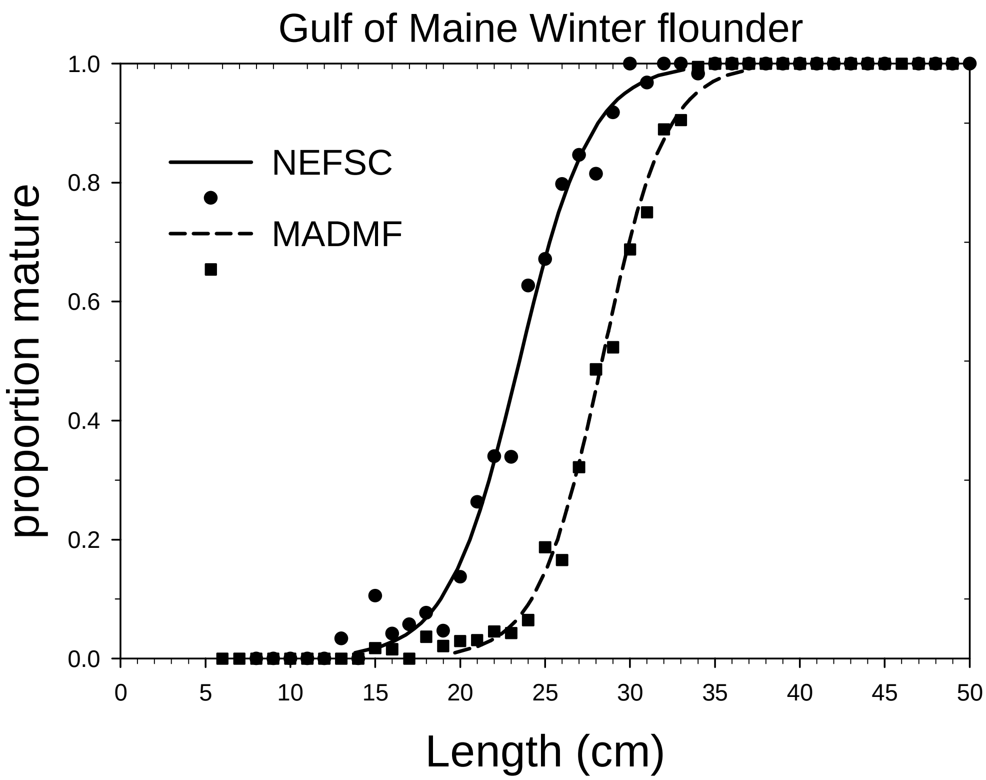

Figure B2.23. Comparison of Gulf of Maine winter flounder maturity ogives (sexes combined) estimated from the MADMF spring survey (strata 25-36) and the spring NEFSC survey data limited in inshore MA strata 58-66.

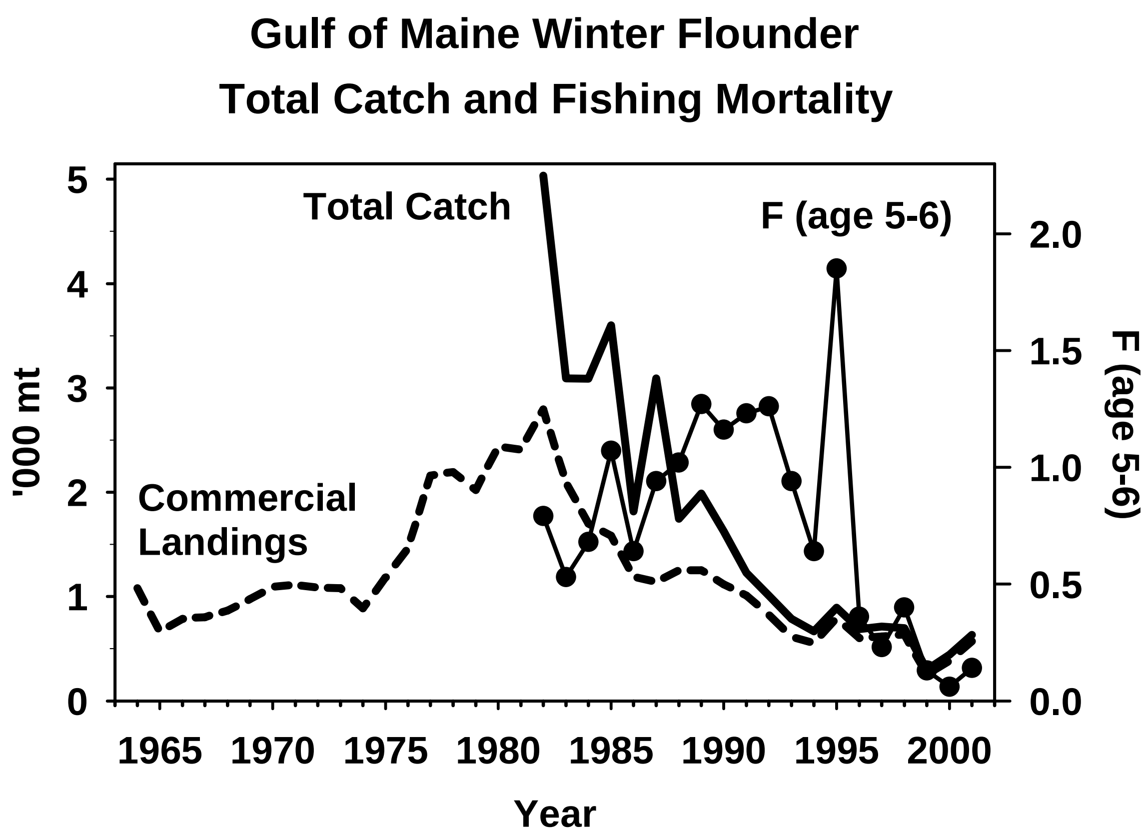

Figure B2.24. Total catch (landings and discards, '000 mt), commercial landings ('000 mt), and fishing mortality rate (F, ages 5-6, unweighted) for Gulf of Maine winter flounder.

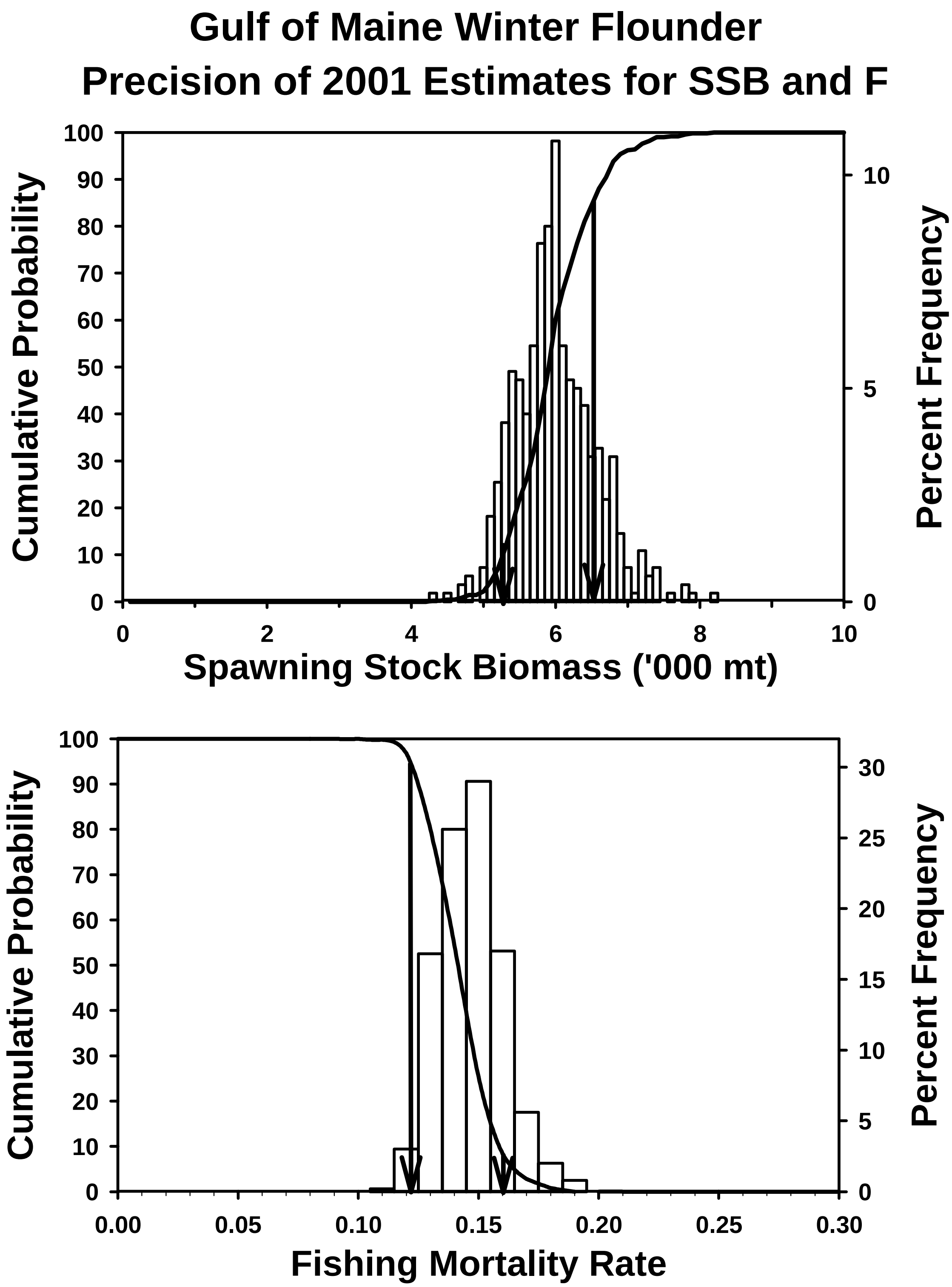

Figure B2.25. Precision of estimates of spawning stock biomass ('000 mt) and fishing mortality rate (F, ages 5-6, unweighted) in 2001 for Gulf of Maine winter flounder. Vertical bars display the range of the bootstrap estimates and the probability of individual values in the range. The solid curve gives the probability of SSB that is less or fishing mortality that is greater than any value along the X axis.

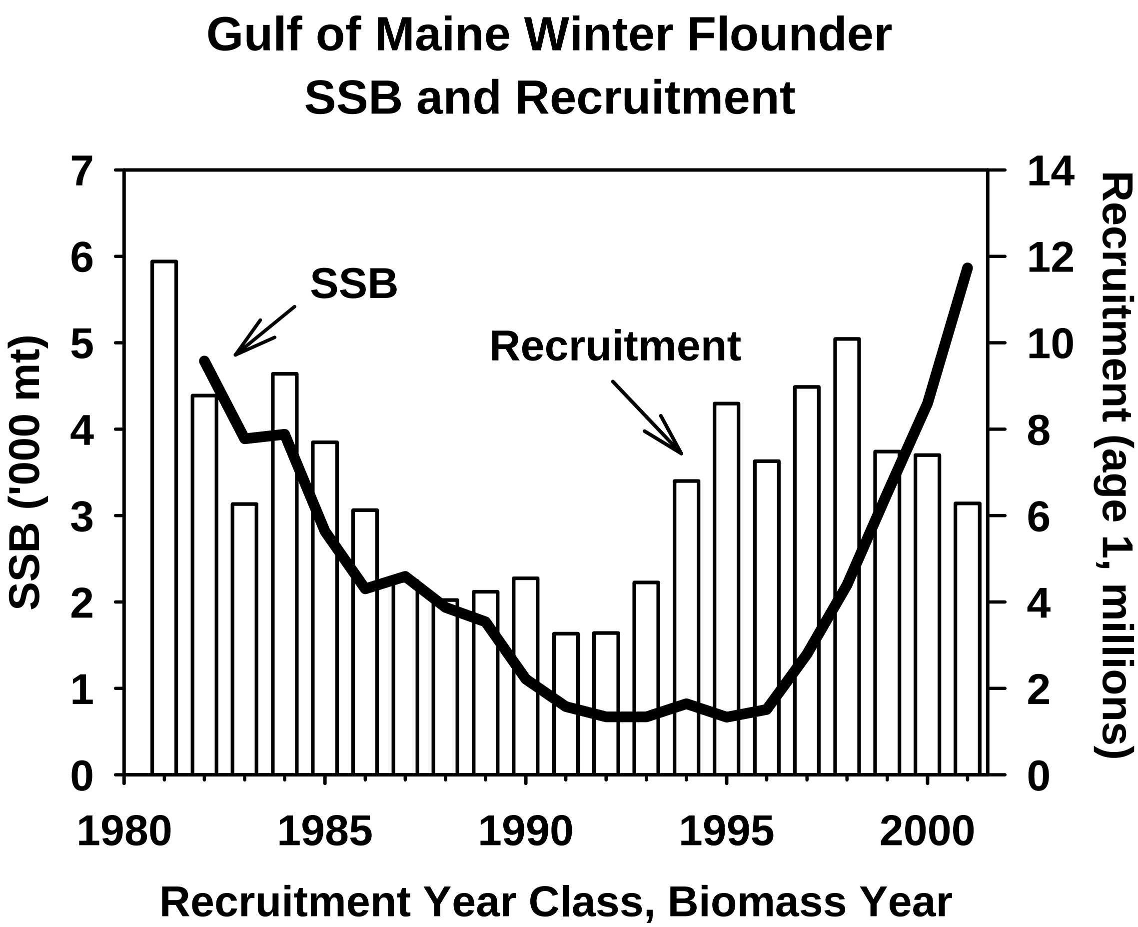

Figure B2.26. Spawning stock biomass (SSB, '000 mt) and recruitment (millions of fish at age-1) for Gulf of Maine winter flounder.

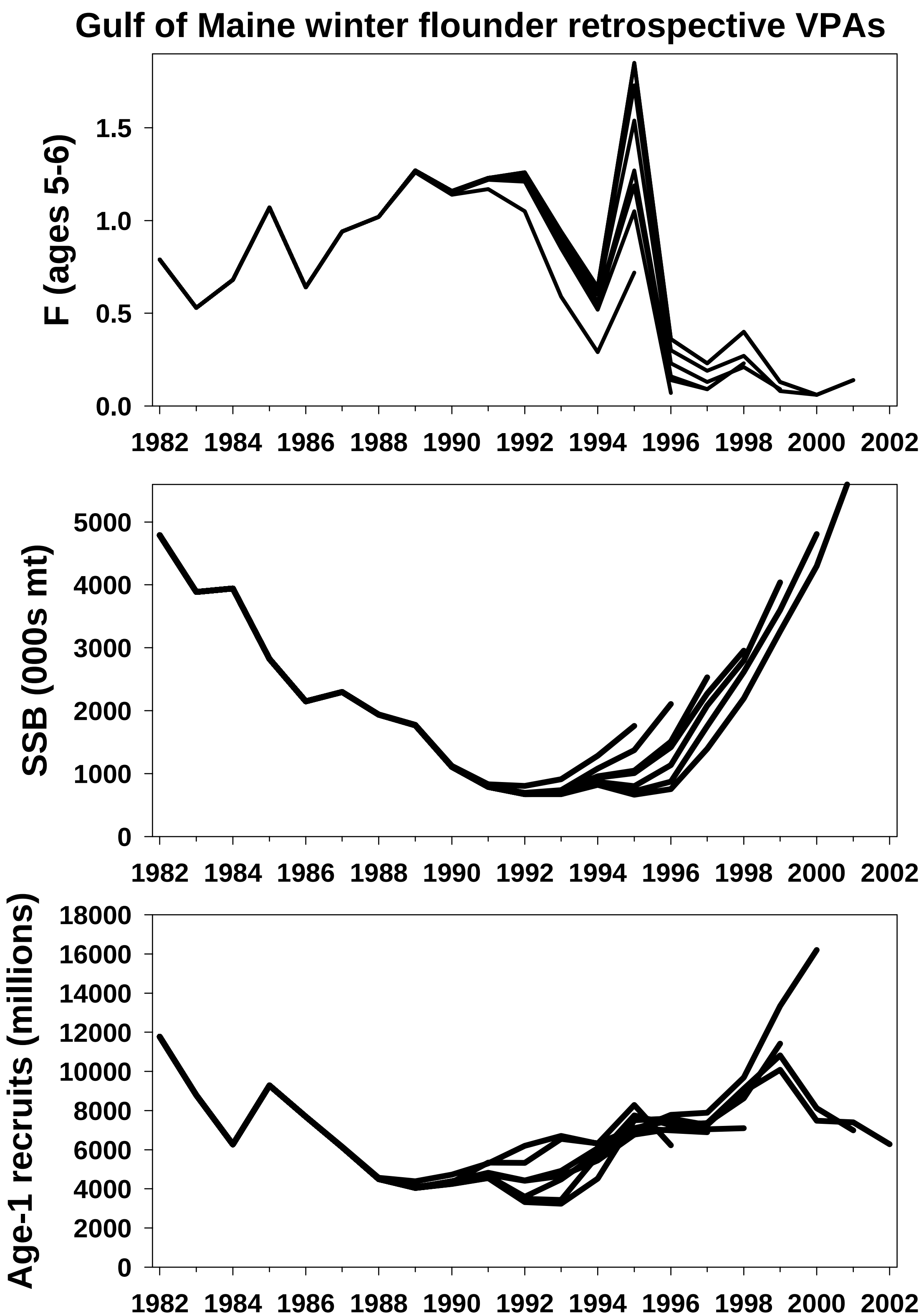

Figure B2.27. Retrospective VPAs for Gulf of Maine winter flounder.

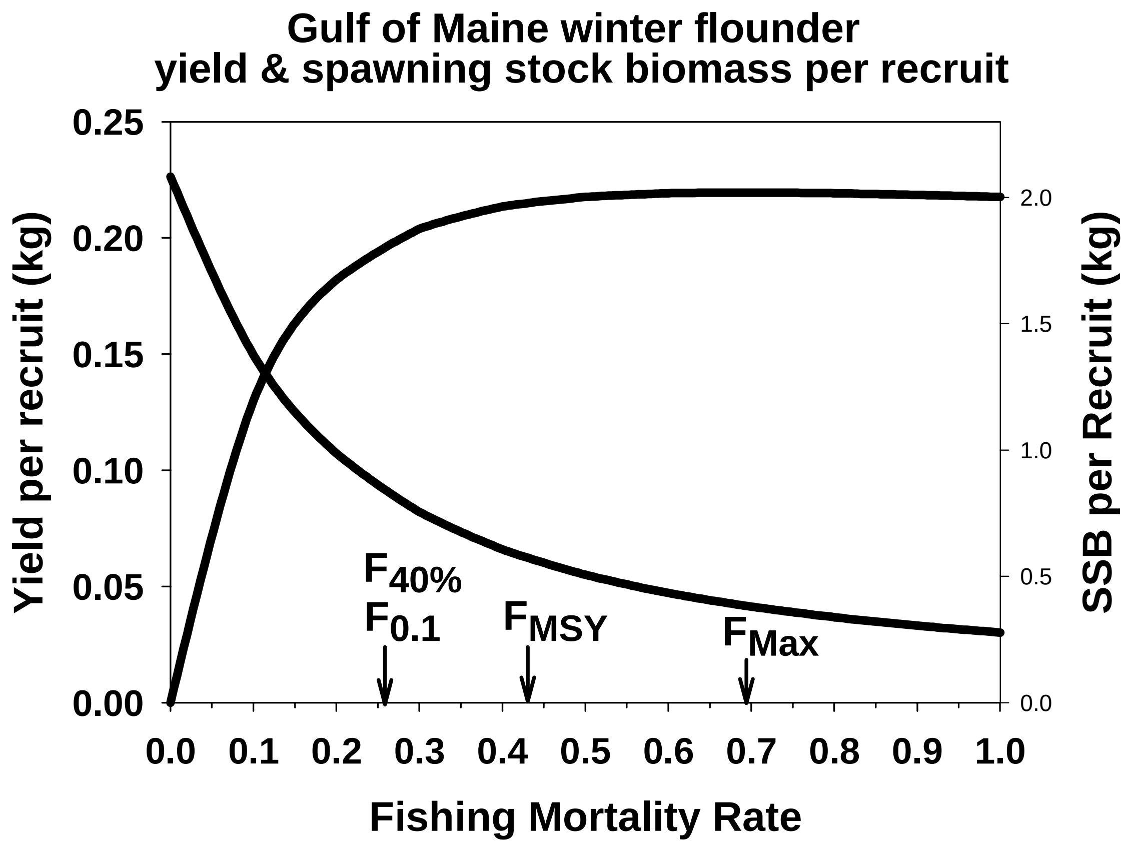

Figure B2.28. Yield and spawning stock biomass per recruit estimates for Gulf of Maine winter flounder.

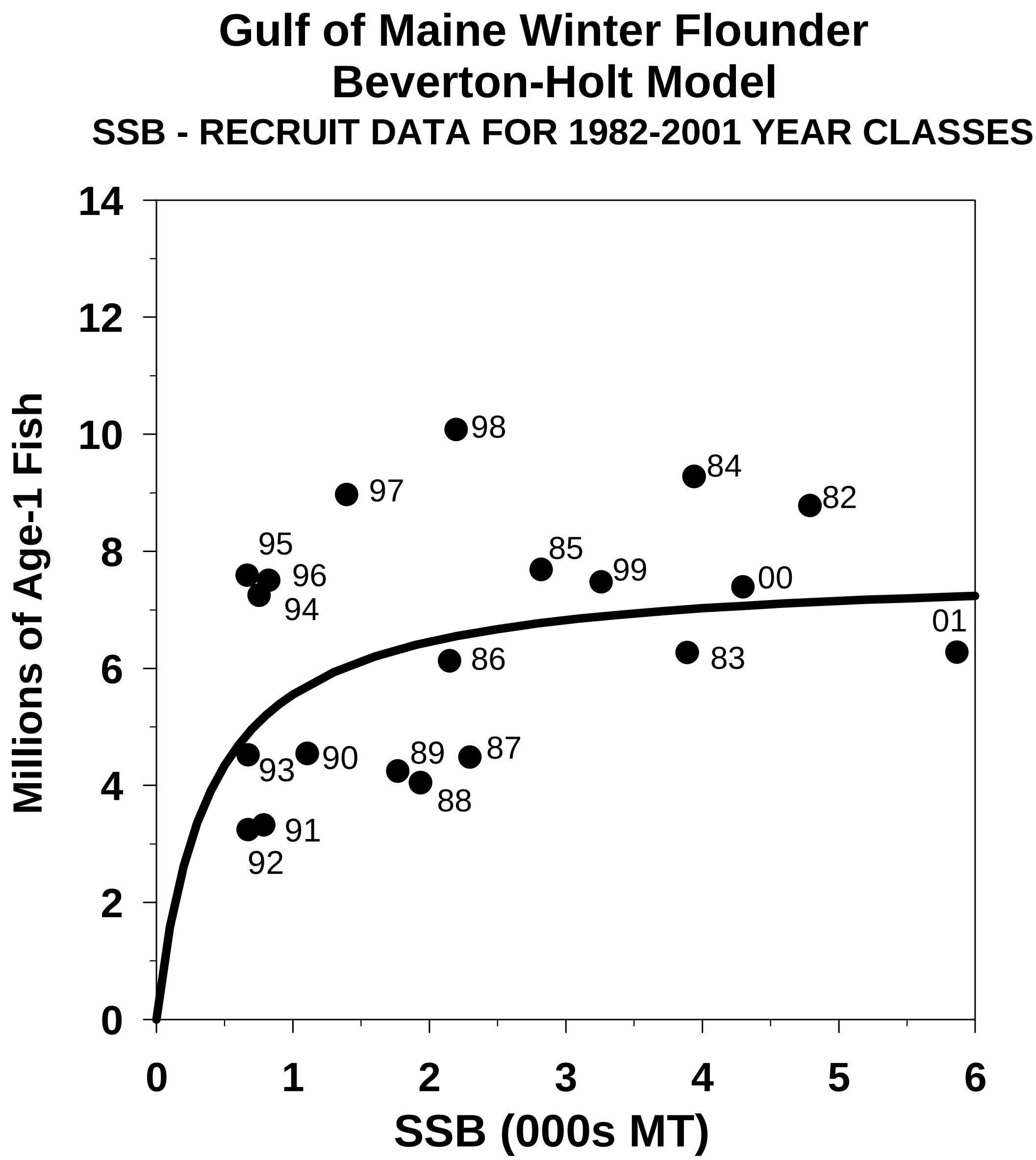

Figure B2.29. Beverton-Holt stock-recruitment model for Gulf of Maine winter flounder.

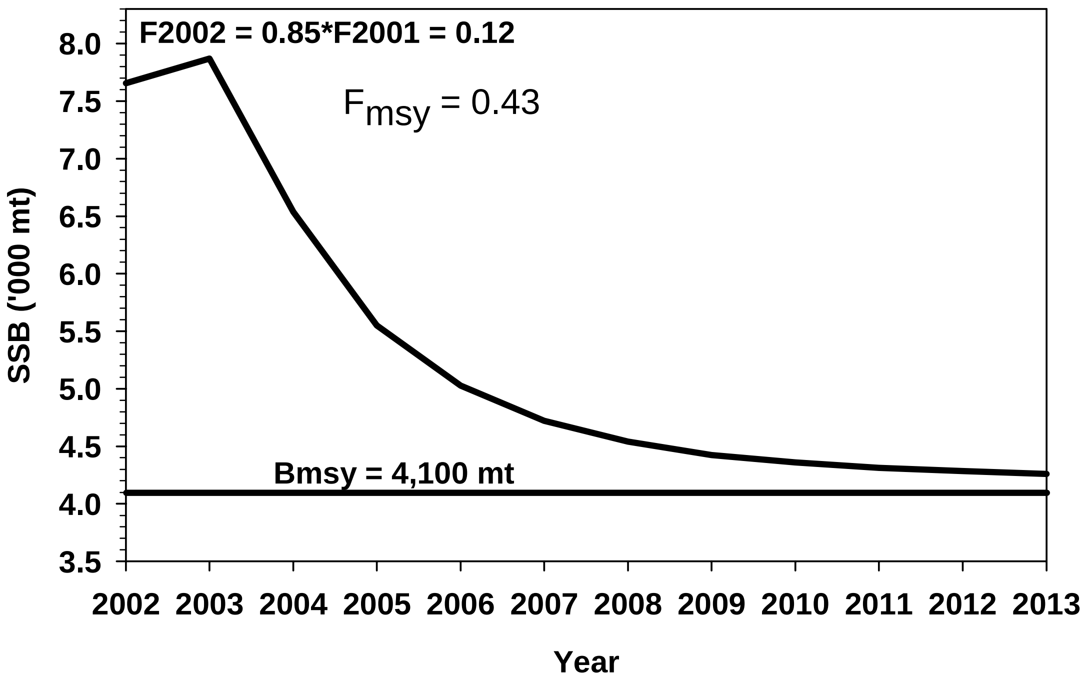

Figure B2.30. Median (50% probability) of forecast spawning stock biomass (SSB, mt) for Gulf of Maine winter flounder assuming F2002 = 0.85*F2001 = 0.12 and Fmsy fishing mortality rates during 2003-2013.

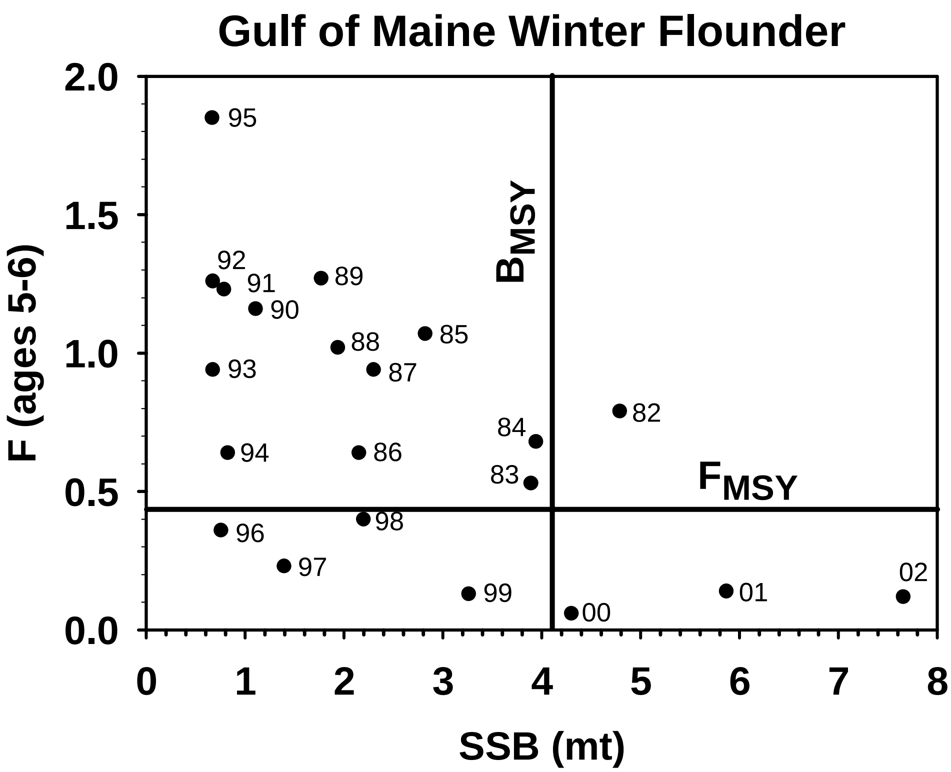

Figure B2.31. SSB and F (ages 5-6) for Gulf of Maine winter flounder. Biological reference points calculated from the Beverton-Holt model are also shown.

C. GULF OF MAINE NORTHERN SHRIMP

Terms of Reference

1. Characterize the commercial and recreational catch including landings and discards.
2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates.
3. Evaluate methodologies for the development of biological reference points for Northern Shrimp.

Introduction

1.0 Management

The Gulf of Maine fishery for northern shrimp (*Pandalus borealis*) is managed through interstate agreement among the states of Maine, New Hampshire and Massachusetts. The management unit is defined as the northern shrimp resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the shoreline to the seaward boundary of the EEZ. It is also recognized that the northern shrimp fishery, as defined here, is interstate and state-federal in nature, and that effective assessment and management can be enhanced through cooperative efforts with state and federal scientists and fishery managers. The management framework evolved from 1972 to 1979 under the auspices of the State/Federal Fisheries Management Program. In 1980, this program was restructured in the Northeast Region as the Interstate Fisheries Management Program of the ASMFC (McInnes 1986). Within the interstate structure, the Northern Shrimp Technical Committee (NSTC) provides annual stock assessments and related information to the ASMFC Northern Shrimp Section, which is the management body that establishes the annual fishing regulations. The management tools currently available to the Section include season length (within a time frame of December 1 through May 31) and gear restrictions.

1.1 Assessment

Stock assessments initially consisted of total landings estimates, indices of abundance from Northeast Fishery Science Center (NEFSC) groundfish surveys, fishing mortality estimates from the application of cohort slicing of length frequencies from the State of Maine survey, and yield per recruit modeling (Clark and Anthony 1980; Clark 1981, 1982). The NSTC unified individual state port sampling programs in the early 1980s to better characterize catch at length and developmental stage (sex and maturity), and established a dedicated research trawl survey for the species in the summer of 1983 to monitor relative abundance, biomass, size structure and demographics of the stock. Subsequent stock assessments provided more detailed description of landings, size composition of catch, patterns in fishing effort, catch per unit effort, relative year class strength and survey indices of total abundance and biomass. Length distributions from the summer shrimp survey have been used for size composition analysis to estimate mortality rates, but did not fit the length-based models well because of variable recruitment and growth (Terceiro and Idoine 1990, Fournier et al. 1991).

Beginning in 1997, the northern shrimp stock in the Gulf of Maine has been evaluated more quantitatively using three analytical models that incorporate much of the available data:

1. Collie-Sissenwine analysis that tracks removals of shrimp using summer survey indices of recruits and fully-recruited shrimp scaled to total catch in numbers (from dealers' reports and port sampling);
2. A surplus production analysis that models the biomass dynamics of the stock with a longer times series of total landings and three survey indices of stock abundance;
3. A yield-per-recruit (YPR) model and an eggs-per-recruit (EPR) model that simulate the life history of northern shrimp (including growth rates, transition rates, natural mortality, and fecundity) and fishing mortality on recruited shrimp. It uses estimates of trawl selectivity to estimate yield and egg production at various levels of fishing mortality, providing guidance on what levels of fishing are most productive and sustainable.

2.0 Life History

Northern shrimp (*Pandalus borealis*) are protandric (sequential) hermaphrodites, maturing first as males at roughly 2½ years of age and then transforming to females at roughly 3½ years of age. In the Gulf of Maine, spawning takes place in offshore waters beginning in late July. By early fall, most adult females extrude their eggs onto the abdomen. Egg bearing females move inshore in late autumn and winter, where the eggs hatch. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where they mature as males. The exact extent and location of these migrations is variable and unpredictable. The males pass through a series of transitional stages before maturing as females. Some females may survive to repeat the spawning process in succeeding years. The females are the individuals targeted in the Gulf of Maine fishery. Natural mortality seems to be most pronounced immediately following hatching, and it is believed that most shrimp do not live past age 5.

Several year classes in the last decade have shown some percentage of 2½ year old shrimp maturing as females instead of males. This presents both sexes in the same year class and may be a reaction to stress in the population as predicted by sex allocation theory (Charnov et al, 1978), or may be temperature or density driven (Apollonio et al, 1984, Koeller et al, 2000). In the 2001 year class, there is some evidence of early-maturing females appearing at 1½ years (Figure 12), which is unprecedented in the Gulf of Maine.

3.0 Fishery Description

Northern shrimp occur in boreal and sub-arctic waters throughout the North Atlantic and North Pacific, where they support important commercial fisheries. In the western North Atlantic, commercial concentrations occur off Greenland, Labrador, and Newfoundland, in the Gulf of St. Lawrence, and on the Scotian Shelf. The Gulf of Maine marks the southernmost extent of its Atlantic range. In the Gulf of Maine, primary concentrations occur in the western Gulf where bottom temperatures are coldest. In summer, adults are most common at depths of 90-180 meters.

The fishery has been seasonal in nature, peaking in late winter when egg-bearing females move into inshore waters and terminating in spring under regulatory closure. Northern shrimp has been an accessible and important resource to fishermen working inshore areas in smaller vessels who otherwise have few options due to seasonal changes in availability of groundfish, lobsters and other species.

The fishery formally began in 1938, and during the 1940s and 1950s almost all of the landings were by Maine vessels from Portland and smaller Maine ports further east. This was an inshore winter fishery, directed towards egg-bearing females in inshore waters (Scattergood 1952). New Hampshire vessels entered the fishery in 1966, but throughout the 1960s and 1970s New Hampshire landings were minor. Landings by Massachusetts' vessels were insignificant until 1969, but in the early 1970s the fishery developed rapidly, with MA landings increasing from 14% of the Gulf of Maine total in 1969 to over 40% in 1974-1975. In contrast to the historical wintertime Maine fishery, these vessels fished continually throughout the year and made significant catches during summer months

A wide variety of vessels have been used in the fishery (Bruce 1971; Wigley 1973). The predominant type during the 1960s and 1970s appears to have been side-rigged trawlers in the 14-23 m range. During the 1980s and 1990s, side trawlers either re-rigged to stern trawling, or retired from the fleet. Currently, the shrimp fleet is comprised of lobster vessels in the 9-14 m range that re-rig for shrimping, small to mid-sized stern trawlers in the 12-17 m range, and larger trawlers primarily in the 17-24 m range. The otter trawl remains the primary gear employed and is typically chain or roller rigged, depending on area and bottom fished. There has been a trend in recent years towards the use of heavier, larger roller and/or rockhopper gear. These innovations, in concert with substantial improvements in electronic equipment, have allowed for much more accurate positioning and towing in formerly unfishable grounds, thus greatly increasing the fishing power of the Gulf of Maine fleet.

A small pot fishery has also existed in mid-coastal Maine since the 1970s, where in many areas bottom topography provides favorable shrimp habitat yet is too rough or restricted for trawling. The trapped product is of good quality, as the traps target only female shrimp once they have migrated inshore. The trap fishery has landed as much as 9% of the landed total, but the annual average is usually around 5%. There is some indication that trap fishing for shrimp has grown in a few areas such as South Bristol (Lower mid-coast Maine). As the trap fishery is dependent on the availability of shrimp in a specific area, there is apparently a shorter season for traps than for draggers. The majority of the shrimp trappers also trap lobsters.

Management measures currently in place include season length (varying from year to year within a time frame of December 1 through May 31), gear restrictions, licensing, and mandatory reporting. Legal restrictions on trawl gear require a minimum 1.75 inch stretch mesh net and the use of a finfish separator device known as the "Nordmore grate" with a maximum grate spacing of 1 inch.

4.0 Habitat Description

Pandalus borealis has a discontinuous distribution throughout the North Atlantic, North Pacific, and Arctic Oceans. In the Gulf of Maine, northern shrimp populations comprise a single stock (Clark and Anthony 1981), which is concentrated in the southwestern region of the Gulf (Haynes and Wigley 1969; Clark et al 1999). Water temperature, depth, and substrate type have all been cited as important factors governing shrimp distribution in the Gulf of Maine (Haynes and Wigley 1969; Apollonio et al. 1986; Clark et al. 1999).

Temperature

The most common temperature range for this species is 0-5 °C (Shumway et al 1985). The Gulf of Maine marks the southern-most extent of this species' range in the Atlantic Ocean, and seasonal water temperatures in many areas regularly exceed the upper physiological limit for northern shrimp. This environmental limitation restricts the amount of available habitat occupied by this species to the western region of the Gulf (west of 680 W) where bottom topography and oceanographic conditions create submarine basins protected from seasonal warming by thermal stratification. The deep basins act as cold water refuges for adult shrimp populations (Apollonio et al 1986). In the northeastern region of the Gulf, large shrimp populations do not persist because bottom waters are not protected from seasonal warming due to continual mixing from intense tidal currents nearer to the Bay of Fundy.

Depth

In the Gulf of Maine, northern shrimp are most frequently found from about 10 m to over 300 m (Haynes and Wigley 1969), with juveniles and immature males occupying shallower, inshore waters and mature males and females occupying cooler, deeper offshore waters for most of the year (Apollonio and Dunton 1969; Haynes and Wigley 1969, Apollonio et al 1986). During the summer months, adult shrimp inhabit water from 93-183 m (Clark et al. 1999); ovigerous female shrimp are found in shallower near-shore waters during the late winter and spring (Clark et al. 1999) when their eggs are hatching.

Substrate

Within its preferred temperature range, northern shrimp most commonly inhabit organic-rich, mud bottoms or near-bottom waters, where they prey on benthic invertebrates; however, the shrimp is not limited to this habitat and has been observed on rocky substrates (Schick 1991). Shrimp distribution in relation to substrate type determined by spring, summer, and autumn fisheries-independent trawl surveys clearly show northern shrimp primarily occupy areas with fine sediments (sand, silt, and clay). Shrimp are often associated with biotic or abiotic structures such as cerianthid anemone

(Langton and Uzmann 1989) and occasional boulders in these fine sediment habitats (Daniel Schick, Maine Department of Marine Resources, pers. comm.).

5.0 Data Sources

5.1 Commercial

5.1.1 Data Collection Methods

Commercial landings by state and month have been compiled by NMFS port agents from dealer reports. It is likely that catches sold to the small "peddler" market have been unreported, as well as some of those sold to those dealers (non-federally permitted) who are not required to report. These data were used for annual stock assessments until 2001, when vessel trip reports (VTRs) were found to be more complete. Small Maine vessels that did not have federal permits were not required to fill out VTRs until 2000. Landings have been calculated from VTRs for use in assessments in 2001 and 2002.

A port sampling program was established in the early 1980s to characterize catch at length and developmental stage, as well as to collect effort and fishing depth and location data. Samplers strive to achieve representative sampling by maintaining up-to-date lists of active buyers and visiting ports in proportion to their landings activity. Sampling consists of interviewing boat captains and collecting a 1 kg sample of shrimp from each catch. The samples are separated and weighed back at the lab by species, sex and development stage. Measurements are made of all shrimp dorsal carapace lengths to the nearest half mm. The numbers of shrimp measured, and a calculation of sampling intensity are shown in Tables 2 and 3.

5.1.2 Landings

Small quantities of northern shrimp have been incidentally caught in New England otter trawl fisheries since 1905 (Scattergood 1952). A directed winter fishery in coastal waters developed in the late 1930s, which landed an annual average of 63 mt from 1938 to 1953, but no shrimp were landed from 1954 to 1957 due to low inshore availability (Wigley 1973; Table 1a). The fishery resumed in 1958, and landings increased steadily to a peak of 12,100 mt during the 1969 season (August 1968 to July 1969) as an offshore, year-round fishery expanded. After 1972, landings declined rapidly, and the fishery was closed in 1978. The fishery reopened in 1979 and seasonal landings increased gradually to 5,300 mt by 1987 and averaged 3,300 mt from 1988 to 1994 (Table 1a&b). Seasonal landings increased to 6,500 mt in 1995 and to 9,200 mt in 1996, which was only exceeded by the five years of landings prior to the late 1970s stock collapse. Landings declined between 1996 and 1999 to 1,900 mt. This was followed by a slight increase to 2,400 mt in the 2000 season. Landings dropped during 2001 to 1,400 mt and in 2002 to a low of 400 mt for the 25-day 2002 season. The 2002 landings were the lowest northern shrimp landings since the fishery was closed in 1978 (Table 1a, Figure1).

Maine landings comprised 75% of season totals during 1984-1996. The proportional distribution of landings among the states has shifted gradually since the 1980's when Massachusetts accounted for about 30% of the catch. In 2001 and 2002, the proportional distribution of landings was still greatest for Maine but was then followed by NH with 18% (2001) and 13% (2002). Massachusett's landings made up 5% of the 2001 landings and 1.5% of the landings in 2002 (Tables 1a&b). The majority of landings generally occur in January and February (Table 1b, Figure 2). Since the 1999 season, there has been a reduction in the number of months fished.

Size composition data (Figures 3, 4a&b), collected since the early 1980's, indicate that trends in landings have been determined primarily by recruitment of strong (dominant) year classes. Landings more than tripled with recruitment of a strong 1982 year class in 1985 and 1986. The 1987 season landings were supported in large part by mature females (assumed age 5) from the 1982 year class. Landings declined sharply in 1988 with the passage of the 1982 year class through the fishery. A strong 1987 year class began to recruit to the fishery in spring of 1989 and was a major contributor to the 1990-1992 fisheries. The 1992 year class was the first year class of notable size since 1987 and began recruiting to the fishery in March and April 1995. The 1992 year class was supplemented by a moderate sized 1993 year class, which partially supported the relatively large annual landings in 1995, 1996 and 1997. The early months of the 1998 season showed high catches from the last of the 1993 year class coming ashore as second year females. Landings were low in the 1999 season due to very poor recruitment in 1994 and 1995, and moderate recruitment in 1996. The increase in landings observed in 2000 was dominated by first year berried females from the 1996 year class. The poor landings observed in 2001 were composed primarily of egg-bearing females from the 1996 yearclass landed early in the season, and males caught in January, March, and April, the males accounting for approximately 30% of the catch during these months and representing the 1999 year class. In the 2002 fishery, the 1997 and 1998 yearclasses (4- and 5- year old females) continued to be weak, and the moderate 1999 yearclass (3-year old males, transitionals, and early-maturing females) dominated the catches. Two-year old shrimp (2000 yearclass) were generally absent, but a noticeable quantity of 1-year-old shrimp (2001 yearclass) were caught (Figures 3, 4a).

Landings from January to March consist primarily of mature female shrimp (presumably ages 3 and older) and December, April, and May landings have included higher proportions of males (assumed ages 1 and 2; Figure 4b). These patterns reflect shifts in distribution of fishing effort in response to seasonal movements of mature females: inshore in early winter and offshore after their eggs hatch.

Catch in numbers was derived by dividing landed weight (Table 1b) by mean individual weights (Table 4) by year, state, and month. The general patterns in size composition of landings are reflected in mean weight of individual shrimp landed by year, state, and month: the size of landed shrimp generally increases from December to January, peaks in February, and decreases through the spring. Three percent of total landings for 1984-1996, were from specific year-state-month strata with no port samples, generally at the beginning or the end of a fishing season. Mean weight for these non-sampled landings was estimated by a general linear model of mean weight incorporating year, month and state effects. Some June landings, which had no associated port samples (126 mt, 0.2% of total time series landings), were described using May samples within the same year and state.

5.1.3 Commercial Discards and Bycatch

Sea sampling observations on shrimp otter trawl trips from 1984 to 1996 indicate that weight of discards is less that 1% of total catch in all years (Table 5). Large year classes appear to contribute some discards as age-2 (e.g., the 1992 cohort produced almost 1% discards in 1994). Industry representatives report substantial discards of shrimp in the small-mesh whiting fishery east of Jeffreys Ledge. Sea sampling observations from finfish trawl fisheries in the Gulf of Maine suggest that bycatch of northern shrimp was inconsequential from 1984-1994. However, in 1995 and 1996 the amount of discarded shrimp per trip increased considerably, and the increase was from small-mesh trips sampled in the area of Jeffreys Ledge. Although the observed discards increased, the total was less than 60 kg per observed trip. Unfortunately, no shrimp lengths were measured during sea sampling, and estimates of total number discarded would be difficult.

5.1.4 Commercial Catch Rates and Fishing Effort

Maine trapping operations accounted for 4% to 8% of the state's total number of trips from 1987 to 1994, and for 15.9, 16.9, and 18.0% in 2000, 2001, and 2002 respectively, according to 2000-2002 Vessel Trip Report (VTR) data.

Since the late 1970's, effort in the fishery (measured by numbers of trips in which shrimp gear is used) has increased and then declined on two occasions. The total number of trawl trips in the fishery peaked at 12,285 during the 1987 season (Table 6, Figure 5). Increases in season length, shrimp abundance and record ex-vessel prices coupled with reduced abundance of groundfish all contributed to this increase. Effort subsequently fell to an average of 9,500 trips for the 1988, 1989, and 1990 seasons, fell further to an average of 7,900 trips in the 1991 and 1992 seasons, and declined to 6,000 trips in the 1994 season. Effort nearly doubled between 1994 and 1996 and then declined again from the 1996 level of 11,791 to 3,811 trips in 1999, 3,335 in 2000, 3,527 in 2001, and 870 in 2002.

Approximately 310 vessels participated in the shrimp fishery in 1997, 260 in 1998, and about 238 in 1999. In 1999, the majority (181) were from Maine, while the number of vessels from New Hampshire ports remained at about 30, and the numbers from Massachusetts declined from 33 vessels in 1998 to 27 in 1999. In 2000 and 2001 there were 285 and 274 vessels participating, respectively. In 2002, there were 133 vessels from Maine, 6 from Massachusetts, and 21 from New Hampshire, for a total of 160 vessels that reported shrimp trips.

Prior to 1994, effort (numbers of trips by state and month) was estimated from landings data collected from dealers, and landings per trip information (LPUE) from dockside interviews of vessel captains:

$$Effort = \frac{Landings}{LPUE}$$

Beginning in the spring of 1994, a vessel trip reporting system (VTR) supplemented the collection of effort information from interviews. From 1995 to 2000, landings per trip (LPUE) from these logbooks were expanded to total landings from the dealer weighouts to estimate the total trips:

$$Total.Trips = VTR.Trips \frac{Total.Landings}{VTR.Landings}$$

Since 2000, VTR landings have exceeded dealer weighout landings, and the above expansion is not necessary. However, VTRs for 2002 are still being received. The vessel logbook database is currently incomplete and has not been thoroughly audited (for an evaluation of vessel trip report data see NEFSC 1996). Therefore, landings and effort estimates reported here for recent years should be considered extremely preliminary. The 1996 assessment report (Schick et al. 1996) provides a comparison of 1995 shrimp catch and effort data from both the NEFSC interview and logbook systems and addresses the differences between the systems at that time. It showed a slightly larger estimate from the logbook system than from the interview system. Thus effort statistics reported through 1994 are not directly comparable to those collected after 1994. However, patterns in effort can be examined if the difference between the systems is taken into account. An additional complication of the logbook system is that one portion of the shrimp fishery may not be adequately represented by the logbook system during 1994-1999. Smaller vessels fishing exclusively in Maine coastal waters are not required to have federal groundfish permits and were not required to submit shrimp vessel trip reports until 2000. In the 1994-2000 assessments, effort from unpermitted vessels was characterized by catch per unit effort of permitted vessels.

Seasonal trends in distribution of effort can be evaluated from port interview data. The relative magnitude of offshore fishing effort (deeper than 55 fathoms) has varied, reflecting seasonal movements of mature females (inshore in early winter and offshore following larval hatching), but also reflecting harvesters' choices for fishing on concentrations of shrimp. As an example, the 1994 fishery stayed in deep water only through the beginning of January, shifted inshore through the middle of March and then moved into deeper water for the duration of the season. The 1995 fishing patterns revealed an early inshore migration in December and an early offshore migration with most fishing occurring offshore even during March. The 1999 season's effort was all offshore in December and almost all offshore in January. Effort moved inshore in February and remained primarily inshore throughout March. Effort in April and May was all offshore. This distribution of effort reflects the fact that the main body of shrimp available to the fleet was from the three-year-old 1996 year class, and they were split between transitionals that remained offshore and early maturing females that made some shoreward migration during the winter. During the 2000 season, effort was almost entirely inshore in January and February and increasingly offshore in March. In 2001, 17% of fishing was offshore in January, decreasing to 5% in February, increasingly offshore (78%) in March and entirely offshore in April, from Maine port interview data. In the 2002 season, 100% of fishing was inshore in February, and 20% was inshore in March, from Maine, New Hampshire, and Massachusetts port interview data.

Catch per unit effort (CPUE) indices have been developed from NMFS interview data (1983-1994) and logbook data (1995-2002) and are measures of resource abundance and availability (Figure 5). They are typically measured in catch per hour or catch per trip. A trip is a less precise measure of effort, because trips from interviews and logbooks include both single day trips and multiple day trips (in the spring), and the proportion of such trips can vary from season to season.

Pounds landed per trip (Figure 5) increased from 844 pounds in 1983 to over 1,300 pounds in 1985 when the strong 1982 year class entered the fishery. CPUE subsequently dropped to below 750 pounds/trip in 1988 but increased to 1,050 pounds in 1990 with entry of the strong 1987 year class. This index averaged 980 pounds between 1991-1992, declined to 767 pounds in 1993, and increased in 1994 to 1,073 pounds. The 1995, 1996 and 1997 CPUEs, from logbooks, rose sharply to 1,362 pounds in 1995, rose again to 1,714 in 1996 and declined to 1,454 in 1997. The CPUEs for 1996 and 1997 were the highest since the early 1970's. The 1998 CPUE was 1,317, showing a continued high level compared to earlier years and the 1999 CPUE dropped to 1,067 pounds per trip, which is still considerably higher than in previous years with poor recruitment. The 2000 CPUE increased to 1,444 pounds per trip. In 2001, the catch per trip dropped to 756 pounds per trip, the lowest since 1993. In 2002, the catch per trip was 872 pounds (Figure 5).

More precise CPUE indices (pounds landed per hour fished) have also been developed for both inshore (depth less than 55 fathoms) and offshore (depth more than 55 fathoms) areas using information collected by Maine's and New Hampshire's port sampling programs, and agree well with the (less precise) catch per trip data from logbooks (see text table below and Figure 5). Inshore CPUE for 2002 was 223 lbs/hr, offshore was 91, and the season average was 194 lbs/hr, (see table below.)

Higher catch rates (per hour) may reflect increased biomass or denser aggregations of shrimp, which make them more available to the gear. Another possible cause for an increase in catch rate is an increase in vessel fishing power, which can not be assessed independently. Higher catch rates (per trip) may indicate a higher than average incidence of multiple-day trips. For these reasons, attempting to interpret catch rate data is not for the faint of heart.

ME/NH CPUE in lbs./hour towed, from port sampling. Catch in lbs./trip is from NMFS weighout and logbook data.

Year	Inshore (<55F)	Offshore (>55F)	Total	Catch/trip
1991	94	152	140	988
1992	132	93	117	974
1993	82	129	92	767
1994	139	149	141	1,073
1995	172	205	193	1,362
1996	340	203	251	1,714
1997	206	192	194	1,454
1998	158	151	154	1,317
1999	159	146	152	1,067
2000	288	337	292	1,444
2001	100	135	109	756
2002	223	91	194	872

5.1.6 Fishery Selectivity

Selectivity of commercial trawl gear was estimated experimentally in July 1995, twenty miles south of Boothbay Harbor (Schick and Brown 1997). Five paired tows were sampled with a trouser trawl over a two-day period. The trouser body consisted of 47.6 mm (1-7/8") diamond polypropylene mesh as did the septum, which divided the trawl in half vertically. The control codend was 12.7 mm (1/2") square polypropylene mesh with a 6.4 mm (1/4") mesh liner. The experimental codend consisted of 47.6 mm (1-7/8") diamond polypropylene mesh.

Three five-kg samples from each codend were bagged, labeled, stored on ice at sea, and then frozen. Mid-dorsal carapace length (CL) was measured for 500 shrimp from each sample. Sample length frequencies were expanded to total catch length frequencies using the ratio of sample weight to catch weight. Observed retention ratios at length were derived by dividing the number at length from the experimental codend (large mesh) by the number at length from the control codend (small mesh). The average of five ratios, one from each tow, was used to fit a selectivity ogive (Nicolajsen 1988):

$$P = 1/(1+e^{-(a\mathrm{CL}+b)}) \qquad (1)$$

where P is the proportion retained at size. The parameters *a* and *b* were estimated using logistic regression. The CL range used in the regression was 13.5-28.5 mm CL.

5.2 Recreational

A very limited recreational fishery exists for northern shrimp. This fishery, using traps, has been for personal use and has not been licensed.

5.3 Fishery-Independent Survey Data

Trends in abundance have been monitored since the late 1960's using data collected by NEFSC spring and autumn bottom trawl surveys and summer surveys by the state of Maine and jointly by the NSTC and NEFSC (Figure 6).

Maine Survey

Maine conducted summer surveys in the Gulf of Maine from 1967 to 1983. Fixed stations were sampled with an otter trawl during daylight at locations where shrimp abundance was historically high (Schick et al. 1981; Figure 7). The Maine survey biomass index began declining in 1968, and depicts the stock collapse in the late 1970s (Figure 6; Clark 1981, 1982; Schick et al. 1981).

Groundfish Surveys

NEFSC autumn bottom trawl surveys have been conducted since 1963, and spring bottom trawl surveys have been conducted since 1968. Stations are sampled from Cape Hatteras to Nova Scotia according to a stratified random design (Figure 8; Despres et al. 1988). Although the groundfish surveys catch relatively fewer northern shrimp and have more measurement error, they represent a longer time series. Correspondence among research surveys and fishery indices of abundance suggests that the autumn survey tracks resource conditions more closely than the spring survey (Clark and Anthony 1980; Clark 1981, 1982). The autumn survey indicates a precipitous decline from peak biomass in the 1960's and early 1970's to 3% of peak levels in the late 1970's. The index subsequently increased in the 1980s and, since the mid 1980s, has fluctuated at approximately 40% of the peak levels observed in the 1960s (Figure 6).

NSTC Shrimp Survey

The NSTC shrimp survey has been conducted each summer since 1983 aboard the R/V Gloria Michelle employing a stratified random sampling design and gear specifically designed for Gulf of Maine conditions (Blott et al. 1983, Clark 1989). The summer survey is considered to provide the most reliable information available on abundance, distribution, age and size structure and other biological parameters of the Gulf of Maine northern shrimp resource. Indices of abundance and biomass are based on catches in the strata that have been sampled most intensively and consistently over time (strata 1, 3 and 5-8; Figure 9). Survey catches have been highest in strata 1, 3, 6 and 8, the region from Jeffreys Ledge and Scantum Basin eastward to Penobscot Bay. The 1983 survey did not sample strata 6-8.

5.3.4 Biomass Indices

Biomass indices for the three surveys are presented in Figures 6 and 11 and Table 10.

The statistical distribution of the summer survey catch per tow (in numbers) was investigated to determine the best estimator of relative abundance. Catches within strata were distributed with significant positive skew, and arithmetic stratum means were correlated to stratum variances. Log transformed catches (Ln[n+1]) were more normally distributed. Log transformation is a common practice for estimating relative abundance from trawl surveys, because stratum means and variances are seldom independent, and log transformation generally normalizes observations, renders the variance independent, and reduces anomalous fluctuations (Grosslein 1971). Geometric means were estimated with more precision (mean CV=2.4%) than arithmetic means (mean CV=13.5%). Therefore, stratified geometric mean catch per tow was used to estimate relative abundance. The nontransformed and transformed indices have different magnitudes and temporal patterns, particularly in recent years (Table 7, Figure 10). Annual variation in the difference between the two series reflects varying degrees of skewness, or patchiness of shrimp aggregations from year to year, which is consistent with observations from the fishery (i.e., the shrimp appear to be more patchily distributed when abundance is low).

Shrimp summer survey catches by length and developmental stage (Figure 12) reflect the predominance of the strong 1982, 1987, 1992, and 2001 cohorts in the stock. Although size at age-1.5 varies from year to year, discrete length modes indicate the relative abundance of age-1.5 shrimp (generally around 12-18.5 mm CL) and age-2.5 shrimp (generally 19-23 mm CL). Length modes for older cohorts overlap extensively.

A “selectivity method” was used to derive indices of recruits and fully-recruited shrimp from survey length frequencies (NEFSC 1995). The number per tow at length was partitioned into three components: fully-recruited, recruits, and pre-recruits (as illustrated in Figure 13). The fishery selectivity curve (Schick and Brown 1997, described above) was used to define fully-recruited shrimp. The products of selectivity at length and survey catch per tow at length were summed to derive total catch per tow of fully-recruited shrimp. The carapace length of each interval was increased by one year of growth according to a vonBertalanffy growth curve:

$$CL_{t+1} = CL_t + (CL_{\infty} - CL_t)\,(1-e^{-K}) \qquad (2)$$

where CL_{∞}=35.2 and K=0.36 (McInnes 1986) to estimate fishery selectivity after a year of growth. The remaining length frequency of recruits and pre-recruits was then multiplied by the end-of-year selectivity at length to obtain an index of recruits. Using the selectivity method, age-classes recruit to the fishery over several years, and recruitment in each year is composed of several cohorts. Therefore, the definition of recruitment used in this assessment is not synonymous with year-class strength (previous northern shrimp assessments defined recruitment as age-2.5 abundance).

Mean weight of recruits and fully recruited shrimp were estimated according to length-weight equations for each developmental stage from Haynes and Wigley (1969) and 1990 northern shrimp survey observations.

ABUNDANCE AND FISHING MORTALITY ESTIMATES

6.0 Methods

6.1 Models

Descriptive information for the Gulf of Maine shrimp fishery (total catch, port sampling, trawl selectivity, survey catches, and life history studies) were modeled to estimate fishing mortality, stock abundance, and candidate target fishing levels. The Collie-Sissenwine Analysis (CSA) (Collie and Sissenwine 1983; Collie and Kruse 1998) tracks the removals of shrimp using summer survey indices of recruits and fully-recruited shrimp scaled to total catch in numbers. This modified DeLury model was applied to the Gulf of Maine northern shrimp fishery:

$$N_{t+1} = (N_t + R_t - C_t)\, e^{-M} \qquad (3)$$

where fully-recruited abundance at the end of the year (N_{t+1}) equals fully-recruited abundance at the beginning of the year (N_t), plus recruitment (R_t), minus catch (C_t), all reduced by one year of natural mortality (e^{-M}).

Natural mortality (M) was assumed to be 0.25, as approximated from the intercept of a regression of total mortality on effort (Rinaldo 1973, Shumway et al. 1985). Estimates of Z for age-2+ shrimp from visual inspection of length modes from the Maine summer survey was 0.17 from 1977 to 1978, when the fishery was closed (Clark 1981, 1982), suggesting, for the population as a whole, M is low relative to estimates for other *Pandalus* stocks, which range from 0.2 to 0.8 (ICES 1977, Abramson 1980, Frechette and Labonte 1980).

Catch was assumed to be taken at mid-year, whereby the summer survey marks the beginning of the "survey year" (August 1), and catch was taken on February 1 of the next calendar year (which was based on the time of 50% cumulative seasonal catch for 1985-1996 (Figure 2):

$$N_{t+1} = [(N_t + R_t)\boldsymbol{e}^{\mathbf{-0.5M}} - C_t]\ \boldsymbol{e}^{\mathbf{-0.5M}} \tag{4}$$

so that recruited shrimp ($N_t + R_t$) experience a half-year of natural mortality ($e^{-0.5M}$), catch is removed, then the survivors $[(N_t + R_t)e^{-0.5M} - C_t]$ experience another half-year of natural mortality.

Abundance is related to survey indices of relative abundance:

$$n_t' = q_n N_t\, e^{\eta t} \tag{5}$$

and

$$r_t' = q_r R_t\, e^{\delta t} \tag{6}$$

where r_t' and n_t' are observed survey indices of recruits and fully-recruited shrimp, q is catchability of the survey gear, and $e^{\eta t}$ and $e^{\delta t}$ are lognormally distributed measurement errors. The process equation is derived by substituting survey indices into equation 4 and including lognormally distributed process error ($e^{\varepsilon t}$):

$$\boldsymbol{n}_{t+1} = [(\boldsymbol{n}_t + \boldsymbol{r_t}/\mathbf{s_r})e^{-0.5M} - \boldsymbol{q}_{\mathbf{n}}C_t]\ e^{-0.5M}\quad \boldsymbol{e}^{\boldsymbol{\varepsilon t}} \tag{7}$$

where

$$s_r = q_r / q_n \tag{8}$$

is the relative selectivity of recruits to fully-recruited shrimp. Selectivity studies (Blott et al. 1983) and survey catch at length suggest that age-1.5 sized shrimp are sampled less efficiently than age-2+ shrimp, because total catch per tow is greater at age-2.5 than at age-1.5 for some cohorts (Figure 12). For the shrimp survey, there are two components to s_r: selectivity and availability of age-1.5 shrimp. The 32mm codend mesh in the survey trawl may not retain some small shrimp, and in some years, age-1.5 males may not completely migrate from inshore areas to the survey strata (Figure 9). Precise estimation of survey selectivity at size was not possible due to high variability in catch at size and few comparative experimental tows (Blott et al. 1983). For the present analysis, s_r was approximated from the relative sampling efficiency of <19mm CL shrimp to that of larger shrimp, and the relative proportions of those sizes comprising total recruits and fully recruited indices.

The parameters n_t, r_t, and q_n were estimated by iteratively minimizing the sum of measurement errors (equations 5 and 6) and process errors (from equation 7) for the entire time series. Total mortality (Z) and fishing mortality (F) were calculated from abundance estimates:

$$Z_{R+N,t} = \text{Ln}\,[(N_t + R_t) / N_{t+1}] \quad (9)$$

and

$$F_{R+N,t} = Z_{R+N,t} - M \quad (10)$$

The fishing mortality can be partitioned according to the average partial recruitment (*p*) of recruits over the survey year:

$$F_{N,t} = [F_{R+N,t}\,(R_t+N_t)] \,/\, p\, R_t \quad (11)$$

and

$$F_{R,t} = p\, F_{N,t} \quad (12)$$

Average partial recruitment was derived from the schedule of growth to fully-recruited size over the survey year, as approximated by observations of monthly growth of age-1.5 shrimp from a mean carapace length of 14.5mm in July to 21.9mm CL the next July (Haynes and Wigley 1969).

Results

CSA results are summarized in Tables 8 & 9 and more detailed model output is reported in Appendix A. Parameters were relatively well-estimated. Coefficients of variation for fully-recruited abundance estimates ranged from 18% to 25%, estimates of recruitment were slightly less precise (CV=23% to 26%), and q_n was estimated with moderate precision (CV=16%). Defining correlation between parameters (Appendix A) as:

$$r_{ij} = CV_{ij}/(CV_{ii} * CV_{jj})^{0.5} \quad (13)$$

there were no large correlations among the 38 parameter estimates (all r's < 0.4). Residuals ranged from –0.33 to 0.35 without significant annual patterns, indicating that the data fit the model well (Figures 14, 15).

Estimates of recruitment to the fishery averaged 0.8 billion individuals, peaked at 1.3 billion before the 1990 fishing season, but declined steadily to less than 0.4 billion before the 2002 fishing season. The current estimate indicates a sharp rise up to 1 billion prior to the next scheduled fishing year (2003). Fully-recruited abundance averaged 1.0 billion individuals and peaked at 1.5 billion before the 1991 season. Fully-recruited abundance decreased to a time series low of less than 0.4 billion in 2000 and increased to 0.6 billion in the current year. Total stock biomass estimates averaged about 13,200 mt, with a peak at over 22,000 mt before the 1991 season, and a decrease to a time series low of 5,600 mt in 1999. Total stock biomass has increased over the last three years to its current value of 9,200 mt (Tables 8a&b, Figure 14).

Annual estimates of fishing mortality (F) averaged 0.34 (26% exploitation) for the 1985 to 1995 fishing seasons, peaked at 0.87 (52% exploitation) in the 1997 season and decreased to 0.28 (22% exploitation) in the 2000 season (Table 8a, Figure 14). In 2001, F rose to 0.40 (29% exploitation). In the most recent fishing year (2002) the short season and poor stock condition (in terms of exploitable shrimp) along with an exceptional recruitment pulse resulted in F estimates for the terminal year (2002) of –0.01. While the removal of at least 375 mt of shrimp by the fishery indicate some level of F, the slightly negative value is analytically plausible. In addition to the relative lack of precision in estimating the terminal year F, there is the possibility that either M is not the constant 0.25 assumed, and/or catch is not measured precisely. The three year (2000 - 2002) average is 0.22 (18% exploitation). The recent pattern in F reflects the pattern in nominal fishing effort (Figure 5). Estimates of mortality in the first and last years are the least reliable in CSA analysis, because they are linked to one adjacent year rather than two. Averages of terminal mortality estimates (e.g., $F_{00\text{-}01}$=0.65 or $F_{99\text{-}01}$=0.54) are less sensitive to measurement error in the 2002 survey observation of fully-recruited shrimp or reporting of catch in 2002. However, averaging F_{01} with previous years may be inappropriate because of the apparently significant decrease in effort and exploitable shrimp stock. Total mortality estimates were within the range of previous estimates using visual inspection of survey length frequencies (previous NSTC reports), Shepherd's Length Composition Analysis (Terceiro and Idoine 1990) and MULTIFAN (Fournier et al. 1991).

Two thousand bootstrap replicates, which were derived by randomly resampling model residuals, suggest that estimates of abundance, biomass and mortality were relatively precise. The median bootstrapped value for the final year (F_{01}) was –0.01 with an 80% confidence interval of -.0.12 to 0.21 (Figure 15). Two approaches were examined to define a multiple year "average" F. The first examined the distribution of bootstrap estimates from all applicable years as if they all represented estimates of the current fishing mortality (Figure 16a). The second approach was to average the estimates for each bootstrap iteration, and examine the resultant distribution (Figure 16b). From this, while the medians of the two approaches agree, it is clear there is a loss of precision of the second due to the reduction of the tails through averaging (Figure 16c). The result for both approaches using a two and three year average are shown below:

	1999-2001 Average	1999-2001 All	2000-2001 Average	2000-2001 All
10th Pctl	0.15	-0.03	0.05	-0.07
Median	0.25	0.26	0.17	0.17
90th Pctl	0.35	0.48	0.28	0.39

Abundance estimates were not bias-corrected, because estimates of bias were not substantial (<10% in most years).

Retrospective Analysis

Comparison of results from 10 retrospective CSA runs to the results reported above was investigated to assess the stability of estimates in the last year of the analysis and the possibility that terminal mortality estimates are systematically inconsistent. The analysis was performed by sequentially deleting the last year of survey and catch data (for five years) to create a retrospective series of CSA estimates as well as runs that similarly truncated the first year (Table 9, Figure 17a-d). Terminal mortality estimates (both initial and final year) were quite stable in most years with minimal retrospective differences in F (Figure 17a). Similar stability was seen in estimates of abundance and biomass (Figures 17b-c). The NLSS estimate of q was also very stable for the series of retrospective analyses (Figure 17d).

Confirmatory Analysis

An alternative method of estimating stock size and F was explored to corroborate results from CSA. A nonequilibrium surplus production model (Prager 1994, 1995) was fit to seasonal catch and survey biomass indices from 1968 to 1996 (summarized in Table 10, more detailed output in Appendix B). The model assumes logistic population growth, in which the change in stock biomass over time (dB_t/dt) is a quadratic function of biomass (B_t):

$$dB_t/dt = rB_t - (r/K)B^2_t \tag{14}$$

where r is intrinsic rate of population growth, and K is carrying capacity. For a fished stock, the rate of change is also a function of F:

$$dB_t/dt = (r - F_t)B_t - (r/K)B_t^2 \tag{15}$$

For discrete time increments, such as annual fishing seasons, the difference equation is:

$$B_{t+1} = B_t + (r - F_t)B_t - (r/K)B_t^2 \tag{16}$$

Initial biomass (B_1), r, and K were estimated using nonlinear least squares. The fall groundfish survey catch per unit effort (CPUE) contributed to the total sum of squares as a series of observed effort (E=CPUE/C); the Maine summer survey and the NSTC shrimp surveys contributed as independent indices of biomass at the start of the fishing season. Note that no assumption about M is needed for the biomass dynamics analysis.

One survey observation (fall 1982) was a statistical outlier, and the pattern of residuals from Maine and NSTC surveys suggest autocorrelation (Figure 18). A fair portion of the variance in the fall and Maine surveys was explained by the model (R^2=0.5 an 0.6, respectively), but much of the variation in the summer shrimp survey was not resolved (R^2=0.3). The model did not account for peaks in biomass from strong recruitment.

Estimates of F from the biomass dynamics model generally confirm the pattern and magnitude of estimates from the CSA model; F_{02} was the lowest value since 1983 (Figure 19). Recruitment of the strong 1982, 1987, 1992, and 2001 cohorts is not as pronounced in the biomass trajectory from the production model, because dynamic recruitment is not explicitly estimated, as it is in the CSA. The biomass dynamics model suggests that a maximum sustainable yield (MSY) of 5,000 mt can be produced when stock biomass is approximately 29,900 mt (B_{MSY}) and F is approximately 0.17 (F_{MSY}; Figure 20). However, B_{MSY} was only exceeded by the first three years in the analysis, which are not reliable (Prager 1994, 1995).

Survey residuals were randomly resampled 1000 times to estimate precision and model bias. Bootstrap results suggest that r, MSY and F_{MSY} were relatively well estimated(relative interquartile ranges were <16%, and bias was <4%). Estimates of K, B_{MSY}, and q's were moderately precise (relative IQs were 20-32%, bias was <8%), and B_1 was not as precisely estimated (relative IQ=43%). The ratio of F/F_{MSY} in 2002 was estimated with moderate precision(relative IQ = 30%, bias = -3.44%.). Similarly, B\ B_{MSY} in 2002 was estimated with moderate precision. (relative IQ =36%, bias = -9.12%)

8.0 Biological Reference Points

Yield per recruit (Thompson and Bell 1934) and percent maximum spawning potential (Gabriel et al. 1989) were estimated for the Gulf of Maine northern shrimp fishery (Table 11, Figure 21). Yield and egg production were derived as a function of abundance at the time of spawning (i.e., abundance at the start of the year, approximately February 1) to reflect size and weight at age during spawning and the fishery. The model assumes annual growth and ontogenetic transition occur before oviposition and the onset of the fishing season. As described above, M was assumed to be 0.25 (Rinaldo 1973). Length at age was estimated using the vonBertalanffy growth parameters L_{∞}=35.2 mm and K=0.36 (McInnes 1986). Proportion female at the time of hatch was the average of 1984-1996 observed sex ratios at length from the summer survey, applied to a carapace length which was increased by a half-year of growth using equation (2). Selectivity at size was estimated using the selectivity curve from Schick and Brown (1997), described above. Mean weight at length for males and females was estimated using relationships developed by Haynes and Wigley (1969). Estimates of fecundity at oblique CL were from a linear relationship developed by Apollonio et al. (1984).

Yield per recruit was maximized at F=0.77 (F_{max}) (Table 11). The increase in yield per unit F decreased to one tenth the initial increase at F=0.46 ($F_{0.1}$). Maximum spawning potential (i.e., with no F) was 2,395 eggs per recruit. Spawning potential was reduced by half at F=0.25 ($F_{50\%}$).

Information from the stock collapse in the 1970s may provide guidance on the level of sustainable F for Gulf of Maine northern shrimp. Biomass indices from the Maine survey and the biomass dynamics model suggest that biomass was declining as early as 1968. Log catch ratios of assumed age-2^+ shrimp from survey length frequencies suggested that F was 0.7 to 0.8 from 1968 to 1970, and continued annual harvests of over 5,000 mt drove F to an annual average of 1.6 from 1971 to 1975 (Clark and Anthony 1980). Estimates of F from the first several years of the production model (e.g., 1968-1972) are imprecise and are not considered reliable (Prager 1994, 1995), but F estimates for 1973-1975 ranged from 0.6 to 1.1 (Figure 19). According to the present egg production per recruit analysis and historical F estimates, the stock was not replacing itself when spawning potential was reduced to less than 18% of maximum, and the stock collapsed when egg production was reduced further. Therefore, $F_{20\%}$ may be an appropriate overfishing threshold, which would result in target Fs well below 0.6.

The survey index of age-1.5 shrimp biomass appears to be correlated to the biomass index of females from two years previous (Figure 22). A survey index of egg production, derived as the sum of catch per tow of females at length multiplied by fecundity at length (Apollonio et al. 1984), had a similar relationship to recruitment. Prior to 2001, the two dominant cohorts in the time series were produced when spawning stock biomass was among the highest levels in the time series. When spawning stock indices were greater than 6 kg/tow, two of four dominant cohorts were produced. These relationships suggest that poor recruitment is more likely at low levels of spawning stock biomass and egg production, and adequate egg production per recruit should be conserved. The last three years average spawning stock index was 2.5 kg/tow. Prior to 2001 all cohorts produced by spawning indices of 3kg/tow or less were below average. However in 2001, the below average SSB of 2.8 kg/tow produced an exceptionally high recruitment index. Based on this it is currently difficult to estimate a SSB/R relationship that is representative of this stock (see SARC36 Working Paper C3).

Survey indices of egg production, recruitment, and spawning biomass (Figure 22), and historical estimates of spawners and recruits (Richards et al. 1996, Richards and Clark 1996) suggested that at median survival rates, greater than 50% of maximum spawning potential was needed to replace the stock. Provisional F_{med} estimates (Sissenwine and Shepherd 1987, Gabriel et al. 1989) averaged 0.20 (0.10 based on eggs/recruit, 0.16 based on spawning biomass/recruit, and 0.35 based on the extended series of spawners/recruit), which is similar to F_{MSY}. However, survival ratios and estimates of F_{med} may be underestimated, because partial selectivity of recruits to the survey was not accounted for.

As noted above, reference points based on SSB/R are problematic, as are extensions to MSY based metrics. The use of proxies (such as periods of “stability”) are being examined in the development of control rules (see SARC36 Working Paper C2 and Figure 20a). However, it is apparent that the choice of the stable period (and the stock status during that time) influence what becomes the M (maximum) of MSY based reference points. Additionally, if the stock has been reduced far enough below a sustainable level, there may need to be an extended period of time for recovery to allow any level of future stability. Further discussion on this point can be found in (see SARC36 Working Paper C3).

9.0 Recommendations and Findings

9.1 Evaluation of current status

Size composition data from both the fishery and summer surveys indicate that good landings have followed the recruitment of strong (dominant) year classes. Poor landings since 1997, as well as low biomass estimates, can be attributed in part to the below-average recruitment of the 1994, 1995, 1997, and 1998 year classes.

In 2003, the 1997 year class will have passed out of the fishery, and the very weak 1998 year class (assumed 5-year old females), moderate 1999 year class (assumed 4-year-old females), virtually absent 2000 year class (assumed 3-year-old males, transitionals, and early-maturing females), very strong 2001 year class (assumed 2-year-old males, transitionals, and early-maturing females), and unknown 2002 year class (juveniles) will remain.

Exploitable biomass as estimated from CSA declined from 15,500 mt in 1995 to a time series low of 5,700 in 1999. Since then the biomass estimate has risen to 9,200 mt in 2002, as a result of the appearance of the moderate 1999 year class and the strong 2001 year class. This estimate is still well below the time-series average of 13,000 mt, and below the average of the 1985-1995 period of 17,000 mt (Table 8a). The estimate of spawning stock biomass (Figure 22a, arrow labeled “03”) is also still well below the time-series mean.

9.2 Research Recommendations

- The potential for improving estimates of mortality, abundance, and biomass from historical fishery and survey data from the 1960’s should be investigated for further guidance on appropriate biological reference points.
- Development of a time series of standardized effort would help to corroborate patterns of estimated F. Such analyses depend on completion of audits, processing of vessel logbook data, and estimation of data not included in logbooks (Maine small vessel fleet before 2000).
- Methods for age determination from length and ontogenetic stage information should be investigated to develop the possibility of using age-based assessment methods.
- A standard set of non-random stations have been sampled during the northern shrimp survey since 1994. When an adequate time series is achieved, catch data from these stations should be incorporated into survey indices of abundance and biomass.
- Estimates of fecundity at length should be updated, and the potential for annual variability should be explored.
- NEFSC fall trawl survey data should be segregated by day/night and analyzed for differences.
- The appropriate weighting of port sample data for estimates of mean weight should be investigated.
- Growth, survival, sex transition, fecundity, and migration in response to environmental conditions and population density should be evaluated.
- A better understanding of juvenile life history is needed.
- The implications of low male abundance should be investigated.
- Models that incorporate environmental variables and changes in life history parameters would be especially useful, if those signals are ever characterized better than they are currently.

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10.0 SARC Comments

The CSA-estimated biomass of 9,200 mt is above the proposed biomass threshold of 9,000 mt, i.e. 50% of B_{MSY}. However, management advice based on the results of biomass dynamics models may not provide sufficient detail relative to the unique life history characteristics of the species. The SARC questioned the usefulness of a single reference point estimate when simple interpretation of empirical data (fishery-independent indices) may provide more reliable management advice. Progress was made in assessing stock status with models, but further work to develop objective decision criteria is needed.

The SARC was concerned that the natural mortality estimate (M = 0.25) used in the CSA approach is uncharacteristically low for a short-lived shrimp species. It was noted that the regression method estimate of M = 0.25 and the Z-based estimate of M = 0.17 derived when the fishery was closed in 1978 are less than or equal to the value currently being used. The calculated Z in 2002, a year of minimal fishing effort, is 0.25. The SARC suggested investigating alternative methods of estimating M, such as maximum expected lifespan, size-dependent mortality, life-history based approaches, and deriving Z from the ratio of female 2 to females 1 and female 2 in the previous year.

Although biomass estimates from the current assessment do not match historical estimates, this discrepancy was attributable to changes in empirical data, including correction of the 1987 summer trawl survey indices, and updating of the time series of catch data. Revisions were also made to partitioning of recruits and fully recruited shrimp. The SARC recommended that any changes made since SARC 25 need to be documented.

The SARC discussed the appropriateness of the method of determining F from the CSA harvest rate. The F generated by this method is a more precise approximation than the log-ratio method.

10.1 Sources of Uncertainty

- Natural mortality is poorly defined.
- Catch reporting is often late and incomplete.
- Northern shrimp are not consistently available to the NEFSC Autumn survey because of:
  a.) diurnal variation
  b.) migration patterns
  c.) egg-bearing females may have a more limited vertical migration pattern
- Growth, upon which YPR and EPR are based, is poorly estimated.

10.2 SARC Research Recommendations

- Further exploration of natural mortality assumption.
- Investigation of growth for improved calculation of YPR and SPR.
- Consider alternative estimators of F.

- Consider a two- rather than a one-stage control rule.
- Investigate survey selectivity.
- Explore alternative assessment models especially, statistical catch-at-length methods.
- Consider the potential for using length-frequency distributions for developing management advice.
- Explore utilizing the ratio of stage 2 to stage 1 females for estimating total mortality.
- Investigate the appropriate weighting of port sample data for estimates of mean weight.

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Table C1a. Commercial landings (metric tons) of northern shrimp in the Gulf of Maine.

Year	Maine		Massachusetts		New Hampshire		Total		$/Lb
1958	2.3		0.0		0.0		2.3		0.32
1959	5.4		2.3		0.0		7.7		0.29
1960	40.4		0.5		0.0		40.9		0.23
1961	30.4		0.5		0.0		30.9		0.20
1962	159.7		16.3		0.0		176.0		0.15
1963	244.0		10.4		0.0		254.4		0.12
1964	419.4		3.1		0.0		422.5		0.12
1965	947.0		8.0		0.0		955.0		0.12
1966	1,737.8		10.5		18.1		1,766.4		0.14
1967	3,141.1		10.0		20.0		3,171.1		0.12
1968	6,515.0		51.9		43.1		6,610.0		0.11
1969	10,992.9		1,772.9		58.1		12,823.9		0.12
1970	7,712.8		2,902.1		54.4		10,669.3		0.20
1971	8,354.7		2,723.8		50.8		11,129.3		0.19
1972	7,515.6		3,504.5		74.8		11,094.9		0.19
1973	5,476.7		3,868.2		59.9		9,404.8		0.27
1974	4,430.7		3,477.3		36.7		7,944.7		0.32
1975	3,177.0		2,080.2		29.5		5,286.7		0.26
1976	617.2		397.8		7.3		1,022.3		0.34
1977	148.0		236.9		2.3		387.2		0.55
1978	0.0		0.0		0.0		0.0		0.24
1979	32.9		451.3		2.3		486.5		0.33
1980	71.4		260.3		7.4		339.1		0.65
1981	528.6		538.1		4.5		1,071.2		0.64
1982	883.2	*(853.3)	658.5	*(655.3)	32.8	*(21.6)	1,574.5	*(1,530.2)	0.60
1983	1,022.0	(892.5)	508.0	(458.4)	36.5	(46.2)	1,566.5	(1,397.1)	0.67
1984	2,564.7	(2,394.9)	565.3	(525.1)	96.8	(30.7)	3,226.8	(2,950.7)	0.49
1985	2,956.9	(2,946.4)	1,030.6	(968.0)	207.4	(216.5)	4,194.9	(4,130.9)	0.44
1986	3,407.3	(3,268.2)	1,085.6	(1,136.3)	191.1	(230.5)	4,684.0	(4,635.0)	0.63
1987	3,534.2	(3,673.2)	1,338.7	(1,422.2)	152.5	(157.8)	5,025.4	(5,253.2)	1.10
1988	2,272.4	(2,257.2)	631.5	(619.6)	173.1	(154.5)	3,077.0	(3,031.3)	1.10
1989	2,542.6	(2,384.0)	749.6	(699.9)	314.3	(231.5)	3,606.5	(3,315.4)	0.98
1990	2,961.5	(3,236.1)	993.2	(974.3)	447.3	(451.2)	4,402.0	(4,661.6)	0.72
1991	2,431.1	(2,488.1)	727.6	(801.1)	208.2	(282.2)	3,366.9	(3,571.4)	0.93
1992	2,973.9	(3,054.1)	291.6	(289.1)	100.1	(100.0)	3,365.6	(3,443.6)	0.99
1993	1,562.8	(1,492.2)	300.3	(292.8)	441.1	(357.4)	2,304.7	(2,142.9)	1.03
1994	2,815.5	(2,239.3)	374.4	(247.5)	520.9	(428.0)	3,710.8	(2,914.8)	0.79
1995		(5,022.7)		(678.8)		(764.9)		(6,466.4)	0.88
1996		(7,737.0)		(658.0)		(771.0)		(9,166.1)	0.72
1997		(6,050.0)		(362.8)		(666.3)		(7,079.1)	0.82
1998		(3482.0)		(247.2)		(445.2)		(4,174.4)	0.94
1999		(1523.4)		(75.7)		(217.0)		(1,816.1)	0.93
2000		(2067.3)		(109.9)		(212.3)		(2,389.5)	0.79
2001		**(1071.8)		**(49.1)		**(205.8)		**(1326.7)	0.90
2002		**(322.1)		**(5.8)		**(47.2)		**(375.0)	

*Numbers in parentheses are computed on a seasonal basis.
**Preliminary.

Table C1b. Distribution of landings (metric tons) in the Gulf of Maine northern shrimp fishery by state and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1986 Season, 203 days, Dec 1 - May 31, extended to June 21								
Maine	346.9	747.8	1,405.3	415.4	104.2	149.2	99.4	3,268.2
Mass.	154.3	213.4	221.2	200.7	111.2	84.8	150.7	1,136.3
N.H.	57.7	75.9	70.8	14.2	1.3	0.0	10.6	230.5
Total	558.9	1,037.1	1,697.3	630.3	216.7	234.0	260.7	4,635.0
1987 Season, 182 days, Dec 1 - May 31								
Maine	485.9	906.2	1,192.7	672.9	287.6	127.9	7.0	3,680.2
Mass.	103.5	260.0	384.9	310.2	180.8	182.8	5.7	1,427.9
N.H.	18.4	53.6	62.8	15.7	7.3	0.0	0.1	157.9
Total	607.8	1,219.8	1,640.4	998.8	475.7	310.7	12.8	5,266.0
1988 Season, 183 days, Dec 1 - May 31								
Maine	339.7	793.9	788.1	243.6	24.6	67.3	1.2	2,258.4
Mass.	14.4	225.8	255.0	104.9	8.6	10.9	0.0	619.6
N.H.	13.0	72.6	53.7	14.9	0.3	0.0	3.1	157.6
Total	367.1	1,092.3	1,096.8	363.4	33.5	78.2	4.3	3,035.6
1989 Season, 182 days, Dec 1 - May 31								
Maine	353.6	770.5	700.6	246.4	218.7	94.2		2,384.0
Mass.	26.2	197.5	154.9	104.8	160.9	55.6		699.9
N.H.	28.5	106.9	77.0	15.4	3.7	0.0		231.5
Total	408.3	1,074.9	932.5	366.6	383.3	149.8		3,315.4
1990 Season, 182 days, Dec 1 - May 31								
Maine	512.4	778.2	509.7	638.5	514.0	282.8	0.1	3,235.7
Mass.	75.6	344.4	184.8	100.2	158.9	110.0	4.3	978.2
N.H.	111.3	191.7	116.1	30.7	1.4			451.2
Total	699.3	1,314.3	810.6	769.4	674.3	392.8	4.4	4,665.1
1991 Season, 182 days, Dec 1 - May 31								
Maine	238.2	509.1	884.0	454.9	251.7	148.2	2.0	2,488.1
Mass.	90.5	174.7	175.9	131.2	93.3	133.8	1.6	801.0
N.H.	107.3	104.4	33.8	27.8	7.8	1.0		282.1
Total	436.0	788.2	1,093.7	613.9	352.8	283.0	3.6	3,571.2
1992 Season, 153 days, Dec 15 - May 15								
Maine	181.1	880.9	1,278.9	462.5	163.6	87.2		3,054.2
Mass.	17.1	148.2	73.3	47.5	2.9		0.1	289.1
N.H.	33.4	47.0	11.9	6.8	1.0			100.1
Total	231.6	1,076.1	1,364.1	516.8	167.5	87.2	0.4	3,443.7
1993 Season, 138 days, Dec 14 - April 30								
Maine	100.9	369.0	597.0	297.5	127.8			1,492.2
Mass.	19.6	82.0	81.9	62.3	42.0	5.0		292.8
N.H.	33.5	85.4	101.7	77.0	59.8			357.4
Total	154.0	536.4	780.6	436.8	229.6	5.0	0.4	2,142.8
1994 Season, 122 days, Dec 15 - Apr 15								
Maine	171.5	647.7	971.9	399.5	48.7			2,239.3
Mass.	27.1	68.0	100.8	38.8	12.8			247.5
N.H.	117.2	124.3	128.7	49.6	8.2			428.0
Total	315.8	840.0	1,201.4	487.9	69.7			2,914.8

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1995 Season, 128 days, Dec 1 - Apr 30, 1 day per week off								
Maine	747.6	1,397.7	1,338.2	912.0	627.2			5,022.7
Mass.	210.7	154.0	104.1	111.0	99.0			678.8
N.H.	160.6	186.8	118.3	158.5	140.7			764.9
Total	1,118.9	1,738.5	1,560.6	1,181.5	866.9			6,466.4
1996 Season, 152 days, Dec 1- May 31, 1 day per week off								
Maine	1,124.1	1,678.3	3,004.6	785.2	350.4	794.5		7,737.1
Mass.	167.9	106.7	188.7	67.8	66.5	60.3		657.9
N.H.	189.8	169.5	234.0	81.9	78.8	17.1		771.1
Total	1,481.8	1,954.5	3,427.3	934.9	495.7	871.9		9,166.1
1997 Season, 156 days, Dec 1- May 27, two 5-day and four 4-day blocks off								
Maine	1,178.5	1,114.9	1,713.1	758.4	754.8	530.3		6,050.0
Mass.	90.2	110.4	111.4	49.0	1.2	0.5		362.7
N.H.	185.6	104.1	140.1	108.6	85.8	42.2		666.4
Total	1,454.3	1,329.4	1,964.6	916.0	841.8	573.0		7,079.1
1998 Season, 105 days, Dec 8-May 22, weekends off except Mar 14-15, Dec 25-31 and Mar 16-31 off.								
Maine	511.1	926.8	1,211.1	401.7	228.7	202.6		3,482.0
Mass.	49.1	78.0	90.5	14.3	15.3	0.0		247.2
N.H.	89.4	106.9	143.5	54.3	49.0	2.1		445.2
Total	649.6	1,111.7	1,445.1	470.3	293.0	204.7		4,174.4
1999 Season, 90 days, Dec 15 - May 25, weekends, Dec 24 - Jan 3, Jan 27-31, Feb 24-28, Mar 16-31, and Apr 29 - May 2 off.								
Maine	79.9	192.7	590.8	240.6	204.5	214.9		1,523.4
Mass.	25.0	23.8	16.0	2.5	8.4			75.7
N.H.	46.5	63.2	52.2	10.0	36.5	8.6		217.0
Total	151.4	279.7	659.0	253.1	249.4	223.5		1,816.1
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off								
Maine		607.4	1,271.4	188.5				2,067.3
Mass.		17.4	78.7	13.8				109.9
N.H.		39.6	131.1	41.6				212.3
Total		664.4	1,481.2	243.9				2,389.5
***2001** Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May								
Maine		573.0	436.1	35.9	26.5	0.3		1,071.8
Mass.		38.5	8.8	1.9	0.0	0		49.1
N.H.		127.4	37.2	12.1	29.0	0		205.8
Total		738.9	482.2	49.8	55.5	0.3		1,326.7
***2002** Season, 25 days, Feb 15 - Mar 11								
Maine			253.6	68.5				322.1
Mass.			3.7	2.1				5.8
N.H.			35.6	11.6				47.2
Total			292.8	82.2				375.0

* Preliminary data

Table C2. Sample size (number of shrimp lengths measured) of Gulf of Maine northern shrimp port samples.

		Fishing Season												1985-96	
Month	State	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	mean	2002
Dec	ME	212	67	318	497		502	820	417	278	394	1149	904	505	
	MA	92	441	287	101		446	205		310	269	1611	1528	529	
	NH		602	884	370	639	761	760	306	331	541	560	389	559	
Jan	ME	326	519	849	825	1204	460	2191	2327	2136	1717	1498	2718	1,398	
	MA	1108		426	354	741	1137	819	642	789	903	1342	1231	863	
	NH	283	876	672	674	631	990	953	551	427	418	499	450	619	
Feb	ME	642	283	187	667	898	190	2816	2058	1915	2722	1420	4862	1,555	2618
	MA	776	195	161	512	900	515	726	198	714	277	835	1709	627	573
	NH	585	788	459	517	551	513	336	480	422	439	370	355	485	455
Mar	ME	368	205	127	506	571	1407	1419	1570	1502	1572	944	3378	1,131	927
	MA	830	388	414	149		232	358	652	1133	607		633	540	138
	NH	91	298	499	75		639	508	97	375	550	598	392	375	532
Apr	ME	38	58			303		1076	526	108	563	2789	2882	927	
	MA	647	236	245	81	313	103	377		1009	104			346	
	NH									107		362	186	218	
May	ME				751	1218	226	1031	287				5638	1,525	
	MA		429	75		1382	127	216					648	480	
	NH														
Jun	ME														
	MA		436											436	
	NH		438											438	
Total		5997	6260	5603	6080	9352	8246	14611	10113	11557	11075	13978	27904	13554	3241

Table C3. Sampling intensity (number of lengths per million landed) of Gulf of Maine northern shrimp port samples.

		Fishing Season											
Month	State	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	mean
Dec	ME	7.64	2.66	9.11	13.64	--	9.60	44.14	35.76	32.42	24.94	18.66	11.10	19.06
	MA	11.12	31.81	32.95	65.28	--	52.99	25.41	--	160.71	80.81	88.57	96.13	64.58
	NH	--	128.06	569.24	313.23	292.63	72.31	86.60	102.54	85.04	28.01	25.96	19.59	156.66
Jan	ME	4.93	10.22	12.72	15.95	19.75	7.33	55.47	38.06	61.70	30.24	14.16	20.38	24.24
	MA	38.85	--	16.42	23.38	34.63	28.57	42.70	51.82	83.54	108.72	76.62	122.53	57.07
	NH	40.65	150.33	148.04	110.90	85.21	53.83	106.93	133.62	52.92	28.06	26.46	27.29	80.35
Feb	ME	7.30	2.86	2.22	13.06	20.68	3.39	44.76	23.06	45.95	38.63	13.67	19.83	19.62
	MA	35.42	10.67	5.95	28.55	36.86	30.84	30.98	32.37	86.69	29.05	72.24	112.38	42.67
	NH	132.22	147.73	96.69	128.16	105.84	52.33	118.73	388.23	39.22	28.67	25.80	16.88	106.71
Mar	ME	7.93	5.83	2.01	21.01	31.69	27.76	38.63	37.42	53.93	39.46	9.31	43.90	26.57
	MA	37.90	21.47	14.73	18.97	--	20.36	19.28	141.89	174.96	159.56	--	107.30	65.13
	NH	93.53	222.54	311.40	68.12	--	200.26	217.01	150.15	39.88	96.50	31.96	41.47	133.89
Apr	ME	3.03	6.13	--	--	11.10	--	44.35	35.42	10.40	104.25	35.23	75.31	32.52
	MA	118.51	20.50	12.00	98.84	23.24	6.99	36.33	--	198.57	107.81	--	--	69.20
	NH	--	--	--	--	--	--	--	--	13.63	--	95.16	26.22	45.00
May	ME	--	--	--	124.49	106.27	8.37	80.98	30.43	--	--	--	67.16	69.61
	MA	--	36.09	4.21	--	217.45	11.09	9.94	--	--	--	--	64.06	57.14
	NH	--	--	--	--	--	--	--	--	--	--	--	--	--
Jun	ME	--	--	--	--	--	--	--	--	--	--	--	--	--
	MA	--	35.36	--	--	--	--	--	--	--	--	--	--	35.36
	NH	--	567.36	--	--	--	--	--	--	--	--	--	--	567.36
Total		17.00	17.33	13.17	26.61	32.97	18.64	45.62	38.53	59.33	40.96	23.14	34.91	35.78

Table C4. Mean weight (g) of Gulf of Maine northern shrimp from port samples.

					Fishing	Season								
Month	State	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	mean
Dec	ME	12.120	13.761	13.913	9.327		9.798	12.825	15.531	11.756		12.142	13.793	12.497
	MA	11.087	11.130	11.900	9.307		8.982	11.228		10.161	8.141	8.830	10.560	10.133
	NH		12.276	11.849	11.009	13.042	10.578	12.223	11.189	8.598	6.071	9.759	9.555	10.559
Jan	ME	12.881	14.734	13.568	15.340	12.639	12.401	12.887	14.406	10.658	11.409	13.214	12.582	13.060
	MA	9.959		10.018	14.905	9.228	8.652	9.109	11.962	8.677	8.184	8.790	10.624	10.010
	NH	12.395	13.024	11.815	11.944	14.439	10.425	11.718	11.396	10.591	8.349	9.905	10.278	11.357
Feb	ME	12.456	14.185	14.161	15.421	16.134	9.086	14.050	14.324	14.328	13.793	12.886	12.256	13.590
	MA	10.871	12.076	14.232	14.217	6.346	11.077	7.507	11.962	9.939	10.552	9.007	12.408	10.850
	NH	11.383	13.265	13.219	13.322	14.781	11.850	11.927	9.627	9.456	8.412	8.247	11.133	11.385
Mar	ME	11.323	11.836	10.651	10.113	13.678	12.596	12.387	11.021	10.684	10.029	8.992	10.204	11.126
	MA	10.922	11.103	11.037	13.338		8.808	7.060	10.340	9.617	10.199		11.502	10.393
	NH	11.923	10.600	9.790	13.533		9.629	11.886	10.526	8.190	8.704	8.468	8.654	10.173
Apr	ME	9.321	11.010			8.020		10.376	11.011	12.318	9.021	8.058	9.157	9.810
	MA	10.592	9.670	8.870	10.494	11.948	10.777	8.984		8.263	13.269			10.319
	NH									7.617		7.989	11.111	8.905
May	ME				11.156	8.215	10.469	11.637	9.241				9.465	10.031
	MA		7.133	10.267		8.749	9.606	6.157					5.960	7.979
	NH													9.005
Jun	ME													12.973
	MA		12.223											12.223
	NH		13.723											13.723
mean		11.326	11.984	11.806	12.387	11.435	10.316	10.748	11.734	10.057	9.703	9.714	10.578	10.982

Table C5. Observed northern shrimp discards from the shrimp trawl fishery and finfish trawl fisheries.

Shrimp Trawl Fishery

Fishing Season	Sampled Trips	lb Kept	lb Discarded	Proportion Discarded
1985	1	2400	0	0.000
1986	3	4300	3	0.001
1987	4	3575	0	0.000
1988	9	18935	0	0.000
1989	17	23260	24	0.001
1990	17	22004	0	0.000
1991	37	66936	159	0.002
1992	57	67433	56	0.001
1993	80	91636	32	0.000
1994	80	101625	795	0.008
1995	57	77346	20	0.000
1996	31	49362.5	0	0.000
average				0.001

Large-mesh Fish Trawl Fishery

Year	Sampled Trips	lb Discard	Discard/ Trip (lb)	Discard/ Trip (mt)
1989	63	5	0.08	0.000
1990	36	1	0.03	0.000
1991	71	35	0.49	0.000
1992	56	5	0.09	0.000
1993	25	9	0.36	0.000
1994	15	0	0.00	0.000
1995	43	22	0.51	0.000
1996	22	0	0.00	0.000
1997	10	0	0.01	0.000
average		9	0.17	0.000

Small-mesh Fish Trawl Fishery

Year	Sampled Trips	lb Discard	Discard/ Trip (lb)	Discard/ Trip (mt)
1989	32	30	0.94	0.000
1990	16	0	0.00	0.000
1991	38	43	1.13	0.001
1992	28	11	0.39	0.000
1993	17	0	0.00	0.000
1994	4	0	0.00	0.000
1995	37	1,084	29.30	0.013
1996	47	5,355	113.94	0.052
1997	34	33	0.96	0.000
average		728	16.30	0.007

Table C6. Distribution of fishing effort (number of trawl trips) in the Gulf of Maine northern shrimp fishery by state and month.

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1986 Season, 203 days, Dec 1 - May 31, extended to June 21								
Maine	590.0	1,309.0	2,798.0	831.0	224.0	133.0	68.0	5,953.0
Mass.	128.0	235.0	225.0	320.0	194.0	133.0	159.0	1,394.0
N.H.	156.0	163.0	165.0	51.0	3.0		17.0	555.0
Total	874.0	1,707.0	3,188.0	1,202.0	421.0	266.0	244.0	7,902.0
1987 Season, 182 days, Dec 1 - May 31								
Maine	993.0	2,373.0	3,073.0	2,241.0	617.0	340.0	16.0	9,653.0
Mass.	325.0	354.0	414.0	426.0	283.0	317.0	164.0	2,283.0
N.H.	67.0	164.0	175.0	95.0	28.0		32.0	561.0
Total	1,385.0	2,891.0	3,662.0	2,762.0	928.0	657.0		12,285.0
1988 Season, 183 days, Dec 1 - May 31								
Maine	972.0	2,183.0	2,720.0	1,231.0	193.0	122.0		7,421.0
Mass.	28.0	326.0	426.0	315.0	26.0	57.0		1,178.0
N.H.	72.0	231.0	236.0	99.0	3.0			641.0
Total	1,072.0	2,740.0	3,382.0	1,645.0	222.0	179.0		9,240.0
1989 Season, 182 days, Dec 1 - May 31								
Maine	958.0	2,479.0	2,332.0	936.0	249.0	84.0		7,038.0
Mass.	103.0	479.0	402.0	254.0	297.0	102.0		1,637.0
N.H.	120.0	369.0	312.0	69.0	16.0			886.0
Total	1,181.0	3,327.0	3,046.0	1,259.0	562.0	186.0		9,561.0
1990 Season, 182 days, Dec 1 - May 31								
Maine	1,036.0	1,710.0	1,529.0	1,986.0	897.0	238.0		7,396.0
Mass.	147.0	459.0	273.0	202.0	175.0	118.0		1,374.0
N.H.	178.0	363.0	284.0	157.0	6.0			988.0
Total	1,361.0	2,532.0	2,086.0	2,345.0	1,078.0	356.0		9,758.0
1991 Season, 182 days, Dec 1 - May 31								
Maine	568.0	1,286.0	2,070.0	1,050.0	438.0	139.0		5,551.0
Mass.	264.0	416.0	401.0	231.0	154.0	147.0		1,613.0
N.H.	279.0	285.0	135.0	82.0	22.0	1.0		804.0
Total	1,111.0	1,987.0	2,606.0	1,363.0	614.0	287.0		7,968.0
1992 Season, 153 days, Dec 15 - May 15								
Maine	411.0	1,966.0	2,700.0	1,222.0	318.0	141.0		6,758.0
Mass.	59.0	337.0	145.0	101.0	41.0			683.0
N.H.	96.0	153.0	76.0	29.0	3.0			357.0
Total	566.0	2,456.0	2,921.0	1,352.0	362.0	141.0		7,798.0
1993 Season, 138 days, Dec 14 - April 30								
Maine	249.0	1,102.0	1,777.0	1,032.0	227.0			4,387.0
Mass.	60.0	200.0	250.0	185.0	72.0			767.0
N.H.	76.0	246.0	275.0	256.0	151.0			1,004.0
Total	385.0	1,548.0	2,302.0	1,473.0	450.0			6,158.0
1994 Season, 122 days, Dec 15 - Apr 15								
Maine	265.0	1,340.0	1,889.0	1,065.0	122.0			4,681.0
Mass.	58.0	152.0	147.0	83.0	15.0			455.0
N.H.	169.0	228.0	266.0	173.0	18.0			854.0
Total	492.0	1,720.0	2,302.0	1,321.0	155.0			5,990.0

	Dec	Jan	Feb	Mar	Apr	May	Other	Season Total
1995 Season, 128 days, Dec 1 - Apr 30, 1 day per week off								
Maine	879.0	2,341.0	2,641.0	1,337.0	694.0			7,892.0
Mass.	145.0	385.0	275.0	157.0	109.0			1,071.0
N.H.	189.0	331.0	279.0	359.0	344.0			1,502.0
Total	1,213.0	3,057.0	3,195.0	1,853.0	1,147.0			10,465.0
1996 Season, 152 days, Dec 1- May 31, 1 day per week off								
Maine	1,341.0	2,030.0	3,190.0	1,461.0	444.0	457.0		8,923.0
Mass.	299.0	248.0	325.0	269.0	106.0	126.0		1,373.0
N.H.	331.0	311.0	389.0	248.0	155.0	61.0		1,495.0
Total	1,971.0	2,589.0	3,904.0	1,978.0	705.0	644.0		11,791.0
1997 Season, 156 days, Dec 1- May 27, two 5-day and four 4-day blocks off								
Maine	1,674.0	1,753.0	2,737.0	1,178.0	793.0	530.0		8,665.0
Mass.	184.0	226.0	245.0	114.0	7.0	1.0		777.0
N.H.	277.0	245.0	301.0	218.0	189.0	62.0		1,292.0
Total	2,135.0	2,224.0	3,283.0	1,510.0	989.0	593.0		10,734.0
1998 Season, 105 days, Dec 8-May 22, weekends off except Mar 14-15, Dec 25-31 and Mar 16-31 off.								
Maine	852.0	1,548.0	1,653.0	725.0	346.0	189.0		5,313.0
Mass.	94.0	200.0	148.0	70.0	3.0	1.0		515.0
N.H.	141.0	216.0	182.0	134.0	83.0	22.0		778.0
Total	1,086.0	1,964.0	1,983.0	929.0	432.0	212.0		6,606.0
1999 Season, 90 days, Dec 15 - May 25, weekends, Dec 24 - Jan 3, Jan 27-31, Feb 24-28, Mar 16-31, and Apr 29 - May 2 off.								
Maine	190.0	556.0	1,125.0	553.0	324.0	172.0		2,920.0
Mass.	39.0	57.0	71.0	9.0	40.0			216.0
N.H.	82.0	192.0	213.0	44.0	123.0	21.0		675.0
Total	311.0	805.0	1,409.0	606.0	487.0	193.0		3,811.0
2000 Season, 51 days, Jan 17 - Mar 15, Sundays off								
Maine		653.0	1,838.0	401.0				2,892.0
Mass.		23.0	100.0	27.0				150.0
N.H.		36.0	179.0	78.0				293.0
Total		712.0	2,117.0	506.0				3,335.0
***2001** Season, 83 days, Jan 9 - Apr 30, Mar 18 - Apr 16 off, experimental offshore fishery in May								
Maine		1491.0	1209.0	112.0	39.0	6.0		2,857.0
Mass.		111.0	46.0	10.0	1.0			168.0
N.H.		302.0	142.0	27.0	31.0			502.0
Total		1904.0	1397.0	149.0	71.0	6.0		3,527.0
***2002** Season, 25 days, Feb 15 - Mar 11								
Maine			502.0	195.0				697.0
Mass.			13.0	8.0				21.0
N.H.			108.0	44.0				152.0
Total			623.0	247.0				870.0

* Preliminary data

Table C7.Stratified mean numbers and weights, per tow,* of northern shrimp collected during R/V Gloria Michelle summer surveys.

Untransformed

Year	Total Number	Age-1.5 Number	>22 mm** Number	Weight (kg)	Weight** >22 mm (kg)
1984	3,005	48	826	22.6	8.9
1985	3,531	643	2,262	29.4	22.3
1986	3,327	703	1,688	29.7	19.6
1987	2,441	545	1,360	21.0	15.2
1988	4,310	2,812	1,012	26.6	11.7
1989	3,580	525	1,072	27.3	11.5
1990	3,021	264	2,097	29.4	22.2
1991	1,992	765	1,042	18.2	12.6
1992	1,503	443	625	12.9	7.6
1993	3,569	2,334	772	17.9	8.5
1994	3,435	1,285	849	21.1	9.3
1995	2,856	576	1,238	21.1	13.8
1996	2,651	793	1,223	20.2	13.8
1997	3,161	1,551	1,017	19.8	11.6
1998	2,319	533	676	15.1	7.4
1999	1,648	471	719	11.9	7.8
2000	1,843	997	647	11.9	7.2
2001	870	69	281	6.5	2.9
2002	3,157	2,313	571	15.0	6.3

Log_e Transformed

Year	Total Number	Age-1.5 Number	>22 mm** Number	Weight (kg)	Weight** >22 mm (kg)
1984	1,152	18	316	10.5	3.4
1985	1,849	337	1,184	17.7	11.7
1986	1,695	358	860	19.6	10.0
1987	1,385	342	854	14.8	9.5
1988	1,269	828	298	12.8	3.4
1989	1,883	276	564	17.0	6.1
1990	1,624	142	1,127	18.1	12.0
1991	1,255	482	657	11.7	8.0
1992	955	282	397	9.4	4.8
1993	1,156	757	250	9.1	2.8
1994	984	368	243	8.7	2.7
1995	1,449	292	628	13.3	7.0
1996	776	232	358	8.8	4.0
1997	762	374	245	7.7	2.8
1998	583	134	170	6.3	1.9
1999	398	114	174	5.8	1.9
2000	807	437	283	6.4	3.2
2001	451	36	146	4.3	1.5
2002	1,446	1,059	261	9.2	2.9

*Based on strata 1, 3, 5, 6, 7 and 8. **Will be fully recruited to the winter fishery.

Table C8a. Summary of results from Collie-Sissenwine analysis of Gulf of Maine shrimp.

Fishing Season	New Recruits (millions)	Fully-Recruited (millions)	F (NR+FR)	Biomass (mt)
1985	987	947	0.09	14,051
1986	1,179	1,370	0.28	21,719
1987	985	1,498	0.40	22,499
1988	757	1,299	0.48	18,799
1989	1,177	987	0.18	14,220
1990	1,313	1,403	0.33	20,637
1991	829	1,519	0.44	22,190
1992	608	1,177	0.46	16,962
1993	512	881	0.42	12,396
1994	711	713	0.32	9,199
1995	975	809	0.33	12,378
1996	883	1,003	0.65	15,516
1997	534	764	0.87	11,008
1998	510	425	0.62	6,728
1999	408	391	0.46	5,791
2000	303	393	0.28	5,658
2001	445	409	0.40	6,238
2002	358	448	-0.01	6,110
2003	1,001	634		9,244
1985-1995 average	912	1,146	0.34	16,823
2000-2003 average	527	471	0.22	6,812

Table C8b. Summary of input and output from Collie-Sissenwine analysis of Gulf of Maine shrimp.

Northern Shrimp using Summer Survey

Survey Year*	Indices of Abundance: Recuits	Indices of Abundance: Full Recruits	Total Catch Millions
1984	447.5580	479.0570	352.7928
1985	619.4560	925.4300	361.1710
1986	533.2920	848.5440	425.2945
1987	482.8980	766.9030	228.4345
1988	459.7550	387.7140	283.6468
1989	701.0930	817.9000	442.4292
1990	511.5210	907.5220	320.2898
1991	374.2770	612.0870	262.4338
1992	313.5950	444.3580	194.7883
1993	410.1960	320.7500	270.4058
1994	368.5900	364.3020	615.3185
1995	485.7860	653.3320	799.3678
1996	257.6520	348.6160	718.4332
1997	257.2980	267.1010	373.6801
1998	217.1340	226.6420	215.1221
1999	137.3900	174.6070	209.2793
2000	276.2810	288.1930	141.4937
2001	171.8090	196.3560	38.6779
2002	550.6000	372.9300	

* Survey Year Data are applied to the following Fishing Year

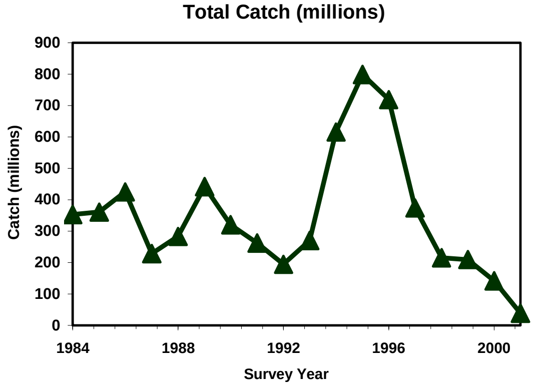
Input File Name	R2002.dat
Tuning Dataset	Survey
Time of Survey (yr)	0
Time of Catch (yr)	0.5
Natural Mortality Rate	0.25
Relative Catchability: Recruits to Full Recruits s_r	0.7 - 1.0
Catchability Estimate and CV	0.550 0.16
Average Partial Recruitment Rate to Fishery	0.63
Average Z_all sizes (1999-2001)	0.59
Average Z_all sizes (2000-2001)	0.44

Survey Year*	Stock Size Estimates millions at time of Survey: Recruits	Stock Size Estimates millions at time of Survey: Full Recruits	Total Mortality Z all sizes	Fishing Mortality All Sizes
1984	986.8	947.3	0.34	0.09
1985	1179.3	1369.9	0.53	0.28
1986	984.7	1497.6	0.65	0.40
1987	757.5	1298.8	0.73	0.48
1988	1176.6	987.2	0.43	0.18
1989	1313.2	1402.9	0.58	0.33
1990	829.4	1519.4	0.69	0.44
1991	608.2	1177.1	0.71	0.46
1992	511.5	881.3	0.67	0.42
1993	711.4	712.6	0.57	0.32
1994	975.1	808.6	0.58	0.33
1995	883.4	1002.7	0.90	0.65
1996	534.0	764.1	1.12	0.87
1997	510.5	424.6	0.87	0.62
1998	408.2	391.5	0.71	0.46
1999	303.4	392.8	0.53	0.28
2000	445.1	409.4	0.65	0.40
2001	357.9	447.9	0.24	-0.01
2002	1000.6	634.2		

Note that the recruit abundance index for the last year is NOT used in the least squares estimation. It is, however, used in conjunction with the least squares estimate of q_n and the selectivity of the recruits to calculate recruit population size in 2001

* Survey Year Data are applied to the following Fishing Year

Total Catch (millions)



Est. Abundance & Total Mortality Rate Z

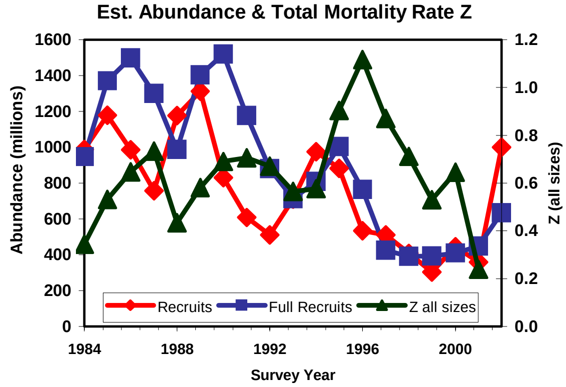


Table C9. Summary of CSA retrospective analyses.

Retrospective CSA Runs

BL	1984 - 2001
R1	1985 - 2001
R2	1986 - 2001
R3	1987 - 2001
R4	1988 - 2001
R5	1989 - 2001
R6	1984 - 2000
R7	1984 - 1999
R8	1984 - 1998
R9	1984 - 1997
R10	1984 - 1996

Fishing Mortality

Year	BL	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1984	0.09						0.10	0.09	0.10	0.09	0.09
1985	0.28	0.31					0.28	0.28	0.28	0.28	0.28
1986	0.4	0.41	0.38				0.40	0.40	0.40	0.40	0.40
1987	0.48	0.18	0.18	0.17	0.13		0.18	0.18	0.18	0.18	0.18
1989	0.33	0.33	0.33	0.33	0.32	0.32	0.33	0.33	0.33	0.33	0.33
1990	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
1991	0.46	0.46	0.46	0.46	0.45	0.45	0.46	0.45	0.46	0.46	0.46
1992	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42
1993	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
1994	0.33	0.33	0.33	0.32	0.32	0.32	0.33	0.32	0.33	0.32	0.32
1995	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.66	0.65	0.65
1996	0.87	0.88	0.87	0.86	0.85	0.85	0.87	0.85	0.89	0.85	0.85
1997	0.62	0.63	0.62	0.62	0.61	0.61	0.62	0.61	0.64	0.58	
1998	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.44	0.52		
1999	0.28	0.29	0.28	0.28	0.27	0.27	0.29	0.22			
2000	0.40	0.40	0.40	0.39	0.39	0.39	0.41				
2001	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01					

Table C9 (cont.). Summary of CSA retrospective analyses

Abundance of Recruits

Year	BL	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1984	986.79						983.33	1010.69	963.94	1001.53	1003.43
1985	1179.3	1143.61					1175.02	1208.87	1151.03	1197.53	1199.89
1986	984.66	965.48	991.53				981.05	1009.6	960.82	1000.04	1002.02
1987	757.48	744.57	755.68	773.71			754.62	777.23	738.59	769.66	771.23
1988	1176.59	1157.57	1174.01	1199.77	1280.87		1172.38	1205.65	1148.81	1194.51	1196.83
1989	1313.15	1292.19	1309.04	1331.99	1373.48	1361.49	1308.42	1345.83	1281.92	1333.3	1335.9
1990	829.43	815.8	826.6	840.84	862.94	858.72	826.34	850.76	809.04	842.58	844.28
1991	608.2	598.24	606.12	616.47	632.24	629.44	605.95	623.79	593.29	617.82	619.06
1992	511.52	503.25	509.78	518.37	531.37	529.1	509.64	524.46	499.14	519.51	520.54
1993	711.37	701.04	709.2	719.93	736.18	733.36	709.02	727.56	695.9	721.4	722.7
1994	975.13	965.95	973.2	982.85	997.74	995.13	973.03	989.84	961.26	984.54	985.79
1995	883.44	876.04	881.88	889.69	901.82	899.7	881.74	895.48	871.96	891.88	893.06
1996	534.01	530.71	533.31	536.83	542.41	541.43	533.23	539.64	528.33	539.19	539.99
1997	510.46	505.01	509.31	515.02	523.78	522.25	509.12	520.3	497.9	526.4	529.21
1998	408.2	402.66	407.04	412.8	421.57	420.05	406.67	420.31	387.43	445.67	
1999	303.41	299.43	302.58	306.73	313.03	311.94	301.9	317.48	270.35		
2000	445.05	437.94	443.56	450.94	462.1	460.17	439.25	515.49			
2001	357.93	352.02	356.69	362.81	372.06	370.46	345.59				
2002	1000.64	983.57	997.06	1014.75	1041.45	1036.85					

Abundance of Post-Recruits

Year	BL	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1984	947.28						943.94	970.32	925.25	961.49	963.32
1985	1369.94	1503.03					1364.46	1407.76	1333.76	1393.26	1396.27
1986	1497.65	1512.24	1376.96				1491.6	1539.39	1457.72	1523.39	1526.72
1987	1298.84	1285.18	1264.24	1148.23			1293.37	1336.64	1262.68	1322.15	1325.16
1988	987.19	971.84	976.01	958.62	746.53		983.12	1015.31	960.28	1004.53	1006.77
1989	1402.9	1378.73	1395.6	1411.33	1383.83	1424.56	1397.25	1441.86	1365.62	1426.93	1430.03
1990	1519.36	1492.03	1513.07	1539.07	1565.46	1569.96	1513.13	1562.43	1478.17	1545.92	1549.35
1991	1177.07	1155.86	1172.49	1193.93	1223.27	1220.34	1172.25	1210.32	1145.26	1197.58	1200.23
1992	881.33	865.41	877.96	894.34	918.33	914.71	877.72	906.26	857.48	896.72	898.71
1993	712.55	700.08	709.93	722.83	742.12	738.93	709.73	732.08	693.86	724.63	726.19
1994	808.58	795.64	805.87	819.28	839.48	836.03	805.65	828.86	789.14	821.24	822.88
1995	1002.71	988.84	999.79	1014.24	1036.23	1032.43	999.55	1024.7	981.57	1017.18	1019.13
1996	764.06	754.71	762.1	771.88	786.87	784.27	761.91	779.23	748.98	775.97	777.7
1997	424.61	416.57	422.92	431.33	444.19	441.96	422.73	438.01	410.26	438.2	440.36
1998	391.46	383.69	389.83	397.93	410.25	408.12	389.52	406.03	371.42	420.06	
1999	392.76	385.58	391.26	398.72	410.04	408.08	390.47	412.56	352.2		
2000	409.36	401.18	407.64	416.14	428.98	426.77	405.07	454.33			
2001	447.86	439.23	446.05	454.99	468.5	466.17	435.15				
2002	634.18	622.73	631.78	643.65	661.58	658.49					

Table C9 (cont.). Summary of CSA retrospective analyses

Biomass of Recruits

Year	BL	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1984	6.31						6.29	6.47	6.17	6.41	6.42
1985	8.85	8.58					8.82	9.07	8.64	8.99	9.00
1986	7.07	6.93	7.12				7.04	7.25	6.90	7.18	7.19
1987	5.48	5.39	5.47	5.60			5.46	5.62	5.35	5.57	5.58
1988	5.74	5.65	5.73	5.85	6.25		5.72	5.88	5.61	5.83	5.84
1989	8.71	8.57	8.69	8.84	9.11	9.03	8.68	8.93	8.51	8.85	8.86
1990	6.84	6.73	6.82	6.93	7.11	7.08	6.81	7.01	6.67	6.95	6.96
1991	4.08	4.02	4.07	4.14	4.25	4.23	4.07	4.19	3.98	4.15	4.16
1992	3.36	3.31	3.35	3.41	3.49	3.48	3.35	3.45	3.28	3.42	3.42
1993	3.31	3.26	3.30	3.35	3.42	3.41	3.29	3.38	3.23	3.35	3.36
1994	5.68	5.62	5.67	5.72	5.81	5.79	5.67	5.76	5.60	5.73	5.74
1995	5.98	5.93	5.97	6.02	6.10	6.09	5.97	6.06	5.90	6.04	6.04
1996	3.51	3.49	3.50	3.53	3.56	3.56	3.50	3.55	3.47	3.54	3.55
1997	2.75	2.72	2.75	2.78	2.83	2.82	2.75	2.81	2.69	2.84	2.86
1998	2.46	2.43	2.46	2.49	2.54	2.53	2.45	2.54	2.34	2.69	
1999	2.00	1.97	1.99	2.02	2.06	2.05	1.99	2.09	1.78		
2000	2.44	2.40	2.43	2.47	2.53	2.52	2.40	2.82			
2001	2.38	2.34	2.37	2.41	2.47	2.46	2.30				
2002	4.48	4.41	4.47	4.55	4.67	4.65					

Biomass of Post-Recruits

Year	BL	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1984	7.74						7.71	7.92	7.56	7.85	7.87
1985	12.87	14.12					12.82	13.22	12.53	13.09	13.12
1986	15.43	15.58	14.19				15.37	15.86	15.02	15.69	15.73
1987	13.32	13.18	12.96	11.77			13.26	13.70	12.95	13.56	13.59
1988	8.48	8.35	8.38	8.23	6.41		8.44	8.72	8.25	8.63	8.65
1989	11.92	11.72	11.86	12.00	11.76	12.11	11.88	12.26	11.61	12.13	12.16
1990	15.35	15.08	15.29	15.55	15.82	15.86	15.29	15.79	14.94	15.62	15.65
1991	12.88	12.65	12.83	13.06	13.38	13.35	12.83	13.24	12.53	13.10	13.13
1992	9.03	8.87	9.00	9.17	9.41	9.38	9.00	9.29	8.79	9.19	9.21
1993	5.89	5.79	5.87	5.98	6.14	6.11	5.87	6.06	5.74	5.99	6.01
1994	6.70	6.59	6.68	6.79	6.96	6.93	6.68	6.87	6.54	6.81	6.82
1995	9.54	9.40	9.51	9.65	9.86	9.82	9.51	9.75	9.34	9.67	9.69
1996	7.50	7.41	7.48	7.58	7.72	7.70	7.48	7.65	7.35	7.62	7.63
1997	3.97	3.90	3.96	4.04	4.16	4.14	3.96	4.10	3.84	4.10	4.12
1998	3.33	3.26	3.31	3.38	3.49	3.47	3.31	3.45	3.16	3.57	
1999	3.66	3.60	3.65	3.72	3.82	3.81	3.64	3.85	3.28		
2000	3.80	3.73	3.79	3.87	3.98	3.96	3.76	4.22			
2001	3.73	3.66	3.71	3.79	3.90	3.88	3.62				
2002	4.76	4.67	4.74	4.83	4.96	4.94					

Table C10. Summary of biomass dynamics model input data, results, and parameter estimates.

	Input				Results			
Fishing Season	**Autumn**	**Maine**	**Summer**	**Catch (mt)**	**Biomass (mt)**	**F**	**Parameter**	**Estimate**
1968	1.8	45.8		5,708	46,330	0.126	**B1969**	45,750
1969	4.5	31.2		12,140	44,520	0.3	**K (mt)**	59,850
1970	3.1	40.8		11,330	36,960	0.337	**r**	0.3345
1971	3.5	9.4		10,590	30,750	0.38	**q autumn**	0.0915
1972	3.4	7.0		11,220	25,300	0.514	**q Maine**	0.4831
1973	5.1	7.8		9,691	18,860	0.614	**q summer**	0.6866
1974	10.0	4.9		8,024	13,160	0.773		
1975	6.8	6.7		6,142	8,075	1.103	**MSY**	5,004
1976	2.3	4.8		1,387	3,660	0.392	**Bmsy**	29,920
1977	1.9	1.6		372	3,416	0.097	**Fmsy**	0.1672
1978	0.0	3.2		17	4,276	0.003	**Ratio of B(2003) to Bmsy**	0.4872
1979	1.0	4.4		487	5,838	0.074	**Ratio of F(2002) to Fmsy**	0.1722
1980	0.7	2.7		339	7,363	0.04	**B2003**	14,580
1981	0.7	3.0		1,071	9,505	0.103	**F2002**	0.029
1982	5.1	2.0		1,530	11,400	0.124		
1983	1.4	4.2		1,397	13,230	0.097		
1984	1.6		10.5	2,951	15,600	0.183		
1985	2.6		17.7	4,131	16,710	0.247		
1986	1.9		19.6	4,635	16,740	0.281		
1987	3.1		15.4	5,253	16,220	0.338		
1988	2.5		12.8	3,031	14,930	0.197		
1989	1.8		17.0	3,315	15,840	0.204		
1990	2.3		18.1	4,662	16,600	0.286		
1991	3.8		11.7	3,571	16,030	0.219		
1992	5.9		9.4	3,444	16,550	0.204		
1993	1.3		9.1	2,143	17,290	0.116		
1994	1.3		8.7	2,915	19,540	0.143		
1995	3.6		13.3	6,466	21,270	0.318		
1996	8.2		8.8	9,166	19,440	0.547		
1997	5.3		7.7	7,154	14,420	0.576		
1998	1.8		6.3	4,174	10,650	0.419		
1999	0.7		5.8	1,816	9,334	0.185		
2000	1.7		6.4	2,389	10,350	0.224		
2001	2.1		4.3	1,327	10,970	0.111		
2002			9.2	375	12,930	0.026		

Table C11. Yield and egg production per recruit of Gulf of Maine northern shrimp.

For an example fishing mortality F = 0.20, natural mortality M = 0.25, and 1,000 age 0 recruits.

Input Data							Results						
Age	Length (mm)	Transition Rate (% Fem)	Fishery Selectivity	Male wt (g)	Female wt (g)	Fecundity at length	Total N	Male N	Female N	Male Catch	Female Catch	Yield (g)	Egg Production
1	11.17	0	0.033	0.84	1.24	0	774	774	0	4	0	4	0
2	18.43	0	0.230	3.79	4.82	0	575	575	0	31	0	117	0
3	23.50	0.081	0.579	7.87	9.30	1,286	399	367	32	56	0	439	41,581
4	27.04	0.922	0.799	12.00	13.58	1,876	265	21	244	48	4	635	458,156
5	29.51	0.997	0.893	15.60	17.19	2,287	173	0	172	3	35	657	393,661
6	31.23	1.000	0.933	18.50	20.04	2,574	112	0	111	0	26	523	287,027
7	32.43	1.000	1.000	20.72	22.19	2,775	71	0	71	0	18	399	197,299
											total	2,773	1,377,725
											total/recruit	2.773	1,378
											% of max		57.52

Ref. Point	F	YPR	%EPR
F_{max}	0.77	4.25	14.77
$F_{0.1}$	0.46	3.99	29.83
$F_{example}$	0.20	2.77	57.52
$F_{50\%}$	0.25	3.14	50
$F_{40\%}$	0.34	3.62	40
$F_{30\%}$	0.45	3.97	30
$F_{20\%}$	0.63	4.21	20
$F_{10\%}$	0.95	4.21	10

Count per pound		
Age	Male	Female
1	540	366
2	120	94
3	58	49
4	38	33
5	29	26
6	25	23
7	22	20

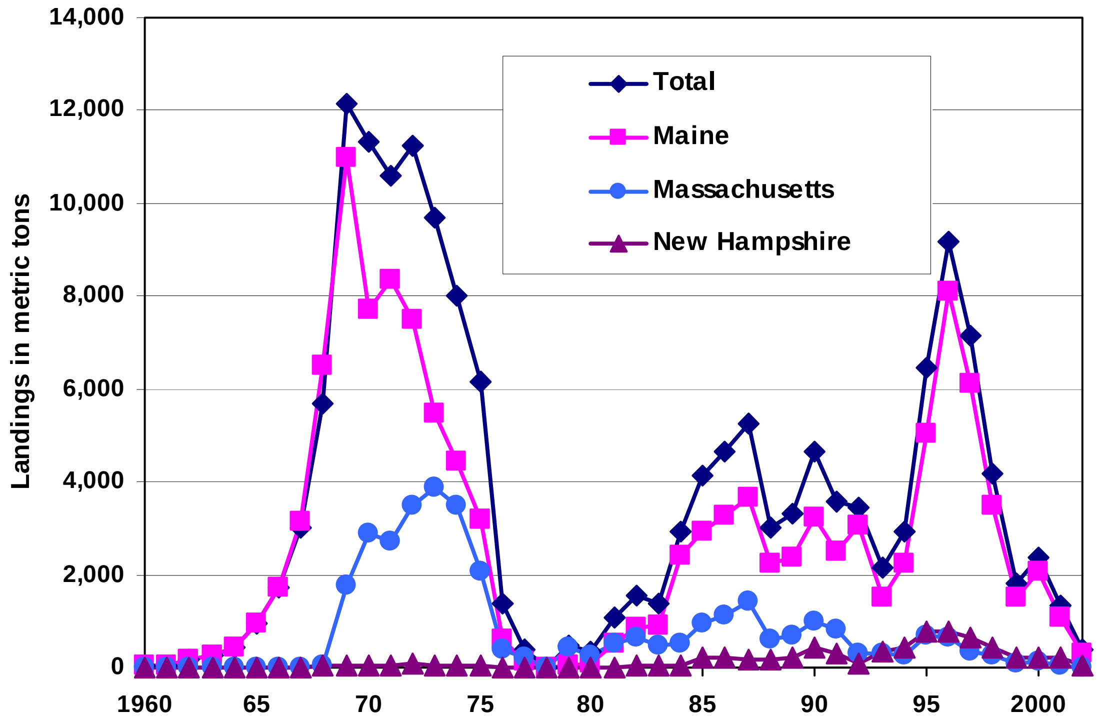


Figure C1. Gulf of Maine northern shrimp landings by fishing season.

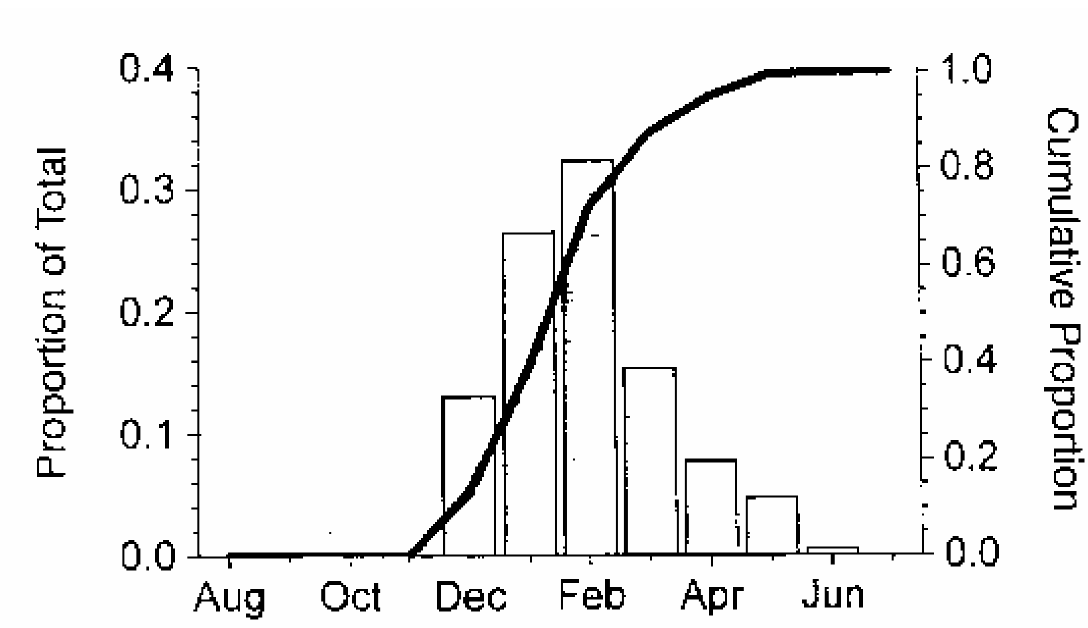


Figure C2. Distribution of monthly landings of Gulf of Maine northern shrimp, 1984 – 1996.

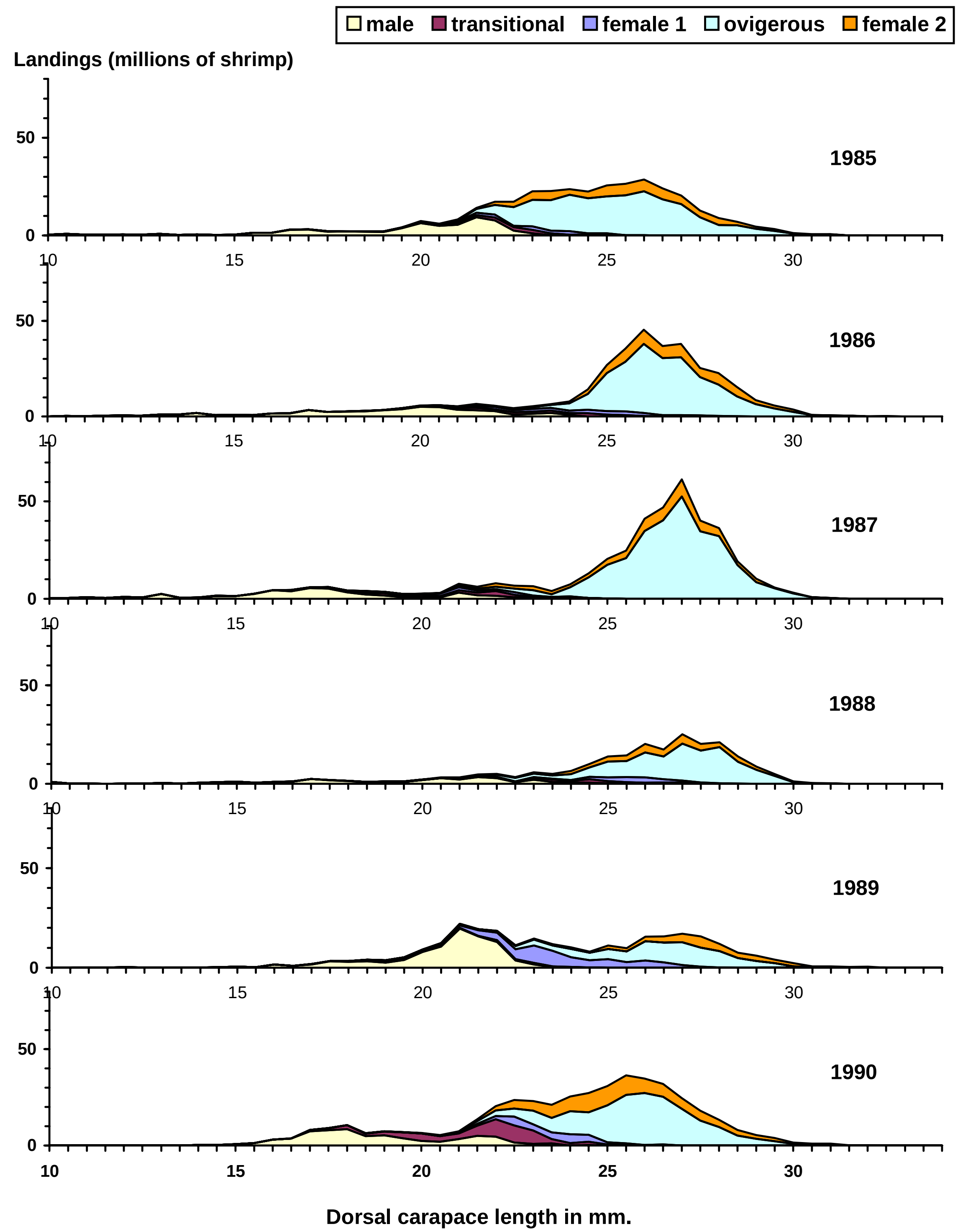
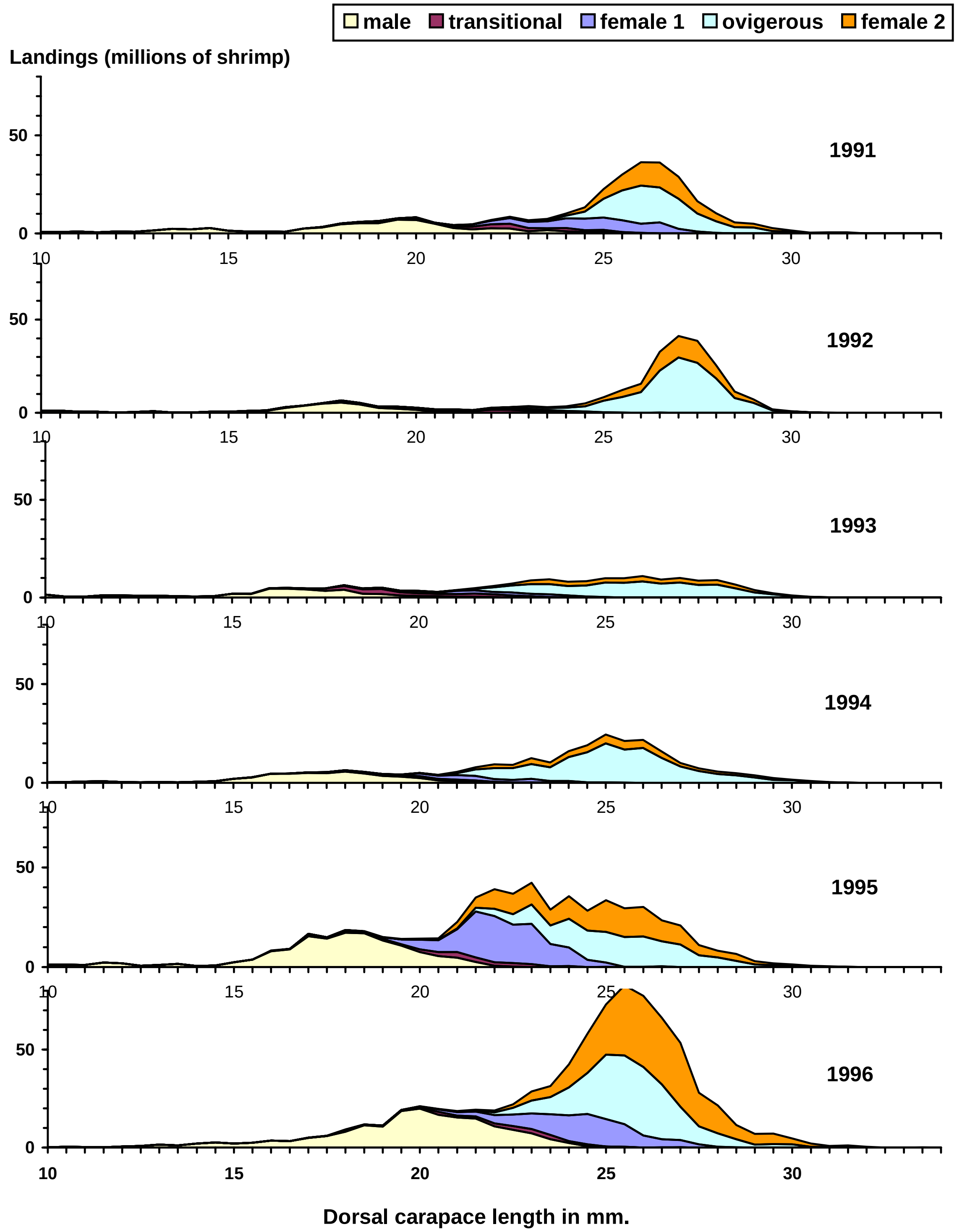


Figure C3. Gulf of Maine northern shrimp landings by length, developmental stage, and fishing season.



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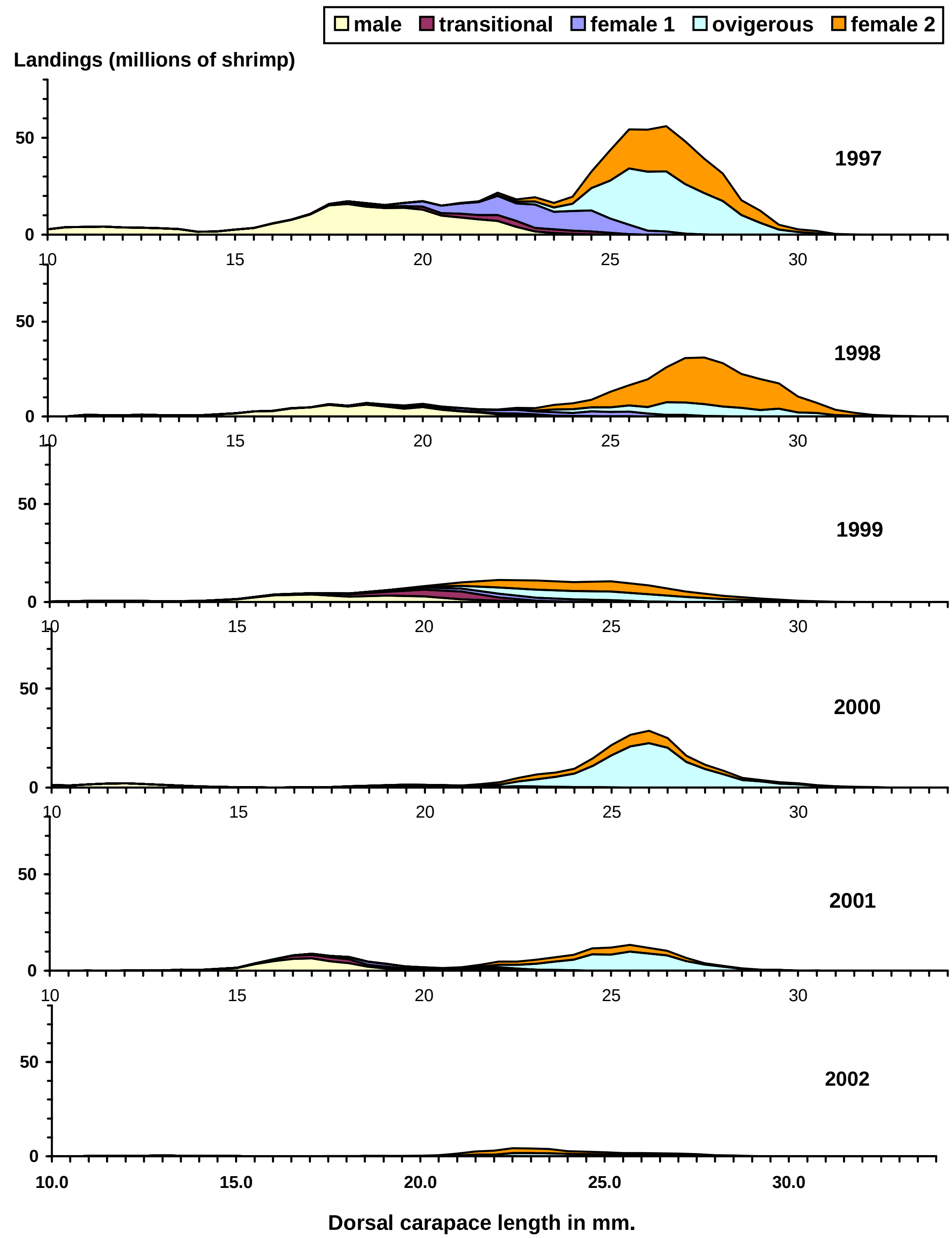

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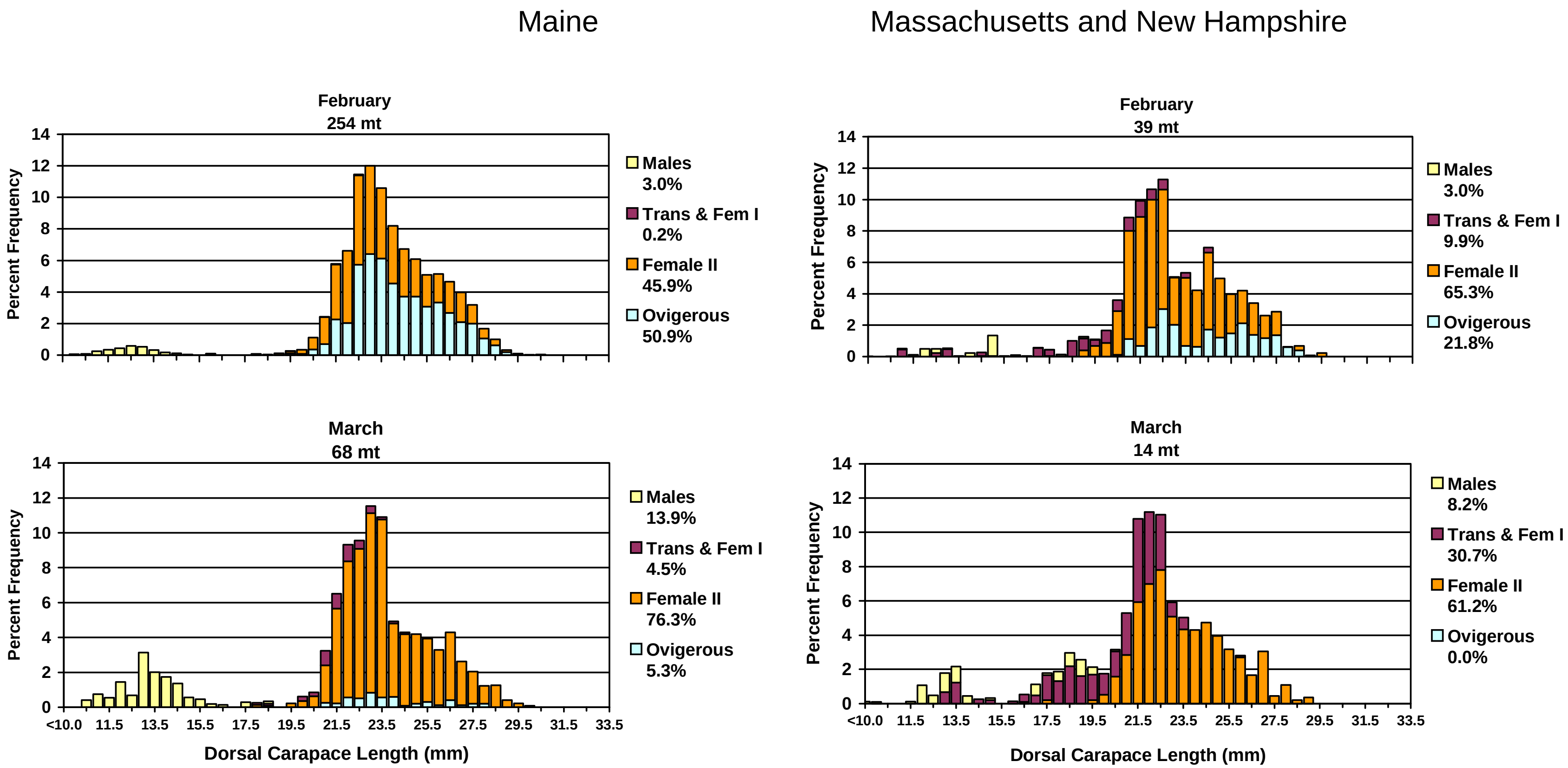


Figure C4a. Gulf of Maine northern shrimp landings by length, developmental stage, and month, 2002 fishing season.

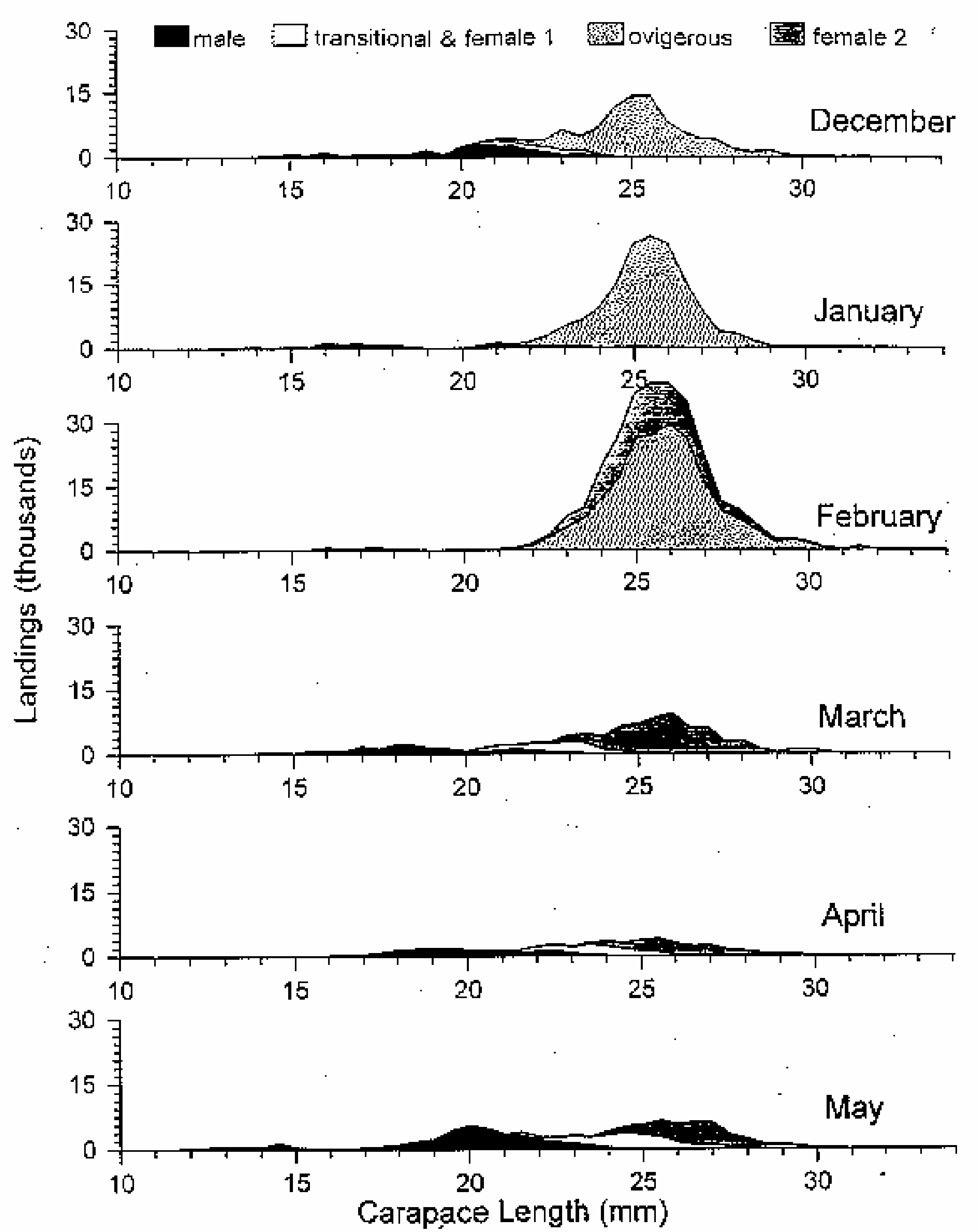
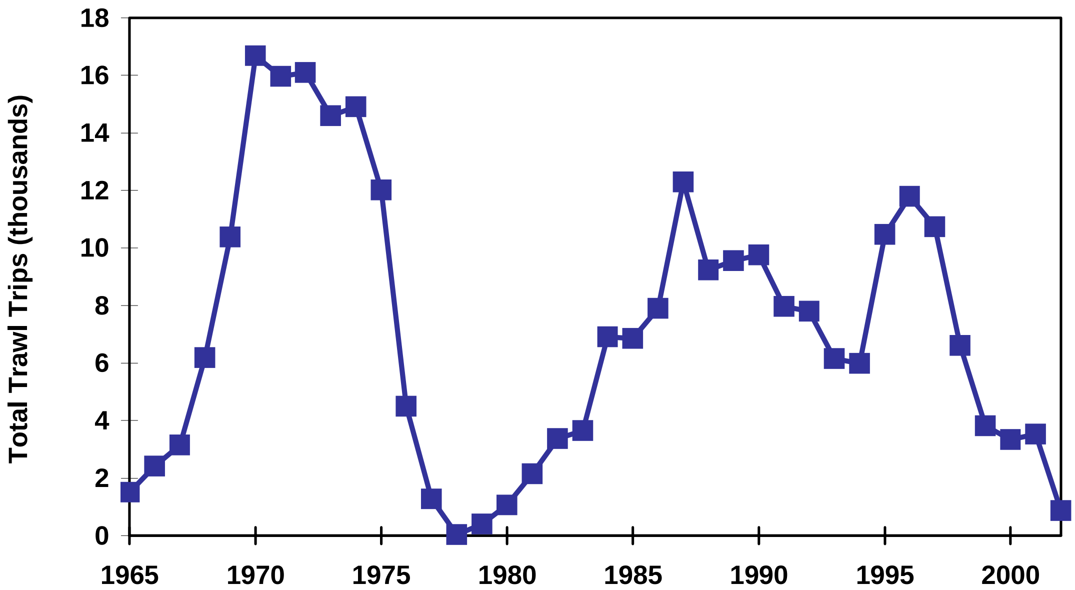


Figure C4b.Gulf of Maine northern shrimp landings by length, developmental stage, and month, 1996 fishing season.



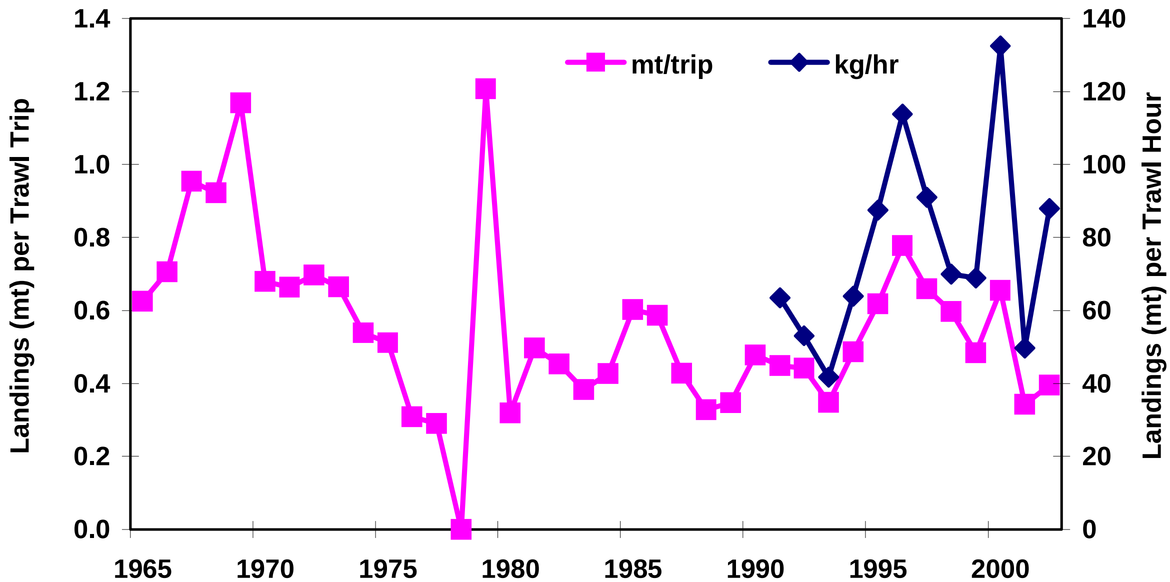


Figure C5. Nominal fishing effort, and CPUE.

Above – trips from NMFS data.

Below – Catch per unit effort in landings per trip, and per hour from state interview data.

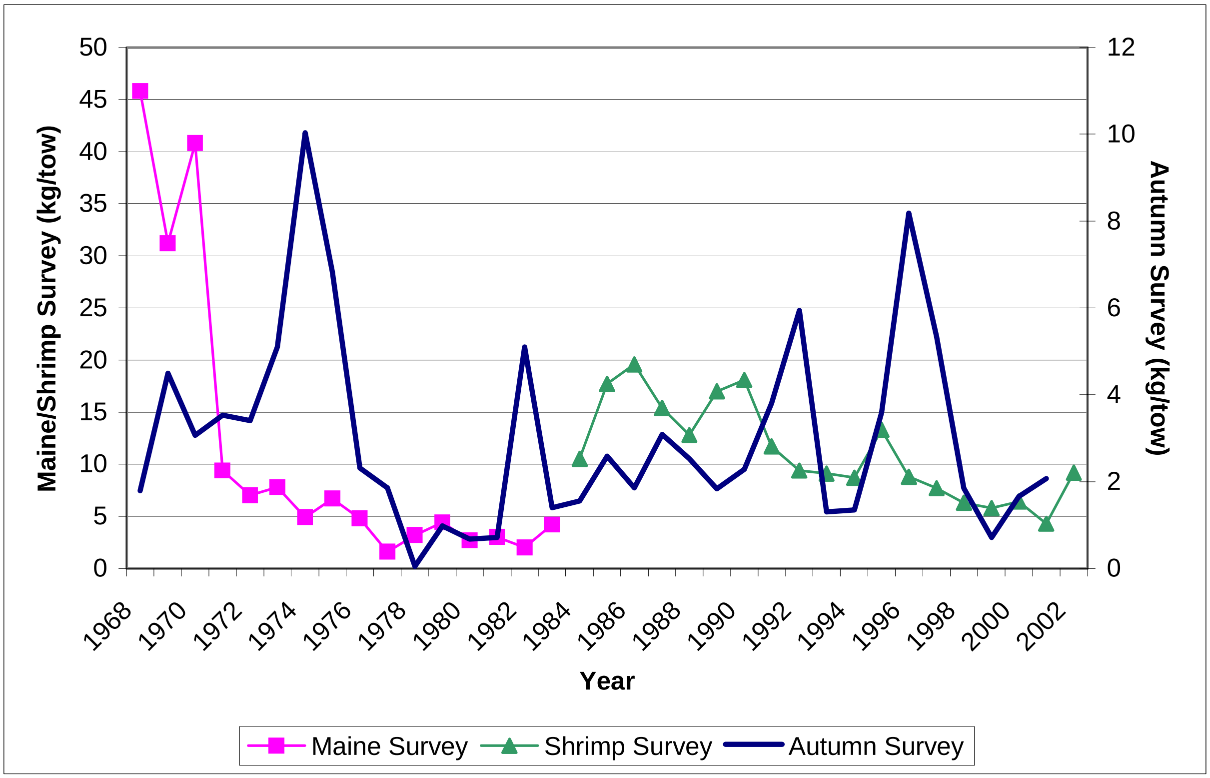


Figure C6. Research trawl survey indices of Gulf of Maine northern shrimp biomass (kg/tow).

Figure C7. State of Maine summer survey fixed station locations.

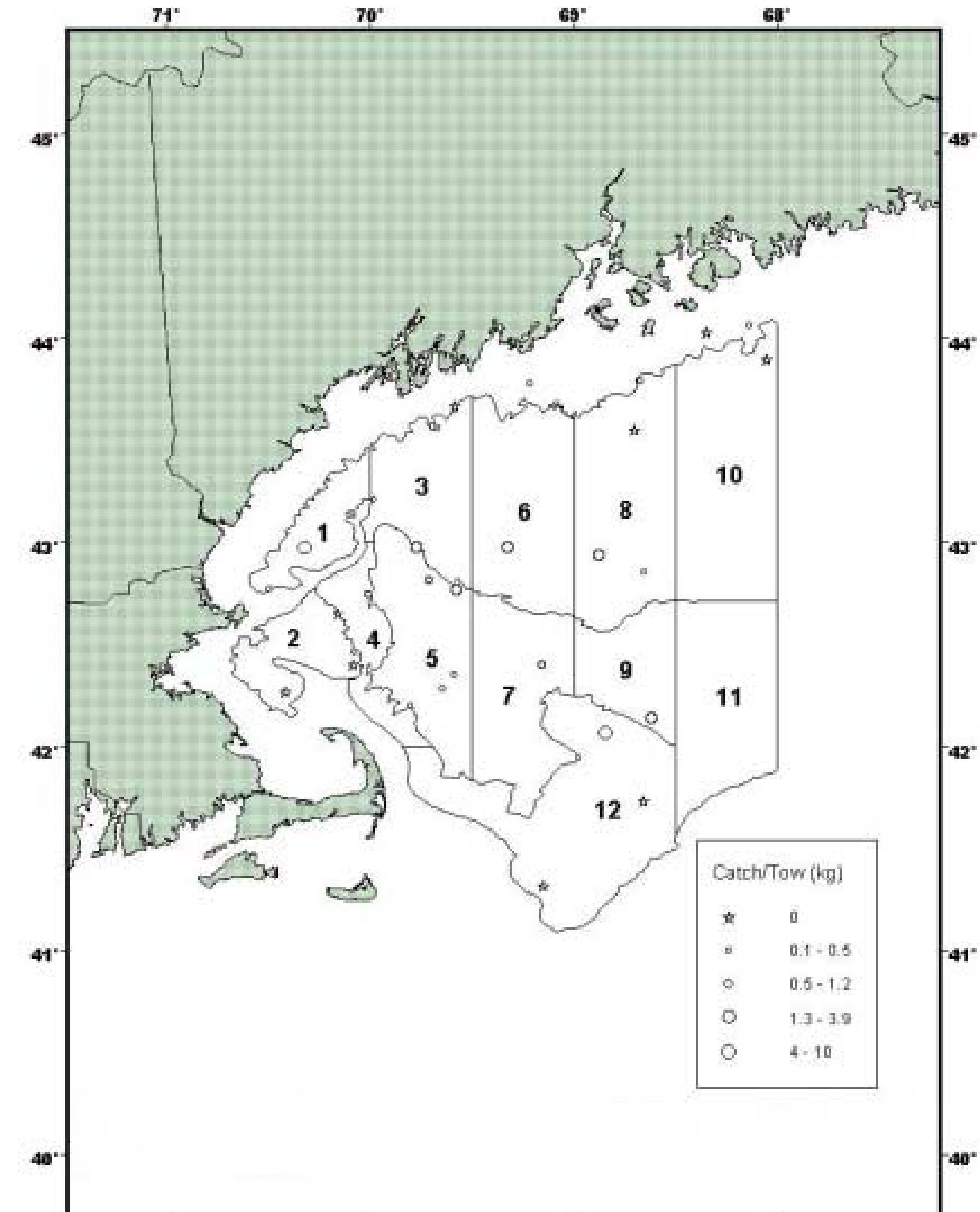


Figure C8. Northern shrimp survey strata and observed distribution of catch per tow (kg) collected during the NEFSC autumn bottom trawl survey in the western Gulf of Maine aboard the R/V Albatross IV, October 2001.

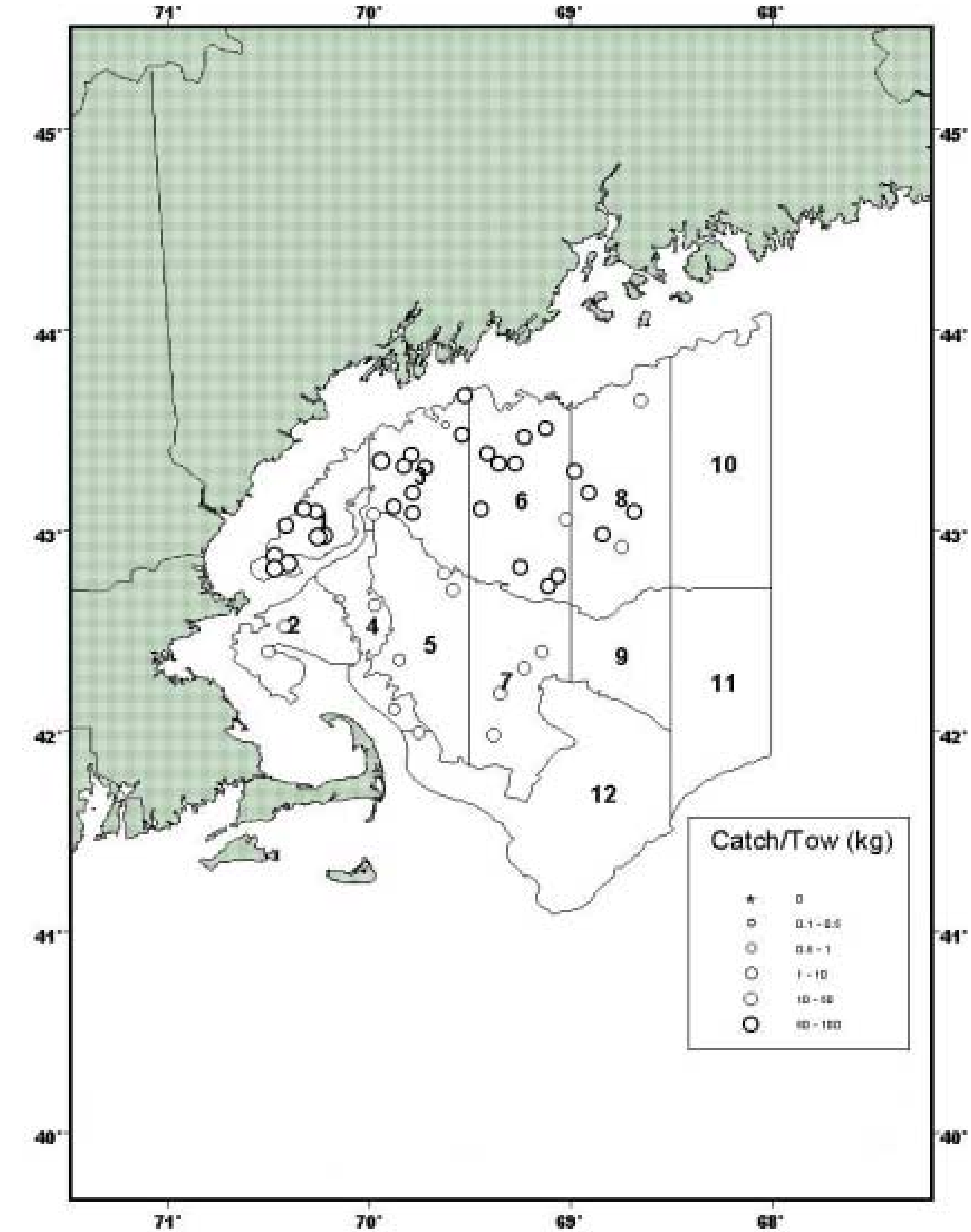


Figure C9.Gulf of Maine northern shrimp summer survey strata and observed distribution of catch per tow (kg) collected during 2002 aboard the R/V Gloria Michelle, July 22 – August 2, 2002.

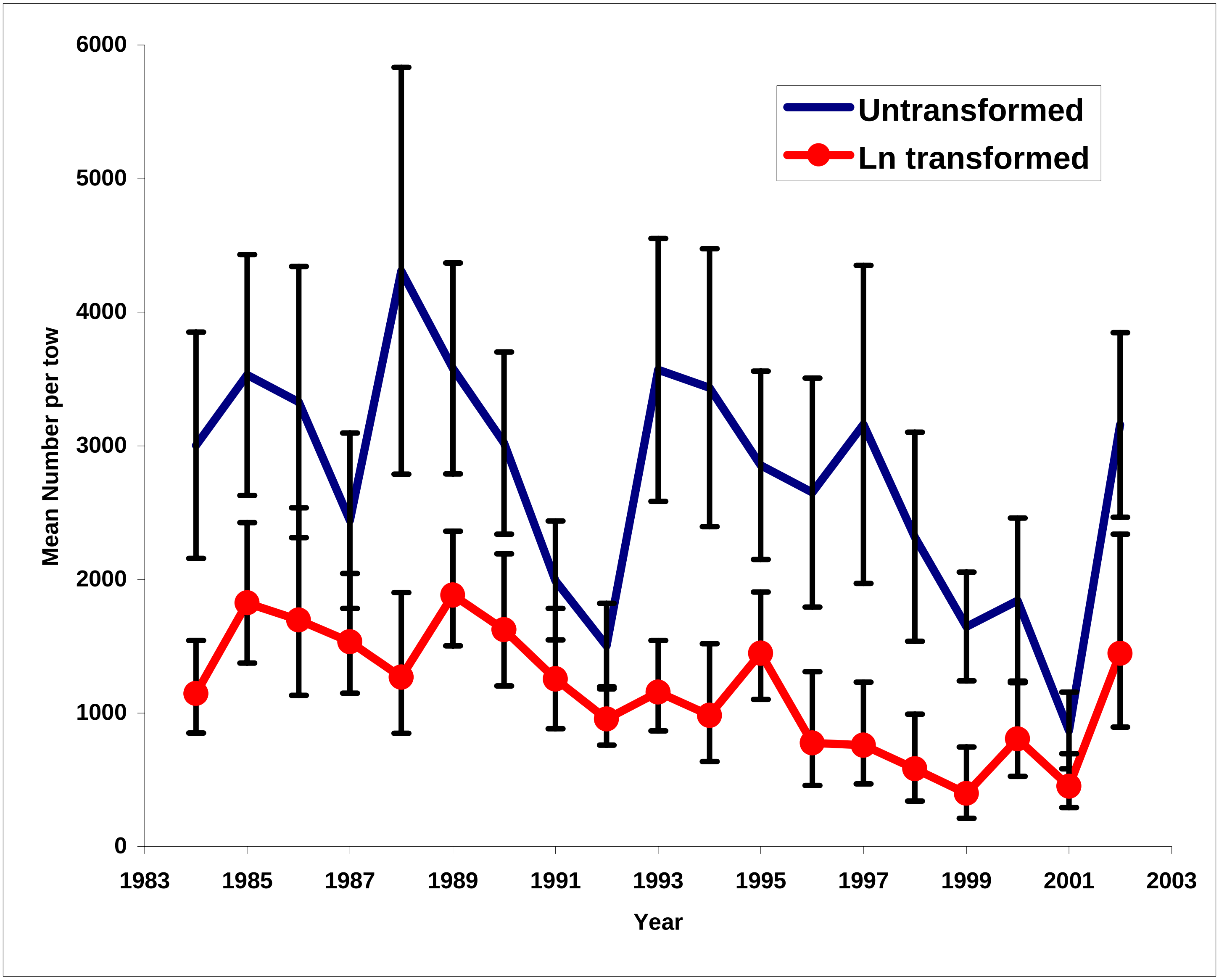


Figure C10. Gulf of Maine summer survey indices of abundance (mean number per tow +/- 2 SE).

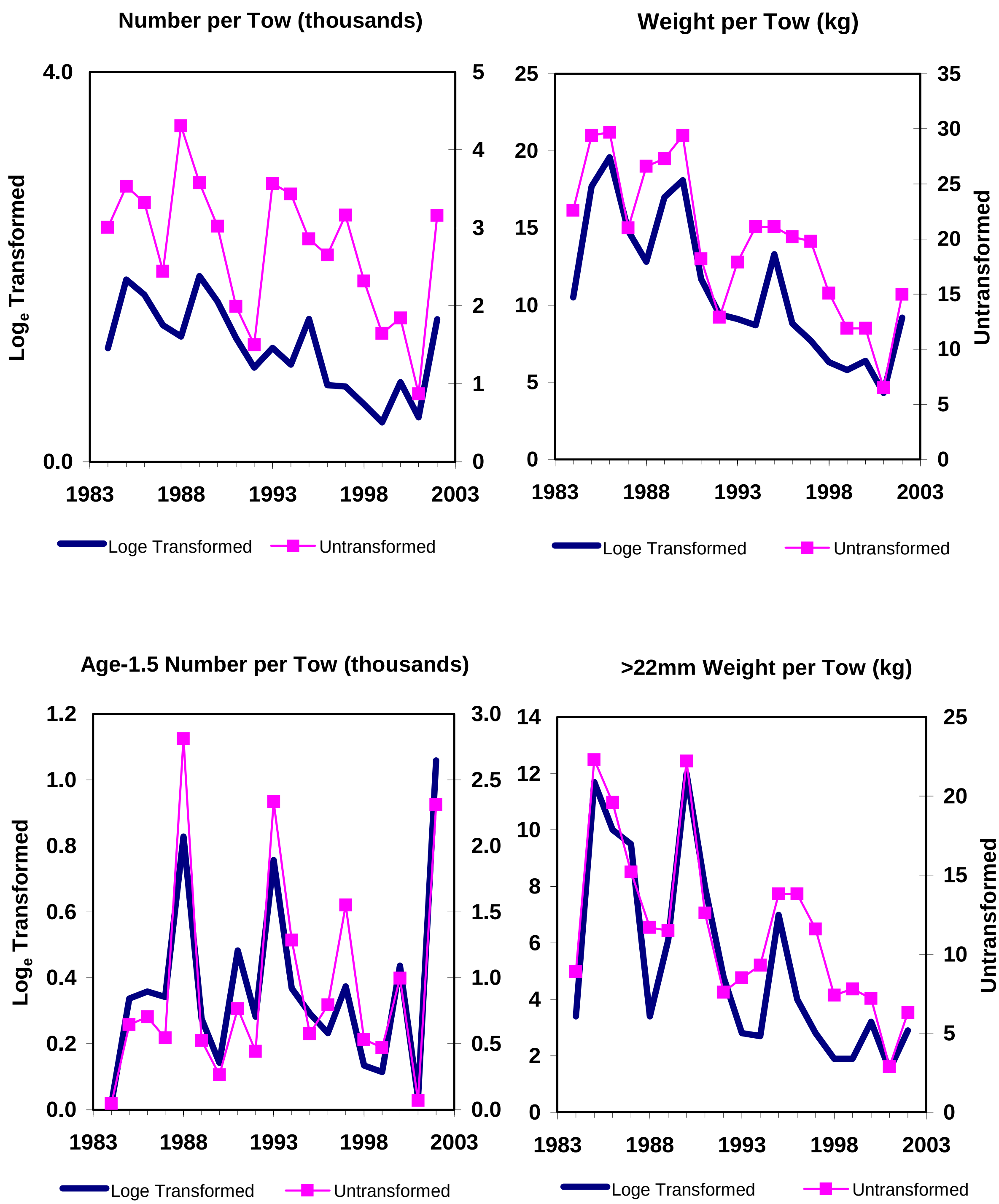


Figure C11. Gulf of Maine northern shrimp summer survey indices of abundance.

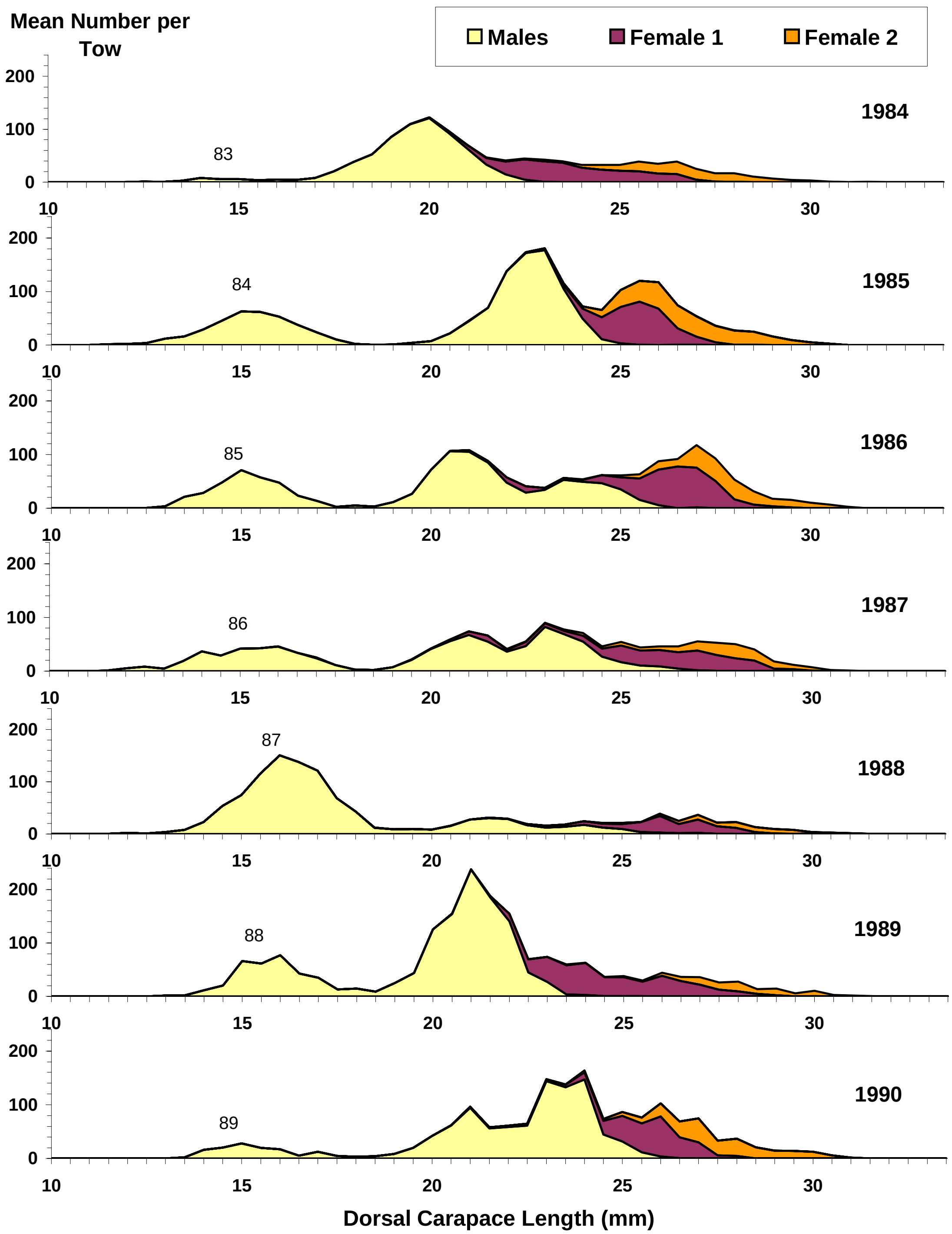


Figure C12. Gulf of Maine northern shrimp summer survey mean catch per tow by length and developmental stage, by survey year. 2-digit numbers are assumed 1.5 age year class.

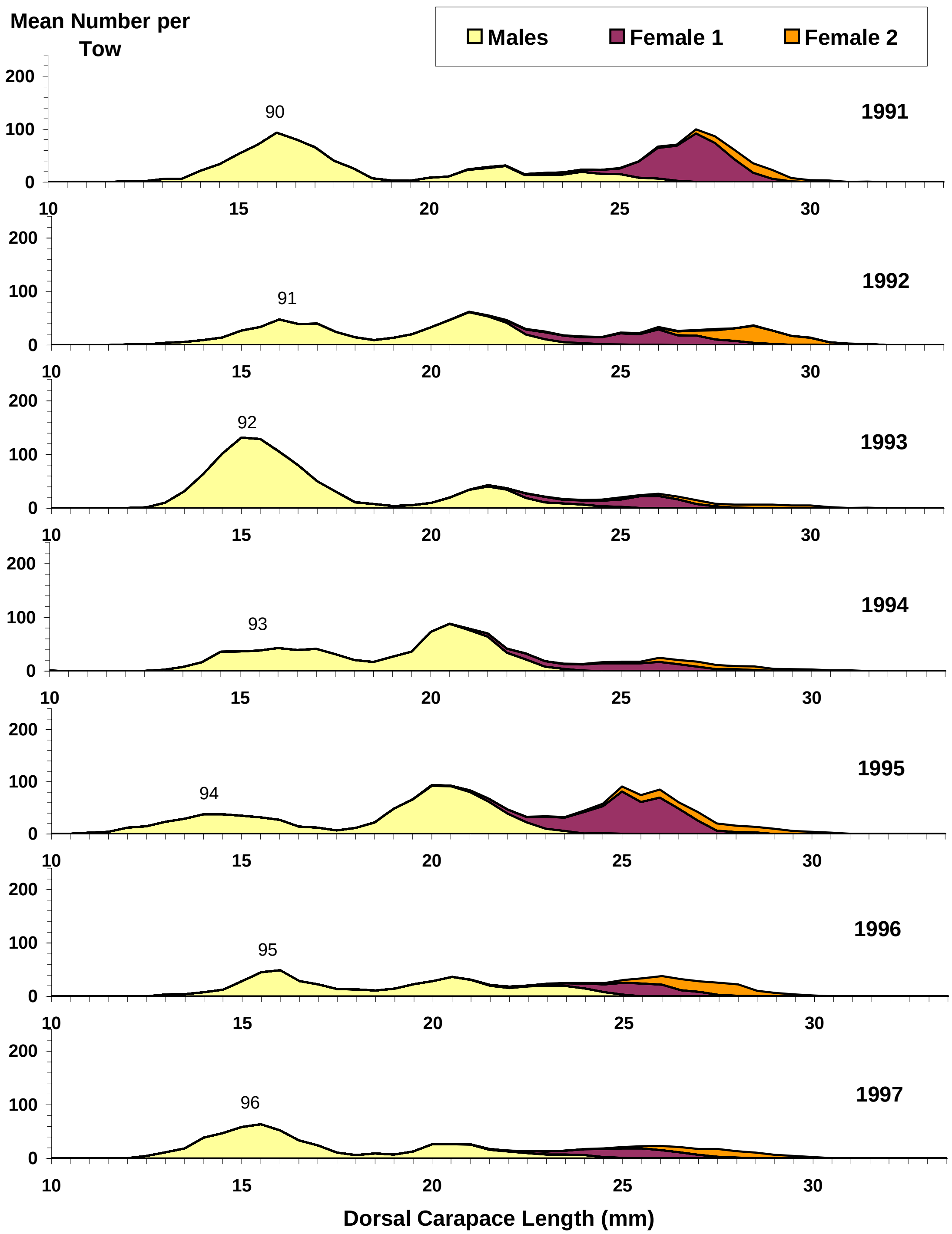


Figure C12 continued.

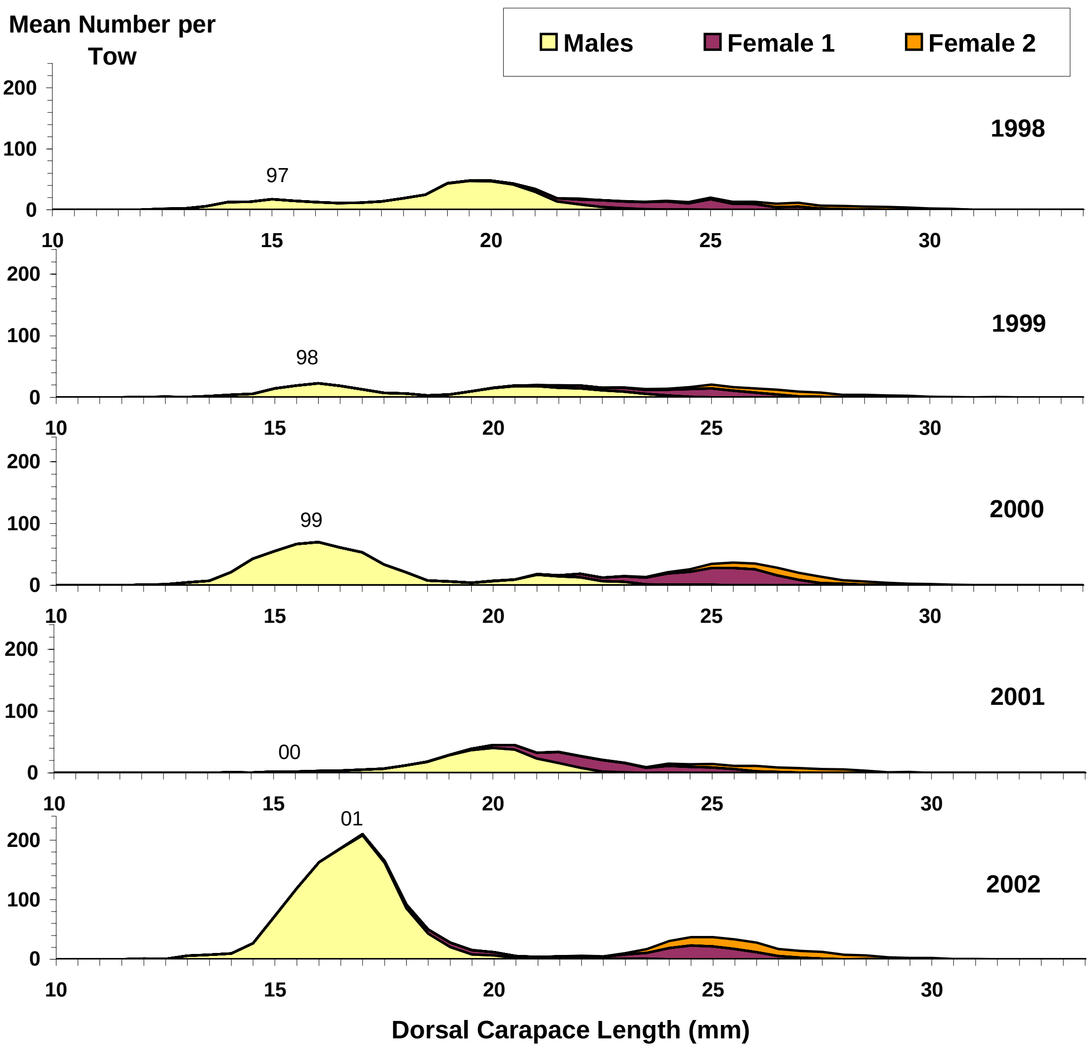


Figure C12 continued.

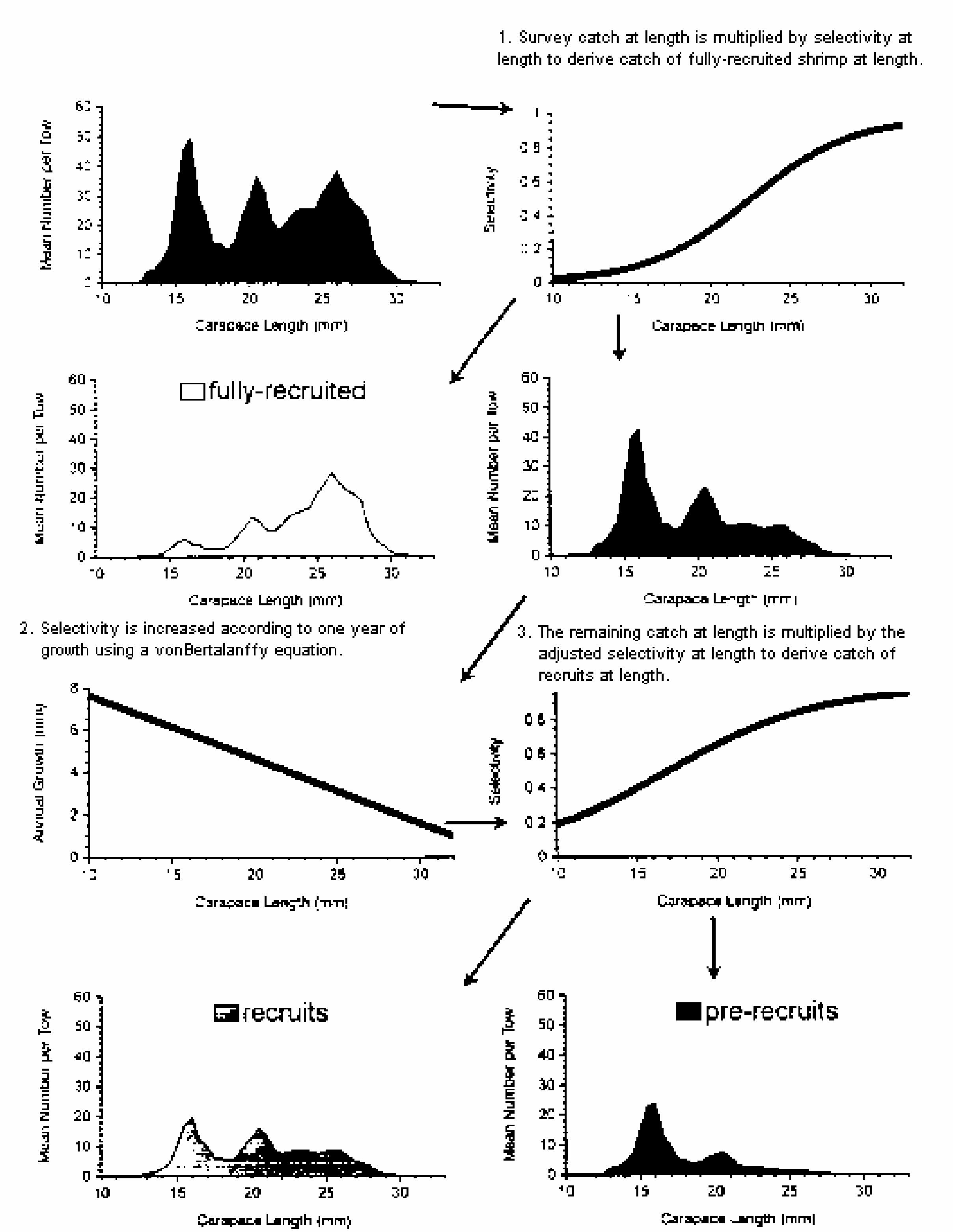


Figure C13. The "selectivity" method of deriving indices of abundance for fully-recruited and recruited Gulf of Maine northern shrimp from summer survey length frequencies. Example illustrated here is from 1996.

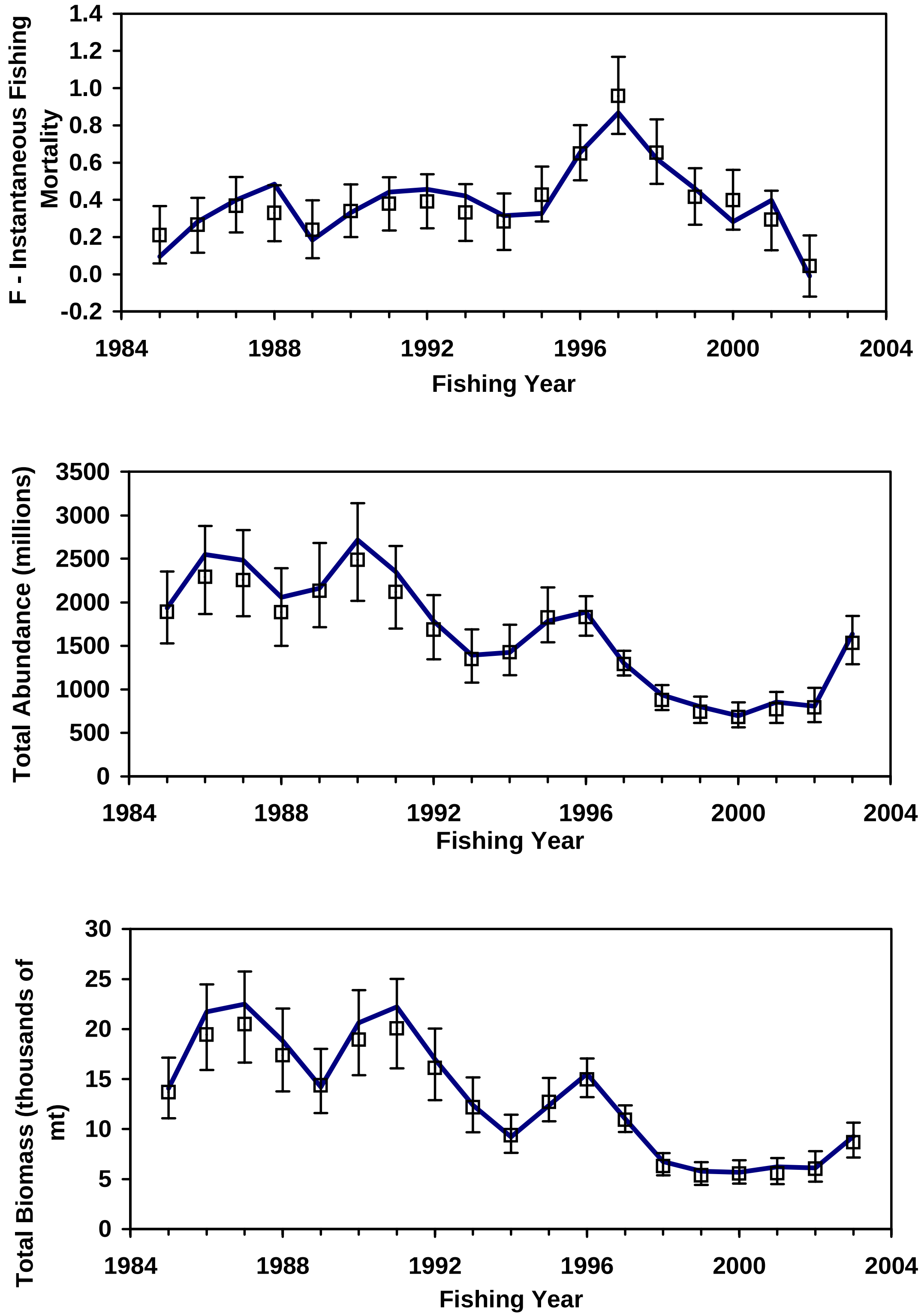


Figure C14. Summary of CSA for Gulf of Maine northern shrimp with least squares estimates, bootstrapped means, and 80% confidence intervals.

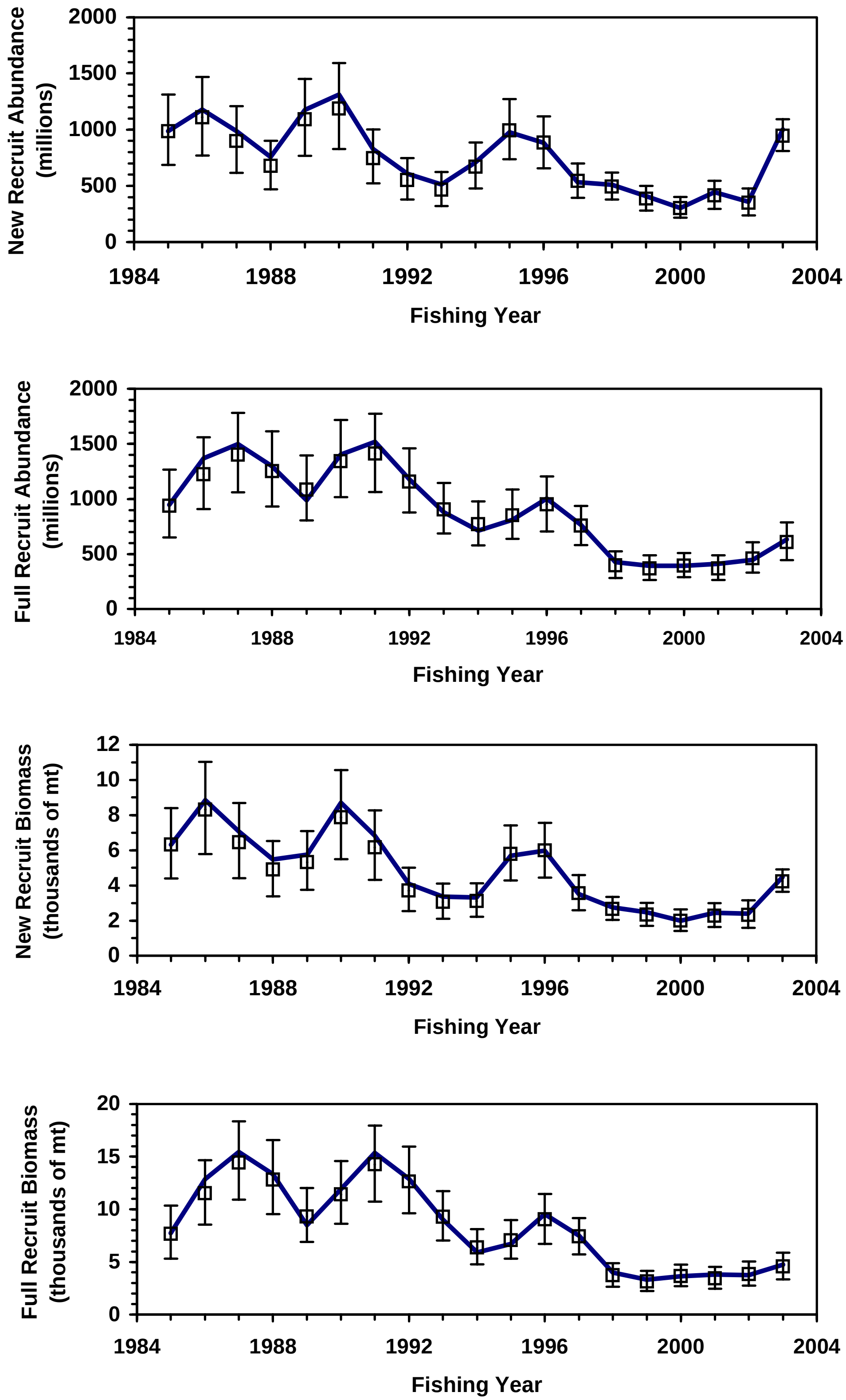


Figure C14 continued.

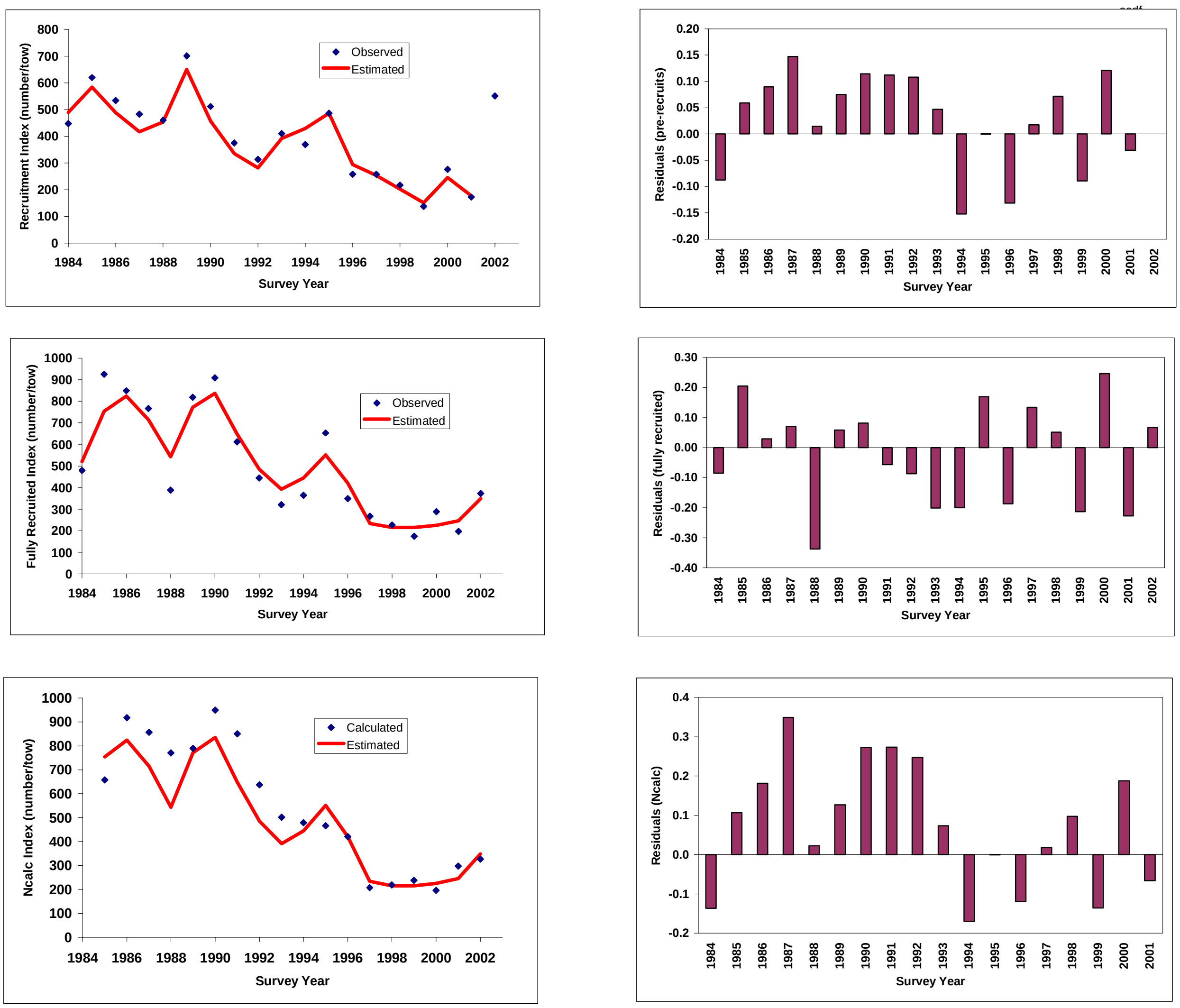


Figure C15. Summary results of CSA of Gulf of Maine northern shrimp with residuals.

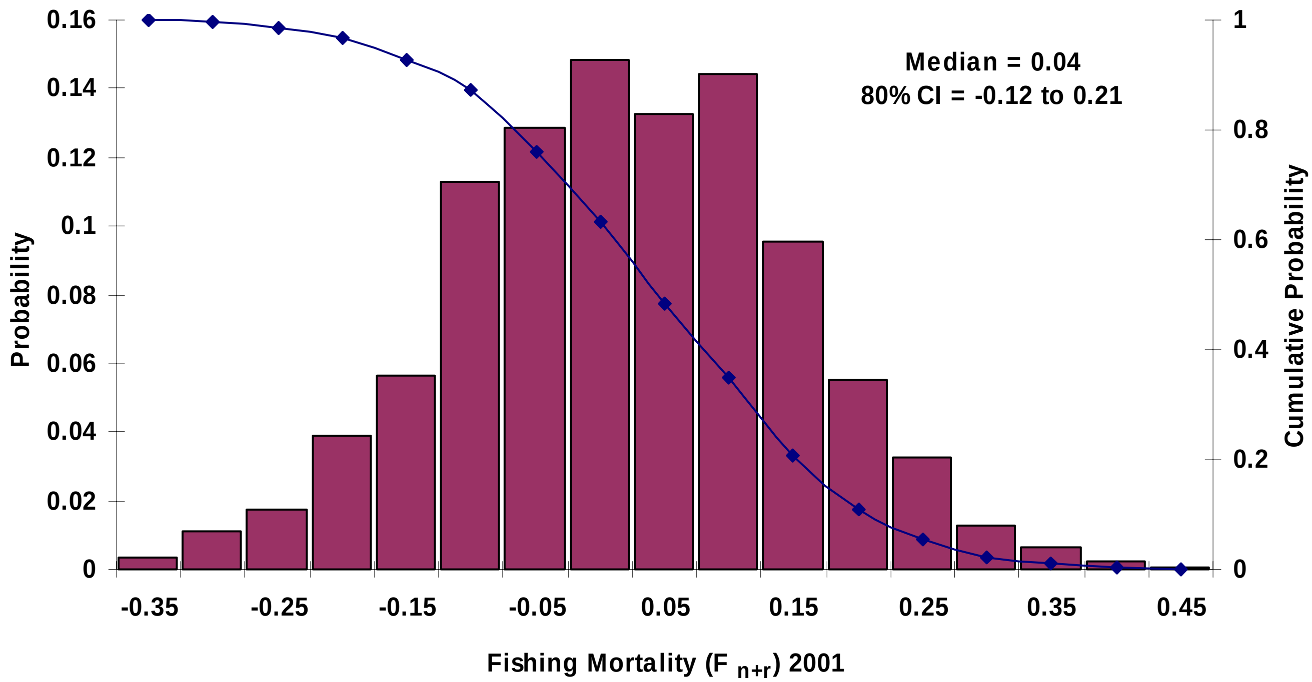


Figure C16a. Bootstrapped CSA estimates of fishing mortality for the 2002 fishing season (2001 survey year) for Gulf of Maine northern shrimp.

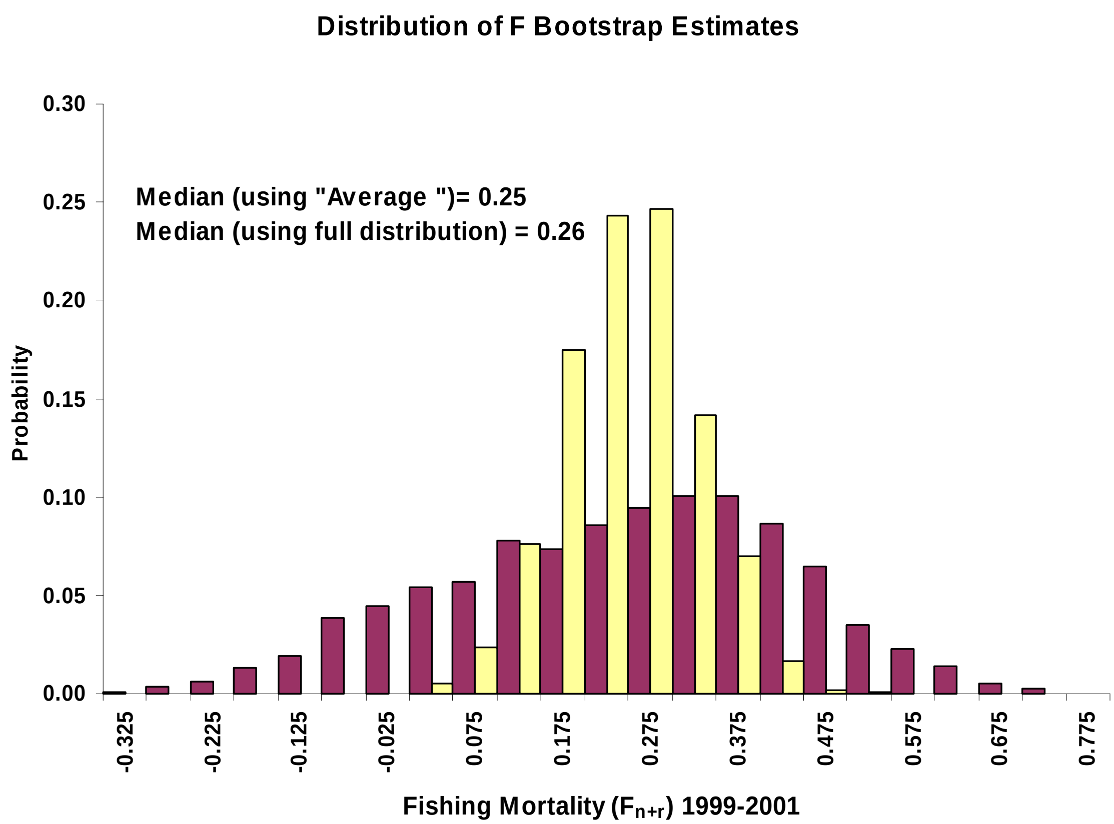


Figure C16b. Bootstrapped CSA estimates of fishing mortality for the 2000-2002 fishing seasons (1999-2001 survey years) for Gulf of Maine northern shrimp.

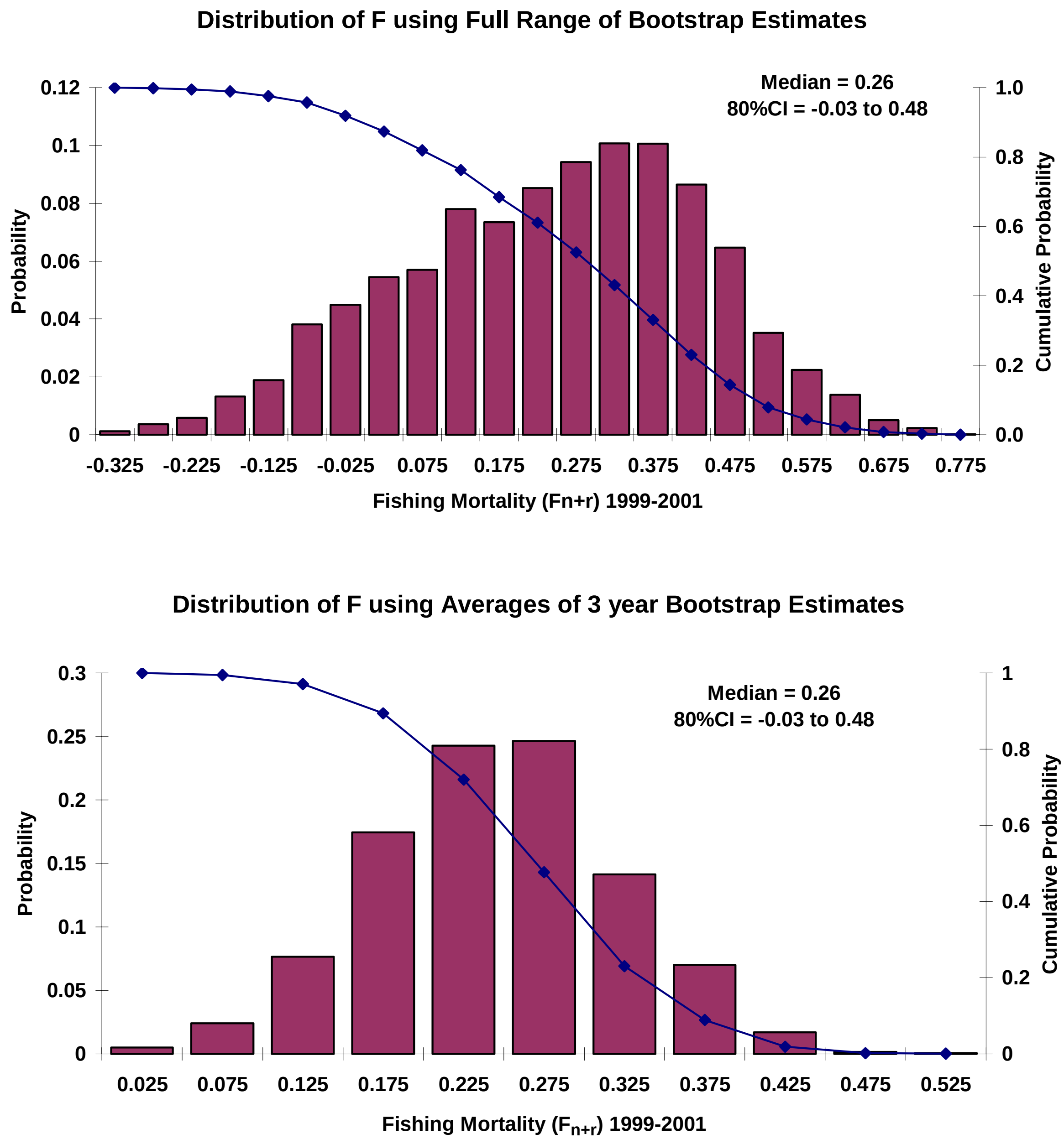


Figure C16c. Bootstrapped CSA estimates of fishing mortality for the 2000-2002 fishing seasons (1999-2001 survey year) for Gulf of Maine northern shrimp using all 6000 bootstrap iterations, and three year averages of the 2000 iterations (see text).

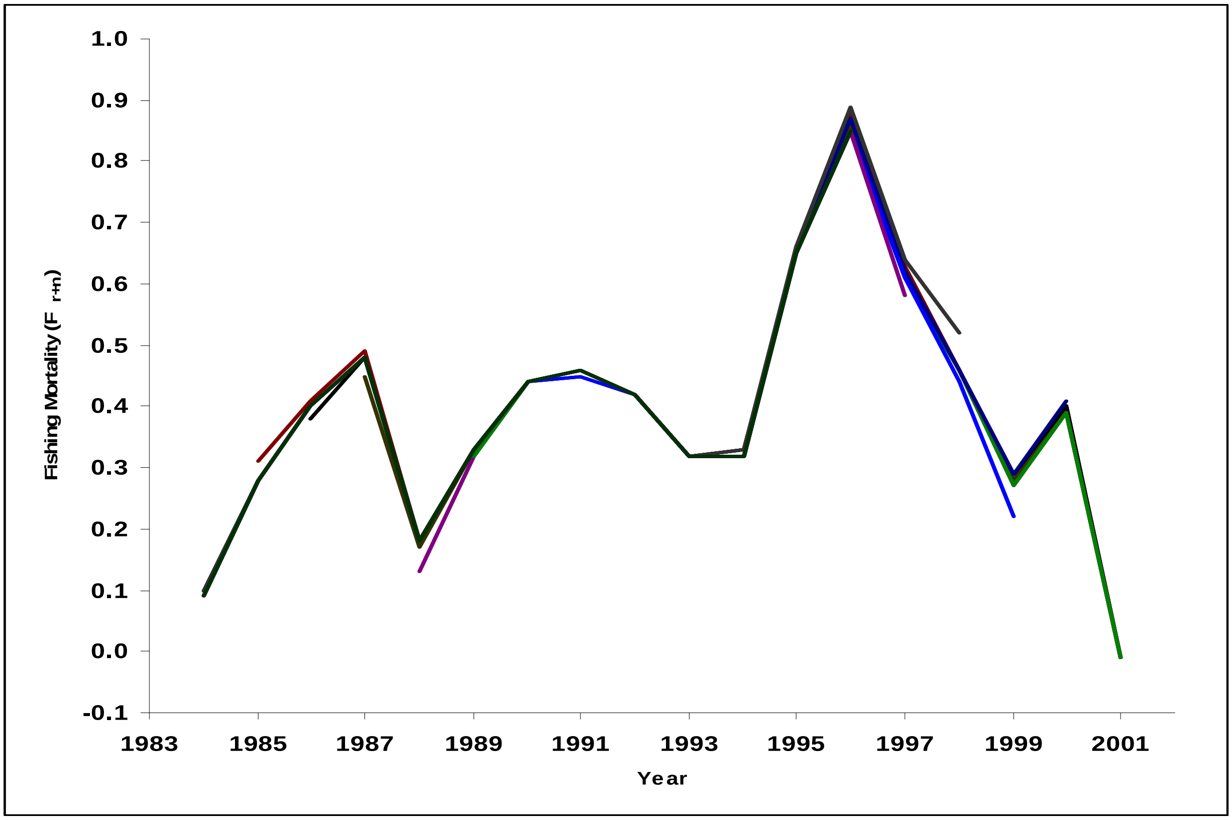


Figure C17a. Retrospective CSA estimates of fishing mortality for Gulf of Maine northern shrimp.

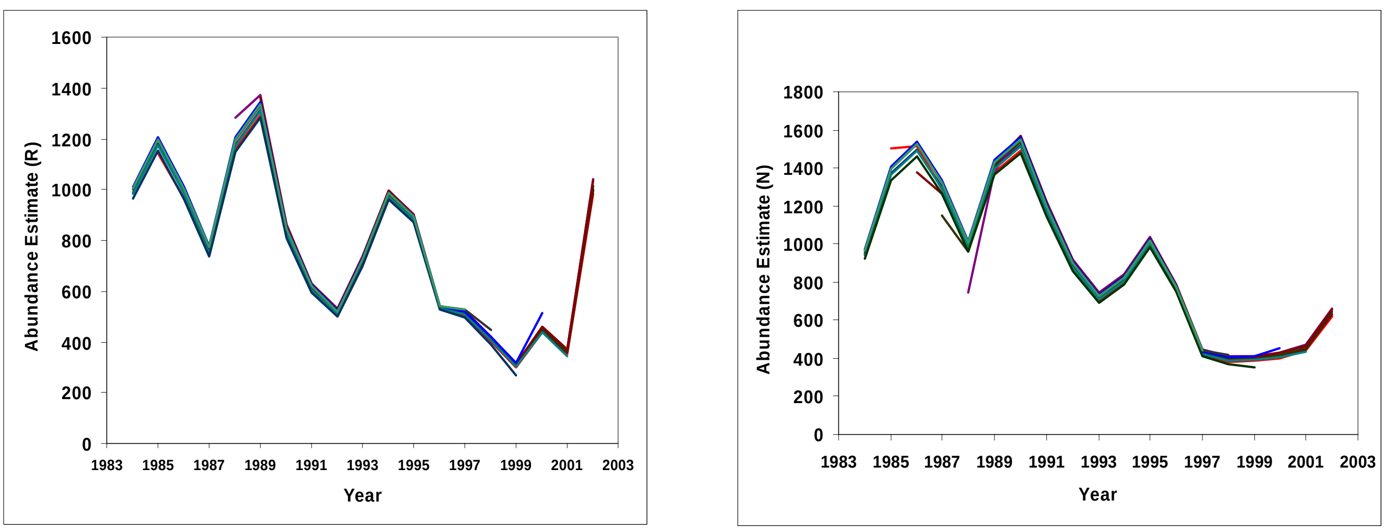


Figure C17b. Retrospective CSA estimates of abundance (recruits and fully recruited) for Gulf of Maine northern shrimp.

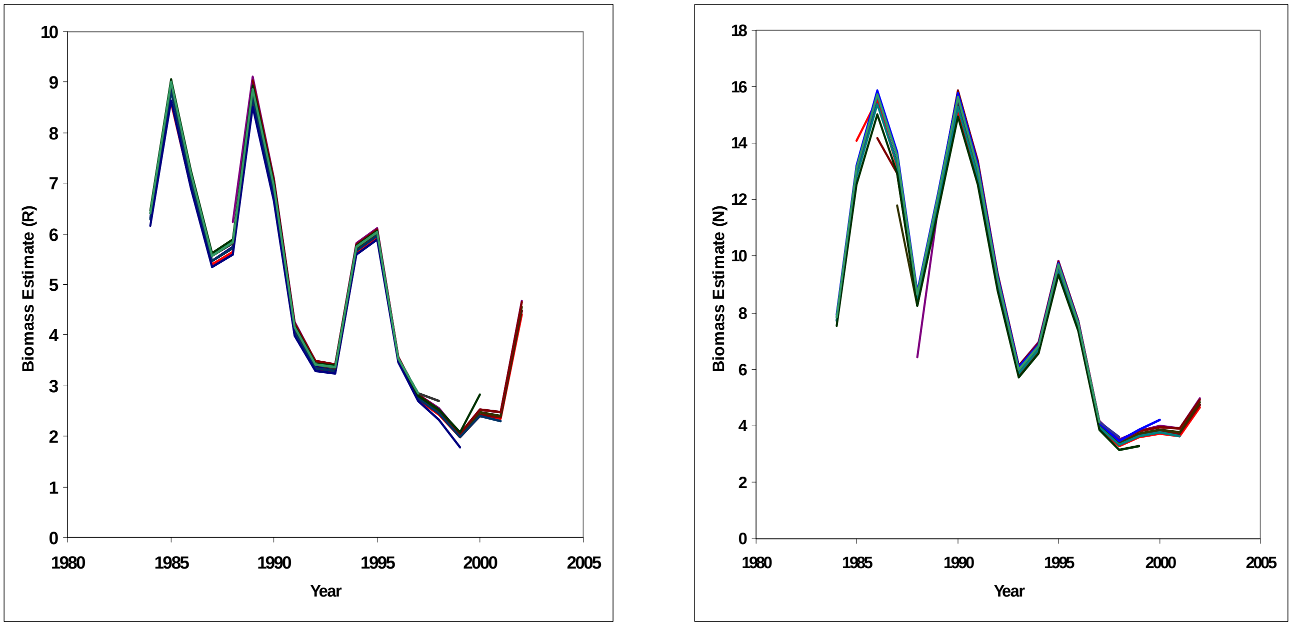
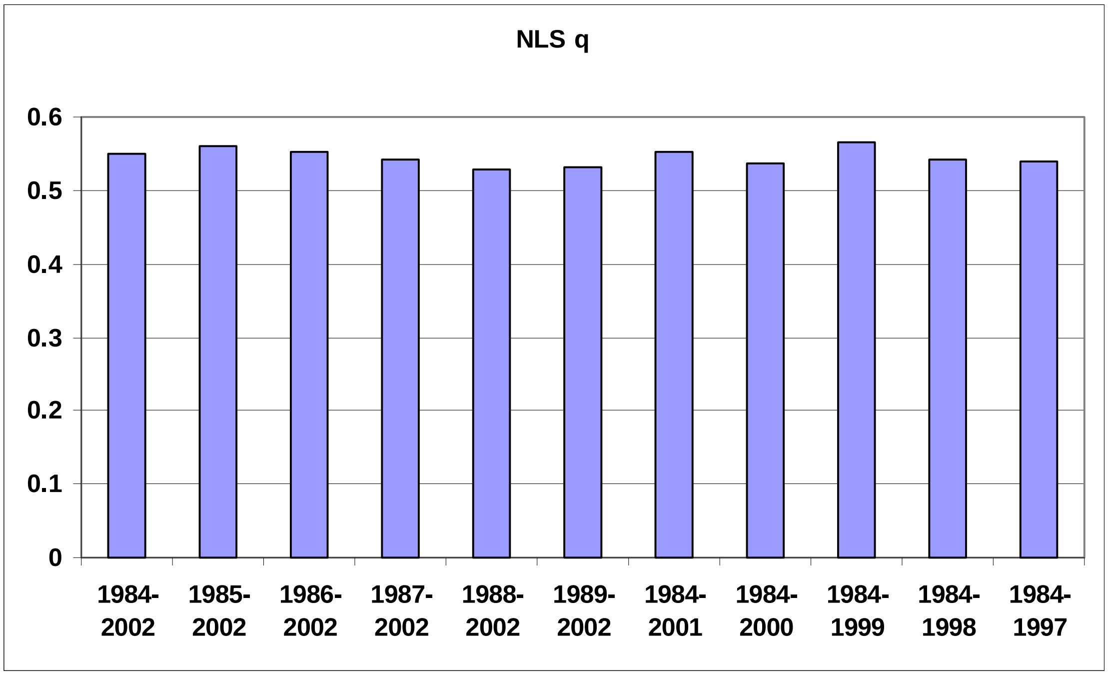


Figure C17c. Retrospective CSA estimates of biomass (recruits and fully recruited) for Gulf of Maine northern shrimp.



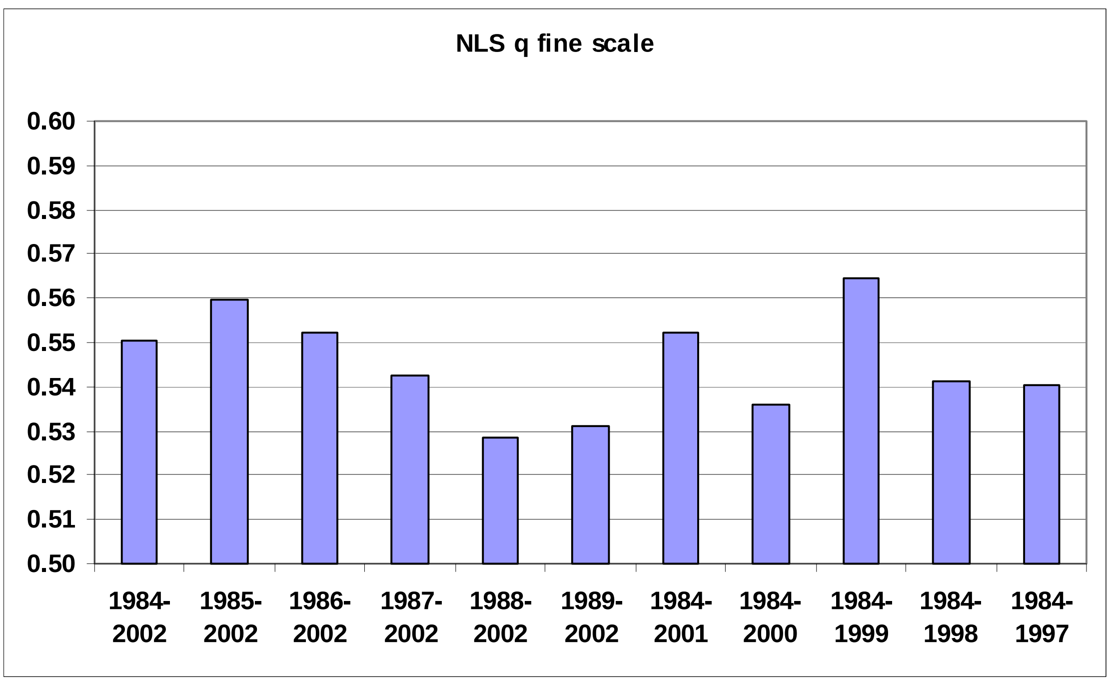


Figure C17d. Retrospective CSA estimates of q for Gulf of Maine northern shrimp.

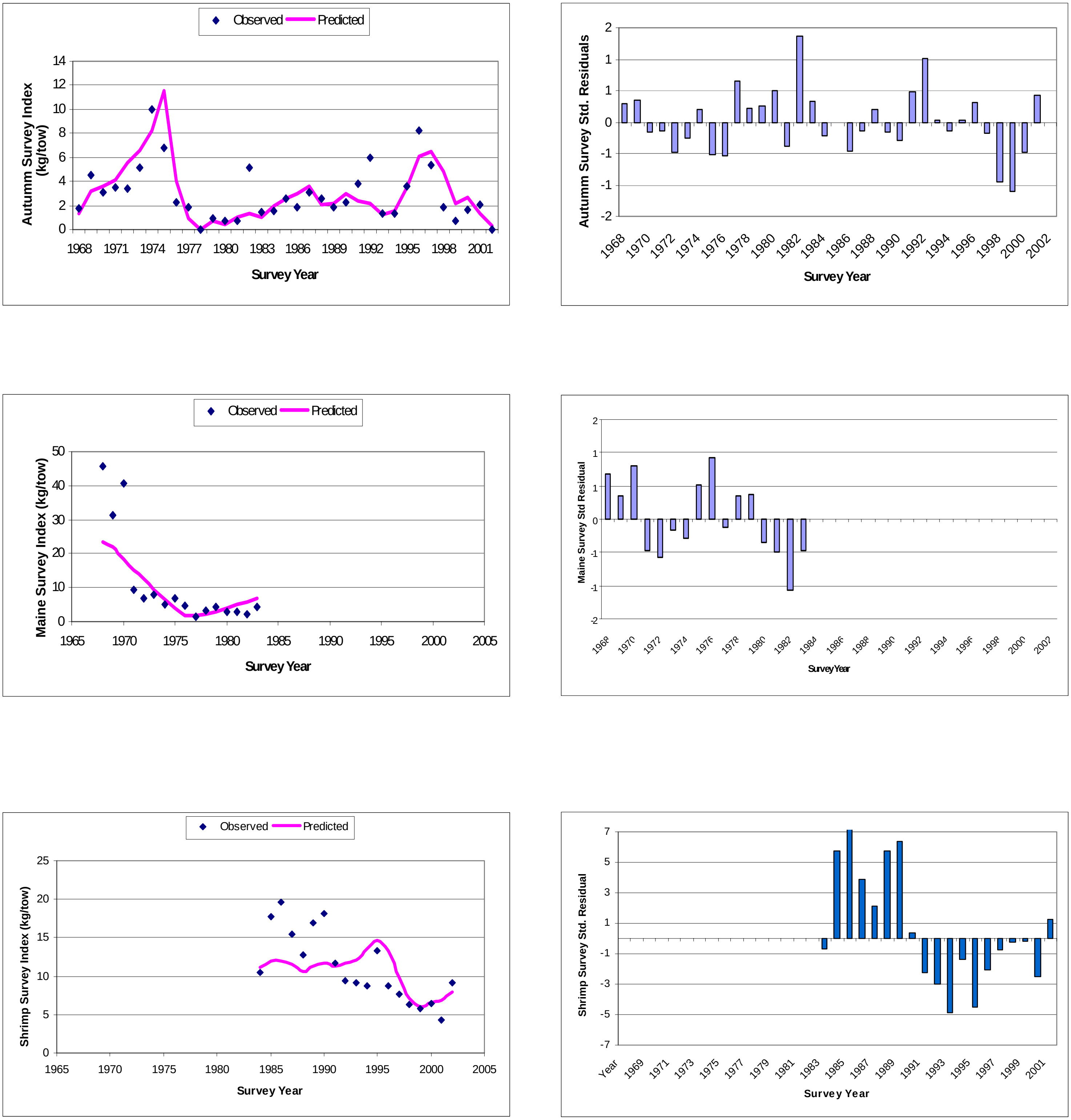


Figure C18. Summary of results from ASPIC analysis of Gulf of Maine northern shrimp biomass dynamics, with residuals.

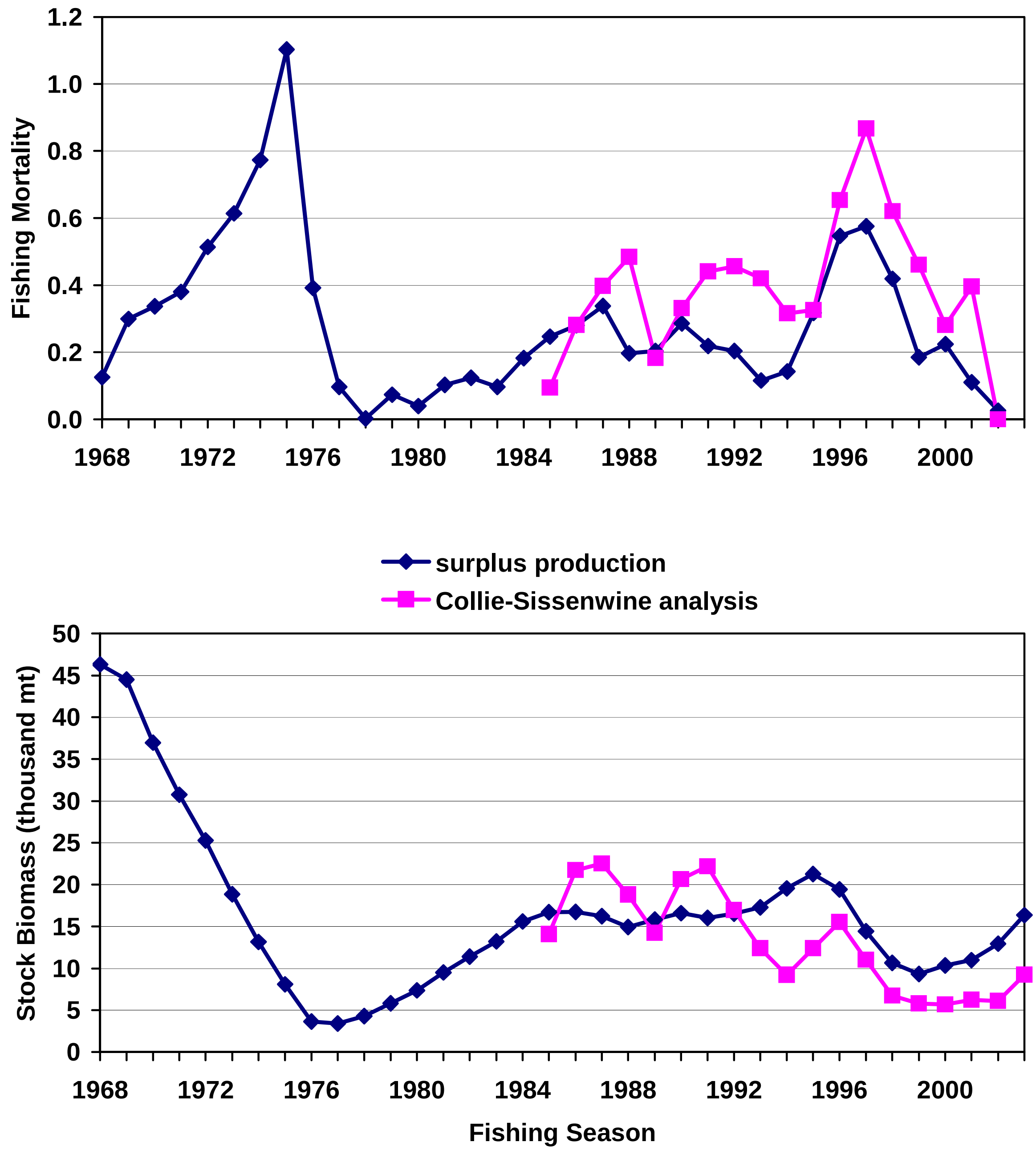
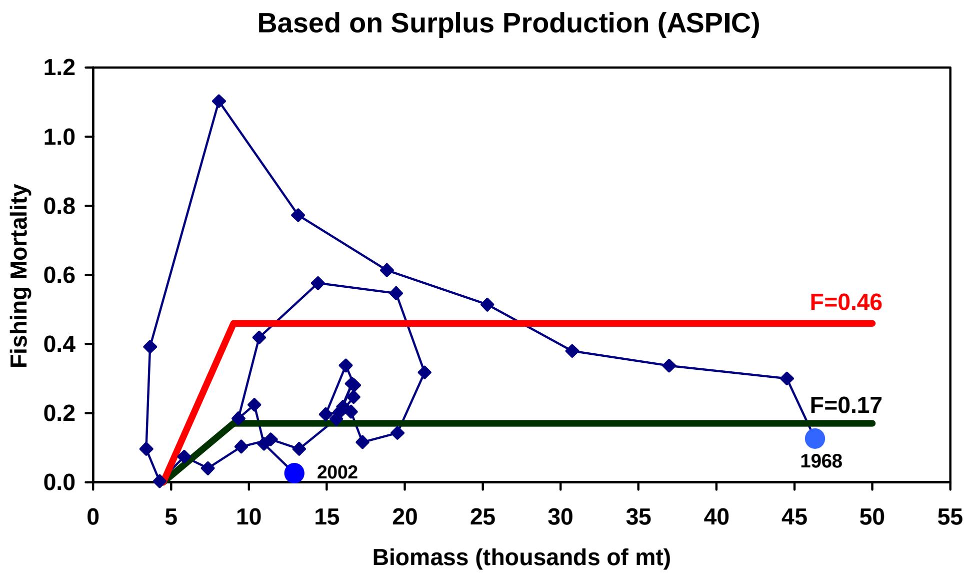


Figure C19. Estimates of fishing mortality (above) and stock biomass (below) for Gulf of Maine northern shrimp from CSA and surplus production (ASPIC) modeling.

Figure C20a. Biomass dynamics of the Gulf of Maine northern shrimp fishery, based on surplus production (ASPIC) modeling (above) and CSA (below) with possible fishing mortality and biomass reference points.



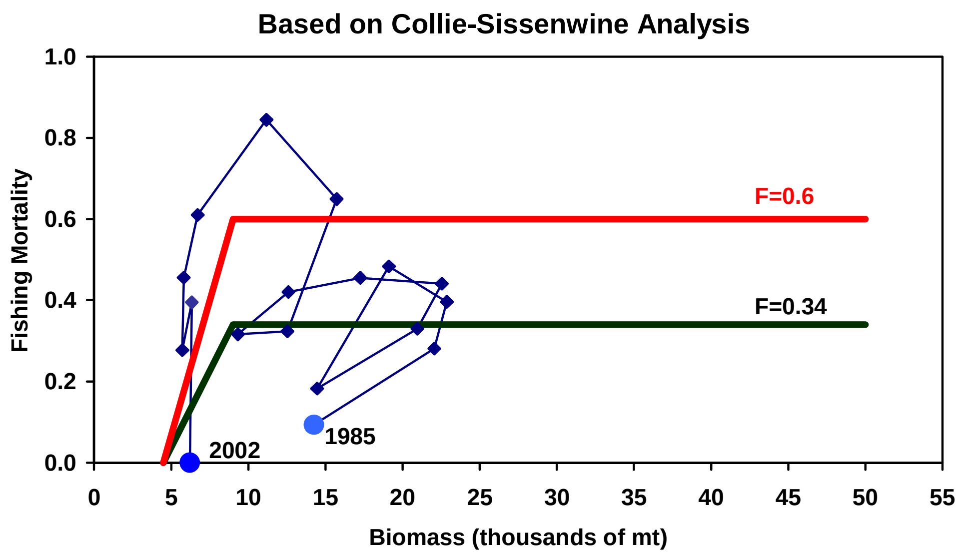
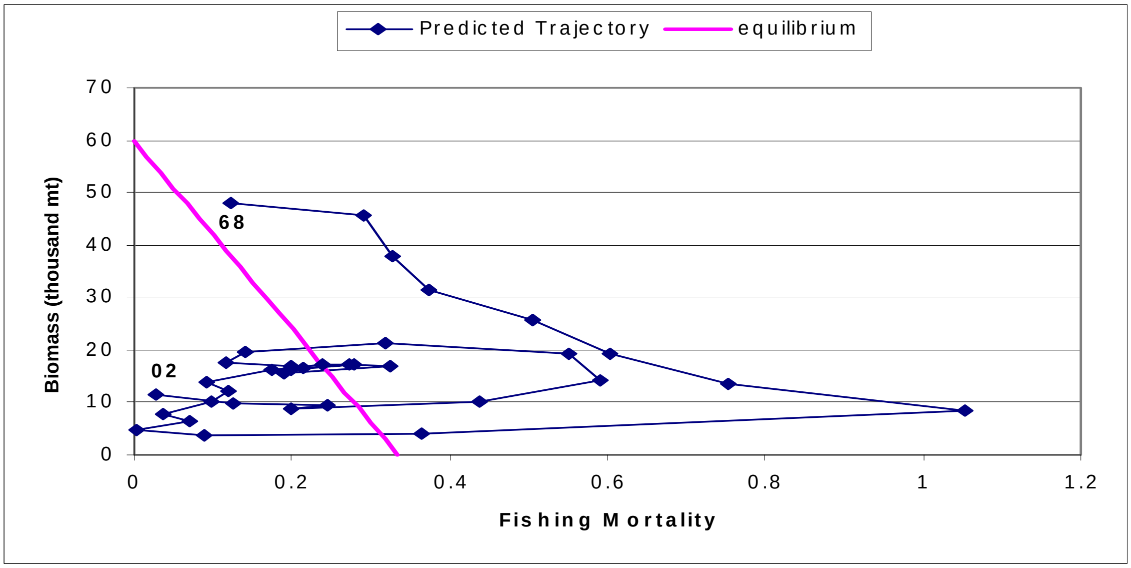
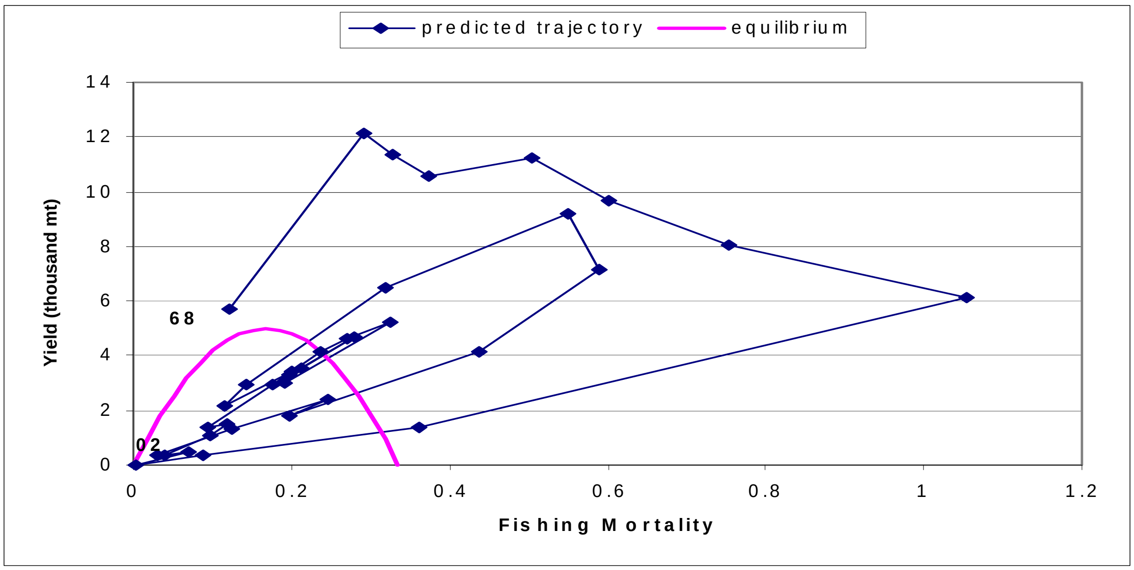
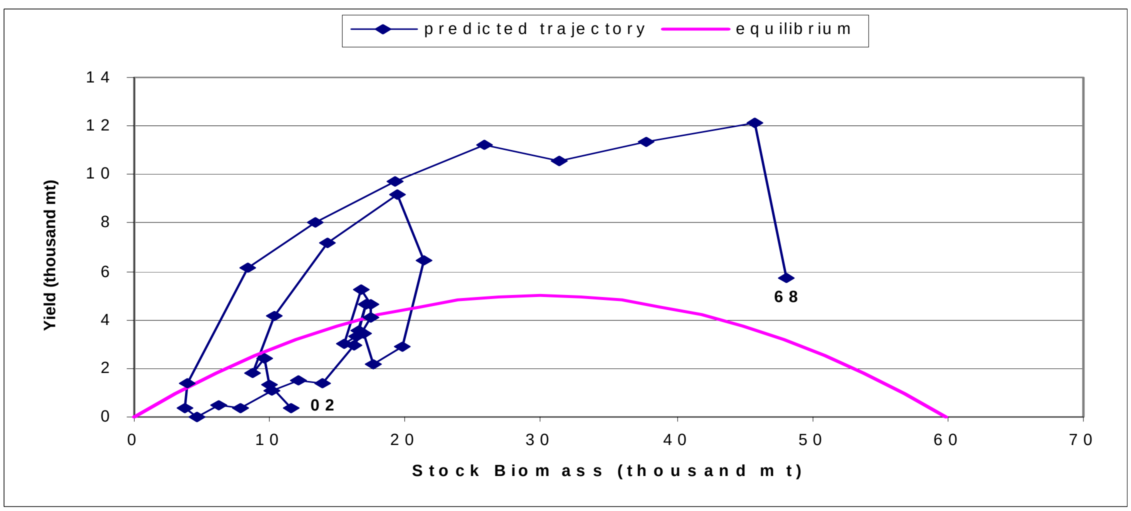


Figure C20b. Biomass dynamics of Gulf of Maine northern shrimp from ASPIC modeling.







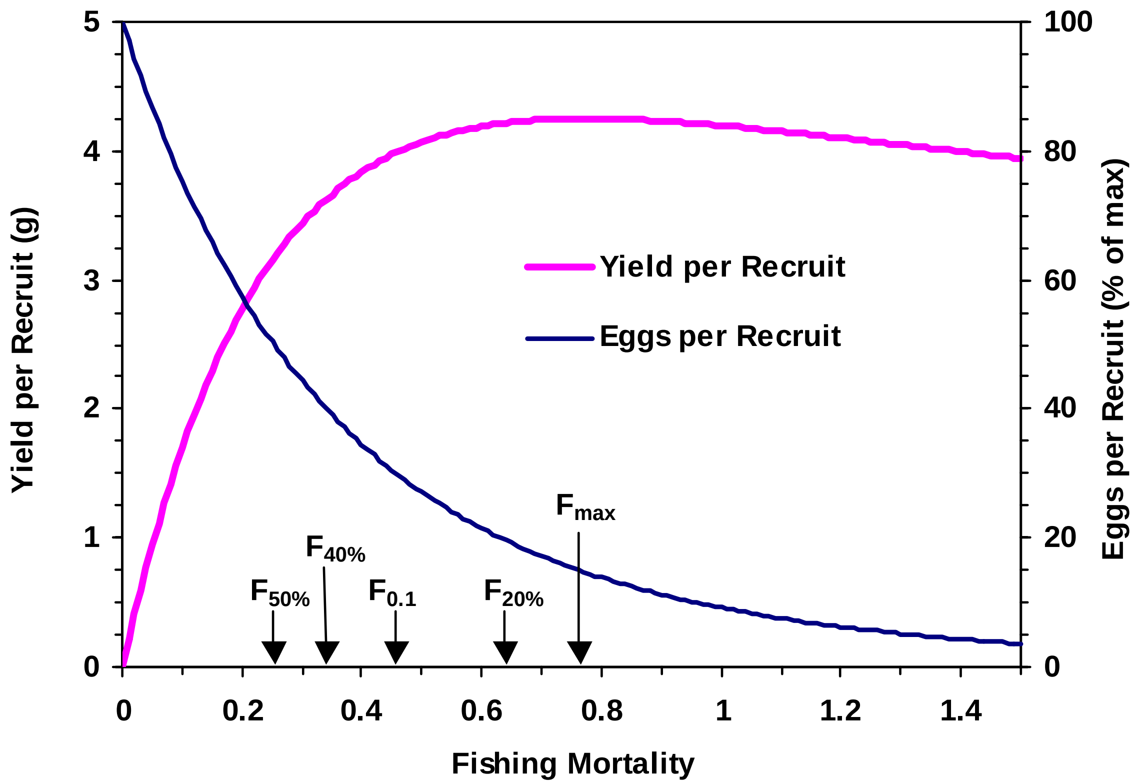


Figure C21. Yield and egg production per recruit for Gulf of Maine northern shrimp.

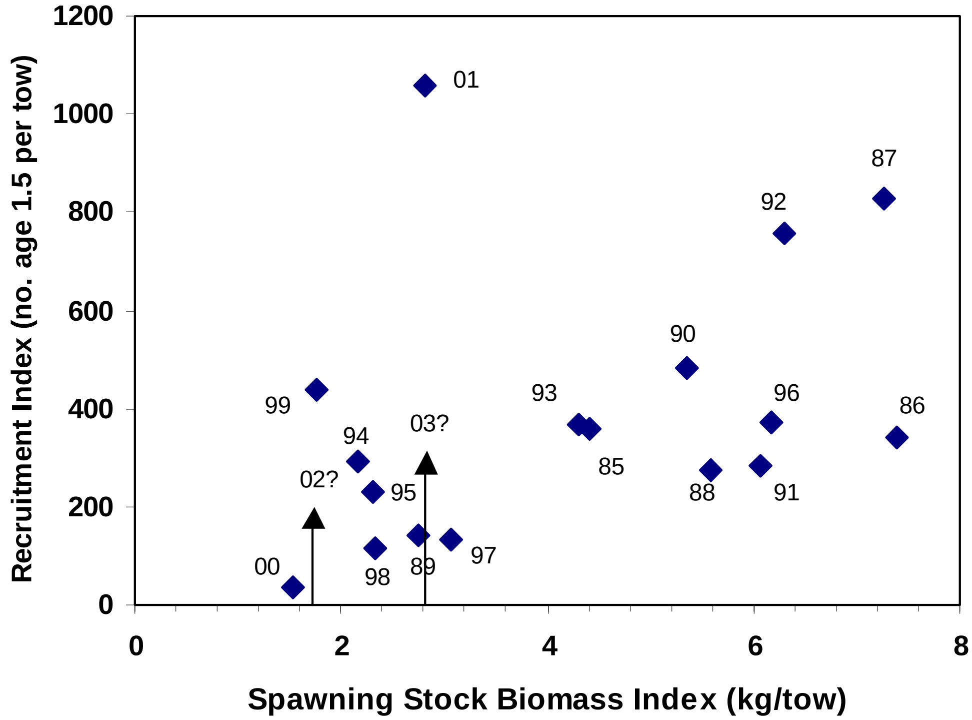


Figure C22a. Relationship between summer survey indices of Gulf of Maine northern shrimp female biomass the summer before egg hatch to age 1.5 abundance two years later. Data labels indicate year of egg hatch.

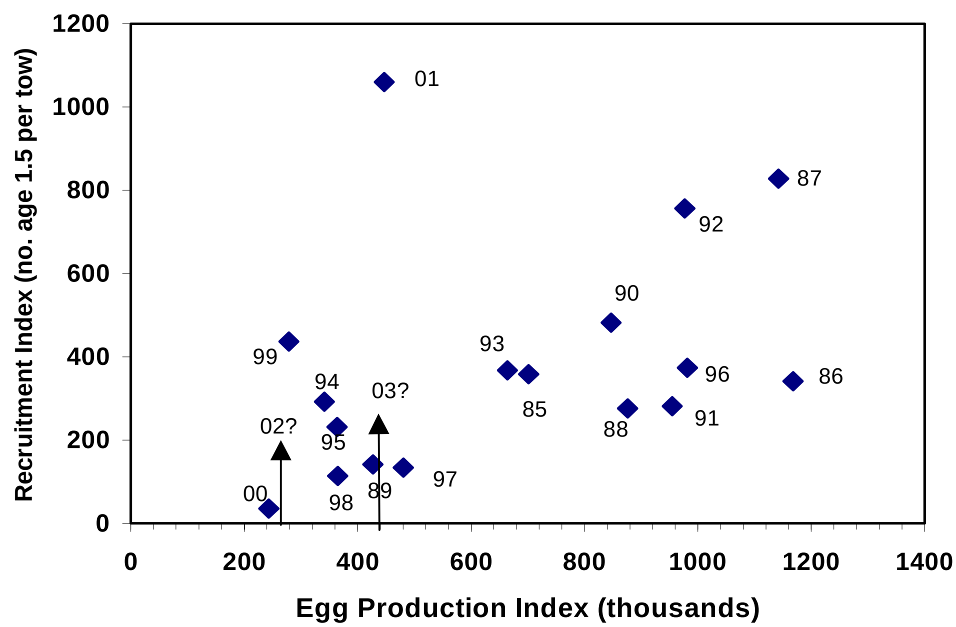


Figure C22b. Relationship between egg production index for Gulf of Maine northern shrimp the summer before egg hatch to age 1.5 abundance two years later. Data labels indicate year of egg hatch.

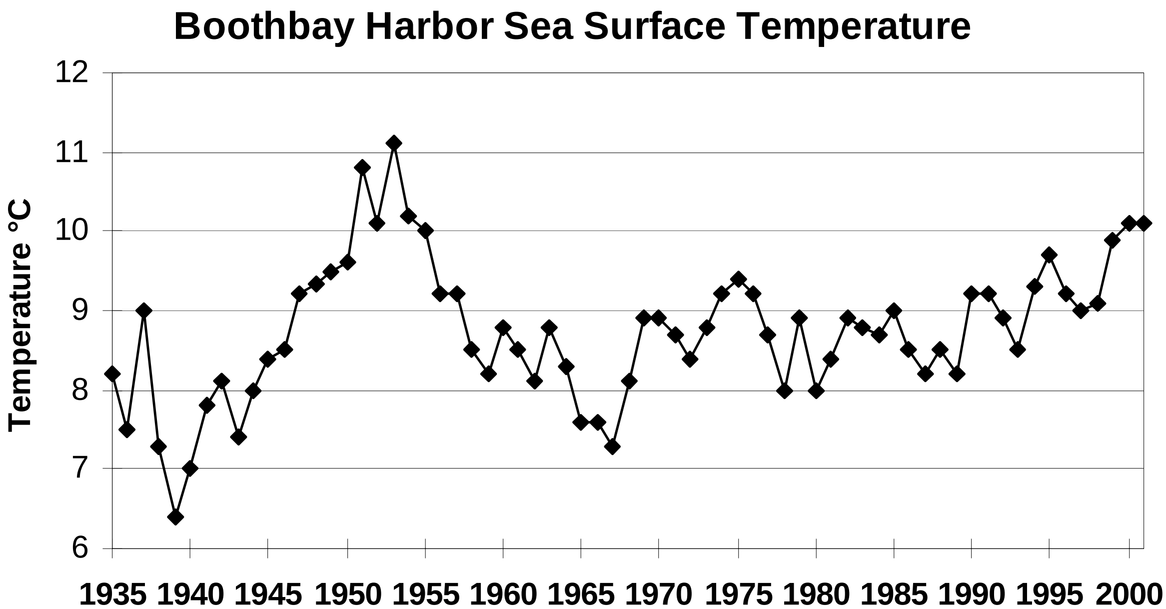


Figure C23. Average annual sea surface temperature in °C at Boothbay Harbor, Maine.

D. ATLANTIC STRIPED BASS

The Atlantic Coast striped bass stock is assessed with two separate methods: 1) catch-age based virtual population analysis, and 2) tag release-recovery based survival estimation. Each program is presented in this report as separate segments. The VPA analysis, prepared by the Stock Assessment Subcommittee, is used to evaluate fishing mortality for the mixed coastal stock and provide estimates of abundance and biomass. The tagging analysis, prepared by the Tagging Workgroup, is used to evaluate fishing mortality for specific stocks and averaged results are used to develop a mixed stock mortality estimate. Fishing mortality rates from both programs are compared. A summary of the Chesapeake Bay tag-based direct enumeration study, used to evaluate compliance of the Chesapeake Bay management program with FMP mortality targets, is also presented. The ASMFC Striped Bass stock assessment sub-committee and Technical Committee met in September 2002 to evaluate the status of the striped bass resource.

I. CATCH-AGE BASED VPA ANALYSIS

The first analytical assessment using virtual population analysis (VPA) was conducted in 1997 (for years 1982-1996) and reviewed by the 26th Stock Assessment Review Committee at the Northeast Fisheries Science Center. The results of the review were reported in the proceedings of the 26th Northeast Regional Stock Assessment Workshop (26th SAW): SARC Consensus Summary of Assessments (NEFSC Ref. Document 98-03). This report represents the latest in the series of annual assessments with the inclusion of the 2001 catch and survey data.

Commercial Fishery

Commercial landings in 2001 totaled 941.7 thousand fish and 6.2 million pounds (2,826 mt) (Table D1, Table D2). The landings represent a decline of 109.5 thousand fish (10.4%) and of 395.7 thousand pounds (6%) compared to 2000 (Table D8). The Chesapeake Region (Maryland, PRFC, and Virginia) accounts for most of the commercial harvest, 65% by weight and 82% by number (Table D3). Overall, commercial harvest represented 22% by number and 24% by weight of total harvest in 2001, and 29 % of total catch in number (harvest + discard) (Figure D1, Table D2). Commercial harvest was comprised primarily of fish ages 4 to 6 (60% of commercial harvest). Ages 3 through 8 comprised 88.5% of the harvest.

Direct measurements of commercial discards of striped bass were not available. For past assessments that incorporated 1982-97, the estimates were based on the ratio of commercial to recreational released fish tag recovery data, scaled by total recreational discards:

$$CD = RD*(CT/RT)$$

where:

CD is an estimate of the number of fish discarded by commercial fishery,
RD - number of fish discarded by recreational fishery,
CT- number of tags returned from discarded fish by commercial fishermen,
RT- number of tags returned from discarded fish by recreational fishermen.

Total discards were allocated to gears based on the overall distribution of recovered tags by gear. Discards by fishing gear were multiplied by gear specific release mortalities and summed to estimate total number of fish killed. The technical committee attempted to improve the estimate of commercial discards for the 1998-2001 period by accounting for spatial distribution of different fishing gear and effort. The ratio of tags recovered in commercial and recreational fisheries and corresponding discards were calculated separately for Chesapeake Bay and the coast. Commercial discards for the Hudson and Delaware Rivers were estimated separately. Total commercial discards losses for 2001 were estimated as 310,900 fish, representing 7.2% of total removals in number (Figure D1, Table 2, Table 4, Table 9).

Commercial discard proportions at age were obtained using age distributions from fishery dependent and independent surveys done using comparable gear. These proportions at age were applied to discard estimates by gear and expanded estimates summed across all gears. Total commercial discards were dominated by fish of ages 3 to 6.

Recreational Fishery

Recreational statistics were collected as part of the MRFSS (Marine Recreational Fishery Statistics Survey) program. Landings (A+B1) in 2001 were 2.0 million fish totaling 19.58 million pounds (8,889 mt) (Table D1, Table D2). The landings represent an increase of 88.3 thousand fish (4.6%) and 2.48 million pounds (14.5%) compared to 2000 (Table D1). The states landing the largest proportion of the recreational landings were New Jersey, Maryland, Virginia, New York, and Massachusetts (Table D6, Figure D2). Overall, recreational landings represented 71% by number and 76% by weight of the reported total landings (Figure D1). Striped bass of age 4 to 8 comprised 75% of landings.

Recreational discards (B2's) declined in 2001 to 13.5 million fish (Table D2) compared to 2000 estimates. Application of an 8% hooking mortality rate resulted in estimated losses of 1.1 million fish (Table D2). The states with the largest proportion of the overall discards were Massachusetts and Maryland (Table D7). Recreational discards represented 25% by number of the total catch (Figure D1, Table D2). Discards of the 1996 year class were greatest among all cohorts both in 2000 and 20001. Total recreational striped bass catch in 2001 was 3.1 million fish. The catch was dominated by ages 4 to 8 (76.5% of total). Total recreational discard and landings losses have been growing steadily between 1982 and 2001, with some intermittent decline in 1998-1999 (Table D10, Figure D3).

Total Catch at Age

The above components are totaled by year to produce the overall catch at age matrix for VPA input (Table D11). The total catch of striped bass in 2001 was 4.3 million fish, a decline from 5.04 million fish in 2000. The decline in harvest occurred primarily in ages 2-7 and especially ages 4 and 5 (Figure D4). At the same time there was in increase in the number of harvested fish of age 8 and older with the exception of age 10.

Indices of Abundance

Fishery Independent Indices

The Maryland gillnet survey of spawning biomass has generally declined since 1993, although there was a strong peak in 1996. The 2002 value was very similar to 2001 about one-half the series average (Figure D5). Values for age-2 were dropped as tuning indices due to frequency of zero catches over time. The New York ocean haul seine index increased considerably for 1996-1998, while the 2001 value decreased from 2000 and was near the 1999 value (Figure D6). The NEFSC spring inshore survey was incorporated as an age-aggregated index in the 1999 assessment, and was used in the 2000 and current assessment as age-specific indices. The aggregated index increased during the early to mid-1990s before declining in 1998 and 1999. The 2002 value increased to one of the highest in the series (Figure D7). The Rappahannock River, Virginia pound net CPUE was included for the first time in 2001, in an attempt to provide more information on the overall spawning stock. This survey, begun in 1991, showed high abundance in 1999 and 2000, while the 2001 value was just below average (Figure D8). Three age-aggregated trawl indices from Connecticut, New Jersey and Delaware were added in the 2000 VPA (Figure D9). All surveys showed a decline from 1999 to 2001 to near or below average although Connecticut and New Jersey indices increased in 2002.

Juvenile indices from the Chesapeake Bay (Maryland and Virginia) show another very strong recruitment in 2001 (Figure D10). Previous strong cohorts in 1993 and 1996 have been clearly detectable in coast-wide landings during recent years. The juvenile index for the Hudson River was very high in 2001, while the Delaware index was below average (Figure D11). The NY and NJ young-of-year surveys showed overall increasing trends since 1991.

The Maryland age-1 index was slightly above average in 2001, and reflected only a slight upward trend over the last few years (Figure D12). The Long Island age 1 index in 2001 was the highest for the time series (Figure D12).

Fishery Dependent Indices

The Massachusetts commercial catch per trip reached the highest level in 2001 (Figure D13). The Connecticut volunteer angler catch per trip was well above average in 2000 and reached the highest level in 2001 (Figure D14). The index for age 1 (lagged ahead as age 2) was not included in the VPA analysis.

The Hudson River shad fishery by-catch of spawning striped bass (age 8+) was reconfigured by the NYDEC for use as an age-aggregate index in the VPA. This survey increased steadily through 1996, then dropped to the average for 1997-1998. The survey index was well below average in 2000 and 2001 (Figure D15).

Weight at Age

Weight at age information was updated for the period 1997-2001. Mean weights at age for the 2001 striped bass catch were determined from available state data. The available data were from Maine and New Hampshire recreational harvest and discards; Massachusetts recreational and commercial catch; New York recreational catch and commercial landings; New Jersey recreational catch; Delaware commercial catch and Virginia recreational and commercial catch. Weighted mean weights at age were calculated as the sum of weight at age multiplied by the catch at age in numbers, divided by the sum of catch in numbers. In the VPA model, the estimated weights at age for 2001 were applied to 1997 to 2000 where weight data were unavailable. Details of developing weights at age for 1982 to 1996 can be found in NEFSC Lab Ref. 98-03. Weight at age for the 1982-2001 period is presented in Table D12.

Virtual Population Analysis

Catch at Age

A catch at age matrix was developed using standard methods described in the previous assessment documents (Anon 2001). Commercial landings at age were estimated by applying corresponding length frequency distributions and age length keys to the reported number of fish landed by the commercial fishery in each state. Length frequencies of recreational landings were based on a combination of MRFSS length samples and volunteer angler logbooks. State specific age-length keys were applied to length frequencies to estimate number of fish at age landed by recreational fishery. Age composition of the recreational discards was estimated using lengths available from volunteer angler logbooks and American Littoral Society data.

All states agencies used striped bass scales to estimate age. However, the Technical Committee was concerned about a problem ageing striped bass. Several recent studies (Secor et al. 1995, Bobko 2002, King 2002) have indicated that scales may not provide a reliable age estimate for older fish, beginning with ages 10 to 12. In previous assessments of striped bass, fish of age 15 and older were combined into a 15+ group. The committee adopted the 12+ configuration as the preferred option because 1) estimation of fewer ages reduced the uncertainty associated with ageing error in older fish 2) the change resulted in a more stable exploitation pattern and 3) the estimates of fishing mortality were more closely aligned with estimates from tag models which do not rely on age data. The ADAPT program, a part of the NEFSC stock assessment software FACT, was used to analyze striped bass populations.

ADAPT model inputs

Fishing mortality estimation for age 11, the oldest true age, was based on ages 5 through 10. Abundance of age classes 1 through 11 in the terminal year was estimated using a Marquardt algorithm. Fishing mortality on the plus group was set equal to the fishing mortality for the last true age and was estimated using a backward method. Natural mortality was assumed constant and equal to 0.15 $year^{-1}$. The model was run using the iterative re-weighting option in FACT.

Model fit.

All estimates of abundance at age (N) and catchability coefficients (q) were significant at the 0.05 level (T statistic > 1.96, Table D13). CVs of the N and q estimates were relatively low (most in the range of 20-30%), indicating a good fit. Estimate of ages 1and 2 abundance had greater CVs (50 and 38%), which were expected due to generally higher variation of indices of abundances of younger ages. Among the catchability coefficient estimates, poor performers were the following indices: NEFSC trawl survey indices for ages 1 and 2 with CVs of 0.5 and 0.38 respectively and Virginia pound net survey indices for ages 1 and 12+ with CVs of 0.49 and 0.33. High variances for these indices were likely caused by the scarcity of either very young (ages 1 and 2) or old fish (ages 10-12+) in the sampling gear. Mean square residuals were 0.95 prior to re-weighting and 0.008 following iterative re-weighting, indicating a good fit of the model. The correlation between parameters was small, which indicated parameters independence, a desired property.

Each survey used to tune the VPA contributes to the overall variance in the model, and the amount of the total variance attributable to an index is indicated by its partial variance (PV). Surveys or particular ages of surveys with high PV's are often deleted from assessment runs because they contribute relatively little additional information, and such an approach has been used in the past to trim down the number of surveys. This assessment was a compilation of several stocks and the relative importance of each component's contribution to the total harvest and population abundance was unknown. Iterative re-weighting was used to reduce the influence of surveys with high partial variance while retaining the information of each survey concerning the abundance of particular stock components. Iterative re-weighting resulted in very small changes in estimates of abundance and fishing mortality, indicating that none of the indices had performed very poorly.

Fishing Mortality

The 2001 average fishing mortality rate (F) for fully recruited ages, 7 through 10 (plus group age minus two), equaled 0.29 and was below current target (0.31) and overfishing values (0.38) (Table D14, Figure D16). Average fishing mortality for ages 4 through 10, which has been reported as average F in previous assessments, was 0.23 (Table D14, Figure D16). Fishing mortality on ages 3-8, which are generally targeted in producer areas, was 0.19. An F weighted by N was calculated for comparison to tagging results since the tag releases and recaptures also weighted by abundance as part of the experimental design. The VPA F weighted by N for ages 5-10 (age 5 to compare with tagged fish > 28") was 0.21.

A bootstrap procedure was used to estimate variation in fully-recruited fishing mortality (ages 7-10). Results of 500 bootstrap iterations show Fs ranging from 0.21 to 0.36 with an 80% probability that F was between 0.26 and 0.32 in 2001 (Figure D22).
The VPA indicates that fishing mortality has been steadily increasing since 1989 (Table D14). The modification of the VPA model to limit the ages to 12 plus changed the estimate of F in the early years of the time series. New estimate in 1982 for fully recruited F was 0.54 (Figure D15) with maximum Fs at age of 0.78.

Partial Recruitment

Full recruitment estimated as the back-calculated partial recruitment was at age 7 in 2001, up from age 6 in 2000. Prior to 2000, age at full F varied between ages 7 and 10 (Table D16). Changes in regulations in 2000 and 2001 to shift exploitation patterns may account for the changes from the 1990s.

Population Abundance

Population abundance (stock size as of January 1, 2002) was at the highest level in time series (Table D17, Figure D19) and was estimated at 59.6 million fish. Bootstrap estimates of population abundance are shown in Figure D23. VPA results suggested that the increase was due to very strong 2000 and 2001 year classes. Recruitment of age 1 fish in 2002 (2001 cohort) was estimated as 17.9 million fish, which makes it the biggest cohort ever, exceeding both 1993 and 1996 year classes (Figure D20). This follows the 2000 cohort estimated as 15.5 million fish which also exceeded 1993 and 1996. Abundance estimates for striped bass age 3 and older have declined slightly since 1999 as the previously strong cohorts move through the fishery. However, both the 1993 and 1996 year classes remain the most abundant at age in the time series.

Spawning Stock Biomass

All VPA runs indicated that spawning stock biomass (SSB) has been growing steadily since 1982 and reached the highest level in 2001 (Figure D21). However, SSB growth was slowed after 1998. Female SSB estimates are of 25.8 mt in 2001.

Retrospective Patterns

A retrospective analysis was conducted on the VPA results with successive terminal years extending back to 1995, in order to determine trends in estimation of F or total abundance in the terminal year. The analysis revealed that there was little evidence of retrospective bias in the assessment. However, there was a tendency of overestimation of age 1 abundance by the model.

Sensitivity Analysis

Due to the uncertainty in age determination, sensitivity runs were made for the VPA using a 13+ group. Changing the plus group ages had a significant change in the estimates. The average F for ages 4 to 11 was 0.32, ages 8 to 10 equaled 0.4 and average F for ages 3 to 8 was 0.22.

Stock size estimates were also influenced, as 1+ abundance with 13+ decreased to 52.6 million fish compared to 59.6 million with 12+. Recruitment estimates at age 1 also declined by 1.8 million fish to 16.1 million.

The overall trend appears to be a decrease in fishing mortality and increase in stock size estimates as the plus group is reduced in age.

II. TAGGING PROGRAM ANALYSIS

Introduction

This report summarizes results from analyses of tagging data from the U.S.F.W.S. Cooperative Striped Bass Tagging Program. The results include estimates of instantaneous fishing mortality (F) and survival (S) rates. Estimates of F and S are provided with and without correction for live release bias. Also, included are QAICc estimates and weights used for model selection and model averaging, length frequency of tag releases, age frequency of recaptures, geographic distributions of recaptures by month, and estimates of catch and exploitation rates by program.

Description of Tagging Programs:

Eight tagging programs provided information for this report, and have been in progress for at least nine years. Producer area tagging programs operate mainly during spring spawning, and use many capture gears, such as pound nets, gill nets, seines and electroshocking. Coastal programs tag striped bass from mixed stocks during fall and use several gears including hook & line, seine, gill net, and otter trawl. Most producer area and coastal programs tag striped bass during routine state monitoring programs. The Western Long Island Survey seines striped bass from May through October in bays along the western end of Long Island, New York; data from May through August are most consistent and were used for tag analysis.

Tag release and recapture data are exchanged between the U.S. Fish and Wildlife Service (USFWS) office in Annapolis, MD, and the cooperating tagging agencies. The USFWS maintains the tag release/recovery database and provides rewards to fishermen who report the recapture of tagged fish. Through July of 2002, a total of 385,891 striped bass have been tagged and released, with 70,118 recaptures reported and recorded in the USFWS database (Tina McCrobie, personal comm.).

Analysis Methods:

The Striped Bass Tagging Committee analysis protocol is based on assumptions described in Brownie et. al. (1985). The tag recovery data is analyzed in program MARK (White, 1999). Important assumptions of the tagging programs (as reported in Brownie 1985) are as follows:

1. The sample is representative of the target population.
2. There is no tag loss.
3. Survival rates are not affected by the tagging itself.
4. The year of tag recoveries is correctly tabulated.

Other assumptions related to the modeling component of the analyses include:

5. The fate of each tagged fish is independent of the fate of other tagged fish.
6. The fate of a given tagged fish is a multinomial random variable.
7. All tagged individuals of an identifiable class (age, sex) in the sample have the same annual survival and recovery rates.

The tagging committee calculates maximum likelihood estimates of the multinomial parameters of survival and recovery based on an observed matrix of recaptures (using Program MARK). The analysis protocol follows an information-theoretic approach based on Kullback-Leibler information theory and Akaike's information criterion (Burnham and Anderson 1988), and involves the following steps. First, a full set of biologically-reasonable candidate models are identified prior to analysis. Various patterns of survival and recovery are used to parameterize the candidate models. These include models, which allow parameters to be constant, time specific, or allow time to be modeled as a continuous variable. Other models allow time periods to coincide with changes in regulatory regimes established coastwide. Candidate models used in the analyses of striped bass tag recoveries are listed and described below.

S(.) r(.)	Constant survival and reporting
S(t) r(t)	Time specific survival and reporting
S(.) r(t)	Constant survival and time specific reporting
S(p) r(t)	*Regulatory period based survival and time specific reporting
S(p) r(p)	*Regulatory period based survival and reporting

S(.) r(p)	*Constant survival and regulatory period based reporting
S(t) r(p)	*Time specific survival and regulatory period reporting
S(d) r(p)	*Regulatory period based survival with unique terminal year and regulatory period based reporting
S(v) r(p)	*Regulatory period based survival with 2 terminal years unique and regulatory period based reporting
S(Tp) r(Tp)	*Linear trend within regulatory period for both survival and reporting
S(Tp) r(p)	*Linear trend within regulatory period survival and regulatory period based reporting (no trend)
S(Tp) r(t)	*Linear trend within regulatory period survival and time specific reporting (no trend)
* Periods	1 = { 87- 89}, 2 = { 90- 94}, 3 = { 95- 2001}

Candidate models are fit to the tag recovery data and arranged in order of fit by the second order adjustment to Akaike's information criterion (AICc) (Akaike, 1973; Burnham and Anderson, 1992). If overdispersion is detected, then an estimate of the variance inflation factor (i.e., c-hat) is used to adjust AICc (after adjustment, AICc is called QAICc; Anderson et al 1994). Annual survival is calculated as a weighted average across all models, where weight is a function of model fit (Burnham and Anderson 1998; Smith et al. 2001). Model averaging eliminates the need to select the single 'best' model, allowing the uncertainty of model selection to be incorporated into the variance of parameter estimates (Burnham and Anderson 1998; Smith et al. 2001). Also, the committee uses a goodness-of-fit bootstrap procedure (included in program MARK) to estimate the probability that the fully time saturated model fits the data. At the Striped Bass Technical/Stock Assessment meeting (10-12 September 2002), it was suggested that a probability under 0.2 represents lack of fit; this is an arbitrary cutoff point but we use it herein to indicate model fit.

Since survival cannot be uniquely estimated for the terminal year in the fully time saturated {S(t)r(t)} model, the time saturated model is excluded from the model averaged survival estimate for the terminal year only. The final steps involve adjusting the estimates of survival for reporting rate (Kahn, 2001) and bias due to live release (Smith et al. 2001). Instantaneous fishing mortality (F), not directly estimated by these analysis procedures, is determined by converting survival (S) to total mortality (Z) and subtracting a constant value for natural mortality (M) of 0.15. Using this technique, natural mortality is held fixed, and any change in total mortality (Z) results in an equal change in fishing mortality (F).

Results

The 2001 weighted-mean instantaneous fishing mortality (F) was **0.53** for >= 18 inch fish from producer area (Delaware and Maryland) tagging programs (Table D20). This weighted mean excluded Hudson River (data were unavailable for 2001) and Virginia (because of lack of fit for the full parameterized model). For the subset of >= 28 inch striped bass, the weighted mean fishing mortality (F) in 2001 was **0.16** (Table D21). The weights used in the calculations were as follows: Delaware (0.10) and Maryland (0.90). These were modified from the previous weight scheme [Hudson (0.13); Delaware (0.09); and Chesapeake Bay (0.78), with MD (0.67) and VA (0.33)] as provided from G. Shepherd (pers. comm.). The weight scheme was modified because of the lack of Hudson River data and the lack of fit of the full parameterized model with Virginia data.

A 2001 unweighted-mean instantaneous fishing mortality (F) was not calculated for >= 18 inch fish from the coastal mixed stock tagging programs (Table D20). Survival estimates from three of the four coastal tagging programs were not representative; MADFW primarily tags fish larger than 28 inches, and GOF bootstrap analyses indicated a lack of model fit of data from NYOHS and NCCOOP. For striped bass tagged at twenty-eight inches and greater in total length (believed to represent those fish fully recruited to the coastal fisheries) the 2001 unweighted-mean fishing mortality was **0.09** (Table D21). This unweighted mean was calculated with data from MADFW, NYOHS, and NJDEL, but excluded NCCOOP because of lack of model fit.

In general, fishing mortality estimated by tag-based survival analyses has increased in recent years for the >= 18 inch group, and decreased for the >= 28 inch group. This relationship is consistent with recent changes to regulations that have shifted harvest to smaller fish.

Tables D22 and D23 provide the raw estimates of survival from MARK, and components of the live release bias adjustment. For most tagging programs, the proportion of >= 28 inch fish released alive was lowest within the years of 1996 to 1999; these estimates in recent years have increased slightly (Table D23). If the entire time series is considered, then live release bias has decreased since the late 1980's and early 1990's and may result from lowered size limits. The overall decreasing trend in the number of fish released alive (based on tag data) differs from recent MRFSS reports.

For bias adjustment calculations, the committee applies an 8% mortality to live releases, because most live releases are captured with hook and line. Also, a reporting rate of 0.433 is used to adjust survival and fishing mortality rates (based on a high reward tag study of striped bass released in Delaware; D.Kahn, pers. comm.).

A GOF bootstrap test indicated that most time saturated models fit the data (exceptions included the >= 18 inch group of NYOHS, and both size groups of VARAP and NCCOOP; Tables D22 and D23).

Tables D24 and D25 provide the Akaike weights used to calculate the model averaged survival estimates for each program. Those highlighted were the highest weighted models for that program. These are provided so that the reader may evaluate the model (or models) that influence the overall results. In nearly each case, the best fitting models inferred time or regulatory period specific survival or reporting. For several programs, a model of trend within regulatory period received highest weight. The only case where a model of constant survival and reporting received highest weight was for fish greater than twenty-eight inches total length in the Virginia/Rappahannock producer area program.

Tables D26 and D27 provide the total length frequencies of fish tagged and released by program for 2001 and the age frequencies of 2001 (year) recaptures. The length frequency data show the relative differences within and between fish tagged on the coast and in producer area programs. The bimodal length frequencies of producer area programs are probably related to differences between sexes. The coast programs exhibit single modes, likely related to differences in program design and gear type. In general, the Massachusetts program (which captures fish with hook and line) releases proportionally more large fish than other coastal programs, whereas the North Carolina trawl survey releases proportionally more small fish than other tag programs.

Age distributions of 2001 recaptures are problematic since few programs assign ages to all tagged fish. Hence, fish not aged at release cannot be assigned an age at recapture. The greatest proportions of recaptures were among ages four through eight, which included 13.3, 25.4, 16.5, 12.4, and 10.1% of the total. In general, these cohorts accounted for 84% of recaptures from fish tagged on the coast, and 64% of those from producer areas.

Table D28 provides geographic distributions of recaptures by state and month during 2001. Northward spring movements followed by southward returns during fall are consistent across programs and reflect migration patterns and fishing effort.

Tables D29 through 12 provide results from the Western Long Island Survey of juvenile striped bass (ages 1, 2, and 3+). These results indicate a decrease in total mortality as age increases from 1 to 3+.

<u>Trends in encounter and exploitation rates</u>:
Annual catch rates and annual exploitation rates were estimated with tag recoveries of striped bass released by seven agencies (1987 - 2001) of the Cooperative Striped Bass Tagging Program (Tables D32 to D35). Previous estimates of VA-York (1991 - 1999) and NYHUD (1988 - 2000) are included for comparison. Each time series of annual catch rates and annual exploitation rates reflects trends in fishing effort and exploitation, respectively.

Catch and exploitation rates are estimated from recaptures of two size groups (>= 18 inch and >= 28 inch) during the first year after release. Adjusted R/M ratios were used as described below (Reporting rate = 0.43, hooking mortality rate = 0.08, R_k = killed recaptures, R_L = recaptures released alive):

(1) Annual catch rate = (R / 0.43) / M
(2) Annual exploitation rate = ((R_k + R_L * 0.08) / 0.43) / M

Herein, we report trends across the entire time series by program. Overall increases in annual catch rates and annual exploitation rates from 1987 - 1997 or 1987 - 1998 suggest an increase in fishing pressure over that part of the time series, but recent estimates (i.e., the previous two years) of annual catch rates and annual exploitation rates have decreased for most tagging programs.

In general, estimates of exploitation rates are consistent with estimates of F (from survival analyses) as reported above for >= 28 inch fish, but not with those reported for >= 18 inch fish.

III. STATUS OF INDIVIDUAL STOCKS

A coast-wide stock of striped bass is comprised of several populations, primarily Hudson River, Delaware Bay and Chesapeake Bay. It is equally important to maintain individual stock at healthy level so that over-fishing does not occur at the local level. For that purpose we report estimates of fishing mortality and population characteristics for each individual stock.

Chesapeake Bay

Fishing mortality

Tag-based estimates of fishing mortality in 2001 for the Chesapeake Bay stock were available only from the Maryland spring tagging program and the direct enumeration study conducted through the calendar year of June 2001-June 2002. For fish $\geq$28 inches, the spring estimate of F = 0.13 was lower than the N-weighted VPA F estimates of 0.27 and 0.37 on ages 8-10 (12+) and 8-11 (13+), respectively. It should be noted that the tag-based F and N-weighted VPA F are not directly comparable to the reference point because of the methods used to calculate that measure.

A direct enumeration study to estimate the bay-wide fishing mortality based on the tag release and recovery data is conducted by Maryland and Virginia since 1993. The multiple release design and analysis used in this study was reported in Hebert et. al. 1997; Goshorn et al. 1998; Goshorn et al. 1999; Goshorn et al. 2000; Hornick et al. 2000; Hornick et al. 2001. Striped bass were tagged and released throughout the Chesapeake Bay prior to and during the recreational fishing seasons for each respective jurisdiction during four release rounds in Maryland, and three in Virginia. Jurisdictional regions within the Chesapeake Bay were open for recreational striped bass fisheries for a combined total of approximately 31 weeks (6/1/01 - 12/31/01) during the 2001 fall season. All tagging was done cooperatively with commercial watermen. Tag recoveries were handled and recorded by each management jurisdiction and by the U. S. Fish and Wildlife Service (USFWS). USFWS internal anchor tags were applied to 6,663 striped bass. A logistic model was applied to tag recovery and release data. The proportion of the number of recovered tags to the number of tags released was the response variable and the explanatory variables consisted of one categorical variable (interval number, which accounted for unequal interval lengths) and two binary variables, disposition and angler type Estimates of exploitation for the recreational/charter season were converted to instantaneous rates for each round and summed across intervals to determine F for the recreational/charter fishery (F_R). This estimate was then adjusted to include the Chesapeake Bay resident portion of the commercial and recreational fisheries that occurred during summer 2001, winter 2001-2002 and during spring of 2002, respectively. The expanded estimates of total F were calculated based on weighting of recreational/charter estimates of F_R by proportional additions of spring recreational or commercial harvest in numbers. The estimate of the Chesapeake Bay-wide F (F_{Bay}) for 2001 is F_{Bay}= 0.23. Non-harvest mortality (0.10) was added to the point estimate of F = 0.13 to obtain the final estimate of bay-wide fishing mortality of F_{Bay} = 0.23 for 2001. The final estimate of bay-wide F (F_{Bay} = 0.23) is below the Atlantic States Marine Fisheries Commission's (ASMFC) determined 2001 target fishing rate of F = 0.28 for the Chesapeake Bay. A time series of fishing mortality estimates derived by this method is presented in Table D38.

Spawning stock
Spawning stock relative abundance (ages 8+) has been increasing since 1999. The index increased to 79.81 in 2001, but dropped slightly in 2002 to 72.7. Although the spawning stock index dropped in 2002, this value is well above the 1985-2001 average of 46.6 and is equivalent to the 1993-1998 levels.

Recruitment
Both Maryland and Virginia index of YOY striped bass abundance (geometric mean) in 2001 was well above the 1957-2000 average. These observations indicated that 2001 was an excellent recruitment year. At the same time the 2002 index was well below the 1957-2001 average.

Hudson River

Fishing mortality
Data from 2001 have not been processed due to lack of staff at NYDEC; therefore; no tag-based estimates were available for the Hudson River.

Spawning stock
Spawning stock relative abundance (gillnet CPUE; ages 8+) increased slightly in 2001 to 633.2; however, the index is still below the 1985-2000 average of 746.9.

Recruitment
The Hudson River index of YOY striped bass abundance (geometric mean) increased to 22.98 in 2001. The 2001 value is well above the 1979-2000 average of 13.32, indicating that 2001 was a relatively good year of recruitment for striped bass.

Delaware Bay

Fishing mortality
Tag-recapture data is employed in two analyses, a Petersen exploitation estimate and an estimate of F based on survival modeling with MARK program software. The two sets of estimates have been the highest on the coast for the last several years. Both estimates, when translated into F, are F weighted by N. The exploitation estimate for 2001 was 28%, which translates into F_{2001} = 0.36. The 2001 F estimate from the MARK program with trend models included was F_{2001} = 0.42. If trend models are eliminated, the MARK estimate was F_{2001} = 0.35. The Delaware River stock suffers high levels of entrainment mortality from the Salem Nuclear Generating Station. This mortality on YOY larvae and juveniles has been estimated as averaging 32% per year, in the worst case of no compensatory increase in survival of those YOY fish escaping entrainment and impingement.

Spawning stock
The spawning stock survey occurs in April and May on the spawning grounds in the tidal freshwater Delaware River from Wilmington through Philadelphia. Two agencies co-operate in this survey, which tags fish and develops Catch Per Unit Effort estimates of abundance in standardized surveys. The Delaware Division of Fish and Wildlife (DDFW) employs electrofishing gear in a formal systematic sampling design (this type of design is randomized), while the Pennsylvania Fish and Boat Commission (PFBC) also employs electrofishing gear, but in a fixed design. Trends in overall abundance are flat from 1995-2001 for the PFBC and

indicate a slow decline in the DDFW estimates for the period 1996-2001. Further analysis will be conducted. The more extensive DDFW data shows an increase in larger, older fish in recent years, but a decline in recruitment of younger age groups into the spawning stock.

Recruitment
A YOY survey is conducted annually by the New Jersey Division of Fish, Game and Wildlife employing a beach seine. The index was extremely low at the beginning of the time series in 1980, then gradually climbed to a value of 1.03 in 1989. Since then, it has fluctuated without trend between about 1.00 and 2.00. The 2001 index was 1.07.

IV. DISCUSSION

VPA Analysis
The results of the VPA analysis indicate that the coastal stocks of striped bass remain at or below the target F and are not in an overfished condition. Recruitment continues to increase to record levels while spawning stock biomass estimates are at the highest level in the time series. Catches in the recreational fishery also continue to increase.

The sensitivity of the VPA model to changes in the plus grouping was of concern to the Technical Committee. The primary purpose of reducing the plus group was to reduce problems associated with age error. This change also illustrated the problems associated with defining plus groups and oldest age F estimates in an age-structured model. A change in the plus group influenced the calculated exploitation pattern and consequently the average F at fully recruited ages. With more ages in the model, the average F tended to be higher. However, due to the direction of the potential age bias in the inputs, it is expected that the model would be over-estimating F by incorporating older and possibly incorrect ages. Consequently there is more uncertainty in the VPA estimates than are indicated by the bootstrap results.

Tag Analysis
There are several sources of uncertainty associated with the estimation of survival and recovery parameters in the tagging analysis for striped bass. The primary source involves the violation of assumptions basic to all tag recovery modeling, as mentioned earlier in this text. Others involve ad-hoc methods employed to correct for live release bias, as well as the use of a contemporary reporting rate to adjust retrospective recaptures. In addition, the best fitting model for several programs in the >= 18 inch total length group was the time saturated model, which is omitted from the suite of models during model averaging due to constraints on the terminal year survival estimate. The application of a constant value for natural mortality across all groups and time does not allow for potential changes in natural mortality, and dictates that changes in survival result only in changes in fishing mortality.

Also, GOF bootstrap analyses indicated a lack of fit for time saturated models from some tagging programs. The c-hat adjustment corrects for lack of fit associated with overdispersion, but will not correct lack of fit when data do not support the full parameterized model. In the latter case, additional thought toward selection of candidate models may be necessary. In general, lack of fit occurred in program results with highest weight on the full parameterized (time saturated) model and large year to year variation in survival estimates. The tagging committee plans to examine the use of covariate models in future analyses; preliminary covariate analyses with the NCCOOP data reduced problems with the full parameterized model and extreme year to year variation in survival estimates.

Additionally, the tagging committee will examine the use of trend models, which have been used to fit increasing or decreasing trends in survival estimates. In all cases for the 2001 analysis, when trend models were given highest weight (such as DE and MD for the >= 18 inch group, and DE and NJ for the >= 28 inch group), F estimates of the terminal year were high. This effect also occurred for the terminal year estimates of NYOHS, NJ, and VA for the >= 18 inch group, because the trend models received highest weight after omission of the time saturated model. Resolution of many of these issues will take time, and may require a change in the analysis protocol adopted by the tagging committee. It is likely that additional research is required to investigate the differences in release mortality associated with different capture gears, or that the committee may need to investigate other methods to directly determine instantaneous fishing mortality (F). Some solutions may take longer, as the state of the theoretical science is generally in advance of any practical application. Perhaps, as in the model averaging approach, we should not focus on individual tagging program results, but instead consider the aggregate, and examine trends applicable to the whole stock over time.

<u>TAG-VPA F Comparison</u>

Results from the VPA average F and the tagging estimates of F are not directly comparable. Since the tag releases are made proportional to abundance, the appropriate comparison between tag and VPA F's are the tag F with the VPA F weighted by N. Tag results are for striped bass 28 inches and greater. Therefore, comparison was between VPA F's weighted by N for ages 5 to 10 and average tag F's from coastal programs (only positive F values were included in the average).

The results from the two independent estimates of fishing mortality show the same increasing trend over time. The VPA Fs tend to be slightly higher than the average coastal tag Fs (Figure D24, D26), although the VPA estimate is not statistically different based on 95% confidence intervals. The NC offshore winter tag program provided the closest comparison with the VPA results as shown in Figure D25. Part of the variation between the two is the result of the different models used for the estimation.

V. CONCERNS

The uncertainty associated with ageing striped bass with scales remains a problem. A thorough analysis of the scale and otolith database is required to develop a reliable procedure for correction of ages estimated with scales. In response to this problem, the ASMFC will convene an ageing workshop during the winter of 2003 to evaluate the problem and develop some possible solutions.

The Technical Committee remained concerned about the high levels of fishing mortality on the Delaware River stock as determined by tagging estimates of survival.

Some members of the Technical Committee were concerned that the distribution of larger striped bass has shifted to offshore waters as the population has increased in abundance. Since the EEZ is closed to harvest and there is limited fishery independent survey data for older striped bass beyond state waters, these fish may not be represented in the assessment. Low tag recovery of fish tagged in MA may be an indication of shifting distribution.

Some members of the Technical Committee were concerned that the VPA is not adequately robust when dealing with a mixed stock such as coastal striped bass. Other methods that are capable of directly accounting for mixed stock management units should be explored in the future. Some members were also concerned that the tag based estimates of survival among coastal programs were so variable. It is possible that the assumption of mixing and dispersal is not being adequately met to provide a comprehensive estimate of mortality.

Developing consensus management recommendations remains difficult when faced with two separate assessment techniques. Methods that combine catch, survey, and tag data into a single analytical framework should be explored.

VI. SARC COMMENTS

VPA Analysis

Selection of ages 5-10 to estimate the F on age 11 will produce strong dome shaped PR. A flat top PR is not appropriate. When fishing offshore is prohibited, it provides a refuge for large fish and may result in a dome shape PR. Availability may be declining not because of the decline of fish numbers but because they are moving out of the area. Partial recruitment calculation is shifting around with age class dominance.

Including ages 5 and 6 may be helpful early on in the time series when there were not many age 7 and older fish, but that is not helpful now. Need to be careful how you calculate the F on the oldest true age. Use the previous age to estimate the F on the first age in the plus group (ie use age 10 to estimate the F on age 11). That allows for a greater potential for allowing a dome to occur. There would be an even stronger dome if the age range were 4-10 rather than 5-10. Catch on age 4, 5 and 6, tagging information, fish moviement into an area where fishing is not occurring- all of these are evidence for a domed shaped curve.

Plots of residual time series are needed to judge the quality of fit.

Estimates of F are sensitive to the plus group. For example, in the 13+ run, the F in 2001 is 0.4 (Table D14).

There are 4 years were the plus group is greater than the sum of the previous plus group.age 11.

There is no description in the document that describes how the target and threshold Fs were derived in Amendment 5. Need some background on the derivation of the target and threshold Fs.

The document should include table of F by age and year in addition to average Fs.

It appears that there is a problem with age precision beyond age 8 in MA scale reading study. The mean weight at age in some cohorts is going down. This is because of the bias and imprecision in ageing.

The SARC recommends developing a calibration matrix that creates conversion between scales and otoliths. This is a very important outcome from the intended ageing workshop.

The issue of an appropriate VPA configuration should also address allowing for a dome shaped selectivity pattern and an objective discrimination of which tuning indices were included or withheld from the model.

Indices should be tested through the randomization tests, PCA.

Range of the stock distribution by season and fraction of the stock that would be present in a certain area should be considered in parallel with the indices selection. All of the indices that are north of the spawning areas may be capturing the stock as a whole and maybe those indices should be provided with greater weight in the VPA.

Error bars should be included around the estimators if it is based on ratios or bootstrap should be done if ratios are not used.

Use the MRFSS estimate for recapture rate (1 in 13 fish is actually retained?) as an independent estimate of recaptures.

Tag Analysis
Tagging in Delaware is done in the Delaware River, this may be a reason for the increase in DE estimates.

Assume the tagging reporting is constant because there aren't better estimates. Reporting rates may vary.

Including the constant survival models is inappropriate if one wants to be able to compare the tagging estimates and the VPA results.

28" or greater (at tag and release) are assumed to be about age 7. Have not run age based models. Analysis uses 28" or greater as a group and that is compared to the 5-10 ages. Probably should be examined a bit further.

Diminishing the quality of the parameter estimates when including models that are not given much weight, although it may not significantly influence the output, it is going to influence the uncertainty. This may be a reason to throw out these models.

Tag analysis implies a very high dome because the F is greater on the 18" and greater (tag analysis) compared to the F estimate from the tag analysis for 28" or greater.
Fish captured more than once are only included the first time around in the analysis.

Research recommendations.

Conduct a workshop to evaluate an appropriateness of scales in ageing old fish.

Explore applicability of Bayesian framework to striped bass assessment.

Develop the model that will combine VPA and tagging data.

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VI. Tables and Figures

VPA Tables and Figures

Table D1. Total Atlantic Coast harvest of striped bass in metric tons and numbers from 1982 to 2001.

Year	Commercial		Recreational		*Total*	
	MT	N	MT	N	MT	N
1982	992	428,630	1,144	217,256	2,136	645,886
1983	639	357,541	1,217	299,444	1,856	656,985
1984	1,104	870,871	579	114,463	1,683	985,334
1985	4,312	174,621	372	133,522	4,684	308,143
1986	68	17,681	501	114,623	569	132,304
1987	63	13,552	388	43,755	451	57,307
1988	117	33,310	570	86,725	687	120,035
1989	91	7,402	332	37,562	423	44,964
1990	313	115,636	1,010	163,242	1,323	278,878
1991	460	153,798	1,653	262,469	2,113	416,267
1992	638	230,714	1,830	300,180	2,468	530,894
1993	777	312,860	2,564	428,719	3,341	741,579
1994	805	307,443	3,084	565,167	3,889	872,610
1995	1,555	534,914	5,675	1,089,183	7,230	1,624,097
1996	2,178	766,518	6,003	1,175,112	8,181	1,941,630
1997	2,679	1,058,181	7,267	1,515,296	9,946	2,573,477
1998	2,936	1,223,828	5,771	1,366,353	8,707	2,590,181
1999	2,941	1,103,812	6,245	1,319,794	9,186	2,423,606
2000	3,003	1,051,275	7,756	1,924,001	10,759	2,975,276
2001	2,826	941,733	8,889	2,012,314	11,715	2,954,047

Table D2. Total 2001 striped bass discard and harvest in numbers and % of total by fishery component.

Fishery Component	Discard	Discard Losses	Harvest	Total Catch
Recreational	13,456,350	1,076,508	2,012,314	3,088,822
Commercial	2,023,439	310,900	941,733	1,252,633
Sampling			2,343	2,343
Total	15,479,789	1,387,408	2,956,390	4,343,798

Percent of Total

Fishery Component	Discard Losses	Harvest	Total Catch
Recreational	24.78%	46.33%	71.11%
Commercial	7.16%	21.68%	28.84%
Sampling		0.05%	0.05%
Total	31.94%	68.06%	100.00%

Table D3. Atlantic Coast striped bass commercial harvest in numbers at age by state, 2001.

State	Age															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Maine																0
New Hampshire																0
Massachusetts	0	0	0	0	0	0	1,877	7,090	6,673	8,342	9,176	3,962	2,294	626	208	40,248
Rhode Island	0	0	16	122	779	1,543	1,841	1,841	744	934	1,139	589	614	458	297	10,917
Connecticut																0
New York	0	0	0	209	6,842	10,682	10,263	23,668	3,700	1,745	768	349	70			58,296
New Jersey																0
Delaware	0	0	34	1,247	10,932	9,448	5,926	5,349	946	89	402					34,373
Maryland	0	0	81,433	141,666	169,554	83,660	32,555	14,582	5,389	4,245	2,749	1,983	795	199		538,808
PRFC	0	0	1,492	40,281	32,396	6,394	3,410	2,558	853	213	0	0	0	213		87,809
Virginal	0	165	3,215	6,077	20,234	26,951	30,885	33,327	9,352	7,183	4,050	4,998	750	1,000	159	148,346
North Carolina	0	0	0	0	0	0	69	3,680	5,710	8,415	3,676	878	439	69		22,936
Total	0	165	86,190	189,602	240,736	138,678	86,825	92,095	33,367	31,165	21,960	12,759	4,962	2,564	665	941,733

Table D4. Estimated Atlantic Coast commercial discard losses at age for 2001.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
2001	1	2,638	58,079	77,958	88,808	29,410	18,877	11,613	9,664	6,371	4,778	1,957	737	10	0	310,900

Table D5. Reported scientific removals at age for 2001.

	Age															
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
2001	0	15	337	956	660	120	63	56	50	51	21	10	3	1		2,343

Table D6. Total Atlantic Coast striped bass recreational landings in numbers at age by state, 2001.

State	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Maine	0	0	12,070	19,382	17,763	5,406	1,862	3,206	7	35	115	42	29	27	6	59,947
New Hampshire	0	0	0	397	1,165	2,289	3,124	2,394	1,804	1,192	1,604	895	429	0	0	15,291
Massachusetts	0	0	0	5,058	6,488	38,087	85,493	71,709	41,694	14,091	13,709	6,312	3,948	1,442	0	288,032
Rhode Island	0	0	0	262	12,953	24,631	19,322	14,236	3,082	1,787	1,746	1,112	661	197	138	80,127
Connecticut	0	0	0	1,027	12,187	11,205	7,608	6,632	3,575	167	312	1,001	1,460	2,731	5,507	53,412
New York	0	0	0	4,173	23,885	55,309	48,074	36,796	7,233	5,135	4,351	1,270	2,026	541	917	189,710
New Jersey	0	0	0	18,505	105,286	159,608	116,225	70,521	39,494	21,947	17,285	6,330	2,989	1,495	523	560,208
Delaware	0	0	736	432	2,026	3,481	10,012	13,089	3,312	1,655	2,926	2,548	671	307	0	41,195
Maryland	0	47,386	81,500	87,717	31,086	33,625	21,125	18,583	19,320	14,548	15,510	5,525	4,434	1,241	956	382,557
Virgina	0	559	17,487	31,868	75,877	62,904	45,005	40,275	8,216	7,581	4,483	5,528	893	1,041	102	301,819
North Carolina	0	0	0	4,214	3,766	181	2,590	9,008	8,358	5,888	6,011	0	0	0	0	40,016
Total	0	47,945	111,793	173,036	292,482	396,725	360,440	286,449	136,095	74,025	68,051	30,562	17,541	9,022	8,149	2,012,314

Table D7. Total Atlantic Coast striped bass recreational discard losses in numbers at age by state, 2001.

State	**Age 1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
Maine	110	3,858	20,848	17,224	13,401	5,883	3,955	3,443	554	134	134	51	32	11	4	69,639
New Hampshire	0	654	2,054	2,800	2,843	1,587	1,268	1,303	279	104	124	67	50	12	0	13,147
Massachusetts	0	6,233	27,455	75,063	89,902	74,347	69,146	60,716	16,978	4,439	4,725	1,979	1,320	258	310	432,872
Rhode Island	0	870	2,103	1,090	5,960	7,839	5,788	4,159	844	489	478	304	181	54	38	30,197
Connecticut	3,367	14,178	10,722	8,064	26,053	8,950	4,608	5,051	3,633	620	1,063	1,152	443	177	532	88,617
New York	276	5,567	11,569	6,884	14,025	10,683	7,969	4,999	1,128	703	590	184	283	85	134	65,073
New Jersey	99	3,824	5,415	14,468	28,558	13,500	6,373	2,820	1,195	522	343	88	42	14	0	77,262
Delaware	0	13	437	568	2,444	2,457	3,500	3,516	725	262	438	342	74	40	0	14,816
Maryland	25,426	62,527	77,792	30,745	19,194	4,643	6,072	2,974	883	466	165	146	94	34	43	231,204
Virgina	5,463	13,434	16,714	6,606	4,124	998	1,305	639	190	100	35	31	20	7	9	49,676
North Carolina	0	0	6	290	1,366	828	555	553	246	94	58	0	0	0	9	4,006
Total	34,741	111,159	175,115	163,803	207,871	131,714	110,540	90,174	26,655	7,933	8,154	4,346	2,541	693	1,079	1,076,508

Table D8. Atlantic Coast striped bass commercial landings in numbers at age, 1982-2001.

	Age														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Total**
1982	0	45,129	200,221	117,158	22,927	5,035	3,328	2,861	1,871	4,407	5,837	7,639	2,509	2,810	6,898	428,630
1983	0	54,348	120,639	120,999	38,278	7,416	1,954	677	607	1,690	1,314	2,375	2,656	1,856	2,733	357,541
1984	0	478,268	270,140	55,598	30,580	21,688	6,441	1,744	1,020	771	146	279	1,096	1,042	2,058	870,871
1985	0	53,699	45,492	7,545	9,448	19,248	21,569	6,581	3,692	1,514	466	607	493	894	3,373	174,621
1986	0	639	6,020	3,207	180	703	1,425	1,199	546	182	105	220	288	963	2,004	17,681
1987	0	0	3,087	4,265	1,618	252	1,104	1,075	448	233	95	273	302	235	565	13,552
1988	0	0	2,086	3,961	15,491	6,469	2,803	539	541	218	266	108	250	41	537	33,310
1989	0	0	0	0	0	139	1,111	959	1,007	631	475	164	343	444	2,129	7,402
1990	0	650	12,551	48,024	29,596	15,122	3,111	2,357	1,147	519	272	130	428	322	1,407	115,636
1991	0	2,082	22,430	44,723	41,048	21,614	8,546	4,412	4,816	1,163	269	125	80	553	1,937	153,798
1992	0	640	32,277	58,009	46,661	41,581	22,186	11,514	8,746	6,314	1,062	464	169	346	745	230,714
1993	0	1,848	21,073	93,868	87,447	42,112	32,485	13,829	8,396	6,420	3,955	763	184	76	404	312,860
1994	0	1,179	22,873	71,614	101,512	48,269	28,530	14,886	8,902	5,323	2,513	1,250	198	68	326	307,443
1995	0	6,726	35,190	114,519	134,709	98,471	38,918	34,191	37,324	21,827	8,364	3,166	997	363	149	534,914
1996	0	557	50,102	127,825	179,031	161,361	120,693	51,995	29,907	18,864	11,663	9,674	2,264	1,134	1,449	766,518
1997	0	335	96,860	293,511	225,218	201,397	103,129	60,000	33,262	18,888	11,811	7,861	2,753	2,178	978	1,058,181
1998	0	3,122	65,861	209,898	526,183	192,473	70,124	59,604	44,017	25,365	14,592	5,878	3,837	1,387	1,487	1,223,828
1999	0	7,344	93,998	233,720	275,305	235,925	76,755	47,252	54,777	35,387	24,006	9,883	6,832	1,836	795	1,103,812
2000	0	0	50,392	217,214	308,615	183,048	127,913	56,940	38,767	42,264	15,849	5,434	2,614	1,593	633	1,051,275
2001	0	165	86,190	189,602	240,736	138,678	86,825	92,095	33,367	31,165	21,960	12,759	4,962	2,564	665	941,733

Table D9. Atlantic Coast striped bass commercial discard losses in numbers at age, 1982-2001.

	age															
year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**total**
1982	0	31,645	3,644	11,456	5,623	1,291	2,397	1,014	369	92	85	0	0	7	0	57,624
1983	0	24,067	1,453	2,878	7,761	2,311	610	610	262	174	0	0	0	0	0	40,127
1984	0	33,575	1,611	5,812	9,734	11,272	2,815	117	586	66	0	52	0	0	0	65,639
1985	0	7,728	30,472	5,939	10,891	3,395	2,742	1,045	261	131	131	0	0	0	0	62,734
1986	0	5,841	20,758	100,067	27,989	13,315	4,295	1,415	346	0	0	0	0	0	0	174,024
1987	0	4,206	14,382	28,597	51,389	16,940	6,520	1,319	1,011	395	111	86	111	0	0	125,066
1988	0	6,142	22,593	36,616	70,959	71,694	23,232	9,116	3,110	1,653	218	195	24	0	0	245,552
1989	0	13,854	50,240	49,029	83,396	82,757	33,479	15,502	6,342	705	1,409	1,409	663	41	0	338,827
1990	0	14,526	68,713	80,935	111,888	115,702	71,600	36,256	5,948	1,539	1,401	1,503	0	0	0	510,011
1991	79	12,632	37,009	64,210	77,335	56,894	36,912	24,857	6,610	4,071	6,542	16	0	0	0	327,167
1992	117	3,698	34,218	36,746	44,412	34,688	14,798	11,179	3,398	2,356	991	0	0	0	0	186,601
1993	0	7,449	50,160	79,011	95,116	63,487	20,941	15,351	9,270	4,606	1,651	536	260	0	0	347,839
1994	0	31,770	47,169	45,081	88,122	84,570	39,229	12,524	6,223	3,674	712	415	30	0	0	359,518
1995	0	72,822	75,520	53,551	94,158	121,592	61,447	19,083	7,569	4,269	2,290	2,346	807	0	0	515,454
1996	0	27,133	114,085	76,336	61,884	58,787	30,835	14,916	6,148	3,989	159	502	50	0	0	394,824
1997	476	7,108	64,352	61,871	30,602	20,951	14,002	6,592	1,963	4,309	2,658	801	1,060	0	0	216,743
1998	0	13,233	53,899	98,510	83,288	29,197	12,970	12,591	7,860	4,372	3,891	2,419	3,311	124	367	326,031
1999	984	58,076	49,894	43,744	55,740	14,477	5,213	3,704	1,980	1,304	648	612	240	3	0	236,620
2000	196	178,457	189,933	157,291	62,699	33,918	26,938	7,831	4,111	3,876	801	863	41	17	25	666,996
2001	0	2,638	58,079	77,958	88,808	29,410	18,877	11,613	9,664	6,371	4,778	1,957	737	10	0	310,900

Table D10. Atlantic Coast striped bass recreational harvest and discard losses in numbers at age, 1982-2001.

Year	age															Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	
1982	1,810	28,781	52,833	92,221	29,879	12,854	18,488	12,927	9,453	6,094	5,095	6,029	938	1,276	1,233	279,911
1983	3,625	31,912	56,144	69,265	103,980	29,559	16,149	2,837	2,026	1,845	3,267	3,269	2,220	2,203	1,880	330,182
1984	5,563	30,909	30,946	21,015	20,060	18,720	9,025	2,807	510	1,242	547	5	1,087	3,199	2,657	148,293
1985	1,311	11,102	25,995	26,999	38,364	20,464	19,211	9,658	2,397	1,760	447	220	29	23	5,509	163,489
1986	11,332	14,529	37,064	29,602	21,730	17,954	14,647	21,383	8,299	5,078	3,250	1,344	587	1,561	4,713	193,072
1987	1,368	6,709	20,160	18,560	14,254	7,849	5,580	4,096	4,925	2,355	1,242	1,608	2,889	1,851	6,963	100,408
1988	2,566	24,740	17,076	22,645	20,650	19,753	14,563	14,756	10,344	3,902	3,192	2,949	2,152	2,991	3,565	165,844
1989	729	22,140	29,416	19,216	21,499	12,542	11,055	4,565	3,074	2,422	1,350	392	909	1,122	3,196	133,626
1990	2,123	31,055	43,205	58,871	31,731	34,344	29,368	29,259	13,600	5,198	3,388	1,874	3,521	3,075	4,918	295,530
1991	1,713	58,121	85,813	99,784	43,567	22,929	45,853	53,651	47,331	18,855	7,362	2,613	2,544	2,751	14,465	507,353
1992	2,797	41,431	133,156	94,464	86,059	33,254	25,436	45,087	46,239	36,112	7,248	3,606	1,554	4,579	8,549	569,572
1993	287	60,335	114,073	154,451	105,949	79,780	33,126	38,157	64,920	65,119	35,527	8,028	4,109	1,097	11,327	776,285
1994	5,655	112,473	278,783	173,947	178,115	99,550	67,673	59,288	84,757	71,964	32,788	20,638	3,131	1,455	9,417	1,199,634
1995	3,838	347,272	348,369	279,759	162,474	250,606	104,445	137,595	106,747	62,459	41,591	10,943	7,720	1,562	3,310	1,868,692
1996	465	64,983	475,768	430,833	292,853	237,424	285,000	141,528	104,054	44,865	30,222	34,487	11,419	3,253	1,052	2,158,205
1997	2,057	278,024	325,236	494,939	360,153	371,499	288,376	305,724	165,092	97,283	45,173	21,325	8,470	5,596	3,816	2,772,763
1998	26,421	167,050	365,650	398,264	515,548	289,268	197,340	192,807	163,616	84,105	76,586	36,875	25,688	13,375	15,918	2,568,510
1999	8,162	50,834	287,988	377,852	320,364	463,488	254,502	175,799	136,715	101,802	72,950	34,535	18,610	11,174	6,196	2,320,972
2000	37,743	145,384	177,411	611,244	648,639	563,116	583,058	246,999	117,697	95,309	42,948	22,994	12,530	6,580	6,710	3,318,362
2001	34,741	159,104	286,908	336,838	500,352	528,438	470,980	376,624	162,750	81,958	76,205	34,909	20,081	9,715	9,219	3,088,822

Table D11. Total Atlantic Coast striped bass catch in numbers at age, including scientific sampling, estimated commercial and recreational discard losses, 1982-2001.

Year	Age															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
1982	1,810	105,555	256,699	220,835	58,429	19,180	24,213	16,802	11,692	10,593	11,017	13,668	3,447	4,093	8,131	766,165
1983	3,625	110,327	178,236	193,141	150,019	39,286	18,713	4,125	2,895	3,709	4,581	5,644	4,876	4,059	4,613	727,849
1984	5,563	542,751	302,698	82,425	60,374	51,680	18,280	4,668	2,117	2,078	693	336	2,183	4,241	4,715	1,084,802
1985	1,311	72,529	101,959	40,483	58,703	43,106	43,522	17,283	6,351	3,404	1,043	827	522	917	8,882	400,844
1986	11,332	21,009	63,841	132,875	49,899	31,972	20,367	23,997	9,191	5,260	3,355	1,564	875	2,524	6,717	384,778
1987	1,368	10,915	37,629	51,422	67,260	25,041	13,204	6,490	6,384	2,982	1,448	1,968	3,302	2,086	7,528	239,026
1988	2,566	30,882	41,755	63,222	107,100	97,917	40,598	24,411	13,995	5,773	3,676	3,251	2,426	3,032	4,102	444,706
1989	729	35,994	79,655	68,244	104,896	95,437	45,645	21,026	10,423	3,758	3,234	1,965	1,915	1,608	5,325	479,855
1990	2,123	46,231	124,469	187,830	173,215	165,168	104,079	67,871	20,695	7,256	5,061	3,507	3,949	3,397	6,325	921,176
1991	1,792	72,836	145,252	208,716	161,950	101,438	91,311	82,920	58,757	24,090	14,173	2,755	2,624	3,304	16,402	988,318
1992	2,914	45,769	199,651	189,219	177,132	109,523	62,419	67,781	58,384	44,782	9,301	4,070	1,723	4,925	9,294	986,887
1993	287	69,633	185,306	327,330	288,512	185,379	86,551	67,337	82,587	76,145	41,133	9,327	4,553	1,173	11,731	1,436,983
1994	5,655	145,422	348,825	290,641	367,749	232,389	135,432	86,698	99,882	80,962	36,013	22,302	3,359	1,523	9,743	1,866,595
1995	3,838	426,821	459,079	447,829	391,341	470,669	204,809	190,869	151,640	88,555	52,246	16,455	9,524	1,925	3,459	2,919,060
1996	465	92,673	639,954	634,993	533,768	457,572	436,529	208,439	140,109	67,719	42,043	44,663	13,733	4,387	2,501	3,319,547
1997	2,533	285,466	486,449	850,321	615,973	593,847	405,508	372,316	200,317	120,479	59,642	29,987	12,282	7,774	4,794	4,047,687
1998	26,421	183,404	485,409	706,672	1,125,019	510,938	280,434	265,002	215,493	113,842	95,070	45,172	32,836	14,886	17,771	4,118,368
1999	9,210	116,452	433,400	656,249	651,804	714,112	336,562	226,801	193,497	138,519	97,623	45,054	25,687	13,018	6,991	3,664,980
2000	37,977	323,937	419,860	989,188	1,021,208	780,437	738,105	311,870	160,636	141,488	59,631	29,301	15,191	8,190	7,370	5,044,390
2001	34,741	159,284	373,435	527,397	741,748	667,237	557,868	468,775	196,167	113,175	98,186	47,677	25,046	12,280	9,883	4,343,798

Table D12. Mean weight at age (kg) 1982-2001.

Year	Age														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1982	0.13	0.64	1.09	1.54	2.42	3.75	4.83	5.79	6.20	8.68	10.80	11.20	12.97	13.26	15.91
1983	0.20	0.55	0.94	1.37	2.37	3.29	3.77	5.36	6.01	8.10	9.57	10.39	11.11	11.10	11.12
1984	0.24	0.60	1.69	1.62	2.67	3.39	5.07	5.65	6.76	7.76	8.41	12.65	10.65	11.75	14.75
1985	0.06	0.61	1.07	1.66	2.19	3.59	4.91	5.46	6.77	7.45	9.00	10.69	11.42	14.34	15.98
1986	0.14	0.57	1.27	2.40	2.44	3.12	3.95	5.05	5.44	6.09	7.75	9.16	10.97	11.55	15.83
1987	0.20	0.77	1.41	2.11	2.50	2.91	3.61	4.74	5.52	6.49	7.77	9.78	11.38	11.62	16.46
1988	0.31	0.91	1.10	1.98	3.12	4.02	4.38	4.70	5.24	5.62	8.58	10.40	11.50	11.31	17.00
1989	0.16	0.83	1.22	2.23	3.06	4.53	5.37	6.23	6.04	8.68	8.94	9.74	13.04	9.93	17.11
1990	0.08	0.89	1.14	2.05	2.35	3.83	4.91	5.96	5.70	5.97	7.44	9.08	9.36	10.80	17.65
1991	0.21	0.92	1.29	2.17	2.62	3.17	4.81	5.64	6.46	6.24	9.46	8.30	9.62	15.96	17.09
1992	0.10	0.69	1.31	1.93	2.81	3.67	4.90	5.79	6.96	8.15	9.77	12.44	13.10	11.15	17.65
1993	0.07	0.76	1.31	1.99	2.77	3.58	4.80	6.11	7.03	8.01	9.53	10.76	14.45	13.85	15.36
1994	0.24	1.05	1.69	2.21	2.85	3.50	4.94	6.20	6.80	7.53	9.73	10.69	11.38	9.06	17.75
1995	0.28	0.70	1.35	2.18	2.77	3.65	5.38	6.16	7.27	8.86	7.57	9.73	13.97	15.65	20.37
1996	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
1997	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
1998	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
1999	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
2000	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30
2001	0.14	1.05	1.47	2.32	3.23	4.52	6.39	7.11	7.81	9.20	9.31	10.10	11.36	12.45	17.30

Table D13. Estimated parameter values and associated SE, T statistic and CV from ADAPT 12+ run prior to re-weighting.

	PAR.	EST.	STD.ERR	T-STATISTIC	C.V.		PAR.	EST.	STD.ERR	T-STATISTIC	C.V.
N	1	1.73E+04	8.72E+03	1.99E+00	0.5	q	NYOHS6	2.60E-04	6.65E-05	3.90E+00	0.26
N	2	1.29E+04	4.95E+03	2.62E+00	0.38	q	NYOHS7	5.47E-04	1.40E-04	3.90E+00	0.26
N	3	6.61E+03	2.04E+03	3.23E+00	0.31	q	NYOHS8	7.92E-04	2.04E-04	3.89E+00	0.26
N	4	4.77E+03	1.32E+03	3.63E+00	0.28	q	NYOHS9	1.27E-03	3.27E-04	3.88E+00	0.26
N	5	3.80E+03	9.64E+02	3.95E+00	0.25	q	NYOHS10	2.13E-03	5.50E-04	3.88E+00	0.26
N	6	4.96E+03	1.20E+03	4.13E+00	0.24	q	NYOHS11	2.74E-03	7.32E-04	3.74E+00	0.27
N	7	2.93E+03	7.40E+02	3.95E+00	0.25	q	NYOHS12+	2.68E-03	6.89E-04	3.88E+00	0.26
N	8	1.52E+03	4.17E+02	3.65E+00	0.27	q	NEFSC2	5.10E-05	1.94E-05	2.63E+00	0.38
N	9	1.61E+03	4.30E+02	3.75E+00	0.27	q	NEFSC3	5.69E-05	1.64E-05	3.48E+00	0.29
N	10	4.57E+02	1.38E+02	3.32E+00	0.3	q	NEFSC4	9.24E-05	2.54E-05	3.63E+00	0.28
N	11	2.86E+02	8.60E+01	3.33E+00	0.3	q	NEFSC5	1.33E-04	3.30E-05	4.04E+00	0.25
q	MACOM7	5.73E-04	1.64E-04	3.49E+00	0.29	q	NEFSC6	2.52E-04	6.24E-05	4.04E+00	0.25
q	MACOM8	8.32E-04	2.39E-04	3.48E+00	0.29	q	NEFSC7	3.89E-04	9.66E-05	4.03E+00	0.25
q	MACOM9	1.46E-03	4.19E-04	3.48E+00	0.29	q	NEFSC8	6.62E-04	1.60E-04	4.14E+00	0.24
q	MACOM10	1.94E-03	5.57E-04	3.48E+00	0.29	q	NEFSC9	9.02E-04	2.25E-04	4.01E+00	0.25
q	MACOM11	2.57E-03	7.38E-04	3.48E+00	0.29	q	NEFSC10	1.51E-03	3.88E-04	3.89E+00	0.26
q	MACOM12+	2.72E-03	7.80E-04	3.48E+00	0.29	q	NEFSC11	1.88E-03	5.40E-04	3.48E+00	0.29
q	CTCPUE3	1.73E-04	3.84E-05	4.52E+00	0.22	q	NEFSC12+	2.69E-03	8.02E-04	3.36E+00	0.3
q	CTCPUE4	2.39E-04	5.17E-05	4.63E+00	0.22	q	HUDSHD8:12	2.76E-04	6.64E-05	4.16E+00	0.24
q	CTCPUE5	3.54E-04	7.64E-05	4.63E+00	0.22	q	YOYNY1	1.12E-04	2.45E-05	4.57E+00	0.22
q	CTCPUE6	4.86E-04	1.05E-04	4.63E+00	0.22	q	YOYNJ1	7.95E-05	1.79E-05	4.45E+00	0.22
q	CTCPUE7	7.33E-04	1.59E-04	4.62E+00	0.22	q	YOYMD1	8.57E-05	1.88E-05	4.57E+00	0.22
q	CTCPUE8	9.35E-04	2.03E-04	4.61E+00	0.22	q	YOYVA1	1.09E-04	2.38E-05	4.57E+00	0.22
q	CTCPUE9	1.52E-03	3.30E-04	4.61E+00	0.22	q	YRLLI2	1.18E-04	2.87E-05	4.13E+00	0.24
q	CTCPUE10	2.74E-03	5.95E-04	4.61E+00	0.22	q	YRLMD2	1.26E-04	2.81E-05	4.49E+00	0.22
q	CTCPUE11	3.30E-03	7.53E-04	4.38E+00	0.23	q	NJTRL2:12	2.12E-05	5.63E-06	3.77E+00	0.27
q	CTCPUE12+	1.06E-03	2.30E-04	4.61E+00	0.22	q	CTTRL4:06	6.49E-05	1.56E-05	4.16E+00	0.24
q	MDSSN3	1.60E-04	3.75E-05	4.27E+00	0.23	q	DETRWL2:07	2.42E-05	6.92E-06	3.50E+00	0.29
q	MDSSN4	2.12E-04	4.96E-05	4.28E+00	0.23	q	VAPN1	8.43E-05	4.14E-05	2.04E+00	0.49
q	MDSSN5	2.75E-04	6.41E-05	4.28E+00	0.23	q	VAPN2	6.41E-05	1.93E-05	3.33E+00	0.3
q	MDSSN6	3.82E-04	8.92E-05	4.28E+00	0.23	q	VAPN3	8.77E-05	2.63E-05	3.34E+00	0.3
q	MDSSN7	5.47E-04	1.28E-04	4.27E+00	0.23	q	VAPN4	1.28E-04	3.81E-05	3.35E+00	0.3
q	MDSSN8	6.35E-04	1.53E-04	4.14E+00	0.24	q	VAPN5	2.12E-04	6.34E-05	3.35E+00	0.3
q	MDSSN9	8.34E-04	1.96E-04	4.26E+00	0.23	q	VAPN6	1.50E-04	4.46E-05	3.35E+00	0.3
q	MDSSN10	1.24E-03	3.11E-04	4.01E+00	0.25	q	VAPN7	5.48E-04	1.64E-04	3.35E+00	0.3
q	MDSSN11	2.33E-03	6.22E-04	3.75E+00	0.27	q	VAPN8	7.96E-04	2.38E-04	3.34E+00	0.3
q	MDSSN12+	1.86E-03	4.36E-04	4.26E+00	0.23	q	VAPN9	1.06E-03	3.17E-04	3.34E+00	0.3
q	NYOHS3	1.10E-04	2.84E-05	3.89E+00	0.26	q	VAPN10	1.55E-03	4.65E-04	3.34E+00	0.3
q	NYOHS4	1.36E-04	3.48E-05	3.90E+00	0.26	q	VAPN11	2.38E-03	7.46E-04	3.19E+00	0.31
q	NYOHS5	1.98E-04	5.08E-05	3.91E+00	0.26	q	VAPN12+	1.81E-03	5.99E-04	3.02E+00	0.33

Table D14. Fishing mortality for several age intervals in 12+ and 13+ runs.

Average F for Ages	**4,11**	**4,10**	**3,8**		**8,11**	**7,10**
Year	**13+**	**12+**	**13+**	**12+**	**13+**	**12+**
1982	0.43	0.41	0.31	0.34	0.60	0.54
1983	0.40	0.30	0.29	0.25	0.44	0.27
1984	0.15	0.15	0.21	0.18	0.09	0.12
1985	0.17	0.15	0.19	0.15	0.12	0.17
1986	0.15	0.13	0.15	0.11	0.17	0.16
1987	0.07	0.05	0.06	0.04	0.08	0.06
1988	0.13	0.10	0.10	0.07	0.17	0.12
1989	0.08	0.06	0.07	0.06	0.10	0.06
1990	0.13	0.10	0.12	0.09	0.12	0.08
1991	0.14	0.10	0.10	0.08	0.19	0.11
1992	0.11	0.08	0.08	0.07	0.13	0.09
1993	0.15	0.11	0.10	0.08	0.20	0.12
1994	0.16	0.12	0.10	0.09	0.21	0.15
1995	0.20	0.18	0.15	0.13	0.25	0.21
1996	0.21	0.18	0.19	0.17	0.22	0.19
1997	0.27	0.23	0.23	0.21	0.30	0.25
1998	0.27	0.21	0.20	0.17	0.32	0.23
1999	0.28	0.21	0.18	0.16	0.38	0.27
2000	0.29	0.24	0.24	0.21	0.33	0.27
2001	0.32	0.24	0.22	0.19	0.40	0.29
1999-2001 Average	**0.30**	**0.23**	**0.21**	**0.19**	**0.37**	**0.28**

Table D15. Fishing mortality at age in 2001 for 12+ and 13+ group runs.

Age	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Plus Group													
13+	0	0.03	0.06	0.16	0.16	0.25	0.34	0.35	0.41	0.44	0.41	0.34	0.34
12+	0	0.02	0.06	0.14	0.15	0.21	0.29	0.28	0.3	0.3	0.29	0.29	

Table D16. Back-calculated partial recruitment and 1996-2001 average PR from 12+ run.

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	97-01 av
1	0	0	0.01	0	0.02	0.01	0	0	0	0	0	0	0	0	0	0	0.01	0	0.02	0.01	0
2	0.11	0.15	0.54	0.1	0.03	0.06	0.06	0.1	0.07	0.08	0.07	0.07	0.1	0.13	0.04	0.08	0.05	0.05	0.12	0.08	0.11
3	0.44	0.33	1	0.16	0.13	0.2	0.11	0.39	0.26	0.2	0.39	0.2	0.33	0.27	0.26	0.19	0.17	0.13	0.26	0.19	0.44
4	0.44	0.78	0.37	0.23	0.31	0.35	0.16	0.48	0.74	0.43	0.5	0.45	0.32	0.4	0.53	0.32	0.36	0.28	0.45	0.45	0.44
5	0.28	0.69	0.7	0.42	0.44	0.54	0.37	0.74	1	0.65	0.71	0.55	0.54	0.39	0.69	0.52	0.6	0.41	0.72	0.48	0.28
6	0.2	0.38	0.66	0.89	0.36	0.77	0.41	0.94	0.96	0.61	0.9	0.54	0.47	0.68	0.67	0.84	0.65	0.51	0.88	0.66	0.2
7	0.37	0.37	0.43	1	0.73	0.51	0.66	0.53	0.84	0.55	0.76	0.52	0.42	0.39	1	0.62	0.62	0.58	0.96	0.93	0.37
8	0.89	0.12	0.22	0.67	1	0.85	0.48	1	0.63	0.69	0.82	0.6	0.56	0.57	0.56	1	0.61	0.69	1	0.9	0.89
9	1	0.39	0.13	0.46	0.59	1	1	0.58	0.81	0.55	1	0.74	1	1	0.61	0.55	1	0.61	0.92	0.97	1
10	0.53	1	0.72	0.32	0.62	0.68	0.48	0.8	0.32	1	0.84	1	0.82	0.95	0.72	0.54	0.46	1	0.81	1	0.53
11	0.33	0.52	0.56	0.62	0.5	0.6	0.43	0.75	0.88	0.62	0.8	0.57	0.53	0.52	0.71	0.67	0.64	0.51	0.85	0.82	0.33
12	0.33	0.52	0.56	0.62	0.5	0.6	0.43	0.75	0.88	0.62	0.8	0.57	0.53	0.52	0.71	0.67	0.64	0.51	0.85	0.82	0.33

Table D17. Estimated population abundance, thousands at age, 1982-2002.

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1,733	4,264	3,431	3,643	3,038	3,703	5,627	6,863	7,690	7,776	7,674	9,035	14,803	11,212	12,509	14,225	8,536	11,442	8,381	15,558	17,967
2	1,402	1,490	3,666	2,948	3,135	2,604	3,186	4,841	5,906	6,617	6,691	6,603	7,776	12,736	9,646	10,766	12,241	7,322	9,840	7,179	13,359
3	953	1,109	1,180	2,652	2,470	2,679	2,232	2,713	4,133	5,040	5,628	5,716	5,618	6,558	10,566	8,217	9,002	10,366	6,194	8,169	6,029
4	817	582	789	735	2,188	2,067	2,271	1,882	2,261	3,442	4,204	4,659	4,748	4,512	5,219	8,500	6,621	7,297	8,520	4,942	6,631
5	319	498	322	603	595	1,760	1,731	1,896	1,557	1,772	2,769	3,443	3,706	3,817	3,468	3,903	6,527	5,043	5,672	6,416	3,692
6	144	220	290	221	464	466	1,453	1,391	1,534	1,179	1,375	2,219	2,695	2,849	2,922	2,490	2,788	4,574	3,736	3,935	4,751
7	104	107	153	201	150	370	377	1,159	1,108	1,167	921	1,082	1,738	2,104	2,015	2,091	1,592	1,925	3,275	2,491	2,740
8	36	67	74	115	133	110	306	287	956	857	920	735	851	1,370	1,621	1,330	1,423	1,110	1,345	2,134	1,609
9	23	16	54	60	83	92	89	241	228	759	661	729	570	652	1,002	1,202	799	979	745	868	1,391
10	34	9	11	45	45	63	73	64	198	177	599	515	551	398	420	733	849	488	663	492	556
11	53	19	4	7	35	34	51	58	51	163	130	474	372	399	260	299	519	625	291	440	313
12+	140	80	74	79	122	351	178	193	173	289	279	308	381	239	403	274	602	579	292	415	550
10+	227	108	89	131	202	448	302	315	422	629	1,008	1,297	1,304	1,036	1,083	1,306	1,970	1,692	1,246	1,347	1,419
8+	286	191	217	306	418	650	697	843	1,606	2,245	2,589	2,761	2,725	3,058	3,706	3,838	4,192	3,781	3,336	4,349	4,419
1+	5,758	8,461	10,048	11,309	12,458	14,299	17,574	21,588	25,795	29,238	31,851	35,518	43,809	46,846	50,051	54,030	51,499	51,750	48,954	53,039	59,588

Table D18. Spawning stock biomass of female striped bass in metric tons at age and annual total in MT and millions of pounds (Mlb), 1982-2001.

Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	19	13	19	23	66	64	73	56	68	102	126	142	157	162	171	293	227	256	296	171
5	40	57	37	70	73	265	273	288	218	252	419	486	540	595	553	640	1,071	828	945	1,069
6	114	130	172	143	258	264	977	1,108	1,116	684	905	1,489	1,772	1,927	2,246	1,952	2,194	3,627	2,924	3,176
7	197	166	261	339	236	524	564	2,267	2,185	2,115	1,529	1,904	3,060	3,806	4,003	4,834	3,490	4,206	7,139	5,380
8	86	152	153	265	290	212	560	666	2,396	1,993	2,165	1,784	2,051	3,316	4,394	3,855	4,408	3,199	3,843	6,133
9	56	43	154	174	212	230	207	608	639	2,221	1,948	2,198	1,715	2,022	3,243	4,152	2,727	3,607	2,508	2,893
10	128	30	35	149	137	176	193	203	563	494	2,049	1,794	1,888	1,433	1,604	2,887	3,343	1,886	2,818	1,862
11	270	81	18	29	126	112	180	194	194	580	479	1,966	1,544	1,424	1,108	1,284	2,224	2,675	1,240	2,079
12	959	409	476	542	811	2,426	1,260	1,375	1,226	2,062	2,084	2,113	2,737	2,026	2,887	1,945	4,263	4,098	2,056	3,244
Total, MT	1,867	1,080	1,322	1,733	2,208	4,273	4,284	6,763	8,603	10,500	11,701	13,873	15,462	16,709	20,208	21,840	23,946	24,379	23,766	26,004
Total, Mlb	4.11	2.38	2.91	3.81	4.86	9.40	9.42	14.88	18.93	23.10	25.74	30.52	34.02	36.76	44.46	48.05	52.68	53.63	52.29	57.21

Table D19. Estimates of bay-wide fishing mortality and ASMFC Target Fishing mortality estimates. (Estimates include a non-harvest mortality of 0.10.)

Year	**Bay-wide F**	**ASMFC target**
1993	**0.19**	0.25
1994	**0.20**	0.25
1995	**0.25**	0.30
1996	**0.33**	0.30
1997	**0.25**	0.28
1998	**0.21**	0.28
1999	**0.31**	0.28
2000	**0.28**	0.28
2001	**0.23**	0.28

Figure D1.Proportions of recreational and commercial fishery landings in numbers for 2001.

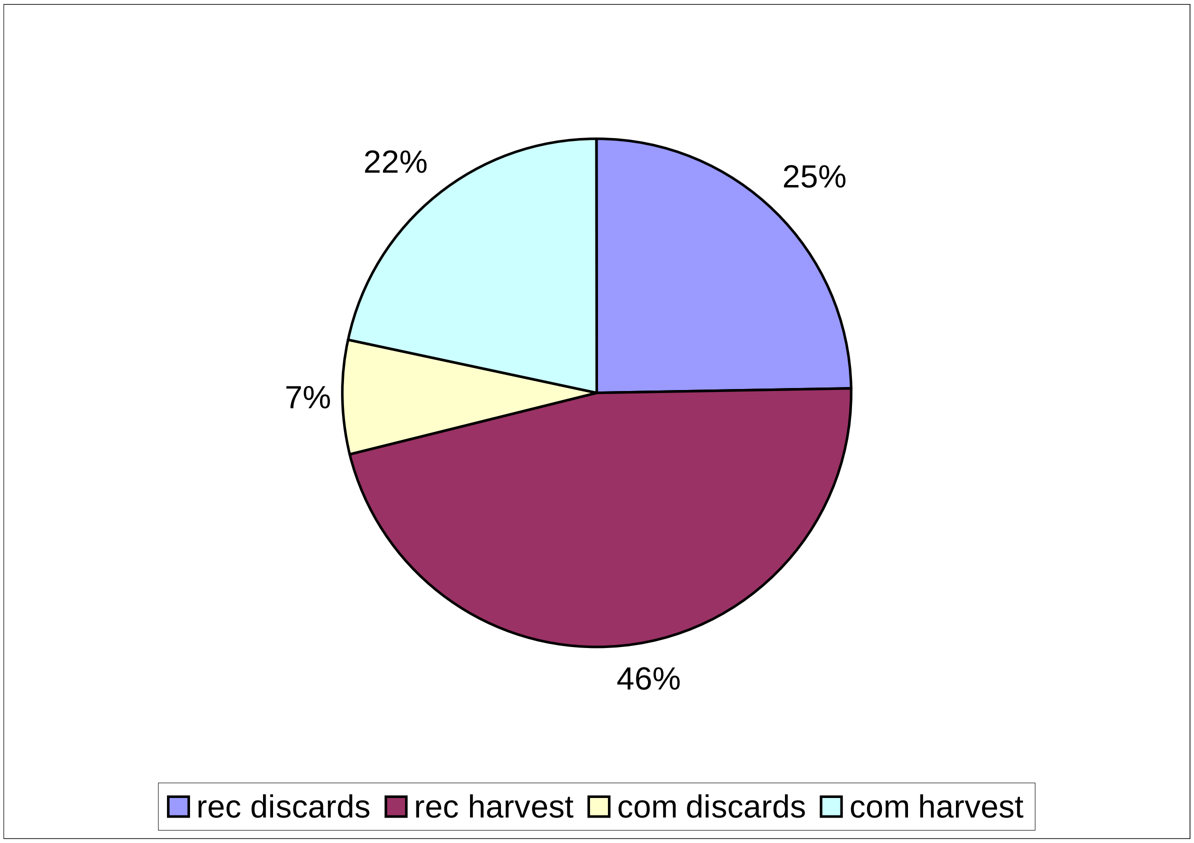
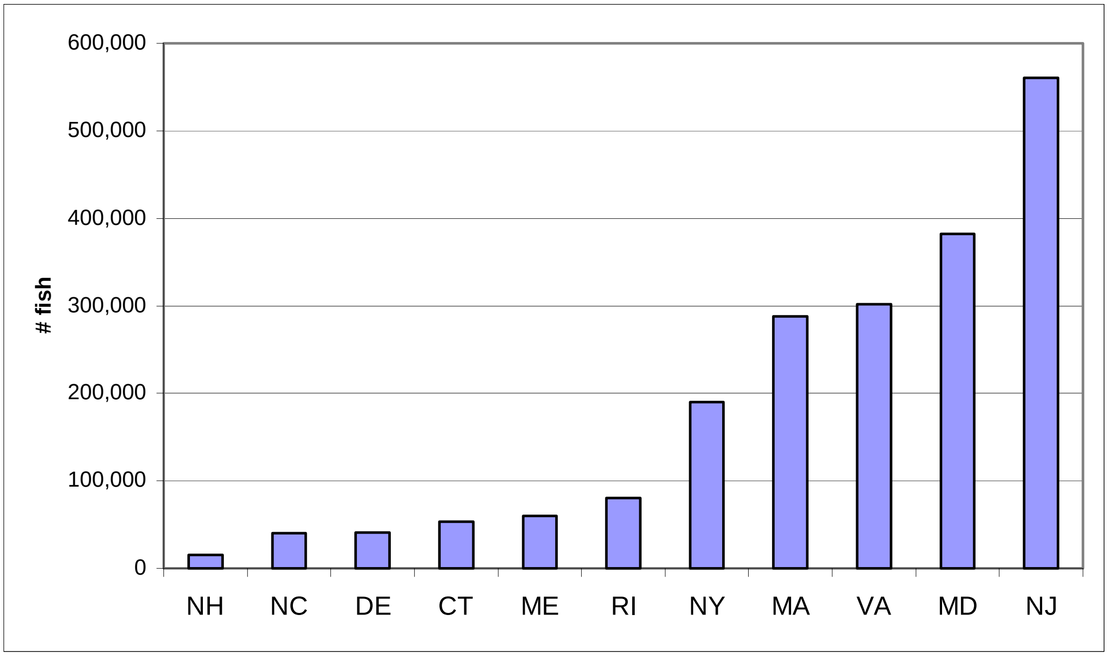


Figure D2. Recreational harvest in numbers of fish and weight (million lb) by state for 2001.



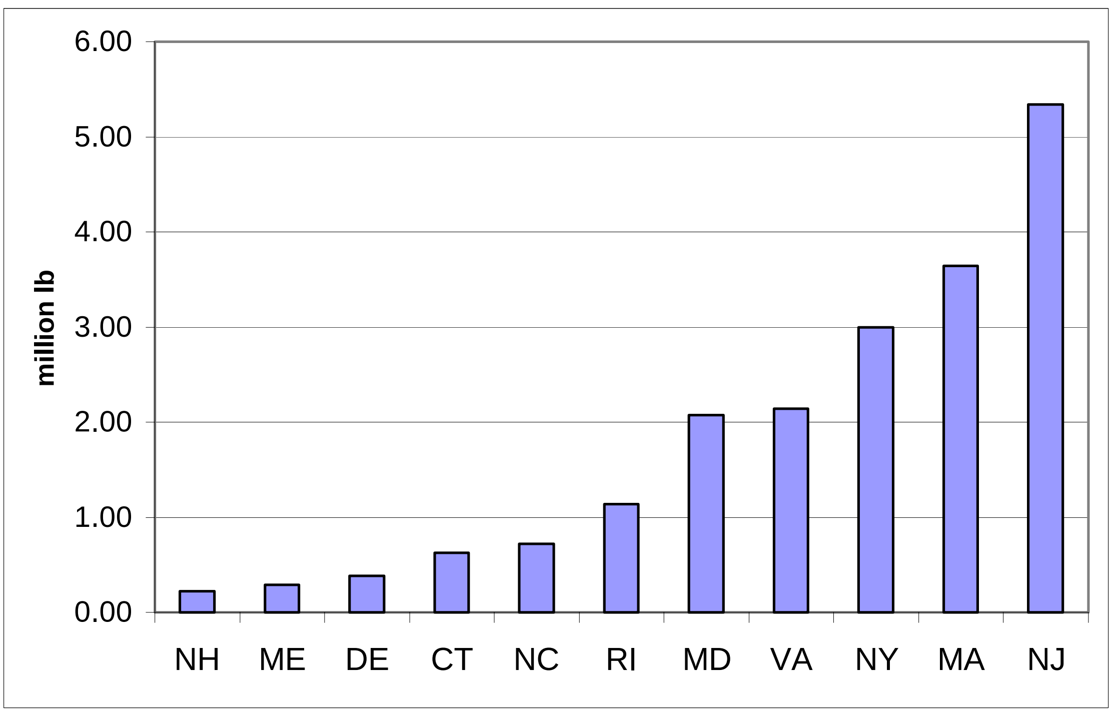


Figure D3. Total losses (harvest and dead discards) for recreational fishery in 1982-2001.

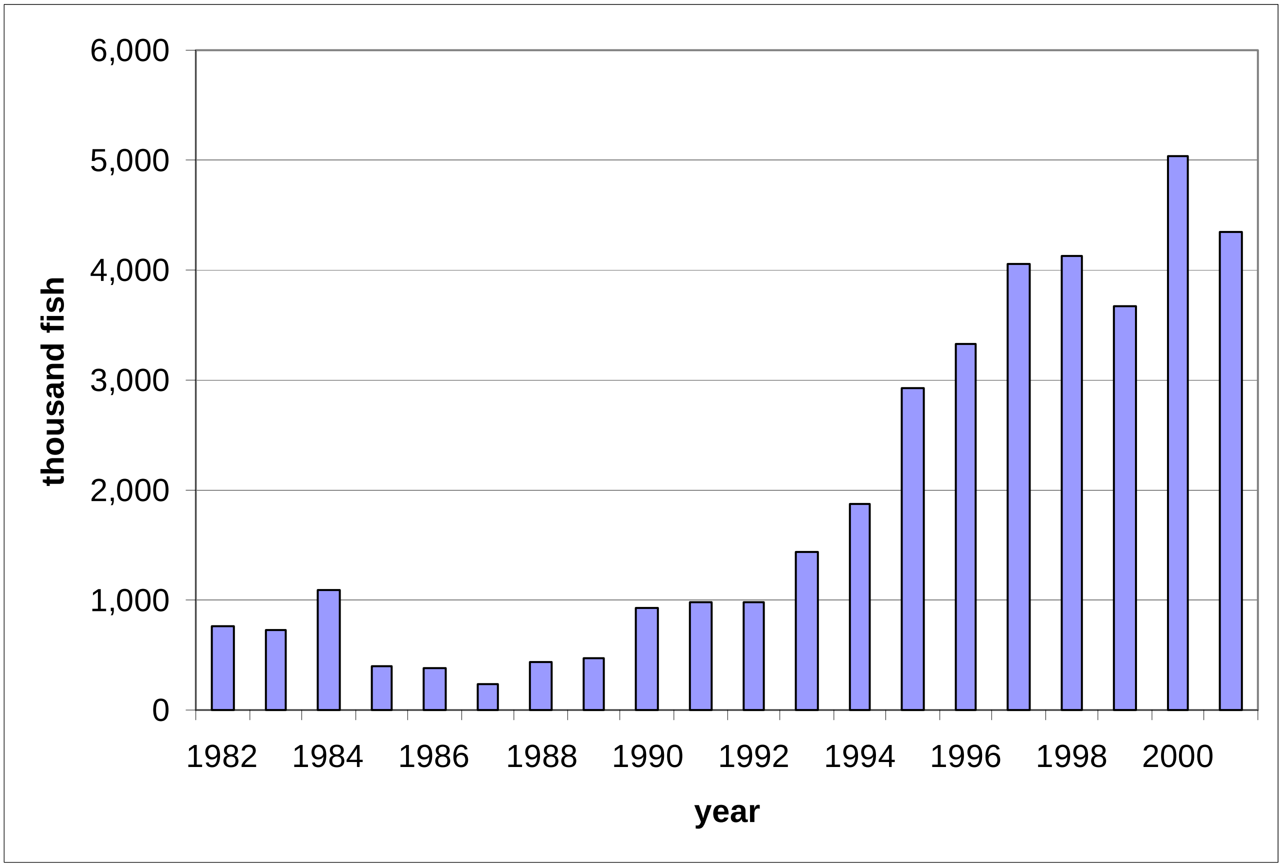


Figure D4. Recreational and commercial catch (harvest and discard) in number in 2000 and 2001.

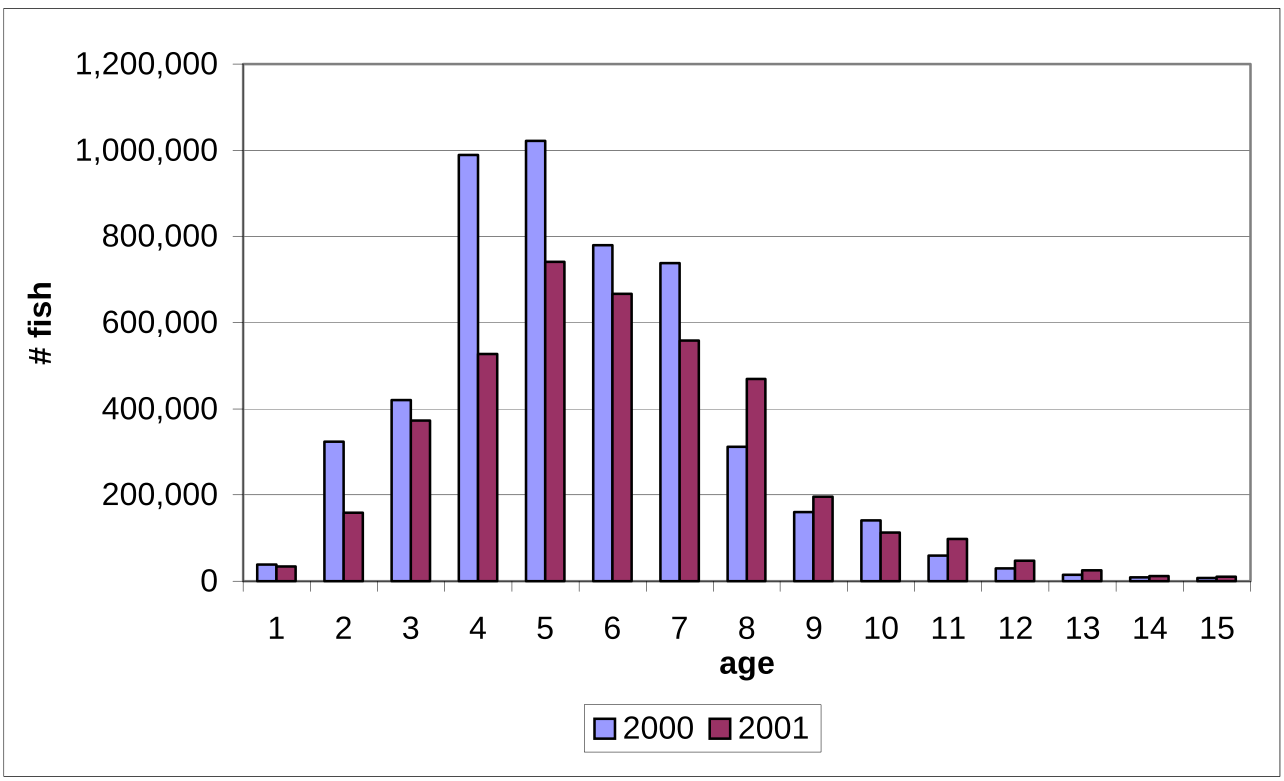


Figure D5. Maryland Spawning Stock Index, ages 2-12+, 1985-2001.

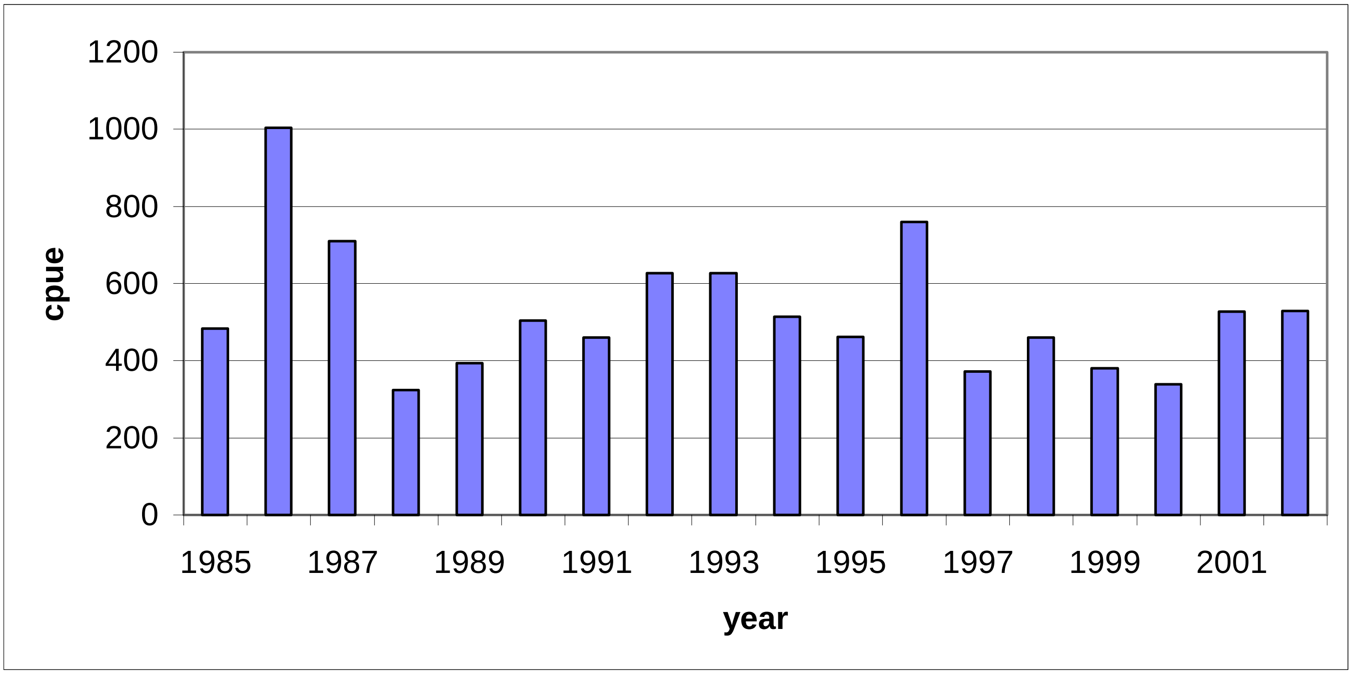


Figure D6. New York Ocean Haul Seine, Total CPUE ages 5-12+, 1987-2001.

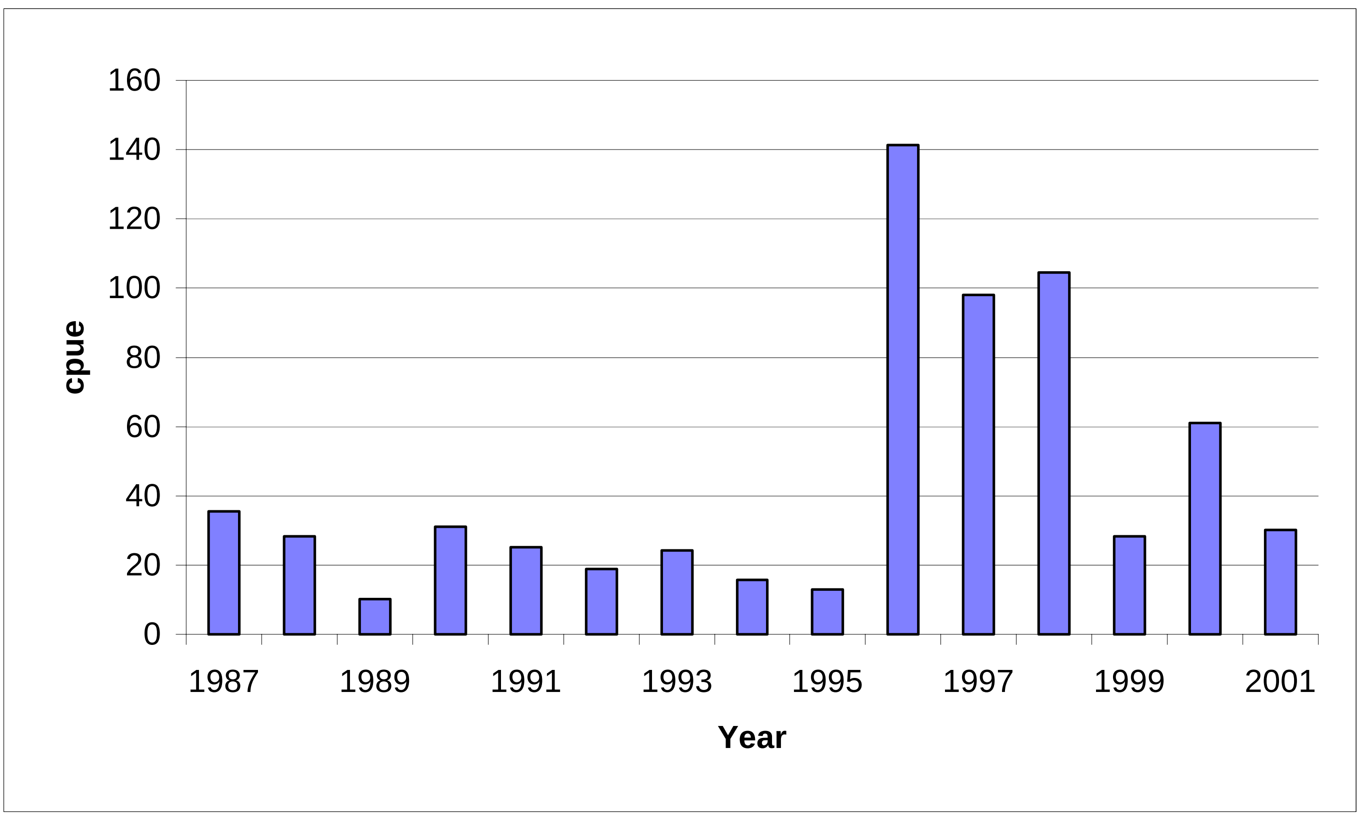


Figure D7. NMFS/NEFSC trawl survey CPUE Ages 2-12+, 1983-2002.

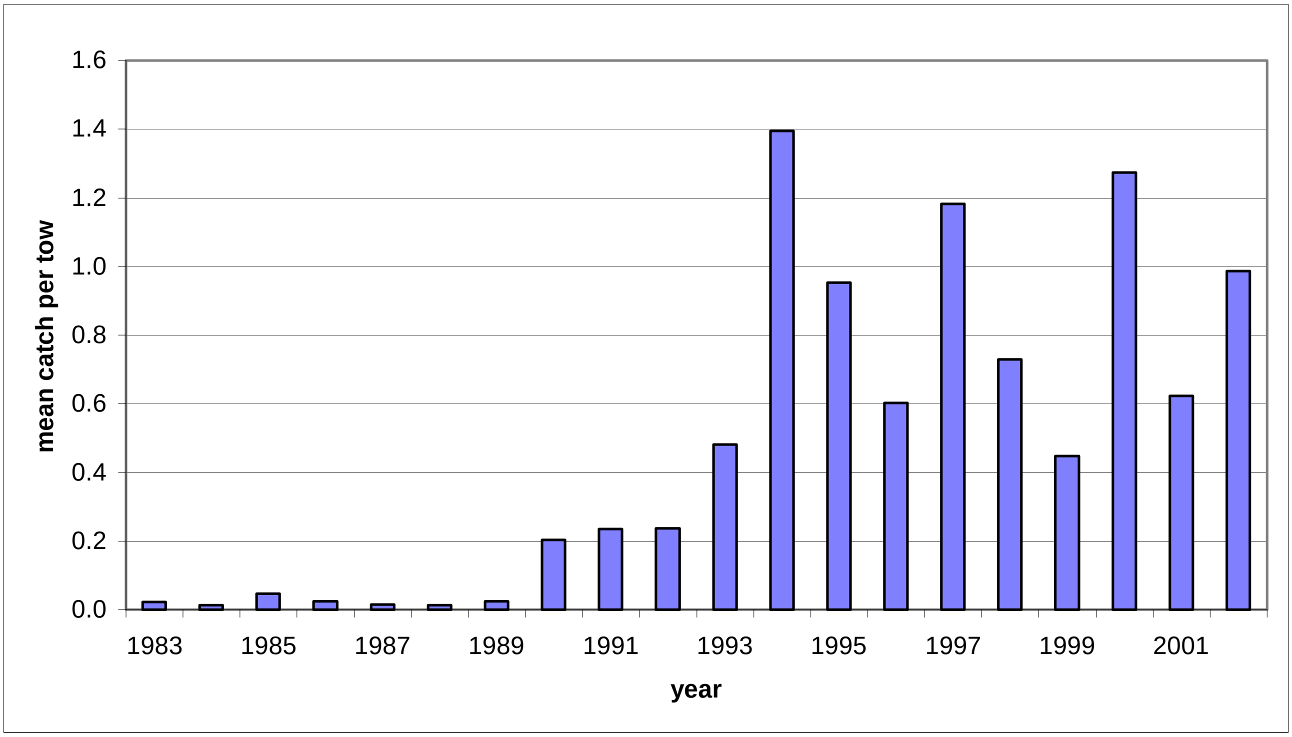


Figure D8. Virginia Rappahannock River Pound Net CPUE, 1991-2002.

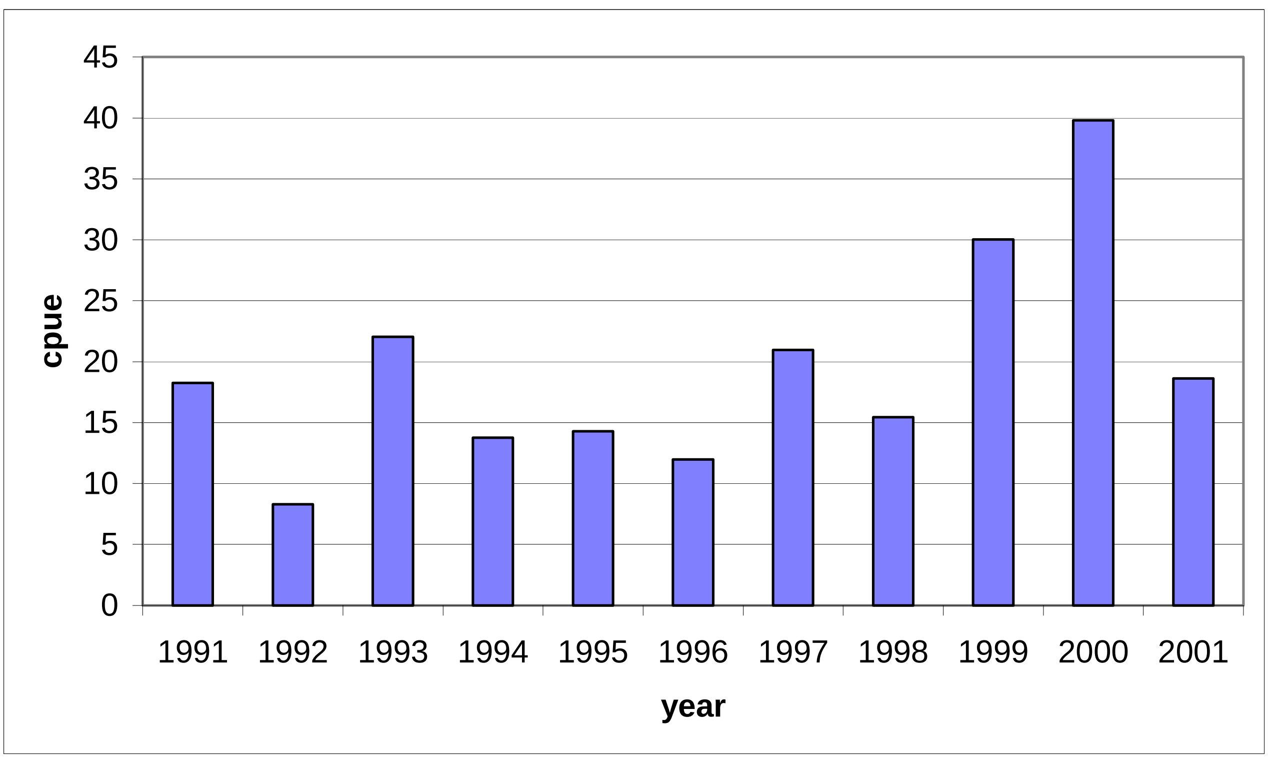


Figure D9. Age aggregated trawl CPUE, Delaware, New Jersey, and Connecticut, 1984-2002.

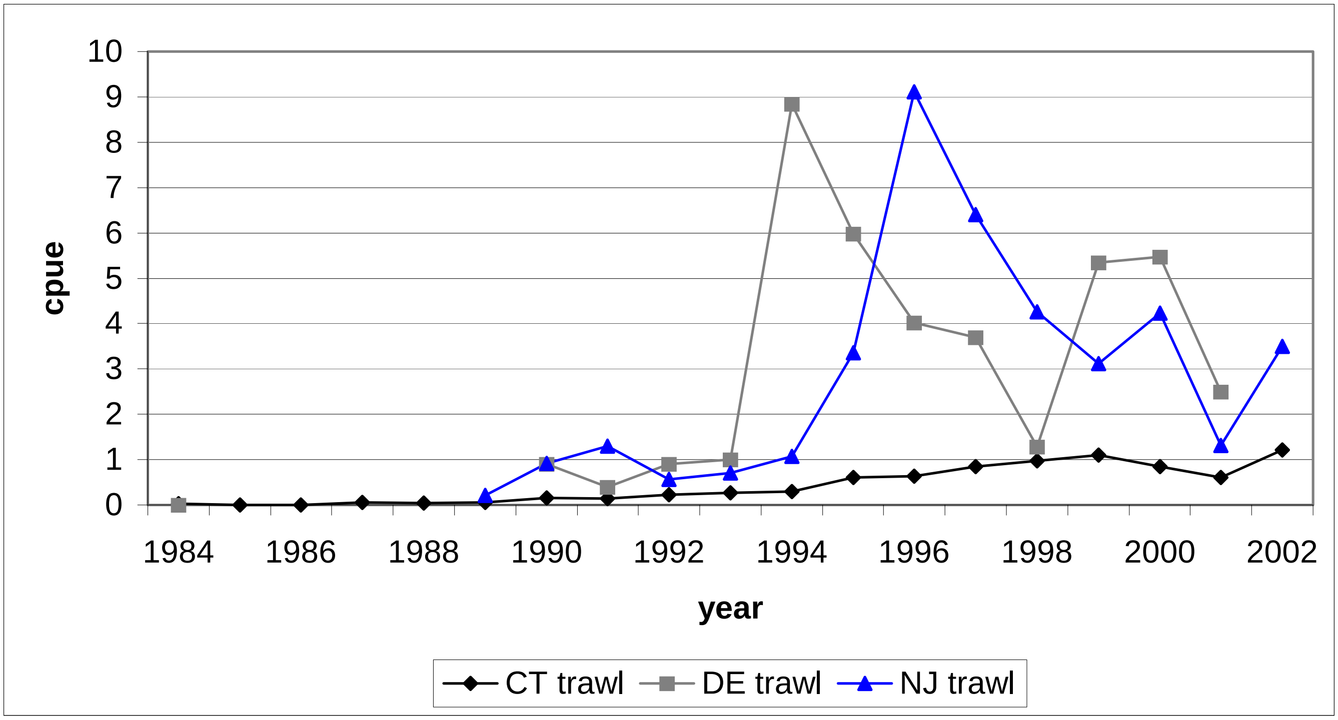


Figure D10. Indices of young of the year abundance for the Chesapeake Stock, Maryland and Virginia surveys, 1981-2001.

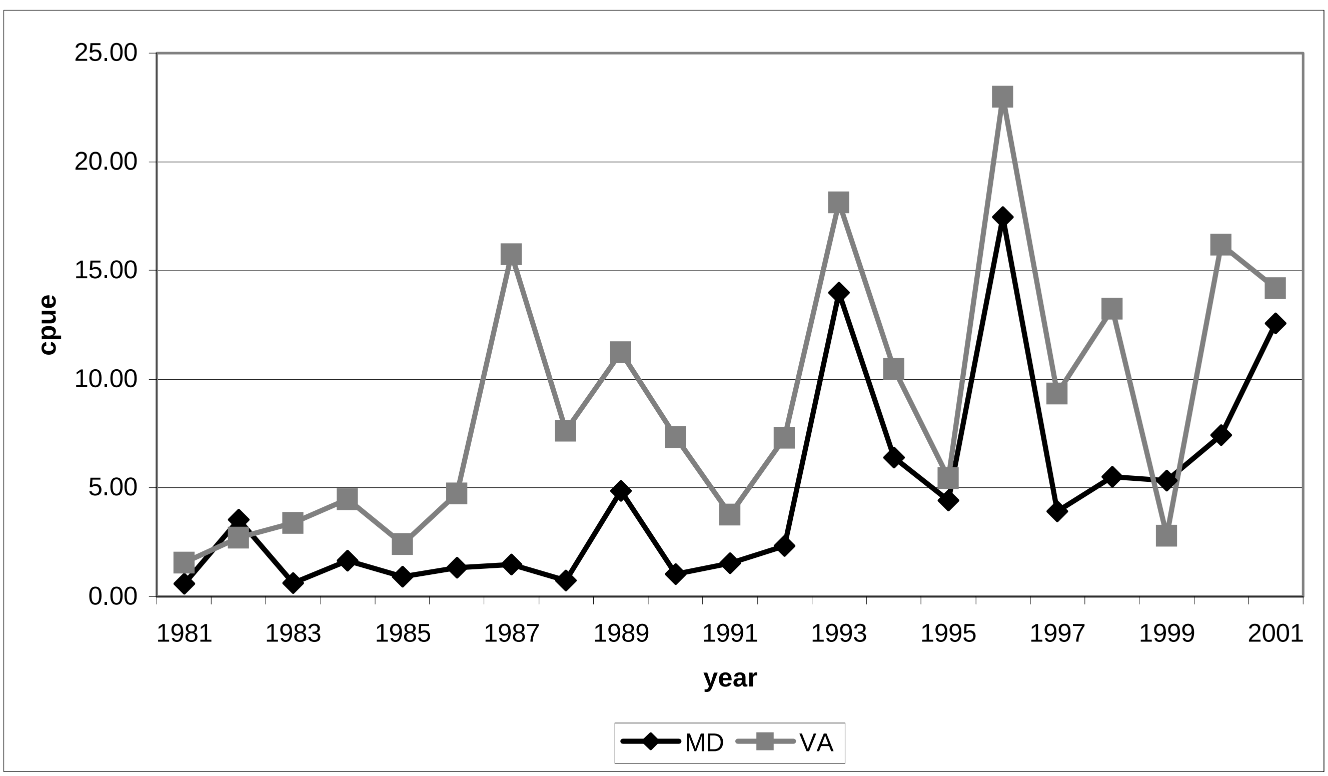


Figure D11. Young of the year survey values for the Hudson (NY) and Delaware Bay (DE, NJ) stocks, 1981-2001.

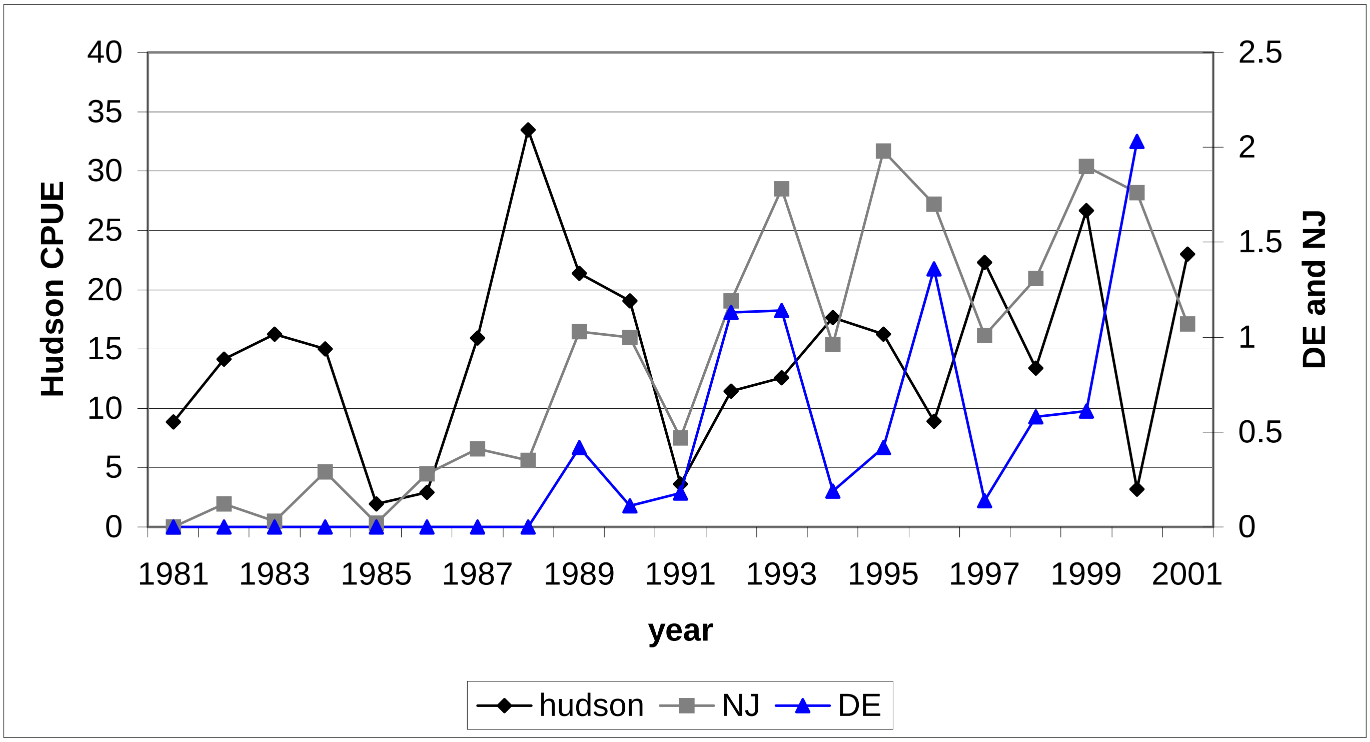


Figure D12. Indices of age-1 striped bass abundance for Long Island and Maryland.

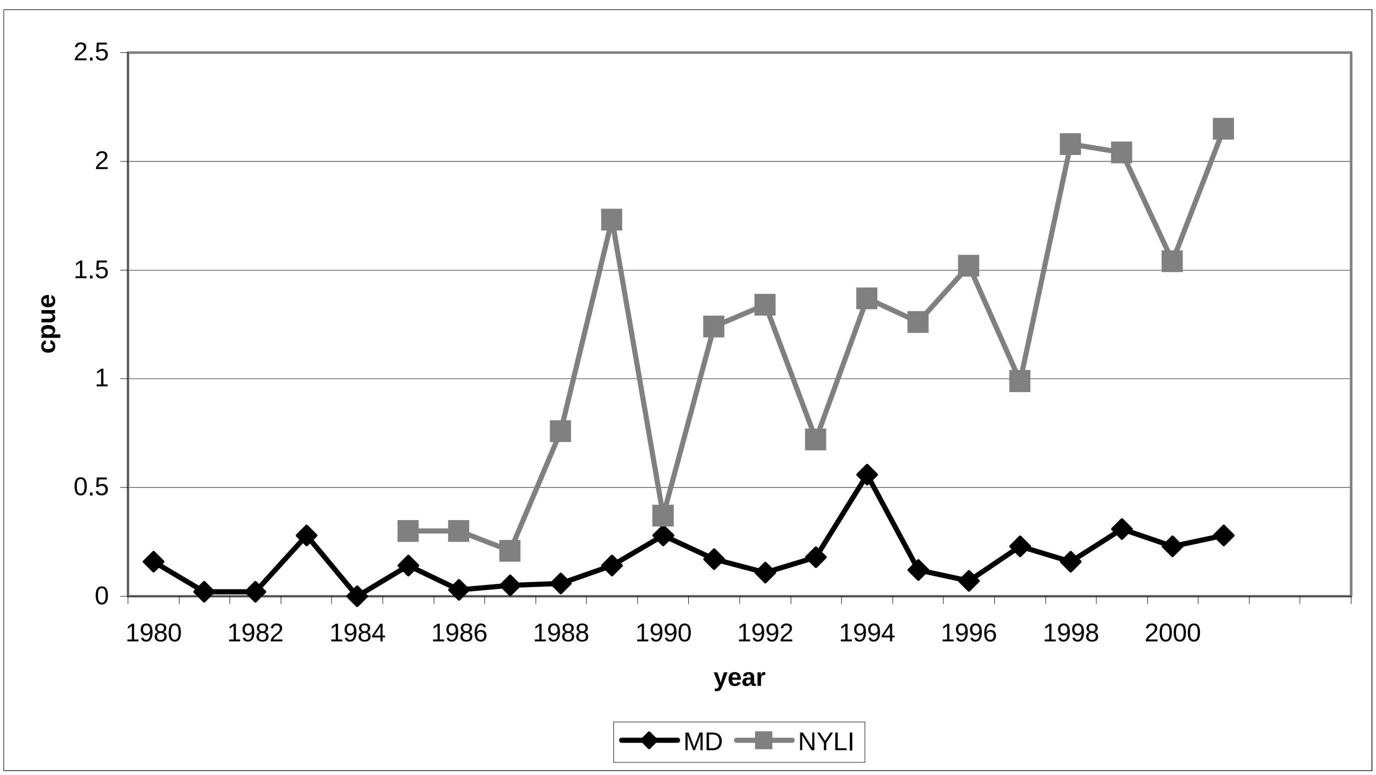


Figure D13. Massachusetts total age 8-12+ CPUE, 1990-2001.

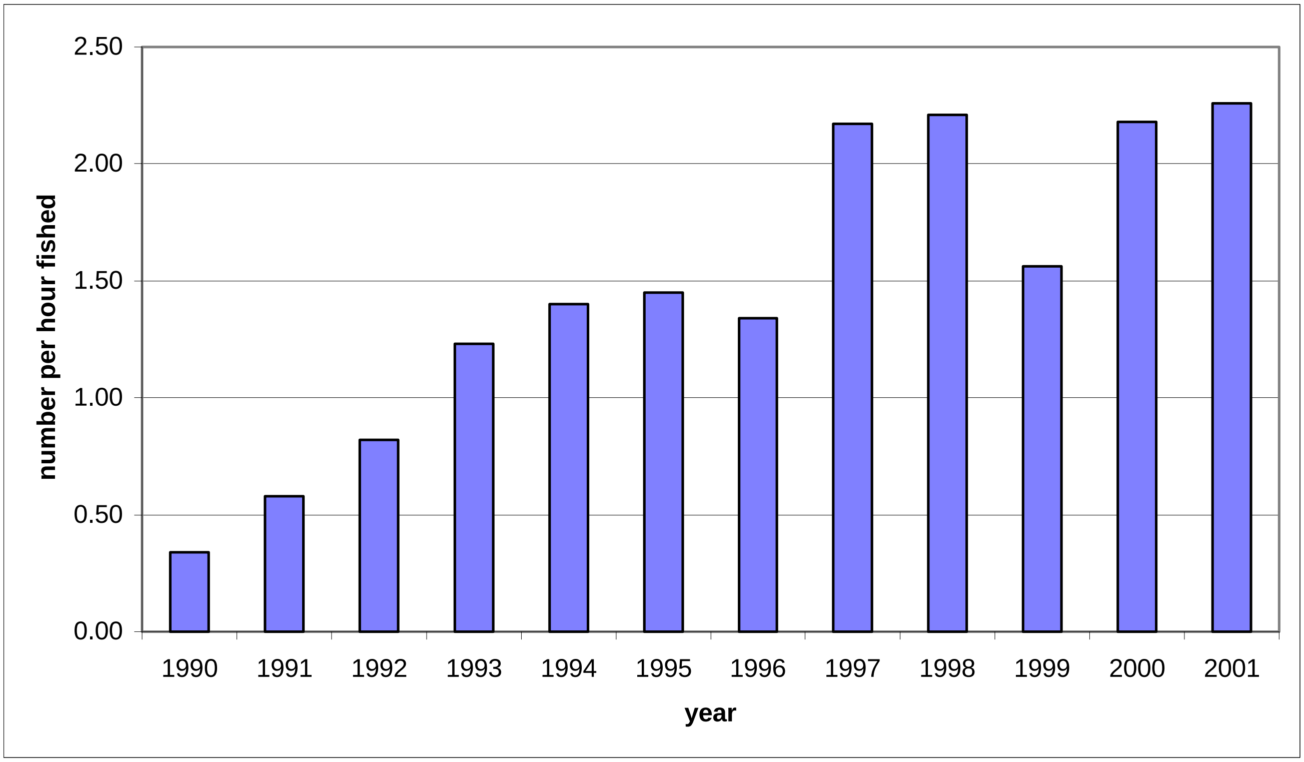


Figure D14. Connecticut total ages 2-12+ CPUE, 1981-2001.

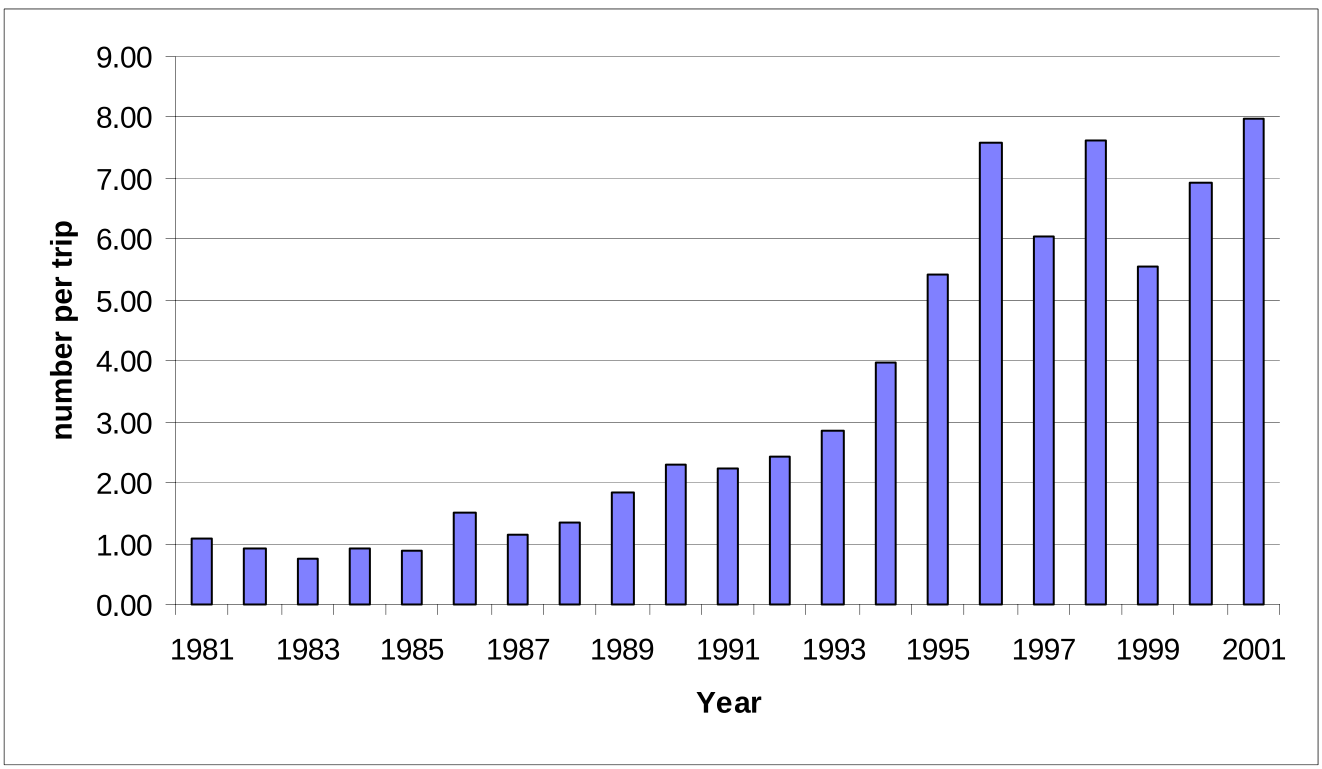


Figure D15. Hudson River shad bycatch indices of striped bass abundance, 1985-2001.

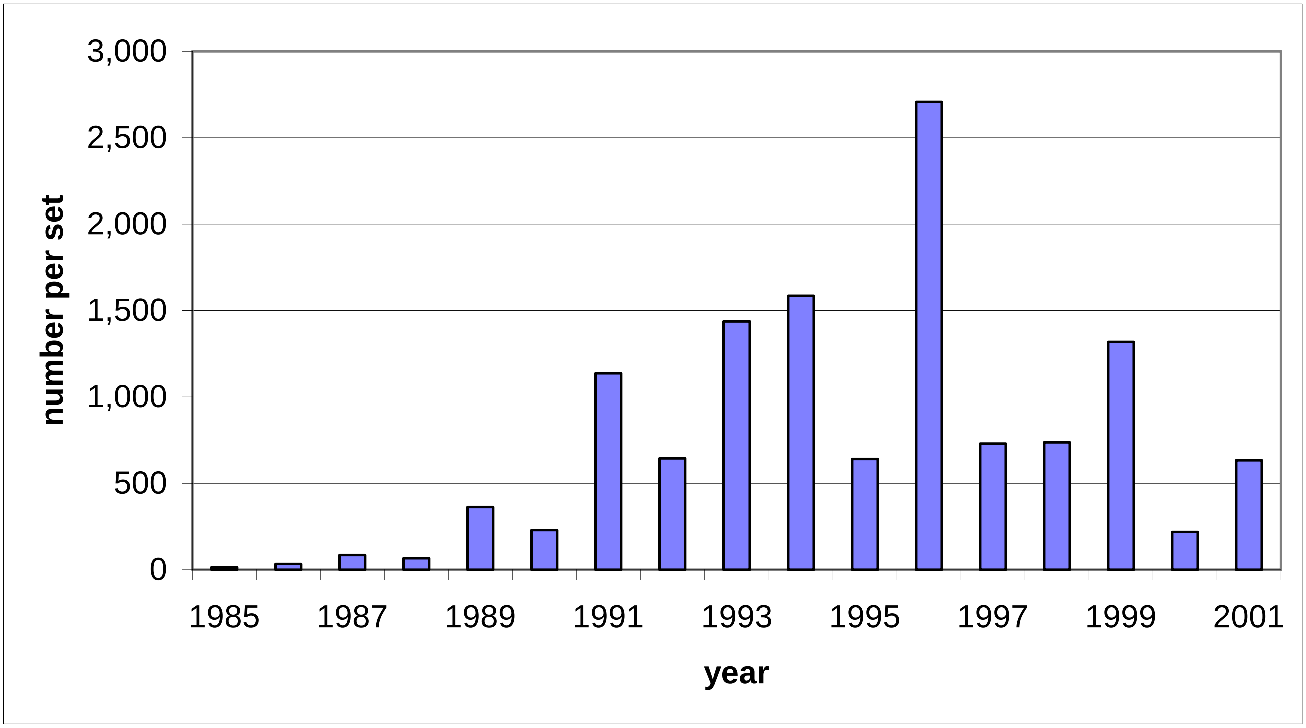


Figure D16. Striped bass fishing mortality from the 2001 ADAPT for age 4 through 10 for 12+ run and 4 through 11 for 13+ run.

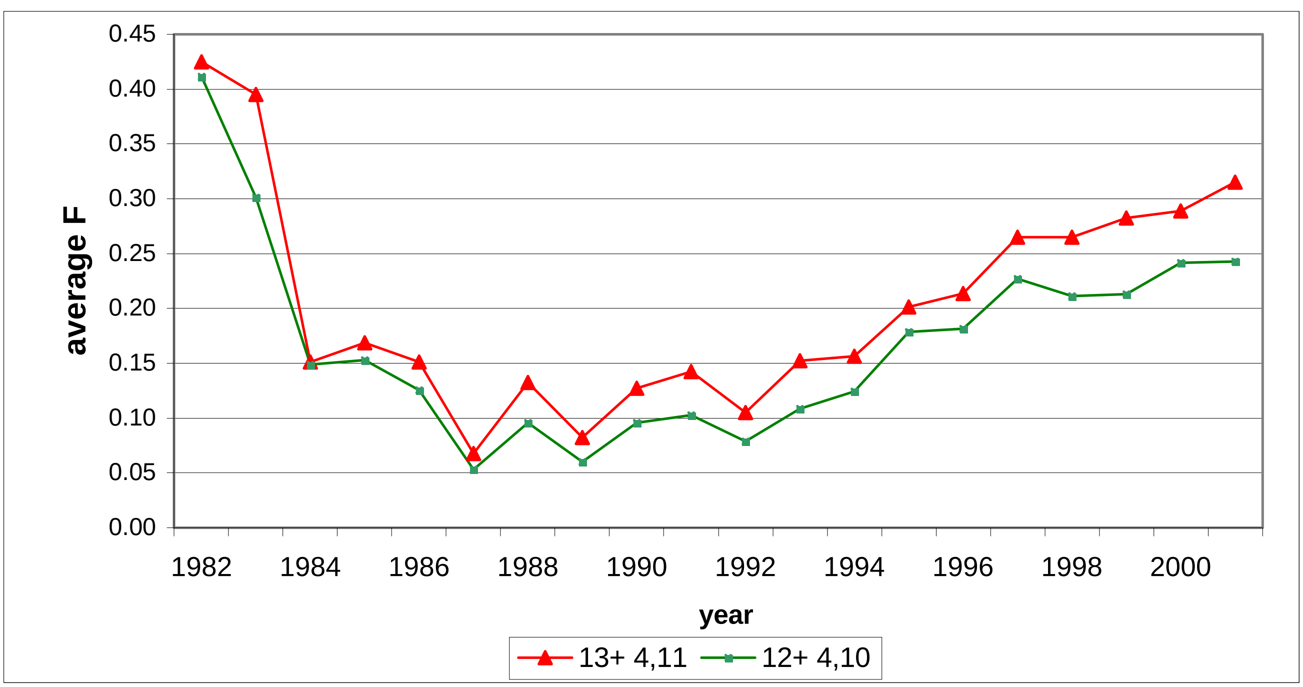


Figure D17. Striped bass fishing mortality from the 2001 ADAPT for ages 7-10 (12+ run) and 8-11 (13+ run).

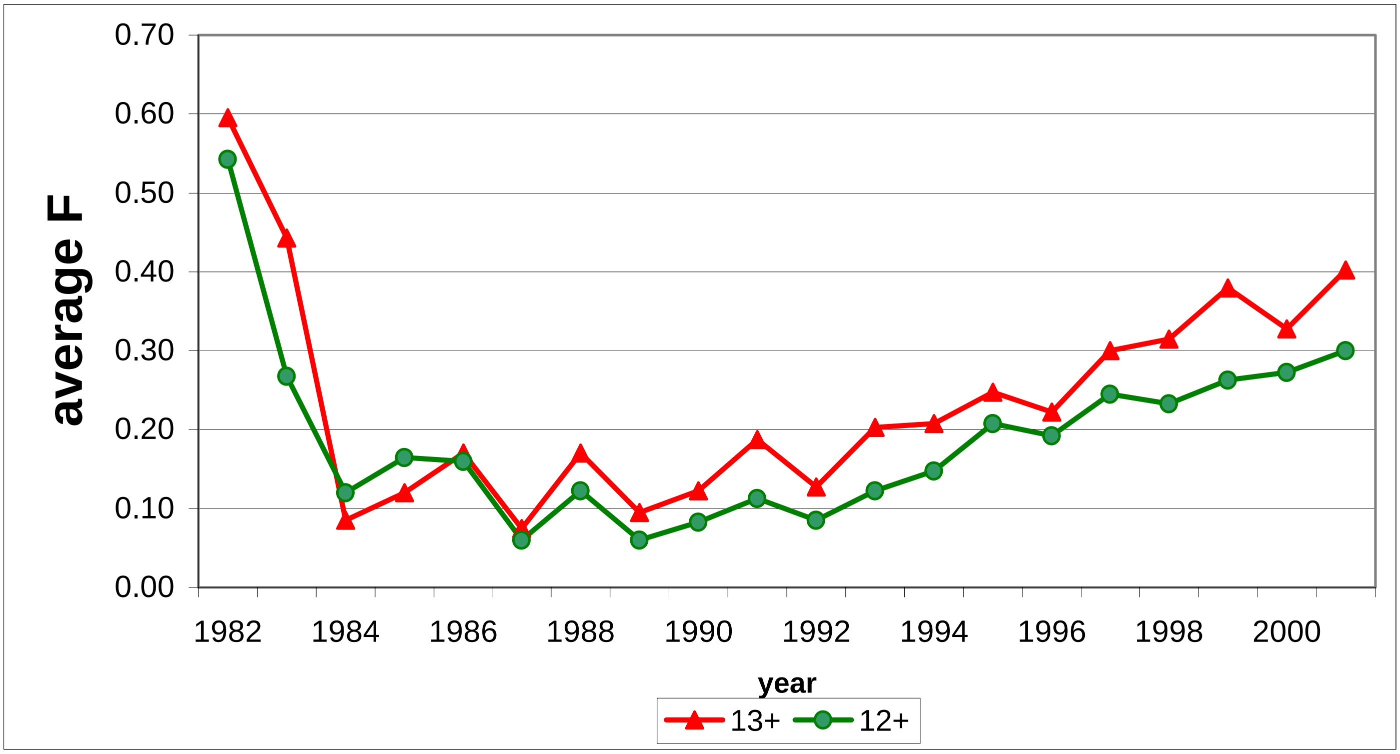


Figure D18. Striped bass fishing mortality from the 2001 ADAPT for ages 3 through 8 for 12+ and 13+ runs.

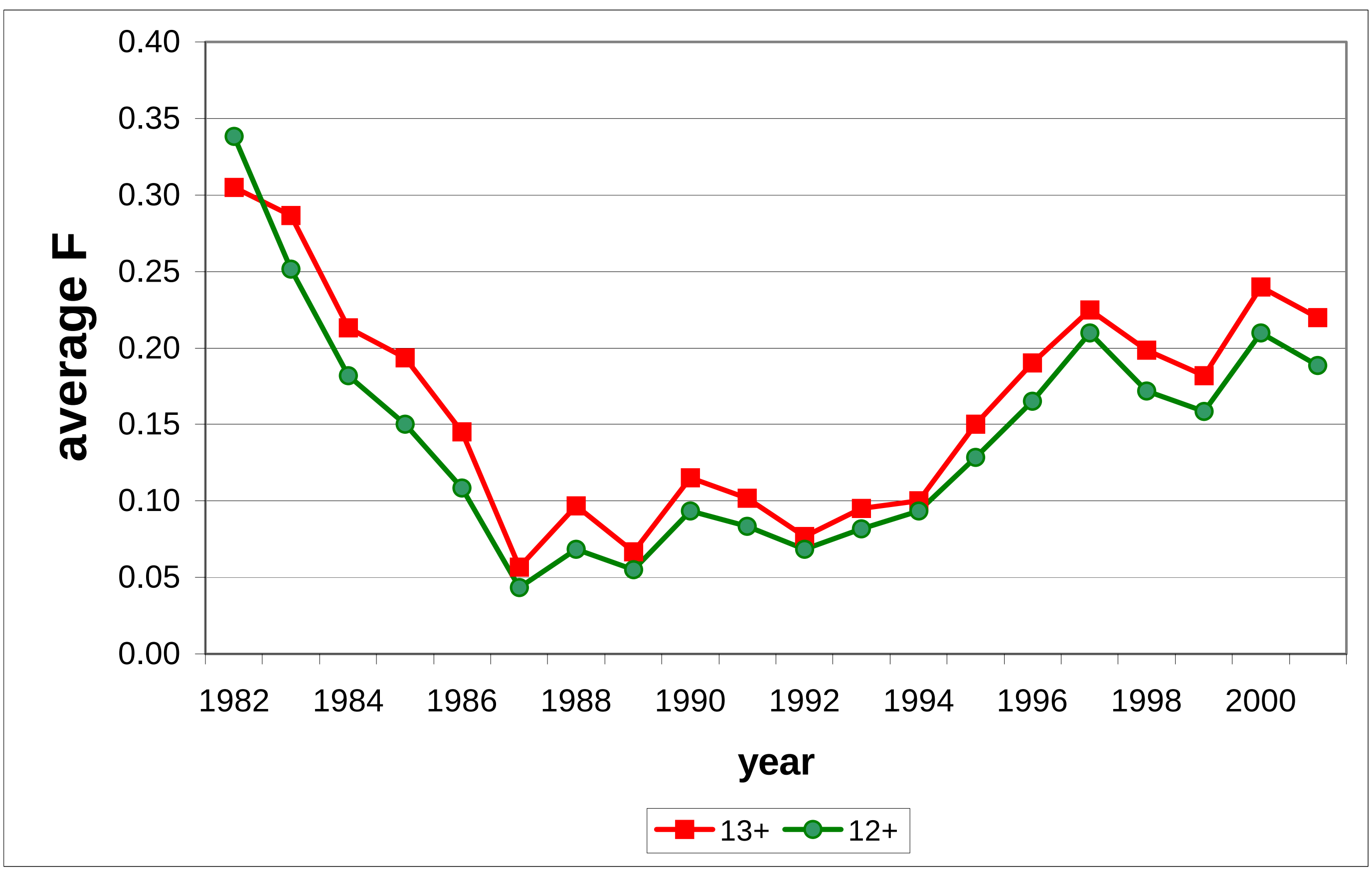


Figure D19. Population size (ages 1-12+) estimates for 12+ and 13+ runs.

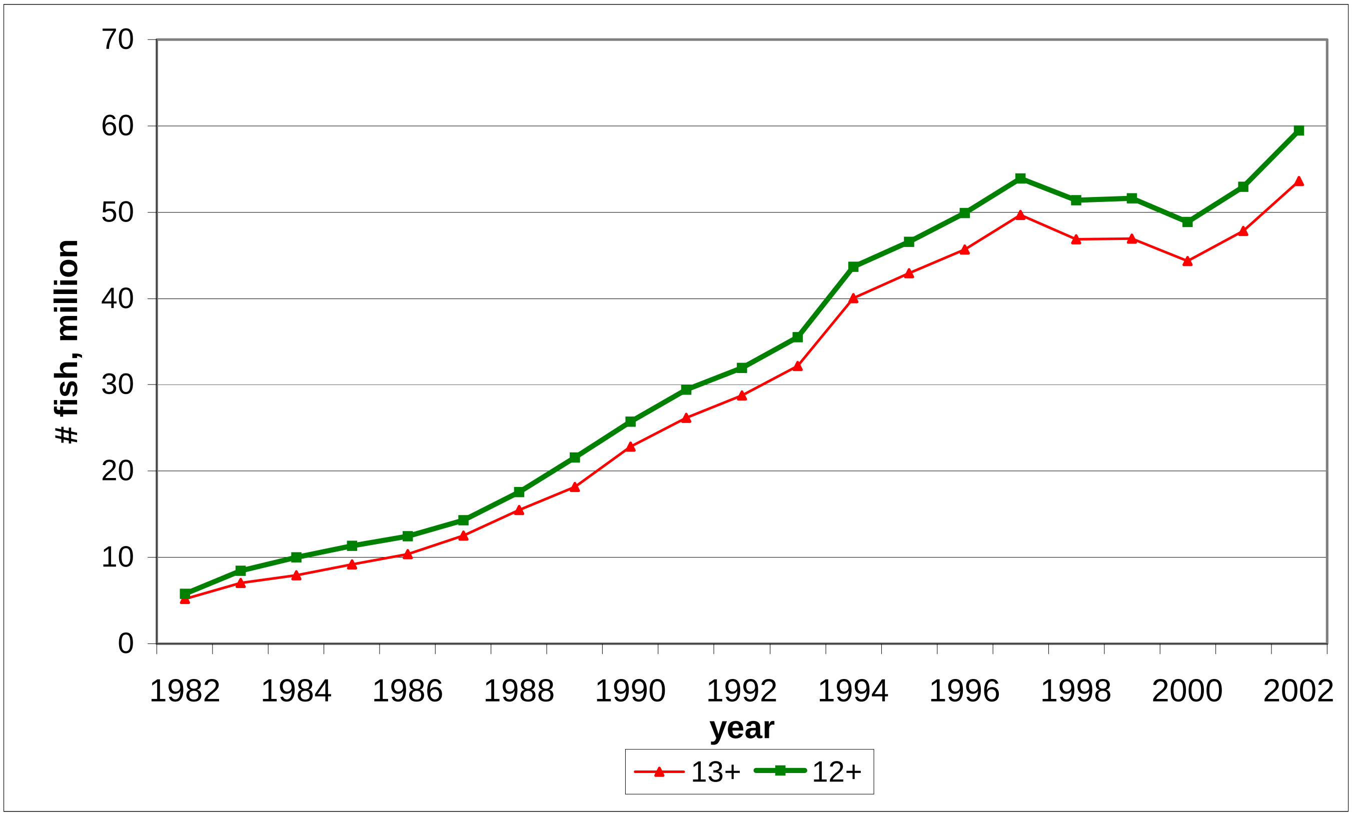


Figure D20. Recruitment (Age 1) for 12+ and 13+ runs.

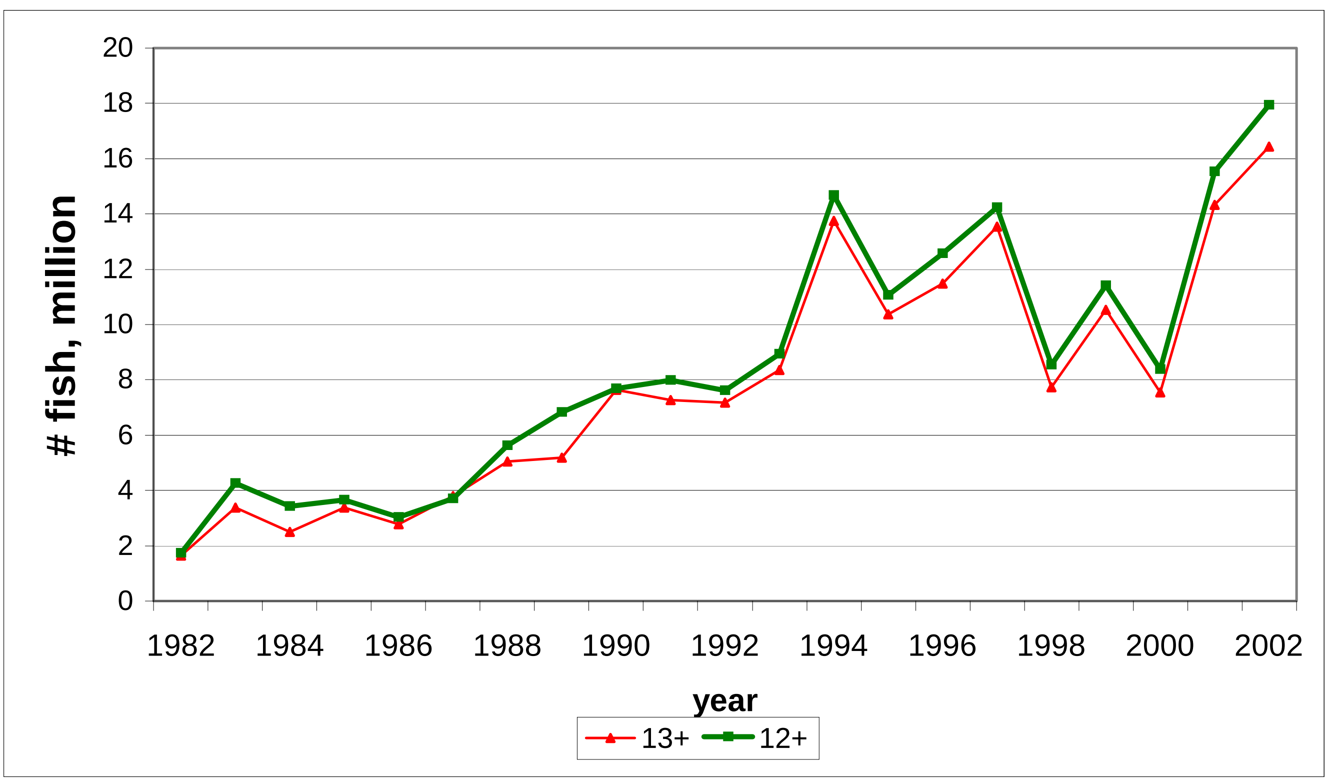


Figure D21. Female spawning stock biomass for 12+ and 13+ runs.

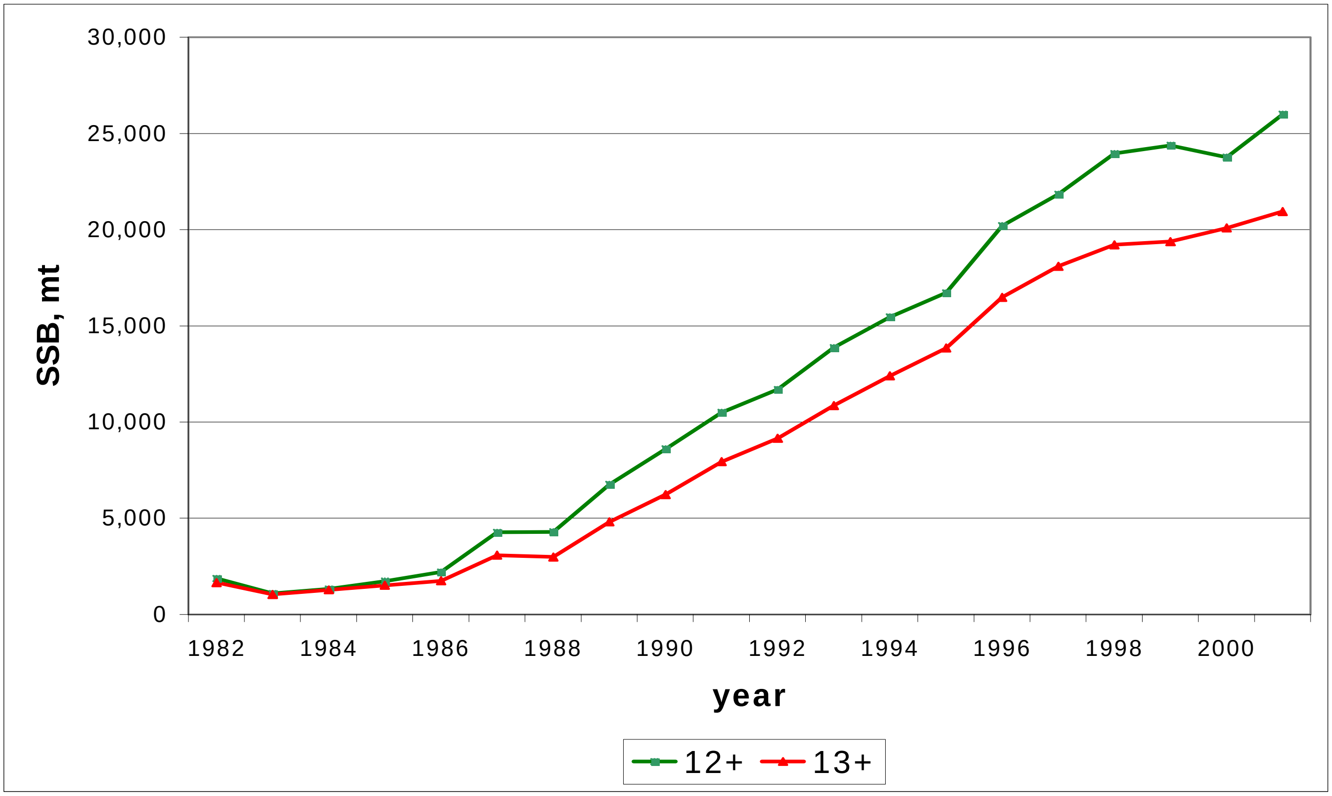


Figure D22. Terminal full F distribution (ages 7-10) based on 500 bootstrap iterations> 80 % confidence intervals are shown by dashed lines.

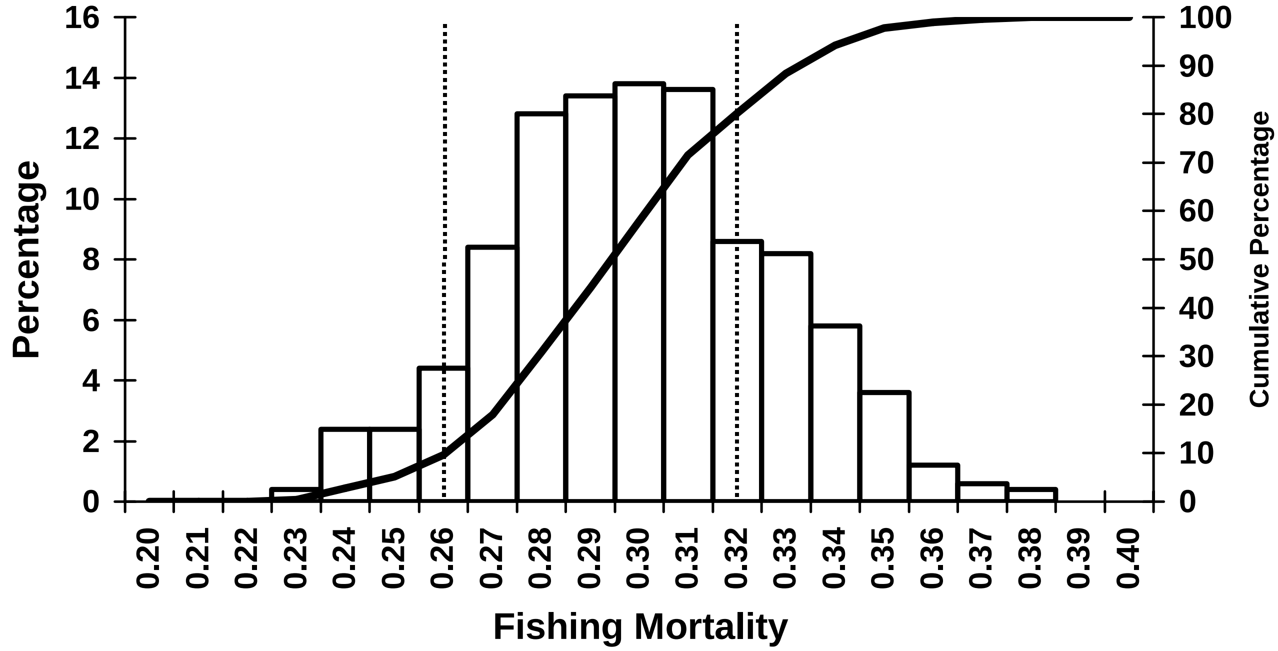
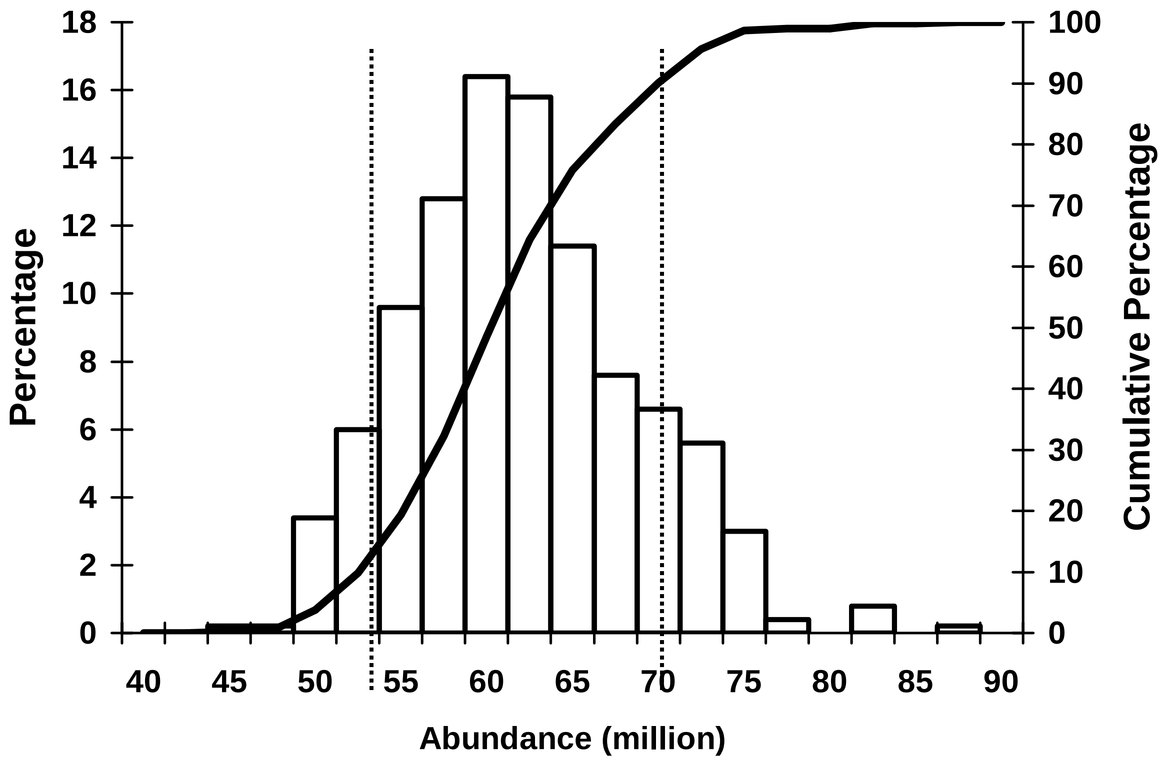


Figure D23. Population size (1+) estimates distribution in 2001 based on 500 bootstrap iterations> 80 % confidence intervals are shown by dashed lines.



Tagging Segment Tables

Table D20. Time series of instantaneous fishing mortality estimates (F) adjusted for live release bias. Results are for Striped bass >= 18 inches. Reporting Rate (DE) = 0.433.

Coast Programs*

Year	MADFW	NYOHS	NJDEL	NCCOOP
1988		0.28		-0.08
1989		-0.26	-0.23	0.34
1990		0.28	-0.17	0.35
1991		0.00	0.25	0.20
1992	-0.02	-0.18	0.19	-0.08
1993	0.00	0.50	0.30	0.01
1994	-0.01	0.12	0.20	0.39
1995	0.07	-0.16	-0.13	-0.16
1996	0.03	0.13	-0.03	0.46
1997	0.08	0.19	0.35	0.46
1998	0.05	0.54	0.02	0.45
1999	0.07	0.20	0.15	-0.06
2000	0.04	0.39	0.14	0.80
2001	-0.02	0.57	0.14	0.50

Producer Area Programs

Year	DE/PA	MDCB	VARAP	Weighted** Average
1987		0.09		
1988		0.06		
1989		-0.08		
1990		0.22	-0.09	
1991		0.21	1.01	
1992		0.18	-0.08	
1993	0.16	0.23	0.26	0.22
1994	0.11	0.21	0.29	0.20
1995	0.12	0.21	0.17	0.20
1996	0.18	0.25	0.32	0.25
1997	0.22	0.32	0.41	0.31
1998	0.24	0.38	0.70	0.37
1999	0.3	0.45	0.89	0.43
2000	0.33	0.47	0.75	0.46
2001	0.33	0.55	1.20	0.53

* A coastal unweighted average of F for striped bass >= 18 inches was not provided because MADFW primarily represents fish larger than 28 inches and GOF bootstrap indicated a lack of fit for the full parameterized models of NYOHS and NCCOOP.

**- Weighting Scheme: Delaware (0.10); Maryland (0.90)
VARAP was excluded from the producer area weighted average because a GOF bootstrap analysis indicated a lack of fit for the full parameterized model.

Table D21. Time series of instantaneous fishing mortality estimates (F) adjusted for live release bias. Results are for Striped bass >= 28 inches. Reporting Rate (DE) = 0.43.

Coast Programs

Year	MADFW	NYOHS	NJDEL	NCCOOP	Unweighted* Average	
1988		-0.20		-0.02	-0.20	**
1989		-0.16	-0.10	0.10	-0.13	**
1990		0.16	-0.25	0.08	-0.05	**
1991		0.15	-0.09	0.03	0.03	
1992	-0.02	0.10	0.20	0.03	0.09	
1993	-0.01	0.17	0.18	0.03	0.11	
1994	-0.01	0.17	0.10	0.07	0.09	
1995	0.10	0.11	0.07	0.12	0.09	
1996	0.09	0.15	0.10	0.27	0.11	
1997	0.11	0.17	0.19	0.24	0.16	
1998	0.08	0.22	0.16	0.22	0.15	
1999	0.10	0.20	0.12	0.24	0.14	
2000	0.08	0.08	0.22	0.22	0.13	
2001	-0.02	0.10	0.18	0.22	0.09	

Producer Area Programs

Year	DE/PA	MDCB	VARAP	Weighted*** Average
1988		-0.13		
1989		-0.16		
1990		0.23	0.19	
1991		0.10	0.18	
1992		0.11	0.13	
1993	-0.10	0.13	0.22	
1994	-0.07	0.11	0.25	
1995	0.26	0.21	0.29	0.21
1996	0.26	0.22	0.35	0.22
1997	0.30	0.23	0.33	0.23
1998	0.34	0.25	0.27	0.26
1999	0.40	0.24	0.31	0.26
2000	0.37	0.12	0.24	0.15
2001	0.43	0.13	0.24	0.16

* NCCOOP was excluded from the coastal weighted average because a GOF bootstrap analysis indicated a lack of fit for the full parameterized model.

** - Total mortality estimates (Z) at or below Natural mortality estimate of 0.15.

*** - Weighting Scheme: Delaware (0.10); Maryland (0.90)
* VARAP was excluded from the producer area weighted average because a GOF bootstrap analysis indicated a lack of fit for the full parameterized model.

Table D22. Survival (S) and fishing mortality (F) rates of striped bass >= 18 inches including estimates adjusted (adj.) for reporting rate (0.433), bias from live releases, and hooking mortality (0.08).

Coast Programs

Massachusetts
C-hat adjustment = 1.727; bootstrap GOF probability = 0.44 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1992	0.798	0.076	0.052	0.750	-0.094	0.880	-0.023	-0.119	0.084
1993	0.799	0.074	0.050	0.583	-0.071	0.860	0.000	-0.086	0.095
1994	0.798	0.076	0.058	0.558	-0.080	0.867	-0.008	-0.102	0.096
1995	0.751	0.136	0.052	0.527	-0.068	0.805	0.066	-0.006	0.144
1996	0.755	0.131	0.090	0.420	-0.100	0.839	0.026	-0.043	0.100
1997	0.762	0.122	0.061	0.278	-0.044	0.797	0.077	0.010	0.148
1998	0.766	0.117	0.074	0.323	-0.063	0.817	0.052	-0.014	0.122
1999	0.770	0.111	0.051	0.310	-0.040	0.802	0.070	0.005	0.141
2000	0.806	0.066	0.046	0.241	-0.028	0.829	0.037	-0.029	0.108
2001	0.846	0.017	0.038	0.358	-0.034	0.875	-0.017	-0.084	0.055

New York - Ocean Haul Seine
bootstrap GOF probability < 0.002 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1988	0.550	0.448	0.075	0.930	-0.150	0.650	0.280	0.117	0.504
1989	0.904	-0.049	0.093	0.940	-0.190	1.121	-0.260	-0.287	-0.234
1990	0.564	0.423	0.072	0.830	-0.130	0.650	0.280	0.104	0.509
1991	0.755	0.131	0.077	0.710	-0.130	0.863	0.000	-0.164	0.321
1992	0.919	-0.066	0.070	0.690	-0.110	1.033	-0.180	-0.263	0.831
1993	0.484	0.576	0.056	0.610	-0.080	0.524	0.500	0.283	0.761
1994	0.683	0.231	0.065	0.720	-0.110	0.763	0.120	-0.026	0.334
1995	0.935	-0.083	0.062	0.550	-0.080	1.015	-0.160	-0.182	-0.141
1996	0.695	0.214	0.059	0.580	-0.080	0.755	0.130	-0.036	0.403
1997	0.652	0.278	0.061	0.600	-0.080	0.711	0.190	-0.017	0.534
1998	0.467	0.611	0.053	0.570	-0.070	0.502	0.540	0.274	0.885
1999	0.655	0.273	0.061	0.510	-0.070	0.706	0.200	-0.052	0.679
2000	0.546	0.455	0.049	0.570	-0.060	0.583	0.390	0.061	0.939
2001	0.454	0.640	0.056	0.510	-0.070	0.485	0.570	0.382	0.799

New Jersey - Delaware Bay
bootstrap GOF probability = 0.35 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1989	0.885	-0.028	0.106	0.743	-0.180	1.081	-0.230	-0.341	0.727
1990	0.797	0.077	0.120	0.794	-0.220	1.020	-0.170	-0.356	0.548
1991	0.573	0.407	0.088	0.722	-0.140	0.670	0.250	0.023	0.579
1992	0.622	0.325	0.078	0.711	-0.130	0.711	0.190	0.043	0.386
1993	0.558	0.433	0.081	0.652	-0.120	0.635	0.300	0.184	0.446
1994	0.626	0.318	0.083	0.579	-0.110	0.705	0.200	0.101	0.315
1995	0.847	0.016	0.096	0.582	-0.130	0.977	-0.130	-0.212	0.035
1996	0.759	0.126	0.113	0.527	-0.150	0.890	-0.030	-0.176	0.228
1997	0.530	0.485	0.089	0.616	-0.130	0.607	0.350	0.146	0.612
1998	0.715	0.185	0.124	0.488	-0.150	0.844	0.020	-0.118	0.229
1999	0.655	0.273	0.083	0.577	-0.110	0.738	0.150	0.024	0.328
2000	0.660	0.266	0.085	0.579	-0.120	0.746	0.140	-0.007	0.356
2001	0.648	0.284	0.093	0.617	-0.130	0.748	0.140	0.014	0.303

North Carolina - Cooperative Trawl Cruise
probability < 0.001 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1988	0.909	-0.054	0.015	0.750	-0.027	0.933	-0.081	-0.105	-0.057
1989	0.604	0.354	0.010	0.720	-0.017	0.615	0.337	0.166	0.542
1990	0.556	0.437	0.057	0.583	-0.082	0.606	0.352	0.193	0.541
1991	0.615	0.336	0.077	0.693	-0.131	0.708	0.196	0.030	0.395
1992	0.814	0.056	0.090	0.531	-0.123	0.928	-0.075	-0.307	0.227
1993	0.757	0.129	0.072	0.647	-0.115	0.855	0.007	-0.211	0.286
1994	0.522	0.499	0.068	0.628	-0.105	0.584	0.389	0.220	0.592
1995	0.906	-0.052	0.080	0.523	-0.107	1.014	-0.164	-0.194	-0.134
1996	0.530	0.486	0.042	0.270	-0.028	0.545	0.457	0.240	0.735
1997	0.523	0.499	0.069	0.228	-0.042	0.546	0.456	0.180	0.838
1998	0.522	0.500	0.073	0.250	-0.048	0.548	0.451	0.167	0.849
1999	0.893	-0.037	0.065	0.150	-0.026	0.917	-0.063	-0.063	-0.063
2000	0.362	0.865	0.047	0.556	-0.064	0.387	0.798	0.540	1.149
2001	0.501	0.541	0.050	0.298	-0.038	0.521	0.503	0.271	0.805

Producer Area Programs

Delaware / Pennsylvania - Delaware River

C-hat adjustment = 1.057; bootstrap GOF probability = 0.44 for the full parameterized model.

With trend models included:

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1993	0.660	0.270	0.100	0.390	-0.098	0.730	0.160	0.010	0.350
1994	0.660	0.270	0.110	0.550	-0.148	0.770	0.110	-0.060	0.300
1995	0.650	0.280	0.120	0.500	-0.151	0.770	0.120	-0.020	0.270
1996	0.630	0.310	0.110	0.440	-0.122	0.720	0.180	0.080	0.300
1997	0.620	0.330	0.080	0.420	-0.099	0.690	0.220	0.120	0.350
1998	0.590	0.380	0.110	0.470	-0.129	0.680	0.240	0.130	0.370
1999	0.570	0.410	0.090	0.470	-0.103	0.635	0.300	0.170	0.460
2000	0.550	0.450	0.100	0.460	-0.114	0.620	0.330	0.140	0.560
2001	0.540	0.470	0.095	0.560	-0.128	0.620	0.330	0.080	0.660

With trend models excluded:

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1993	0.670	0.250	0.100	0.390	-0.098	0.740	0.150	-0.020	0.350
1994	0.657	0.270	0.110	0.550	-0.148	0.770	0.110	-0.050	0.300
1995	0.610	0.340	0.120	0.500	-0.151	0.720	0.180	0.100	0.270
1996	0.600	0.360	0.110	0.440	-0.122	0.680	0.230	0.130	0.340
1997	0.620	0.330	0.080	0.420	-0.099	0.690	0.220	0.120	0.350
1998	0.590	0.380	0.110	0.470	-0.129	0.680	0.290	0.130	0.370
1999	0.610	0.340	0.090	0.470	-0.103	0.680	0.240	0.150	0.330
2000	0.610	0.340	0.100	0.460	-0.114	0.690	0.220	0.140	0.320
2001	0.615	0.340	0.095	0.560	-0.128	0.700	0.200	0.120	0.290

Maryland - Chesapeake Bay Spring Spawning Stock

C-hat adjustment = 1.335; bootstrap GOF probability = 0.76 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1987	0.809	0.062	0.070	0.950	-0.145	0.946	-0.095	-0.188	0.060
1988	0.842	0.023	0.042	0.840	-0.077	0.911	-0.057	-0.104	0.006
1989	0.872	-0.014	0.034	0.930	-0.068	0.936	-0.084	-0.152	0.042
1990	0.638	0.299	0.055	0.580	-0.073	0.689	0.223	0.159	0.294
1991	0.635	0.303	0.082	0.450	-0.089	0.698	0.210	0.166	0.257
1992	0.630	0.312	0.111	0.430	-0.120	0.717	0.183	0.150	0.218
1993	0.626	0.319	0.089	0.380	-0.084	0.683	0.231	0.186	0.280
1994	0.622	0.325	0.100	0.430	-0.106	0.696	0.212	0.144	0.289
1995	0.626	0.318	0.117	0.320	-0.100	0.696	0.213	0.117	0.328
1996	0.601	0.359	0.110	0.350	-0.100	0.668	0.254	0.189	0.325
1997	0.575	0.403	0.114	0.270	-0.082	0.627	0.317	0.267	0.371
1998	0.544	0.458	0.111	0.250	-0.074	0.588	0.381	0.299	0.472
1999	0.519	0.506	0.109	0.200	-0.059	0.551	0.446	0.313	0.600
2000	0.490	0.563	0.095	0.360	-0.086	0.537	0.473	0.281	0.707
2001	0.463	0.620	0.082	0.330	-0.066	0.496	0.551	0.298	0.876

Virginia - Rappahannock River
C-hat adjustment = 1.377; bootstrap GOF probability = 0.18 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1990	0.810	0.060	0.111	0.481	-0.143	0.945	-0.094	-0.282	0.138
1991	0.287	1.098	0.063	0.524	-0.082	0.313	1.012	0.711	1.443
1992	0.801	0.072	0.125	0.408	-0.143	0.934	-0.082	-0.408	0.404
1993	0.594	0.370	0.089	0.456	-0.106	0.665	0.258	-0.090	0.798
1994	0.587	0.383	0.087	0.402	-0.092	0.647	0.286	-0.062	0.823
1995	0.688	0.223	0.076	0.255	-0.052	0.726	0.170	-0.160	0.667
1996	0.601	0.359	0.055	0.278	-0.039	0.626	0.319	-0.035	0.872
1997	0.537	0.471	0.068	0.330	-0.058	0.571	0.411	0.099	0.867
1998	0.400	0.766	0.066	0.371	-0.063	0.427	0.701	0.390	1.155
1999	0.329	0.961	0.081	0.294	-0.064	0.352	0.895	0.555	1.414
2000	0.376	0.827	0.069	0.436	-0.077	0.408	0.747	0.401	1.280
2001	0.240	1.278	0.075	0.368	-0.072	0.259	1.203	0.879	1.684

Table D23. Survival (S) and fishing mortality (F) rates of striped bass >= 28 inches including estimates adjusted (adj.) for reporting rate (0.433), bias from live releases, and hooking mortality (0.08).

<u>Coast Programs</u>

Massachusetts
C-hat adjustment = 1.494; bootstrap GOF probability = 0.32 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1992	0.804	0.068	0.048	0.750	-0.087	0.880	-0.023	-0.118	0.083
1993	0.806	0.066	0.054	0.571	-0.076	0.872	-0.013	-0.104	0.086
1994	0.807	0.064	0.059	0.486	-0.072	0.869	-0.010	-0.103	0.093
1995	0.736	0.157	0.056	0.405	-0.057	0.781	0.098	0.026	0.175
1996	0.739	0.152	0.089	0.255	-0.062	0.788	0.088	0.018	0.164
1997	0.742	0.148	0.076	0.205	-0.042	0.775	0.105	0.036	0.179
1998	0.744	0.146	0.086	0.274	-0.064	0.795	0.079	0.010	0.154
1999	0.746	0.143	0.066	0.271	-0.047	0.783	0.095	0.026	0.169
2000	0.766	0.117	0.059	0.222	-0.034	0.793	0.082	0.011	0.158
2001	0.850	0.013	0.046	0.316	-0.036	0.882	-0.025	-0.101	0.059

New York - Ocean Haul Seine
bootstrap GOF probability = 0.29 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1988	0.806	0.066	0.116	0.890	-0.230	1.050	-0.200	-0.310	0.006
1989	0.806	0.066	0.104	0.870	-0.200	1.011	-0.160	-0.272	0.044
1990	0.635	0.304	0.088	0.660	-0.130	0.734	0.160	0.092	0.235
1991	0.634	0.306	0.109	0.540	-0.140	0.742	0.150	0.087	0.217
1992	0.633	0.307	0.142	0.510	-0.190	0.780	0.100	0.039	0.163
1993	0.632	0.309	0.111	0.450	-0.130	0.724	0.170	0.111	0.242
1994	0.632	0.309	0.108	0.480	-0.130	0.725	0.170	0.104	0.249
1995	0.665	0.258	0.144	0.340	-0.140	0.769	0.110	0.028	0.214
1996	0.663	0.261	0.135	0.290	-0.110	0.743	0.150	0.069	0.240
1997	0.660	0.266	0.141	0.220	-0.090	0.725	0.170	0.095	0.261
1998	0.657	0.270	0.095	0.190	-0.050	0.690	0.220	0.139	0.319
1999	0.654	0.275	0.154	0.140	-0.070	0.701	0.200	0.113	0.317
2000	0.731	0.163	0.134	0.210	-0.080	0.795	0.080	-0.089	0.391
2001	0.740	0.151	0.092	0.210	-0.050	0.779	0.100	-0.064	0.410

New Jersey - Delaware Bay
bootstrap GOF probability = 0.48 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1989	0.819	0.050	0.104	0.565	-0.140	0.953	-0.100	-0.257	0.416
1990	0.817	0.052	0.135	0.833	-0.260	1.101	-0.250	-0.401	0.269
1991	0.578	0.398	0.249	0.500	-0.380	0.939	-0.090	-0.370	0.381
1992	0.616	0.335	0.080	0.710	-0.130	0.707	0.200	0.007	0.470
1993	0.646	0.287	0.100	0.417	-0.100	0.720	0.180	0.066	0.320
1994	0.686	0.227	0.103	0.466	-0.120	0.778	0.100	0.032	0.182
1995	0.715	0.185	0.102	0.448	-0.110	0.806	0.070	-0.038	0.204
1996	0.688	0.224	0.118	0.397	-0.120	0.782	0.100	0.004	0.210
1997	0.672	0.247	0.082	0.261	-0.050	0.709	0.190	0.123	0.276
1998	0.665	0.258	0.157	0.200	-0.090	0.734	0.160	0.085	0.244
1999	0.664	0.259	0.119	0.421	-0.130	0.761	0.120	0.015	0.261
2000	0.654	0.275	0.080	0.279	-0.050	0.692	0.220	0.061	0.441
2001	0.647	0.285	0.105	0.359	-0.100	0.716	0.180	-0.008	0.481

North Carolina - Cooperative Trawl Cruise
C-hat adjustment = 1.545; bootstrap GOF probability = 0.092 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1988	0.709	0.194	0.105	0.750	-0.194	0.880	-0.022	-0.188	0.177
1989	0.701	0.205	0.059	0.720	-0.102	0.781	0.097	-0.062	0.286
1990	0.703	0.202	0.075	0.583	-0.110	0.791	0.085	0.008	0.168
1991	0.704	0.201	0.089	0.693	-0.153	0.831	0.035	-0.034	0.109
1992	0.714	0.187	0.106	0.531	-0.147	0.837	0.028	-0.044	0.105
1993	0.709	0.195	0.092	0.647	-0.150	0.834	0.032	-0.036	0.104
1994	0.703	0.203	0.077	0.628	-0.121	0.800	0.074	-0.008	0.162
1995	0.651	0.278	0.104	0.523	-0.143	0.760	0.125	0.019	0.243
1996	0.637	0.301	0.050	0.270	-0.035	0.660	0.265	0.180	0.358
1997	0.634	0.305	0.098	0.228	-0.063	0.677	0.240	0.149	0.341
1998	0.637	0.301	0.113	0.250	-0.082	0.694	0.216	0.118	0.324
1999	0.643	0.291	0.103	0.150	-0.045	0.674	0.245	0.118	0.390
2000	0.639	0.297	0.053	0.556	-0.072	0.689	0.223	0.078	0.392
2001	0.640	0.296	0.091	0.298	-0.074	0.692	0.218	0.069	0.394

Producer Area Programs

Delaware / Pennsylvania - Delaware River

C-hat adjustment = 1.25; bootstrap GOF probability = 0.36 for the full parameterized model.

With trend models included:

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1993	0.870	-0.010	0.105	0.330	-0.090	0.960	-0.110	-0.270	0.090
1994	0.870	-0.010	0.085	0.290	-0.061	0.930	-0.070	-0.240	0.120
1995	0.590	0.380	0.120	0.350	-0.111	0.660	0.260	0.130	0.410
1996	0.580	0.390	0.152	0.280	-0.124	0.660	0.260	0.160	0.380
1997	0.570	0.410	0.080	0.520	-0.099	0.630	0.310	0.210	0.420
1998	0.560	0.430	0.150	0.170	-0.079	0.610	0.350	0.230	0.480
1999	0.550	0.450	0.093	0.210	-0.051	0.580	0.400	0.250	0.570
2000	0.545	0.460	0.160	0.170	-0.083	0.590	0.370	0.170	0.620
2001	0.540	0.470	0.120	0.120	-0.041	0.560	0.420	0.180	0.750

With trend models excluded:

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1993	0.860	0.000	0.105	0.330	-0.090	0.945	-0.090	-0.310	0.180
1994	0.860	0.000	0.085	0.290	-0.061	0.920	-0.060	-0.270	0.210
1995	0.575	0.400	0.120	0.350	-0.111	0.650	0.290	0.190	0.400
1996	0.575	0.400	0.152	0.280	-0.124	0.660	0.270	0.170	0.380
1997	0.575	0.400	0.080	0.520	-0.099	0.640	0.300	0.200	0.410
1998	0.570	0.410	0.150	0.170	-0.079	0.620	0.330	0.230	0.440
1999	0.570	0.410	0.093	0.210	-0.051	0.600	0.360	0.260	0.470
2000	0.580	0.390	0.160	0.170	-0.083	0.630	0.310	0.190	0.440
2001	0.580	0.390	0.120	0.120	-0.041	0.600	0.350	0.210	0.520

Maryland - Chesapeake Bay Spring Spawning Stock

C-hat adjustment = 1.281; bootstrap GOF probability = 0.98 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1987	0.925	-0.072	0.034	0.000	0.000	0.925	-0.072	-0.136	0.225
1988	0.922	-0.069	0.041	0.670	-0.062	0.983	-0.133	-0.196	0.124
1989	0.919	-0.065	0.052	0.790	-0.091	1.011	-0.161	-0.224	0.068
1990	0.624	0.322	0.070	0.570	-0.092	0.687	0.226	0.062	0.451
1991	0.641	0.295	0.123	0.590	-0.178	0.779	0.100	-0.004	0.226
1992	0.658	0.268	0.113	0.510	-0.143	0.768	0.114	0.059	0.175
1993	0.675	0.244	0.099	0.460	-0.112	0.760	0.125	0.058	0.203
1994	0.689	0.222	0.093	0.460	-0.105	0.770	0.111	0.007	0.247
1995	0.644	0.289	0.115	0.260	-0.080	0.701	0.206	0.129	0.294
1996	0.643	0.292	0.097	0.280	-0.070	0.691	0.220	0.157	0.290
1997	0.640	0.296	0.112	0.220	-0.067	0.686	0.227	0.171	0.290
1998	0.637	0.300	0.099	0.190	-0.050	0.671	0.250	0.183	0.324
1999	0.635	0.304	0.120	0.180	-0.060	0.676	0.242	0.160	0.337
2000	0.731	0.163	0.083	0.190	-0.040	0.762	0.122	-0.042	0.419
2001	0.729	0.166	0.066	0.250	-0.040	0.760	0.125	-0.048	0.450

Virginia - Rappahannock River
C-hat adjustment = 1.860; bootstrap GOF probability = 0.12 for the full parameterized model.

Year	S(unadj.)	F(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	F(adj.)	95%LCL F(adj)	95%UCL F(adj)
1990	0.622	0.325	0.086	0.577	-0.127	0.712	0.189	0.094	0.294
1991	0.622	0.325	0.091	0.560	-0.131	0.716	0.184	0.090	0.287
1992	0.622	0.325	0.123	0.535	-0.176	0.755	0.131	0.038	0.233
1993	0.624	0.321	0.099	0.349	-0.094	0.689	0.222	0.126	0.329
1994	0.624	0.321	0.084	0.318	-0.072	0.672	0.247	0.148	0.356
1995	0.597	0.367	0.123	0.189	-0.070	0.642	0.294	0.179	0.423
1996	0.597	0.366	0.046	0.130	-0.015	0.606	0.351	0.237	0.479
1997	0.597	0.366	0.080	0.167	-0.037	0.620	0.329	0.216	0.456
1998	0.597	0.366	0.137	0.217	-0.093	0.658	0.269	0.155	0.397
1999	0.597	0.366	0.102	0.200	-0.059	0.634	0.305	0.190	0.436
2000	0.628	0.315	0.079	0.349	-0.073	0.677	0.239	0.081	0.428
2001	0.636	0.303	0.071	0.304	-0.056	0.674	0.245	0.075	0.448

Table D24. QAICc weights used to derive model averaged parameter estimates given by Program MARK. Results are for Striped bass >= 18 inches.

Coast Programs

Model	MADFW	NYOHS	NJDEL	NCCOOP
{S(t)r(t)}	0.0002	**0.9808**	**0.9340**	**0.9999**
{S(Tp)r(t)}	0.0089	0.0004	0.0649	0.0000
{S(p)r(t)}	0.0630	0.0000	0.0000	0.0000
{S(t)r(p)}	0.0385	0.0000	0.0000	0.0000
{S(.)r(t)}	**0.1331**	0.0000	0.0000	0.0000
{S(Tp)r(Tp)}	0.0663	0.0188	0.0011	0.0000
{S(Tp)r(p)}	0.0070	0.0000	0.0000	0.0000
{S(d)r(p)}	**0.3254**	0.0000	0.0000	0.0000
{S(v)r(p)}	**0.3501**	0.0000	0.0000	0.0000
{S(p)r(p)}	0.0047	0.0000	0.0000	0.0000
{S(.)r(p)}	0.0006	0.0000	0.0000	0.0000
{S(.)r(.)}	0.0024	0.0000	0.0000	0.0000

Producer Area Programs*

Model	DE/PA *	DE/PA **	MDCB	VARAP
{S(t)r(t)}	0.0200	0.0540	0.0033	**0.9930**
{S(Tp)r(t)}	**0.4590**		**0.8023**	0.0070
{S(p)r(t)}	0.1240	**0.3299**	0.1943	0.0000
{S(t)r(p)}	0.1240	0.0924	0.0001	0.0000
{S(.)r(t)}	0.1480	**0.3947**	0.0000	0.0000
{S(Tp)r(Tp)}	**0.1600**		0.0000	0.0000
{S(Tp)r(p)}	0.0090		0.0000	0.0000
{S(d)r(p)}	0.0100	0.0260	0.0000	0.0000
{S(v)r(p)}	0.0070	0.0300	0.0000	0.0000
{S(p)r(p)}	0.0150	0.0400	0.0000	0.0000
{S(.)r(p)}	0.0009	0.0280	0.0000	0.0000
{S(.)r(.)}	0.0100	0.0030	0.0000	0.0000

* DE/PA with trend models, ** DE/PA without trend models

Model Descriptions

S(.) r(.)	Constant survival and reporting
S(t) r(t)	Time specific survival and reporting
S(.) r(t)	Constant survival and time specific reporting
S(p) r(t)	Regulatory period based survival and time specific reporting
S(p) r(p)	Regulatory period based survival and reporting
S(.) r(p)	Constant survival and regulatory period based reporting
S(t) r(p)	Time specific survival and regulatory period based reporting
S(d) r(p)	Regulatory period survival with terminal year unique and regulatory period reporting
S(v) r(p)	Regulatory period survival with 2 terminal years unique and regulatory period reporting
S(Tp) r(Tp)	Linear trend within regulatory period on both survival and reporting
S(Tp) r(p)	Linear trend within regulatory period survival and regulatory period reporting (no trend)
S(Tp) r(t)	Linear trend within regulatory period survival and time specific reporting (no trend)

Table D25. QAICc weights used to derive model averaged parameter estimates given by Program MARK. Results are for striped bass tagged at >= 28 inches. Models are described in Table 5.

Coast Programs

Model	MADFW	NYOHS	NJDEL	NCCOOP
{S(t)r(t)}	0.00002	0.00009	0.02076	0.03473
{S(Tp)r(t)}	0.00149	0.00022	**0.24351**	0.02508
{S(p)r(t)}	0.01026	0.00089	0.05423	0.05999
{S(t)r(p)}	0.00712	0.00090	0.01566	0.00193
{S(.)r(t)}	0.00997	0.00005	**0.26631**	0.05709
{S(Tp)r(Tp)}	0.03188	0.09525	**0.25370**	0.02335
{S(Tp)r(p)}	0.00443	0.02121	0.06528	0.07649
{S(d)r(p)}	**0.70171**	**0.11307**	0.00353	**0.12263**
{S(v)r(p)}	**0.21241**	**0.64935**	0.07345	**0.22490**
{S(p)r(p)}	0.01581	0.08943	0.00202	**0.31851**
{S(.)r(p)}	0.00197	0.01322	0.00054	0.04838
{S(.)r(.)}	0.00294	0.01632	0.00102	0.00690

Producer Area Programs

Model	DE/PA*	DE/PA**	MDCB	VARAP
{S(t)r(t)}	0.00040	0.00080	0.00012	0.00000
{S(Tp)r(t)}	0.14500		**0.23914**	0.00008
{S(p)r(t)}	0.00390	0.00800	0.00213	0.00037
{S(t)r(p)}	0.00290	0.00600	0.00767	0.00019
{S(.)r(t)}	0.00030	0.00050	0.00000	0.00089
{S(Tp)r(Tp)}	0.00400		0.07671	0.00806
{S(Tp)r(p)}	**0.36100**		0.00020	0.02050
{S(d)r(p)}	0.09700	**0.19800**	0.00079	0.08558
{S(v)r(p)}	0.09900	**0.20200**	**0.67319**	**0.24505**
{S(p)r(p)}	**0.26500**	**0.54100**	0.00004	0.11910
{S(.)r(p)}	0.00600	0.01300	0.00000	**0.17794**
{S(.)r(.)}	0.01500	0.03100	0.00000	**0.31845**

* DE/PA with trend models, ** DE/PA without trend models

Table D26. Total length frequencies of fish tagged in 2001 by program.

	Coast Programs				Producer Area Programs		
TL	MADFW	NYOHS	NJDEL	NCCOOP	DE/PA	MDCB	VARAP
249							
299						1	
349				1		9	
399		3		9	1	33	
449		36	15	114	69	126	
499		157	52	399	128	252	118
549	2	260	153	455	160	200	212
599	4	171	518	389	179	115	143
649	19	133	669	357	130	58	39
699	57	85	363	237	80	42	14
749	99	38	219	189	65	65	15
799	93	47	202	133	42	87	41
849	81	38	128	66	47	102	59
899	44	17	48	43	34	80	70
949	20	25	14	25	17	61	38
999	18	8	2	9	11	44	22
1049	10	5	2	2	13	27	14
1099	9				6	8	7
>1099		4		2	2	4	5
Total	456	1027	2385	2430	984	1314	797

Table D27. Age frequencies of tagged fish recaptured in 2001 by program.

	Coast Programs				Producer Area Programs		
AGE	MADFW	NYOHS	NJDEL		DE/PA	MDCB	VARAP
1							
2						1	
3		15	11		5	3	
4	1	16	118		4	1	21
5	4	48	186		22	7	41
6	4	33	126		19	2	16
7	22	19	59		34	10	6
8	16	27	15		36	21	7
9	15	8	5		14	6	11
10	9	6	1		8	8	4
11	10	9			4	8	3
12	6	3			14	11	4
13	1	3			3	4	2
14	8	3				7	4
15	1	5			1	1	1
16	1	4			1	3	2
17	2	4					1
18		1			1		1
19	1	2				2	
Total	101	206	521		166	95	124

Table D28. Distribution of tag recaptures by state (program) and

Coast Programs

Massachusetts (recaptures in 2001 from fish tagged and released during 1992-

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME							1						1
MA						5	11	11	5	2			34
RI							2	1	1	1			5
CT					1					1		1	3
NY				1	3	1				1	5	3	14
NJ				3	2		1			7	9	4	26
DE						1					1		2
MD				5	6						2		13
VA		3	1							1	4	2	11
NC		1									3	1	5
Total	0	4	1	9	12	7	15	12	6	13	24	11	114

New York - Ocean Haul Seine (recaptures in 2001 from fish tagged/release during 1988-

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME						3	6	5					14
NH						2			1				3
MA					7	14	6	5	5	3			40
RI					3	3	2	1	1	1	1		12
CT			2	1	1	2	4	2			1		13
NY	1		2		7	9	7	3	10	7	7	4	57
NJ	2	1		6	6	6	2		1	1	8	6	39
PA													0
DE			2							1			3
MD		1	1		1			1			1		5
VA	4			1	1		1				1	6	14
NC													0
Total	7	2	7	8	26	39	28	17	18	13	19	16	200

New Jersey - Delaware Bay (recaptures in 2001 from fish tagged/release during 1989-2001)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					1	2	9	3	1				16
NH						3			1				4
MA					12	23	30	19	16	6			106
RI				1	4	10	7	7	2	1			32
CT				1	4	4	4	3	1	1			18
NY				2	17	25	16	9	12	16	9		106
NJ			4	3	27	16	7	2	5	17	34		115
PA				1		1			2				4
DE			1	1	3						3	1	9
MD				2	3	1		1	2	1	3	2	15
VA			1									7	8
NC											1		1
Total	0	0	6	11	71	85	73	44	42	42	50	10	434

North Carolina - Cooperative Trawl Cruise
(recaptures in 2001 from fish tagged/release during 1988-2001)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME					1	1							2
NH													0
MA					4	14	14	12	2	1			47
RI					1	5	1						7
CT							1	1		1			3
NY					4	4	3	3	6	3			23
NJ				1	2	2			1	3	9		18
PA													0
DE		1	1	1	1	1		1					6
MD	1	4	7	11	13	40	12	14	9	21	9	5	146
VA	2	9	6	1	8	2	2	1	1	16	35	21	104
NC	3	12	1	3				1			1	3	24
Total	6	26	15	17	34	69	33	33	19	45	54	29	380

Producer Area Programs

Delaware / Pennsylvania - Delaware River (1993 - 2001)
(recaptures during 1993-2001 from fish tagged/release during 1993-2001)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME						1	1						2
NH						1							1
MA					4	11	26	20	7	5			73
RI					1	7	4	5	4	1			22
CT					1	2		1	2	2			8
NY					4	6	9	5	3	6	2	1	36
NJ			3	10	62	63	27	29	23	55	50	8	330
PA			4	25	14	4		2	2				51
DE	1		9	13	16	37	33	17	7	10	10	6	159
MD	9	9	4	11	14	50	31	26	27	42	27	15	265
VA	5	3	5		1	4	1		1	3	28	22	73
NC	1	1									2	2	6
Total	16	13	25	59	117	186	132	105	76	124	119	54	1026

Maryland - Chesapeake Bay Spring Spawning Stock
(recaptures in 2001 from fish tagged/release during 1987-2001)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
ME			1										1
NH							1						1
MA					1	1	6	3	1				12
RI						2	2	1	1	1			7
CT						1		2					3
NY					2	1	2	4	1	2			12
NJ						4				2	3		9
PA					1								1
DE											1		1
MD	3	3	3	5	13	39	20	7	3	8	8	5	117
VA		1	1		4	5				4	10	6	31
NC	1										1	1	3
Total	4	4	5	5	21	53	31	17	6	17	23	12	198

Virginia - Rappahannock River (recaptures in 2001 from fish tagged/release during 1990-2001)

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
MA					1	1	4	4	4				14
RI						2		1	2				5
CT							1	1					2
NY					1	1			3				5
NJ					2					4	1		7
MD		1			3	6	4	5	3	6	4	1	33
VA	1		6	23	7	3		2	1	7	15	8	73
NC		1										1	2
													0
Total	1	2	6	23	14	13	9	13	13	17	20	10	141

Table D29.Time series of survival (S) and total mortality (Z) estimates adjusted for live release bias.
Results are for age 1, 2, and older striped bass tagged during Western Long Island survey.
Reporting Rate (DE) = 0.433
Bootstrap GOF S(a*t) r(a*t) prob = 0.51; c-hat was estimated as model dev/mean simulation dev = 180.288/182.654 = 0.98, no c-hat adjustment was used.

Models and AICc weights used to derive model averaged parameter estimates given by Program MARK. All other models tested had delta AIC > 7, and AICc weight < 0.01.

Model	AICc Weights
S(a) r(a*v)	0.45
S(a) r(a*p)	0.40
S(a) r(a*d)	0.12
S(a) r(a*t)	0.02

Age 1 Survival

Year	S(unadj.)	Z(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	Z(adj.)	LCLM (Z) Z(adj.)	UCLM (Z) Z(adj.)
1988	0.277	1.29	0.02	1.00	-0.053	0.292	1.23	1.01	1.47
1989	0.277	1.29	0.01	1.00	-0.024	0.283	1.26	1.04	1.50
1990	0.277	1.29	0.06	0.87	-0.116	0.313	1.16	0.94	1.40
1991	0.277	1.29	0.03	0.91	-0.056	0.293	1.23	1.01	1.47
1992	0.277	1.29	0.01	0.80	-0.017	0.281	1.27	1.05	1.51
1993	0.277	1.29	0.03	0.88	-0.066	0.296	1.22	1.00	1.46
1994	0.277	1.29	0.02	0.86	-0.034	0.286	1.25	1.03	1.49
1995	0.277	1.29	0.01	0.75	-0.019	0.282	1.27	1.05	1.50
1996	0.277	1.29	0.01	0.77	-0.022	0.283	1.26	1.04	1.50
1997	0.277	1.29	0.07	1.00	-0.155	0.327	1.12	0.90	1.36
1998	0.277	1.29	0.02	1.00	-0.040	0.288	1.24	1.03	1.48
1999	0.277	1.29	0.01	1.00	-0.027	0.284	1.26	1.04	1.50
2000	0.277	1.29	0.02	0.94	-0.041	0.288	1.24	1.02	1.48
2001	0.277	1.29	0.00	0.81	-0.007	0.279	1.28	1.06	1.52

Age 2 Survival

Year	S(unadj.)	Z(unadj.)	Recovery Rate	% Live Release	Bias Live Release	S(adj.)	Z(adj.)	LCLM (Z) Z(adj.)	UCLM (Z) Z(adj.)
1988	0.408	0.90	0.04	1.00	-0.097	0.452	0.79	0.62	1.00
1989	0.408	0.90	0.06	0.96	-0.128	0.468	0.76	0.58	0.96
1990	0.408	0.90	0.08	0.93	-0.155	0.483	0.73	0.55	0.93
1991	0.408	0.90	0.08	1.00	-0.170	0.492	0.71	0.53	0.91
1992	0.408	0.90	0.06	0.93	-0.124	0.466	0.76	0.59	0.97
1993	0.408	0.90	0.08	1.00	-0.163	0.487	0.72	0.54	0.92
1994	0.408	0.90	0.03	0.90	-0.056	0.432	0.84	0.66	1.04
1995	0.408	0.90	0.09	0.91	-0.172	0.493	0.71	0.53	0.91
1996	0.408	0.90	0.04	0.89	-0.076	0.442	0.82	0.64	1.02
1997	0.408	0.90	0.07	0.80	-0.120	0.464	0.77	0.59	0.97
1998	0.408	0.90	0.03	0.65	-0.048	0.429	0.85	0.67	1.05
1999	0.408	0.90	0.03	0.82	-0.045	0.427	0.85	0.67	1.05
2000	0.408	0.90	0.06	0.92	-0.119	0.463	0.77	0.59	0.97
2001	0.408	0.90	0.06	0.84	-0.109	0.458	0.78	0.60	0.98

Table D29. Continued.

Age 3+ Survival

Year	S(unadj.)	Z(unadj.)	Recovery	% Released	bias	S(adj.)	Z(adj.)	LCLM (Z)	UCLM (Z)
1988	0.604	0.50	0.07	1.00	-0.161	0.719	0.33	0.26	0.40
1989	0.604	0.50	0.14	0.92	-0.289	0.849	0.16	0.10	0.24
1990	0.604	0.50	0.13	0.87	-0.265	0.822	0.20	0.13	0.27
1991	0.604	0.50	0.09	0.94	-0.177	0.734	0.31	0.24	0.38
1992	0.604	0.50	0.11	0.87	-0.222	0.776	0.25	0.19	0.33
1993	0.604	0.50	0.07	1.00	-0.153	0.713	0.34	0.27	0.41
1994	0.604	0.50	0.03	1.00	-0.070	0.649	0.43	0.37	0.51
1995	0.604	0.50	0.07	0.73	-0.121	0.687	0.38	0.31	0.45
1996	0.604	0.50	0.07	0.73	-0.116	0.683	0.38	0.32	0.46
1997	0.604	0.50	0.05	0.58	-0.066	0.647	0.44	0.37	0.51
1998	0.604	0.50	0.11	0.56	-0.147	0.707	0.35	0.28	0.42
1999	0.604	0.50	0.05	0.56	-0.057	0.641	0.45	0.38	0.52
2000	0.604	0.50	0.06	0.75	-0.101	0.671	0.40	0.33	0.47
2001	0.604	0.50	0.11	1.00	-0.230	0.784	0.24	0.18	0.32

Table D30. Total length frequencies of WLI 2001 tag releases, and ages of WLI 2001 tag recaptures.

TL	WLI
199	86
249	126
299	72
349	29
399	30
449	22
499	21
549	12
599	8
649	3
699	
749	
799	1
849	
899	
949	
999	
1049	
1099	
>1099	
Total	410

AGE	WLI
1	1
2	19
3	10
4	6
5	5
6	2
7	
8	
9	2
10	
Total	45

Table D31. Distribution of tag recaptures by state and month for all recaptures 1988 - 2001

State	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
NB								1	1				2
ME					1	3	2	5	1				12
NH													0
MA					5	14	10	2	3	3		1	38
RI				3	5	2		1	3	3	1		18
CT			1		6	3	2	2	2	4	1	1	22
NY	5	3	8	34	54	67	63	63	85	119	73	16	590
NJ		1	1	1	3		1	3	1	3	11	3	28
PA													0
DE												1	1
MD	1		1	1	2					2	1		8
VA	1		1							1		1	4
NC												1	1
Total	7	4	12	39	76	89	78	77	96	135	87	24	724

Table D32. R/M estimates of exploitation rates of >= 28 inch striped bass from tagging programs (with reporting rate adjustment of 0.43, and hooking mortality rate adjustment of 0.08).

Year	NJDB	NYOHS	NCCOOP	MA	VA York	VA Rap	MDCB	DE/PA	NYHUD
1987	*	0.052	*	*	*	0.031	0.006	*	*
1988	*	0.038	0.076	*	*	0.132	0.041	*	0.110
1989	0.019	0.060	0.048	*	*	0.007	0.037	*	0.083
1990	0.041	0.063	0.080	*	*	0.090	0.084	*	0.135
1991	0.333	0.131	0.076	0.051	0.107	0.125	0.135	*	0.102
1992	0.078	0.140	0.140	0.070	0.034	0.121	0.131	0.178	0.152
1993	0.089	0.135	0.112	0.041	0.090	0.163	0.123	0.213	0.172
1994	0.086	0.197	0.088	0.052	0.138	0.103	0.115	0.121	0.118
1995	0.122	0.144	0.142	0.089	0.229	0.298	0.208	0.142	0.153
1996	0.217	0.475	0.116	0.140	0.233	0.040	0.172	0.337	0.232
1997	0.255	0.133	0.202	0.098	0.643	0.192	0.239	0.323	0.335
1998	0.371	0.341	0.224	0.084	0.160	0.324	0.196	0.300	0.218
1999	0.173	0.258	0.236	0.137	0.005	0.232	0.198	0.177	0.225
2000	0.139	0.059	0.062	0.071	*	0.128	0.173	0.322	0.139
2001	0.154	**	0.154	**	*	0.101	0.128	0.280	*

* Years when few or no striped bass were tagged and
** NYOHS and MA have fall tagging programs, and recapture interval of terminal year (2000) is fall 2000 to fall 2001; NCCOOP is a winter tagging program (Jan./Feb.) with recapture interval of terminal year (2001) from January 2001 to January 2002; others are spring tagging programs recapture interval of terminal year (2001) from spring 2001 to spring 2002.

Table D33. R/M estimates of catch rates of >= 28 inch striped bass from tagging programs. (with reporting rate adjustment of 0.43)

Year	NJDB	NYOHS	NCCOOP	MA	VA York	VA Rap	MDCB	DE/PA	NYHUD
1987	*	0.284	*	*	*	0.388	0.080	*	*
1988	*	0.224	0.256	*	*	0.312	0.091	*	0.220
1989	0.233	0.215	0.141	*	*	0.090	0.095	*	0.285
1990	0.517	0.215	0.173	*	*	0.203	0.175	*	0.362
1991	0.620	0.345	0.206	0.156	0.155	0.212	0.277	*	0.250
1992	0.275	0.268	0.269	0.133	0.089	0.216	0.248	0.179	0.302
1993	0.230	0.273	0.278	0.106	0.211	0.266	0.266	0.326	0.348
1994	0.302	0.358	0.208	0.161	0.278	0.191	0.225	0.201	0.256
1995	0.240	0.267	0.275	0.187	0.310	0.336	0.274	0.252	0.250
1996	0.355	0.589	0.154	0.241	0.287	0.074	0.262	0.409	0.330
1997	0.445	0.133	0.254	0.203	0.930	0.228	0.298	0.345	0.437
1998	0.406	0.392	0.285	0.155	0.197	0.423	0.229	0.353	0.304
1999	0.322	0.258	0.273	0.151	0.068	0.273	0.237	0.197	0.315
2000	0.250	0.152	0.128	0.107	*	0.182	0.200	0.396	0.217
2001	0.230	**	0.212	**	*	0.171	0.169	0.312	*

* Years when few or no striped bass were tagged and
** See footnote in Table D32.

Table D34. R/M estimates of exploitation rates of >= 18 inch striped bass from tagging programs (with reporting rate adjustment of 0.43, and hooking mortality rate adjustment of 0.08).

Year	NJDB	NYOHS	NCCOOP	MA	VA York	VA Rap	MDCB	DE/PA	NYHUD
1987	*	0.024	*	*	*	0.051	0.021	*	*
1988	*	0.031	0.047	*	*	0.132	0.017	*	0.060
1989	0.037	0.035	0.032	*	*	0.046	0.013	*	0.059
1990	0.112	0.044	0.070	*	*	0.120	0.068	*	0.094
1991	0.055	0.053	0.085	0.051	0.114	0.075	0.102	0.031	0.077
1992	0.060	0.047	0.164	0.057	0.096	0.063	0.140	0.133	0.105
1993	0.030	0.046	0.106	0.038	0.101	0.114	0.111	0.116	0.123
1994	0.041	0.064	0.089	0.040	0.094	0.102	0.121	0.119	0.085
1995	0.061	0.035	0.139	0.064	0.169	0.196	0.196	0.129	0.132
1996	0.102	0.060	0.109	0.109	0.155	0.132	0.172	0.170	0.170
1997	0.111	0.032	0.166	0.103	0.223	0.200	0.210	0.156	0.250
1998	0.136	0.055	0.150	0.056	0.167	0.149	0.207	0.146	0.177
1999	0.057	0.044	0.219	0.090	0.118	0.153	0.163	0.117	0.152
2000	0.072	0.039	0.088	0.050	*	0.096	0.133	0.147	0.101
2001	0.093	**	0.118	**	*	0.066	0.124	0.145	*

* Years when few or no striped bass were tagged and
** NYOHS and MA have fall tagging programs, and recapture interval of terminal year (2000) is fall 2000 to fall 2001; NCCOOP is a winter tagging program (Jan./Feb.) with recapture interval of terminal year (2001) from January 2001 to January 2002; others are spring tagging programs recapture interval of terminal year (2001) from spring 2001 to spring 2002.

Table D35. R/M estimates of catch rates of >= 18 inch striped bass from tagging programs. (with reporting rate adjustment of 0.43)

Year	NJDB	NYOHS	NCCOOP	MA	VA York	VA Rap	MDCB	DE/PA	NYHUD
1987	*	0.177	*	*	*	0.080	0.157	*	*
1988	*	0.242	0.216	*	*	0.274	0.100	*	0.192
1989	0.297	0.193	0.119	*	*	0.205	0.082	*	0.232
1990	0.675	0.174	0.180	*	*	0.279	0.131	*	0.293
1991	0.234	0.202	0.200	0.156	0.252	0.157	0.187	0.100	0.272
1992	0.264	0.142	0.293	0.120	0.341	0.125	0.245	0.211	0.238
1993	0.189	0.187	0.207	0.124	0.235	0.214	0.187	0.253	0.285
1994	0.200	0.155	0.199	0.143	0.253	0.179	0.218	0.226	0.214
1995	0.211	0.139	0.232	0.183	0.294	0.255	0.290	0.263	0.223
1996	0.265	0.190	0.151	0.237	0.221	0.190	0.281	0.263	0.288
1997	0.332	0.141	0.227	0.199	0.305	0.239	0.306	0.261	0.356
1998	0.323	0.150	0.247	0.105	0.230	0.219	0.297	0.265	0.260
1999	0.190	0.152	0.274	0.107	0.160	0.216	0.232	0.192	0.233
2000	0.215	0.141	0.158	0.093	*	0.144	0.233	0.269	0.205
2001	0.217	**	0.180	**	*	0.148	0.175	0.242	*

* Years when few or no striped bass were tagged and
** See footnote in Table D34.

Figure D24. Comparison of VPA and Tag program fishing mortality estimates.

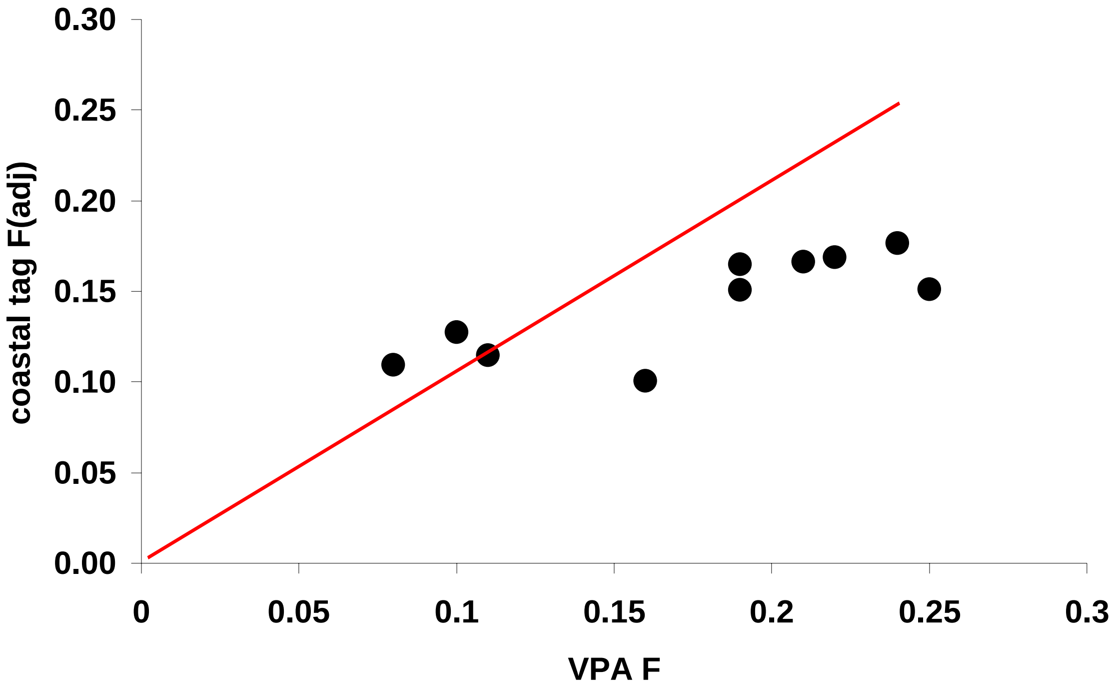


Figure D25. Comparison of VPA and Cooperative Cruise Tag program fishing mortality estimates.

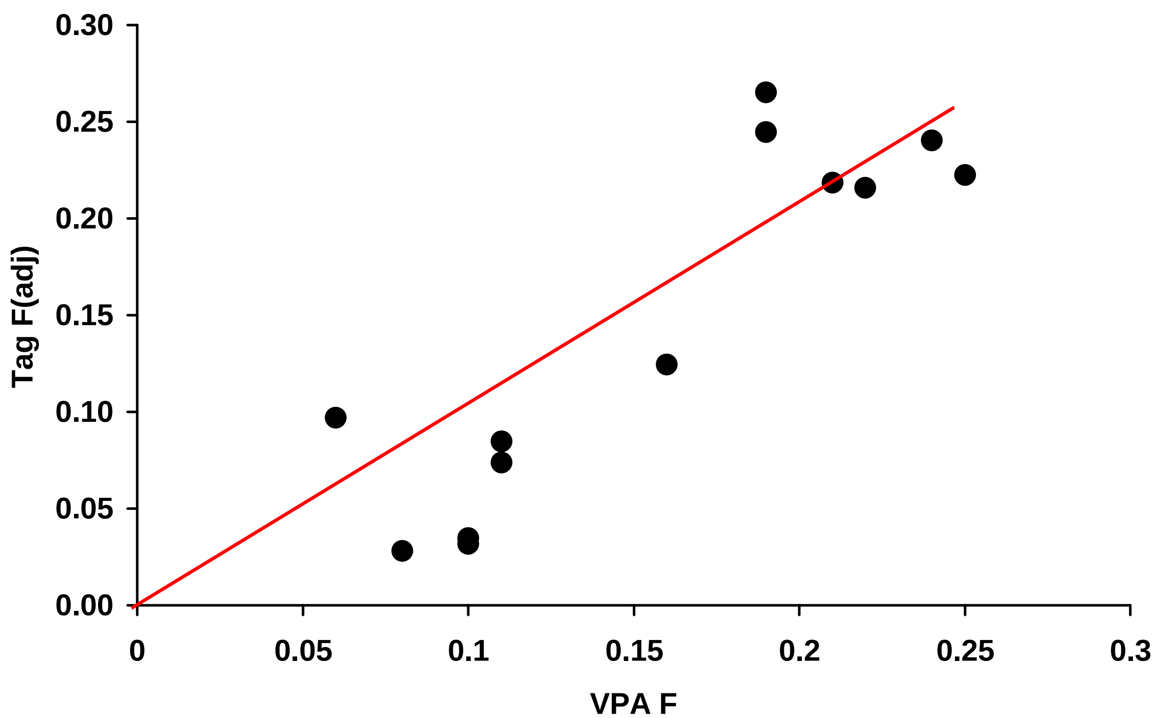
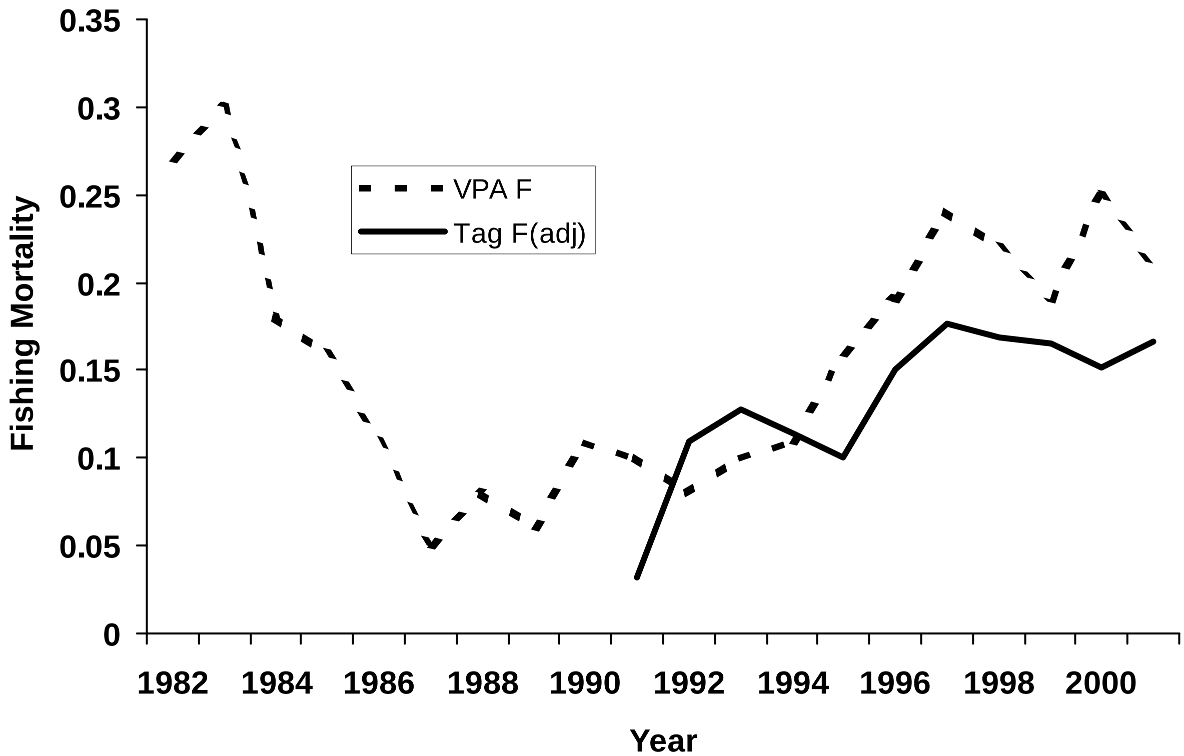


Figure D26. Time series of VPA and Tag estimated fishing mortality.



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