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A Report of the 28th Northeast Regional Stock Assessment Workshop

28th Northeast Regional Stock Assessment Workshop (28th 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

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MEETING OVERVIEW

The Stock Assessment Review Committee (SARC) meeting of the 28th Northeast Regional Stock Assessment Workshop (28th SAW) was held at the Carriage House of the Woods Hole Oceanographic Institution in Falmouth, MA during 30 November - 4 December 1998. The SARC Chairman was Dr. Terry Smith of the Northeast Fisheries Science Center (NEFSC). Members of the SARC included scientists from the NEFSC, the Northeast Regional Office (NERO), the New England Fishery Management Council (NEFMC), Atlantic States Marine Fisheries Commission (ASMFC), the States of Rhode Island and Maine, Rutgers University, and the NMFS Pilot Project, a pool of assessment experts (Table 1). In addition, nearly 30 other persons, including five Industry Observers, attended some or all of the meeting (Table 2). The meeting agenda is presented in Table 3.

Table 1. SAW-28 SARC Composition.

Chairman:
Terrence Smith, NMFS/NEFSC

Four *ad hoc* experts chosen by the Chair:
Stephen Clark, NMFS/NEFSC
Wendy Gabriel, NMFS/NEFSC
William Overholtz, NMFS/NEFSC
Debra Palka, NMFS/NEFSC

One person from the NMFS Northeast Regional Office:
John Witzig, NMFS/NERO

One person from each regional Fishery Management Council:
Andrew Applegate, NEFMC

Atlantic States Marine Fisheries Commission/State personnel:
Joseph Desfosse, ASMFC
Najih Lazar, RI DF&W
Dan Shick, ME DMR

One or more scientists from:
Academia - **Waldo Wakefield, Rutgers University**
NMFS Pilot Project - **Robert Mohn, DFO,Canada**

Opening

Dr. Fred Serchuk, Chief of the NEFSC Resource Assessment Division, welcomed the meeting participants. In his introductory remarks, he thanked the Working Group members who, he indicated, "worked in the trenches for several weeks" to prepare the documentation for SARC review.

Dr. Terry Smith had previously served as SAW Chairman during SAWs 18 through 21 and has returned to Chair this meeting in place of Dr. Emory Anderson, who took a position with the NOAA Sea Grant Office at Silver Spring, MD.

Table 2. List of Participants.

National Marine Fisheries Service
<u>Northeast Fisheries Science Center</u>

Frank Almeida	Gavin Begg
Russell Brown	Steve Cadrin
Joseph Idoine	Ralph Mayo
Steve Murawski	Helen Mustafa
Paul Nitschke	Loretta O'Brien
Paul Rago	Fred Serchuk
Gary Shepherd	Katherine Sosebee
Lynette Suslowicz	Mark Terceiro
Bonnie van Pelt	Susan Wigley

<u>NOAA/UMass CMER</u>
Kevin Friedland

Massachusetts Division of Marine Fisheries
Steven Correia — Arnold Howe
Jeremy King

Maine Division of Marine Fisheries
Chris Finlayson

Rhode Island Division of Fish and Wildlife
Mark Gibson

Conservation Law Foundation
Anthony Chatwin

Industry Observers

Robert Hamilton, Jr.	Frank Mirarchi
Maggie Raymond	Russell Sherman
Matthew Stommel	

Table 3. Agenda of the 28th Northeast regional Stock Assessment Workshop (SAW-28) Stock Assessment Review Committee (SARC) meeting.

Carriage House
WHOI Quissett Campus (Route 28)
Falmouth, Massachusetts

30 November (1:00 PM) - 4 December (6:00 PM) 1998

AGENDA

TOPIC	WORKING GROUP & PRESENTER(S)	SARC LEADER	RAPPORTEUR(S)
MONDAY, 30 November (1:00 PM - 6:00 PM)........			
Opening Welcome Agenda Conduct of meeting	**Terry Smith, Chairman**		**H. Mustafa**
Cape Cod yellowtail flounder (A)	Southern Demersal W.G. **S. Cadrin**	**W. Overholtz**	**S. Wigley**
TUESDAY, 1 December (9:00 AM - 6:00 PM)........			
White hake (B)	Northern Demersal W.G. **K. Sosebee**	**S. Clark**	**R. Mayo**
Georges Bank winter flounder (C)	Southern Demersal W.G. **R. Brown**	**W. Gabriel**	**P. Nitschke**
WEDNESDAY, 2 December (9:00 AM - 5:00 PM)........			
American plaice (D)	Northern Demersal W.G. **L. O'Brien**	**R. Mohn**	**R. Mayo**
Southern New England winter flounder (E)	Southern Demersal W.G. **M. Terceiro**	**W. Wakefield**	**G. Shepherd**
SOCIAL at the Smiths' (7:00 PM)			
THURSDAY, 3 December (9:00 AM - 6:00 PM)........			
Review Advisory Reports and Sections for the SARC Report			
FRIDAY, 4 December (9:00 AM - 6:00 PM)........			
SARC comments, research recommendations, and 2nd drafts of Advisory Reports			
Other business			**H. Mustafa**

Dr. Smith invited the meeting participants to introduce themselves and explained the role of the Industry Observers.

At the request of the SAW Steering Committee, Industry Observers were invited to actively participate in the Stock Assessment Review Committee meetings. Nominations for Observers were made by the New England and Mid-Atlantic Fishery Management Councils and all nominees were invited to the SARC. Although observers would not have a "vote" or participate in the formulation of the SARC consensus, the SAW Steering Committee believes that their contributions to discussions at SARC meetings will be valuable.

The Process

The SAW Steering Committee, which guides the SAW process, is composed of the 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. Dr. Smith indicated that the SARC members have a dual role; panelists are both reviewers of assessments and drafters of management advice. More specifically, although the SARC's primary role is peer review of the assessments tabled at the meeting, the Committee also prepares a report with advice for fishery managers known as the *Advisory Report on Stock Status*.

Dr. Smith reviewed the responsibilities of SARC members, the SARC leaders, rapporteurs, and presenters, as well as the list of working papers. Working papers included assessments for the stocks on the agenda, a paper by Rago and Sosebee inferring the availability of white hake from spring and fall sampling surveys, and a background paper by Mayo, O'Brien, and Buxton on discard estimates of American plaice in the Gulf of Maine Northern shrimp fishery and the Gulf of Maine Georges Bank large-mesh otter trawl fishery that was presented at SAW-14. Assessments for SARC review were prepared at meetings listed in Table 4.

Table 4. SAW-28 Working Group meetings and participants.

Working Group and Participants	Meeting Date	Stock/Species
Southern Demersal Working Group	13-16 October 1998	Cape Cod Yellowtail Flounder
D. A. Abasi, UMass		Georges Bank Winter Flounder
G. Begg, NEFSC		Southern New England/MidAtlantic Winter Flounder
R. Brown, NEFSC		
S. Cadrin, NEFSC		
S. Correia, MA DMF		
T. Currier, MA DMF		
M. Gibson, RI DFW		
R. Hamilton, MAFMC		
A. Howe, MA DMF		
P. Howell, CT DEP		
M. Johnson, CT DEP		
J. King, MA DMF		
N. Lazar, RI DFW		
M. Terceiro, NEFSC (Chair)		
Northern Demersal Working Group	16-20 November 1998	American Plaice
L. Alexander, Industry Rep., Portland, ME		White Hake
G. Begg, NEFSC; R. Brown, NEFSC		
S. Cadrin, NEFSC; R. Mayo, NEFSC (Chair)		
L. O'Brien, NEFSC; P. Rago, NEFSC		
R. Sherman, Industry Rep., Gloucester, MA		
K. Sosebee, NEFSC; S. Wigley, NEFSC		

Agenda and Reports

The SAW-28 SARC agenda (Table 3) included presentations on Cape Cod yellowtail flounder, white hake, Georges Bank winter flounder, American plaice, and Southern New England winter flounder.

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.

SARC documentation includes two reports, one containing the assessments, SARC comments, and research recommendations, and another produced in a standard format which includes the status of stocks and management advice. The draft reports will be available at two sessions of the SAW-28 Public Review Workshop that will be held during regularly scheduled NEFMC and MAFMC meetings (27 - 28 January and 2 - 4 February 1999, respectively). The documents will be published in the NEFSC Reference Document series as *SARC Consensus Summary of Assessments* and *SAW Public Review Workshop* (the latter document includes the Advisory Report), after the Public Review Workshop sessions.

Highlights of Presentations and Discussion

Assessment presentations included a review of the terms of reference, background information, assessment components, and assessment methodology. The terms of reference for all the stocks on the agenda were written to take into account landings through 1997. The SARC, in some cases, requested additional model runs and supplemental analyses. Industry Observers contributed to the discussion in areas where individuals had particular interest or experience. In addition to items related to specific stocks, a significant amount of the SARC members' and other participants' time was devoted to discussing current and proposed overfishing definitions in the Northeast Multispecies Fishery Management Plan; including associated Amendment 9 control rules, and how to document and illustrate the new SFA-related information.

Cape Cod Yellowtail Flounder

This was the first time that the Cape Cod yellowtail flounder (*Limanda ferruginea*) stock was assessed within the SAW process. Management of the stock is generally the responsibility of the NEFMC except for the portion of the stock that is found within the Massachusetts territorial sea which is managed by the Massachusetts Division of Marine Fisheries (MADMF).

Points of discussion included the sensitivity of VPA, disagreement between the VPA and ASPIC results for total stock biomass, methods used to estimate discards and the survivorship of discards, as well as the management implications to this stock from other fisheries. How to deal with the new Amendment 9 overfishing definition and associated Control Rule was a major issue in preparing the Cape Cod yellowtail advisory.

Research recommendations addressed the need to investigate the use of NEFSC inshore strata and geographic patterns in determining sex ratio and maturity at age, the need to look into the resolution of stock boundaries (including stock identification techniques), revision of discard estimates from the shrimp and whiting fisheries, the need to increase observer sampling on the exempted whiting fishery, and the need to continue processing of archived MADMF samples and to process NEFSC observer age samples.

The stock was found to be over-exploited and at a medium level of biomass in 1997.

White Hake

The Gulf of Maine-Georges Bank white hake (*Urophycis chuss*) stock was last reviewed within the SAW process in 1994 during SAW-19. At this meeting, in addition to the assessment paper, the

Paul Rago and Kathy Sosebee presented an analysis that falls between a VPA and a simple production model. The paper infers the availability of white hake from the spring and fall sampling surveys, highlighting the fact that the stock is not fully available in the spring. The essence of this paper will be incorporated into the body of the white hake section of the SARC report.

The SARC addressed several input data issues. The Committee questioned some discrepancies in landing data, discussed gear and market category stratification, and expressed concern over the augmentation of survey age/length keys. Relative to input data, the SARC recommended investigation of effort units in the VTR data, as they may not be comparable to effort units obtained from the interview data. The SARC also recommended an inventory of age samples from sea sampling trips to improve the determination of the age/length relationship. Discussed also were fishing mortality and stock size estimates, derived from a number of sources, and the use of catchability coefficients for tuning the DeLury model. For better evaluation of spatial distribution of white hake, the SARC recommended the use of GIS plots.

The stock was found to be over-exploited in 1997 with an extremely low biomass level.

Georges Bank Winter Flounder

The Georges Bank winter flounder (*Psueudopleuronectes americanus*) stock was last assessed within the SAW process in 1991 during SAW-13, providing summaries of catch, effort, survey indices and yield per recruit modeling. The current assessment represents an attempt to assemble an analytical assessment of the stock.

The stock is fished by both USA and Canada. Canadian survey indices, however, were received just before the SARC meeting and were not available at the time of the Working Group meeting. There has been a recent decline in effort on this stock in the central portion of Georges Bank because of closed areas.

Discussed was the unreliability of discard estimates from log books, problems associated with inclusion of unreliable estimates in the catch-at-age, as well as the overlap between winter flounder and scallops in Closed Area II. Discard survivorship, however, was noted to be high for the species. Points of discussion also included the lack of commercial sea sampling data for the species, the higher catchability of Canadian survey gear, and the use of NEFSC length-weight indices to estimate Canadian biomass. The possibility of developing a recommendation to amend the current overfishing definition based on new and better information was also discussed.

Research recommendations addressed expanded sampling of commercial landings, better information on discards, examination of the distribution of winter flounder in Stratum 23, investigation of the effects of door correction coefficients, and the use of Canadian research vessel biomass indices.

The stock was found to be fully exploited and at low biomass levels in 1997.

American Plaice

The Gulf of Maine-Georges Bank American plaice (*Hippoglossoides platessoides*) stock was last assessed within the SAW process in 1992 during SAW-14. The current assessment is a revised assessment of the stock for the period 1980-1997 based on analysis of commercial discards, landings and effort data, and research vessel survey data. Since the last assessment, the catch-at-age was re-estimated using commercial age data, discards were updated, and four out of six research recommendations were addressed. In addition to the assessment paper, as background information, an additional reference on discard estimates in the Gulf of Maine Northern shrimp fishery and the Gulf of Maine-Georges Bank large-mesh otter trawl fishery (Mayo, O'Brien, Buxton; SAW-14) was noted.

Points of discussion included the possibility of there being more than one stock, and the inconsistency in the estimation of discards from the shrimp fishery VTR data.

Research recommendations addressed estimation and calculation of discards, characterization of the seasonality and spatial variability of spawning in the Gulf of Maine, and estimates of discards for the small-mesh otter trawl component.

The stock was found to be over-exploited and at a low biomass level in 1997.

Southern New England Winter Flounder

The Southern New England winter flounder (*Pleuronectes americanus*) stock complex was last assessed within the SAW process in 1995 during SAW-21 and by the ASMFC Winter Flounder Technical Committee in 1998. The current assessment is an update of the two assessments.

Points of discussion included differences in market categories by port, the use of large number of indices from several different state and federal sources in the VPA, and the calculation of reference points with respect to the complicated winter flounder Control Rule.

Research recommendations addressed commercial and recreational discards, sampling levels and information from MRFSS samples, comparability of age-length keys from different areas, re-examination of the maturity ogive, implications of anthropogenic mortalities, implications of stock mixing, ageing of MA DMF survey samples, utility of NEFSC Winter Survey abundance indices, and the utility of MA DMF sea sampling data.

The stock complex was found to be fully exploited and at a medium level of biomass.

General Issues

Sea Sampling

Currently, sea sampling coverage is primarily determined by the needs of the marine mammal program. The non-marine mammal related or discretionary part of the domestic sea sampling program has no dedicated source of funding. As a result sampling can be ad hoc and some assessment are attempted without adequate estimates of at-sea discards. With respect to discards, the SARC notes that because of continued concerns with VTR data, specifically species misidentification, and discard reporting biases, it may be more effective to increase sampling or formalize sampling protocols in the sea sampling program.

In 1995, the SARC recommended an examination of the sea sampling program; specifically that a sampling protocol be developed that would make it possible to collect additional data for assessment purposes. Although a committee was formed, no recent meetings have occurred.

Discussed also were current funding initiatives which could augment the collection of sea sampling data. Actions in this regard have also been taken by the NEFMC and a cooperative program involving the ASMFC and NMFS is looking to develop a comprehensive protocol regarding by catch. It was noted, with respect to sea sampling, that current, one-time initiatives will not be particularly useful. What is necessary is long-term or permanent funding of such programs.

Amendment 9 Control Rule Complications

Amendment 9 to the Northeast Multispecies FMP revises current overfishing definitions for the stocks managed in the northeast groundfish complex. Associated with the overfishing definitions are species specific control rules or prescriptions for establishing fishing mortality rate targets and thresholds.

The overfishing definitions and control rules adopted by the NEFMC are essentially those recommended by the Overfishing Definition Review Panel (Applegate et al., 1998). One particular issue is that the biomass-based reference points of the overfishing definitions were, for the most part, derived from application of a simplistic production model. The biomass level estimated by such a model is often inconsistent with that estimated by the VPA. One solution, and in general the approach favored by the SARC was to re-estimate the production model using the catchability coefficients estimated by the VPA. This 'scaling' of the production model resulted in re-estimation of several Amendment 9 overfishing definition reference points. It is important to note, however, that the SARC did not amend the fundamental definition, control rules, etc., but rather, recalculated the parameters used in the definitions and control rule.

Specific issues on various species' control rules were also discussed and appear in the separate chapters to follow. More generally, however, the SARC discussed how to present advice in the new SFA-based framework and how to make the new basis comparable to previous overfishing definitions and advice.

One particular topic discussed was the technical issue of biomass-based versus fully-recruited fishing mortality. The new overfishing definitions are based on considerations of MSY and the biomass that produces MSY (B_{MSY}). Fishing mortality thresholds (maximum rates of fishing mortality) and fishing mortality targets (risk-averse rates designed to prevent the thresholds from being exceeded) are tied-to the current biomass level of the stock and how that biomass relates to a biomass threshold (the level of biomass below which fishing must be eliminated or sharply curtailed). Since biomass is the metric for these considerations, the overall fishing mortality rate should be calculated from current biomass distributions. This differs from the situation where the old reference points were based on fully-recruited mortality rates. Because of this change in perspective, it has been necessary to present both sets of fishing mortalities, a fully-recruited F, applicable to the old overfishing definitions (and the customary VPA result reporting) and biomass-weighted F, applicable when examining stock status under the new Amendment 9 overfishing definitions.

A discussion of the differences in the two metrics, along with an example, is included in the SAW 28 *Advisory Report.*

Before the meeting adjourned, some additional time was devoted to the discussion of the SFA requirements and control rule implications and how to appropriately capture this in the current SAW documentation. It was suggested that the standard format of graphs in the Advisory Report now include a statement regarding Control Rule implications as well as an illustration (figure) of the control rule and current reference values. In addition to the technical issue related to the calculation of overall F, the SARC decided to develop an overview or preamble section where the issue could be addressed. A committee selected by the Chair would prepare this overview soon after the meeting based on discussion of draft materials reviewed at the meeting. A draft document would be circulated to members of the SARC before it would be added to the meeting report.

That overview is now included in the draft *Advisory Report* and will become part of the *SAW Public Review Workshop* report.

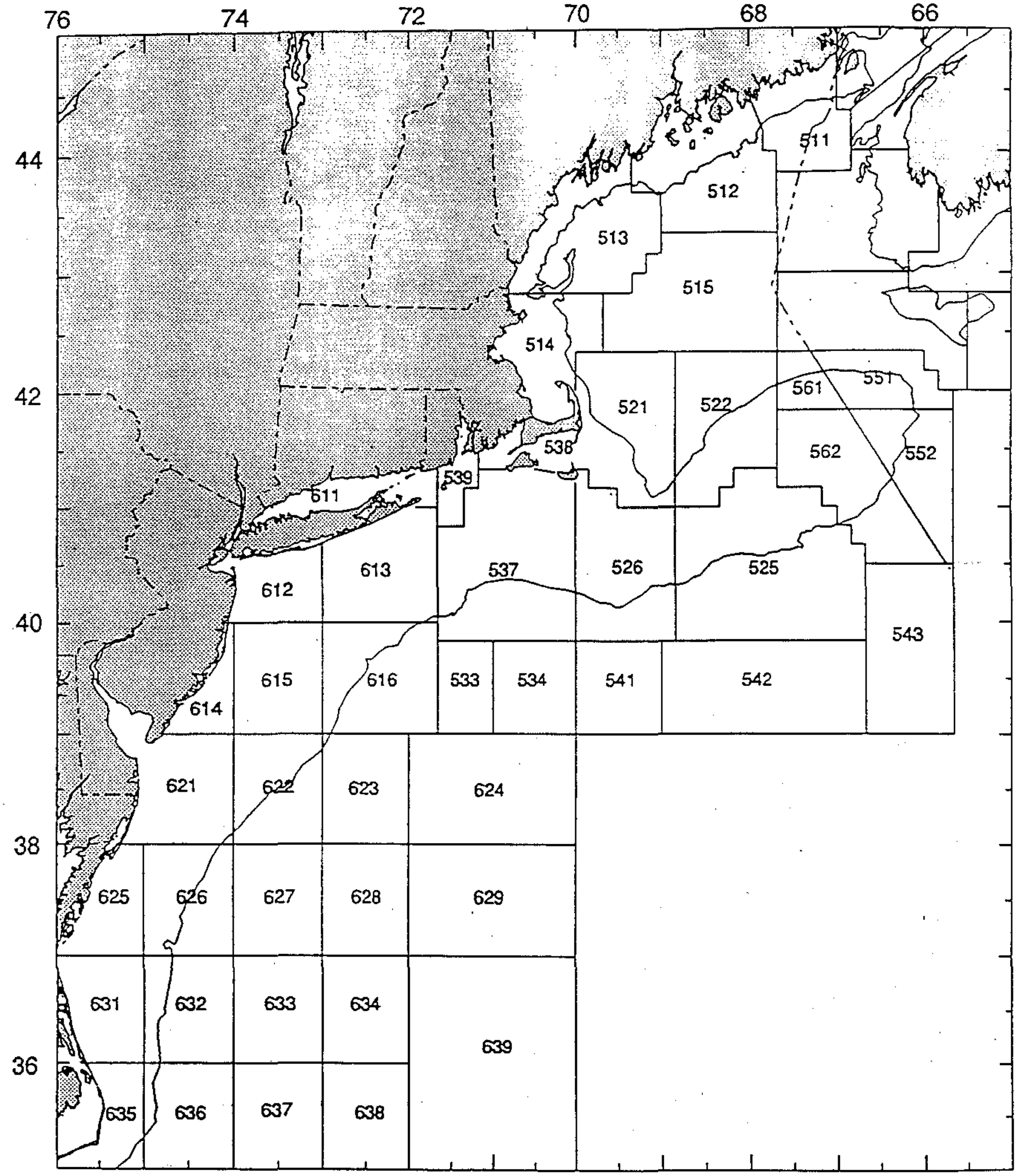

Figure 1. Statistical areas used for catch monitoring in offshore fisheries in the Northeast United States.

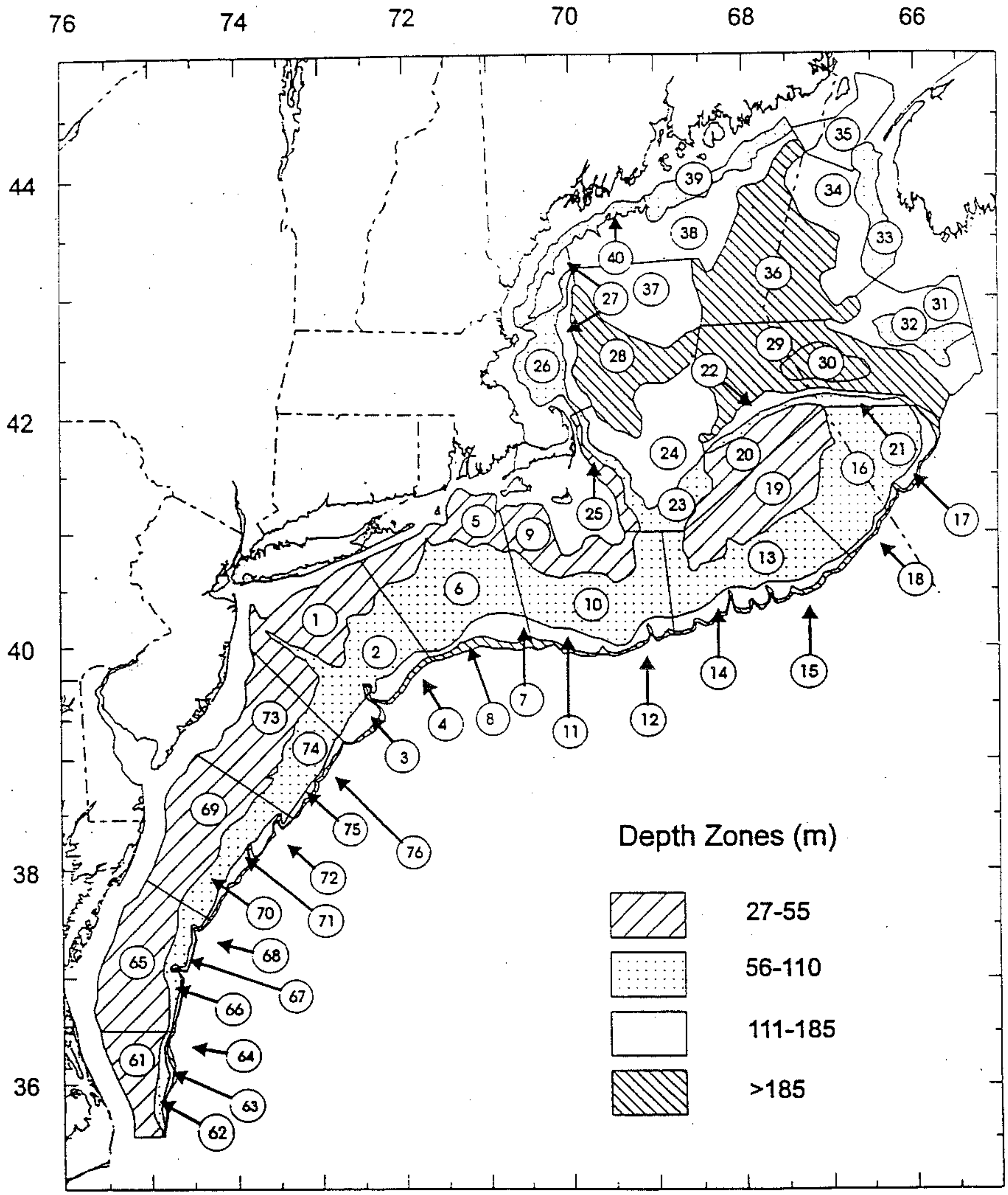

Figure 2. Offshore sampling strata used in NEFSC bottom trawl surveys.

A. CAPE COD YELLOWTAIL FLOUNDER

INTRODUCTION

Yellowtail flounder, *Limanda ferruginea*, inhabit the continental shelf of the northwest Atlantic from Labrador to Chesapeake Bay. 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 A1). Cape Cod yellowtail inhabit relatively shallow water (10-60 m; 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 (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, since the collapse of Georges Bank and southern New England stocks in the early 1990s (NEFSC 1994), the Cape Cod stock has been the most productive of the U.S. yellowtail stocks (Overholtz and Cadrin 1998).

Stock Identification

Geographic patterns of landings and survey data, larval distribution, tagging observations, and life history information indicate relatively discrete stocks of yellowtail flounder on Georges Bank, in Southern New England waters, and off Cape Cod. Survey catches off Cape Cod are not correlated with those from Georges Bank nor from southern New England waters (Figure A2). Concentrations of pelagic larvae are discontinuously distributed among the three geographic areas (Cape Cod grounds, Georges Bank, and southern New England; Silverman 1983). Larvae may be retained on the Cape Cod, because vertical movement of larvae limits horizontal drift (Smith et al. 1978).

Royce et al. (1959) defined five 'more or less distinct' stocks of yellowtail flounder based on tagging observations and concentrations of fishing effort (southern New England, Georges Bank, Cape Cod, northern Gulf of Maine, and Nova Scotia). The Cape Cod stock was delineated as statistical reporting areas 514 and 521, "east and north of Cape Cod, in Cape Cod Bay, and north to the vicinity of Cape Ann and Ipswich Bay. It is limited in all directions by deep water, although to the south and north there are narrow strips of water of the preferred depth." Lux (1963a) confirmed that yellowtail in the Cape Cod area comprise a relatively local and stationary group through additional tagging. Subsequent tagging information (Lux, unpublished) also confirms that movement from the Cape Cod area is rare. A summary of all documented yellowtail movements off the northeast U.S. indicates that 98% of fish recaptured from release sites on the Cape Cod grounds remained in the area (0.6% moved to the northern Gulf of Maine, 0.3% moved to Georges Bank, and 1.1% moved to southern New England), 0.8% of fish recaptured from southern New England release sites moved to the Cape Cod grounds, and none of the fish recaptured from Georges Bank release sites moved to the Cape Cod grounds (Table A1).

Life history information also suggests that yellowtail on the Cape Cod grounds are distinct from those in adjacent waters. Yellowtail on the Cape Cod grounds generally mature later (O'Brien et al. 1993), spawn later in the spring (Silverman 1983), grow to larger sizes (Lux and Nichy 1969), and are found in shallower water (10-60 m) than those in other areas off the northeast U.S. (Lux 1964). A large portion of yellowtail sampled from the Cape Cod area were infested with trematodes that depend on intertidal hosts, indicating that infested fish inhabited nearshore waters for a portion of their life. However, none of the samples from Georges Bank or southern New England were infested, suggesting that none had moved from inshore areas (Lux 1963a). A more extensive investigation confirmed geographic differences in the number of parasites and degree of infestation: there were two major communities (on the Cape Cod grounds and on Georges Bank), two intermediate communities (off southern New England and in the northern Gulf of Maine), and local aggregations (in Massachusetts Bay/Stellwagen Bank and off the north shore of Massachusetts; Testeverde 1987).

In summary, Cape Cod yellowtail appear to comprise a discrete group with minimal movement to and from other stock areas. Therefore, yellowtail flounder on the Cape Cod grounds are considered a single unit stock and interchange with adjacent stocks is assumed to be negligible for this assessment.

Management Summary

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's Atlantic Groundfish Fishery Management Plan established optimum yield thresholds for yellowtail west of 69° longitude (which included Cape Cod and southern New England yellowtail stocks) and imposed minimum mesh size, spawning closures, and trip limits. 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 (Figure A3). 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.

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. Current small mesh trawling in state waters north of Cape Cod is limited to an experimental whiting fishery with drastic ground gear modifications for bycatch reduction, prohibitions on groundfish 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 complementing federal closures to protect harbor porpoises. State waters from Marblehead to the New Hampshire border are closed to sink gillnets from November 1 - December 30. Massachusetts Bay and Cape Cod Bay are closed to sink gillnets from March 1 - 30. Right whale critical habitat in Cape Cod Bay is off limits to gillnets from January 1 - May 15.

Terms of Reference

The Steering Committee of the 28th Northeast Regional Stock Assessment Workshop issued the following objectives for the present investigation.

a. Update the status of the Cape Cod yellowtail flounder stock through 1997 and characterize the variability of estimates of stock size and fishing morality.
b. On the basis of anticipated catches and abundance indicators in 1998, estimate stock size at the beginning of 1999 and provide projected estimates of catch and spawning stock biomass for 1999-2000 at various levels of F.
c. Comment on and revise, if necessary, the overfishing definition reference points for Cape Cod yellowtail flounder recommended by the Overfishing Definition Review Panel.

The Cape Cod yellowtail stock has traditionally been 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 & 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). Similar to other U.S. stocks of yellowtail, 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 over-exploited (Rago 1995). The present assessment updates catch and survey information through 1998 and provides quantitative estimates of stock size, mortality, and overfishing reference points.

A draft of this report was presented to the Southern Demersal Working Group of the SAW (October 13-16, 1998, Woods Hole) and reviewed by the following working group members. This report represents the Working Group's consensus on analytical decisions, interpretation, and conclusions.

Name	Affiliation
Daniel Ama-Abasi	UMass, Amherst
Gavin Begg	NEFSC, Woods Hole
Russ Brown	NEFSC, Woods Hole
Steve Cadrin	NEFSC, Woods Hole
Steve Correia	MADMF, Pocasset
Arnie Howe	MADMF, Pocasset
Jeremy King	MADMF, Pocasset
Lynette Suslowicz	NEFSC, Woods Hole
Mark Terceiro; chair	NEFSC, Woods Hole
Sue Wigley	NEFSC, Woods Hole

METHODS AND RESULTS

Commercial Landings

U.S. commercial landings of yellowtail flounder were derived from dealer weighout reports. 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 of Cape Cod yellowtail rapidly increased in the late 1930s to an annual average of 1,300 mt from 1940 to 1962 (Table A2, Figure A4). Landings increased sharply in 1963 to 3,600 mt, then decreased to an annual average of 1,500 mt from 1964 to 1973. Landings increased in the 1970s to a peak of 5,100 mt in 1980, then declined to an annual average of 1,000 from 1984 to 1989. Landings increased in 1990, then returned to an annual average of 1,000 since 1991.

Recent geographic and seasonal patterns of Cape Cod yellowtail landings can be inferred from logbook information. Most landings from 1995 to 1997 (72%) were from statistical area 514 (Figure A1), almost entirely in the first, second, and fourth quarters of the year. A large portion of area 521 landings during 1995 to 1997 (41%) were taken in the fourth quarter. The seasonal pattern of recent landings is similar to historical patterns reported by Royce et al. (1959): 90% of landings are taken in the fall, winter, and spring.

Otter trawls are the principal fishing gear used to catch yellowtail flounder. Until recently, small-mesh otter trawls (<127mm, 5" mesh) were the dominant gear landing Cape Cod yellowtail (averaging 51% of annual landings from 1982 to 1993), with most of the remaining landings from large-mesh otter trawls (39% of 1982-1993 landings; Table A3). Gill nets and scallop dredges contributed minor portions of landings. However, since prohibitions on landing groundfish with small-mesh trawls in 1994, large-mesh trawls have dominated landings (averaging 74% of total landings), and landings from gillnets have increased to greater than 20% of total landings since 1995.

Some market categories were not sampled in many half-years prior to 1985. The apparent truncation in age distribution in the late 1970s reported by McBride et al. (1980) may be an artifact of sampling only the large category in late 1977 and all of 1978 and only the small category in 1979. McBride and Clark (1983) concluded that biological sampling up to the early 1980s was inadequate for monitoring trends in age composition. Sampling improved substantially after 1984, however each market category was not always sampled in each statistical area. Therefore, landings at age were estimated for 1985-1997 stratified by half-year and market category for the entire stock area. All strata were sampled, except for the unclassified category in the second half of 1985 to 1988 and second half of 1994 (unclassified landings were prorated to small and large categories for those half-years) and the small category in the second half of 1995 (all landings were characterized by unclassified samples for that half-year; Table A4)

Sample length frequencies were expanded to total landings at size using the ratio of landings to sample weight (predicted from length-weight relationships by sex and season; Lux 1969b), and portioned to age using pooled-sex age-length keys from commercial and survey samples. Despite sexually dimorphic growth of Cape Cod yellowtail (Lux and Nichy 1969; Libey 1973; Moseley 1986), sample sizes were too small to produce reliable age-length keys by sex. Estimated landings and mean weights at age indicate that the 1984 and 1987 cohorts dominated catches in the late 1980s and early 1990s, respectively (Table A5). Inconsistent catches and variable mean weights of yellowtail older than age-6 suggest that old fish are rarely landed or poorly sampled.

Discarded Catch

Estimates of discards for the Cape Cod yellowtail fishery 1963-1969 were derived from interviews with vessel captains; historical discards were approximated by Brown and Hennemuth (1971) from the 1963-1969 average discard rate (Table A2, Figure A4). Discards for 1970-1977 were also based on interview data, however yellowtail interview data was suspect from 1978 to 1982 (particularly for the Cape Cod area) 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).

Neither sea sampling nor interview data were available to estimate Cape Cod yellowtail discards for 1984-1988. Using the method described by McBride and Clark (1983), selectivity at size was applied to survey size distributions to approximate the magnitude and size distribution of discards for 1984-1988, assuming a 28 cm cull-point for 1984-85 and a 30 cm cull-point for 1986-88. The regulated mesh size during 1984-1988 was 140 mm (5.5"), but a large portion of Cape Cod yellowtail were landed in exempted small-mesh fisheries. The relative proportions of landings by gear type during 1984-1988 were similar to 1989-1991 (Table A3) and was under similar gear restrictions. The effective selectivity of the Cape Cod yellowtail fishery was approximated by the average ratio of cumulative commercial catch at length to cumulative survey catch at length, by half-year from 1989 to 1991 (Figure A5). By comparison, selectivity of yellowtail with 129 mm (5.1") and 145 mm (5.7") mesh was estimated by Lux (1968) and Hennemuth and Lux (1970), and selectivity of 102 mm (4") mesh and 133 mm (5.25") mesh was estimated by Smolwitz (1979; Figure A5). The effective selectivity estimates for 1989-1991 are between the retention reported for 102 mm and 129 mm mesh; which may result from the large portion of small-mesh landings. Therefore, selectivity for 1984-1988 was approximated from the effective selectivity during 1989-1991 (indicated as '1989-91 fit' in Figure A5). The survey-selectivity method was tested on 1989-1991 survey data and produced discard estimates within 7% of those from sea sampling, and length distributions were similar (Figure A6).

Cape Cod yellowtail discards for 1989-1997 were estimated using ratios of discarded to landed catch, by gear and half-year, observed at sea (as described by Mayo 1998), except for small-mesh and scallop dredge discards in recent years (described below). Since 1989, the Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (MADMF) observers sampled 1,963 fishing trips in which yellowtail were caught on the Cape Cod grounds (Table A6). Discard ratios were significantly greater from small-mesh trips than from large-mesh trips in a two-factor analysis with half-year ($P=0.056$ from conventional ANOVA; $P=0.050$ from randomization test, Manly 1997). Therefore, small-mesh and large-mesh trips were treated separately. However, there was no detectable difference in discard ratios within small-mesh fisheries (i.e., shrimp trips vs. whiting trips: $P=0.691$ from ANOVA; $P=0.679$ from RT), and all small-mesh trips were treated as a group. Pooling small-mesh fisheries can be justified by the similar gear requirements from 1989 to 1992 (1.75", 44 mm codend mesh). Trimmed ratio estimates (which exclude data from the trips with maximum and minimum discard ratios), mean ratios (which exclude trips with discards, but no yellowtail landings), and trimmed mean ratios were calculated to investigate sensitivity of estimates to extreme observations and trips with no landings.

Estimated discard ratios from 145 large-mesh otter trawl trips (1989-1997) averaged 0.16 (ranging from 0.02 to 0.62), and were generally greater in the first half of the year than the second half of the year (2 factor analysis with year; P=0.010, ANOVA; P=0.012 RT). Ratio estimates were robust to elimination of extreme observations and zero landings in most years. A ratio of 0.04 (average of 1995-1997 ratios for the 2nd half of the year) was used for the 2nd half of 1994, when no trips were sampled. Estimates of total discards from large-mesh otter trawls averaged 87 mt annually from 1989 to 1997, ranging from 9 to 186 mt.

Discard estimates for gillnets were based on many sampled trips (1,527 from 1989 to 1997). Discard ratios averaged 0.10 (ranging from 0.00 to 0.34) and were robust to elimination of extreme observations and zero landings in most years. Estimates of total discards from gillnets averaged 12 mt annually from 1989 to 1997, decreasing from 36 mt in 1990 to 5 mt or less in recent years.

Estimated discard ratios from 61 small-mesh otter trawl trips averaged 1.01 from 1989 to 1992 (ranging from 0.06 to 2.39) and were quite sensitive to elimination of extreme observations in most years. Therefore, trimmed ratio estimates were used to approximate total discards for half-years with greater than 7 observed trips (i.e., trimmed estimates were based on at least 5 trips). Mean ratios were not used to estimate discards, because small-mesh trips with no groundfish landings may realistically represent the fishery. Estimates of total discards from small-mesh otter trawls averaged 409 mt annually from 1989 to 1992, ranging from 130 to 815 mt. Requirements for finfish exclusion devices and prohibitions on landing groundfish with small-mesh otter trawls precluded estimation of small-mesh discards for 1993-1997 using discard:kept ratios. Effort-based discard estimates for 1993-1997 small-mesh fisheries are described below.

Estimated discard ratios from 22 scallop dredge trips averaged 1.08 from 1989 to 1995 (ranging from 0.16 to 1.82). Few trips per half-year were available for calculation of trimmed estimates. Estimates of total discards from scallop dredges averaged 75 mt annually from 1989 to 1995, decreasing from 184 mt in 1991 to 13 mt in 1995. Trip limits for landing groundfish with scallop dredges decreased to 200 lb in 1996 and to 100 lb in 1997, precluding estimation of dredge discards using discard:kept ratios for 1996 and 1997. Effort-based discard estimates for 1996 and 1997 are described below.

Effort-based estimates of Cape Cod yellowtail discards were calculated for fisheries that had prohibitions or severe restrictions on groundfish landings: small mesh fisheries from 1993 to 1997 and the scallop fishery from 1996 to 1997 (Table A7). Total effort by fishery was estimated from interview data for 1993 and January-April of 1994, and from expanded logbook data from 1994 to 1997. Reported effort from logbooks were expanded by the portion of total target species landings reported by logbooks (Table A7). These effort-based discard estimates should be considered provisional, because logbook data remains partially unaudited (NEFSC 1996a, 1997).

Shrimp fisheries were treated separately from other small-mesh trips, because of different gear requirements since 1993 (e.g., finfish exclusion devices in the shrimp fishery). The 'raised footrope' experimental whiting fishery was well sampled (15 trips sampled in 1996 and 51 trips sampled in 1997), and total annual yellowtail discards were estimated to be less than 1 mt (McKiernan et al. 1998; R. Johnston, personal communication). Therefore, effort in the experimental fishery was excluded from the total whiting effort in 1996 and 1997; yellowtail discards from earlier experimental fishing was assumed to be similar to exempted whiting fishing. The 'whiting grate' experimental fishery does not extend as far south as the Cape Cod grounds. Note that fishermen in the whiting fishery may also target dogfish, but small-mesh trips other than shrimp trips were not discriminated by target species. There were no observed trips in the exempted whiting fishery in 1996 and 1997; the 1993-1995 average (0.09 mt/df) was assumed, producing annual discard estimates of 31 to 117 mt.

Estimated discard rates from recent shrimp trips (1993-1997) were negligible (0.003 mt/df), averaged 0.05 mt/df (ranging from 0.01 to 0.12), and produced annual discard estimates of approximately 0.2 mt. Estimated discard rates from scallop trips averaged 0.03 mt/df (ranging from 0.02 to 0.05) and produced annual discard estimates of 66 mt in 1996 and 159 mt in 1997.

In summary, estimated discards of Cape Cod yellowtail averaged 22% of total catch by weight from 1963 to 1997 (Table A2, Figure A4) and 37% by number from 1985 to 1997. Recent discard estimates remain substantial (20% during 1994-1997; Table A2), with 40% from the large mesh fishery, 30% from the exempted whiting fishery, and 30% from the scallop fishery (Figure A7). Sample length frequencies from observed discards (1989-1997) were expanded to total discards at size using the ratio of landings to sample weight (predicted from length-weight relationships by sex and season; Lux 1969b). Discards at size for 1985-1988 were estimated from survey size distributions by half-year and estimated selectivity from 1989 to 1991 (Figure A5). Discards at size were portioned to age using pooled-sex age-length keys from commercial and survey samples. Discards from unsampled strata were characterized by samples from adjacent strata (Table A8) Estimated discards at age and mean weight of 1994-1996 discards are presented in Table A9.

Total catch at age and mean weight at age in the catch are reported in Table A10. Estimated catch at age indicates that the 1984 and 1987 cohorts dominated catches in the late 1980s and early 1990s, respectively.

Historical Catch Rates

Lux (1964) developed an index of fishing effort based on interviews from New Bedford trips with landings composed of greater than 50% yellowtail, standardized to a vessel size class of 26-50 tons. The standardization methods were used to derive a time series of standardized catch per unit effort (CPUE) from 1943-1987 (McBride 1988; Table A2, Figure A8). Despite the fact that a small portion of total Cape Cod yellowtail landings were represented in the analysis used to derive CPUE values in some years, "they provide a broad picture of abundance fluctuations on this ground" (Lux 1964), and the index was used as the sole basis for monitoring relative abundance of the stock for two decades (Brown and Hennemuth 1971, Parrack 1974, Sissenwine et al. 1978, McBride and Sissenwine 1979, McBride et al. 1980, McBride and Sissenwine 1980). However, standardized catch rates became difficult to interpret after trip limits were imposed in 1977 (Clark et al. 1981), and the interview process was discontinued in 1994 (NEFSC 1996a). The CPUE time series indicates that stock biomass generally decreased from high levels in the early 1960s.

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; Figure A9). However, survey catches of Cape Cod yellowtail in offshore strata are too variable for reliable indices of relative abundance (McBride and Sissenwine 1980). Inshore strata in the Cape Cod stock area (56-66) were sampled since 1977, and inclusion of inshore data reduces some interannual variation in the overall index (offshore 25 and 26; inshore 56-66; Figure A10). However, inshore strata do not extend to nearshore yellowtail flounder habitat. McBride and Sissenwine included offshore stratum 24 and inshore stratum 55 in Cape Cod strata sets. However, much of the area and the majority of yellowtail caught in stratum 24 are in the Georges Bank stock area, and much of the area and most catches in stratum 55 are in the southern New England stock area. Therefore, both strata were excluded from the present analyses. Standardization coefficients, which compensate for survey door, vessel, and net changes in NEFSC groundfish surveys (1.22 for old doors, 0.85 for the Delaware II, and 1.76 for the 'yankee 41' net; NEFSC 1997) were applied to the catch of each tow.

Age-based indices for NEFSC spring and autumn surveys (Tables A11 and A12, respectively) were derived from dedicated age-length keys. The sampling design for yellowtail flounder weights, lengths, and ages for NEFSC surveys precludes estimation of sex specific biomass indices, abundance indices, or complete age-length keys.

The MADMF spring and autumn surveys have sampled inshore waters since 1978 (Figure A11; Howe 1989). The MADMF surveys catch more yellowtail than the NEFSC surveys within the Cape Cod area (strata 17-36; Figure A12). The MADMF surveys do not extend to offshore yellowtail flounder habitat. The aggregate number and weight per tow indices are slightly different than previously reported (NEFSC 1996b, Overholtz and Cadrin 1998), because short tows (<13 min) were excluded in the present analysis. MADMF age-based indices (Tables A13 and A14, respectively) were derived from dedicated age-length keys, where available. Age samples have been collected for yellowtail for both surveys since 1978. Age-based estimates for 1978-1983 were reported by Clark et al. (1984). Provisional age-based indices were extended using NEFSC keys for surveys that did not have age samples processed in time for this assessment (autumn 1984-1995, spring 1984).

Correspondence among NEFSC and MADMF survey indices was assessed using correlations among normalized observations [Ln(x/mean); Table A15]. Autumn survey indices were lagged to represent abundance at the beginning of the following year. Correlations varied widely with age: most indices of abundance at age 2-5 were moderate to strong, some indices of ages 1, 5, and 6 were negative.

Virtual Population Analysis

Virtual abundance estimates from catch at age of ages 1-6+, 1985-1997, were calibrated using an ADAPT algorithm (Gavaris 1988) that estimated age 2-5 survivors in 1998 and survey catchability coefficients (*q*) using nonlinear least squares of survey observation errors. Abundance at the start of the year was calibrated with 15 indices: NEFSC spring ages 2-5, NEFSC fall ages 1-4 (lagged to tune ages 2-5), MADMF spring ages 1-4, and MADMF fall ages 1-3 (lagged to tune ages 2-4).

The instantaneous rate of natural mortality (M) was assumed to be 0.2 based on tag returns (Lux 1969a), 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 with sustained yields of approximately 1,000 mt since the late 1930s.

Maturity at age for Cape Cod yellowtail flounder was reported by O'Brien et al. (1993) from 1985-1990 NEFSC spring survey samples. Subsequent NEFSC spring samples (1986-1997) confirm the reported estimates. However, samples from the Massachusetts spring survey suggest significantly lower proportion mature at age-3, suggesting geographic patterns in maturity at age. The maturity schedule reported by O'Brien et al. (1993) was assumed for estimates of spawning stock biomass (SSB), because the NEFSC strata set was considered to best represent the entire stock area. Sex ratios also appear to have strong geographic patterns. Preliminary results from 1997-1998 Massachusetts surveys indicate that there are significant differences in sex ratio in the Massachusetts survey area. Several of the most populous yellowtail flounder survey strata and the northernmost region appear to be dominated by males in the spring. Sex ratios for the VPA time series were assumed to be 50%, because exploratory investigations on sex ratios are not definitive.

The mean residual for VPA calibration was 0.59. The model generally fit the data well, but there was one statistical outlier (i.e., the standardized residual for MADMF spring age-1 in 1991 was 4.2). Residuals do not appear to be correlated among indices (only 5 of the 105 correlations among 15 time series of residuals [4.8%] were significant at the 5% level).

The VPA indicated that stock abundance increased in the late 1980s peaking at 29 million in 1988, and the 1987 cohort dominated the population through the early 1990s (Figure A13; Table A16). The stock remained relatively stable through the 1990s, averaging 17 million from 1991 to 1996, but age-1 recruitment in 1997 appears to have been poor and total abundance decreased to 15 million. Age-1 recruitment peaked at 21 million in 1988, was relatively constant from 1989 to 1996 (averaging 7 million), but decreased to 3 million in 1997.

Estimates of fishing mortality on fully recruited ages (age-4+) from VPA has been extremely high and variable, peaked in 1988, and generally decreased to 0.64 in 1997 (Figure A14, Table A17). The temporal pattern and approximate magnitude of F estimates from VPA are confirmed from the moving average of survey index log ratios [$Ln(n_{4+}/n_{5+})$-M], which peaked at approximately 2.0 in the late 1980s and gradually declined to approximately 1.0 in the late 1990s (Figure A14). Fishing mortality on total biomass averaged 0.55 for the VPA time series and was 0.41 in 1997.

Total stock biomass estimates peaked at 5,700 mt in 1990 and decreased to an annual average of 2,800 mt from 1991 to 1997 (Table A18). Spawning stock biomass peaked in 1990 at 2,100 mt when most of the 1987 cohort matured, decreased in 1991 and 1992, then generally increased to 1,700 mt in 1997 (Figure A15, Table A19). The age distribution of SSB indicates that most of the current mature biomass is composed of fist-time spawners (Figure A15).

Survey residuals were randomly resampled for 1,000 bootstrap solutions. Bootstrap percentiles suggest that the 80% confidence interval of 1997 SSB is 1,140 mt to 1,750 mt, and the 80% CI of 1997 F is 0.75 to 1.35 (Figure A16). Bootstrap coefficients of variation (CVs) for abundance estimates ranged 29-39%. Estimates of q for each index were relatively precise (CV=19-25%).

Several alternative ADAPT configurations were inspected (Table A20). All age-6 indices were excluded, because they were composed mainly of large fish with few age samples at length, and survey catchability coefficients were poorly estimated (Tables A11-A14). The MADMF fall age-1 index (which is based on young-of-the year observations the year before) was excluded, because age-0 fish were not caught in most years (Table A14). Calibration results were relatively robust to exclusion of age-1 and age-6+ tuning indices. However, results are sensitive to exclusion of age-5 indices.

Retrospective analysis of preliminary calibrations (e.g., run#9) suggested that terminal estimates of SSB were generally overestimated (the mean retrospective difference was +250 mt), age-1 recruitment was overestimated (mean difference was +1.4 million), and fully-recruited F was underestimated (mean difference was -0.18). A revised run (run#14, Appendix A) without MADMF age-5 indices had much less of a retrospective pattern (mean retrospective differences were +130 mt SSB, +0.5 million recruits, and +0.07 fully-recruited F). Therefore, age-5 indices from MADMF surveys were excluded, presumably because they don't sample offshore areas well. Conversely, NEFSC age-1 indices were excluded, because the surveys don't extend to nearshore concentrations of juveniles. The configuration reported in Appendix A was considered to include the most reliable information on relative stock size and to have the best properties for estimating abundance and mortality.

Biological Reference Points

Estimates of yield per recruit (Thompson and Bell 1934) and spawning biomass per recruit (Gabriel et al. 1989) are listed in Table A21. The fishing mortality pattern was based on geometric mean F at age from 1994 to 1997, and mean weights at age were based on 1994-1997 mean catch weight at age. Proportion mature was from O'Brien et al. (1993). The model indicates that maximum yield per recruit of 0.23 kg is produced at a fully-recruited F of 0.47 (F_{max}), however the yield curve is relatively flat, and the maximum was not well defined (Figure A17). The increase in yield per recruit per unit F is decreased to one-tenth the initial increase at an F of 0.21 ($F_{0.1}$). Spawning biomass per recruit (SSB/R) is 2.8 kg with no fishing, and is reduced to 40% of maximum at an F of 0.20. Howe (1975) estimated F_{max} = 0.63 for a 114 mm (4.5") mesh size using a Beverton and Holt (1957) yield per recruit model. Other reported estimates of yield per recruit reference points (Rago 1995) were for the management area west of 69° longitude and were based on data for the southern New England stock.

A nonequilibrium surplus production analysis (ASPIC; Prager 1994, 1995) of total catch, standardized CPUE, and survey indices of stock biomass from 1963 to 1996 was attempted to provide perspective on historical stock levels, and offer guidance on SFA reference points (Table A22). Initial biomass (B_I: B_{63}/B_{MSY}), maximum sustainable yield (MSY), intrinsic rate of increase (r), and catchability (q_i) of each biomass index (i) were estimated by nonlinear least squares of biomass index residuals. The model was calibrated with historical standardized CPUE index, the NEFSC spring and fall biomass indices, and the MADMF spring and fall indices. Biomass indices were well correlated (r=0.4 to 0.7) and fit the model moderately well (R^2=0.12 to 0.31). Estimates from the present analysis are very similar to those reported by Applegate et al. (1998). However, estimated biomass was approximately 2.5 times greater than from the VPA, suggesting that the estimates of q_i were not accurate. Therefore, the VPA suggests that absolute biomass levels from the production model can not be used for SFA reference points.

Most production models require a time series which encompasses a broad range of stock biomass and yield to provide dependable parameter estimates (Prager et al. 1996). In cases where the data series is not informative enough to reliably estimate all parameters, independent data can be used to fix certain parameters. For example, Prager (1993) fixed the value of r to provide guidance on MSY, but fixing r will determine the level of F_{MSY}. Application of ASPIC to other stocks in the northeast U.S. demonstrates that values of q can be fixed according to VPA estimates of stock biomass (Applegate et al. 1998). Catchability coefficients were fixed for a 'conditioned' analysis, forcing agreement between ASPIC and VPA, however biomass indices did not fit the conditioned model well (R^2<0, strong residual patterns).

Prager (1994, 1995) suggested that ratios of biomass and F to MSY reference points are more reliable than absolute biomass or F estimates. The production model indicates that biomass was approximately $1.5 \cdot B_{MSY}$ during the 1960s and early 1970s, but decreased to approximately $0.5 \cdot B_{MSY}$ in the late 1980s and early 1990s, then gradually increased to $0.7 \cdot B_{MSY}$ in 1998 (Figures A18 and A19). According to the average biomass ratio (B_t/B_{MSY}) from the production model and VPA estimates of biomass (1985-1994, Table A22), B_{MSY} is approximately 6,100 mt. The ASPIC estimate of MSY (2,400 mt) and the rescaled estimate of B_{MSY} (6,100 mt) suggest that F_{MSY} is 0.40 on biomass, which is equivalent to a fully-recruited F of 0.54 (slightly greater than F_{max}).

Technical guidance on defining overfishing according to the Sustainable Fisheries Act suggests that F_{max} is the most liberal of reference points that can be considered as a candidate for a F_{MSY} proxy, because it assumes no stock-recruit relationship (i.e., recruitment is not expected to increase at higher levels of stock biomass or lower levels of F; Restrepo et al. 1998). The stock-recruit relationship for Cape Cod yellowtail flounder appears to be 'flat' according to the short VPA time series (Figure A20), but there is no information for SSB less than 450 mt. Fitting a Beverton and Holt (1957) stock recruit function to VPA estimates suggests that for all observed levels of SSB, recruitment approaches an asymptote of approximately 8 million, but the slope at the origin is poorly defined. Applying an age-based approach to estimating MSY reference points (Sissenwine and Shepherd 1987) confirms that the production curve closely reflects the yield-per recruit curve, F_{MSY} is equivalent to F_{max}, and SSB_{MSY} and B_{MSY} are equivalent to the product of SSB/R and B/R with average observed recruitment. However, without more dynamic range in observed SSB and recruitment, age-based MSY reference points should be considered provisional.

The Amendment 9 control rule was developed to define overfishing thresholds and targets (Applegate et al. 1998). When the stock biomass exceeds B_{MSY}, the overfishing threshold is F_{MSY}, and target F is based on a 10% risk of exceeding the threshold. When the stock biomass is less than B_{MSY}, the overfishing threshold is based on maximum F that would allow rebuilding to B_{MSY} in five years, and target F is based on a 10% risk of exceeding the threshold (Cadrin 1998). The revised control rule (based on rescaled reference points) and recent stock status are illustrated in Figure A21. Note that F values pertain to F on biomass, not fully-recruited F, because the control rule was derived from a surplus production model.

Projections

Stochastic projections were performed using 1,000 bootstrap estimates of abundance at age for the ADAPT calibration, assuming 1998 landings of 1,320 mt (based on January-August 1998 landings and the portion of total 1997 landings reported during January-August, S. Correia, personal communication), a range of 1998 discards of approximately 300 mt (based on the 1994-1997 mean discard proportion at age), and 100 randomly drawn recruitment values from the VPA time series for each bootstrap realization. The fishing mortality pattern was based on geometric mean F at age from 1994 to 1997, and mean weights at age were based on 1994-1997 mean catch weight at age.

Fully-recruited F in 1998 is 1.01 (0.56 on biomass), and January 1, 1999 biomass is projected to be 2,700 mt (a decrease from 2,900 mt in 1998), based on VPA estimates of abundance for January 1, 1998, assumed mean weights at age, and the preliminary estimate of 1998 catch. According to the control rule and the 1999 level of biomass, threshold F (the overfishing definition) is 0.13 on biomass (Figure A21; 0.23 on fully-recruited ages) and target F is zero.

Projections that assume status quo F in 1999 (1.01 fully-recruited, 0.56 on biomass) indicate that landings will decrease to 1,100 mt and biomass in 2000 will slightly increase to the 1998 level (2,900 mt or 48% of B_{MSY}; Figure A22, Table A23). Projections that assume the threshold F in 1999 (0.23 on fully-recruited ages, 0.13 on biomass) indicate that landings will significantly decrease to 300 mt and biomass in 2000 will substantially increase to 3,800 mt (62% of B_{MSY}; Figure A22, Table A24). Projections that assume the target F in 1999 (0.00) indicate that biomass in 2000 will substantially increase to 4,200 mt (69% of B_{MSY}; Figure A22, Table A25).

Long-term projections were performed to test the performance of the control rule. A target F of 0.00 was assumed for five years, and a long-term target F of 0.33 on fully-recruited ages, 0.26 on biomass was assumed for the next 20 years. Long-term projections suggest that there would be a high probability of attaining B_{MSY}, stock biomass would approach an equilibrium of approximately 7,000 mt

(115% B_{MSY}) with high probability of exceeding B_{MSY}, and landings would approach 1,500 mt (63% of MSY; Figure A23).

WORKING GROUP DISCUSSION

The Southern Demersal Working Group questioned the accuracy of estimating discards using survey size distributions and the estimate of 1989-1991 selectivity. The Group suggested to compare survey length frequency derived by the survey-selectivity method and the method using observer data (Figure A6). The Group noted that the abundant 1987 year class apparently didn't produce many discards. Concern was raised that seasonal movements may effect discard and catch rates by half year. The Working Group requested a descriptive analysis of landings by month and statistical area. Descriptive analysis showed that seasonal patterns have been relatively stable with most landings from statistical area 514 in fall winter and early spring and some landings from area 521 in the fall.

The Working Group discussed two aspects of NEFSC survey strata and recommended further investigations: 1) substantial portions of offshore stratum 24 and inshore stratum 55 are in area 521; poststratification of catches will increase the number of observations comprising tuning indices and may improve performance of indices. 2) inshore strata are sampled inconsistently (no single strata was sampled in all years); poststratification of inshore data into fewer, larger strata will allow stratification to consistent survey areas for all years and may also improve the performance of survey indices. The Working Group noted that catchability of older fish appeared to be exceptionally high for the NEFSC spring survey in 1987.

The Working Group requested estimates of F which are independent of catch. The moving average of survey index log ratios [$Ln(n_{4+}/n_{5+})-M$] generally confirmed the temporal pattern and magnitude of VPA F estimates (Figure A14).

Several alternative ADAPT configurations were requested (Table A20). The MADMF fall age-1 and all age-6+ indices were excluded, because catchabilities were poorly estimated (high CVs), they are based on few age samples, and there were many years with zero indices.

Age-based MSY proxy estimates were considered to be more informative and reliable than those from the production model. The Group rejected a constrained ASPIC analysis, because the model did not fit the data well. The Group suggested that historical catches may not be reliable, because of the effect of quotas and trip limits on reported landings. Several alternative analyses were explored (including omitting the CPUE series, including the earlier offshore survey data), but all alternatives were equally or more problematic.

The Working Group agreed that there is little information on weight of fish older than age-8 and accepted the present yield-per-recruit analysis which is based on an age-8+ group. The Group also agreed that averaging mean weights and F at age for exploitation pattern from 1994-1997 was appropriate, because Amendment 7 was the most significant recent regulatory change.

SARC DISCUSSION

It was pointed out that the estimate of M=0.2 seemed inconsistent given the later maturation and recent observed maximum age characteristic for this stock. However, given that the stock has been heavily exploited since the 1930s, the SARC agreed that the age structure was truncated by exploitation and not indicative that M is greater than 0.2. It was suggested that looking at a stock with a less truncated age distribution, such as Georges Bank yellowtail flounder, may provide insight with respect to M. Although tagging studies and research conducted by Brown and Hennemuth (1971) suggested M=0.2, the SARC requested a VPA sensitivity run with M=0.3. The SARC also noted that there should be consistency in M between models (VPA and ASPIC). The sensitivity run with M=0.3 did not produce biomass estimates similar to those from the production model. Sensitivity analyses for YPR estimates which also assumed M=0.3 produced much higher levels of F_{max}.

Given the dimorphic growth exhibited by yellowtail flounder (i.e. age 4+ females are larger at age than males), the use of unsexed survey catch data in the VPA may result in slightly biased estimates of F and SSB. At the recent high levels of mortality and truncated age structure, the SARC felt that this was not a major issue, but may become problematic when age structure rebuilds.

The use of NEFSC inshore survey strata, which have been inconsistently sampled over the time series, should be further explored. The survey catch-at-age may need modification, and thus this refinement was recommended for further exploratory research. The SARC also noted that some of the survey strata extend beyond the stock boundary, especially along the northern boundary, and post-stratification may be need to align survey strata set with statistical area stock boundaries.

The SARC commented that a constant maturity ogive from NEFSC surveys was used in the VPA. Annual maturity ogives from NEFSC data appear similar over time. When MADMF maturity data were included, maturity estimates changed. Exploration of geographic patterns of maturity-at-age and sex ratio differences are needed before the two data sets can be combined.

It was noted that there was an inconsistency in the plus group used in the VPA (6+) and in the YPR (8+) analyses. The Southern Demersal working group noted that since yellowtail flounder were still growing at age 6, and that 8+ was appropriate for yield per recruit analysis. The working group decided that the entire time series of weight at age for 6, 7, 8 is based on more samples than available growth curves.

The SARC noted that the selectivity method used to estimate 1985-1988 discards assumed that relative proportions of effort were constant among gear types. Figure A4 indicates that proportions were relativity stable for the period.

The SARC discussed the utility of including the Mass survey as tuning indices for the VPA. When the Mass survey indices for older ages were included, there was a non-random residual pattern and a retrospective pattern that are not present when these indices are excluded. The two surveys used different gear and have different spatial coverage of the resource. The Mass survey catches more yellowtail flounder than the NEFSC survey; however, the SARC noted the sampling may not represent the entire population. A juvenile yellowtail flounder distribution plot from the Mass survey revealed there were centers of abundance which were not sampled by the NEFSC survey. Since there were negative correlations among the age 5 and older indices in the Mass survey and the NEFSC surveys, the SARC requested an additional run in which the Mass age 5 indices were omitted from the calibration, as well as the age 1 indices from the NEFSC surveys. Results from this formulation had similar stock size and F estimates, yet did not have the troublesome retrospective pattern. This formulation was accepted by the SARC (Run 14).

It was noted that the total stock biomass from the VPA and the production model (ASPIC) tracked each other; however, there was a difference in magnitude. In general, ASPIC estimates some parameters better than others. The VPA was believed to best represent total stock biomass since the VPA incorporates information on age-structure and biomass estimates are scaled by a virtual population.

The SARC discussed the generic issue of what should be done when the overfishing definition is not cast in terms of the analytic model used to assess a stock. The SARC discussed re-scaling methods to bridge ASPIC results to match VPA results. Many concerns surround re-scaling, including the assumption of stationarity of the B-ratio and which time period of the VPA should be used (i.e. only the converged section or just the most recent years). The SARC did not conclude which re-scaling method was most appropriate; however, the SARC did note that whether re-scaling was used or the dynamic-pool model (i.e., YPR) estimates were used, the management advice would not change. The SARC agreed that the current control rule should be re-scaled according to VPA biomass levels for the present advice; however, generic recommendations were needed to adopt age-based reference points when the existing overfishing definition was based on a production model. The SARC also agreed that a trajectory of recent estimates would provide perspective.

RESEARCH RECOMMENDATIONS

- 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.

CONCLUSIONS

The Cape Cod yellowtail flounder stock is at a medium level of biomass and is over-exploited. Virtual population analysis of total catch, calibrated with research survey indices, indicated that total biomass since the early 1990s remained below the level that can produce maximum sustainable yield (1997 biomass was 2,700 mt, which is 44% of B_{MSY}, 6,100 mt). Fishing mortality generally decreased in the mid 1990s; fully-recruited F in 1997 was 0.64, and F on total biomass was 0.41. Age-1 recruitment averaged 7 million fish from 1988-1995, but the 1996 year class is about half the long term average. The estimated level of biomass in 1998 is 2,900 mt and fully-recruited F is projected to increase to 1.01. Relative to the Amendment 9 overfishing definition and the associated control rule, which is based on a surplus production model, the stock is overfished, and overfishing is occurring (threshold F = 0.13 on biomass, 0.23 on fully-recruited ages). Applying the Amendment 9 control rule to the 1998 total stock biomass implies a fishing mortality target rate of 0 in 1999. Projections suggest that catch and biomass will decline in 1999 as the apparently poor 1996 year class recruits to the fishery. Projected 2000 biomass remains below ½ B_{MSY} at status quo harvest rates, but can substantially increase at low F.

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Table A1. Observed movements of yellowtail flounder among stock areas (GOM: northern Gulf of Maine; CC: Cape Cod; GB: Georges Bank; SNE; southern New England; MA; mid-Atlantic) from Royce et al. (1959), Lux (1963a, 1963b), and Lux (unpublished).

release	recapture site						proportional recaptures				
site	GOM	CC	GB	SNE	MA	sum	GOM	CC	GB	SNE	MA
CC	2	345	1	4	0	352	0.006	0.980	0.003	0.011	0.000
GB	0	0	148	8	0	156	0.000	0.000	0.949	0.051	0.000
SNE	0	5	16	578	14	613	0.000	0.008	0.026	0.943	0.023
MA	0	0	0	64	28	92	0.000	0.000	0.000	0.696	0.304
sum	2	350	165	654	42	1213					

Table A2. Catch and effort of Cape Cod yellowtail flounder (1935-1959 from Brown and Hennemuth, 1971; 1960-1982 from McBride 1988).

year	Landings (mt)	Discards (mt)	Percent Discard	Total (mt)	Effort (thous d)	CPUE (mt/d)
1935	400	100	25	500		
1936	400	100	25	500		
1937	500	200	40	700		
1938	500	200	40	700		
1939	600	200	33	800		
1940	900	300	33	1,200		
1941	1,300	400	31	1,700		
1942	1,500	500	33	2,000		
1943	1,300	400	31	1,700	0.53	3.2
1944	1,500	500	33	2,000	1.01	2.0
1945	1,200	400	33	1,600	0.61	2.6
1946	1,200	400	33	1,600	0.62	2.6
1947	1,100	300	27	1,400	0.75	1.9
1948	700	200	29	900	0.47	1.9
1949	1,200	400	33	1,600	0.68	2.4
1950	1,300	400	31	1,700	0.95	1.8
1951	800	200	25	1,000	0.79	1.3
1952	800	200	25	1,000	0.76	1.3
1953	800	200	25	1,000	0.78	1.3
1954	1,100	300	27	1,400	0.89	1.6
1955	1,300	400	31	1,700	1.00	1.7
1956	1,400	400	29	1,800	1.34	1.3
1957	2,400	700	29	3,100	1.44	2.2
1958	1,600	500	31	2,100	0.92	2.3
1959	1,500	500	33	2,000	0.76	2.6
1960	1,500	500	33	2,000	1.12	1.8

Table A2 (continued).

year	Landings (mt)	Discards (mt)	Percent Discard	Total (mt)	Effort (thous d)	CPUE (mt/d)
1961	1,800	600	32	2,400	0.91	2.6
1962	1,900	600	32	2,500	1.01	2.5
1963	3,600	1,000	28	4,600	1.00	4.6
1964	1,851	600	32	2,451	0.71	3.5
1965	1,498	500	33	1,998	0.70	2.9
1966	1,808	300	17	2,108	1.37	1.5
1967	1,542	800	52	2,342	1.69	1.4
1968	1,569	600	38	2,169	0.99	2.2
1969	1,346	300	22	1,646	0.68	2.4
1970	1,185	400	34	1,585	0.53	3.0
1971	1,662	700	42	2,362	0.79	3.0
1972	1,364	300	22	1,664	0.67	2.5
1973	1,662	0	0	1,662	0.89	1.9
1974	2,054	200	10	2,254	1.21	1.9
1975	2,027	0	0	2,027	1.25	1.6
1976	3,587	100	3	3,687	2.31	1.6
1977	3,469	0	0	3,469	2.42	1.4
1978	3,683	400	11	4,083	2.05	2.0
1979	4,163	500	12	4,663	2.61	1.8
1980	5,106	600	12	5,706	3.25	1.8
1981	3,149	600	19	3,749	2.30	1.6
1982	3,150	400	13	3,550	2.02	1.8
1983	1,884	300	16	2,184	1.25	1.7
1984	1,121	20	2	1,141	1.01	1.1
1985	967	77	8	1,044	1.30	0.8
1986	1,041	305	29	1,346	1.46	0.9
1987	1,159	198	17	1,357	1.55	0.9
1988	1,085	283	26	1,368		
1989	909	390	43	1,299		
1990	2,984	1,141	38	4,125		
1991	1,472	405	28	1,877		
1992	828	637	77	1,465		
1993	628	90	14	718		
1994	978	192	20	1,170		
1995	1,207	233	19	1,440		
1996	1,064	182	17	1,246		
1997	1,040	257	25	1,297		
mean	1,593	367	26	1,960	1.19	2.0

Table A3. Cape Cod yellowtail flounder landings (mt) by gear type (small mesh: <5").

landings year	large mesh	small mesh	gill net	scallop dredge	other	sum
1982	881	2,228	8	30	3	3,150
1983	723	1,133	10	12	6	1,884
1984	544	571	2	1	2	1,121
1985	430	531	2	3	1	967
1986	437	555	31	16	1	1,041
1987	465	569	73	39	13	1,159
1988	484	488	65	45	3	1,085
1989	394	375	67	68	4	909
1990	1,580	1,109	181	113	2	2,984
1991	557	662	108	134	11	1,472
1992	227	416	121	60	4	828
1993	155	345	88	41	0	628
1994	832	36	50	16	43	978
1995	902	27	238	8	31	1,207
1996	754	20	268	13	9	1,064
1997	722	14	279	7	18	1,040
mean	630	567	99	38	10	1,345

annual % year	large mesh	small mesh	gill net	scallop dredge	other	sum
1982	28	71	0	1	0	100
1983	38	60	1	1	0	100
1984	49	51	0	0	0	100
1985	44	55	0	0	0	100
1986	42	53	3	2	0	100
1987	40	49	6	3	1	100
1988	45	45	6	4	0	100
1989	43	41	7	8	0	100
1990	53	37	6	4	0	100
1991	38	45	7	9	1	100
1992	27	50	15	7	1	100
1993	25	55	14	6	0	100
1994	85	4	5	2	4	100
1995	75	2	20	1	3	100
1996	71	2	25	1	1	100
1997	69	1	27	1	2	100
mean	48	39	9	3	1	100

Table A4. Sample sizes used to estimate landings at age of Cape Cod yellowtail flounder.

		landings (mt)			port samples (trips)			observed	lengths			ages
year	half	unclass.	small	large	unclass.	small	large	trips	unclass.	small	large	all
1985	1	44	213	302	1	2	2	0	109	304	196	292
	2	23	177	209	0	6	6	0	*	825	543	357
1986	1	20	400	198	0	2	2	0	*	608	206	217
	2	57	164	203	0	4	2	0	*	321	172	240
1987	1	89	308	323	0	2	4	0	*	300	352	353
	2	20	228	192	0	2	3	0	*	284	269	207
1988	1	88	185	291	0	3	3	0	*	477	267	286
	2	19	289	213	0	1	4	0	*	291	364	252
1989	1	66	129	224	0	2	4	16	10	261	314	305
	2	19	256	215	0	2	2	40	97	262	173	200
1990	1	118	366	435	0	4	4	44	536	532	374	339
	2	36	1324	705	0	3	3	20	636	429	276	137
1991	1	104	250	395	0	4	4	69	811	501	332	610
	2	40	303	380	0	4	3	160	109	531	242	277
1992	1	84	193	226	0	1	3	190	707	126	254	339
	2	26	166	132	0	2	5	81	136	262	457	268
1993	1	59	121	124	0	1	2	144	170	145	182	177
	2	16	160	147	0	2	1	43	273	244	74	114
1994	1	96	170	195	0	2	2	127	100	261	170	273
	2	30	231	256	0	2	1	55	*	106	144	149
1995	1	84	279	284	0	2	2	203	39	276	201	196
	2	21	242	297	0	3	3	78	998	392	275	157
1996	1	66	330	231	0	0	1	189	2560	**	87	196
	2	27	186	225	1	4	7	60	118	495	640	485
1997	1	44	290	192	0	3	4	293	343	388	483	556
	2	21	174	319	0	7	10	45	317	996	869	634
	sum	1316	7134	6911	2	70	87	1857	8069	9617	7916	7616

* unclassified landings prorated to large and small categories.
** entire catch characterized by unclassified samples.

Table A5. Landings at age (above) and mean weight at age (below) of landed 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
mean	0	553	1,432	599	151	31	9	3	2,779

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
mean	0.15	0.33	0.40	0.52	0.68	0.88	1.16	1.28

Table A6a. Observations of proportion discarded at sea and total discard estimates of Cape Cod yellowtail flounder.

large-mesh otter trawl						trimmed	mean	trimmed	dealer	discards
year	half	trips	kg kept	kg disc	ratio*	ratio	ratio	mean	landings	(mt)
1989	1	11	1083	675	0.62	0.62	0.50	0.39	160	100
	2	13	569	209	0.37	0.36	0.51	0.45	234	86
1990	1	8	1617	335	0.21	0.12	2.01	0.37	213	44
	2	10	4500	405	0.09	0.12	0.41	0.19	1367	123
1991	1	10	1156	101	0.09	0.07	0.07	0.05	158	14
	2	18	4624	348	0.08	0.06	0.20	0.18	399	30
1992	1	22	1855	345	0.19	0.17	0.27	0.25	91	17
	2	8	368	12	0.03	0.02	0.03	0.01	136	4
1993	1	1	19	1	0.05	–	0.05	–	53	3
	2	7	978	44	0.05	0.05	0.09	0.07	141	6
1994	1	5	15	5	0.30	–	0.58	–	81	25
	2	0	–	–	0.04 (<– 2nd half average, '94-96)				751	34
1995	1	6	58	18	0.31	–	0.11	–	467	143
	2	7	6980	131	0.02	0.02	0.08	0.04	435	8
1996	1	4	288	35	0.12	–	0.08	–	375	46
	2	3	1473	97	0.07	–	0.20	–	379	25
1997	1	5	107	24	0.22	–	0.29	–	248	55
	2	7	9757	490	0.05	0.05	0.17	0.09	409	21
mean					0.16	0.15	0.33	0.19	339	43

gill net						trimmed	mean	trimmed	dealer	discards
year	half	trips	kg kept	kg disc	ratio*	ratio	ratio	mean	landings	(mt)
1989	1	1	0	0	0.00	–	0.00	–	65	0
	2	13	56	6	0.11	0.10	0.07	0.03	2	0
1990	1	34	2869	654	0.23	0.21	0.22	0.21	160	36
	2	4	23	0	0.00	–	0.00	–	21	0
1991	1	54	2355	246	0.10	0.10	0.16	0.14	103	11
	2	134	513	91	0.18	0.17	0.21	0.15	4	1
1992	1	154	5797	967	0.17	0.17	0.19	0.18	117	20
	2	57	71	16	0.22	0.19	0.17	0.15	4	1
1993	1	128	5769	1154	0.20	0.20	0.22	0.21	103	21
	2	24	79	27	0.34	0.25	0.20	0.15	7	3
1994	1	104	4357	109	0.03	0.02	0.10	0.07	36	1
	2	51	204	1	0.01	0.00	0.01	0.00	14	0
1995	1	189	22629	354	0.02	0.02	0.02	0.02	231	4
	2	46	109	16	0.15	0.05	0.14	0.04	7	1
1996	1	166	14465	276	0.02	0.02	0.02	0.01	257	5
	2	49	77	1	0.01	0.01	0.00	0.00	11	0
1997	1	282	23632	506	0.02	0.02	0.04	0.01	242	5
	2	37	170	4	0.02	0.00	0.01	0.00	6	0
mean					0.10	0.09	0.10	0.09	77	6

* ratio estimator used to derive total discards.

Table A6b. Observations of proportion discarded at sea and total discard estimates of Cape Cod yellowtail flounder.

small-mesh otter trawl

year	half	trips	kg kept	kg disc	ratio	trimmed ratio**	mean ratio	trimmed mean	dealer landings	discards (mt)
1989	1	4	12	3	0.26	–	0.36	–	187	48
	2	14	368	215	0.58	0.43	0.75	0.71	189	82
1990	1	2	6	4	0.57	–	0.33	–	531	303
	2	6	8	7	0.88	–	0.67	–	579	512
1991	1	5	214	13	0.06	–	0.63	–	450	27
	2	7	40	97	2.39	0.65	3.73	0.65	212	139
1992	1	11	132	201	1.51	1.03	2.54	2.09	269	276
	2	12	34	61	1.78	1.70	1.67	1.54	147	250
1993	1	10	0	15	–	–	–	–	251	***
	2	12	30	228	7.61	7.34	6.90	5.55	183	***
1994	1	17	2	32	14.19	–	–	–	1	***
	2	16	0	205	–	–	–	–	35	***
1995	1	11	0	17	–	–	–	–	20	***
	2	27	0	187	–	–	–	–	8	***
1996	1	18	5	18	3.69	–	0.09	–	9	***
	2	18	3	1	0.35	–	0.08	–	12	***
1997	1	6	230	62	0.27	–	0.26	–	5	***
	2	52	0	0	–	–	–	–	9	***
mean					2.63	2.23	1.50	2.11	172	205

scallop dredge

year	half	trips	kg kept	kg disc	ratio*	trimmed ratio	mean ratio	trimmed mean	dealer landings	discards (mt)
1989	1	0	–	–	1.08 (<– '89-95 mean)			–	5	6
	2	0	–	–	1.08 (<– '89-95 mean)			–	63	68
1990	1	0	–	–	1.08 (<– '89-95 mean)			–	15	16
	2	0	–	–	1.08 (<– '89-95 mean)			–	98	106
1991	1	0	–	–	1.08 (<– '89-95 mean)			–	29	32
	2	1	16	23	1.46	–	1.46	–	105	153
1992	1	3	48	8	0.16	–	0.26	–	23	4
	2	4	97	176	1.82	–	0.85	–	36	66
1993	1	5	49	40	0.81	–	1.06	–	19	15
	2	0	–	–	1.08 (<– '89-95 mean)			–	33	35
1994	1	1	413	157	0.38	–	0.38	–	5	2
	2	4	226	273	1.21	–	0.88	–	11	13
1995	1	0	–	–	1.08 (<– '89-95 mean)			–	2	3
	2	4	132	228	1.73	–	2.00	–	6	10
1996	1	8	186	1217	6.53	5.65	19.97	7.61	9	***
	2	5	9	583	67.62	–	20.90	–	4	***
1997	1	6	79	1602	20.41	–	13.81	–	3	***
	2	2	0	397	–	–	–	–	3	***
mean					6.45	5.65	6.16	7.61	26	38

* ratio estimator used to derive total discards.
** trimmed ratio estimator used to derive total discards when n>7.
*** for total discards, see effort-based estimates (Table A7).

Table A7. Effort-based estimates of Cape Cod yellowtail flounder discards for fisheries prohibited or restricted from landing groundfish.

whiting fishery				Cape Cod area					
halfyear	wo mt	vtr mt	portion	vtr df	total df	obs df	disc (mt)	mt/df	disc mt
1993.25		–		–	7	(93-95 mean –>)		0.09	1
1993.75		–		–	406	2.7	0.202	0.07	30
1994.25	7922	2248	0.28	77	271	(93-95 mean –>)		0.09	23
1994.75	8136	5848	0.72	559	777	1.6	0.188	0.12	94
1995.25	7087	6182	0.87	331	379	(93-95 mean –>)		0.09	33
1995.75	7641	5383	0.70	390	554	7.0	0.450	0.06	36
1996.25	7941	6492	0.82	217	265	(93-95 mean –>)		0.09	23
1996.75	8258	7739	0.94	222	236	(93-95 mean –>)		0.09	20
1997.25	8204	6598	0.80	77	96	(93-95 mean –>)		0.09	8
1997.75	7358	6353	0.86	152	176	(93-95 mean –>)		0.09	15
mean	7818	5855	0.75	253	317	3.8	0.280	0.09	28

shrimp fishery				Cape Cod area					
halfyear	wo mt	vtr mt	portion	vtr df	total df	obs df	disc (mt)	mt/df	disc mt
1993.25		–		–	127	9.4	0.032	0.003	0.4
1993.75		–		–	14	1.1	0.003	0.003	0.0
1994.25		–		–	130	7.7	0.033	0.004	0.6
1994.75	1118	1143	1	31	31	0.8	0.010	0.013	0.4
1995.25	5348	5068	0.95	103	108	4.5	0.017	0.004	0.4
1995.75	1482	1572	1.00	29	29	0.9	0.001	0.001	0.0
1996.25	7684	7125	0.93	123	133	5.8	0.018	0.003	0.4
1996.75	1415	1521	1.07	38	36	1.3	0.001	0.001	0.0
1997.25	5699	5039	0.88	95	108	2.9	0.003	0.001	0.1
1997.75	650	972	1.00	16	16	0.2	0.000	0.000	0.0
mean	3342	3206	0.98	62	73	3.5	0.012	0.003	0.2

scallop fishery				Cape Cod area					
halfyear	wo mt	vtr mt	portion	vtr df	total df	obs df	disc (mt)	mt/df	disc mt
1996.25	4088	4057	0.99	1025	1032	58.6	1.217	0.021	21
1996.75	3805	3616	0.95	1770	1862	23.9	0.582	0.024	45
1997.25	3316	3546	1.00	1950	1950	32.2	1.602	0.050	97
1997.75	2688	2484	0.92	1871	2025	13.1	0.397	0.030	62
mean	3474	3426	0.97	1654	1717	31.9	0.950	0.031	56

Table A8. Sample sizes used to estimate discards at age of Cape Cod yellowtail flounder.

year	half	discards (mt)				observed trips				lengths				ages
year	half	LgMsh	SmMsh	gillnet	dredge	LgMsh	SmMsh	gillnet	dredge	LgMsh	SmMsh	gillnet	dredge	all
1985	1	20												128
	2	57												63
1986	1	152												158
	2	153												48
1987	1	56												183
	2	142												85
1988	1	109												182
	2	174												86
1989	1	100	48	0	6	11	4	1	0	1333	41	0	*	274
	2	86	82	0	68	13	14	13	0	283	90	0	*	205
1990	1	44	303	36	16	8	2	34	0	121	42	508	*	438
	2	123	512	0	106	10	6	4	0	621	12	0	*	199
1991	1	14	27	11	32	10	5	54	0	278	41	10	*	682
	2	30	139	1	153	18	7	134	1	195	112	18	167	292
1992	1	17	276	20	4	22	11	154	3	143	44	508	145	373
	2	4	250	1	66	8	12	57	4	8	100	1	52	120
1993	1	3	1	21	15	1	10	128	5	*	46	545	145	312
	2	6	30	3	35	7	12	24	0	201	695	45	*	84
1994	1	25	23	1	2	5	17	104	1	*	264	71	193	300
	2	34	94	0	13	0	16	51	4	*	454	0	205	168
1995	1	143	33	4	3	6	11	189	0	24	44	4306	145	248
	2	8	36	1	10	7	27	46	4	83	192	38	60	157
1996	1	46	23	5	21	4	18	166	8	52	59	1570	596	261
	2	25	20	0	45	3	18	49	5	20	3	0	124	529
1997	1	55	8	5	97	5	6	282	6	154	36	989	749	603
	2	21	15	0	62	7	52	37	2	176	3	0	208	708
sum		783	2783	108	753	145	248	1527	43	3692	2278	8609	2789	6886

* samples from adjacent cells used to characterize discards at length.

Table A9. Discards at age (above) and mean weight at age (below) of discarded Cape Cod yellowtail flounder.

Discards at age (thousands)			age				
	1	2	3	4	5	6	sum
1985	340	184	34	0	0	0	558
1986	79	1,657	75	26	0	0	1,837
1987	14	877	168	0	0	0	1,059
1988	360	1,328	177	0	0	0	1,864
1989	114	1,405	396	1	0	0	1,917
1990	81	2,047	2,501	19	0	0	4,648
1991	460	895	561	100	7	0	2,023
1992	1,688	3,543	731	29	3	0	5,994
1993	138	324	173	30	0	0	665
1994	60	383	279	49	4	1	776
1995	453	469	652	50	2	0	1,627
1996	7	397	327	94	11	0	837
1997	1	399	351	117	22	1	891
mean	292	1,070	494	40	4	0	1,900

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
mean	0.09	0.17	0.24	0.33	0.49	0.49

Table A10. Total catch at age (above) and mean weight at age (below) of Cape Cod yellowtail flounder.

Total catch at age (thousands)				age					
	1	2	3	4	5	6	7	8+	sum
1985	344	922	734	522	268	89	3	7	2,890
1986	79	3,655	654	250	32	6	0	1	4,676
1987	14	1,486	1,954	268	100	29	12	5	3,867
1988	361	2,130	1,219	625	172	36	0	0	4,543
1989	114	2,131	1,385	233	31	3	2	2	3,903
1990	81	2,738	8,692	435	32	16	7	3	12,005
1991	460	1,206	1,464	1,555	256	33	27	1	5,001
1992	1,688	3,881	1,538	543	153	6	5	1	7,815
1993	138	349	857	602	91	24	15	7	2,083
1994	60	471	1,301	699	240	66	38	9	2,885
1995	453	702	2,382	858	154	78	5	0	4,633
1996	7	547	1,425	892	298	11	5	2	3,186
1997	1	880	1,437	819	182	13	0	1	3,334
mean	292	1,623	1,926	638	155	32	9	3	4,678

weight at age (kg)				age				
	1	2	3	4	5	6	7	8+
1985	0.13	0.28	0.36	0.49	0.60	0.73	1.20	1.39
1986	0.10	0.25	0.43	0.53	0.73	0.90	—	1.40
1987	0.06	0.24	0.40	0.55	0.65	0.81	1.03	1.18
1988	0.12	0.21	0.34	0.53	0.70	0.85	—	—
1989	0.13	0.27	0.39	0.65	0.92	1.41	1.24	1.24
1990	0.08	0.26	0.37	0.55	0.82	0.90	0.99	1.17
1991	0.12	0.23	0.34	0.53	0.73	0.99	1.06	1.01
1992	0.05	0.13	0.32	0.52	0.61	0.73	1.53	1.91
1993	0.09	0.16	0.36	0.43	0.74	0.95	1.01	1.17
1994	0.08	0.22	0.36	0.49	0.62	0.68	1.04	1.11
1995	0.07	0.22	0.33	0.42	0.61	0.78	1.11	—
1996	0.04	0.19	0.39	0.49	0.53	0.91	1.19	1.18
1997	0.03	0.31	0.38	0.46	0.57	0.77	1.30	1.31
mean	0.09	0.23	0.37	0.51	0.68	0.88	1.16	1.28

Table A11. NEFSC spring survey indices of abundance at age and total biomass (offshore strata 25 and 26; inshore strata 56-66).

	age										mature
year	1	2	3	4	5	6	7	8+	sum	kg/tow	kg/tow
1979	0.55	0.71	1.33	0.85	0.04	0.03	0.00	0.00	3.51	1.20	1.00
1980	0.00	7.14	4.08	1.43	0.29	0.00	0.00	0.00	12.94	4.89	3.69
1981	0.10	6.30	4.27	0.93	1.06	0.51	0.66	0.00	13.83	4.41	3.55
1982	0.08	2.79	7.23	3.71	1.00	0.57	0.63	0.16	16.17	7.16	6.50
1983	2.36	6.33	5.09	2.09	0.22	0.15	0.00	0.00	16.24	4.78	4.03
1984	0.09	2.39	1.42	0.92	0.60	0.05	0.07	0.16	5.70	1.99	1.79
1985	0.13	1.86	1.81	0.43	0.25	0.10	0.00	0.00	4.58	1.37	1.14
1986	0.04	4.33	0.37	0.10	0.24	0.00	0.00	0.00	5.08	1.04	0.69
1987	0.15	3.44	5.15	0.84	1.30	1.31	1.52	0.74	14.45	7.14	7.16
1988	2.13	9.11	1.87	1.22	0.47	0.18	0.08	0.00	15.06	2.51	1.48
1989	0.53	6.33	3.88	0.35	0.17	0.00	0.00	0.00	11.26	1.93	1.36
1990	0.00	5.51	13.35	0.35	0.00	0.24	0.00	0.00	19.45	4.38	2.95
1991	0.96	8.23	5.67	1.80	0.42	0.00	0.11	0.00	17.19	3.76	2.44
1992	0.37	2.25	3.52	0.98	0.04	0.00	0.00	0.00	7.16	1.67	1.34
1993	0.15	1.51	1.75	0.87	0.00	0.00	0.00	0.00	4.28	0.93	0.66
1994	0.80	5.64	2.33	0.90	0.33	0.19	0.00	0.00	10.19	1.79	1.01
1995	0.32	2.10	7.33	4.74	0.46	0.11	0.00	0.00	15.06	3.68	3.00
1996	0.03	0.85	1.18	0.63	0.00	0.00	0.00	0.00	2.69	0.62	0.48
1997	0.05	1.98	3.15	2.54	0.56	0.00	0.00	0.00	8.28	2.43	2.05
1998	0.00	1.71	5.03	1.83	0.42	0.00	0.00	0.00	8.99	2.32	1.90
mean	0.44	4.03	3.99	1.38	0.39	0.17	0.15	0.05	10.61	3.00	2.41

Table A12. NEFSC autumn survey indices of abundance at age and total biomass (offshore strata 25 and 26; inshore strata 56-66).

					age					
year	1	2	3	4	5	6	7	8+	sum	kg/tow
1979	7.87	8.02	2.41	0.60	0.11	0.03	0.00	0.00	19.04	5.34
1980	20.70	17.63	8.00	3.04	0.67	0.00	0.07	0.00	50.11	13.52
1981	6.34	9.64	1.74	0.45	0.29	0.00	0.00	0.00	18.46	4.11
1982	1.13	5.39	5.18	0.63	0.70	0.06	0.00	0.00	13.09	4.32
1983	0.66	0.88	0.55	0.04	0.00	0.00	0.00	0.00	2.13	0.49
1984	0.64	2.25	1.04	1.31	0.93	0.30	0.15	0.15	6.77	2.79
1985	9.03	3.48	2.65	0.40	0.00	0.00	0.00	0.00	15.56	3.25
1986	2.62	7.14	0.60	0.00	0.00	0.00	0.00	0.00	10.36	1.98
1987	1.08	2.60	0.91	0.11	0.09	0.00	0.00	0.00	4.79	1.12
1988	6.16	9.01	0.89	0.17	0.00	0.00	0.00	0.00	16.23	2.29
1989	3.53	11.39	4.19	0.74	0.00	0.00	0.00	0.14	19.99	4.70
1990	7.01	11.90	5.58	0.09	0.02	0.00	0.00	0.00	24.60	4.76
1991	3.57	3.33	2.88	0.59	0.00	0.00	0.00	0.00	10.37	2.34
1992	4.82	5.29	3.68	1.52	0.36	0.27	0.00	0.00	15.94	3.81
1993	8.76	8.60	1.01	0.15	0.00	0.00	0.00	0.00	18.52	2.15
1994	4.78	14.27	5.13	1.40	0.43	0.00	0.00	0.00	26.01	5.38
1995	1.18	1.64	1.57	0.34	0.08	0.00	0.00	0.00	4.81	1.49
1996	2.07	5.36	8.78	2.31	0.26	0.00	0.00	0.00	18.78	5.12
1997	2.07	4.79	5.45	2.46	1.33	0.23	0.00	0.00	16.33	4.63
mean	4.95	6.98	3.28	0.86	0.28	0.05	0.01	0.02	16.42	3.87

Table A13. Massachusetts DMF spring survey indices of abundance at age and total biomass (strata 17-36).

year	1	2	3	4	age 5	6	7	8+	sum	kg/tow	mature kg/tow
1978	2.71	20.69	11.82	1.60	0.63	0.54	0.10	0.13	38.22	10.16	8.60
1979	2.63	22.58	13.85	3.68	0.86	0.00	0.17	0.00	43.77	11.38	9.01
1980	2.68	17.62	10.10	2.30	0.15	0.00	0.00	0.00	32.85	10.03	7.93
1981	5.61	58.83	9.00	2.26	1.59	0.27	0.00	0.00	77.56	16.35	10.34
1982	0.69	17.06	17.04	4.45	0.94	0.06	0.04	0.00	40.28	12.85	11.75
1983	3.13	8.50	11.51	4.28	0.04	0.17	0.03	0.00	27.66	9.00	7.09
1984*	0.57	15.38	8.17	3.51	1.48	0.04	0.06	0.04	29.26	7.37	5.68
1985	1.97	8.27	7.15	1.52	0.59	0.39	0.05	0.05	19.99	5.21	4.22
1986	1.73	15.39	1.74	0.24	0.21	0.04	0.00	0.00	19.36	4.52	2.92
1987	2.53	4.95	5.31	0.97	0.27	0.11	0.08	0.00	14.22	3.67	3.15
1988	3.10	14.46	2.52	0.60	0.05	0.02	0.00	0.00	20.74	3.83	2.06
1989	0.67	22.26	3.18	1.08	0.06	0.00	0.00	0.00	27.25	4.73	2.71
1990	0.63	11.77	15.57	0.63	0.14	0.01	0.02	0.01	28.77	6.60	4.73
1991	0.06	5.34	3.31	2.15	0.48	0.12	0.05	0.00	11.50	3.32	2.61
1992	1.30	11.03	9.71	2.38	1.45	0.03	0.03	0.00	25.94	6.54	5.18
1993	0.63	7.99	6.31	1.94	0.23	0.06	0.20	0.03	17.38	4.60	3.72
1994	2.67	24.02	7.53	1.49	0.33	0.12	0.00	0.00	36.15	6.23	3.72
1995	7.51	14.64	24.96	2.88	1.20	0.02	0.02	0.00	51.22	10.38	7.37
1996	1.17	18.03	14.70	6.78	1.74	0.00	0.04	0.00	42.46	9.25	6.50
1997	0.52	16.94	12.22	4.04	0.54	0.00	0.00	0.00	34.26	7.55	5.52
1998**	0.48	9.54	26.77	2.41	0.32	0.04	0.00	0.00	39.55	5.18	
mean	2.05	16.44	10.59	2.44	0.63	0.10	0.04	0.01	32.30	7.56	5.74

* provisional, based on NEFSC age-length key.

** preliminary estimates, based on unaudited data.

Table A14. Massachusetts DMF autumn survey indices of abundance at age and total biomass (strata 17-36).

	age										
year	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	3.56	8.39	3.06	0.96	0.12	0.00	0.00	0.00	16.09	3.27
1995*	0.00	11.54	11.97	4.71	1.18	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
mean	0.04	7.51	7.38	2.46	0.36	0.04	0.00	0.00	0.00	17.79	3.12

* provisional, based on NEFSC age-length key.

Table A15. Correlations among normalized indices of Cape Cod yellowtail flounder abundance at age.

age-1	NMFSs1	MASSs1	MASSf1	
NMFSs1	1.00			
MASSs1	-0.09	1.00		
MASSf1	0.61	-0.02	1.00	
age-2	NMFSs2	NMFSf2	MASSs2	MASSf2
NMFSs2	1.00			
NMFSf2	0.41	1.00		
MASSs2	0.03	0.14	1.00	
MASSf2	0.20	0.37	0.42	1.00
age-3	NMFSs3	NMFSf3	MASSs3	MASSf3
NMFSs3	1.00			
NMFSf3	0.69	1.00		
MASSs3	0.52	0.13	1.00	
MASSf3	0.53	0.41	0.41	1.00
age-4	NMFSs4	NMFSf4	MASSs4	MASSf4
NMFSs4	1.00			
NMFSf4	0.42	1.00		
MASSs4	0.66	0.33	1.00	
MASSf4	0.25	0.38	0.57	1.00
age-5	NMFSs5	NMFSf5	MASSs5	MASSf5
NMFSs5	1.00			
NMFSf5	0.16	1.00		
MASSs5	-0.19	0.35	1.00	
MASSf5	-0.43	0.24	0.46	1.00
age-6	NMFSs6	NMFSf6	MASSs6	MASSf6
NMFSs6	1.00			
NMFSf6	0.25	1.00		
MASSs6	0.02	0.29	1.00	
MASSf6	-0.51	0.13	0.29	1.00

Table A16. Virtual population analysis estimates of Cape yellowtail flounder abundance (thousands).

	age						
year	1	2	3	4	5	6+	total
1985	9,891	2,702	1,443	657	326	116	15,135
1986	4,712	7,787	1,378	517	65	14	14,473
1987	6,755	3,787	3,068	536	197	89	14,432
1988	21,230	5,518	1,756	744	196	39	29,483
1989	7,700	17,055	2,591	334	43	11	27,734
1990	6,293	6,201	12,035	868	63	50	25,510
1991	9,176	5,079	2,599	1,989	317	73	19,233
1992	7,306	7,097	3,067	803	221	17	18,511
1993	7,455	4,455	2,299	1,120	167	83	15,579
1994	6,839	5,979	3,331	1,107	372	171	17,799
1995	6,554	5,545	4,469	1,550	274	145	18,537
1996	6,829	4,956	3,905	1,504	493	29	17,716
1997	3,397	5,585	3,563	1,908	424	32	14,909
1998	—	2,780	3,776	1,617	821	196	—
mean	8,011	6,038	3,520	1,090	284	76	19,018

Table A17. Virtual population analysis estimates of fishing mortality of Cape yellowtail flounder.

	age						age-1+
	1	2	3	4	5	age-4+	on biomass
1985	0.04	0.47	0.83	2.11	2.40	2.26	0.48
1986	0.02	0.73	0.74	0.76	0.78	0.77	0.60
1987	0.00	0.57	1.22	0.80	0.82	0.81	0.72
1988	0.02	0.56	1.46	2.64	3.43	3.04	0.40
1989	0.02	0.15	0.89	1.47	1.56	1.52	0.24
1990	0.01	0.67	1.60	0.81	0.83	0.82	1.09
1991	0.06	0.30	0.97	2.00	2.23	2.12	0.66
1992	0.29	0.93	0.81	1.37	1.45	1.41	0.86
1993	0.02	0.09	0.53	0.90	0.93	0.92	0.34
1994	0.01	0.09	0.56	1.20	1.25	1.23	0.40
1995	0.08	0.15	0.89	0.95	0.97	0.96	0.53
1996	0.00	0.13	0.52	1.07	1.10	1.09	0.48
1997	0.00	0.19	0.59	0.64	0.64	0.64	0.41
mean	0.04	0.39	0.89	1.29	1.41	1.35	0.55

Table A18. Virtual population analysis estimates of Cape yellowtail flounder biomass (mt).

			age				
year	1	2	3	4	5	6+	total
1985	930	611	429	263	177	92	2,500
1986	306	1,402	478	226	39	14	2,465
1987	216	587	969	261	116	81	2,230
1988	1,698	618	502	342	122	33	3,316
1989	693	3,070	741	157	30	14	4,705
1990	296	1,160	3,803	325	45	48	5,678
1991	1,055	691	788	881	163	74	3,652
1992	205	887	831	338	126	20	2,406
1993	418	397	497	415	103	83	1,912
1994	356	861	800	465	192	142	2,815
1995	275	865	1,211	558	148	116	3,174
1996	96	570	1,265	589	215	30	2,765
1997	27	620	958	799	220	26	2,651
mean	505	949	1,021	432	130	59	3,098

Table A19. Virtual population analysis estimates of Cape yellowtail flounder spawning stock biomass (mt).

			age				
year	1	2	3	4	5	6+	total
1985	0	46	275	123	66	31	541
1986	0	106	324	183	32	9	654
1987	0	53	551	194	84	53	935
1988	0	68	243	121	30	7	469
1989	0	319	519	108	19	7	972
1990	0	93	1,706	205	33	32	2,069
1991	0	76	439	423	84	27	1,049
1992	0	46	523	217	68	10	864
1993	0	51	495	304	77	52	978
1994	0	97	707	303	126	78	1,311
1995	0	104	736	346	101	71	1,358
1996	0	66	916	426	152	17	1,577
1997	0	118	789	604	167	18	1,697
mean	0	96	633	274	80	32	1,113

Table A20. Summary of results from alternative ADAPT calibrations of the Cape Cod yellowtail flounder virtual population analysis.

run#	2	3	4	6	7	9	10	11	12	13	14*
tuning indices											
NMFSs	1-6+	1-5	1-4	1-5	2-4	1-5	1-4	1-5	1-4	2-5	2-5
NMFSf	2-6+	2-5	2-4	2-5	2-4	2-5	2-5	2-5	2-4	2-5	2-5
MASSs	1-6+	1-5	1-4	1-6+	1-5	1-5	1-5	—	1-4	1-4	1-4
MASSf	1-6+	1-5	1-4	2-5	2-5	2-5	2-5	—	2-4	2-4	2-4
M	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2
results											
N 2	2163	2161	2257	2384	2751	2364	2372	2271	2454	3278	2780
N 3	3063	3059	3217	3053	3767	2998	3010	1989	3124	4163	3776
N 4	1688	1684	1834	1669	1633	1591	1602	1376	1711	1744	1617
N 5	472	449	1547	322	281	438	512	646	1309	841	821
CV(N2)	36%	35%	30%	37%	37%	36%	36%	50%	31%	36%	36%
CV(N3)	34%	33%	28%	32%	31%	32%	32%	46%	27%	29%	29%
CV(N4)	37%	35%	30%	35%	33%	35%	34%	49%	29%	31%	32%
CV(N5)	33%	40%	39%	38%	53%	39%	42%	50%	42%	38%	39%
mean square	0.817	0.753	0.562	0.742	0.637	0.714	0.702	0.676	0.526	0.579	0.586
retro pattern	Y	Y	Y	Y	Y	Y	Y	N	Y	N	N
F4+,97	0.94	0.98	0.39	1.19	1.29	0.99	0.90	0.76	0.45	0.61	0.64
SSB97	1454	1435	2255	1333	1307	1392	1451	1437	2047	1851	1697

* configuration accepted by SARC and reported in Appendix A.

Table A21. Yield and spawning biomass per recruit estimates for Cape Cod 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: 10-12-1998; Time: 09:01:00.96
CAPE COD YELLOWTAIL FLOUNDER - SAW28

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:
==> CCYT8.DAT

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0200	1.0000	.0000	.056	.056
2	.1400	1.0000	.0800	.235	.235
3	.6600	1.0000	.8100	.365	.365
4	1.0000	1.0000	1.0000	.463	.463
5	1.0000	1.0000	1.0000	.582	.582
6	1.0000	1.0000	1.0000	.785	.785
7	1.0000	1.0000	1.0000	1.162	1.162
8+	1.0000	1.0000	1.0000	1.198	1.198

Summary of Yield per Recruit Analysis for:
CAPE COD YELLOWTAIL FLOUNDER - SAW28

Slope of the Yield/Recruit Curve at F=0.00: --> 2.6950
F level at slope=1/10 of the above slope (F0.1): -----> .208
Yield/Recruit corresponding to F0.1: -----> .2098
F level to produce Maximum Yield/Recruit (Fmax): -----> .469
Yield/Recruit corresponding to Fmax: -----> .2316
F level at 20 % of Max Spawning Potential (F20): -----> .448
SSB/Recruit corresponding to F20: --------> .5515

Listing of Yield per Recruit Results for:
CAPE COD YELLOWTAIL FLOUNDER - SAW28

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	3.2772	3.3453	2.7580	100.00
F0.1	.21	.33681	.20978	3.8432	1.5182	1.6792	1.0526	38.17
-	.25	.36734	.21882	3.6925	1.3771	1.5300	.9191	33.32
Fmax	.47	.46798	.23161	3.1988	.9563	1.0449	.5276	19.13
F20%	.45	.46109	.23157	3.2324	.9825	1.0777	.5515	20.00
	.50	.47740	.23147	3.1529	.9213	1.0003	.4957	17.97
	.75	.53284	.22697	2.8849	.7344	.7430	.3279	11.89
	1.00	.56749	.22201	2.7196	.6357	.5888	.2418	8.77
	1.25	.59190	.21809	2.6046	.5744	.4852	.1900	6.89
	1.50	.61044	.21497	2.5181	.5321	.4104	.1553	5.63
	1.75	.62525	.21234	2.4495	.5006	.3535	.1303	4.72
	2.00	.63753	.21002	2.3931	.4759	.3087	.1114	4.04
	2.25	.64798	.20789	2.3453	.4557	.2724	.0966	3.50
	2.50	.65706	.20590	2.3039	.4388	.2425	.0847	3.07
	2.75	.66509	.20402	2.2674	.4242	.2174	.0749	2.72
	3.00	.67228	.20222	2.2347	.4115	.1960	.0667	2.42
	3.25	.67878	.20049	2.2052	.4002	.1776	.0597	2.16
	3.50	.68473	.19882	2.1782	.3900	.1616	.0537	1.95
	3.75	.69020	.19720	2.1533	.3808	.1477	.0486	1.76
	4.00	.69526	.19563	2.1302	.3724	.1354	.0440	1.60
	4.25	.69998	.19411	2.1086	.3646	.1245	.0401	1.45
	4.50	.70440	.19263	2.0884	.3574	.1148	.0366	1.33
	4.75	.70856	.19118	2.0693	.3506	.1062	.0335	1.22
	5.00	.71248	.18977	2.0512	.3443	.0985	.0308	1.12

Table A22. Estimates of relative biomass (expressed as a ratio to B_{MSY}) and relative fishing mortality (expressed as a ratio to F_{MSY}) and VPA estimates of mean biomass and fishing mortality on biomass.

year	B/Bmsy	F/Fmsy	mean biomass	F on biomass
1968	1.54	0.59		
1969	1.51	0.42		
1970	1.52	0.40		
1971	1.54	0.65		
1972	1.50	0.43		
1973	1.52	0.46		
1974	1.52	0.62		
1975	1.49	0.57		
1976	1.47	1.09		
1977	1.35	1.11		
1978	1.25	1.44		
1979	1.12	1.89		
1980	0.95	2.93		
1981	0.69	2.50		
1982	0.56	3.00		
1983	0.43	2.24		
1984	0.38	1.19		
1985	0.41	1.00	2,247	0.48
1986	0.46	1.21	2,288	0.60
1987	0.48	1.12	1,974	0.72
1988	0.52	1.06	3,569	0.40
1989	0.56	0.93	5,533	0.24
1990	0.61	3.32	3,958	1.09
1991	0.44	1.83	2,950	0.66
1992	0.42	1.44	1,746	0.86
1993	0.43	0.64	2,223	0.34
1994	0.50	0.92	2,962	0.40
1995	0.56	1.04	2,882	0.53
1996	0.60	0.83	2,717	0.48
1997	0.66	0.78	3,235	0.41
mean 85-94	0.48	1.35	2,945	0.58

Table A23. Stochastic projection of Cape Cod yellowtail flounder, assuming status quo F in 1999.

PROJECTION RUN: Cape Cod yellowtail
INPUT FILE: ccytfsq.in
OUTPUT FILE: ccytfsq.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		1.320
1999	1.010	
2000	1.010	

JAN 1 STOCK BIOMASS (THOUSAND MT)

YEAR	AVG B (000 MT)	STD
1998	2.919	.456
1999	2.786	.685
2000	3.062	.795

PERCENTILES OF JAN 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.985	2.214	2.357	2.604	2.884	3.197	3.512	3.722	4.116
1999	1.512	1.800	1.975	2.306	2.702	3.176	3.717	4.109	4.692
2000	1.902	2.170	2.317	2.570	2.863	3.248	4.360	4.890	5.430

ANNUAL PROBABILITY THAT B EXCEEDS THRESHOLD: 6.100000 THOUSAND MT

YEAR	Pr(B > Threshold Value)
1998	.000
1999	.000
2000	.005

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	8001.269	4129.533
1999	8018.301	4130.094
2000	8013.215	4136.996

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
1999	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
2000	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	1.319	.001
1999	1.090	.322
2000	1.182	.343

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320
1999	.424	.595	.691	.867	1.065	1.294	1.521	1.623	1.971
2000	.670	.799	.870	.979	1.116	1.269	1.497	2.116	2.329

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.274	.037
1999	.263	.073
2000	.340	.112

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.200	.222	.230	.247	.271	.298	.322	.341	.372
1999	.151	.181	.195	.217	.249	.286	.348	.450	.502
2000	.189	.222	.242	.280	.308	.352	.528	.612	.661

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	1.078	.341
1999	1.010	.000
2000	1.010	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.579	.678	.731	.850	1.010	1.229	1.493	1.702	2.330
1999	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010
2000	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010	1.010

Table A24. Stochastic projection of Cape Cod yellowtail flounder, assuming threshold F in 1999.

PROJECTION RUN: Cape Cod yellowtail
INPUT FILE: ccytfth.in
OUTPUT FILE: ccytfth.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		1.320
1999	.230	
2000	.230	

JAN 1 STOCK BIOMASS (THOUSAND MT)

YEAR	AVG B (000 MT)	STD
1998	2.919	.456
1999	2.786	.685
2000	3.991	.946

PERCENTILES OF JAN 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.985	2.214	2.357	2.604	2.884	3.197	3.512	3.722	4.116
1999	1.512	1.800	1.975	2.306	2.702	3.176	3.717	4.109	4.692
2000	2.443	2.811	3.009	3.366	3.795	4.365	5.397	6.023	6.803

ANNUAL PROBABILITY THAT B EXCEEDS THRESHOLD: 6.100000 THOUSAND MT

YEAR	Pr(B > Threshold Value)
1998	.000
1999	.000
2000	.045

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	8001.269	4129.533
1999	8018.301	4130.094
2000	8013.215	4136.996

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
1999	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
2000	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	1.319	.001
1999	.332	.101
2000	.521	.134

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320
1999	.123	.175	.207	.262	.324	.396	.464	.502	.607
2000	.290	.344	.374	.433	.501	.582	.703	.810	.930

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.274	.037
1999	.071	.019
2000	.107	.034

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.200	.222	.230	.247	.271	.298	.322	.341	.372
1999	.041	.048	.052	.059	.068	.078	.095	.115	.130
2000	.062	.072	.078	.089	.099	.112	.153	.195	.210

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	1.078	.341
1999	.230	.000
2000	.230	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.579	.678	.731	.850	1.010	1.229	1.493	1.702	2.330
1999	.230	.230	.230	.230	.230	.230	.230	.230	.230
2000	.230	.230	.230	.230	.230	.230	.230	.230	.230

Table A25. Stochastic projection of Cape Cod yellowtail flounder, assuming target F in 1999.

PROJECTION RUN: Cape Cod yellowtail
INPUT FILE: ccytf0.in
OUTPUT FILE: ccytf0.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		1.320
1999	.000	
2000	.000	

JAN 1 STOCK BIOMASS (THOUSAND MT)

YEAR	AVG B (000 MT)	STD
1998	2.919	.456
1999	2.786	.685
2000	4.392	1.020

PERCENTILES OF JAN 1 STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.985	2.214	2.357	2.604	2.884	3.197	3.512	3.722	4.116
1999	1.512	1.800	1.975	2.306	2.702	3.176	3.717	4.109	4.692
2000	2.658	3.071	3.291	3.708	4.201	4.851	5.870	6.508	7.386

ANNUAL PROBABILITY THAT B EXCEEDS THRESHOLD: 6.100000 THOUSAND MT

YEAR	Pr(B > Threshold Value)
1998	.000
1999	.000
2000	.081

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	8001.269	4129.533
1999	8018.301	4130.094
2000	8013.215	4136.996

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
1999	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000
2000	3397.000	3397.000	4712.000	6554.000	6839.000	7700.000	9891.000	21230.000	21230.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	1.319	.001
1999	.000	.000
2000	.000	.000

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320	1.320
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.274	.037
1999	.000	.000
2000	.000	.000

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.200	.222	.230	.247	.271	.298	.322	.341	.372
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	1.078	.341
1999	.000	.000
2000	.000	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.579	.678	.731	.850	1.010	1.229	1.493	1.702	2.330
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

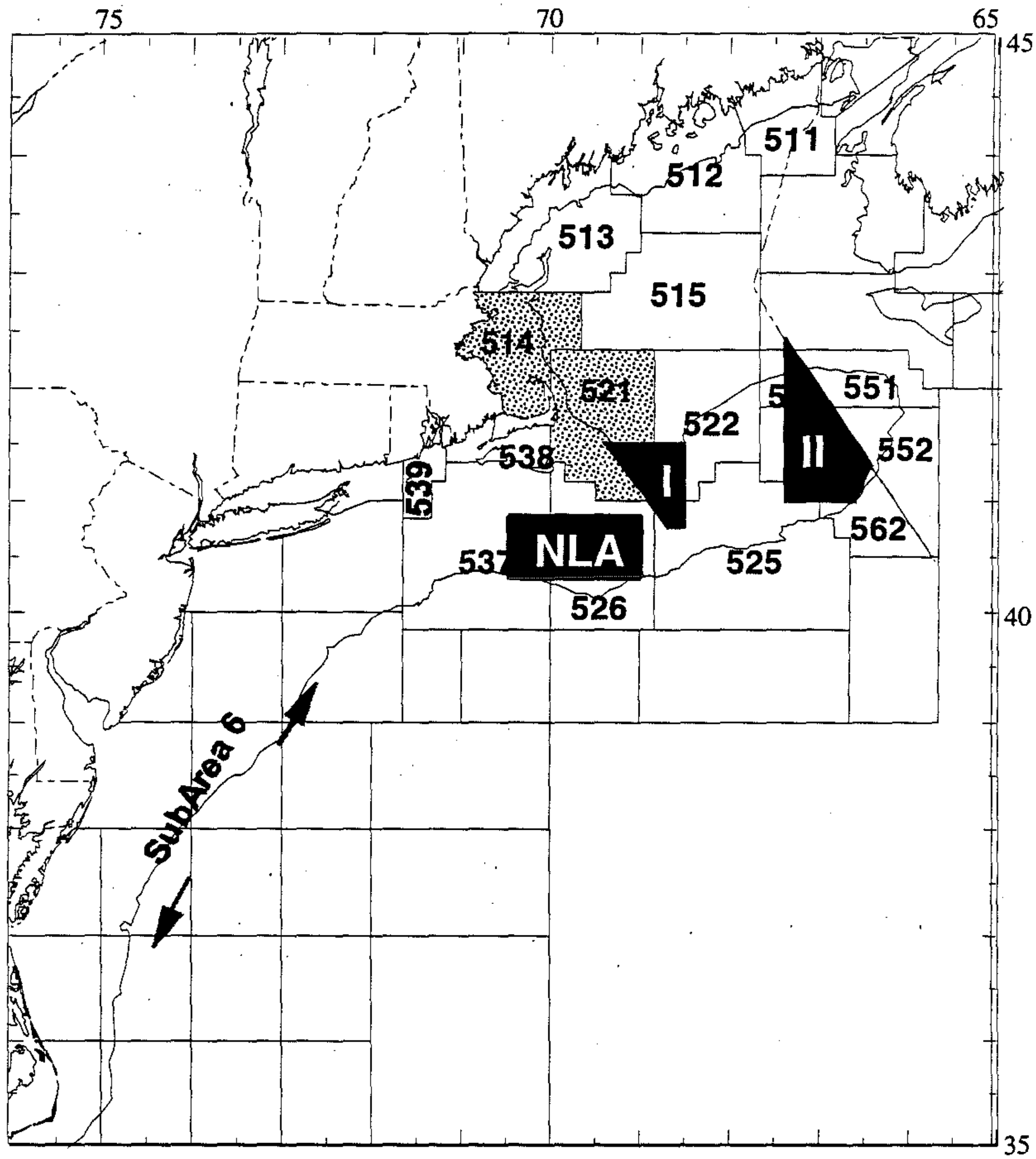


Figure A1. Statistical areas used for monitoring northeast fisheries. Catches from stippled areas are included in the Cape Cod yellowtail flounder assessment.

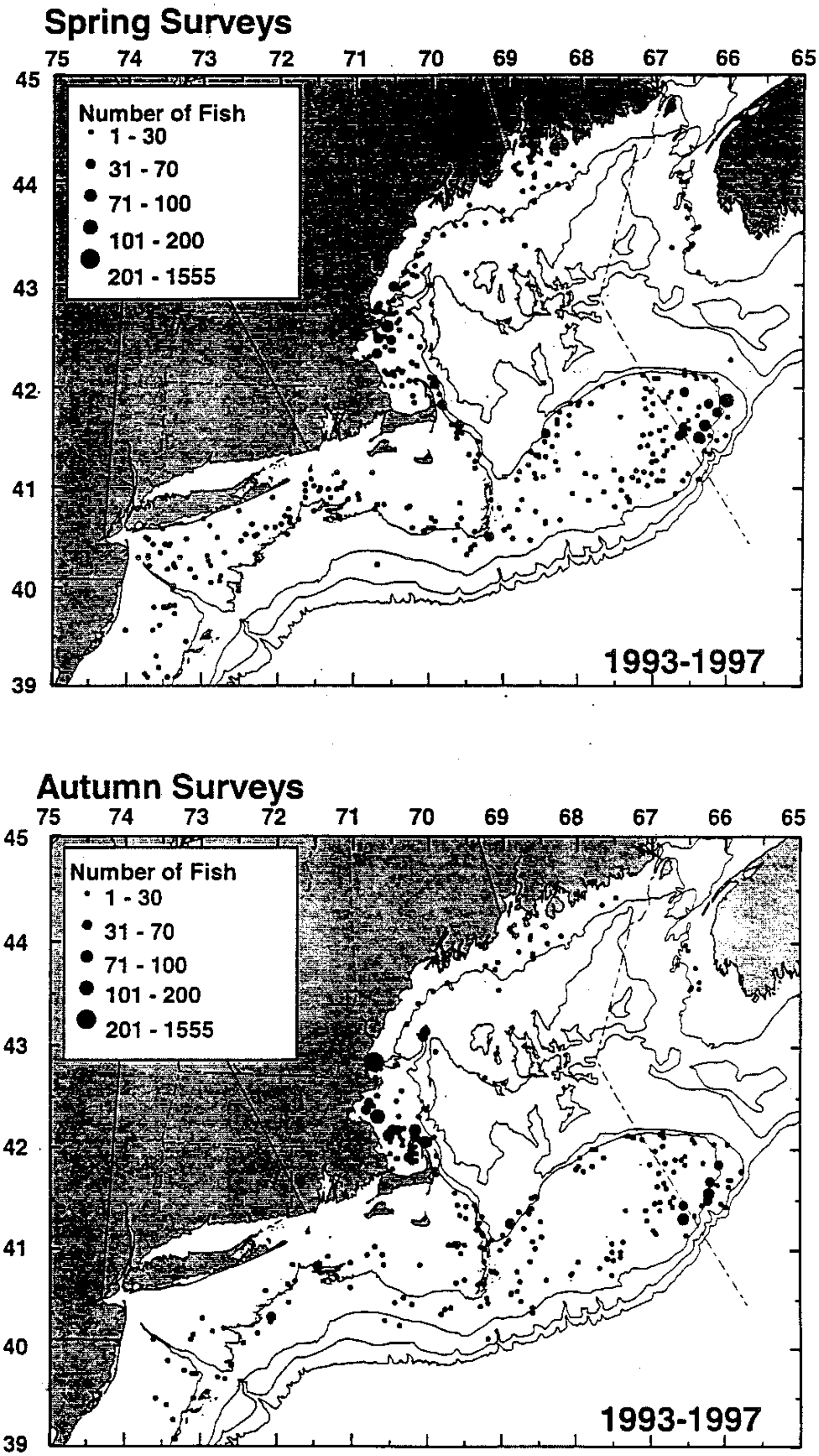


Figure A.2 Distribution of Cape Cod yellowtail flounder in the NEFSC spring and autumn bottom trawl surveys.

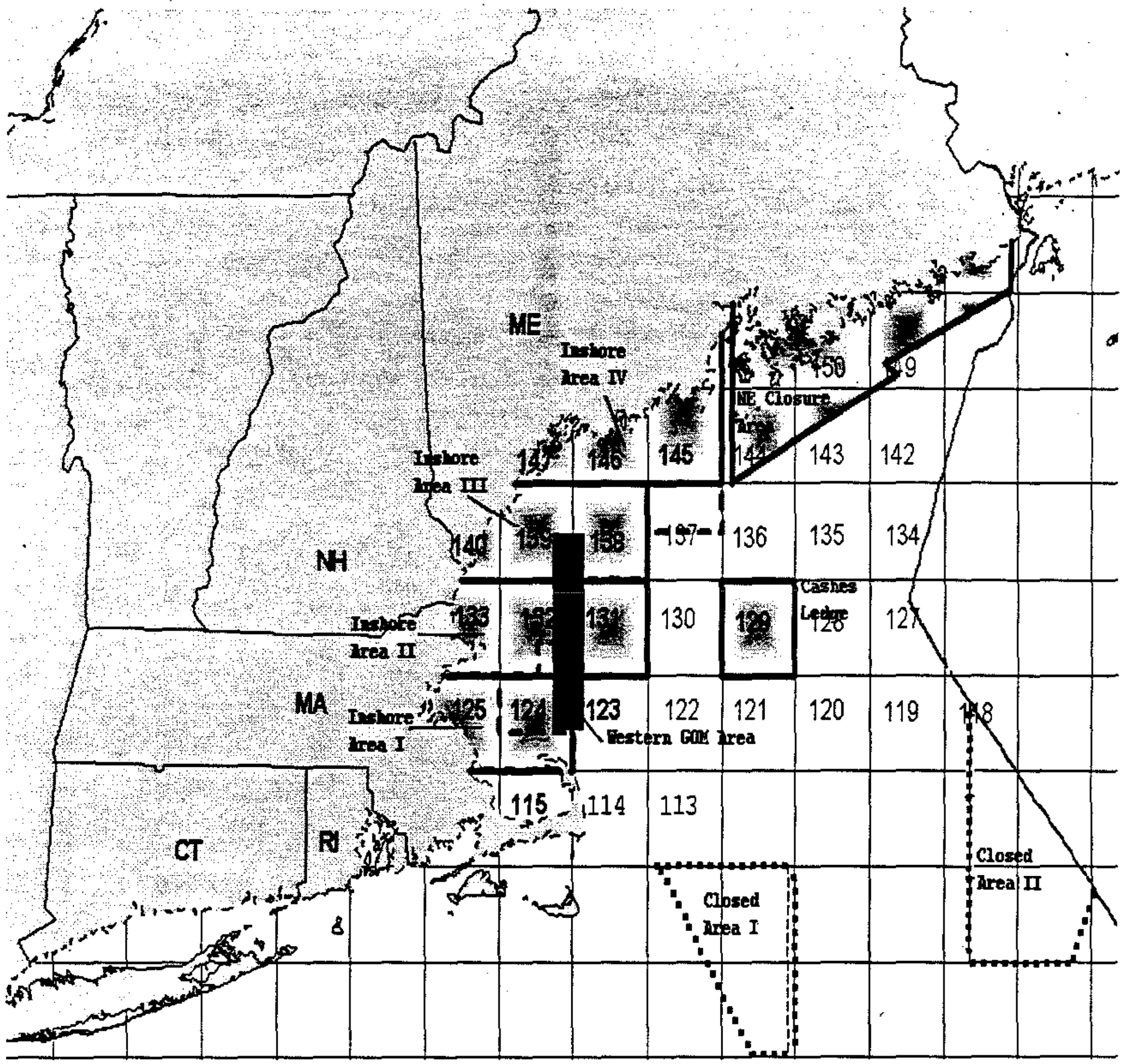
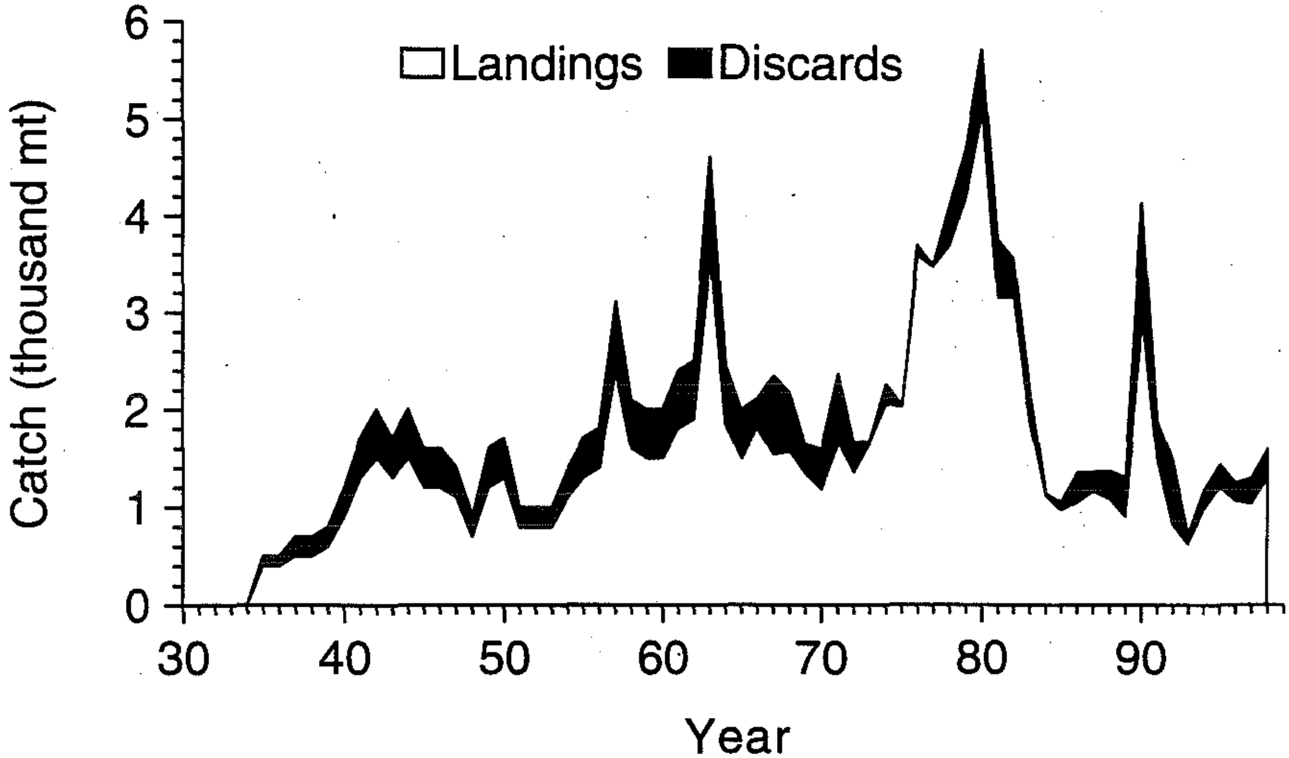


Figure A3. Boundaries of existing Multispecies FMP area closures. Quarter-degree square blocks are numbered sequentially to describe and evaluate proposed area closures. Shaded blocks represent the Gulf of Maine Inshore Closure Areas, the Cashes Ledge Closure Area, and the Northeast Closure Area. Dashed lines in the Gulf of Maine indicate the boundaries of the Massachusetts Bay and Mid-Coast Closure Areas.



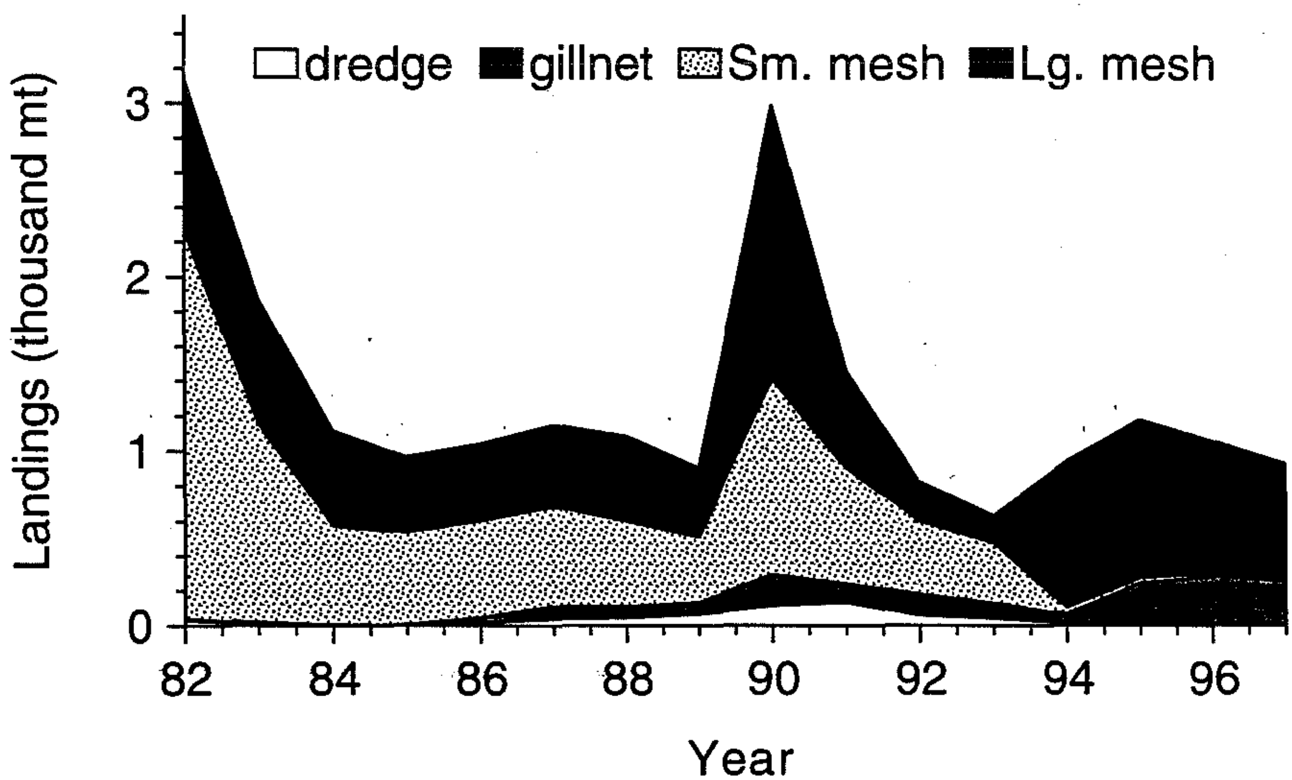
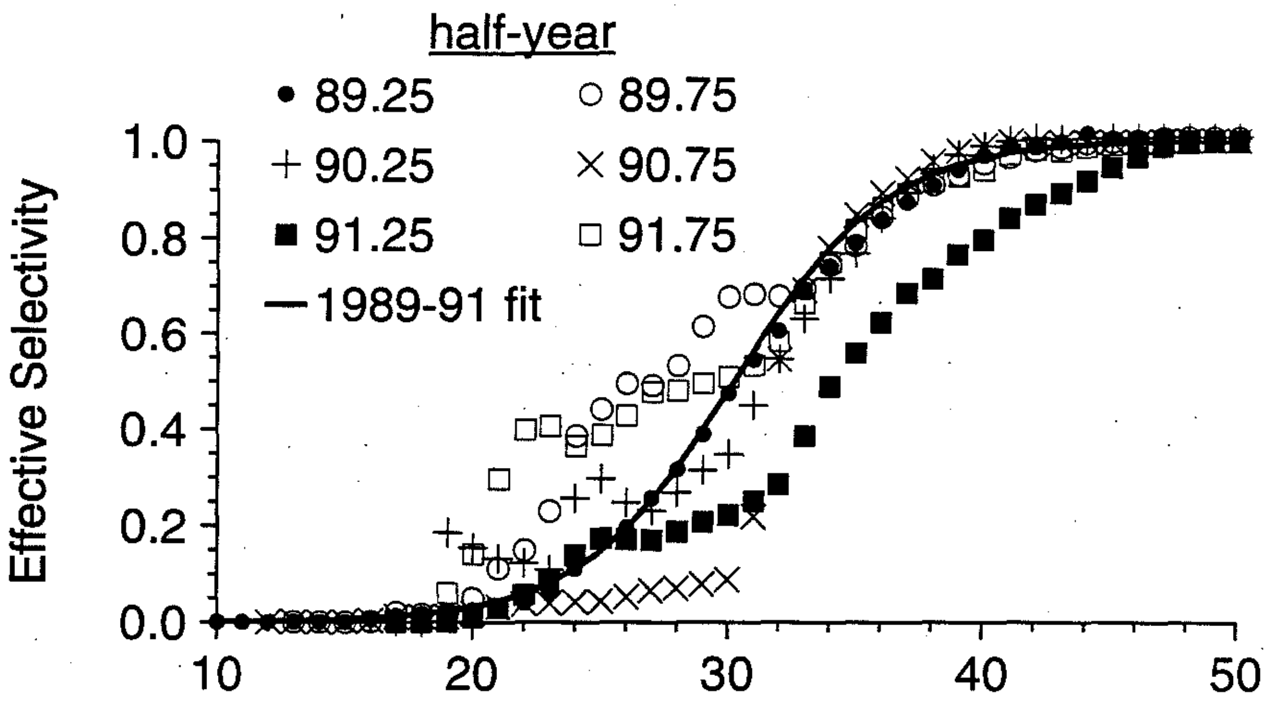


Figure A4. Landings and discards of Cape Cod yellowtail flounder (above) and landings by gear type (below).



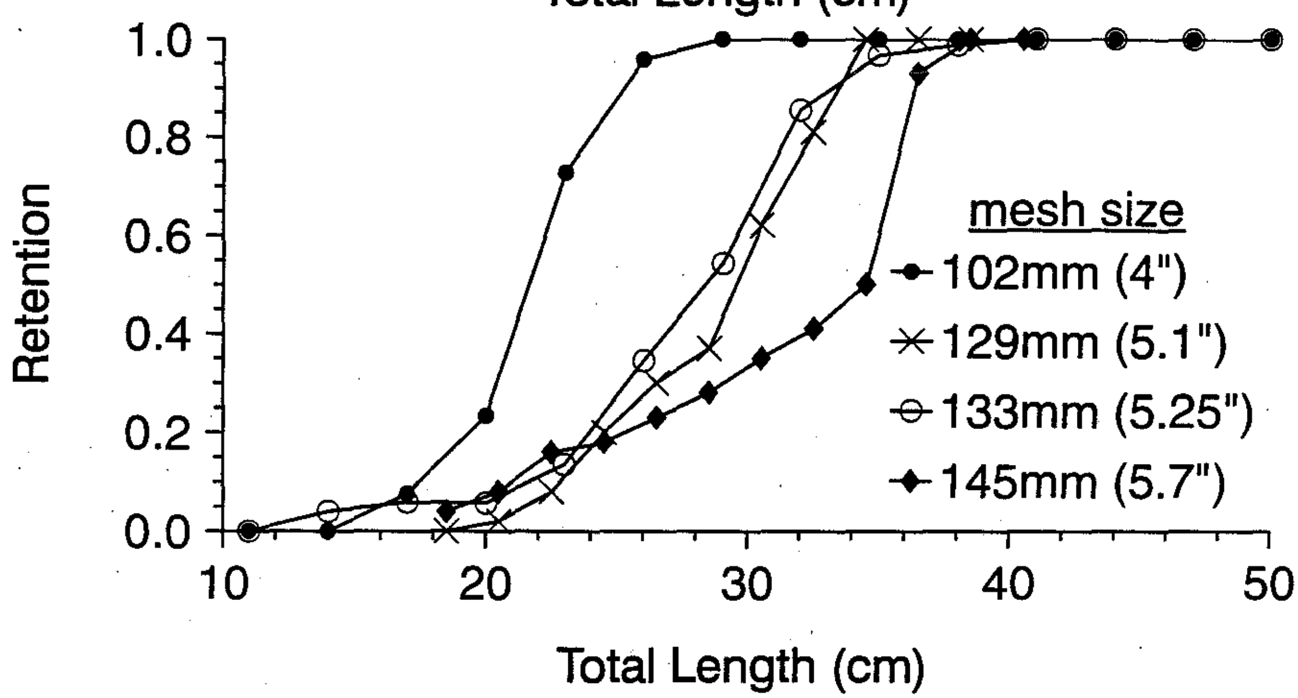


Figure A5. Effective selectivity of the Cape Cod yellowtail fishery, 1989-1993, by half-year (above) and retention of yellowtail flounder by several mesh sizes from Smolwitz (1979) and Lux (1968; below).

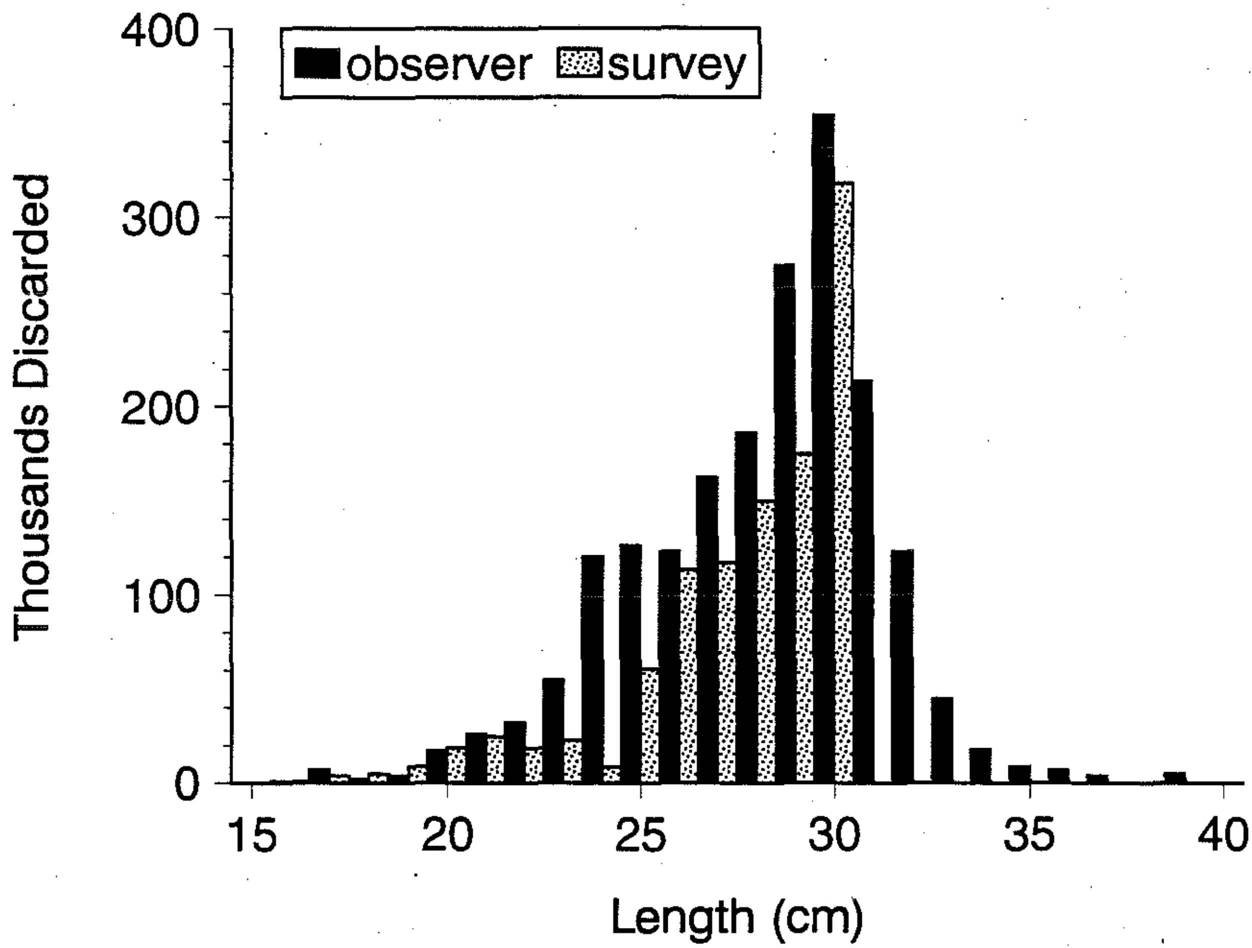


Figure A6. Estimates of discards at length of Cape Cod yellowtail flounder in 1989 using two estimation methods for all gear types combined.

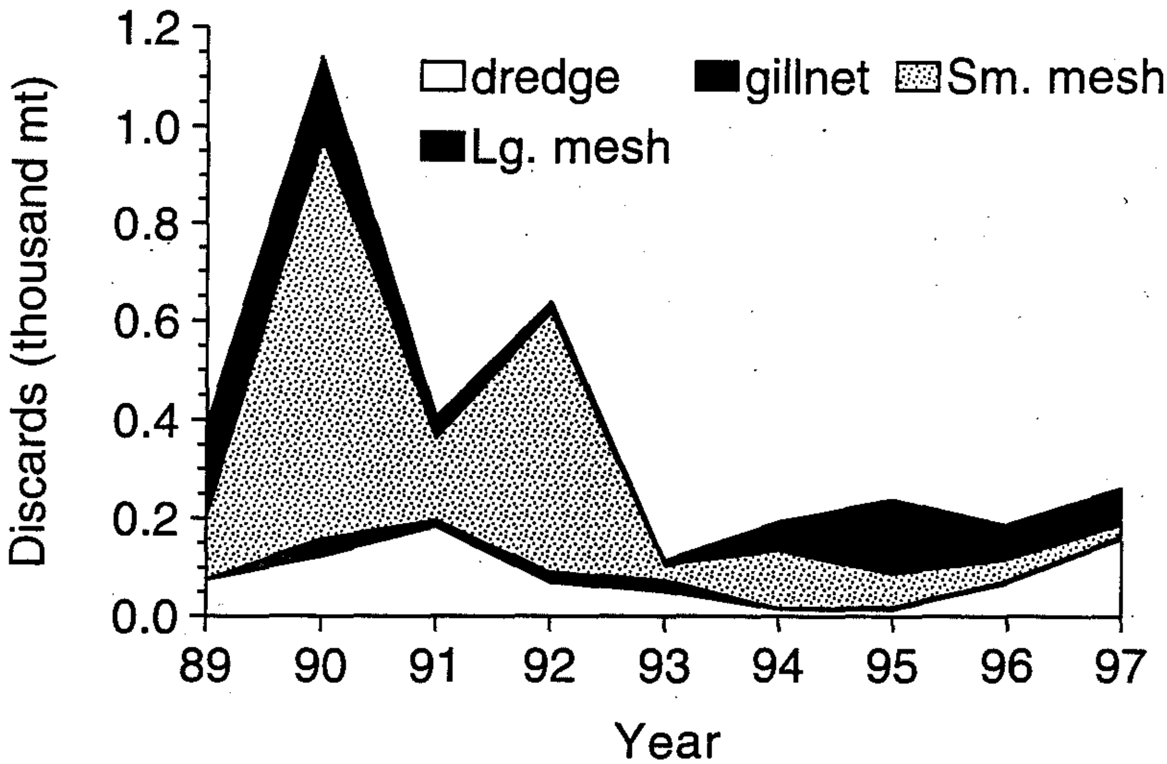


Figure A7. Discards of Cape Cod yellowtail flounder by gear type.

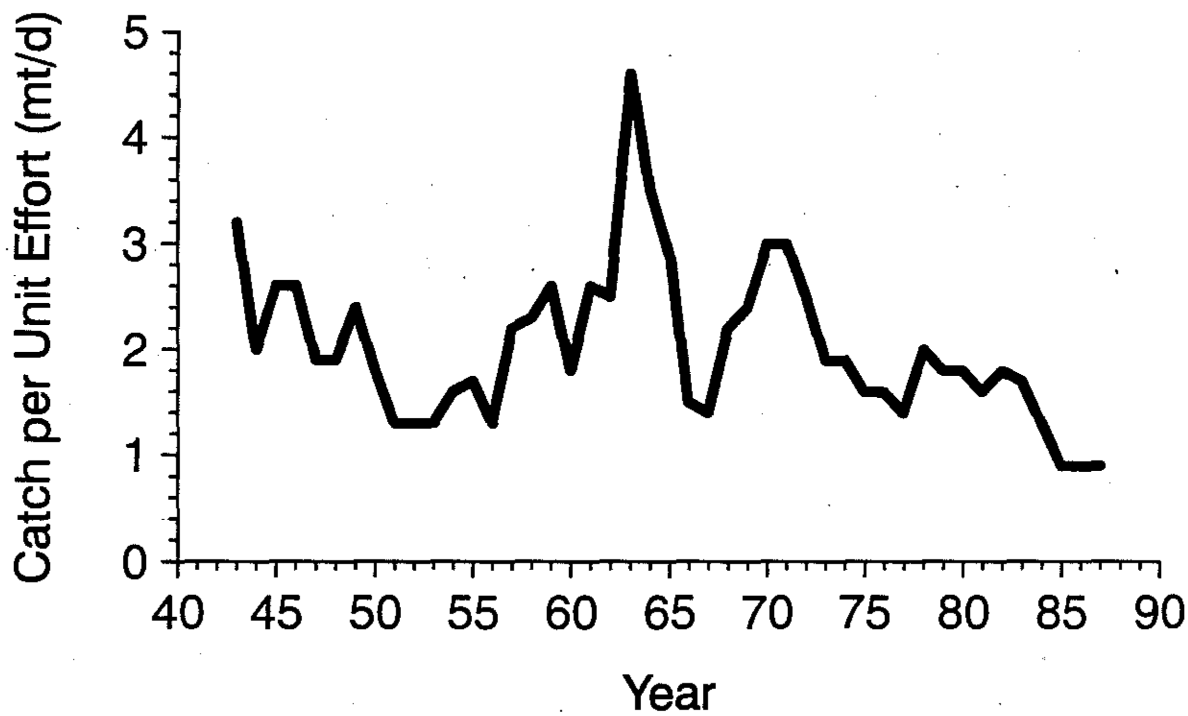


Figure A8. Standardized catch per unit effort of Cape Cod yellowtail flounder.

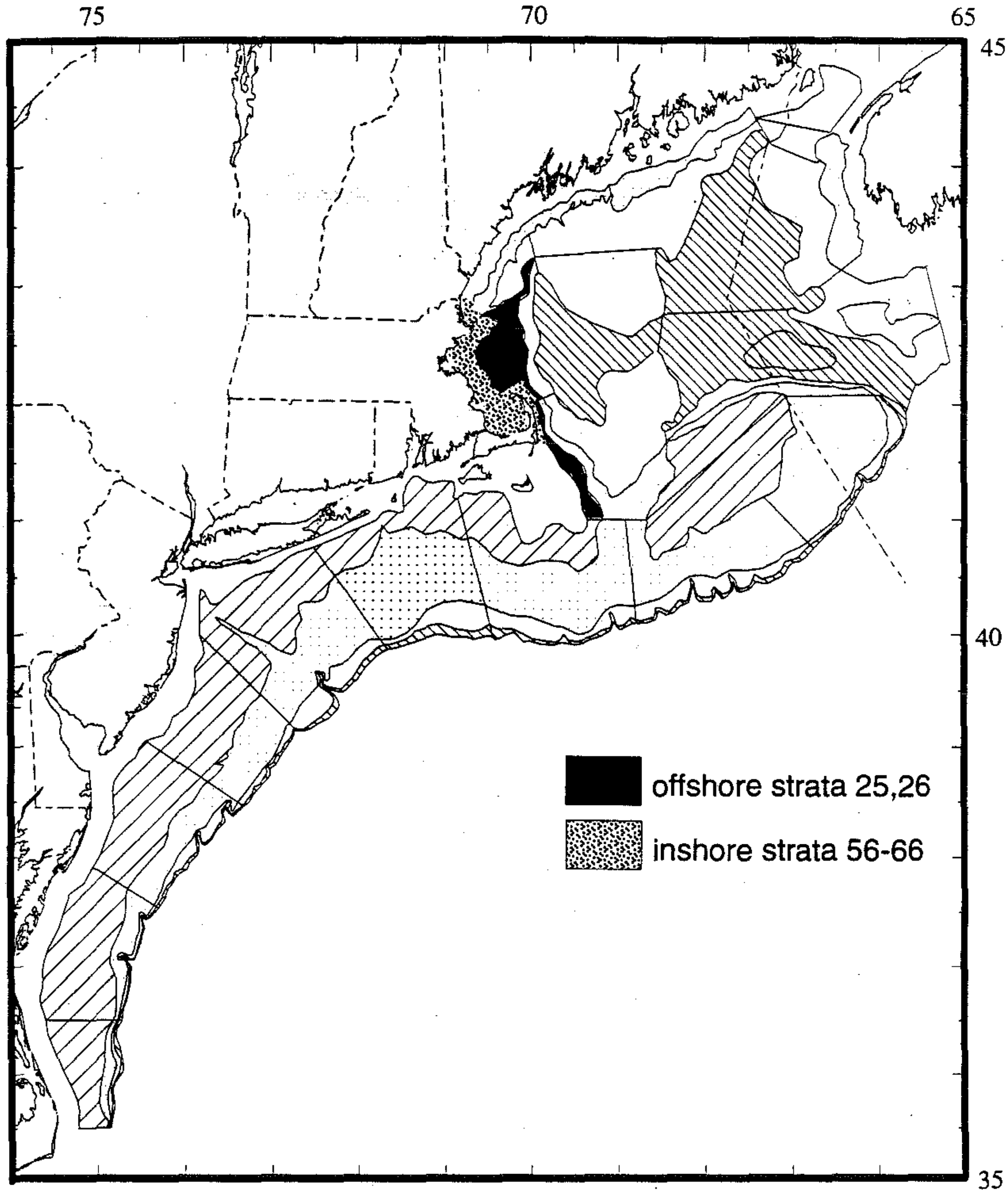


Figure A9. NEFSC bottom trawl survey strata. Stations in the shaded strata are included in the Cape Cod yellowtail flounder assessment

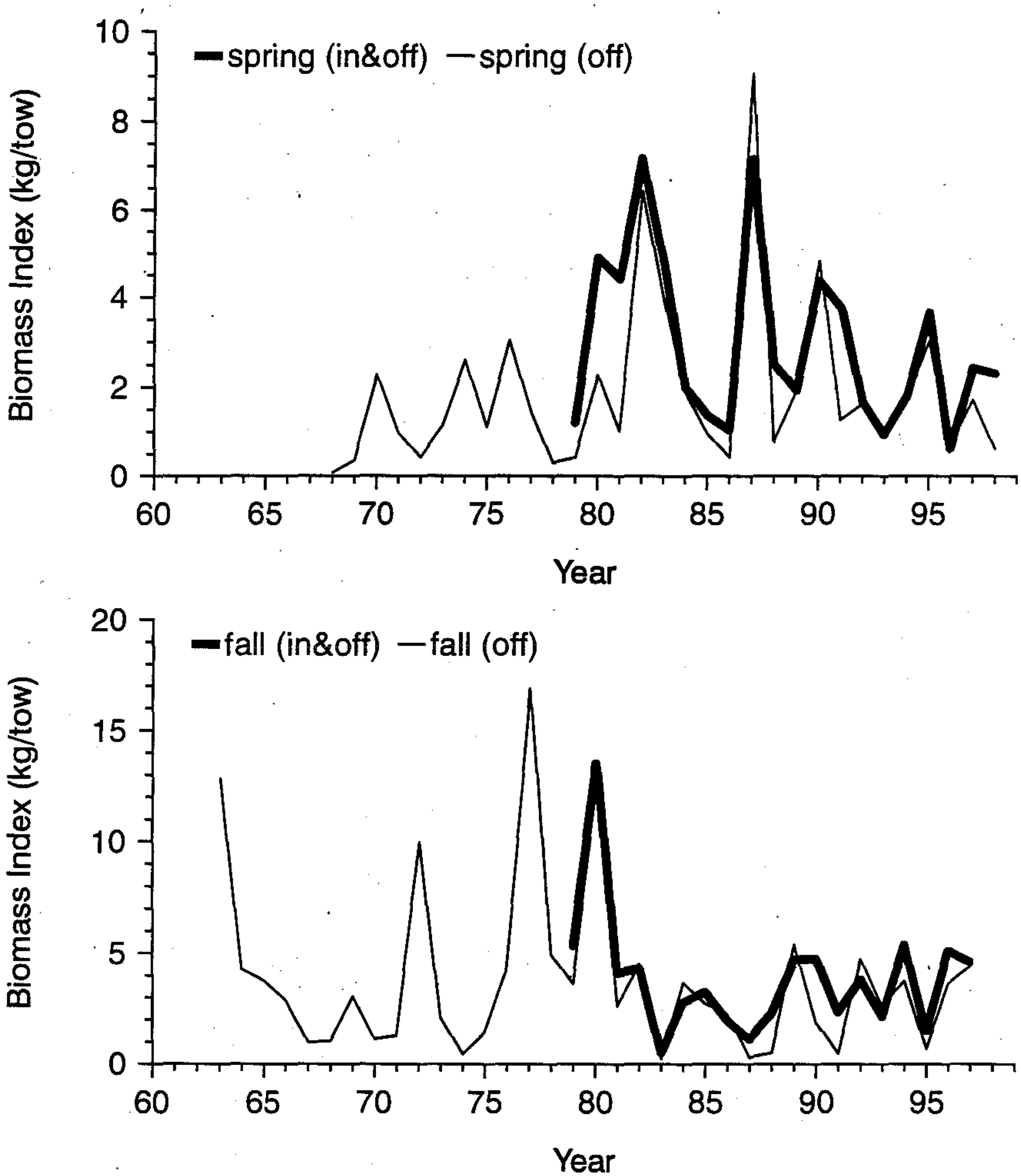


Figure A10. NEFSC survey indices of Cape Cod yellowtail flounder biomass (offshore strata: 25 and 26; inshore strata 56-66.

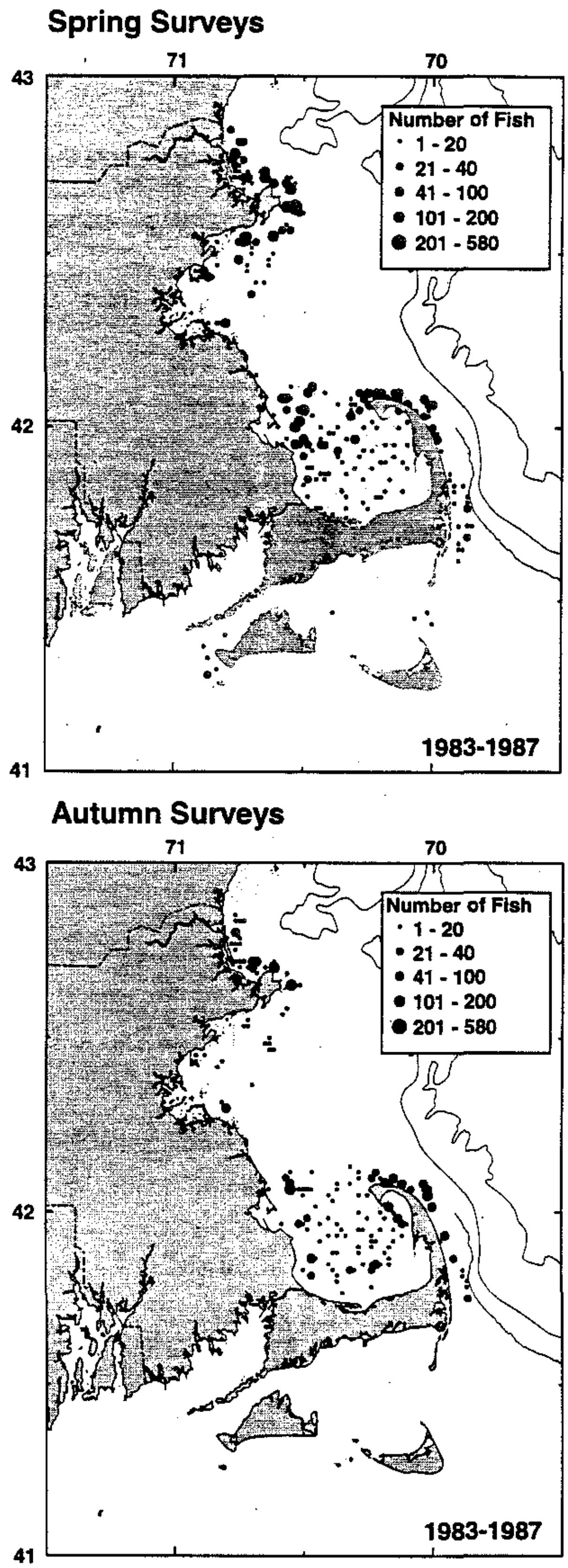


Figure A11. Distribution of Cape Cod yellowtail flounder in the MADMF spring and autumn bottom trawl surveys.

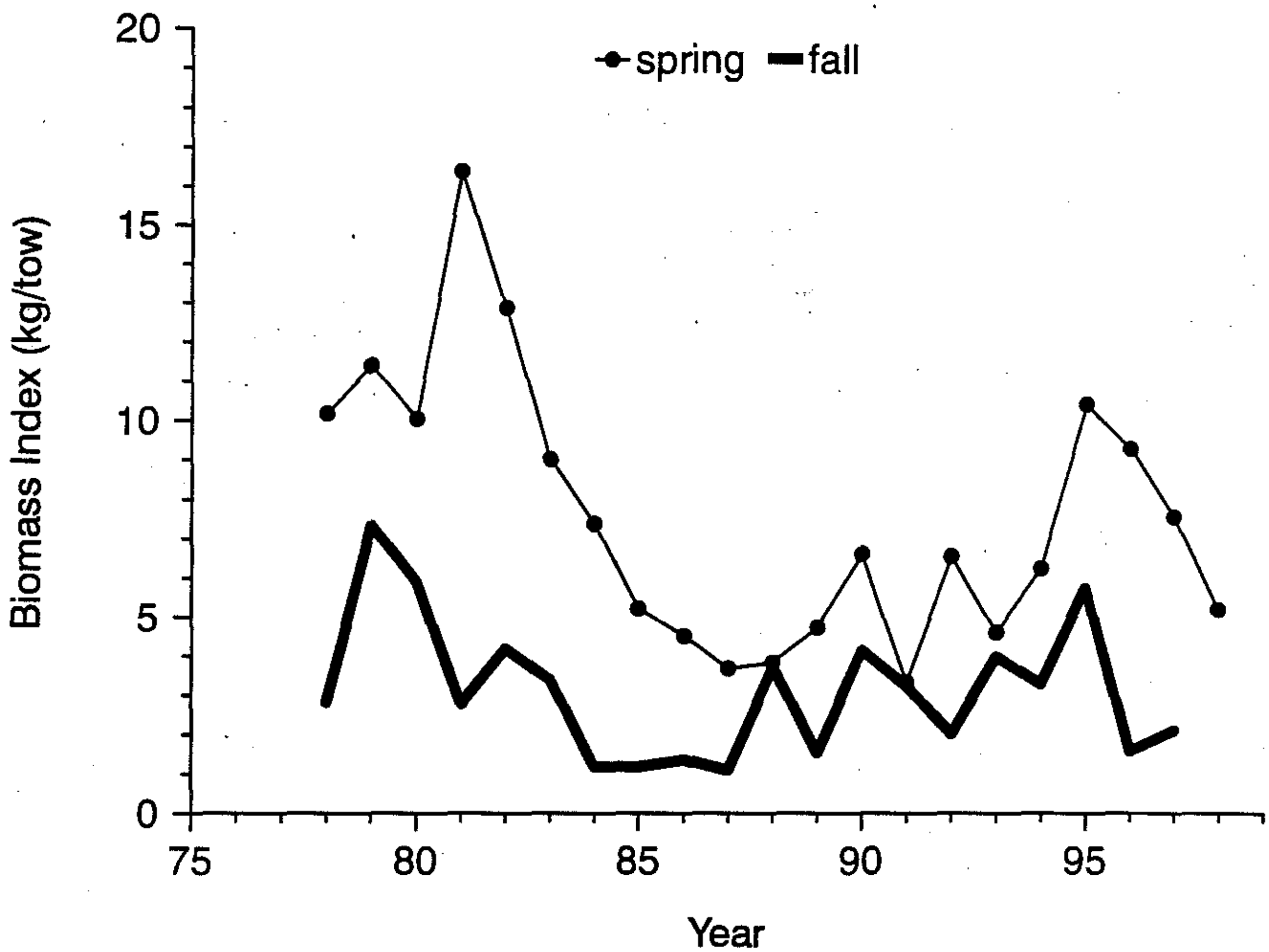


Figure A12. Massachusetts survey indices of Cape Cod yellowtail flounder biomass (strata 17-36).

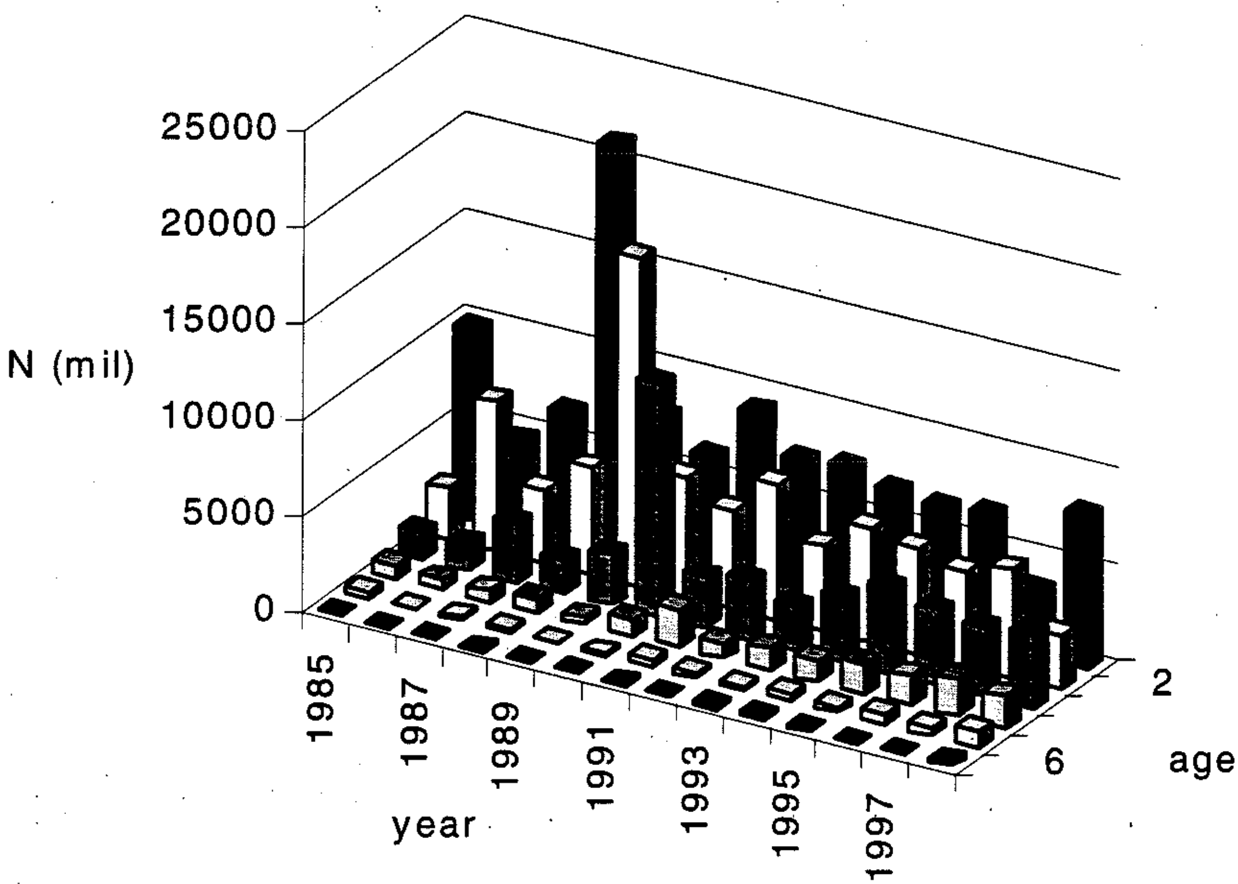


Figure A13. Estimated abundance at age of Cape Cod yellowtail flounder from VPA.

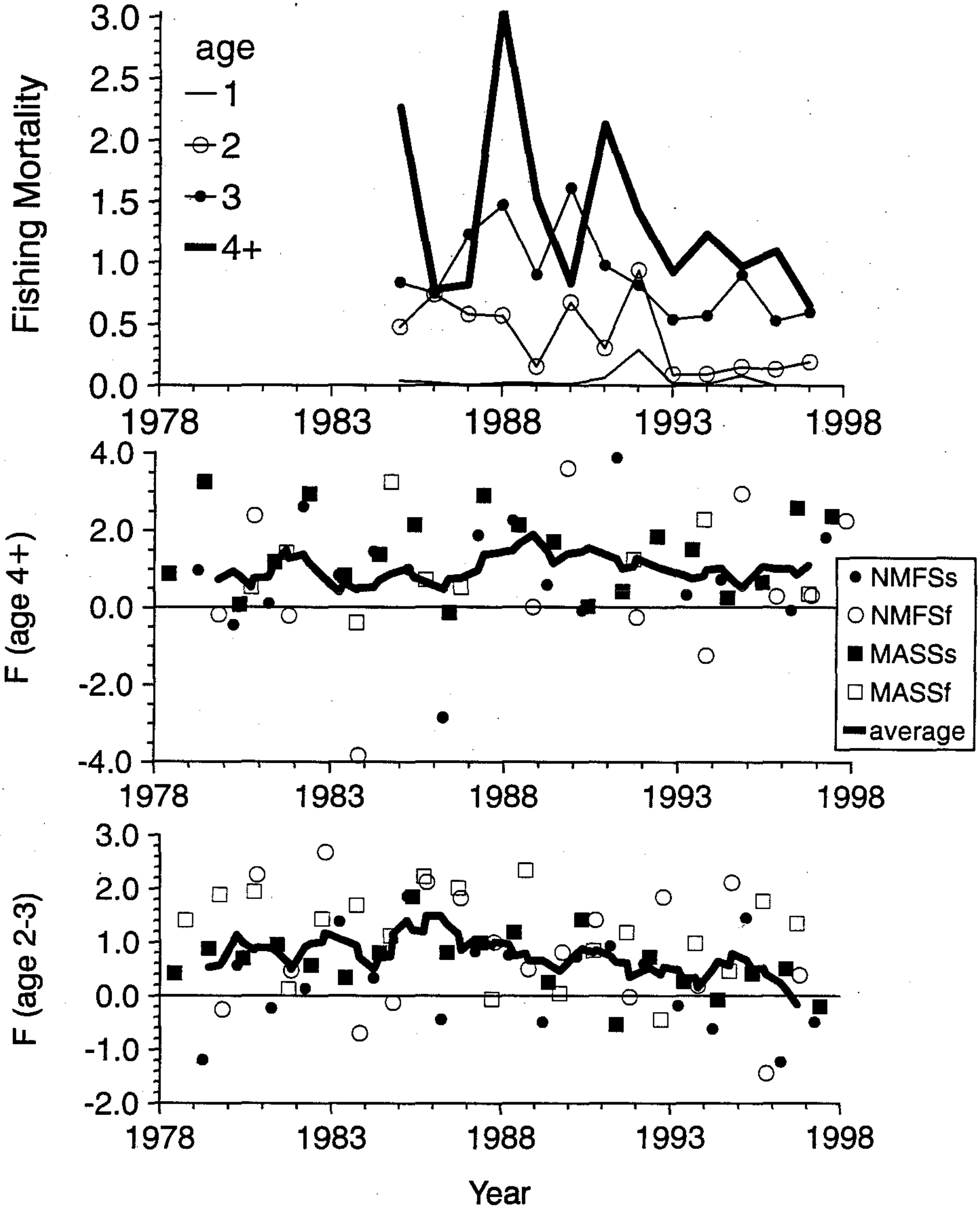


Figure A14. Instantaneous rate of fishing mortality of Cape Cod yellowtail flounder from VPA (above) and log ratios of survey indices (below).

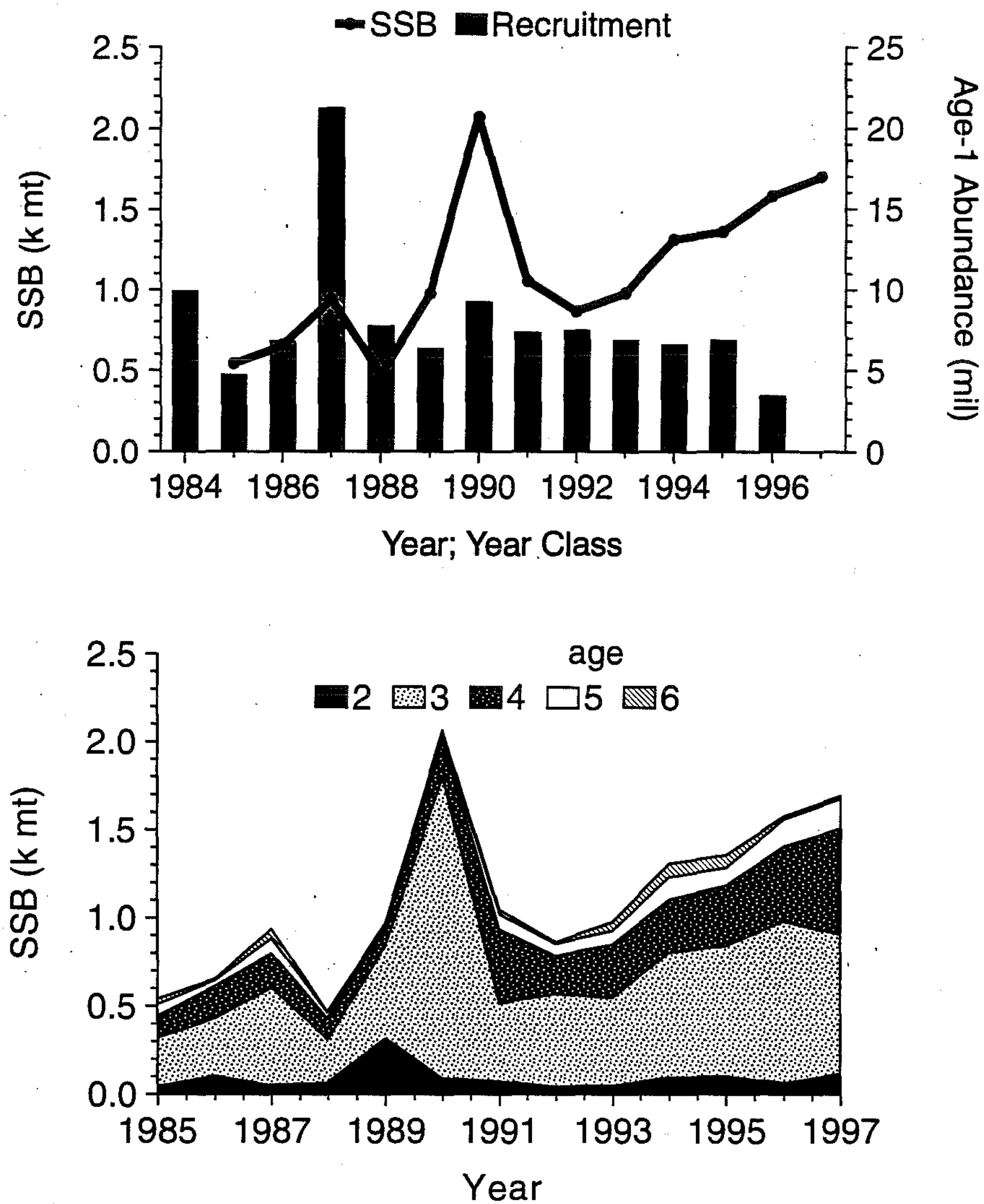
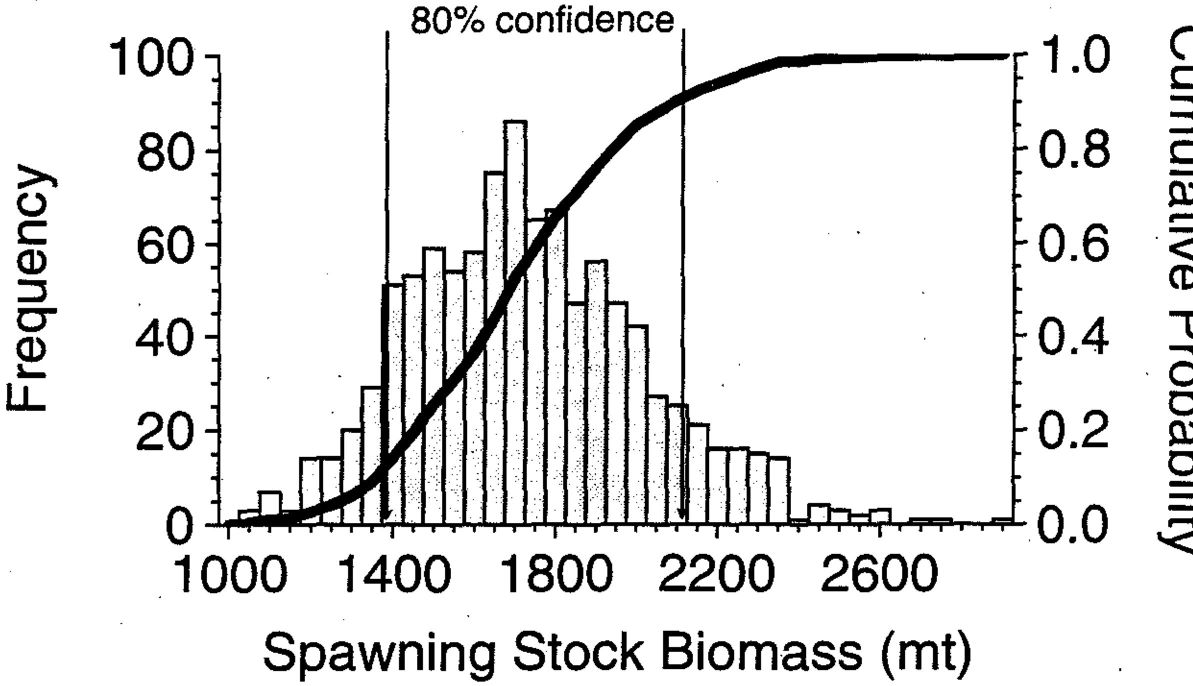


Figure A15. Spawning stock biomass and age-1 recruitment (above) and age distribution of mature biomass (below) of Cape Cod yellowtail flounder.



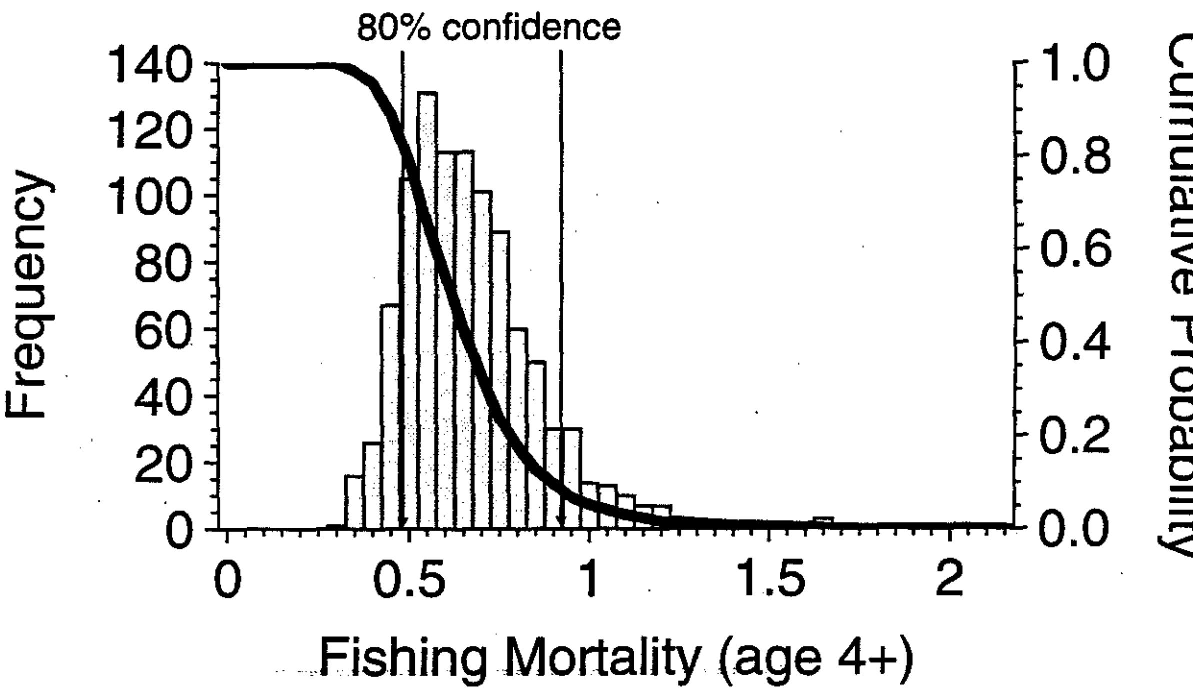


Figure A16. Bootstrap distributions of fully-recruited fishing mortality (above) and spawning stock biomass (below) of Cape Cod yellowtail flounder.

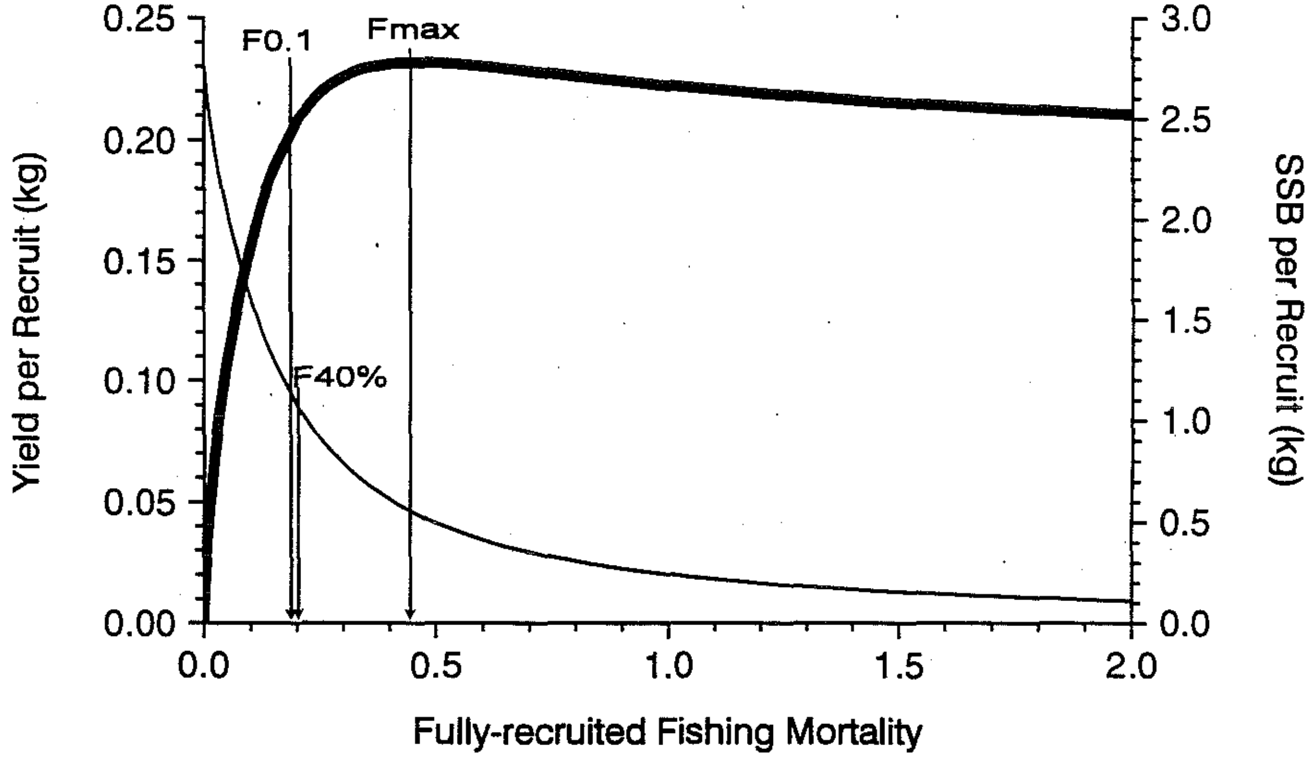


Figure A17. Yield and spawning biomass per recruit estimates for Cape Cod yellowtail flounder.

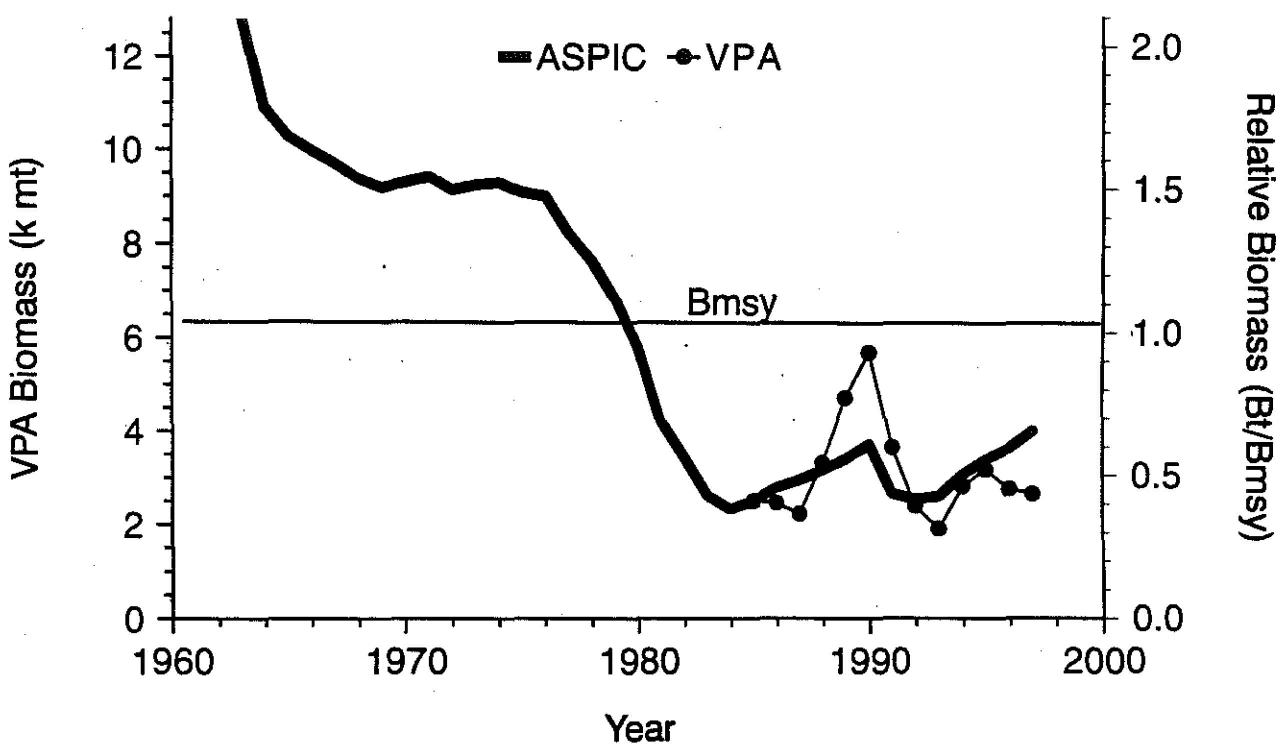


Figure A18. Predicted biomass of Cape Cod yellowtail from surplus production analysis, 1963-1997 and VPA 1985-1997.

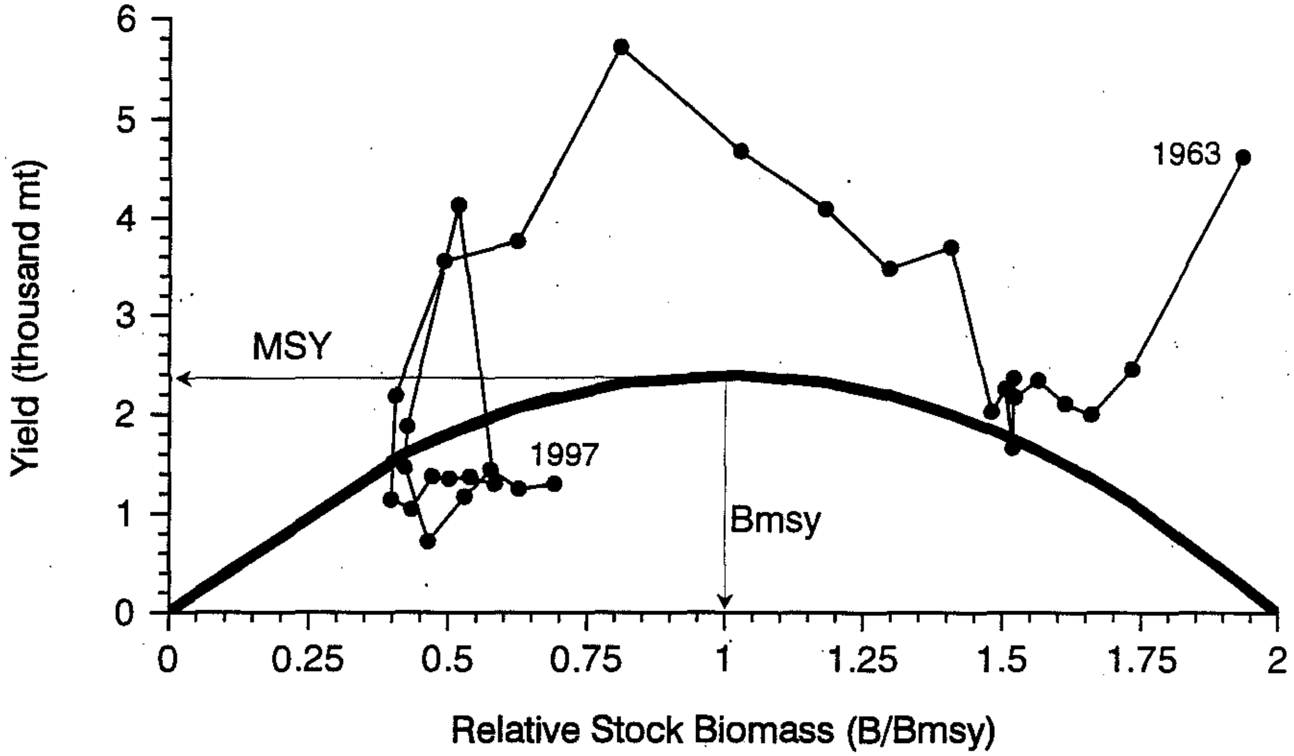


Figure A19. Biomass dynamics of Cape Cod yellowtail flounder.

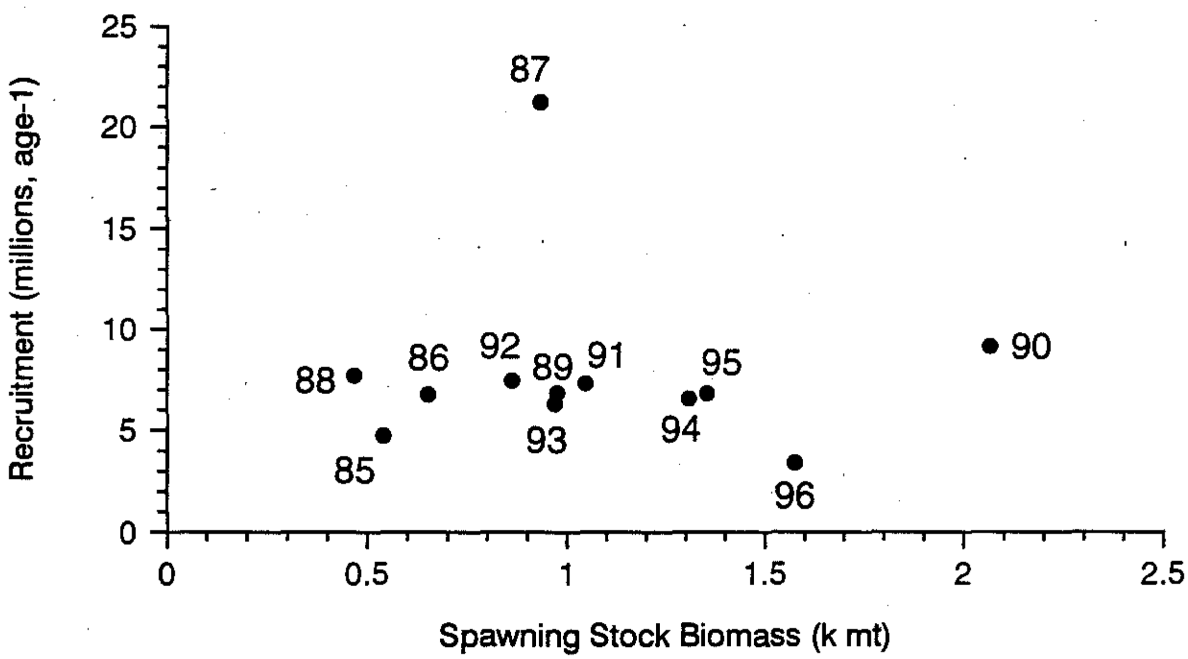


Figure A20. Spawning stock and recruitment of Cape Cod yellowtail flounder.

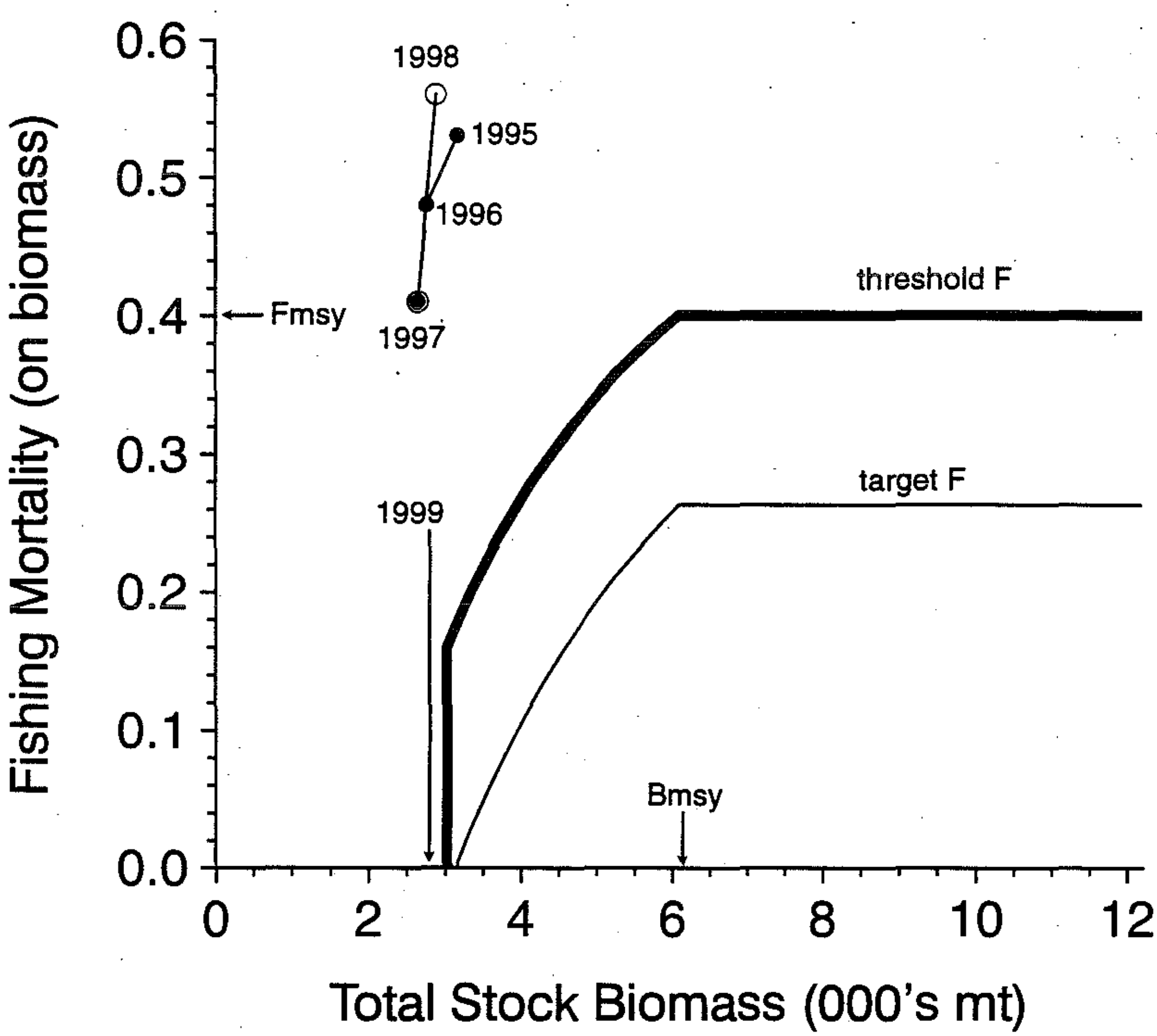


Figure A21. Amendment 9 control rule for Cape Cod yellowtail flounder rescaled to VPA biomass levels.

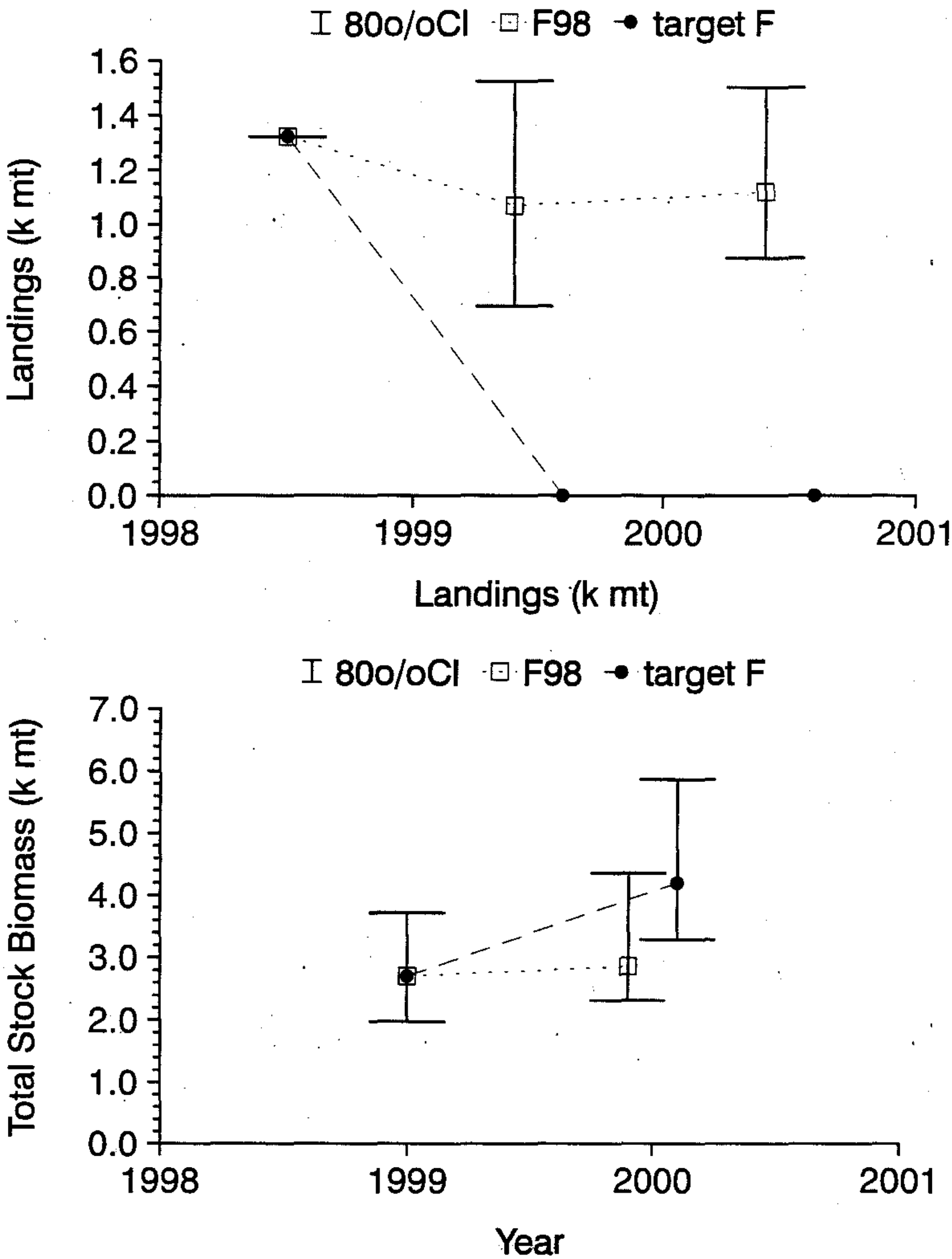


Figure A22. Stochastic projection of Cape Cod yellowtail flounder landings (above) and spawning stock biomass (below) assuming status quo F (F98=1.01) and target F (0.00) from the Amendment 9 control rule.

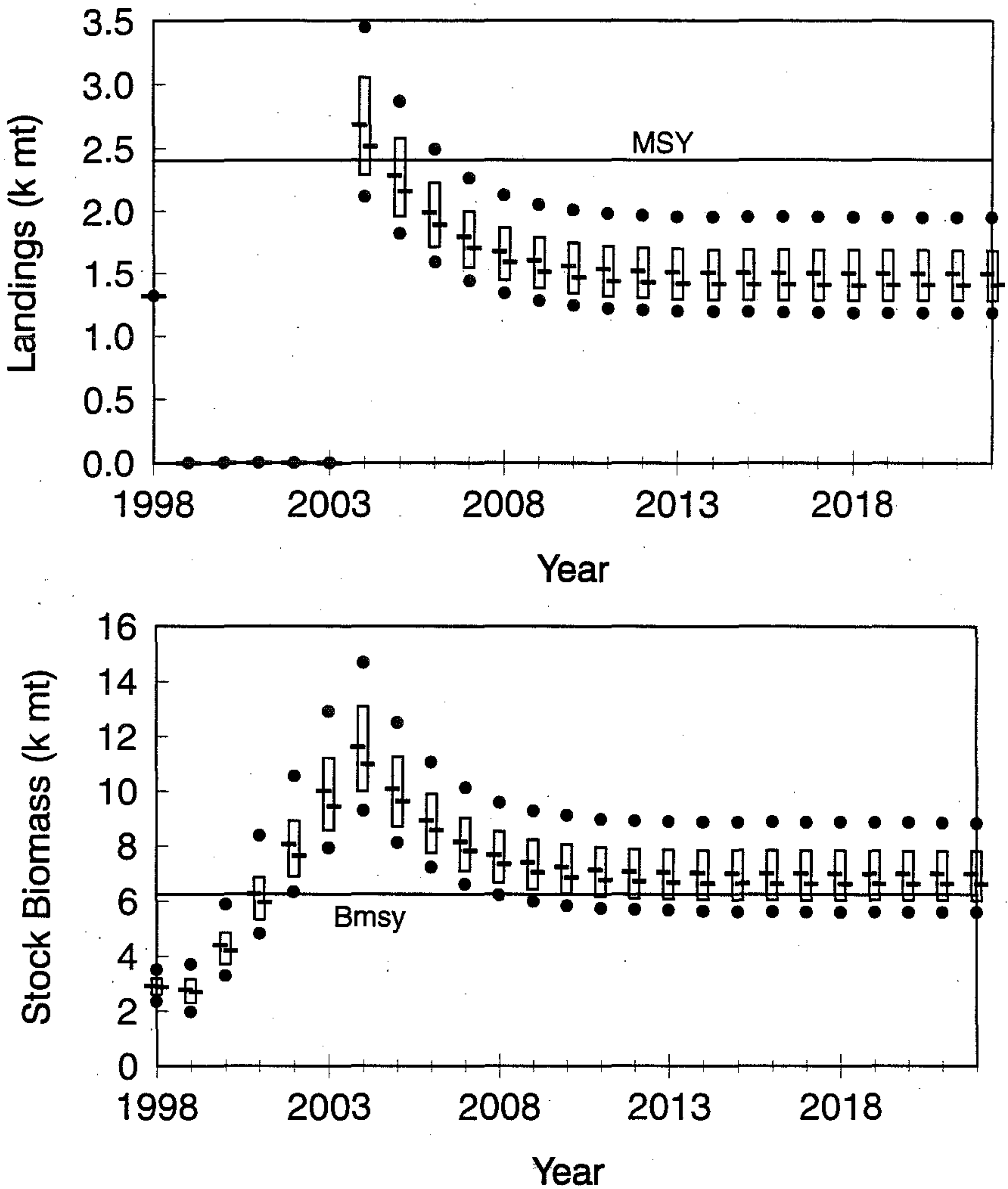


Figure A23. Long-term projection of Cape Cod yellowtail flounder landings (above) and spawning stock biomass (below) at target F from the control rule (five years of 0.00 and 20 years of 0.33). Dots indicate 80% confidence limit, bars indicate interquartile range, and vertical bars indicate mean (left) and median (right).

B. Gulf of Maine - Georges Bank White Hake

Terms of Reference

a. Characterize current and historic length and age composition, abundance, and catch for the Gulf of Maine - Georges Bank white hake stock as data permit.

b. Provide current information on stock structure and biological parameters based on growth and maturation rates, yield and spawning stock biomass per recruit analyses, and surplus production models.

c. If possible, provide current and historical estimates of stock size and fishing mortality and projected levels of catch and stock size for 1999-2000 at various levels of F.

d. Comment on and revise, if necessary, the overfishing definition reference points for white hake recommended by the Overfishing Definition Review Panel.

INTRODUCTION

White hake (*Urophycis tenuis*) are distributed from the Gulf of St. Lawrence to North Carolina (Figure B1; Bigelow and Schroeder, 1953). Much confusion on the distribution of this species exists because of the close resemblance to its congener, the red hake (*Urophycis chuss*). Both species occupy much of the same habitat (mud bottom) and have often been described together (Bigelow and Schroeder, 1953; Musick, 1974; Markle et al. 1982). White hake tend to be found in deeper water than red hake, but are also found with red hake in shallow bays and estuaries in the Gulf of Maine. This is especially true for juveniles which are the hardest size classes to distinguish from red hake.

Landings of white hake have been viewed as less important than more desirable species of groundfish such as cod and haddock. In 1993, however, white hake landings exceeded those for Gulf of Maine cod (CUD 1995). Concern arose about the sustainability of such high landings. A preliminary assessment of white hake in 1994 showed that fishing mortality rates based on a Modified DeLury model were higher than any biological reference points. Information from a surplus production model also demonstrated that landings were exceeding MSY. This paper summarizes all current information on the white hake fishery and gives estimates of current fishing mortality rates and stock levels.

STOCK STRUCTURE

There is no new information about the stock structure of white hake. In light of this, all the white hake found in NAFO subareas 5 and 6 were treated as one stock as in the 1994 assessment (Sosebee et al. 1998).

THE FISHERY

Commercial Landings

Total landings of white hake decreased from about 3,000 mt in 1964 to a low of 1,100 mt in 1967 (Table B1, Figure B2). Landings then gradually increased and peaked at 8,300 mt in 1985. Landings fluctuated around 5,000 to 6,000 mt until they peaked again in 1992 at 9,600 tons and declined slightly to 9,100 tons in 1993 (Table B1). Since that time, landings have fallen sharply to a 1997 level of 2500 tons. The US has accounted for the major portion of landings with small amounts landed by Canada. Landings from other countries have been negligible since 1977.

The primary gear type used to catch white hake is the otter trawl (Table B2, Figure B3). Historically, line trawls were also important, but from 1980 to 1991, this gear accounted for less than 5% of the total. Recently, however, line trawls increased in importance and, in 1997, represented 18% of the total landings. Sink gill nets have historically (1960s) accounted for less than 10% of total landings but the share enlarged in the 1970s to between 20 and 40% of the total.

The primary season for landing white hake is summer or quarter 3 (Table B3, Figure B4). The highest percentage of landings occurs in August, with the months of July, September and October each accounting for over 10% of the annual landings.

Maine landings have averaged between 40 and 70% of the total US landings since 1964 (Table B4, Figure B5). Massachusetts landings exceeded those of Maine from 1968 to 1974 but have since accounted for 20 to 40% of the total landings. Other states contributing to landings are New Hampshire, Connecticut, Rhode Island, New York, New Jersey, Delaware, and Virginia.

Under-tonnage vessels (less than 5 GRT) traditionally accounted for between 20 and 40% of US landings (Table B5), but have since become less important and, in 1997, were not represented in the total landings. Tonnage classes 2 and 3 (5-50 GRT and 51-150 GRT, respectively) have accounted for the majority of the landings with tonnage class 3 dominating landings for the last ten years. Tonnage class 4 vessels (151-500 GRT) increased in importance in the 1980s and 1990s but have since declined.

Recreational Catches

The amount of white hake recreational catches reported in the Marine Recreational Fishery Statistical Survey since 1979 is insignificant (< 0.1 mt per year).

Discards

Preliminary estimates of total discards were estimated but not used in the assessment (Sosebee et al 1999).

Sampling Intensity

Since the majority of white hake are landed in headed and gutted condition, length measurements have not generally been available from port samples. A regression developed to convert dorsal fin-caudal fin length to total length (Creaser and Lyons, 1985), has allowed measurements obtained from landed catch to be used to evaluate overall length composition since 1985. Age samples are still unavailable from port samples since otoliths are the structures used for ageing and are lost when the head is removed.

Table B6 shows the summary of commercial length samples from the ports by market category. Since medium white hake were poorly sampled at the beginning of the sampling period and since there appeared to be no difference in length composition between small and medium market categories, the two size categories were pooled. The sampling intensity overall has been adequate (< 300 mt/sample), except in 1989 and 1995 when only 13 and 12 samples were taken (one sample taken for every 350 mt and 361 mt landed). The sampling intensity in 1997 was very good (32 mt/sample), but the unclassified market category had only one sample for the entire year.

Length and Age Composition

Commercial length composition during 1985-1997 was estimated by market category (pooling small and medium size categories together) from length frequency samples, pooled on a semiannual basis. Mean weights were obtained by applying the NEFSC survey length-weight equation,

$$\ln \text{Weight (kg, live)} = -12.58 + 3.2196 * \ln \text{Length (cm)}$$

to the semiannual market category length frequencies. Mean weight values were then divided into semiannual market category landings to derive estimated numbers landed by market category. These numbers were then summed over market categories and half-years to produce the annual length compositions shown in Figure B6. White hake less than 40 cm in length are usually not landed in large numbers, but, in 1988, 1991, and 1994 some white hake less than 30 cm were landed. This is probably due to the market accepting smaller fish in those years.

Commercial landings-at-age were derived by applying age-length keys from the NEFSC survey to the length composition. The number of ages used in each cell is given in Table B7. The spring survey was used for the first half and the autumn survey used for the second half. The survey does not sample large white hake adequately, so the keys were filled out using pooled keys by season. This resulted in some high percentages of the older ages filled in and possibly smearing age classes (Table B8). The percent of the total landings-at-age affected by this process is generally very small and mainly affected the plus-group. Estimates of US landings-at-age in numbers and weight, mean weight at age and mean length at age are shown in Table B9.

STOCK ABUNDANCE AND BIOMASS INDICES

Commercial LPUE

Fishing effort was standardized by a General Linear Model to the LPUE data. The five-factor model (year, quarter, area, tonnage class, and depth) was applied to log LPUE data derived for all otter trawl trips taking white hake from 1985 through 1997 (Table B10). The model accounted for 32% of the total variation. All of the main effects were highly significant and interactions were not examined.

Standardized effort was calculated by multiplying the nominal effort in each cell by the product of the retransformed log coefficients for each factor (excluding year). The estimated standardized effort was then summed over all categories to give annual totals (Table B11). The trend in the shortened standardized series follows a similar pattern to the trend in the nominal LPUE series (Figure B7) with a decline seen in 1994 through 1997.

Research Vessel Abundance and Biomass Indices

The NEFSC autumn bottom trawl survey has been in existence since 1963 (Azarovitz, 1981). Offshore areas from the Gulf of Maine to Southern New England are sampled, and, beginning in 1967, offshore areas in the Mid-Atlantic were sampled as well. The NEFSC spring bottom trawl survey began in 1968. The surveys have been conducted with the same gear and vessel as often as possible. The strata set used for white hake is the Gulf of Maine to Northern Georges Bank (offshore strata 21-30 and 33-40). Indices of abundance and biomass were calculated following the methods of Cochran (1977). Vessel, door, and gear effects were not found to be significant for white hake (NEFC, 1991).

Spring stratified mean number and weight per tow are variable but have been declining since 1990 (Table B12, Figures B8 and B9). The autumn weight per tow index fluctuated around 5 kg/tow in the early 1960s and increased to approximately 12 kg/tow during the 1970s (Table B13, Figure B10). Excluding the 1982 data point, the autumn mean weight per tow index fluctuated around 10 kg/tow from 1983 to 1993. Since that time the index has declined and is currently at 4.55, the lowest value since 1968 (excluding 1982 which is thought to be anomolous). The previous overfishing definition states that overfishing is occurring when the three-year moving average of the autumn biomass index falls into the lower quartile. The current average is among the lowest in the time series (Figure B11). Over the time period, the autumn abundance index increased relative to the biomass index indicating a gradual shift from larger to smaller fish during the 1970s and 1980s (Figure B12).

The state of Massachusetts has also conducted spring and fall surveys since 1978 (Howe et al., 1981). The survey only covers a portion of the white hake stock area but can still be useful. The spring survey shows a decline over the time series until about 1988 when it dropped to a low level and remained until the present (Figure B13). The autumn series is more variable, particularly for abundance but has shown a similar decline (Figure B14).

The ASMFC conducts a summer shrimp survey in the Gulf of Maine. Finfish are also weighed and measured on these surveys and white hake are often caught. This survey also shows a decline over the short time series (Figure B15).

STOCK PARAMETERS

Natural Mortality

Natural mortality (M) for most gadid stocks is assumed to be 0.2. Hoenig (1983) developed an empirical relationship between total mortality (Z) and longevity (T_{max}):

$$\ln Z = 1.46 - 1.01 \ln T_{max}$$

Assuming a maximum age of 20 years for white hake (the oldest fish in the samples used in section on total mortality was 15 years and the maximum length is larger than this fish) this relationship estimates a Z of 0.2. In the absence of fishing mortality Z = M = 0.2.

Total Mortality

The NEFSC spring and fall surveys have been aged from 1982-1998. The ages from the last assessment have been reaged and the new ages give different results. The fish are now older at size than in the previous assessment (Table B14). Estimates of instantaneous total mortality were derived from NEFSC spring and fall survey catch per tow at age data (Table B15) for 1982-1997. Age at full recruitment to the survey was assumed to be 4 (3 in the autumn). Therefore, an estimate was derived by taking the natural logarithm of pooled age 4+ to pooled age 5+ (age3+/age4+ in the autumn). The estimates of Z have ranged from 0.5 to 1.6 and are consistent between surveys. One estimate of total mortality was derived by taking the geometric mean of the two estimates. These show an increase during the time period.

Maturity

Maturity ogives were reestimated with the new age data. The A_{50} estimate for females is 2.8 years and for males is 2.5 years. With sexes combined the age at 50% maturity is 2.6 years.

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

Virtual Population Analysis

Abundance estimates from a virtual population analysis (VPA) for ages 1-9+, 1985-1997, were calibrated using ADAPT (Gavaris 1988), which estimated survivors at ages 2-7 and survey catchability coefficients (q) using a nonlinear least squares function to minimize the difference between survey indices and abundance estimates. White hake were assumed to be fully recruited at age 4 and ages 4-8 were used to estimate F for ages 8 and 9+. NEFSC survey indices for ages 3-7 (2-6 for autumn) and standardized LPUE (tuned to ages 5-9) were used in the VPA calibration.

Several other formulations of the VPA were examined (Table B16). The first run estimated ages 3-7, but used survey indices for ages 2-7 in the tuning. This resulted in higher CVs on all ages and very high residuals on age 2 indices. Once age 2 was added to the estimation (Run 8), the high residuals were removed and fishing mortality increased. A run without age 2 in the tuning and not estimating age 2 was attempted to determine if fishing mortality was high (Run 10). The results for this run were similar to Run 8. Finally, in order to reduce the variance on older ages, the LPUE index was used to tune ages 5-8. This resulted in the lowest CVs of all the runs.

The mean square residual for the calibration was 0.39 (Appendix A). Coefficients of variation (CVs) for abundance estimates ranged from 0.29 to 0.59, decreasing to age 4 then increasing with age. The CVs around the estimates of q were from 0.17 to 0.21. There were no severe residual patterns detected.

The VPA indicated that stock abundance increased in the late 1980s due to two large year classes (1988 and 1989), peaked in 1991 at 24 million fish and has since declined to ten million fish in 1996, the lowest level in the time series (Table B17). Fishing mortality has been variable during the time series (Figure B16) but has ranged from 0.6 to 1.2. Spawning stock biomass (SSB) was around 12,000 mt in the 1985-1986 (Figure B17). A decline followed through 1989. Due to the strong recruitment of the 1988 and 1989 year classes, SSB increased to 10,000 mt in 1992 and has since declined to a series low of 3,000 mt. There does not appear to be much evidence for a strong stock-recruitment relationship (Figure B18). Other than the 1988 and 1989 year classes which were strong (10 million and 10.4 million, respectively), the recruitment averaged 5 million fish from 1985-1992. The next three year classes were very poor (around two million fish). The 1996 year class, however, appears to be better and more like average recruitment.

The uncertainty and bias associated with the estimated parameters were evaluated using bootstrap analysis of the VPA calibration. One thousand bootstrap replications were performed by randomly resampling survey and LPUE residuals. The bootstrapped CVs of the youngest and older ages are slightly higher. The estimates of q had similar CVs to the calibration. SSB was well estimated (CV of 12%).

The bias estimates around the population estimates at age ranged from 2%-14% with the higher estimates around the ages that were poorly estimated (2,6,7). Bias estimates for fishing mortality were small as well as the bias around SSB. The distribution of bootstrapped estimates of fully-recruited F suggests an 80% chance that F was between 0.92 and 1.35 (Figure B19A). The distribution around the SSB estimates suggests an 80% chance that SSB is between 2,600mt and 3,500 mt (Figure B19B).

Retrospective analyses were conducted, however, due to the brevity of the time series, only five years were examined (Figure B20). These analyses indicate a tendency to overestimate fishing mortality in the terminal year. Spawning stock biomass is well estimated and mean biomass is slightly overestimated. Recruitment at age 1 tends to be overestimated in the terminal year particularly when recruitment is average or higher.

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per recruit

Yield-per-recruit, total stock biomass per recruit, and spawning stock biomass per recruit calculations were performed using the Thompson and Bell (1934) method. Mean weights at age in the catch were derived by averaging the entire time series (1985-1997). The stock mean weights used an average of the Rivard weights for the entire VPA time series. The maturity ogive was the same as used in the VPA. The partial recruitment vector was taken as the geometric mean of 1994-1997 because of changes in mesh size. Input data and results of the yield and SSB per recruit analyses are presented in Table B18 and are illustrated in Figure B21. The yield per recruit analyses indicate that $F_{0.1} = 0.14$, $F_{max} = 0.24$ and $F_{20\%} = 0.30$.

SFA Requirements

A non-equilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) was employed to derive estimates of survey catchability (q), maximum sustainable yield (MSY) for the stock, intrinsic rate of increase (r) and annual estimates of biomass. Estimates of stock biomass and catchability were obtained by minimizing the difference between the observed and predicted values in a nonlinear least squares objective function. The 1982 autumn value was deleted because it resulted in a very high residual and is thought to be anomolously low. The full model results are presented in Appendix C. The model previously run by the Overfishing Definition Panel had agreed with the DeLury from the previous assessment. With a new age-based assessment, however, the magnitude of the biomasses differed (Figure B22). The SARC decided to use the B ratios to scale the results to the biomass from the VPA. This resulted in an estimate of B_{msy} of 22,300 mt and an biomass-weighted F_{msy} of 0.24 (0.27 on fully-recruited ages).

CATCH AND STOCK BIOMASS PROJECTIONS

Short-term projections of spawning stock biomass, mean biomass, recruitment at age 1, and commercial landings were performed using the VPA-calibrated 1998 stock sizes estimates from the 1000 bootstrap replications and the projected 1998 catch of 2665 mt as starting conditions. The stochastic simulations were repeated 100 times to obtain a series of probablility profiles for each projected variable. The partial recruitment and maturation ogives were the same as described in the yield and SSB per recruit section and the mean weights at age were calculated using a three-year arithmetic average over the 1995-1997 period.

Recruitment was generated based on the model 3 formulation of Brodziak and Rago (MS 1994). The recruitment at age 1 was derived by resampling the empirical distribution of values for the 1991-1996 year classes. This period was chosen based on the expectation that large year classes will be unlikely to occur given the low level of SSB but average year classes could occur. Projections are provided for F=0.0 and F_{98}. Results from the projections are given in Table B19. The assumption of catch in 1998 resulted in an increase in fishing mortality to 1.43, a decline in mean biomass to 3,300 mt and a decline in SSB to 1,600 mt. Continued fishing at F=1.43 in 1999 will result in a halt in the decline of both mean biomass and SSB due to the incoming 1996 year class (Figure B23). With no fishing mortality, both mean biomass and SSB will more than double in the year 2000.

CONCLUSIONS

The Gulf of Maine to Mid-Atlantic white hake stock is currently at a low stock level and is overfished. Continued fishing at current levels of fishing mortality will cause the stock to further decline. The mean biomass is the lowest in the VPA time series and is currently below 1/4 of the B_{msy} threshhold. Fishing mortality is very high and is more than three times the F_{msy} threshhold. According to the proposed control rule for this stock fishing mortality should be zero.

SARC Comments

Input Data

The commercial landings, discard, and biological sampling data were reviewed by the SARC. There was a slight discrepancy between the tables containing the total USA landings for Subareas 5 and 6, and those listing USA landings by gear type, season, tonnage class and state of landing. The detailed tables included all USA landings, including small amounts from Subareas 3 and 4, and the SARC recommended that these tables be reconstructed to include only USA landings of white hake from Subareas 5 and 6. It was noted that since 1994, when spatial information was obtained from VTR records, landings reported from statistical area 537 increased substantially compared to previous years. The SARC was informed that this discrepancy was due to a few operators reporting whiting as white hake due to mis-coding of the VTR logs. The SARC questioned the pervasiveness of this type of error and was informed that when the master commercial landings database is reconstructed back to 1994, these errors will be eliminated because the VTR records will only be used to assign spatial information to the dealer records which contain the correct species composition of the trip.

Initial estimates of discarded white hake derived from 1989-1997 DSSP data were presented to the SARC. Large quantities of white hake discards were estimated for 1989 and 1990 but the SARC was informed that these estimates may be 'contaminated' with red hake because sea samplers were not properly trained in species identification until 1991. It was also noted that estimates of white hake discard may actually be relatively high in these years due to the presence of the relatively strong 1988 and 1989 year classes. All discard estimates were considered preliminary and were not included in further analyses.

Biological sampling data were derived from commercial length frequency samples obtained in the ports of landing and age/length keys derived from otolith samples collected aboard research vessel surveys. Age samples are not available at the ports because white hake are traditionally landed in headless condition. Estimates of commercial landings at length were derived using market category stratification pooled over gear type. The SARC questioned whether gear stratification would have been preferable and it was noted that market category stratification generally accounts for differential size composition among gear types. Market category stratification was considered preferable because it reduces the range of lengths within the stratum and because sampling is often incomplete for most gear types other than otter trawl.

Survey age/length keys did not represent older age groups very well, and considerable augmentation of the keys was necessary for ages greater than 6. The SARC expressed concern that this approach may affect the estimates of landings at age and, more importantly, estimates of mean weights at age. *Noting this, the SARC recommends that all available age samples collected aboard sea sampling trips be inventoried to determine their potential for better determining age/length relationships, particularly for older fish.* The SARC expressed concern about possible impacts of sexually dimorphic growth on the distribution of pooled-sex commercial length compositions over age. The SARC was informed that all white hake otolith samples have been re-aged, and based on the revised ages, growth differences between sexes are less evident than in previous analyses.

Landings per unit effort indices were presented in both nominal and standardized form. The SARC observed a disjoint between the 1993 LPUE estimate and those computed for 1994-1997. It was noted that the 1994-1997 LPUE indices were derived from VTR records and it was suggested that effort units may not be comparable to those derived from the interview system. *Noting this, the SARC recommended that effort units in the VTR data be further investigated to determine the extent of these possible differences.*

Stock Size and Fishing Mortality Estimates

The SARC was presented fishing mortality and stock size estimates derived from several sources including survey-based Zs, and estimates derived from a modified age-based DeLury model, a non-equilibrium production model incorporating covariates (ASPIC), and a VPA. Estimates of F derived from the ASPIC model were generally lower and biomass higher than the VPA-based estimates. Estimates of F derived directly from survey Zs, while variable, were generally consistent with those derived from the VPA, both methods indicating relatively high Fs, around 1.0, particularly in recent years. The DeLury model produced lower estimates of derived F when spring survey indices were included compared to autumn indices. A 'two-bin mass balance model' was presented in an attempt to reconcile difference obtained from the DeLury analyses. An hypothesis to explain the differences was offered with the following main features:

1. The white hake stock may not be completely available in the Gulf of Maine-Georges Bank area in the spring,

2. There may be unknown sources of mortality present between inter-annual spring periods, and

3. Implications of gear efficiency should be taken into account.

It was concluded that use of catchability coefficients (q) from each survey could be used to 'tune' the model to blend information contained within each survey series. Finally, the SARC noted that this approach may be most useful for models in which biomass is estimated directly from swept area calculations, and that a possible solution to the lower availability of white hake during spring may be achieved by extending the survey area used in the calculations to encompass a wider distribution of the species during that time of year. *Noting this, the SARC recommended that GIS plots of white hake be presented in future assessments to better evaluate the spatial distribution of the species.*

Summaries of several formulations of the VPA were presented. The SARC noted that a strong residual pattern on age 2 in 1998 was alleviated when stock size of age 2 was estimated as a parameter in the VPA formulation, and agreed that this formulation was the preferable one to use. The VPA produced stock biomass estimates that were consistent with observed indices, and noting that the VPA integrated all available external information, the SARC accepted the VPA results as a basis for determining stock status.

Biological Reference Points

The SARC reviewed yield and SSB per recruit analyses and noted that estimates of F0.1, Fmax and F20% were similar to those presented in the previous analysis. A proxy for Bmsy was determined by inspection of catch history and survey-extrapolated SSB patterns during the period 1970-1980 when both measures appeared to be relatively stable. Based on this analysis, the SARC determined that an SSBmsy estimate of 12,000 mt may be applicable to this stock. Total landings during the same period averaged 3,962 mt, but the SARC was unable to conclude whether this constituted an estimate of MSY. Although the production model results were considered uncertain, the SARC concluded that useful information on relative levels of biomass may be useful for corroborating longer-term stock biomass trajectories.

Sources of Uncertainty

1. Effect of not incorporating discards into the VPA catch at age.

2. Effect of possible mis-identification of red hake as white hake and *vice versa.*

3. Effect of interpolation of missing ages in survey age/length keys.

4. Impact of possible seasonal emigration of white hake from the defined stock area.

Research Recommendations

1. Investigate the potential utility of stratifying estimates of discard by mesh size in the otter trawl fishery data.

2. Incorporate all sources of catch in Catch at Age, including Canadian 4X landings and investigate feasibility of including discards throughout the 1985-present period.

3. Investigate stock structure and spawning patterns throughout the Gulf of Maine area, including relationships to areas in 4X and in deeper waters off Georges Bank and the Scotian Shelf.

4. Further work on the 2-Bin Mass Balance Model should continue particularly as this relates to changes in catchability related to seasonal emigration of white hake during the autumn.

5. Investigate the availability and potential use of sea sample age samples to augment survey age/length keys.

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Table B1. Total landings (mt,live)[1] of white hake by country from the Gulf of Maine to Cape Hatteras (NAFO Subareas 5 and 6), 1964-1997.

	Canada	USA	Other	Total
1964	29	3016	0	3045
1965	0	2615	0	2615
1966	0	1562	0	1562
1967	16	1126	0	1142
1968	85	1209	0	1294
1969	34	1343	6	1383
1970	46	1807	280	2133
1971	100	2583	214	2897
1972	40	2946	159	3145
1973	117	3278	5	3400
1974	232	3773	0	4005
1975	146	3673	0	3819
1976	195	4104	0	4299
1977	170	4976	338	5484
1978	155	4869	29	5053
1979	251	4044	4	4299
1980	305	4746	2	5053
1981	454	5970	0	6424
1982	764	6179	2	6945
1983	810	6408	0	7218
1984	1013	6757	0	7770
1985	953	7353	0	8306
1986	956	6109	0	7065
1987	555	5818	0	6373
1988	534	4783	0	5317
1989	583	4547	0	5130
1990	547	4927	0	5474
1991	552	5607	0	6159
1992	1138	8444	0	9582
1993	1681	7466	0	9147
1994	955	4737	0	5692
1995	481	4333	0	4814
1996	372	3287	0	3659
1997	290	2225	0	2515

[1]Canada and Other as reported to ICNAF/NAFO for 1964-1992. USA Landings derived from NEFSC Weighout files.
[4]Includes Japan, Spain, and USSR.

Table B2. US commercial landings (mt,live) and the annual percentage of total landings of white hake by gear type, 1964-1997.

	Landings (mt, live)					Percentage of Annual Landings				
Year	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other[1] Gear	Total	Line Trawl	Bottom Otter Trawl	Sink Gill Net	Other[1] Gear	Total
1964	1228	1681	99	8	3016	40.7	55.7	3.3	0.3	100.0
1965	1513	1034	64	4	2615	57.9	39.5	2.4	0.2	100.0
1966	704	755	99	5	1562	45.1	48.3	6.3	0.3	100.0
1967	326	730	67	4	1126	28.9	64.8	5.9	0.4	100.0
1968	265	825	116	3	1209	21.9	68.2	9.6	0.3	100.0
1969	228	1005	108	2	1343	17.0	74.8	8.0	0.2	100.0
1970	201	1474	129	4	1807	11.1	81.5	7.2	0.2	100.0
1971	532	1925	118	9	2583	20.6	74.5	4.6	0.3	100.0
1972	834	1717	384	11	2946	28.3	58.3	13.0	0.4	100.0
1973	840	1941	491	6	3278	25.6	59.2	15.0	0.2	100.0
1974	638	1852	1274	9	3773	16.9	49.1	33.8	0.2	100.0
1975	993	1356	1320	4	3673	27.1	36.9	35.9	0.1	100.0
1976	546	1606	1943	9	4104	13.3	39.2	47.3	0.2	100.0
1977	391	2316	2257	12	4976	7.9	46.5	45.4	0.2	100.0
1978	321	2183	2341	23	4869	6.6	44.8	48.1	0.5	100.0
1979	206	2058	1752	28	4044	5.1	50.9	43.3	0.7	100.0
1980	90	2656	1967	33	4746	1.9	56.0	41.5	0.7	100.0
1981	108	3473	2376	13	5970	1.8	58.2	39.8	0.2	100.0
1982	97	3860	2202	20	6179	1.6	62.5	35.6	0.3	100.0
1983	79	4868	1395	66	6408	1.2	76.0	21.8	1.0	100.0
1984	22	5158	1486	90	6757	0.3	76.3	22.0	1.4	100.0
1985	315	5508	1418	112	7353	4.3	74.9	19.3	1.5	100.0
1986	231	4671	1163	44	6109	3.8	76.5	19.0	0.7	100.0
1987	86	4798	911	24	5818	1.5	82.5	15.6	0.4	100.0
1988	85	3655	1008	35	4783	1.8	76.4	21.1	0.7	100.0
1989	15	2552	1892	88	4547	0.3	56.1	41.6	2.0	100.0
1990	78	3286	1508	54	4927	1.6	66.7	30.6	1.1	100.0
1991	249	3553	1616	189	5607	4.4	63.4	28.8	3.4	100.0
1992	948	5195	2262	40	8444	11.2	61.5	26.8	0.5	100.0
1993	1203	4656	1590	16	7466	16.1	62.4	21.3	0.2	100.0
1994	1186	2479	1065	7	4737	25.0	52.3	22.5	0.2	100.0
1995	764	2407	1123	39	4333	17.6	55.6	25.9	0.9	100.0
1996	307	2036	926	19	3287	9.3	61.9	28.2	0.6	100.0
1997	394	1283	543	5	2225	17.7	57.7	24.4	0.2	100.0

[1] Includes handline, Scottish seine, drift gill net, scallop dredge, Danish seine, pound net, floating trap net, longline, midwater trawl, lobster pots, fish pots, purse seine, troll line, common seine, diving gear, set gill net, harpoon, rakes, and trammel net.

Table B3. Landings (mt,live) and the annual percentage of landings of white hake by season, 1964-1997.

						Month							
Year	Unk.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1964	111	148	126	125	166	110	221	721	406	364	220	199	99	3016
1965	22	82	105	88	38	26	151	763	551	371	163	134	121	2615
1966	26	37	40	67	47	29	94	91	552	224	168	104	83	1562
1967	17	55	29	50	22	22	33	58	241	234	207	97	61	1126
1968	17	38	52	51	22	28	67	103	302	220	165	79	65	1209
1969	8	55	44	19	24	34	69	81	264	254	216	163	112	1343
1970	12	57	54	50	38	115	160	183	243	259	331	171	134	1807
1971	37	82	39	37	43	99	180	181	453	405	443	400	184	2583
1972	22	123	65	54	45	150	186	379	628	423	495	211	165	2946
1973	252	124	54	65	78	145	191	311	578	415	481	323	261	3278
1974	133	175	51	85	148	164	194	354	529	557	640	417	326	3773
1975	187	105	72	64	98	233	296	464	727	500	312	422	193	3673
1976	184	96	147	152	128	133	316	758	563	667	364	378	218	4104
1977	236	117	91	199	146	191	283	684	852	645	648	612	272	4976
1978	185	105	147	114	131	172	271	370	1084	859	761	480	190	4869
1979	262	102	34	78	106	232	322	642	964	433	379	308	182	4044
1980	380	109	108	106	102	131	442	720	860	636	553	405	195	4746
1981	53	196	86	126	116	129	437	903	1375	798	649	766	336	5970
1982	6	174	180	194	134	190	462	1139	1280	809	693	571	348	6179
1983	4	405	237	284	211	334	630	817	1015	745	744	577	406	6408
1984	13	425	228	221	208	341	537	770	1209	961	934	549	362	6757
1985	4	273	231	292	345	358	705	1097	1030	1115	825	633	445	7353
1986	2	309	276	288	386	392	619	999	851	723	623	370	272	6109
1987	4	135	188	221	163	270	724	1000	936	805	694	411	267	5818
1988	7	183	100	132	165	287	646	682	761	844	503	314	159	4783
1989	5	149	130	130	137	204	596	795	807	603	540	291	161	4547
1990	7	157	112	172	135	269	595	812	916	635	617	319	181	4927
1991	7	163	162	90	114	457	554	846	1126	871	624	345	247	5607
1992	5	277	247	294	283	344	832	1487	1756	1203	802	595	321	8444
1993	4	272	213	274	307	532	1000	1319	1232	790	744	514	266	7466
1994		143	275	198	325	348	617	688	717	447	465	293	221	4737
1995		141	180	190	138	261	504	712	597	504	566	366	175	4333
1996		135	149	152	100	243	382	366	553	448	402	236	122	3287
1997		97	116	73	73	62	209	271	344	343	287	206	144	2225
							Percentage of total							
1964	3.7	4.9	4.2	4.1	5.5	3.6	7.3	23.9	13.5	12.1	7.3	7.0	3.3	100.0
1965	0.8	3.1	4.0	3.4	1.5	1.0	5.8	29.2	21.1	14.2	6.2	5.1	4.6	100.0
1966	1.7	2.4	2.6	4.3	3.0	1.9	6.0	5.8	35.3	14.3	10.7	6.7	5.3	100.0
1967	1.5	4.9	2.6	4.4	2.0	2.0	2.9	5.2	21.4	20.8	18.4	8.6	5.4	100.0
1968	1.4	3.1	4.3	4.2	1.8	2.3	5.5	8.5	25.0	18.2	13.6	6.5	5.4	100.0
1969	0.6	4.1	3.3	1.4	1.8	2.5	5.1	6.0	19.6	18.9	16.1	12.2	8.3	100.0
1970	0.7	3.2	3.0	2.8	2.1	6.4	8.8	10.1	13.4	14.3	18.3	9.5	7.4	100.0
1971	1.4	3.2	1.5	1.5	1.7	3.8	7.0	7.0	17.5	15.7	17.1	15.5	7.1	100.0
1972	0.7	4.2	2.2	1.8	1.5	5.1	6.3	12.9	21.3	14.3	16.8	7.2	5.6	100.0
1973	7.7	3.8	1.6	2.0	2.4	4.4	5.8	9.5	17.6	12.7	14.7	9.9	8.0	100.0
1974	3.5	4.6	1.4	2.3	3.9	4.3	5.1	9.4	14.0	14.8	17.0	11.0	8.6	100.0
1975	5.1	2.9	2.0	1.7	2.7	6.3	8.1	12.7	19.8	13.6	8.5	11.5	5.3	100.0
1976	4.5	2.4	3.6	3.7	3.1	3.2	7.7	18.5	13.7	16.2	8.9	9.2	5.3	100.0
1977	4.7	2.4	1.8	4.0	2.9	3.8	5.7	13.8	17.1	13.0	13.0	12.3	5.5	100.0
1978	3.8	2.2	3.0	2.3	2.7	3.5	5.6	7.6	22.3	17.7	15.6	9.9	3.9	100.0
1979	6.5	2.5	0.8	1.9	2.6	5.7	8.0	15.9	23.8	10.7	9.4	7.6	4.5	100.0
1980	8.0	2.3	2.3	2.2	2.2	2.8	9.3	15.2	18.1	13.4	11.7	8.5	4.1	100.0
1981	0.9	3.3	1.4	2.1	1.9	2.2	7.3	15.1	23.0	13.4	10.9	12.8	5.6	100.0
1982	0.1	2.8	2.9	3.1	2.2	3.1	7.5	18.4	20.7	13.1	11.2	9.2	5.6	100.0
1983	0.1	6.3	3.7	4.4	3.3	5.2	9.8	12.7	15.8	11.6	11.6	9.0	6.3	100.0
1984	0.2	6.3	3.4	3.3	3.1	5.0	7.9	11.4	17.9	14.2	13.8	8.1	5.4	100.0
1985	0.1	3.7	3.1	4.0	4.7	4.9	9.6	14.9	14.0	15.2	11.2	8.6	6.1	100.0
1986	0.0	5.0	4.5	4.7	6.3	6.4	10.1	16.4	13.9	11.8	10.2	6.1	4.5	100.0
1987	0.1	2.3	3.2	3.8	2.8	4.6	12.5	17.2	16.1	13.8	11.9	7.1	4.6	100.0
1988	0.1	3.8	2.1	2.8	3.4	6.0	13.5	14.3	15.9	17.6	10.5	6.6	3.3	100.0
1989	0.1	3.3	2.9	2.9	3.0	4.5	13.1	17.5	17.8	13.3	11.9	6.4	3.5	100.0
1990	0.1	3.2	2.3	3.5	2.7	5.5	12.1	16.5	18.6	12.9	12.5	6.5	3.7	100.0
1991	0.1	2.9	2.9	1.6	2.0	8.2	9.9	15.1	20.1	15.5	11.1	6.1	4.4	100.0
1992	0.1	3.3	2.9	3.5	3.4	4.1	9.8	17.6	20.8	14.2	9.5	7.0	3.8	100.0
1993	0.1	3.6	2.9	3.7	4.1	7.1	13.4	17.7	16.5	10.6	10.0	6.9	3.6	100.0
1994	0.0	3.0	5.8	4.2	6.9	7.3	13.0	14.5	15.1	9.4	9.8	6.2	4.7	100.0
1995	0.0	3.2	4.1	4.4	3.2	6.0	11.6	16.4	13.8	11.6	13.1	8.5	4.0	100.0
1996	0.0	4.1	4.5	4.6	3.0	7.4	11.6	11.1	16.8	13.6	12.2	7.2	3.7	100.0
1997	0.0	4.4	5.2	3.3	3.3	2.8	9.4	12.2	15.5	15.4	12.9	9.3	6.5	100.0

Table B4. Total US Landings (mt,live) and the annual percentage of landings of white hake by state, 1964-1997.

	Landings (mt, live)				Percentage of total			
Year	Maine	Mass.	Others[1]	Total	Maine	Mass.	Others[1]	Total
1964	1603	1362	51	3016	53.1	45.2	1.7	100.0
1965	1743	831	41	2615	66.7	31.8	1.5	100.0
1966	914	598	50	1562	58.5	38.3	3.2	100.0
1967	639	453	34	1126	56.8	40.2	3.0	100.0
1968	569	576	64	1209	47.1	47.6	5.3	100.0
1969	475	818	51	1343	35.3	60.9	3.8	100.0
1970	639	1088	81	1807	35.3	60.2	4.5	100.0
1971	892	1563	128	2583	34.5	60.5	5.0	100.0
1972	1329	1538	79	2946	45.1	52.2	2.7	100.0
1973	1295	1812	171	3278	39.5	55.3	5.2	100.0
1974	1708	1905	160	3773	45.3	50.5	4.2	100.0
1975	2063	1439	170	3673	56.2	39.2	4.6	100.0
1976	2502	1431	171	4104	61.0	34.9	4.1	100.0
1977	2967	1785	223	4976	59.6	35.9	4.5	100.0
1978	3047	1645	178	4869	62.6	33.8	3.6	100.0
1979	2404	1394	246	4044	59.4	34.5	6.1	100.0
1980	2729	1598	419	4746	57.5	33.7	8.8	100.0
1981	3756	2028	186	5970	62.9	34.0	3.1	100.0
1982	4253	1794	133	6179	68.8	29.0	2.2	100.0
1983	4289	1874	245	6408	66.9	29.3	3.8	100.0
1984	3881	2444	431	6757	57.4	36.2	6.4	100.0
1985	3696	3370	287	7353	50.3	45.8	3.9	100.0
1986	2955	2875	280	6109	48.4	47.1	4.5	100.0
1987	3246	2255	317	5818	55.8	38.8	5.4	100.0
1988	2695	1900	188	4783	56.3	39.7	4.0	100.0
1989	3123	1324	100	4547	68.7	29.1	2.2	100.0
1990	2744	2108	74	4927	55.7	42.8	1.5	100.0
1991	3280	2122	205	5607	58.5	37.8	3.7	100.0
1992	5357	2521	566	8444	63.4	29.9	6.7	100.0
1993	5042	2067	357	7466	67.5	27.7	4.8	100.0
1994	2940	1385	412	4737	62.1	29.2	8.7	100.0
1995	2532	1526	275	4333	58.4	35.2	6.3	100.0
1996	1950	1129	208	3287	59.3	34.3	6.3	100.0
1997	1427	623	175	2225	64.1	28.0	7.9	100.0

[1]Others include NH,RI,NY,NJ,VA

Table B5. US Landings (mt,live) and the annual percentage of total landings of white hake by tonnage class[1], 1964-1997.

	Tonnage Class (TC)					Percentage of total				
Year	2	3	4	Others[2]	Total	2	3	4	Others[2]	Total
1964	450	991	230	1345	3016	14.9	32.9	7.6	44.6	100.0
1965	312	510	198	1595	2615	11.9	19.5	7.6	61.0	100.0
1966	280	404	125	753	1562	17.9	25.9	8.0	48.2	100.0
1967	206	333	111	476	1126	18.3	29.6	9.9	42.3	100.0
1968	300	414	162	333	1209	24.8	34.2	13.4	27.5	100.0
1969	286	532	227	298	1343	21.3	39.6	16.9	22.2	100.0
1970	520	728	296	263	1807	28.8	40.3	16.4	14.6	100.0
1971	600	1084	341	558	2583	23.2	42.0	13.2	21.6	100.0
1972	738	972	303	934	2946	25.0	33.0	10.3	31.7	100.0
1973	934	913	287	1144	3278	28.5	27.9	8.8	34.9	100.0
1974	1334	884	338	1217	3773	35.4	23.4	9.0	32.3	100.0
1975	1302	603	254	1514	3673	35.5	16.4	6.9	41.2	100.0
1976	1587	837	279	1401	4104	38.7	20.4	6.8	34.1	100.0
1977	2363	1008	485	1119	4976	47.5	20.3	9.7	22.5	100.0
1978	2161	1083	534	1091	4869	44.4	22.2	11.0	22.4	100.0
1979	1687	1055	469	833	4044	41.7	26.1	11.6	20.6	100.0
1980	1809	1143	730	1065	4746	38.1	24.1	15.4	22.4	100.0
1981	2346	1492	1348	784	5970	39.3	25.0	22.6	13.1	100.0
1982	2626	1828	1309	417	6179	42.5	29.6	21.2	6.7	100.0
1983	1964	2402	1798	244	6408	30.6	37.5	28.1	3.8	100.0
1984	1966	2746	1621	424	6757	29.1	40.6	24.0	6.3	100.0
1985	1883	2987	2180	303	7353	25.6	40.6	29.7	4.1	100.0
1986	1189	2257	2195	468	6109	19.5	36.9	35.9	7.7	100.0
1987	1078	2556	1865	319	5818	18.5	43.9	32.1	5.5	100.0
1988	1114	1753	1682	234	4783	23.3	36.7	35.2	4.9	100.0
1989	1535	1495	1220	297	4547	33.8	32.9	26.8	6.5	100.0
1990	1330	1696	1702	199	4927	27.0	34.4	34.5	4.0	100.0
1991	1749	1895	1688	275	5607	31.2	33.8	30.1	4.9	100.0
1992	2665	2925	2362	491	8444	31.6	34.6	28.0	5.8	100.0
1993	1994	2563	2704	204	7466	26.7	34.3	36.2	2.7	100.0
1994	1294	1733	1695	15	4737	27.3	36.6	35.8	0.3	100.0
1995	1381	1564	1366	22	4333	31.9	36.1	31.5	0.5	100.0
1996	1202	1162	909	15	3287	36.6	35.3	27.7	0.4	100.0
1997	850	951	424	0	2225	38.2	42.7	19.0	0.0	100.0

[1]TC2 = 5-50 GRT, TC3 = 51-150 GRT, TC4 = 151-500 GRT.
[2]Undertonnage vessels

Table B6. Summary of US commercial white hake landings (mt), number of length samples (n), and number of fish measured(len) by market category and quarter from the Gulf of Maine to the Mid-Atlantic (SA 464, 465, 511-515, 521-526, 533-539, 611-626) for all gear types, 1985-1997.

		small					medium					large					unclassified					Sampling Intensity All	mt/
Year		Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Q1	Q2	Q3	Q4	sum	Total	sample
1985	mt	129	162	235	167	694	63	78	181	124	446	237	433	1135	623	2428	367	737	1690	988	3782	7349	272
	N	-	2	4	3	9	-	-	-	-	-	-	5	5	3	13	-	1	3	1	5	27	
	#fish	-	233	323	317	873	-	-	-	-	-	-	632	519	271	1422	-	101	293	104	498	2793	
1986	mt	59	134	105	100	398	86	89	55	54	284	274	422	835	417	1948	455	752	1578	694	3478	6107	235
	N	1	3	2	1	7	1	1	-	2	4	1	3	2	1	7	2	2	3	1	8	26	
	#fish	102	263	215	101	681	94	122	-	229	445	122	315	248	96	781	215	206	292	106	819	2726	
1987	mt	98	300	641	576	1616	13	49	122	123	306	171	326	943	372	1813	262	482	1035	301	2080	5814	194
	N	-	2	4	5	11	-	2	1	1	4	-	1	6	3	10	2	1	1	1	5	30	
	#fish	-	240	291	507	1038	-	203	91	109	403	-	111	518	236	865	218	140	112	125	595	2901	
1988	mt	181	549	893	397	2020	26	82	262	120	489	136	330	695	325	1486	73	137	437	134	782	4776	165
	N	5	6	3	5	19	1	1	1	-	3	1	1	2	1	5	-	1	-	1	2	29	
	#fish	558	764	240	478	2040	100	92	105	-	297	112	121	214	85	532	-	100	-	41	141	3010	
1989	mt	149	221	404	358	1132	41	54	124	68	287	188	473	904	470	2035	33	190	774	96	1092	4547	350
	N	1	1	2	2	6	-	-	1	-	1	-	-	2	2	4	1	-	1	-	2	13	
	#fish	91	94	213	195	593	-	-	103	-	103	-	-	206	204	410	100	-	106	-	206	1312	
1990	mt	207	411	885	450	1953	43	108	303	171	625	167	300	596	320	1382	24	182	580	176	962	4922	234
	N	3	4	4	2	13	-	-	2	1	3	2	-	1	1	4	-	-	-	1	1	21	
	#fish	309	408	399	151	1267	-	-	302	99	401	214	-	101	103	418	-	-	-	101	101	2087	
1991	mt	150	366	1215	612	2342	88	160	381	129	758	126	241	533	338	1238	52	358	714	138	1262	5601	156
	N	2	5	6	4	17	1	1	3	1	6	4	1	1	4	10	-	2	1	-	3	36	
	#fish	151	471	485	244	1351	103	100	382	100	685	375	99	96	539	1109	-	207	94	-	301	3446	
1992	mt	424	626	1735	848	3633	102	202	766	358	1428	231	351	699	371	1651	60	280	1246	141	1727	8439	211
	N	4	4	8	3	19	1	4	3	3	11	-	2	3	2	7	1	-	2	-	3	40	
	#fish	329	432	655	240	1656	80	388	266	317	1051	-	194	325	297	816	97	-	237	-	334	3857	
1993	mt	331	502	453	214	1500	161	397	1117	461	2136	173	476	795	416	1860	94	463	975	433	1965	7462	191
	N	2	5	4	1	12	2	3	2	1	8	2	3	7	2	14	-	2	2	1	5	39	
	#fish	150	504	275	50	979	184	309	196	95	784	199	262	676	175	1312	-	214	196	97	507	3582	
1994	mt	63	82	116	56	317	154	374	593	265	1386	206	481	687	407	1782	193	352	457	251	1252	4737	144
	N	-	2	4	1	7	-	2	3	3	8	-	3	4	2	9	-	2	4	3	9	33	
	#fish	-	167	386	100	653	-	230	305	272	807	-	303	363	304	970	-	236	431	372	1039	3469	
1995	mt	39	43	98	56	245	140	238	616	399	1393	197	398	595	374	1564	134	225	504	268	1130	4333	361
	N	-	1	1	1	3	-	2	2	1	5	-	2	-	1	3	-	1	-	-	1	12	
	#fish	-	107	97	105	309	-	191	222	111	524	-	221	-	103	324	-	100	-	-	100	1257	
1996	mt	23	34	80	43	181	96	207	531	269	1103	208	331	416	280	1234	110	152	339	169	769	3287	122
	N	-	-	-	-	-	1	-	4	4	9	-	2	4	5	11	1	1	3	2	7	27	
	#fish	-	-	-	-	- -	101	-	435	541	1077	-	202	451	759	1412	127	72	326	220	745	3234	
1997	mt	31	58	124	83	295	76	113	369	193	751	146	146	438	335	1065	34	28	26	26	113	2225	32
	N	4	2	4	2	12	3	7	6	13	29	5	7	7	9	28	-	-	-	1	1	70	
	#fish	458	206	430	261	1355	276	694	564	1200	2734	541	720	678	896	2835	-	-	-	58	58	6982	

Table B7. Number of ages used to age the commercial length composition.

Year	Spring (Half 1)	Autumn (Half 2)	Total
1985	217	338	555
1986	655	653	1308
1987	171	392	563
1988	273	454	727
1989	104	352	456
1990	428	643	1071
1991	492	762	1254
1992	300	674	974
1993	323	556	879
1994	276	525	801
1995	225	459	684
1996	140	226	366
1997	80	195	275

Table B8. Percentage by age of landings-at-age that were filled out to account for missing ages-at-length. The total is the percentage of the entire landings-at-age.

	Age						
	5	6	7	8	9	10+	Total
			Numbers				
1985	0.0	10.6	70.1	40.5	92.8	77.1	2.4
1986	0.0	6.4	0.0	79.5	51.9	71.6	11.1
1987	11.1	4.0	13.3	8.4	45.2	74.3	4.6
1988	0.0	20.1	85.7	90.0	100.0	100.0	1.4
1989	0.0	0.0	2.6	24.8	100.0	100.0	0.8
1990	0.0	20.2	40.2	51.8	76.8	81.9	1.3
1991	0.0	6.8	59.6	90.9	81.7	98.6	1.3
1992	0.0	0.0	21.9	22.2	100.0	23.1	0.5
1993	0.0	12.5	100.0	97.4	100.0	100.0	0.9
1994	0.0	0.0	35.4	45.5	100.0	97.4	1.0
1995	0.9	20.4	49.6	0.0	100.0	100.0	1.1
1996	0.0	36.1	34.7	0.0	100.0	55.3	4.0
1997	38.3	54.1	26.5	64.9	42.4	41.2	20.8
			Weight				
1985	0.0	10.8	58.4	28.9	54.7	36.2	5.6
1986	0.0	7.6	0.0	79.8	57.2	78.0	30.3
1987	10.1	3.9	15.6	10.1	49.8	78.2	15.1
1988	0.0	24.5	91.8	91.8	100.0	100.0	11.4
1989	0.0	0.0	2.8	26.6	100.0	100.0	3.4
1990	0.0	26.2	50.5	54.7	79.7	82.0	6.9
1991	0.0	10.0	67.0	93.1	83.4	97.2	7.1
1992	0.0	0.0	26.3	27.1	100.0	26.9	2.2
1993	0.0	13.0	100.0	98.3	100.0	100.0	3.6
1994	0.0	0.0	37.5	50.4	100.0	97.7	4.3
1995	1.4	24.5	52.3	0.0	100.0	100.0	4.3
1996	0.0	39.3	42.9	0.0	100.0	65.7	8.8
1997	40.2	56.3	27.4	71.3	46.9	44.1	29.4

Table B9. Total US commercial landings-at-age of white hake.

Year	Age 1	2	3	4	5	6	7	8	9+	Total
			Total Commercial Landings in Numbers (000s) at age							
1985	0	12	617	1847	679	157	55	20	34	3422
1986	0	18	285	371	289	187	146	84	214	1593
1987	0	46	839	697	351	164	66	74	92	2329
1988	15	1077	966	938	431	86	5	10	27	3556
1989	0	12	531	797	503	259	39	18	13	2172
1990	22	561	1085	1108	305	59	43	6	17	3206
1991	9	237	1458	1276	365	101	20	15	22	3502
1992	0	43	2006	2224	432	214	78	24	11	5032
1993	0	39	1557	2380	632	172	14	5	11	4810
1994	45	28	798	1045	513	225	40	25	7	2726
1995	0	286	1677	808	200	130	13	12	4	3130
1996	0	31	370	554	399	132	46	11	7	1550
1997	0	2	86	309	296	125	21	23	6	867
			Total Commercial Landings in Weight (Tons) at age							
1985	0	8	677	3775	2171	706	344	158	466	8306
1986	0	10	289	626	937	926	858	677	2743	7066
1987	0	25	857	1338	1221	901	372	497	1161	6373
1988	3	491	837	1801	1238	365	34	77	472	5317
1989	0	8	582	1488	1494	1043	233	133	149	5131
1990	5	261	1252	2143	1006	264	251	52	241	5474
1991	2	90	1656	2551	987	353	111	126	283	6159
1992	0	28	2093	4106	1488	1089	441	178	159	9582
1993	0	14	1639	4466	1939	787	96	43	163	9147
1994	6	10	815	1820	1495	983	254	213	97	5692
1995	0	175	1858	1514	537	502	79	94	56	4814
1996	0	19	436	1117	1187	502	238	83	76	3659
1997	0	1	92	649	901	529	125	162	56	2515
			Total Commercial Landings Mean Weight (kg) at age							
1985	0.000	0.682	1.096	2.044	3.195	4.505	6.281	8.104	13.525	2.427
1986	0.000	0.562	1.015	1.686	3.242	4.958	5.898	8.095	12.804	4.435
1987	0.000	0.541	1.022	1.920	3.474	5.492	5.681	6.713	12.677	2.736
1988	0.176	0.455	0.867	1.919	2.874	4.245	7.238	7.604	17.504	1.495
1989	0.000	0.686	1.096	1.867	2.969	4.022	6.050	7.503	11.212	2.362
1990	0.224	0.465	1.153	1.934	3.303	4.473	5.819	8.393	14.331	1.707
1991	0.253	0.379	1.136	1.998	2.708	3.512	5.438	8.712	12.865	1.759
1992	0.000	0.645	1.044	1.847	3.443	5.086	5.668	7.376	13.980	1.904
1993	0.000	0.353	1.053	1.877	3.070	4.571	6.912	9.132	14.312	1.902
1994	0.130	0.362	1.021	1.742	2.914	4.361	6.358	8.483	13.627	2.088
1995	0.000	0.612	1.108	1.874	2.684	3.849	6.095	7.824	14.343	1.538
1996	0.000	0.619	1.177	2.018	2.974	3.807	5.218	7.500	10.554	2.361
1997	0.000	0.714	1.067	2.102	3.047	4.224	5.862	7.084	9.860	2.899
			Total Commercial Landings Mean Length (cm) at age							
1985	0.0	43.8	50.8	61.5	71.0	79.3	87.9	95.4	110.2	63.3
1986	0.0	40.8	49.3	58.0	71.2	81.6	86.3	95.2	107.5	72.6
1987	35.0	40.7	49.7	60.3	72.9	84.0	85.2	89.6	108.5	63.2
1988	28.7	37.7	47.0	60.4	68.7	77.5	92.0	93.6	120.3	52.1
1989	0.0	44.0	50.7	60.0	69.5	76.5	87.2	93.2	105.5	62.8
1990	30.3	38.9	51.4	60.7	71.7	79.2	85.4	96.7	113.2	55.6
1991	31.8	35.6	50.7	60.8	67.1	73.2	84.1	97.1	109.7	56.4
1992	0.0	42.9	49.9	59.1	72.4	82.1	85.2	92.5	113.2	58.1
1993	0.0	35.7	50.0	59.9	70.3	79.7	90.7	98.2	113.3	58.8
1994	26.3	34.8	49.6	58.5	69.0	78.5	88.6	96.4	111.2	59.7
1995	0.0	42.4	50.9	60.1	67.4	75.2	87.5	94.7	115.2	55.0
1996	0.0	42.5	51.8	61.4	69.5	75.1	82.5	93.0	102.5	63.0
1997	0.0	43.6	50.1	62.1	70.1	77.7	86.3	91.5	101.7	67.5

Table B10. White hake effort (days fished) standardization. Run through 1993
Standard: Year = 85; Area = 515[1]; Qtr = 3; TC = 3[2]; Depth = 3[3];

GENERAL LINEAR MODEL 2

Dependent Variable :LNCPUEDF

Source	DF	Sum of Squares	Mean Square	F Value	PR > 1	R-Square	CV
Model	26	24810.2	954.2	508.47	0.0001	0.323238	-57.8
Error	27679	51945.0	1.9				
Corrected Total	27705	76755.2					

Source	DF	Type I SS	Mean Square	F Value	PR > F
Year	12	5632.6	469.4	250.11	0.0001
Area	6	9966.0	1661.0	885.07	0.0001
Qtr	3	4287.8	1428.9	761.40	0.0001
TC	2	2657.4	1328.7	707.99	0.0001
Depthcd	3	2267.5	755.8	402.75	0.0001

Source	DF	Type III SS	Mean Square	F Value	PR > F
Year	12	4951.2	412.6	219.85	0.0001
Area	6	3809.9	635.0	338.35	0.0001
Qtr	3	5868.5	1956.2	1042.35	0.0001
TC	2	2363.8	1181.9	629.78	0.0001
Depthcd	3	2267.5	755.8	402.75	0.0001

Parameter		Estimate	T for H_0 : Coefficient	Pr > |T| Parameter = 0	Std Error of Estimate	Re-Transformed Estimate
Intercept		-2.28779 B	-56.29	0.0001	0.040643	
Area	511	0.41926 B	7.06	0.0001	0.059344	1.520840
	512	0.22294 B	6.34	0.0001	0.035138	1.249749
	513	-0.61583 B	-21.75	0.0001	0.028319	0.540194
	514	-0.48061 B	-14.12	0.0001	0.034034	0.618408
	515	0.00000 B	-	-	-	1.000000
	522[1]	-0.50581 B	-19.89	0.0001	0.025435	0.603016
	525[2]	-1.55057 B	-35.61	0.0001	0.043549	0.212126
Quarter	1	-1.28868 B	-51.14	0.0001	0.025197	0.275634
	2	-0.89520 B	-40.08	0.0001	0.022335	0.408524
	3	0.00000 B	-	-	-	1.000000
	4	-0.44162 B	-19.98	0.0001	0.022105	0.643000
TC	2	-0.27750 B	-10.83	0.0001	0.025630	0.757673
	3	0.00000 B	-	-	-	1.000000
	4	0.61575 B	31.44	0.0001	0.019588	1.851053
Depthcd	1	-0.55165 B	-12.09	0.0001	0.045617	0.575999
	2	-0.46233 B	-19.45	0.0001	0.023770	0.629814
	3	0.00000 B	-	-	-	1.000000
	4[4]	0.52220 B	23.03	0.0001	0.022673	1.685737

[1]Includes 521,522,523(561).
[2]Includes 524(562) 525,526.
[4]Includes depthcd 4-7.

Table B11. Nominal and standardized (through 1993) white hake landings (mt), effort (days fished) and landings per day fished (LPUE) for the otter trawl fleet.

Year	Landings (mt)	Nominal Effort	Nominal LPUE	Standardized Effort	Standardized LPUE
1985	3370	8605	0.392	6488	0.519
1986	2786	8218	0.339	6387	0.436
1987	2832	9723	0.325	6088	0.465
1988	2456	8236	0.298	5489	0.448
1989	1312	6320	0.208	3816	0.344
1990	1761	6541	0.269	4117	0.428
1991	1924	7022	0.274	4428	0.435
1992	2638	7790	0.339	4828	0.547
1993	2423	7525	0.322	4863	0.498
1994	808	5468	0.148	3489	0.232
1995	498	4472	0.111	2926	0.170
1996	886	6851	0.129	4776	0.186
1997	654	5488	0.119	3419	0.191

Table B12. Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore spring research vessel bottom trawl surveys (strata 21-30,33-40), 1968-1998

	Abundance						Biomass											
	Raw Index			Smoothed			Raw Index			Smoothed			Individual	Length				Number
Year	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean Wt	Min	Mean	Max	Number of Tows	of Nonzero Tows
1968	1.60	0.99	2.21	2.80			1.74	0.85	2.63	3.63			1.09	10	44.1	118	84	32
1969	3.76	2.14	5.38	3.59			5.09	3.15	7.03	5.02			1.36	11	46.3	127	83	40
1970	5.84	3.48	8.19	4.50			11.86	2.60	21.12	6.92			2.03	21	52.9	114	90	47
1971	3.31	2.16	4.47	5.03	3.21	7.88	5.14	3.03	7.25	7.50	4.40	12.77	1.55	17	51.3	121	94	45
1972	10.18	6.71	13.65	6.78	4.33	10.61	12.66	6.03	19.30	9.60	5.64	16.36	1.24	18	47.3	112	94	59
1973	9.24	4.96	13.52	7.62	4.87	11.93	12.22	7.30	17.15	10.89	6.39	18.54	1.32	18	49.9	120	85	55
1974	8.08	5.61	10.54	7.86	5.02	12.32	13.99	9.06	18.93	11.72	6.88	19.96	1.73	10	55.0	126	81	56
1975	9.32	5.94	12.70	8.02	5.12	12.56	11.22	7.60	14.85	11.67	6.85	19.88	1.21	9	44.7	115	81	48
1976	9.98	6.90	13.06	7.66	4.89	11.99	17.01	9.27	24.74	11.83	6.94	20.14	1.70	10	52.7	122	97	70
1977	6.13	3.82	8.43	6.50	4.15	10.17	11.01	6.79	15.23	10.20	5.99	17.37	1.79	22	55.5	128	105	52
1978	3.22	2.10	4.34	5.66	3.61	8.86	6.14	3.76	8.52	8.51	4.99	14.49	1.91	20	51.8	131	112	49
1979	5.26	3.40	7.11	6.32	4.04	9.90	4.97	2.56	7.38	8.19	4.81	13.96	1.02	16	43.0	113	131	65
1980	10.38	7.26	13.49	7.66	4.89	12.00	13.96	9.51	18.41	9.85	5.79	16.78	1.35	10	49.7	123	83	54
1981	17.09	12.45	21.73	8.12	5.19	12.72	19.92	8.91	30.93	10.15	5.96	17.29	1.17	11	45.9	131	84	66
1982	6.06	3.33	8.78	6.20	3.96	9.70	8.91	4.86	12.95	7.76	4.56	13.22	1.47	16	51.0	122	90	52
1983	3.23	2.26	4.19	4.77	3.05	7.47	3.12	2.13	4.11	5.58	3.28	9.50	0.97	15	43.7	102	87	54
1984	2.75	1.85	3.65	4.37	2.79	6.84	4.17	2.10	6.24	5.19	3.05	8.84	1.52	15	51.4	118	83	38
1985	4.33	2.97	5.68	4.90	3.13	7.68	5.38	3.12	7.64	5.32	3.12	9.05	1.24	20	48.5	117	78	39
1986	8.24	6.39	10.10	5.82	3.72	9.11	5.61	3.97	7.25	5.42	3.18	9.23	0.68	11	40.0	96	87	60
1987	7.15	5.29	9.00	5.92	3.78	9.27	6.44	4.56	8.31	5.44	3.19	9.26	0.90	12	45.3	128	81	49
1988	4.52	3.58	5.45	5.54	3.54	8.67	3.69	2.82	4.57	5.06	2.97	8.62	0.82	13	41.9	95	87	50
1989	3.65	2.06	5.24	5.67	3.62	8.88	3.22	1.22	5.22	5.42	3.18	9.23	0.88	16	43.0	92	79	42
1990	11.11	0.84	21.38	7.05	4.50	11.04	18.37	-8.27	45.00	7.31	4.29	12.45	1.65	22	53.3	119	87	50
1991	8.42	6.30	10.55	7.17	4.58	11.23	6.14	4.05	8.23	6.56	3.85	11.17	0.73	9	41.6	131	83	55
1992	7.59	4.95	10.24	6.79	4.33	10.63	7.11	3.54	10.69	6.06	3.55	10.32	0.94	22	45.1	105	77	48
1993	7.93	5.50	10.35	6.11	3.90	9.58	6.84	4.49	9.19	5.21	3.06	8.88	0.86	17	45.1	85	84	48
1994	4.59	3.29	5.89	4.91	3.13	7.71	3.17	1.69	4.66	3.97	2.32	6.78	0.69	18	40.1	96	85	55
1995	4.38	3.20	5.55	4.06	2.57	6.41	4.02	2.58	5.46	3.34	1.94	5.75	0.92	14	44.1	100	86	48
1996	2.87	2.17	3.58	3.25	2.01	5.25	3.07	2.22	3.92	2.59	1.47	4.58	1.07	12	45.9	104	78	47
1997	1.88	1.27	2.48	2.75	1.58	4.78	0.89	0.58	1.20	1.87	0.97	3.60	0.47	18	38.4	67	87	36
1998	2.25	1.57	2.92				1.09	0.70	1.48					17	37.7	74	113	53

Table B13. Stratified mean catch per tow in numbers and weight (kg) for white hake from NEFSC offshore autumn research vessel bottom trawl surveys (strata 21-30,33-40), 1963-1997.

	Abundance						Biomass											
	Raw Index			Smoothed			Raw Index			Smoothed			Individual	Length			Number	Number of Nonzero
Year	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean Wt	Min	Mean	Max	of Tows	Tows
1963	5.00	3.85	6.15	3.87			6.31	4.66	7.97	5.75			1.26	9	46.2	121	90	54
1964	1.77	1.22	2.31	3.46			4.14	2.51	5.78	5.52			2.38	24	56.3	123	86	36
1965	4.39	2.75	6.02	4.16			6.86	4.61	9.11	6.02			1.56	15	50.4	125	87	60
1966	6.79	5.06	8.53	4.88	3.30	7.21	7.67	5.75	9.59	6.20	4.28	8.97	1.13	18	45.1	121	85	66
1967	3.92	2.85	5.00	4.94	3.35	7.31	3.64	2.33	4.95	5.80	4.01	8.40	0.93	9	42.6	117	83	53
1968	4.24	2.57	5.91	5.55	3.76	8.21	4.54	2.46	6.62	6.68	4.61	9.66	1.07	11	44.9	120	84	54
1969	9.24	7.08	11.41	7.03	4.76	10.39	13.09	9.00	17.19	9.12	6.30	13.19	1.42	14	46.8	112	85	62
1970	8.05	6.17	9.92	7.89	5.34	11.66	12.82	8.95	16.70	10.60	7.33	15.34	1.59	5	51.3	127	90	68
1971	10.38	6.33	14.43	8.77	5.93	12.96	12.10	9.49	14.71	11.34	7.83	16.41	1.17	5	43.6	130	92	76
1972	12.52	5.80	19.24	9.05	6.12	13.38	13.10	8.54	17.65	11.78	8.14	17.04	1.05	9	45.2	122	92	74
1973	9.05	6.39	11.72	8.09	5.47	11.95	13.46	9.15	17.76	11.67	8.06	16.89	1.49	8	51.7	119	89	72
1974	5.35	4.12	6.59	6.88	4.65	10.16	11.00	7.96	14.04	10.85	7.50	15.71	2.06	7	54.5	130	95	73
1975	5.28	4.03	6.53	6.53	4.42	9.66	7.23	5.43	9.03	10.04	6.94	14.53	1.37	15	48.5	116	105	74
1976	6.04	4.09	7.99	6.82	4.62	10.09	10.56	7.39	13.72	10.73	7.42	15.54	1.75	8	54.7	134	91	68
1977	9.78	7.77	11.78	7.52	5.09	11.12	13.74	10.51	16.96	11.56	7.99	16.73	1.41	10	47.8	123	122	94
1978	7.87	6.25	9.49	7.38	4.99	10.91	12.54	9.73	15.35	11.54	7.97	16.70	1.59	12	50.2	131	191	146
1979	5.62	4.38	6.85	7.04	4.76	10.41	10.31	7.27	13.36	11.10	7.67	16.06	1.84	22	53.1	127	203	146
1980	10.86	7.38	14.33	7.42	5.02	10.97	16.66	8.79	24.54	11.03	7.62	15.96	1.54	4	48.8	118	94	76
1981	8.70	6.87	10.53	6.61	4.47	9.77	12.16	9.69	14.63	9.13	6.31	13.21	1.40	20	49.9	132	88	65
1982	1.96	1.37	2.55	5.21	3.52	7.70	2.11	1.35	2.88	6.65	4.60	9.63	1.08	12	46.7	93	92	49
1983	8.22	6.11	10.32	6.33	4.28	9.36	10.79	8.16	13.42	8.06	5.57	11.67	1.31	22	48.8	117	80	59
1984	5.32	4.38	6.26	6.86	4.64	10.14	8.23	6.60	9.86	8.59	5.93	12.42	1.55	22	51.9	123	86	69
1985	9.37	6.79	11.94	8.31	5.62	12.28	9.74	6.48	12.99	9.32	6.44	13.48	1.04	9	42.9	128	85	68
1986	14.42	11.34	17.50	9.55	6.46	14.11	11.56	9.54	13.58	9.91	6.85	14.35	0.80	10	41.9	108	89	79
1987	7.59	6.16	9.02	9.14	6.19	13.51	9.62	6.79	12.44	9.85	6.81	14.26	1.27	17	49.2	113	85	61
1988	8.12	6.35	9.89	9.51	6.43	14.05	9.88	6.87	12.90	9.90	6.84	14.32	1.22	19	46.1	136	86	69
1989	11.76	7.94	15.58	10.60	7.17	15.66	9.23	7.39	11.07	9.95	6.87	14.40	0.79	9	40.5	91	85	68
1990	13.09	9.76	16.41	11.28	7.63	16.67	10.58	6.87	14.28	10.34	7.14	14.96	0.81	5	41.5	83	87	72
1991	13.22	9.77	16.68	11.24	7.61	16.62	12.20	8.05	16.36	10.64	7.35	15.40	0.92	16	44.6	94	87	76
1992	10.16	8.57	11.76	10.43	7.06	15.42	11.24	9.09	13.39	10.30	7.11	14.91	1.11	16	47.7	115	84	68
1993	11.35	8.64	14.05	9.79	6.62	14.48	11.66	8.89	14.42	9.59	6.62	13.89	1.03	11	45.2	86	84	75
1994	8.44	6.67	10.20	8.61	5.81	12.75	7.02	5.02	9.02	8.19	5.65	11.88	0.83	3	42.3	88	86	73
1995	9.54	7.81	11.28	7.64	5.13	11.37	8.20	6.43	9.96	7.49	5.14	10.92	0.86	3	40.8	126	91	72
1996	4.52	3.66	5.37	6.14	4.05	9.32	6.35	4.74	7.96	6.58	4.44	9.77	1.41	10	51.2	97	83	56
1997	4.69	3.58	5.80	5.65	3.49	9.15	4.55	3.29	5.80	5.88	3.73	9.27	0.97	18	41.5	118	88	65

Table B14. Stratified mean number per tow at age of white hake in the NEFSC spring and autumn bottom trawl surveys (Strata 21-30,33-40), 1982 and 1987-1989. Also shown at the bottom of the page are the plus groups used in deriving the estimates of instantaneous total mortality.

	Age Group											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring																	
1982	0.0000	0.0559	0.8951	2.7397	0.8080	1.1785	0.2447	0.0205	0.0341	0.0177	0.0618	6.0560	6.0560	6.0001	5.1050	2.3653	1.5573
1983	0.0000	0.0658	1.0135	1.2366	0.5966	0.1495	0.0854	0.0435	0.0339	0.0000	0.0000	3.2248	3.2248	5.3703	4.1337	3.5371	3.3876
1984	0.0000	0.0193	0.4363	1.0334	0.5940	0.4108	0.1602	0.0479	0.0352	0.0000	0.0156	2.7527	2.7527	2.7334	2.2971	1.2637	0.6697
1985	0.0000	0.0605	0.8190	1.7399	1.1089	0.4023	0.1100	0.0298	0.0189	0.0000	0.0388	4.3281	4.3281	4.2676	3.4486	1.7087	0.5998
1986	0.0000	0.1429	3.2192	3.1799	1.0404	0.4654	0.1794	0.0000	0.0153	0.0000	0.0000	8.2425	8.2425	8.0996	4.8804	1.7005	0.6601
1987	0.0000	0.0196	1.3290	4.1538	1.1008	0.3596	0.1181	0.0000	0.0313	0.0000	0.0326	7.1448	7.1448	7.1252	5.7962	1.6424	0.5416
1988	0.0000	0.1813	1.6423	1.2877	0.8169	0.3738	0.1099	0.0221	0.0697	0.0000	0.0139	4.5176	4.5176	4.3363	2.6940	1.4063	0.5894
1989	0.0000	0.0663	1.2371	1.5201	0.2697	0.3827	0.1540	0.0203	0.0000	0.0000	0.0000	3.6502	3.6502	3.5839	2.3468	0.8267	0.5570
1990	0.0000	0.0706	1.7355	2.3733	4.3770	1.8403	0.2864	0.1086	0.1417	0.0589	0.1178	11.1101	11.1101	11.0395	9.3040	6.9307	2.5537
1991	0.0000	0.2341	2.7823	2.4390	1.7550	0.8637	0.2549	0.0439	0.0153	0.0000	0.0276	8.4158	8.4158	8.1817	5.3994	2.9604	1.2054
1992	0.0000	0.0000	0.8169	2.5201	3.8107	0.3157	0.0879	0.0337	0.0084	0.0000	0.0000	7.5934	7.5934	7.5934	6.7765	4.2654	0.4457
1993	0.0000	0.0362	2.0586	3.1199	2.2549	0.4293	0.0276	0.0000	0.0000	0.0000	0.0000	7.9265	7.9265	7.8903	5.8317	2.7118	0.4569
1994	0.0000	0.0335	1.6935	1.8829	0.6658	0.1965	0.0831	0.0080	0.0224	0.0000	0.0000	4.5857	4.5857	4.5522	2.8587	0.9758	0.3100
1995	0.0000	0.1134	0.8956	2.1134	0.7609	0.2467	0.1499	0.0331	0.0638	0.0000	0.0000	4.3768	4.3768	4.2634	3.3678	1.2544	0.4935
1996	0.0000	0.2441	0.4780	1.0302	0.5293	0.4181	0.0978	0.0188	0.0298	0.0261	0.0000	2.8722	2.8722	2.6281	2.1501	1.1199	0.5906
1997	0.0000	0.0360	0.6734	0.8669	0.2508	0.0479	0.0000	0.0000	0.0000	0.0000	0.0000	1.8750	1.8750	1.8390	1.1656	0.2987	0.0479
1998	0.0000	0.0127	1.1398	0.8587	0.1591	0.0641	0.0126	0.0000	0.0000	0.0000	0.0000	2.2470	2.2470	2.2343	1.0945	0.2358	0.0767
Autumn																	
1982	0.0043	0.3170	0.5152	0.7349	0.2107	0.1048	0.0577	0.0171	0.0000	0.0000	0.0000	1.9617	1.9574	1.6404	1.1252	0.3903	0.1796
1983	0.0000	0.5652	2.8285	2.6364	1.6096	0.2240	0.2413	0.0076	0.0000	0.0139	0.0696	8.2161	8.2161	7.6509	4.8224	2.1860	0.5764
1984	0.0000	0.3774	1.0913	2.1531	1.1271	0.3589	0.1357	0.0292	0.0107	0.0000	0.0346	5.3180	5.3180	4.9406	3.8493	1.6962	0.5691
1985	0.3101	2.9641	1.8769	2.0345	1.4613	0.4341	0.1397	0.0685	0.0245	0.0000	0.0517	9.3654	9.0553	6.0912	4.2143	2.1798	0.7185
1986	0.8543	1.1644	6.6635	4.0970	0.8765	0.4968	0.1413	0.0831	0.0000	0.0281	0.0153	14.4203	13.5660	12.4016	5.7381	1.6411	0.7646
1987	0.0633	0.5314	1.6312	3.7002	1.0633	0.2483	0.1572	0.0804	0.0452	0.0390	0.0314	7.5909	7.5276	6.9962	5.3650	1.6648	0.6015
1988	0.0000	0.5094	3.7547	2.0666	1.2842	0.3477	0.1104	0.0000	0.0000	0.0000	0.0448	8.1178	8.1178	7.6084	3.8537	1.7871	0.5029
1989	0.2911	3.0347	3.2924	3.4743	0.8438	0.4093	0.3410	0.0441	0.0196	0.0000	0.0057	11.7560	11.4649	8.4302	5.1378	1.6635	0.8197
1990	0.9693	1.8051	4.8687	3.6504	1.4762	0.2934	0.0222	0.0000	0.0000	0.0000	0.0000	13.0853	12.1160	10.3109	5.4422	1.7918	0.3156
1991	0.1897	1.1341	5.8094	4.3180	1.3777	0.3326	0.0431	0.0000	0.0196	0.0000	0.0000	13.2242	13.0345	11.9004	6.0910	1.7730	0.3953
1992	0.1454	0.4136	2.3525	5.5875	1.2894	0.1618	0.1287	0.0346	0.0299	0.0000	0.0196	10.1630	10.0176	9.6040	7.2515	1.6640	0.3746
1993	0.1559	1.4687	2.6703	4.1235	2.3872	0.4213	0.1202	0.0000	0.0000	0.0000	0.0000	11.3471	11.1912	9.7225	7.0522	2.9287	0.5415
1994	0.3556	0.9621	2.8374	2.9629	0.9868	0.2072	0.1024	0.0204	0.0000	0.0000	0.0000	8.4348	8.0792	7.1171	4.2797	1.3168	0.3300
1995	1.1788	0.5332	3.9421	2.8394	0.7083	0.1930	0.0124	0.1070	0.0000	0.0000	0.0302	9.5444	8.3656	7.8324	3.8903	1.0509	0.3426
1996	0.0239	0.2953	1.0225	1.5424	1.2022	0.3342	0.0276	0.0274	0.0248	0.0000	0.0160	4.5163	4.4924	4.1971	3.1746	1.6322	0.4300
1997	0.0000	1.6117	1.2346	0.9233	0.5920	0.1766	0.0640	0.0124	0.0196	0.0000	0.0558	4.6900	4.6900	3.0783	1.8437	0.9204	0.3284

Table B15. Estimates of instantaneous total mortality (Z) and fishing mortality (F) for Gulf of Maine-Northern Georges Bank white hake, 1982-1998, derived from NEFSC offshore spring and autumn Bottom trawl survey data.

Time Period	Spring Z	Spring F	Autumn Z	Autumn F	Geometric Mean Z	Geometric Mean F
1982-1986	0.51	0.31	0.60	0.40	0.55	0.35
1987-1991	0.79	0.59	1.04	0.84	0.91	0.71
1992-1996	1.60	1.40	1.18	0.98	1.37	1.17
1993-1997	1.44	1.24	1.31	1.11	1.37	1.17

Table B16. Summary of results from alternative ADAPT calibrations.

run#	1	7	8	10	11	13*
Tuning	2-7	2-7	2-7	2-7 + LPUE1	3-7 + LPUE1	2-7 + LPUE2
Estimation	3-7	3-7	2-7	2-7	3-7	2-7
Ages for est. of Z on 8	5-7	5-8	5-8	5-8	5-8	4-8
results						
N2	-	-	4670	4670	-	4660
N3	1060	1060	1280	1280	1290	1280
N4	629	629	707	707	579	706
N5	315	315	317	317	273	302
N6	325	326	56	58	57	59
N7	323	320	60	65	66	58
CV(N2)	-	-	0.47	0.46	-	0.46
CV(N3)	0.49	0.49	0.33	0.32	0.46	0.33
CV(N4)	0.43	0.43	0.29	0.28	0.35	0.29
CV(N5)	0.56	0.56	0.38	0.37	0.40	0.38
CV(N6)	0.51	0.51	0.46	0.44	0.45	0.45
CV(N7)	0.62	0.62	0.62	0.57	0.58	0.59
F97	0.45	0.45	1.41	1.37	1.37	1.15
SSB97	5206	5202	2862	2901	2733	2945
High Residuals	High on 2s	High on 2s	None	None	None	None

*Configuration accepted by working group

Table B17. Estimates of stock size (000s of fish), instantaneous fishing mortality rate (F), mean biomass (mt), and spawning stock biomass for Gulf of Maine-Northern Georges Bank white hake obtained from Virtual Population Analysis.

STOCK NUMBERS (Jan 1) in thousands

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	4951	4629	6315	6222	10000	10413	5743	4548	4804	2341	1471	1911	5692	00
2	3277	4052	3789	5170	5081	8186	8506	4694	3723	3932	1875	1204	1564	4659
3	2064	2672	3302	3060	3258	4149	6194	6750	3804	3012	3195	1277	957	1279
4	2780	1131	1930	1944	1631	2186	2415	3753	3712	1705	1745	1098	711	706
5	1150	605	590	949	743	614	788	822	1060	885	451	697	398	302
6	613	326	233	165	387	153	227	315	282	297	261	188	210	59
7	307	360	98	43	58	82	72	95	64	75	39	95	35	58
8	34	202	163	21	31	12	28	40	07	40	26	20	37	09
9	59	511	199	56	23	33	42	18	17	11	08	13	09	12
1+	15234	14488	16619	17630	21211	25830	24015	21035	17474	12299	9070	6504	9612	7084

FISHING MORTALITY

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
2	0.00	0.00	0.01	0.26	0.00	0.08	0.03	0.01	0.01	0.01	0.18	0.03	0.00
3	0.40	0.13	0.33	0.43	0.20	0.34	0.30	0.40	0.60	0.35	0.87	0.39	0.11
4	1.33	0.45	0.51	0.76	0.78	0.82	0.88	1.06	1.23	1.13	0.72	0.81	0.65
5	1.06	0.75	1.07	0.70	1.38	0.79	0.72	0.87	1.07	1.02	0.67	1.00	1.72
6	0.33	1.00	1.50	0.86	1.35	0.56	0.67	1.39	1.12	1.83	0.81	1.49	1.08
7	0.22	0.59	1.33	0.13	1.34	0.86	0.38	2.37	0.27	0.88	0.46	0.75	1.15
8	1.01	0.61	0.70	0.75	1.02	0.82	0.83	1.10	1.22	1.18	0.73	0.94	1.15
9	1.01	0.61	0.70	0.75	1.02	0.82	0.83	1.10	1.22	1.18	0.73	0.94	1.15
Avg 4-8 u	0.79	0.68	1.02	0.64	1.17	0.77	0.69	1.36	0.98	1.21	0.68	1.00	1.15
Avg 4-8 w	1.07	0.62	0.73	0.74	1.03	0.80	0.82	1.08	1.18	1.16	0.71	0.94	1.05
Biomass Weighted F	0.61	0.45	0.51	0.51	0.43	0.39	0.40	0.62	0.80	0.71	0.66	0.67	0.49

MEAN BIOMASS (using catch mean weights at age)

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	897	839	1145	991	1813	2112	1316	824	871	273	267	346	1032
2	2022	2059	1846	1884	3155	3322	2878	2731	1184	1285	953	666	1011
3	1700	2315	2620	1969	2945	3695	5535	5304	2755	2370	2176	1137	880
4	2914	1402	2653	2396	1944	2650	2954	3934	3701	1643	2140	1393	1004
5	2089	1264	1160	1801	1107	1285	1396	1739	1840	1489	806	1207	541
6	2142	943	617	434	792	479	532	802	717	553	633	345	499
7	1574	1467	286	263	178	295	295	194	353	293	174	322	111
8	160	1117	723	104	133	65	155	166	36	184	131	90	144
9	463	4477	1667	629	147	294	340	145	134	82	77	81	49
1+	13961	15884	12716	10471	12213	14195	15401	15838	11591	8171	7356	5586	5271

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

Age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	22	21	32	21	50	68	35	26	27	05	06	08	23
2	453	335	307	362	436	605	607	468	244	261	125	104	146
3	1099	1434	1535	1254	1457	2255	2781	2559	1795	1104	1084	655	505
4	2742	1163	2008	1904	1446	2195	2493	3528	3232	1474	1707	1134	804
5	2110	1202	1019	1746	1170	1165	1405	1618	1799	1495	767	1195	600
6	2071	943	631	478	876	451	610	769	789	640	666	386	528
7	1528	1523	356	248	198	305	305	223	338	311	170	337	116
8	179	1174	820	110	167	68	156	184	37	217	143	102	160
9	589	5337	2017	768	188	363	422	187	176	107	93	102	63
1+	10793	13134	8725	6891	5988	7476	8813	9563	8438	5612	4762	4023	2945

Table B18. Yield and spawning stock biomass per recruit analyses for white hake.

PC Ver.1.2 [Method of Thompson and Bell (1934)] 1-Jan-1992
Run Date: 20-11-1998; Time: 15:32:39.46
WHITE HAKE (1985-1997) - 1998 UPDATED AVE WTS, FPAT AND MAT VECTORS

Proportion of F before spawning: .2500
Proportion of M before spawning: .2500
Natural Mortality is Constant at: .200
Initial age is: 1; Last age is: 9
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file:
==> WHYR.DAT

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0000	1.0000	.0400	.199	.124
2	.0399	1.0000	.2600	.544	.340
3	.5191	1.0000	.7000	1.066	.756
4	1.0000	1.0000	.8900	1.910	1.437
5	1.0000	1.0000	.9800	3.069	2.416
6	1.0000	1.0000	.9800	4.393	3.681
7	1.0000	1.0000	1.0000	6.040	5.175
8	1.0000	1.0000	1.0000	7.886	6.910
9+	1.0000	1.0000	1.0000	13.200	13.200

Summary of Yield per Recruit Analysis for WHITE HAKE
Slope of the Yield/Recruit Curve at F=0.00: --> 20.7511
F level at slope=1/10 of the above slope (F0.1): -----> .144
Yield/Recruit corresponding to F0.1: -----> 1.1944
F level to produce Maximum Yield/Recruit (Fmax): -----> .237
Yield/Recruit corresponding to Fmax: -----> 1.2707
F level at 20 % of Max Spawning Potential (F20): -----> .296
SSB/Recruit corresponding to F20: --------> 4.0878

Listing of Yield per Recruit Results for:
WHITE HAKE (1985-1997) - 1998 UPDATED AVE WTS, FPAT AND MAT VECTORS

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.5167	22.1016	3.4939	20.4412	100.00
	.10	.20658	1.05601	4.4887	11.6995	2.4715	10.3052	50.41
F0.1	.14	.26016	1.19443	4.2230	9.3512	2.2079	8.0448	39.36
	.20	.31082	1.26156	3.9723	7.3254	1.9597	6.1099	29.89
Fmax	.24	.33759	1.27070	3.8402	6.3454	1.8291	5.1807	25.34
F20%	.30	.37223	1.25547	3.6696	5.1844	1.6609	4.0878	20.00
	.30	.37407	1.25382	3.6605	5.1261	1.6520	4.0332	19.73
	.40	.41682	1.19386	3.4511	3.8897	1.4460	2.8830	14.10
	.50	.44781	1.12783	3.3002	3.1358	1.2981	2.1912	10.72
	.60	.47145	1.06845	3.1858	2.6456	1.1864	1.7471	8.55
	.70	.49017	1.01809	3.0959	2.3094	1.0988	1.4459	7.07
	.80	.50542	.97603	3.0231	2.0682	1.0281	1.2321	6.03
	.90	.51815	.94087	2.9628	1.8884	.9697	1.0742	5.26
	1.00	.52898	.91123	2.9119	1.7500	.9205	.9538	4.67
	1.10	.53833	.88598	2.8682	1.6405	.8783	.8593	4.20
	1.20	.54652	.86423	2.8302	1.5518	.8417	.7833	3.83
	1.30	.55376	.84529	2.7967	1.4785	.8096	.7210	3.53
	1.40	.56024	.82864	2.7670	1.4169	.7811	.6690	3.27
	1.50	.56608	.81387	2.7404	1.3644	.7556	.6249	3.06
	1.60	.57138	.80067	2.7164	1.3190	.7327	.5871	2.87
	1.70	.57622	.78879	2.6946	1.2794	.7118	.5543	2.71
	1.80	.58067	.77804	2.6747	1.2444	.6928	.5256	2.57
	1.90	.58478	.76825	2.6563	1.2133	.6753	.5002	2.45
	2.00	.58860	.75930	2.6394	1.1855	.6592	.4775	2.34

Table B19. Stochastic short-term projections of mean biomass (000s mt), spawning stock biomass (000s mt) and landings (000s mt) for Gulf of Maine-Georges Bank white hake, assuming landings of 2665 mt are caught in 1998 and various F levels in 1999-2000.

	1998				1999			2000		
F	Landings	Biomass	SSB	$F_{1999-2000}$	Landings	Biomass	SSB	Biomass	SSB	Consequences/Implications
1.4	2.7	3.3	1.6	0.00	0.0	5.0	3.2	8.3	6.4	Biomass increases to 37% B_{msy} in 2000; SSB increases in 2000.
				1.43 (F_{98})	3.3	3.5	2.0	3.4	2.0	Biomass stabilizes at 15% B_{msy} in 2000; landings increase in 1999; SSB stabilizes in 2000.

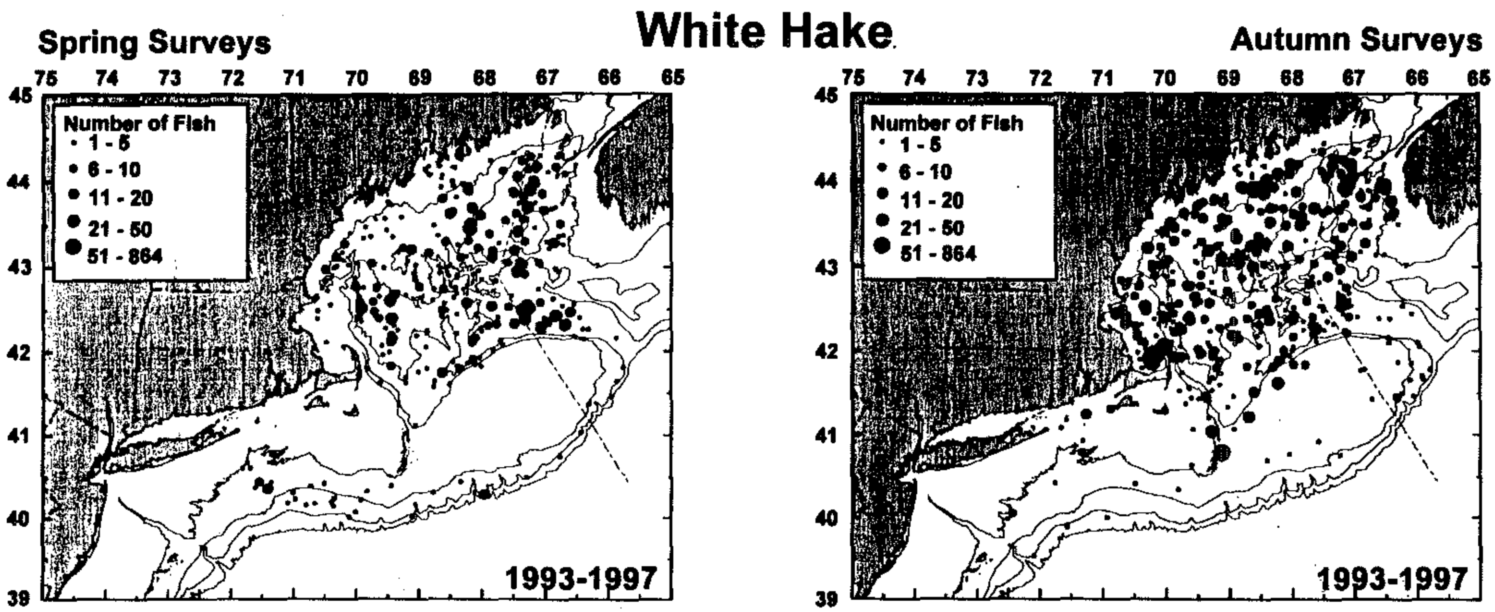


Figure B1. Distribution of white hake in the NEFSC spring and autumn bottom trawl surveys from 1993-1997.

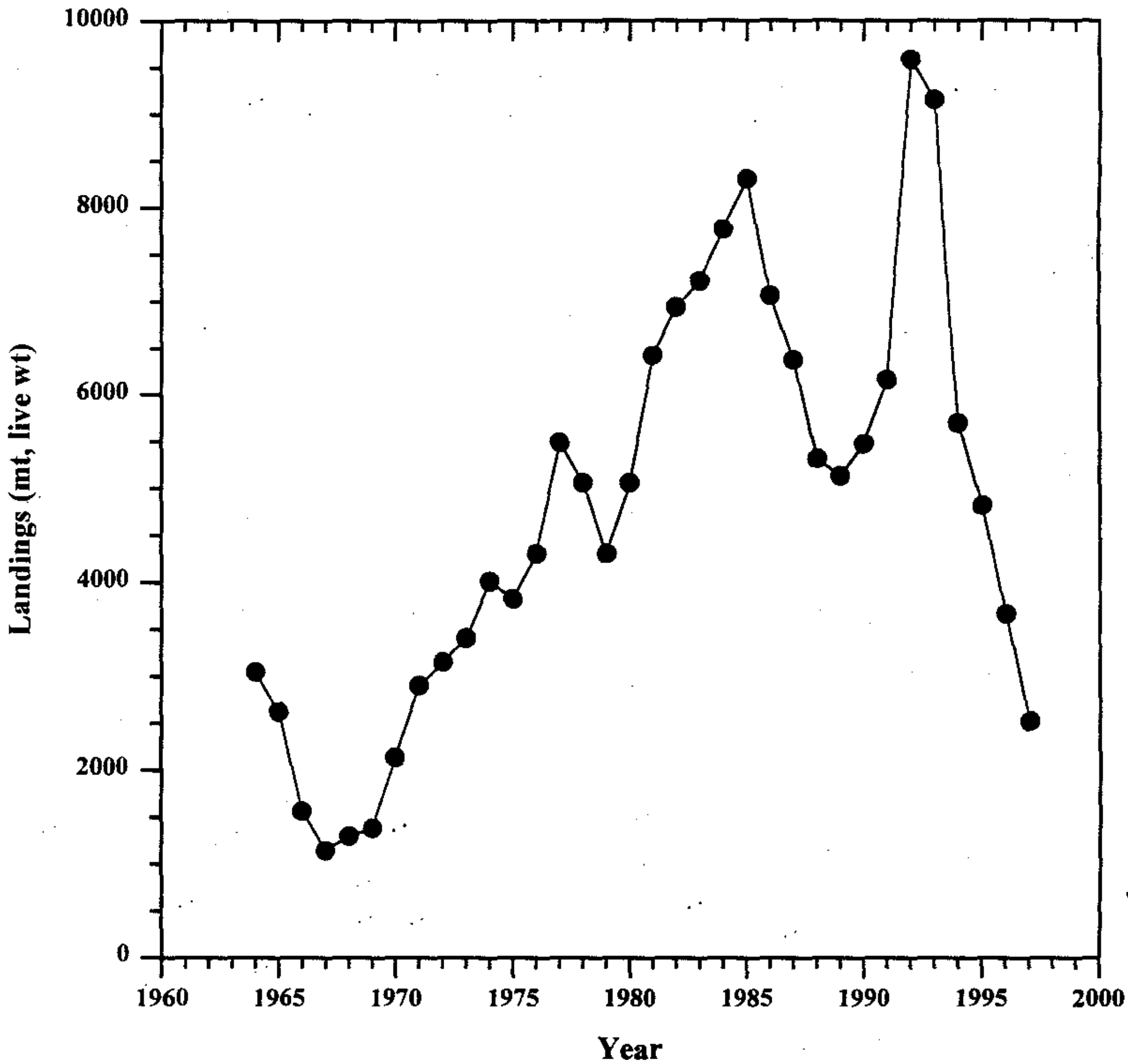


Figure B2. Total landings of white hake from the Gulf of Maine to Mid-Atlantic region, 1964-1997.

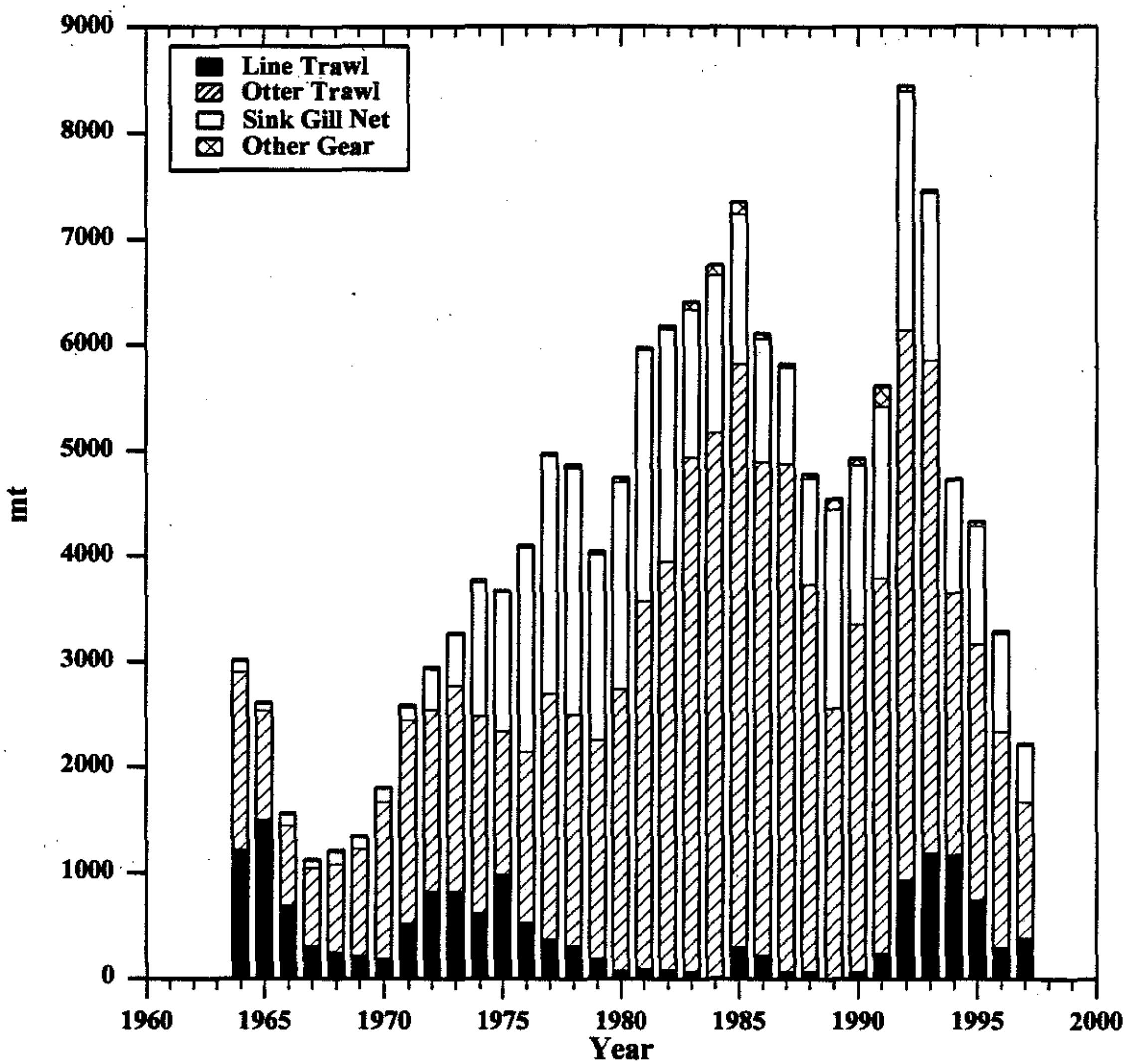


Figure B3. Total US landings of white hake (mt, live weight) by gear, 1964-1997.

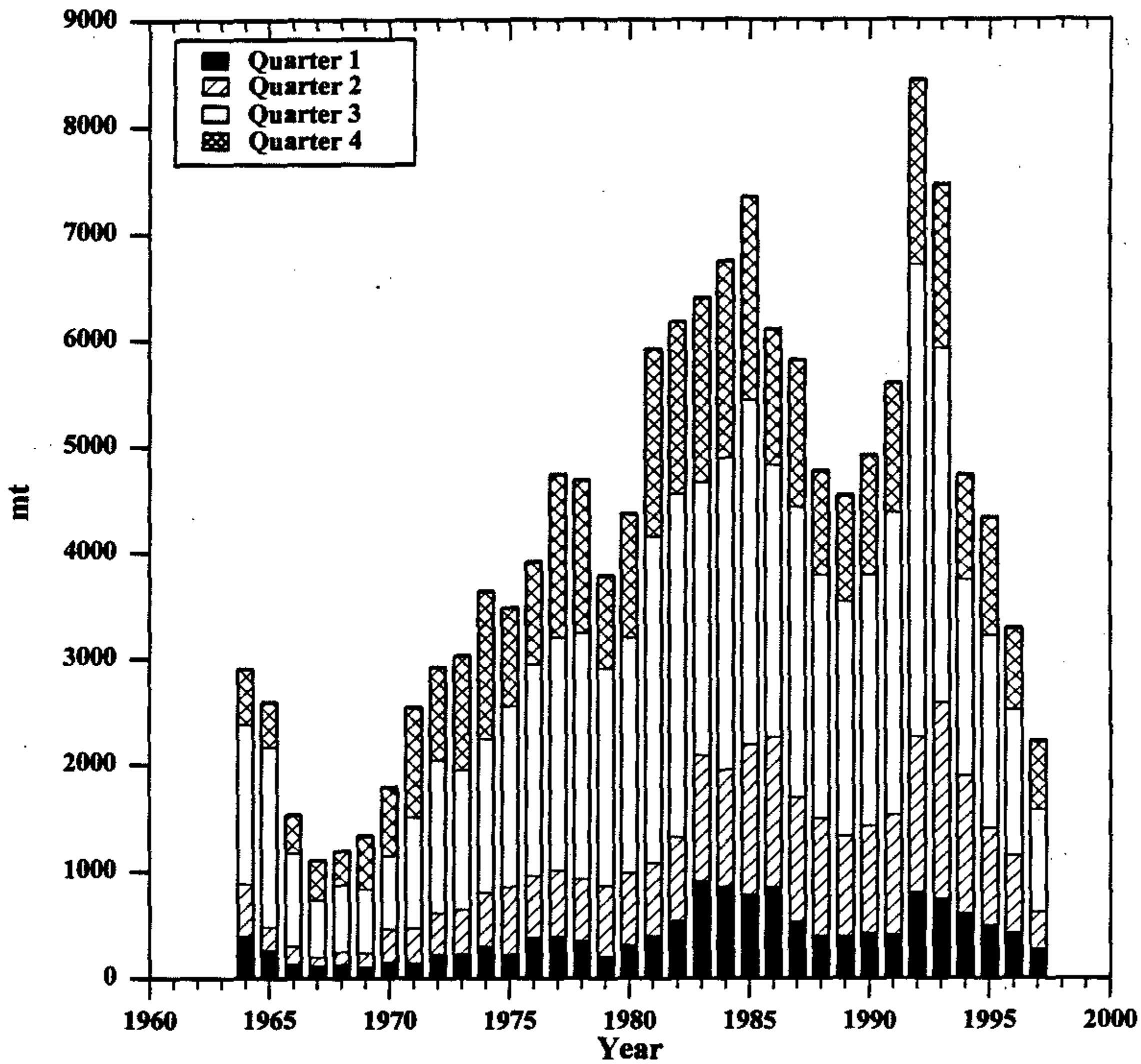


Figure B4. Total US landings of white hake (mt, live weight) by quarter, 1964-1997.

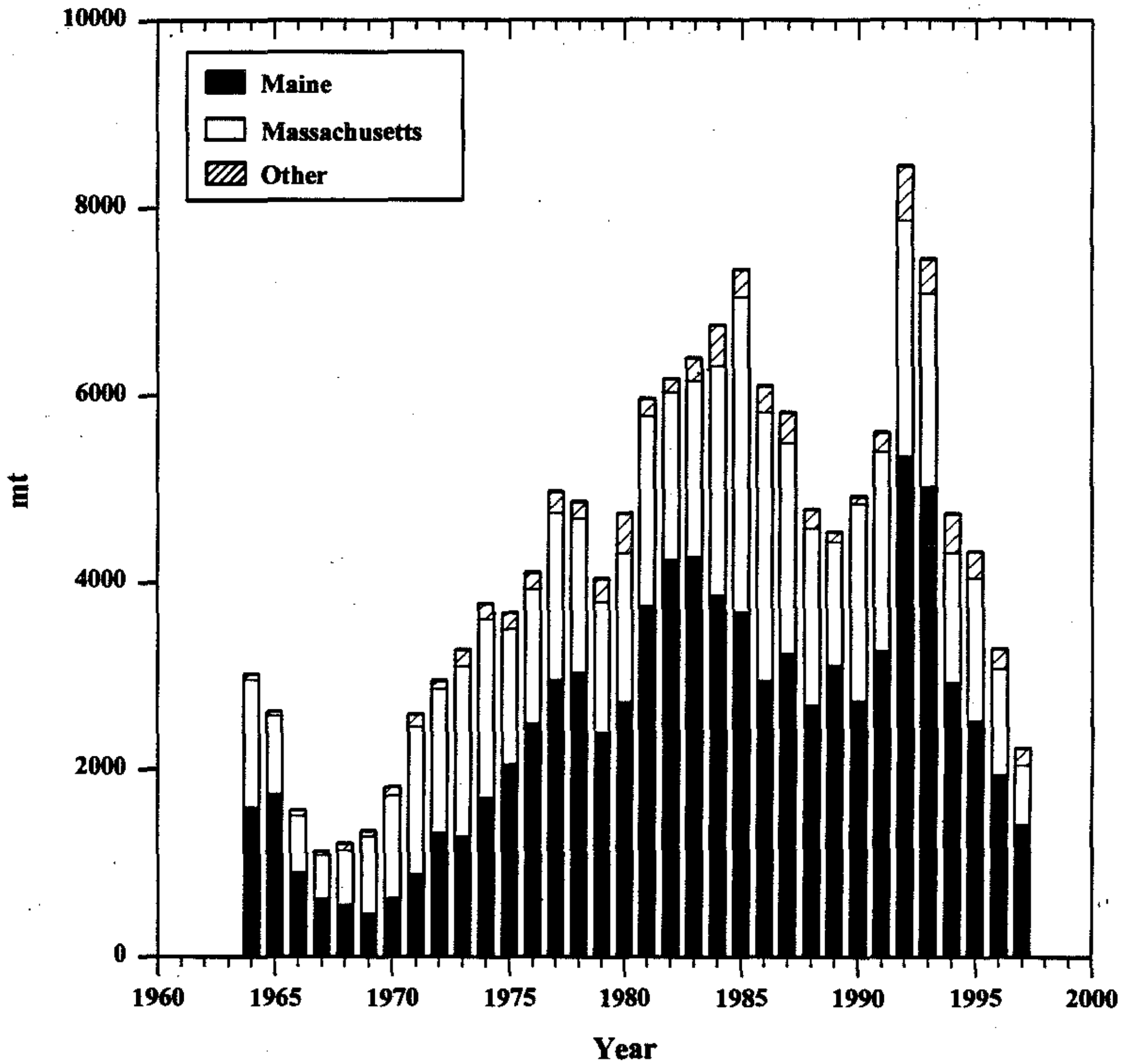


Figure B5. Commercial landings (mt, live weight) of white hake in Maine, Massachusetts, and other states.

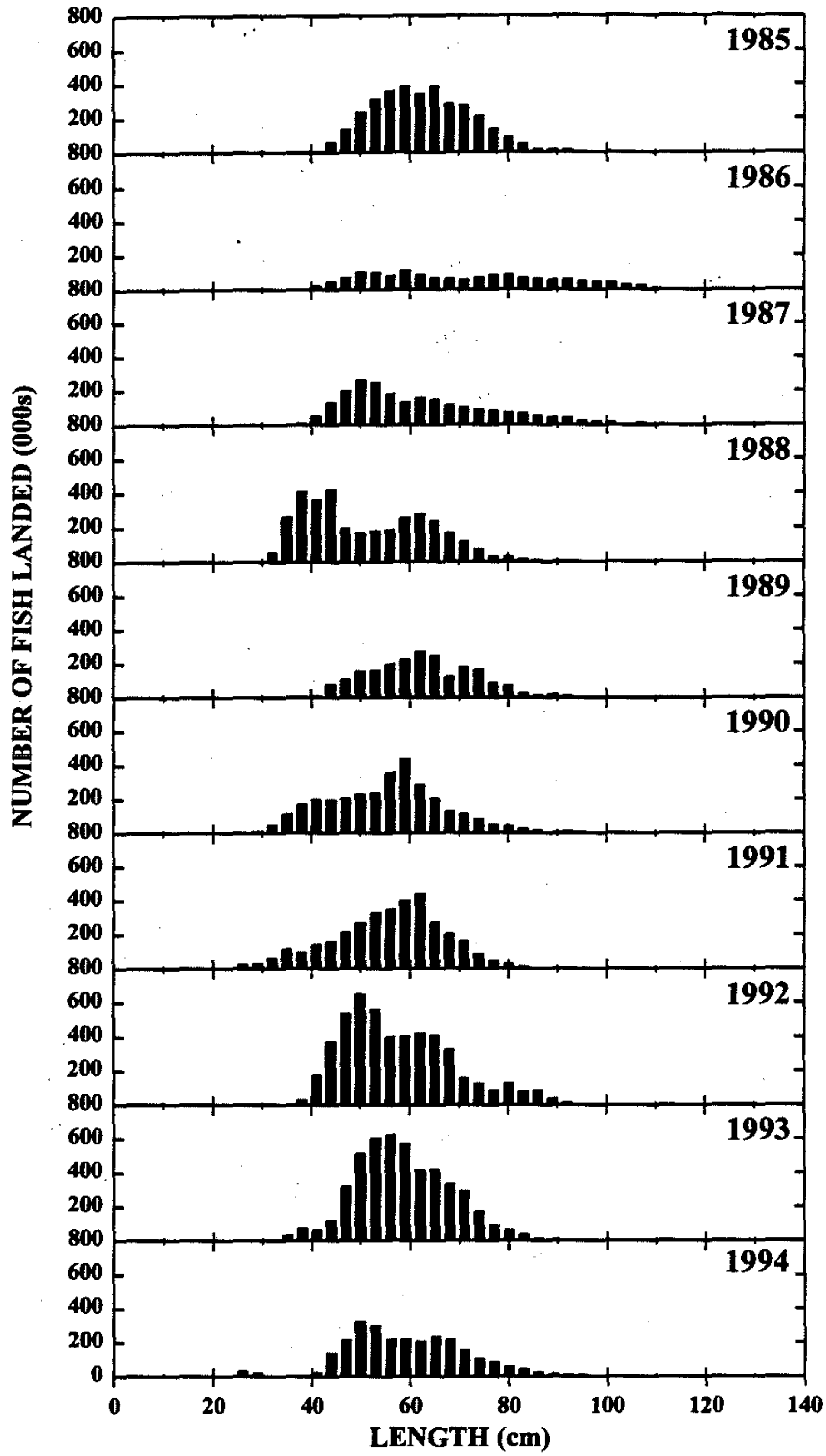


Figure B6. Commercial length composition of white hake landings for all gear types, 1985-1997.

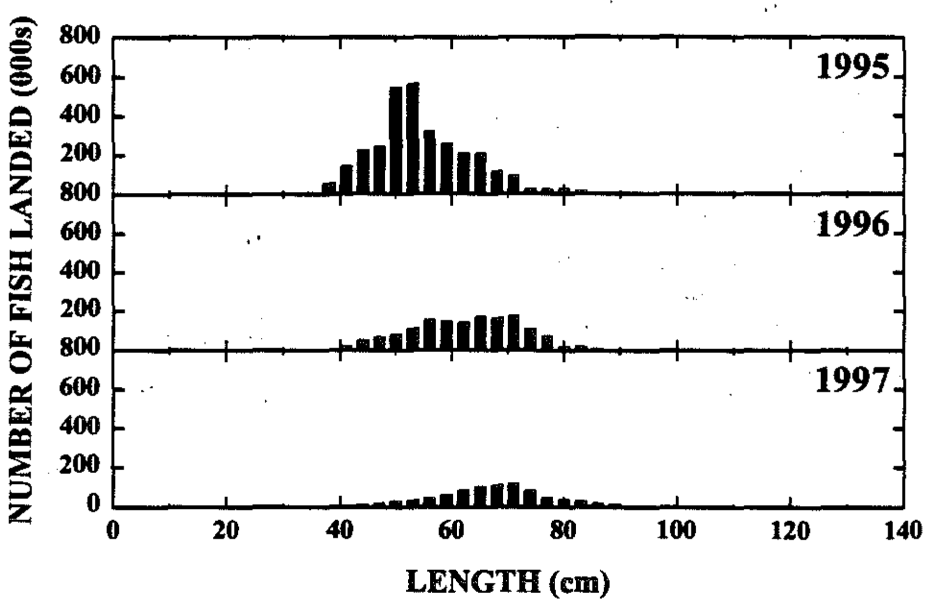


Figure B6. cont.

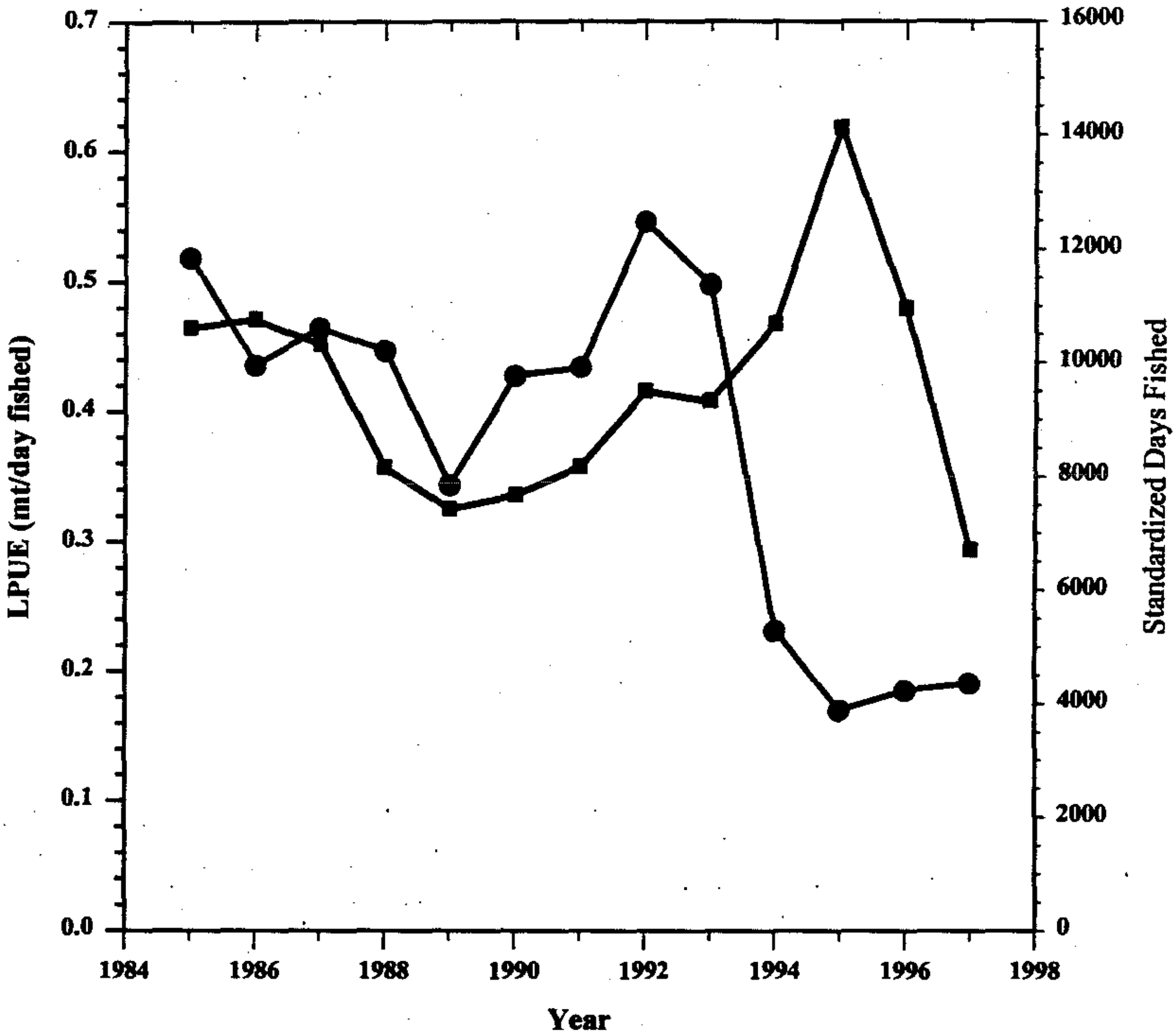


Figure B7. Standardized landings per day fished (LPUE, circles) and effort (days fished raised to total otter trawl landings, solid line) of white hake using a general linear model: year, quarter, area, tonnage class, and depth.

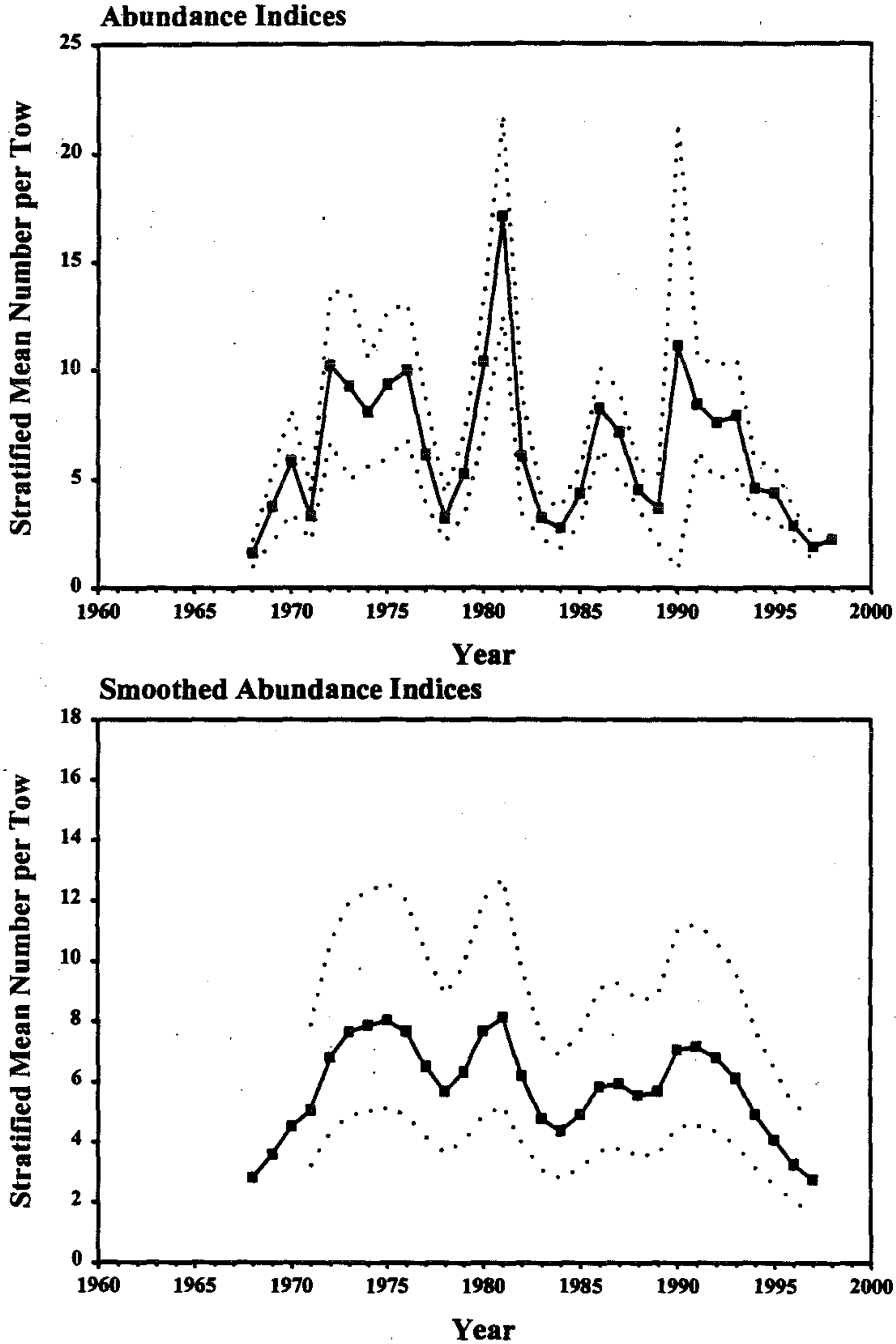


Figure B8. Abundance indices and smoothed indices from the NEFSC spring bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1968-1998. The 95% confidence limits are shown by the dashed line.

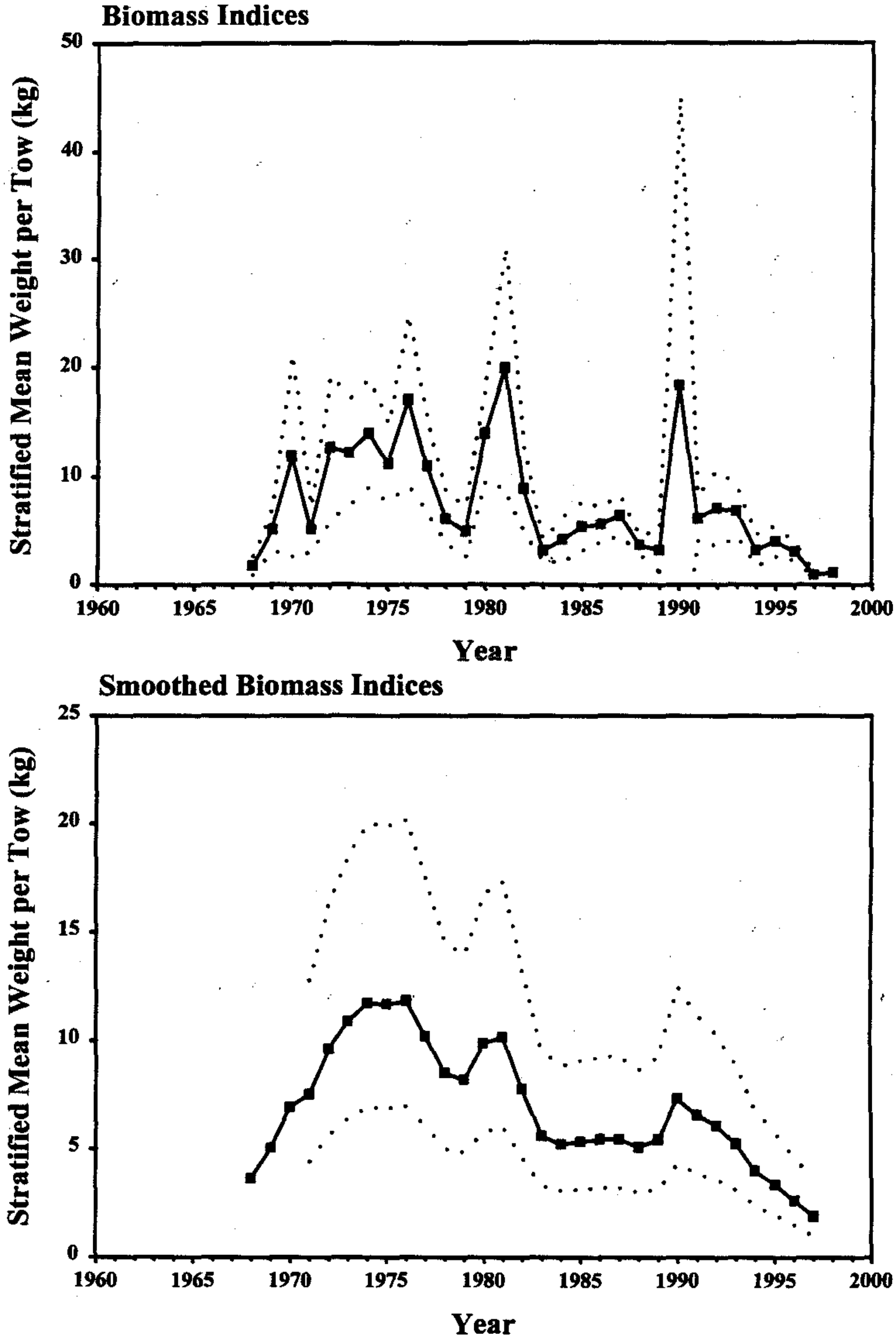


Figure B9. Biomass indices and smoothed indices from the NEFSC spring bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1963-1997. The 95% confidence limits are shown by the dashed line.

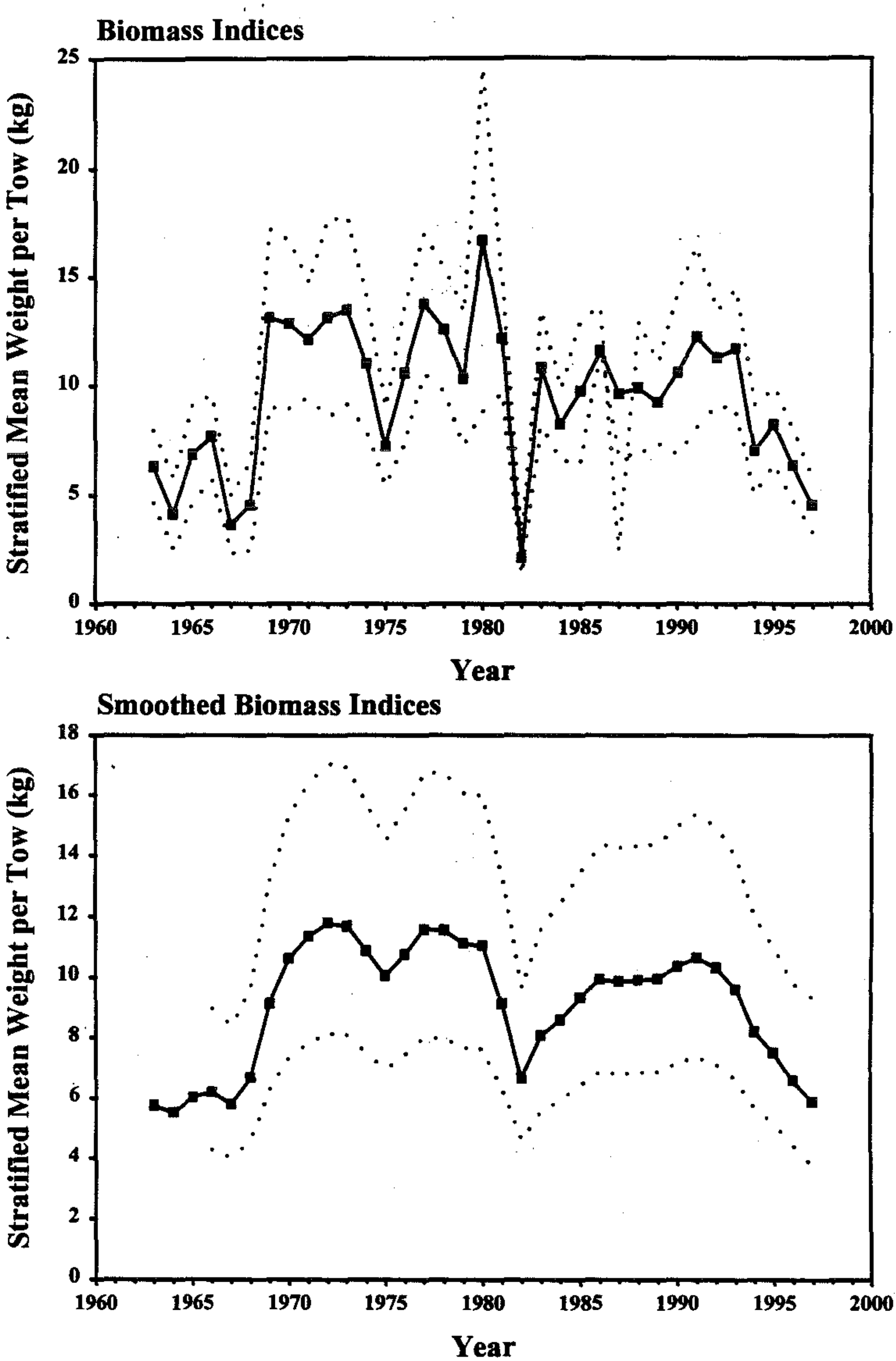


Figure B10. Biomass indices and smoothed indices from the NEFSC autumn bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1963-1997. The 95% confidence limits are shown by the dashed line.

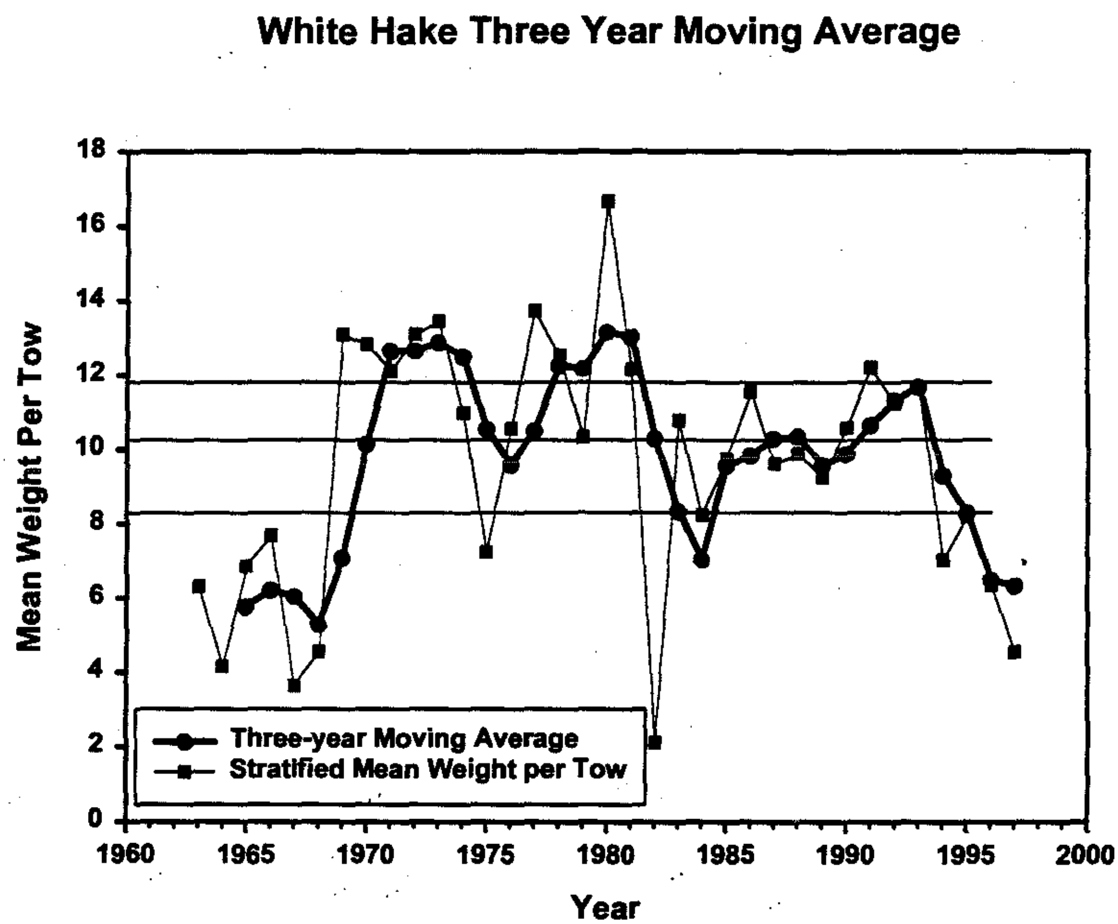


Figure B11. Three-year moving average and stratified mean weight per tow from the autumn survey.

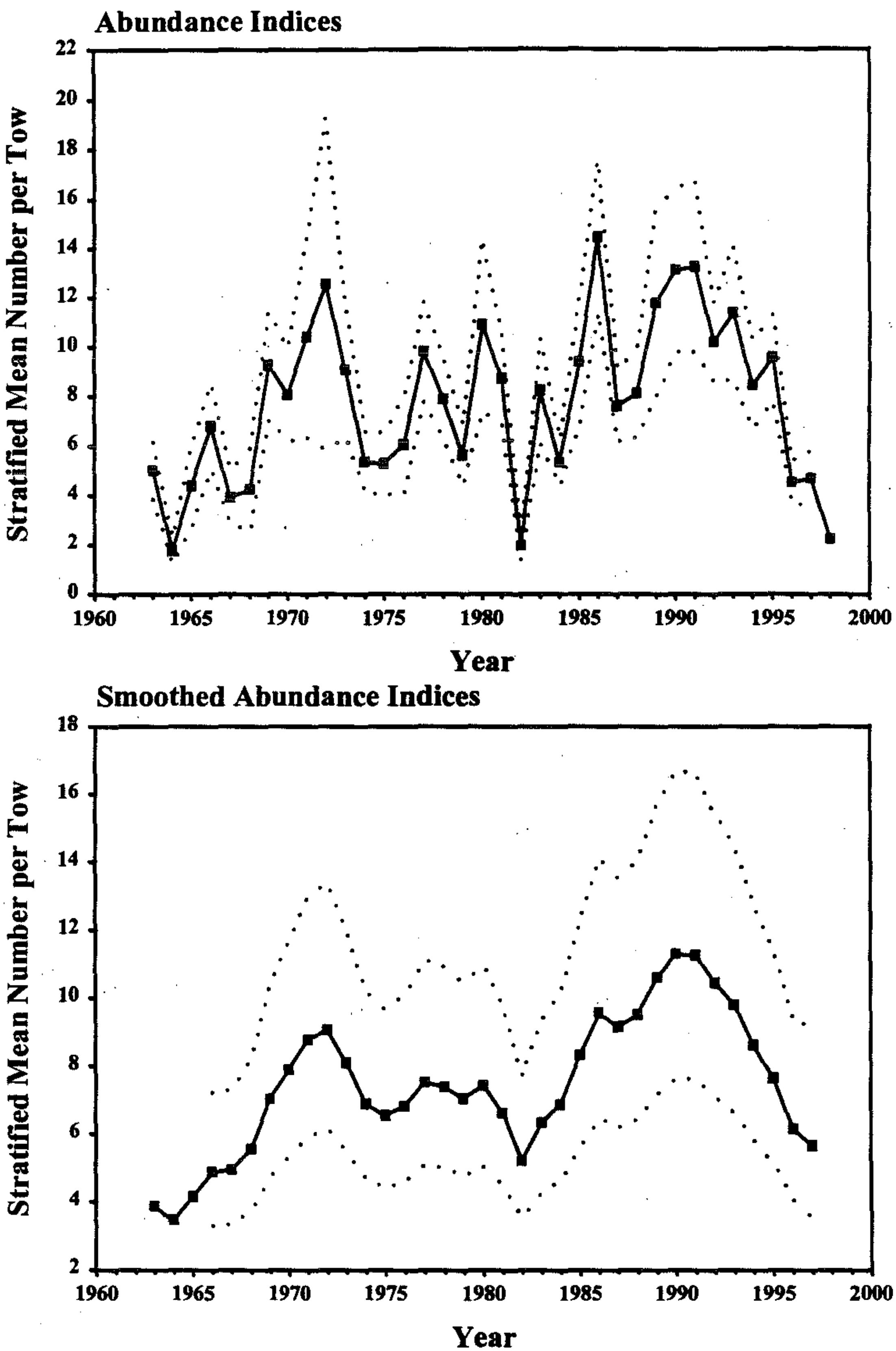
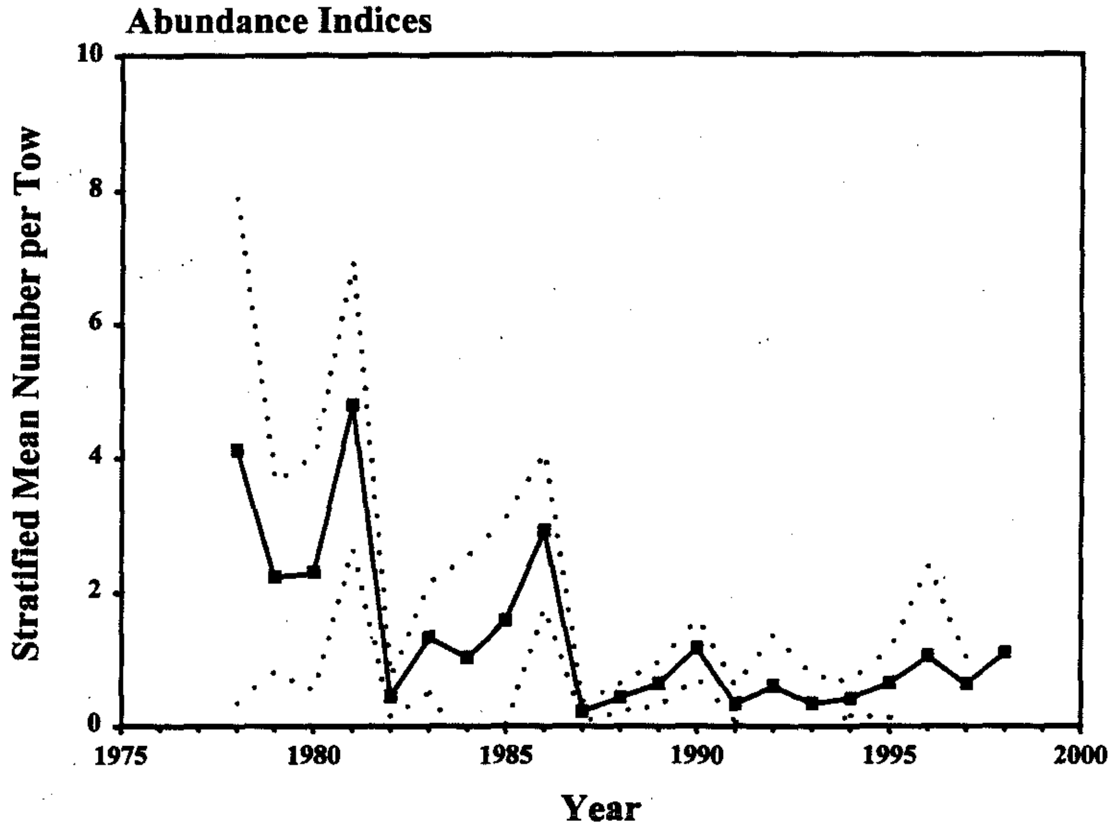


Figure B12. Abundance indices and smoothed indices from the NEFSC autumn bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1968-1997. The 95% confidence limits are shown by the dashed line.



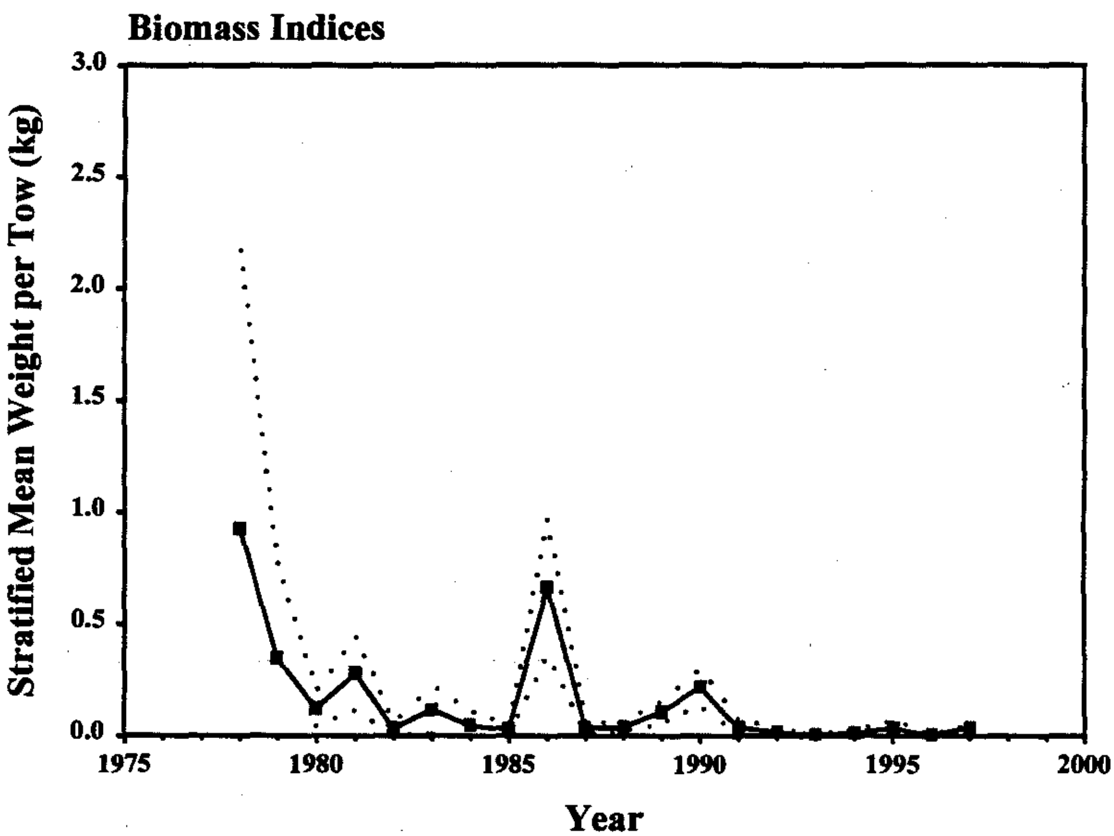


Figure B13. Abundance and biomass indices from the Massachusetts spring bottom trawl survey
The 95% confidence limits are shown by the dashed line.

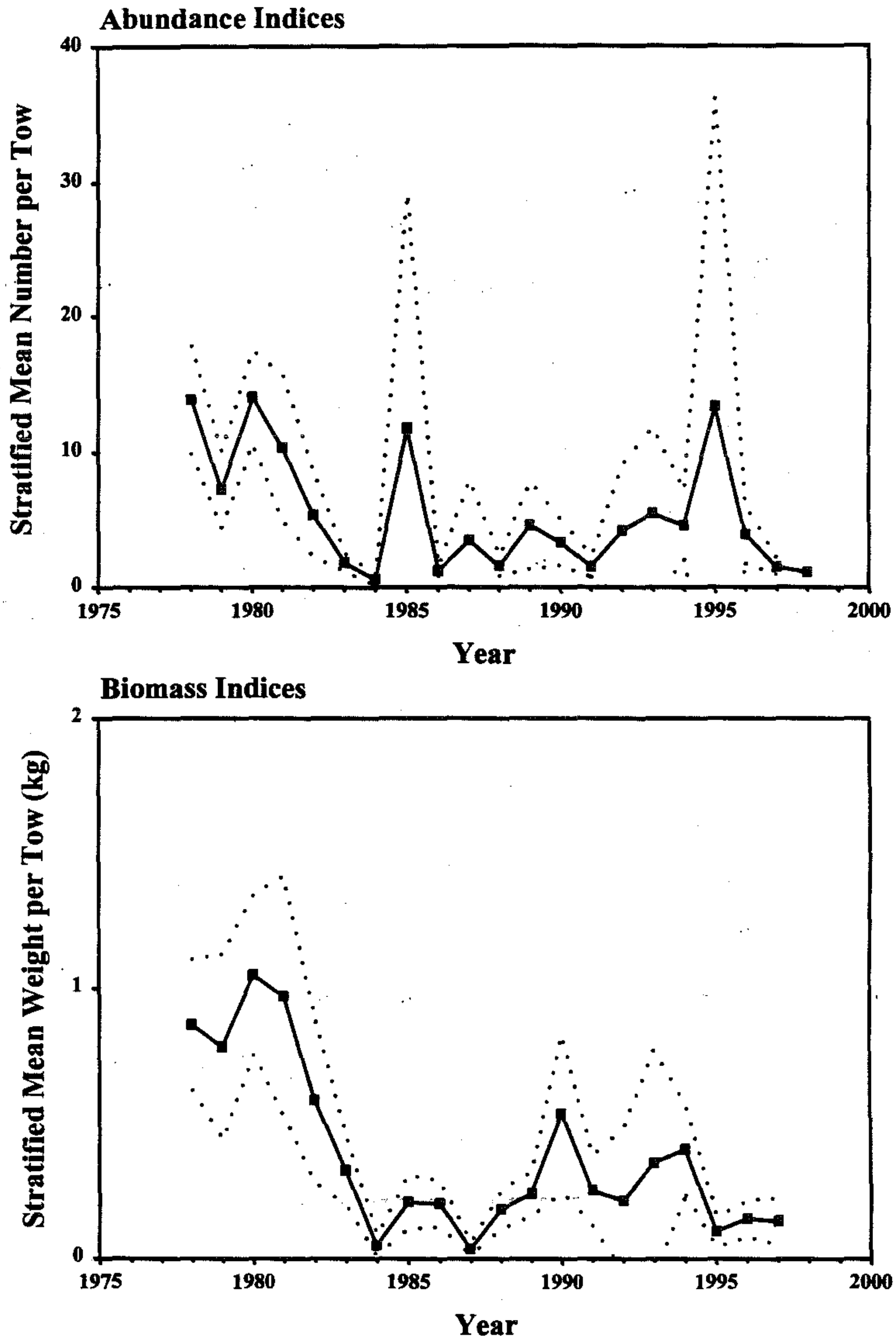


Figure B14. Abundance and biomass indices from the Massachusetts autumn bottom trawl survey. The 95% confidence limits are shown by the dashed line.

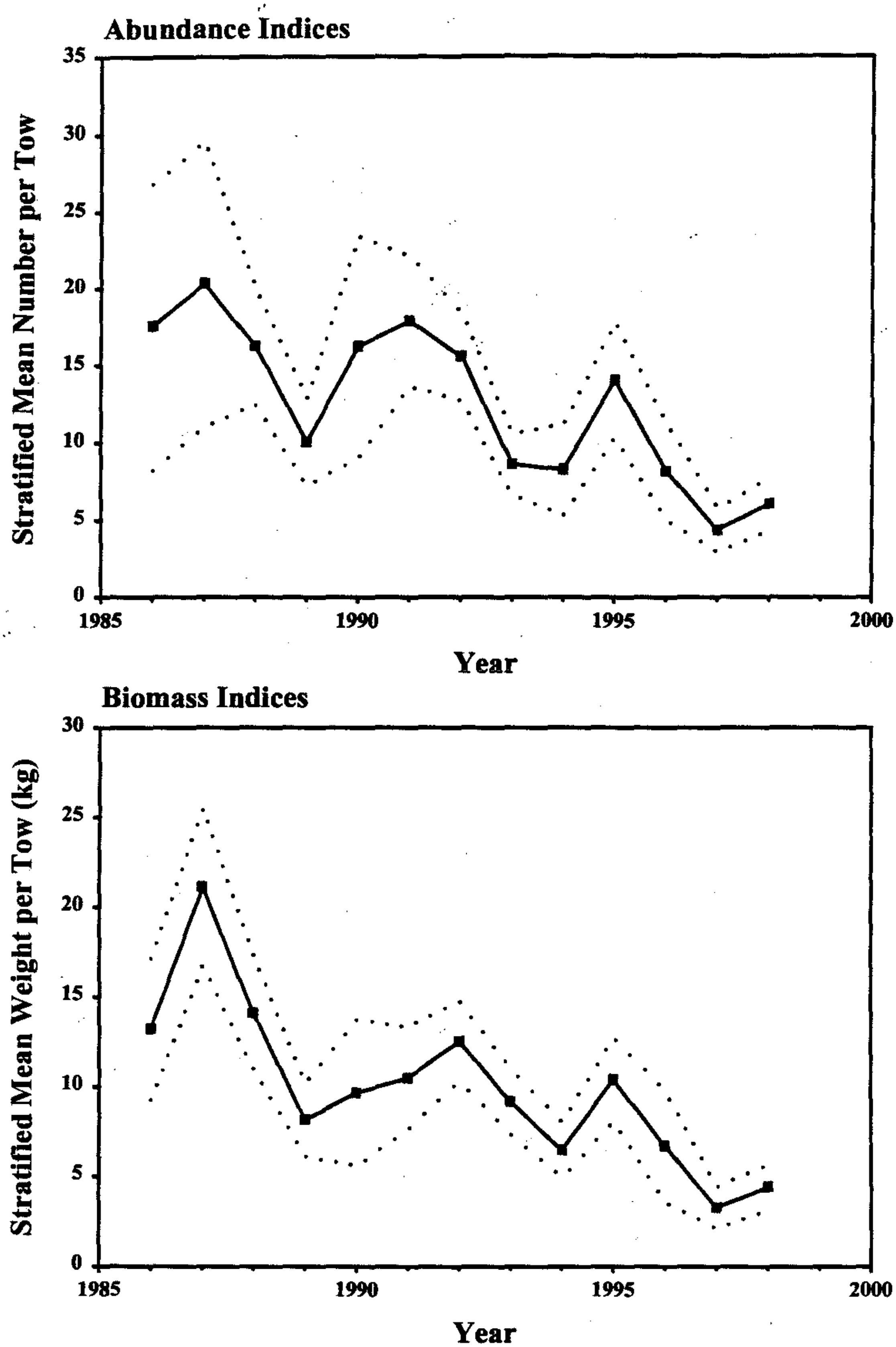


Figure B15. Abundance and biomass indices from the ASMFC shrimp survey.
The 95% confidence limits are shown by the dashed line.

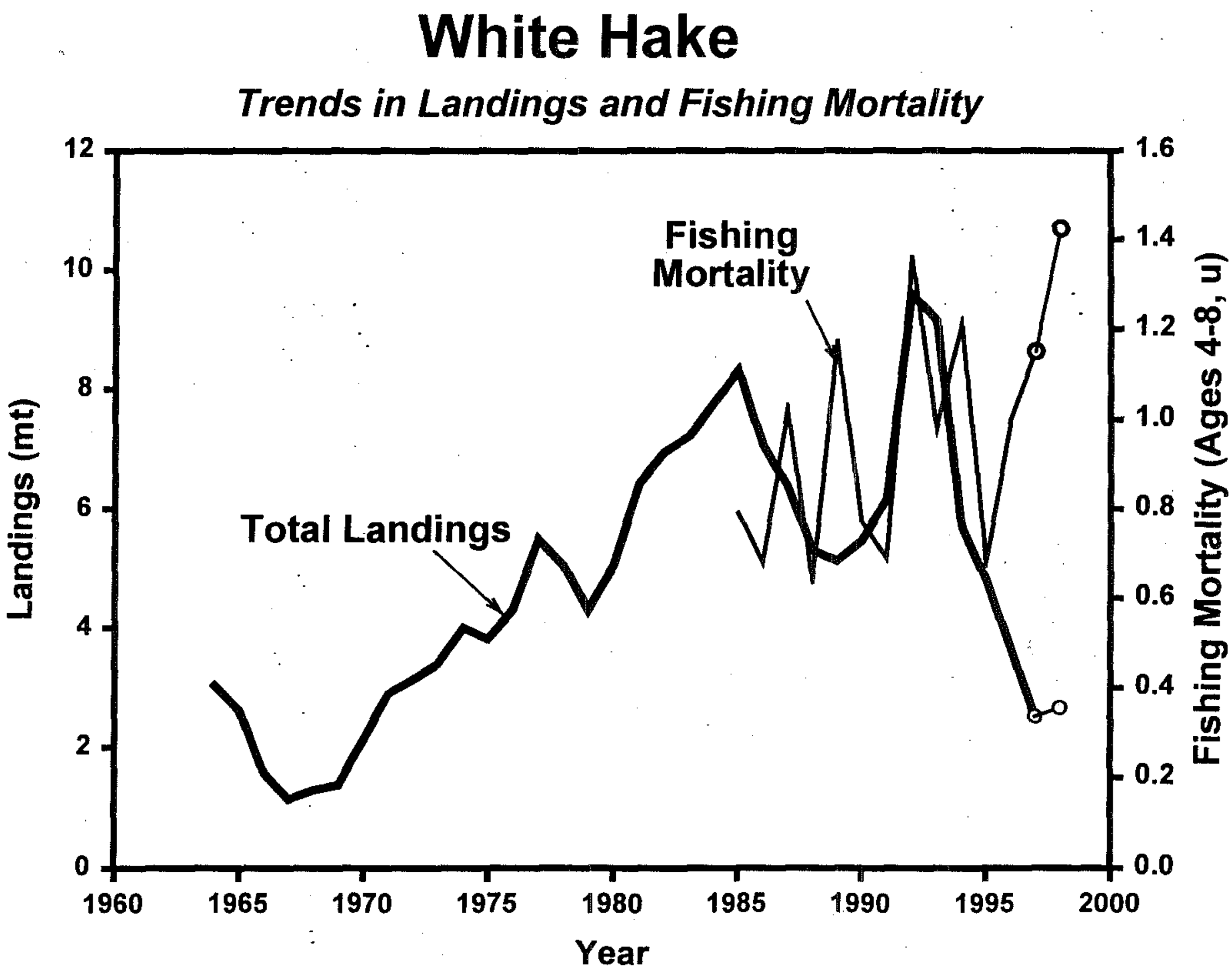


Figure B16. Total commercial landings and fishing mortality from the VPA calibration.

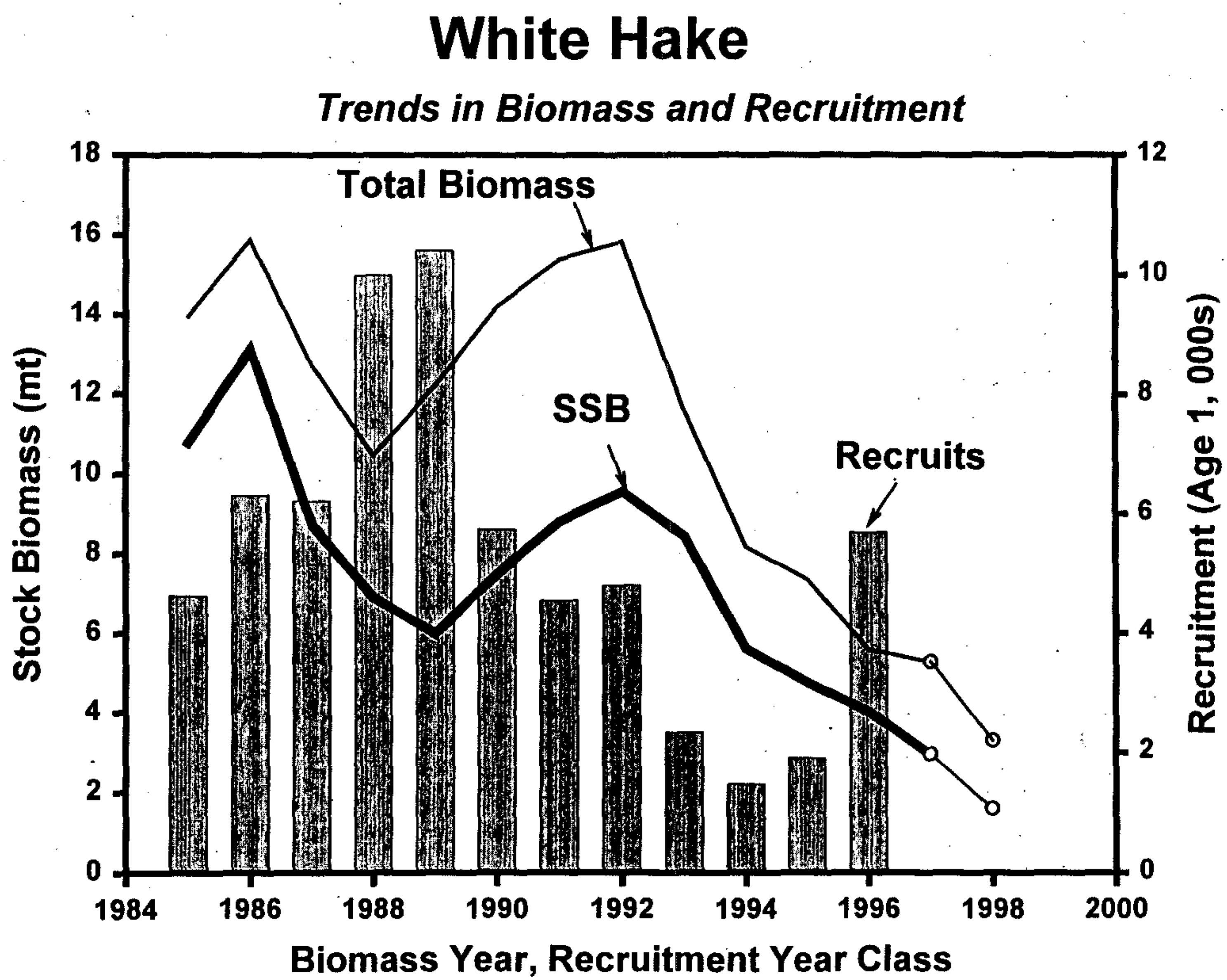


Figure B17. Trends in total biomass, spawning stock biomass, and recruitment from the VPA calibration.

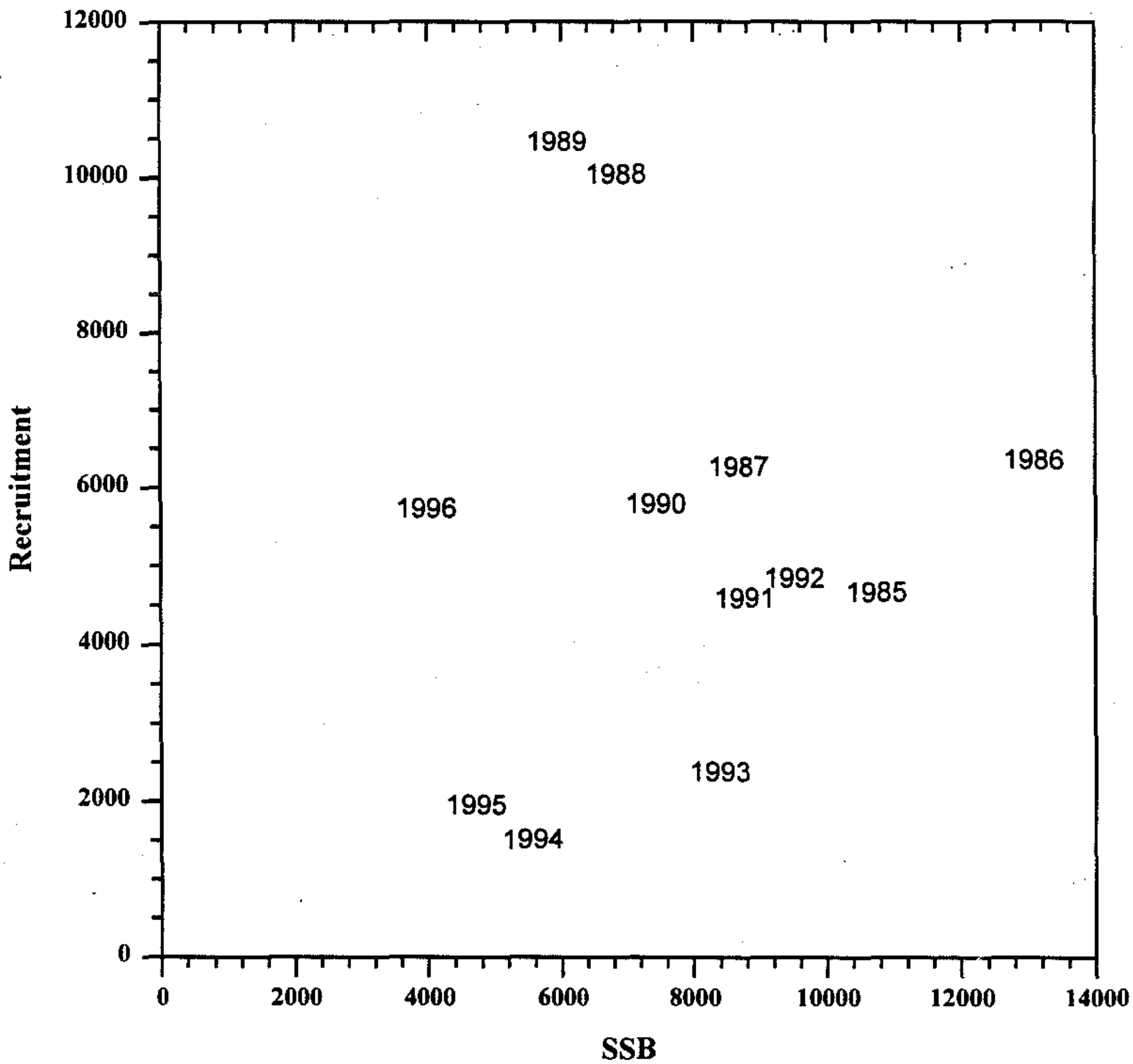


Figure B18. Spawning stock/recuitment relationship for white hake.

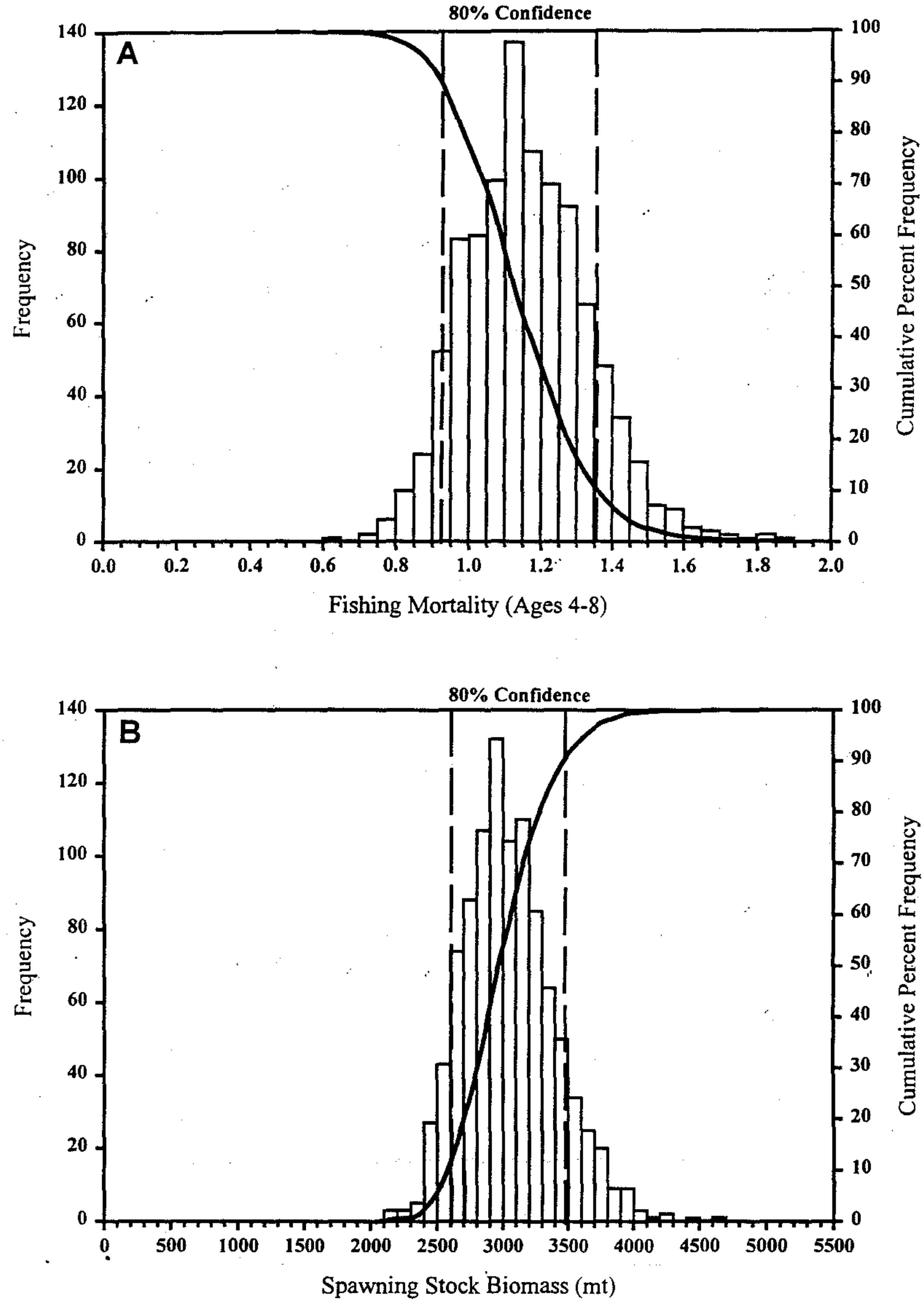


Figure B19. Distribution of bootstrap estimates of fishing mortality and spawing stock biomass for white hake in 1997.

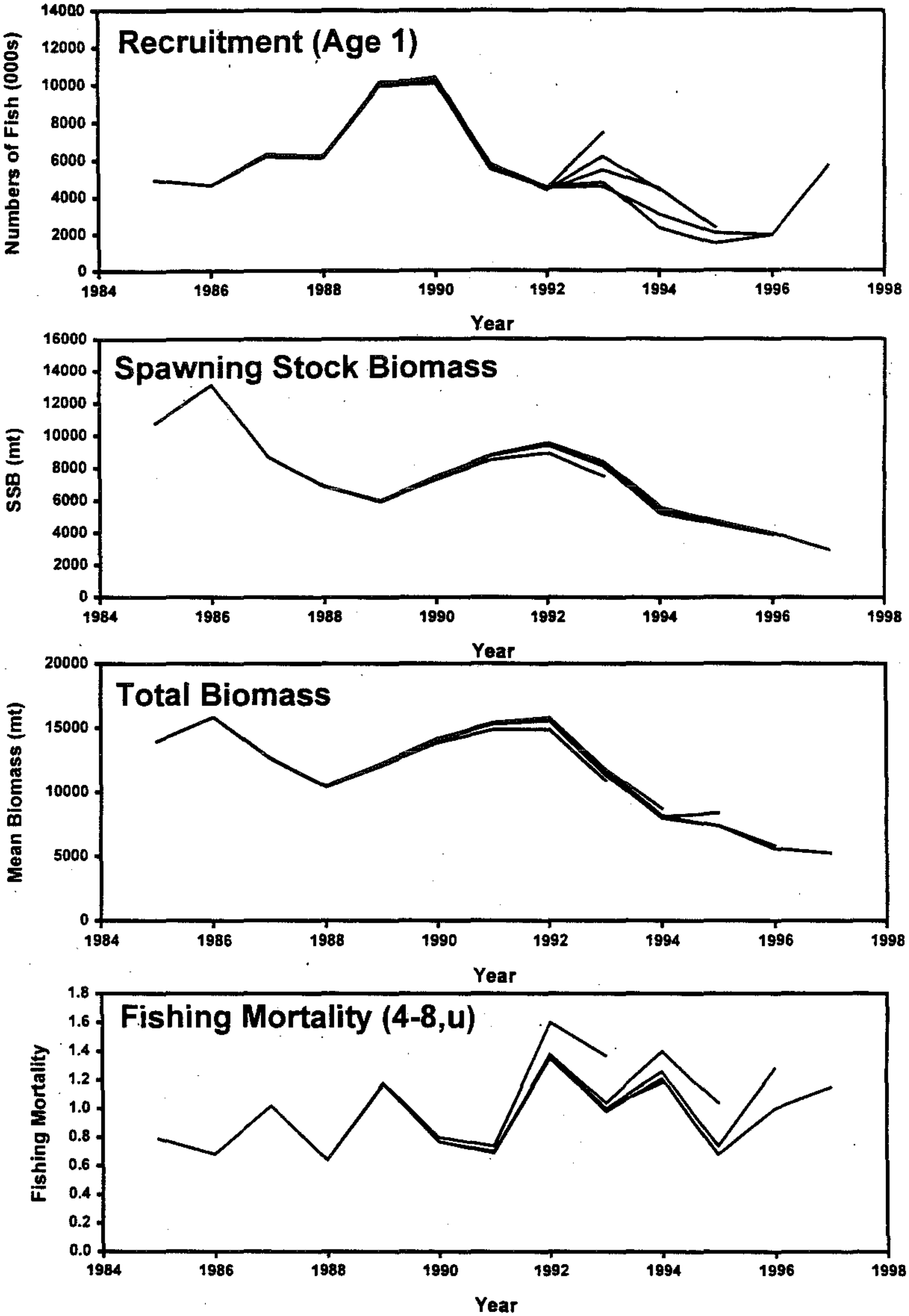


Figure B20. Recruitment at age 1, spawning stock biomass, total biomass and fishing mortality from the retrospective analysis.

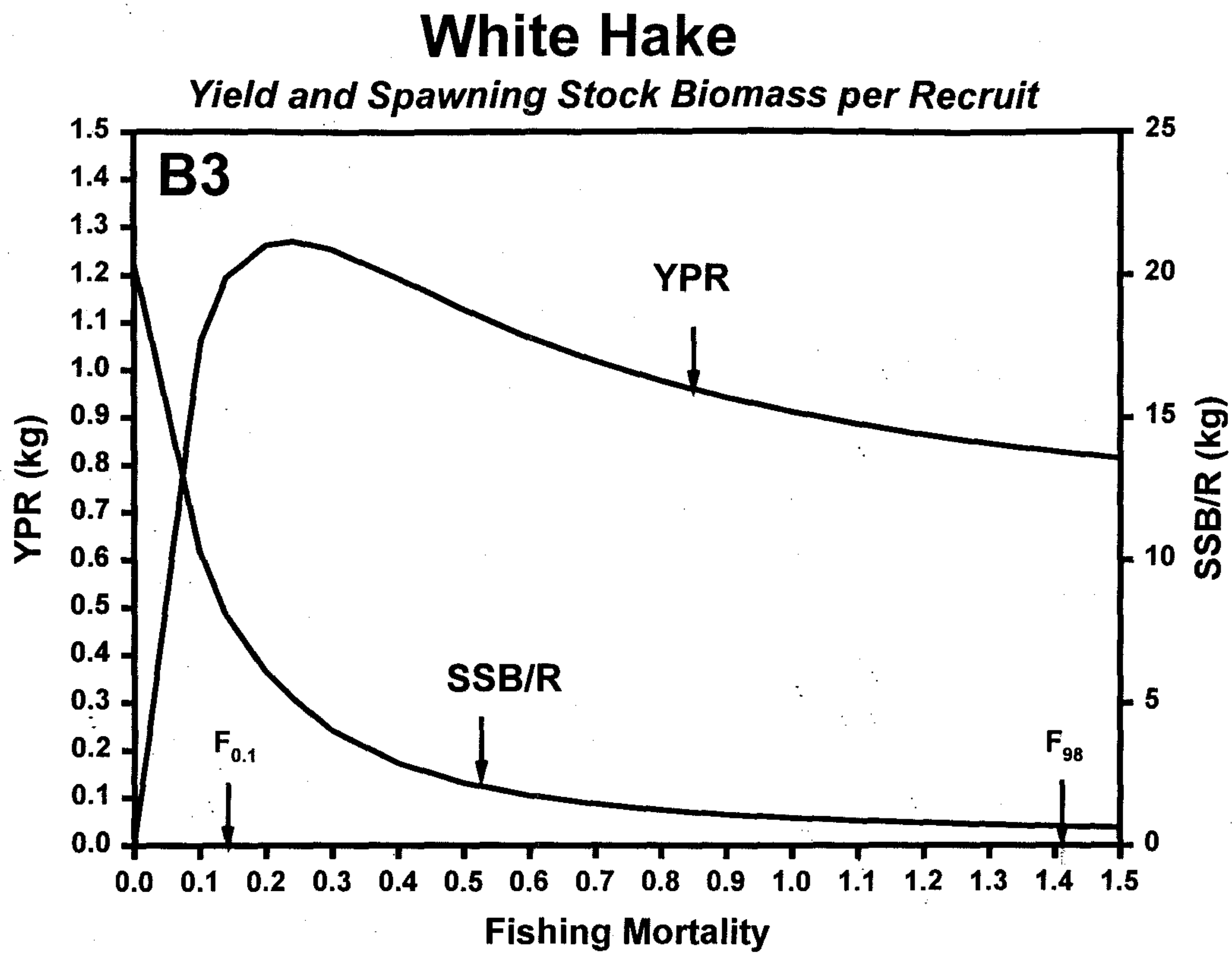


Figure B21. Yield and spawning stock biomass per recruit for white hake.

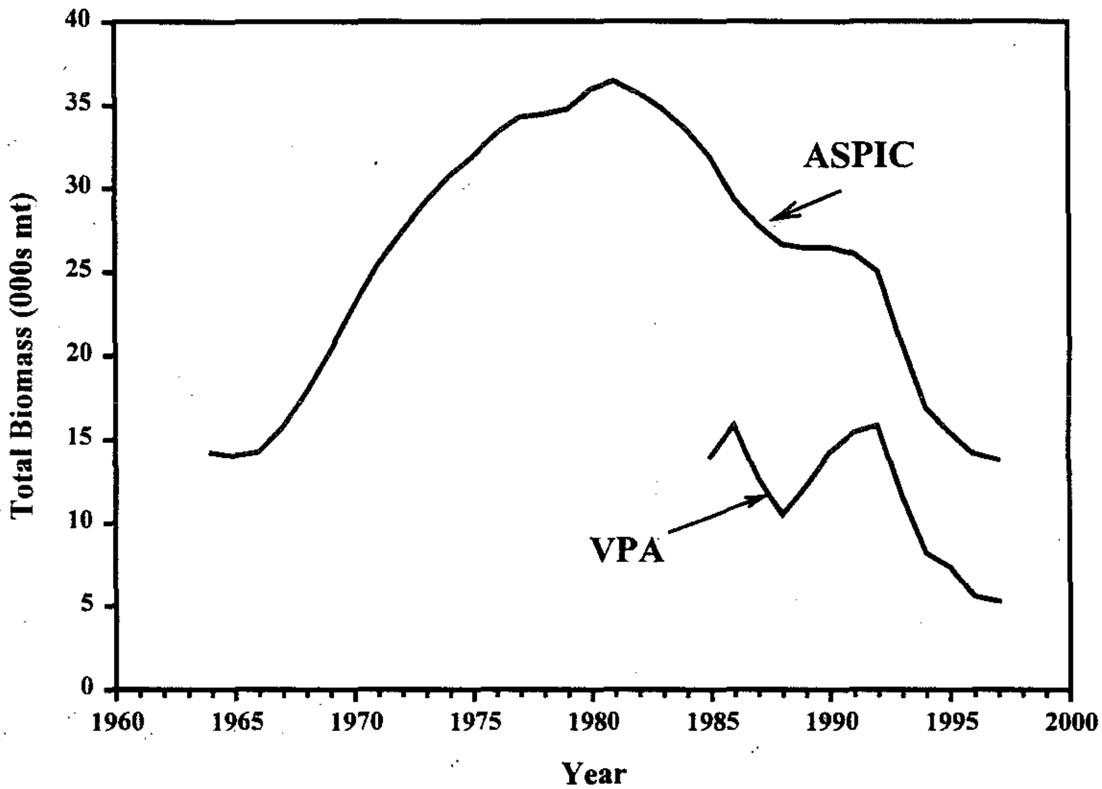


Figure B22. Estimates of total biomass from virtual population analysis and ASPIC surplus production model.

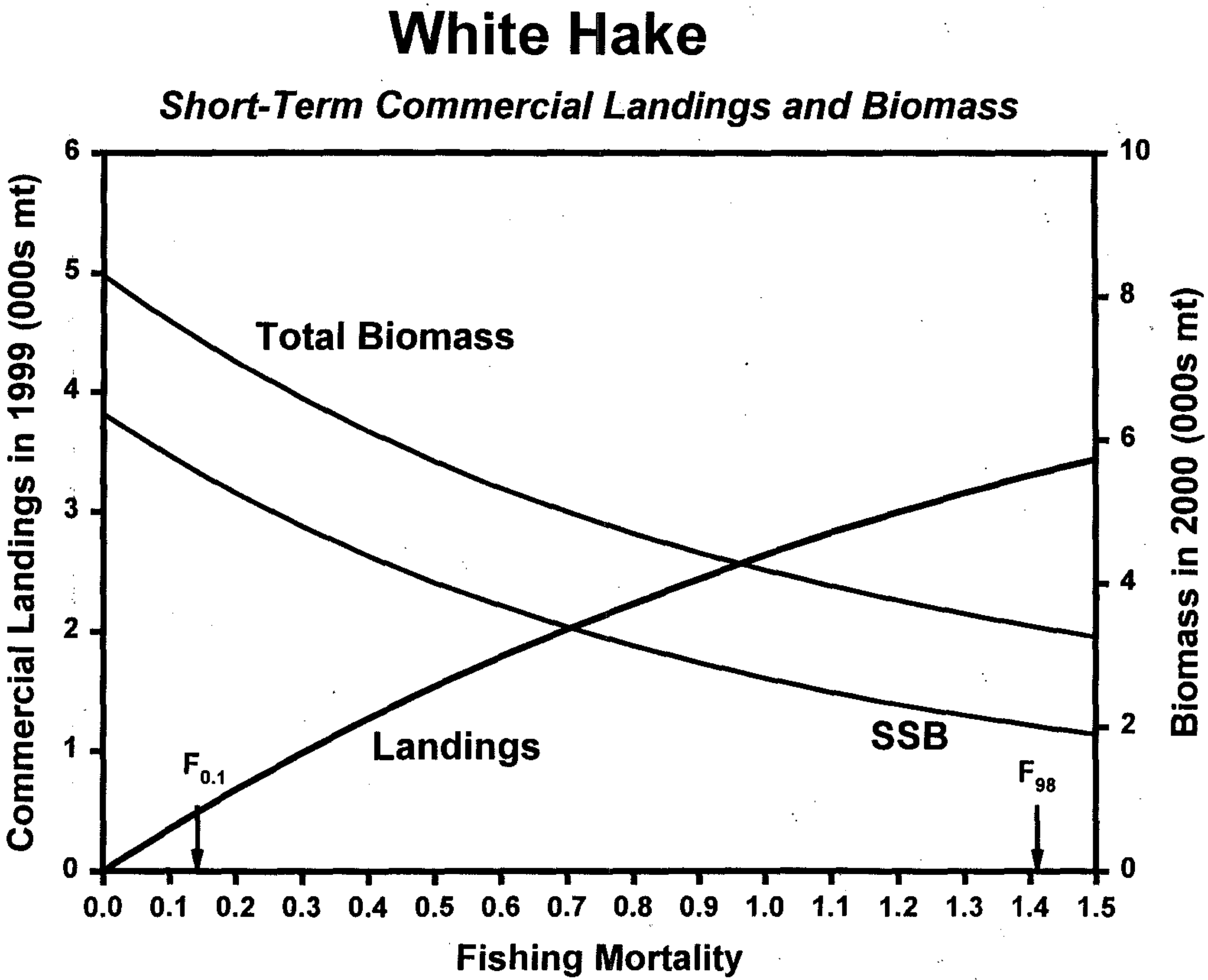


Figure B23. Landings in 1999, total biomass in 2000 and spawning stock biomass in 2000 from stochastic projections.

C. Georges Bank Winter Flounder

TERMS OF REFERENCE

The Steering Committee of the 28th Northeast Regional Stock Assessment Workshop established the following terms of reference for the Georges Bank winter flounder assessment:

a. Update the status of the Georges Bank winter flounder stock through 1997 and characterize the variability of estimates of stock size and fishing morality.

b. On the basis of anticipated catches and abundance indicators in 1998, estimate stock size at the beginning of 1999 and provide projected estimates of catch and spawning stock biomass for 1999-2000 at various levels of F.

c. Comment on and revise, if necessary, the overfishing definition reference points for Georges Bank winter flounder recommended by the Overfishing Definition Review Panel.

SUMMARY

Georges Bank winter flounder was previously assessed in 1978 and 1986 when assessments provided descriptive summaries of catch, effort, survey indices, and yield per recruit modeling. The current assessment represents the initial attempt to assemble an analytical assessment of the stock. Georges Bank winter flounder is a discrete offshore stock distributed in the shallower areas of the bank complex. The stock is exploited by both directed otter trawl fisheries and as by-catch in large and small mesh otter trawl and scallop dredge fisheries targeting other species. Management measures to date have been directed at other principal groundfish species or the entire groundfish complex, but management actions including seasonal and year-round area closures, mesh size restrictions, effort controls, and retention restrictions on specific gear sectors likely have a significant effect on the condition of the Georges Bank winter flounder resource.

The Georges Bank winter flounder stock has been exploited by U.S., Canada, and distant water fleets historically, but the U.S. fishery has generated most of the reported landings since 1970. Landings during the 1970s and 1980s ranged between 2,000 and 4,000 mt, but declined to approximately 1,700 mt in 1993. Otter trawl gear accounts for greater than 95% of landings in most years, although the proportion of landings from the scallop dredge sector increased in the early 1990s. Discards are known to occur in both the otter trawl and scallop dredge fisheries. Although available data were inadequate to either estimate the magnitude of discards or characterize their size or age distribution, information from sea sampling observations indicates that discards are a relatively low proportion of the total catch in the otter trawl fishery. However, both sea sampling and vessel trip record data indicate that discarding may have increased recently in the scallop dredge fishery due to groundfish retention limits.

Landings per unit effort indices for all trips landing winter flounder and directed trips declined between the mid-1970s and early 1990s. U.S. and Canadian research vessel survey indices are highly variable, but appear to indicate a significant decline in abundance and biomass between the early 1980s and early 1990s.

A research vessel survey calibrated Virtual Population Analysis indicates strong year classes in 1980 (8.2 million), 1985 (6.6 million), 1987 (7.4 million), and 1994 (5.4 million) based on age 2 recruitment numbers. Spawning stock biomass declined from 8,300 mt in 1982 to 2,000 mt in 1994 and has increased to 3,500 mt in 1997. There is little apparent relationship between stock and recruitment. Age 2 recruitment from the 1995 and 1996 year classes

is poor, and the 1996 year class (0.77 million) is the weakest in the time series. Average fishing mortality (4-6, unweighted) increased from approximately 0.5 in 1982 to above 1.0 in 1984, and ranged between 0.66 and 1.36 in the mid-1980s to early 1990s. Fishing mortality declined to below 0.5 in 1994 and has ranged between 0.32 and 0.53 through 1997.

A yield per recruit analysis estimatesd $F_{0.1} = 0.21$ and $F_{max} = 0.42$, and an SSB per recruit analysis estimated F20% = 0.47. An unconstrained surplus production analysis estimated MSY as 3,100 mt and the stock biomass at MSY (B_{MSY})of 11,400 mt. The Amendment #9 harvest control rule was re-estimated and at the current biomass proxy, the corresponding fully recruited threshold and target fishing mortality rates are 0.04 and 0.03, respectively. Relative to the Amendment #9 harvest control rule, the stock is both overfished and overfishing is occurring ($F_{1998} = 0.34$). Short-term stochastic projections indicated that SSB will increase slightly (3%) between 1999 and 2000 if the stock is fished at $F_{20\%} = 0.47$ in 1999, and increase between 13% ($F_{1998} = 0.34$) and 44% (F = 0.00) if fished at lower levels.

INTRODUCTION

Georges Bank winter flounder (*Psueudopleuronectes americanus*) is a demersal flatfish species distributed in the Northwest Atlantic from Labrador to Georgia (Bigelow and Schroeder 1953; Klein-MacPhee 1978). Although primarily distribution in shallow inshore waters where estuarine habitat serves as important spawning and nursery areas, winter flounder are also distributed on some shallow offshore banks including Nantucket Shoals and Georges Bank principally in waters shallower than 80 m in depth. Adult winter flounder feed primarily on benthic invertebrates including annelids (predominately polychaetes), Cnidarids, and Anthoza (Langton and Bowman 1981). Principal predators include striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), goosefish (*Lophius americanus*), spiny dogfish (*Squalus acanthias*), and sea raven (*Hemitripterus americanus*; Dickie and McCraken 1955, Grosslein and Azarovitz 1982). Spawning peaks on Georges Bank during March and April, as evidenced by the presence of spawning condition fish in the Northeast Fisheries Science Center (NEFSC) spring research vessel bottom trawl survey and high densities of eggs and larvae detected by MARMAP ichthyoplankton surveys.

Stock Structure

Evidence from tagging data, differences in life history characteristics, and meristic studies provide evidence for discrete stocks of winter flounder in the U.S. waters of the Northwest Atlantic. Winter flounder on Georges Bank have considerably higher growth rates than fish from inshore waters (Bigelow and Shroeder 1953, Lux 1973); and historically, the Georges Bank stock was considered as a separate species (*Psudopleuronectes dignabilis*; Kendall 1912). Meristic studies indicate that fin ray counts differ for fish from Georges Bank and inshore areas indicating further evidence for a discrete offshore stock of winter flounder on Georges Bank (Perlmutter 1947; Lux *et al.* 1970). Extensive tagging studies of winter flounder indicate little mixing of fish between Georges Bank and inshore areas (Coates *et al.* 1970, Howe and Coates 1975), providing further evidence for discrete stock structure (Pierce and Howe 1977).

For the purposes of this assessment, the Georges Bank stock was defined to include U.S. statistical areas 522-525, 551, 552, 561, and 562 (Figure C1) which corresponds approximately to NAFO area 5Zh,j,m,n. Corresponding survey data include NEFSC offshore survey strata 01130 to 01220. NEFSC offshore strata 01230 appears to include a mix of winter flounder from the Southern New England/Mid Atlantic stock complex and the Georges Bank stock, and therefore was not included in survey analyses for this assessment. Canadian survey strata include the portions of strata 5Z1 to

5Z8 occurring in NAFO area 5Zh,j,m,n.

Fishery Description

Winter flounder, often known as blackback or lemon sole within the commercial fishery sector, are harvested primarily using otter trawl gear, and landings occur in both targeted landings and as by-catch in fisheries targeting other species. Bycatch landings and discards occur in trawl fisheries targeting other groundfish species and scallop dredge fisheries. Although recreational landings are a significant source of fishing mortality in inshore waters for the Southern New England stock complex, recreational landings from the Georges Bank stock are insignificant and are not included in this assessment.

Management History

Over the past 25 years, management of the commercial fishery for Georges Bank winter flounder has focused on minimum size limits and management measures (seasonal and year-round area closures, mesh size regulations, effort control measures, and fleet capacity reduction programs) primarily intended to address management needs for other demersal species (Atlantic cod, haddock, and yellowtail flounder). Seasonal spawning closures of haddock spawning grounds, which increased in temporal and spatial coverage since their inception in 1970 (Clark 1976), have provided some measure of protection for the stock.

Winter flounder was included in the New England Fishery Management Council's Atlantic Groundfish Fishery Management Plan (1977-1982). This initial plan established a minimum commercial size limit (11 inches, 28 cm), imposed minimum mesh sizes for trawls, and established spawning stock biomass per recruit targets. In 1982, the Council adopted an Interim Groundfish Plan, which established a minimum mesh size of 130 mm (5 1/8"). In 1983, the minimum mesh size was increased to 140 mm (5.5") In 1986, the Council's Multispecies Fishery Management Plan increased the minimum legal size to 30 cm (12 in) and imposed seasonal area closures. Amendments #5 and #7 (1994, 1996), established effort controls (days at sea limits), further increased minimum mesh size to 142 mm (6" diamond or square mesh), imposed trip limits for regulated groundfish bycatch in the sea scallop fishery, and prohibited small-mesh fisheries from landing regulated groundfish. In December 1994, two large areas on Georges Bank were closed to fishing on a year-round basis to protect overfished groundfish species. These areas include both the eastern and western edges of the distribution of winter flounder on the bank.

Amendment #9 to the Multispecies Fishery Management Plan was submitted in 1998 to revise the overfishing definition according to Sustainable Fisheries Act requirements. The Overfishing Definition Review Panel (Applegate *et al.* 1998) recommended an MSY-based control rule derived from survey based proxies of MSY-reference points. Biomass reference points were based on the NEFSC Autumn research vessel biomass index (stratified mean kg•tow^{-1}) and fishing mortality reference points were based on an exploitation index (catch•NEFSC Autumn research vessel biomass index^{-1}). Final approval of Amendment 9 was still pending in December 1998.

Georges Bank winter flounder was previously assessed in 1978 (Lange and Lux 1978) and 1986 (Gabriel and Foster 1986). These two assessments provided descriptive summaries of catch, effort, survey indices, and yield per recruit modeling. The current assessment represents the initial attempt to assemble an analytical assessment of the stock.

THE FISHERY

Commercial Landings

Before 1976, commercial landings of Georges Bank winter flounder were reported from the United States, Canada, and distant water fleets including the former Soviet Union. From 1964 to 1971, commercial landings increased reaching a peak of 3,200 mt in 1971 (Figure C2, Table C1). Landings declined from 1971 to 1976, before increasing sharply to 3,700 mt in 1977. Commercial landings peaked between 1980 and 1984 (averaging 3,800 mt•yr^{-1}), but declined sharply 1985 (Figure C2). Landings have trended downward since 1984, with the exception of landings from the strong 1984 year class in 1987 and 1988. Commercial landings in 1995 (760 mt) were the lowest recorded in the landings time series dating back to 1962. Since the late 1960's, U.S. landings have been the dominate component of total commercial landings. Canadian landings have averaged 0.1% to 2.7% of total fishery landings since 1970. The Canadian industry's interest in the Georges Bank winter flounder resource is increasing (S. Gavaris, personal communication), and reported Canadian landings in 1997 reached their highest levels since 1966 (Table C1).

Otter trawls have been the dominate gear accounting for greater than 98% of landings in the U.S. fishery through 1985 (Table C2). Since 1985, the proportion of landings taken by scallop dredges has increased steadily from less than 1% to approximately 7% by 1993. The proportion of winter flounder landings accounted for by scallop dredges declined from 1994 to 1997 in response to U.S. groundfish retention limits imposed in the scallop fishery. Tonnage class 3 (51-150 GRT) otter trawlers generally account for approximately 60 to 80% of U.S. landings, while tonnage class 4 (151-500 GRT) otter trawlers generally account for all but a few percent of the remaining U.S. landings (Table C3).

Commercial landings since 1982 are reported for 8 market categories (unclassified, lemon sole, small, large, extra-large, large/mixed, medium, and peewee) based primarily on the individual fish size. Three categories (lemon sole, small, and large) comprised approximately 85% of the commercial landings from 1982 to 1997 (Table C4).

Commercial Discards

Commercial discarding occurs in the otter trawl and scallop gear sectors due to marketability (size and condition), minimum size limit regulations, effort restriction regulations, and groundfish retention limits which prohibit groundfish retention in some small mesh fisheries and restrict retention in others (scallop fishery). Discard information is available from two primary sources, the sea sampling database which summarizes information collected by trained observers riding on commercial trips and the Vessel Trip Record (VTR) database which contains records of commercial operator reported discards.

Sea sampling data (available 1989 to 1997) represents the most reliable source of information available for estimating commercial discards. The total number of Georges Bank trips where winter flounder weights were collected ranged from 4 to 17 trips annually. Sea sampling of scallop dredge trips was limited with no more than 5 trips available annually where weights of landed and discarded winter flounder were sampled. Based on this limited amount of information, estimated total discards in the trawl gear sector ranged from 1.2 to 24.9 mt annually, representing 0.2 to 1.6% of otter trawl landings. Limited sampling of sea scallop trips precludes even preliminary estimates of discards for this fleet sector. However, limited sea sampled trips occurring in 1995 to 1997 (eight trips) appear to indicate that discarding of winter flounder by this gear sector may have increased significantly in response to groundfish retention regulations.

Length frequency information available in the sea sampling database were examined to determine the feasibility of partitioning discard weight estimates into numbers at length. The number of discarded winter flounder measured annually by the Sea Sampling Program ranged from 70 in 1989 to none in 1997. Clearly the number of discarded winter flounder measured was insufficient to characterize the overall length frequency distribution of the discarded portion of the catch. The number of discarded winter flounder measured in the scallop dredge gear sector was insignificant in every year except 1997, when 239 discarded winter flounder were measured in the second quarter and a total of 274 were measured across all quarters. Based on the limited data available to either estimate the magnitude of total discards or to characterize their size distribution, we concluded that it would be inappropriate to generate estimates of discards based on an analysis of sea sampled data.

Commercial operator reported discards in the VTR database (available 2nd Quarter of 1994 to 1997) represented the next best available source for estimating discards. Reporting rates in the VTR database are known to be incomplete because many operators fail to reliably report discards. To avoid problems associated with incomplete reporting, we estimated discard ratios using VTR data based on a subset of logbook records that reported at least 1 pound of discards for any species (DeLong *et al.* 1997, Brown 1998). By using this subset to characterize discard ratios, we made three basic assumptions: 1) it is highly unlikely that a groundfish trip could operate within the Georges Bank stock area without generating discards of some species, 2) trips that reported discards of some species reliably reported discards of winter flounder, and 3) the ratio of landed to discarded weight from this subset was representative of the discarding behavior of the entire fleet. Thus, the subset used to estimate discard ratios included 1) trips reporting both landings and discards of winter flounder, 2) trips reporting winter flounder discards but no landings, and 3) trips reporting winter flounder landings and discards for some other species.

For the otter trawl gear sector, the number of trips included in the discard ratio estimate ranged from 73 to 182 trips annually. Based on logbook reported discards, estimated total discards in the trawl gear sector ranged from 7.2 to 21.9 mt annually, representing 0.5 to 3.0% of otter trawl landings. Based on the number of scallop dredge trips reporting discards of winter flounder, it is clear that discard reporting rates for winter flounder are extremely low in this gear sector. From a regulatory standpoint, there are a number of disincentives to accurately reporting groundfish bycatch by scallop dredges. The limited number of trips reporting discards appear to indicate that discarding rates by this gear sector are significant, and therefore represent a significant source of uncertainty relative to the total fishery removals from the stock.

The third approach attempted to estimating discards involved using a combination of commercial sea sample data and research vessel survey data to estimate the total numbers discarded at length (following Mayo *et al.* 1992). Three significant weaknesses were encountered that precluded the use of this information. First, the length frequency distribution from a research vessel survey is assumed to be representative of the size distribution of the winter flounder resource seasonally. The limited number of strata and tows made on the NEFSC Spring and Autumn research vessel surveys produce limited numbers of winter flounder to characterize the length frequency distribution. For the period when the catch at age was produced for this assessment (1982 to 1997), the total number of winter flounder captured in representative tows during NEFSC Spring Research Vessel surveys ranged from 31 to 256 fish, and in 7 of the 17 years the total number of fish captured was less than 70 fish. For the NEFSC Autumn Research Vessel survey, the total number of winter flounder captured ranged from 12 to 320 fish, and in 8 of the 17 years the total number of fish captured was less than 70 fish. The low numbers of fish sampled result in an increased likelihood that there are some seasons when the NEFSC survey performs poorly in representing the length frequency distribution of the resource.

Second, the discard length frequency information available from sea sampling was limited resulting in a potentially poor determination of the discard selectivity ogive used in the analysis. One diagnostic for determining the performance of this estimation method is examination of the relationship between the research vessel bottom trawl survey number per tow discarded and the sea sample estimated number discarded. The expectation of is that this relationship will have a positive slope and that the correlation will be positive. The correlations between these estimated variables was weak, and in some cases negative, ranging from -0.1 to 0.7. This diagnostic indicates a significant problem with one of the inputs to this discard estimation procedure.

Third, if the number discarded at length could be reliably estimated, the number of age determinations for smaller size winter flounder from survey data is limited. While commercial age data could be used to augment age keys for older individuals, research vessel survey and sea sampling data are the only source of age determinations for sub-legal size fish. The number of survey ages available ranged as low as 12 determinations (NEFSC Autumn 1991 survey) when every winter flounder captured within the strata set was aged.

In summary, available survey, vessel trip record, and sea sampling data were insufficient to produce reliable estimates of the magnitude or age composition of winter flounder discards occurring in the Georges Bank otter trawl or scallop dredge fisheries. However, both the sea sampling and vessel trip record approaches produced consistent information concerning the magnitude of discards occurring in the otter trawl and scallop dredge fisheries. Both approaches produced relatively low estimates of discards relative to landings (Sea Sample: 0.2% to 1.6%; VTR: 0.5 to 3.0%) for the otter trawl fishery.

In addition, both data sources appear to indicate that discarding increased in the scallop dredge fishery following the implementation of groundfish retention limits. The recent scallop dredge discards represent a significant source of uncertainty relative to the total fishery removals from this stock. However, an analysis of the spatial overlap of exploitable scallop resources and winter flounder distributions indicated little spatial overlap. Because of the uncertainty in both the underlying data and the performance of the discard estimation approaches, no commercial discards were included in the catch at age analyzed in this assessment.

Sampling Intensity of Commercial Landings

Although the U.S. commercial landings of Georges Bank winter flounder are reported for 8 market categories (unclassified, lemon sole, small, large, extra-large, large/mixed, medium, and peewee), three categories (lemon sole, small, and large) comprised 85% of the commercial landings from 1982 to 1997 (Table C4). After comparing the length frequencies by market categories across years, other market categories including peewee (5.9%), medium (1.7%), extra-large (0.6%) and large/mixed (0.2%) were combined with the small, large, and lemon sole market categories to estimate catch at age (see Table C5 for details). U.S. commercial length samples were aggregated by quarter and combined market categories and summarized in Table C5. Since 1982, annual sampling intensity by combined market category ranged from 36 to 902 mt of landings•sample^{-1}. Sampling intensity has been lower for lemon sole than for small or large combined market categories, and sampling in all market categories deteriorated after 1992. Poor sampling intensity prior to 1982 preclude extension of the landings at age time series prior to 1982. There is no formal commercial sampling program for Canadian landings of Georges Bank winter flounder.

Landings at Age

Age composition of the 1982 to 1997 commercial landings from Georges Bank were estimated by applying commercial age-length keys to quarterly commercial numbers at length, aggregated by market category. In some instances, the landings at age analysis was pooled to half year, and in one case across three quarters of the calendar year because of insufficient length frequency sampling. Details regarding pooling across time periods and market categories are summarized in Table C6. Mean weights at age were estimated by applying the length-weight equations to the quarterly length frequency samples by market category. Total numbers landed per quarter were estimated by applying the mean weights to the quarterly landings by market category and prorating according to the sample length frequency. Numbers at age were summed over market category for each quarter and annual estimates of landings at age were obtained by summing values over quarters. Landings from both the unclassified market category for U.S. landings and total reported Canadian landings were assumed to have the same age composition as the sampled U.S. landings, and the estimated landings at age was adjusted to incorporate these landings. The unsampled portion of landings generally accounted for less than 10% of the total landings at age.

Estimated total landings at age for 1982 to 1997 are summarized in Table C7A. Landings of age 2 to 4 fish dominate landings, and two relatively large year classes appear to track well through the catch at age matrix. Landings of age 1 fish are insignificant except in 1995 when almost 264,000 landed age 1 fish were estimated. Examination of the U.S. commercial samples indicated that large numbers of age 1 fish were present in multiple samples occurring in the third and fourth quarters of 1995. In addition, relatively large numbers of the 1994 cohort were landed as age 2 fish in 1996 and age 3 fish in 1997. Estimated landed weight (mt) of Georges Bank winter flounder by age and year is summarized in Table C7B.

Mean Weights at Age

Mean length and weight at age from the analysis of total landings at age are summarized in Tables C7C and C7D, respectively. Mean weights at age have remained relatively stable from 1982 to 1997, although poor sampling of older ages results in some instability in the estimated length and weight for ages 7 and older.

STOCK ABUNDANCE AND BIOMASS INDICES

U.S. Landings per Unit Effort (LPUE) Indices

Landings per unit effort (landings•days fished^{-1}) were tabulated from the weighout database by tonnage class from 1964 to 1993 for all otter trawl trips landing winter flounder and for directed trips (trips with >= 50% winter flounder landings). Landings per unit effort indices for all and directed winter flounder trips demonstrated similar trends with high levels of landings per unit effort in the 1980s, and declines in both indices to their lowest levels in the time period in the early 1990s (Figure C3).

U.S. Research Vessel Bottom Trawl Survey Indices

The Northeast Fisheries Science Center of the U.S. National Marine Fisheries Service has conducted a stratified random bottom trawl survey designed to assess the abundance and biomass of fish species along the continental shelf of the United States from the Scotian Shelf to Cape Hatteras since 1963 (Azarovitz 1981; Despres *et al.* 1988, Azarovitz *et al.* 1997). Two stratified random bottom trawl surveys, a spring survey (April 1968-1998) and an autumn survey (October 1963-1997) are used to estimate changes in abundance (stratified mean number per tow) and biomass (stratified mean weight (kg) per tow) of demersal fish species including winter flounder. The indices for Georges Bank winter flounder include data from representative tows occurring in the NEFSC offshore strata 01130 to 01220. Significant changes in the catchability of winter flounder due to a door gear change in 1995 necessitates adjusting pre-1995 using door standardization coefficients (1.46 numbers; 1.39 weight;

NEFSC 1991) estimated through fishing power experiments. These experiments indicated no significant differences in the catchability of winter flounder between the two research vessels (Delaware II and Albatross IV) during the survey time series.

Standardized, stratified abundance and biomass indices for Georges Bank winter flounder from the U.S. Spring and Autumn Research Vessel Bottom Trawl surveys are shown in Table C8 and Figure C4. Abundance and biomass indices exhibit a considerable amount of variability but generally exhibit intermediate levels of abundance from the early 1960s to early 1980s, and declining levels of abundance since the mid-1980s (Figure C4). Both surveys have exhibited a declining trend over the final two years of the survey. The stratified mean length (cm) in both the U.S. Spring and Autumn surveys exhibited a general declining trend between the mid 1960s and early 1990s, but the stratified mean length has increased over the past five years (Figure C5).

Stratified mean number at age for the NEFSC Spring and Autumn surveys is shown in Tables C9A and C9B, respectively. Although these indices are noisy, larger cohorts appear to track through the numbers at age matrix for the 1980, 1985, 1987, and 1994 cohorts.

Canadian Research Vessel Bottom Trawl Survey

The Department of Fisheries and Oceans, Canada has conducted a stratified random bottom trawl survey on Georges Bank since 1996. The Canadian survey, normally conducted during February or early March, occupies stations in both U.S. and Canadian waters. Station density is generally higher than on U.S. surveys of Georges Bank. For the purposes of this assessment, stations occurring in strata 5Z1 to 5Z8 occurring the NAFO area 5Zh,j,m,n were included in the estimation of abundance indices. Weight data area collected, but were unavailable for estimating biomass indices ($kg \cdot tow^{-1}$). Stratified mean numbers per tow at length were available for winter flounder from 1987 to 1998. Biomass indices were generated by applying the U.S. survey length-weight regression relationship (Weight (kg) = 0.0000079099 * Length (cm) $^{3.1378}$) to the stratified mean numbers at length from the Canadian survey. Indices of abundance and biomass for the Canadian survey are summarized as stratified mean number per tow from 1986 to 1998 (Table C8, Figure C4).

Winter flounder captured during the Canadian survey are counted and measured, but no aging program exists to generate age determinations from this survey. U.S. survey and commercial age keys were used to partition stratified mean numbers at length into stratified mean numbers at age. Sufficient age determinations were available from U.S. Spring survey data to partition stratified mean numbers at length into numbers at age for fish smaller than 40 cm. U.S. commercial age keys from the first quarter of the corresponding year were applied for fish longer than 40 cm. The application of commercial age keys will provide unbiased estimates of catch at age if both the U.S. commercial fleet and the Canadian survey are sampling fish that grow at the same rate. Since the principal winter flounder habitat is located in U.S. waters and the Canadian survey samples across both U.S. and Canadian waters with primary catches occurring in U.S. waters, this assumption appears to be valid.

MORTALITY AND MATURATION

Natural Mortality

For this assessment, natural mortality was assumed to be constant and equal to 0.20 throughout the time series. The observation of maximum ages in the populations occasionally exceeding 15 years is consistent with this assumption of natural mortality (3/m rule of thumb).

Total Mortality

Estimates of instantaneous total mortality (Z) and fishing mortality (F, assuming natural mortality = 0.20) were estimated from the stratified number at age indices from the NEFSC Spring and Autumn surveys. Because of interannual variability in the survey indices, pooled estimates of mortality rates were estimated across running three year time periods from 1981 to 1997. Total mortality (Z) was estimated as the natural log of the ratio of 3+/4+ indices from the autumn survey, and 4+/5+ indices from the spring survey. Mortality rates for both surveys exhibited similar patterns with relatively low mortality rates in the early 1980s, higher mortality rates in the mid-1980s to early 1990s, and lower mortality rates in the mid-1990s (Figure C6). The two surveys exhibit divergent trends in the most recent years (1993 to 1997), with the spring survey estimate high and increasing fishing mortality, while the autumn survey estimates lower and decreasing fishing mortality (Figure C6).

Maturity

Maturation determinations for female winter flounder were collected on the NEFSC Spring Research vessel survey from 1982 to 1997. The total number of maturation determinations annually is limited, particularly in terms of the number of determinations for ages 2 and 3 fish which determine the character of the maturation relationship at age. We used a logistic regression approach (O'Brien *et al* 1993) to estimate the proportion of females mature at age. Logistic equations for individual years were used to estimate age at 50% maturity for individual years. Age at 50% maturation for female winter flounder appeared to fluctuate without trend from 1982 to 1998 (Table C10). After attempts to pool across various time periods produced stable results, a logistic regression using the entire time series (1982 to 1998) was performed. Age at 50% maturity was estimated to be 1.83 years and the resulting maturity ogive (0.00 at age 1, 0.62 at age 2, 0.92 at age 3, 1.00 at age 4) was used in subsequent analyses (Table C10). O'Brien *et al* (1993) reported age at 50% maturation of 1.9 years and a similar estimated maturity ogive (0.03 at age 1, 0.62 at age 2, 0.99 at age 3, 1.00 at age 4) for data from 1985 to 1989.

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

Virtual Population Analysis Calibration

The ADAPT virtual population analysis (VPA) calibration method (Parrick 1986, Gavaris 1988; Conser and Powers 1990) was used to estimate terminal stock abundance at ages 2-6 and derive age specific estimates of fishing mortality in 1997 and stock sizes at the beginning of 1998. The catch at age in the VPA consisted of combined U.S. and Canadian landings during 1982 to 1997 for ages 1-6 with a 7+ age group. Indices available to calibrate the VPA included the U.S. Spring Research Vessel Survey catch (numbers) at age (ages 1 to 7), the Canadian Spring Research Vessel Survey catch (numbers) at age (ages 1 to 7), and the U.S. Autumn Research Vessel Survey catch (numbers) at age (ages 0 to 6) lagged forward one age and one year. Several VPA calibrations were completed and evaluated during the Southern Demersal Subcommittee and SAW/SARC meetings. A summary of these calibrations including key diagnostics and terminal year results are summarized in Table C11.

The final accepted calibration (Run 15) estimated ages 2 to 6 and included the U.S. Spring indices (ages 1 to 7), the Canadian Spring indices (ages 1 to 7), and the U.S. Autumn indices (ages 1-6, lagged forward one age and one year). This calibration was successful in reducing the coefficients of variation on the youngest ages (2 and 3) and produced favorable diagnostics (Table C11).

Virtual Population Analysis Results

The assessment results indicate that stock numbers exceeded 25 million in the early 1980s, gradually declined reaching a low level of approximately 8.8 million in 1993, increased to 13.6 million in 1995, and have again declined to 9.6 million fish in 1997 (Table C12). Age 2 recruitment was relatively stable throughout the time period, but larger 1980, 1985, 1987 and 1994 year classes exceed 5 million fish at age 2 (Table C12, Figure C7). Recent recruitment, as measured by the 1995 and 1996 year classes, has been the lowest in the time series (Figure C7). There appears to be little discernable relationship between stock and recruitment over the time period analyzed in this assessment (Figure C7).

Spawning stock biomass declined from levels exceeding 8,000 mt in the early 1980's to less than 2000 mt in 1994, but increased to almost 3,700 mt in 1996 (Table C12, Figure C7). Spawning stock biomass declined slightly from almost 3;700 mt in 1996 to 3,500 mt in 1997. In the early 1980s, spawning stock biomass consisted of a wide range of ages and the youngest mature ages (2 and 3) comprised less than 40% of the total spawning stock biomass (Figure C8). The age structure of the spawning stock biomass became truncated in the mid 1980s to mid 1990s, when the youngest mature ages (2 and 3) comprised 45% to 75% of the spawning stock biomass. Some broadening of the age structure of spawning stock biomass is evident after 1994, but the age structure spawning component of the stock remains truncated (Figure C8).

From the early 1980s to the early 1990's, fishing mortality ranged from approximately 0.5 to as high as 1.4. Fishing mortality declined sharply after 1993 and has fluctuated between 0.3 and 0.5 from 1994 to 1997 (Table C12). There is a reasonable level of agreement between VPA estimated fishing mortality rates and survey estimated rates of fishing mortality (Z estimates assuming m=0.2) throughout the time series (Figure C6). However, in the most recent three years VPA estimates of fishing mortality correspond more closely with fishing mortality estimates from the autumn survey. Patterns in fishing mortality appear to be reasonably well correlated with reported landings included in the assessment (Figure C9).

Precision Estimates of F and SSB

Uncertainty and potential bias estimates were assessed using a bootstrap analysis of the VPA calibration. One thousand bootstrap realizations were produced by randomly resampling survey residuals produced by the final ADAPT calibration. Bootstrap abundance indices had slightly larger CV's that the least squares estimates produced by the final ADAPT VPA calibration (Appendix C2). Estimates of bias on all ages was relatively low, ranging from 3.7% to 6.4%. Bias estimates for fully recruited F and spawning stock biomass were each below 3%.

The distribution of bootstrap realizations of spawning stock biomass indicates that there is an 80% chance that the 1997 estimate of SSB is between 3100 and 4200 mt (Figure C10). The distribution of bootstrap realizations of fishing mortality suggests that there is an 80% probability that F_{1997} is between 0.33 and 0.51 (Figure C10).

Retrospective Analysis

Retrospective analyses of the Georges Bank winter flounder VPA were performed from 1997 to 1990 by sequentially reanalyzing the ADAPT calibration after removing the terminal year of input data. Retrospective patterns for fishing mortality (Figure C11A) indicates a pattern of slightly overestimating average fishing mortality in the terminal year. The tendency was more pronounce in the terminal year 1992 and 1993 assessments. The retrospective patterns for spawning stock biomass (Figure C11B) indicate that there is a tendency in the most recent years to slightly overestimate spawning stock biomass in the terminal year. This patterns shifts before 1993 with a tendency to underestimate SSB in the terminal year estimates evident before 1993.

The retrospective patterns for age 2 recruitment (Figure C11C) indicate considerable variability in the performance of the terminal year estimation of stock numbers at age 2. Performance was generally acceptable with a slight tendency to underestimate age 2 recruitment for most year classes. However, retrospective performance was particularly poor for the 1992 and 1994 year classes, where initial estimates were considerably higher than converged estimates of these year classes. Both of these year classes had estimated age 1 landings included in the catch at age, whereas landings at age from other year classes indicated no landings at age 1. This observation should be considered when evaluating the reliability of the terminal estimate of age 2 recruitment, which estimates that incoming age 2 recruitment is the weakest in the time series.

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit Analyses

Yield per recruit (Thompson and Bell 1934) and yield per recruit (Gabriel *et al.* 1989) analyses were conducted using the partial recruitment vector estimated from the calibrated VPA. Since major fishery management measures have been implemented beginning in 1994, 4-year arithmetic mean weights and geometric mean partial recruitment were used as inputs in these analyses. The maturation schedule for Georges Bank winter flounder has been stable through time, so the long-term estimate of the maturation schedule was used as an input. Results of the analysis indicate that that $F_{0.1}$ is currently estimated to be 0.21, F_{max} is estimated to be 0.42, and $F_{20\%}$ is estimated to be 0.47 (Table C13, Figure C12).

SFA Overfishing Definitions

The overfishing panel (Applegate *et al.* 1998) proposed and the New England Fishery Management Council adopted (Amendment #9 to the Northeast Multispecies Fishery Management Plan) an MSY-based control rule for Georges Bank winter flounder derived from survey-based proxies of biomass and exploitation. The Council defined maximum sustainable yield as 2,700 mt, identified a threshold fishing mortality proxy (F_{MSY}) as a level of an exploitation index (catch•Autumn survey biomass^{-1}) of 0.98, and identified a target stock biomass proxy as the NEFSC Autumn survey biomass index value of 2.74. Further, target fishing mortality proxy was estimated to be 75% of the threshold proxy value, and stock biomass proxies were established as 50% of the target B_{MSY} proxy values. Figure C13 provides a graphic representation of the Amendment #9 overfishing definition.

A non-equilibrium surplus production analysis (ASPIC; Prager 1993, 1994) was completed using landings biomass and the NEFSC Spring, Canada Spring, and NEFSC Autumn survey indices of stock biomass from 1963 to 1997 to provide perspective on historical stock levels and to provide information relative to SFA reference points. Initial biomass, maximum sustainable yield, the intrinsic rate of increase and catchability (q) of the survey biomass indices were estimated by nonlinear least squares of the biomass index residuals.

The current surplus production model differed from the model used to construct the Amendment #9 harvest control rule in two respects. First, the catch input included foreign landings (primarily from the 1960s) that were not included in the Amendment #9 surplus production model. Second, the strata set used to estimate the NEFSC spring and autumn indices included a larger strata set than the indices used to estimate the Amendment #9 harvest control rule. The two strata sets produced highly correlated survey indices, although the current survey indices are scaled lower than the previous indices.

Results of the surplus production analysis indicated a reasonable fit to the input data, and estimated trends in biomass were well matched with results from the Virtual Population Analysis (Figure C14). A maximum sustainable biomass (MSY) of 3,100 mt was estimated to be produced by a biomass (B_{msy}) of 11,400 mt (Table C14). A time trajectory of results from the surplus production model indicates that yield has generally exceeded estimated surplus production for the past two decades (Figure C15).

The Amendment #9 harvest control rule was re-estimated in it's original format based on a current NEFSC research vessel survey indices (revised strata set) and a revised surplus production model that incorporated the Canadian research vessel survey indices and foreign commercial landings in the 1960s and early 1970s. The target B_{MSY} proxy (NEFSC Autumn Survey biomass units) was estimated to be 2.730 (MSY/f_{msy}), and the threshold B_{MSY} proxy was estimated to be 50% of the B_{MSY} proxy. The threshold and target F_{msy} proxies (in exploitation index units) were estimated to be 1.125 (MSY Proxy / B_{msy} proxy) and 0.843 (0.75*$F_{threshold}$ proxy), respectively.

The revised harvest control rule is displayed graphically in Figure C13. For the latest time period for which data were available (1995-1997), the three year average of the NEFSC Autumn survey index (1.542) and the exploitation index (0.754) indicate that the stock is being overfishing and is in an overfished condition relative to the harvest control rule. If the harvest control rule were applied for the 1999 fishing year, the corresponding threshold fishing mortality rate (fully recruited F) would be 0.04 and the target fishing mortality rate (fully recruited F) would be 0.03.

PROJECTIONS

Short-Term Stochastic Projections

Short-term deterministic projections were performed for 1998, 1999, and 2000. 1998 U.S. landings were assumed to be 964 mt based on the landings projections by the New England Fishery Management Council's Multispecies Monitoring Committee. Canadian landings in 1998 were assumed to be equal to the 1997 (143 mt). The projections were based on a partial recruitment vector estimated as the geometric mean of 1994 to 1997 F's at age from the final VPA calibration, 1994 to 1997 arithmetic mean stock and catch weights, and the long-term (1982-1997) maturity schedule for Georges Bank winter flounder. Age 1 recruitment was estimated from the terminal year bootstrap realizations of the VPA in 1998, and recruitment in 1999 and 2000 was resampled from observed age 2 recruitment estimated by the ADAPT VPA calibration from 1982 to 1997 (Age Pro Model 3).

Projections were run at F = 0.00 (maximum stock rebuilding rate), F_{target} = 0.03 (management target associated with the Amendment #9 harvest control rule), $F_{threshold}$ = 0.04 (management threshold associated with the Amendment #9 harvest control rule), $F_{0.1}$ = 0.21 (commonly used yield per recruit reference point), F_{1998} = 0.34 (based on projected landings of 1,107 mt in 1998), and $F_{20\%}$ = 0.47 (current New England Fishery Management Council overfishing definition) for years 1999 and 2000. Results for these reference points of F are presented in Table C15.

Projections at F = 0.00 in 1999/2000 provide a benchmark for the maximum projected stock rebuilding rate. For this level of fishing mortality (i.e., fishery closure), there would be no projected landings. Age 1+ biomass is projected to increase 33% from 5,680 mt in 1999 to 7,552 mt in 2000. Spawning stock biomass is projected to increase from 44% from 3,735 mt in 1999 to 5,374 mt in 2000 (Table C15, Figure C16). Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 4,098 mt and 6,793 mt (Table C15).

Projections at F_{target} = 0.03 in 1999/2000 result in a 91% decline in landings from 1,107 mt in 1998 to 118 mt in 1999 (Table C15, Figure C16). Age 1+ biomass is projected to increase 31% from 5,619 mt in 1999 to 7,342 mt in 2000. Spawning stock biomass is projected to increase 41% from 3,716 mt in 1999 to 5,228 mt in 2000. Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 3,986 mt and 6,613 mt (Table C15).

Projections at $F_{threshold} = 0.04$ in 1999/2000 result in a 86% decline in landings from 1,107 mt in 1998 to 157 mt in 1999 (Table C15, Figure C16). Age 1+ biomass is projected to increase 30% from 5,600 mt in 1999 to 7,274 mt in 2000. Spawning stock biomass is projected to increase 40% from 3,709 mt in 1999 to 5,181 mt in 2000. Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 3,948 mt and 6,552 mt (Table C15).

Projections at $F_{0.1} = 0.21$ in 1999/2000 result in a 31% decline in landings from 1,107 mt in 1998 to 764 mt in 1999 (Table C15, Figure C16). Age 1+ biomass is projected to increase 18% from 5,279 mt in 1999 to 6,244 mt in 2000. Spawning stock biomass is projected to increase 24% from 3,597 mt in 1999 to 4,446 mt in 2000. Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 3,377 mt and 5,639 mt (Table C15).

Based on projected landings of 1,107 mt in 1998, the projected level of fishing mortality in 1998 is 0.34. Fishing at $F_{1998} = 0.34$ in 1999/2000, landings would increase by 6% from 1,107 mt in 1998 to 1,172 mt in 1999 (Table C15, Figure C16). Age 1+ biomass is projected to increase 11% from 5,050 mt in 1999 to 5,596 mt in 2000. Spawning stock biomass would increase 13% from 3,514 mt in 1999 to 3,967 mt in 2000. Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 3,004 mt and 5,046 mt (Table C15).

The overfishing definition previously established by the New England Fishery Management Council for Georges Bank winter flounder is $F_{20\%}$, which is currently estimated to be 0.47. Fishing at $F_{20\%} = 0.47$ in 1999/2000, landings would increase by 42% from 1,107 mt in 1998 to 1,575 mt in 1999 (Table C15, Figure C16). Age 1+ biomass is projected to increase 4% from 4,836 mt in 1999 to 5,042 mt in 2000. Spawning stock biomass is projected to increase 3% from 3,433 mt in 1999 to 3,550 mt in 2000. Accounting for some sources of uncertainty in the stock assessment, there is an 80% chance that SSB in 2000 would be between 2,676 mt and 4,529 mt.

CONCLUSIONS

The Georges Bank winter flounder stock is overexploited and at a low level of biomass. Fishing mortality rates were very high in the early 1990s (1990-1993 average F=0.74), but have declined since 1994. Spawning stock biomass levels and age composition have improved since 1993, but incoming recruitment, particularly the 1995 and 1996 year classes, is poor. Stock biomass in 1997 was at 60% of the biomass proxy specified in the Amendment 9 control rule. Assuming a catch of 1,100 mt in 1998 the estimated level of SSB in 1998 is 3,300 mt and fully recruited F is projected to increase to 0.34. Relative to the Amendment 9 overfishing definition and control rule (Figure C7), the stock is overfished and overfishing is occurring ($F_{target} = 0.03$)

SARC COMMENTS

The SARC concluded that discard estimates were unreliable and should not be included in the catch at age. An industry representative also stated that discard estimates reported in logbooks are unreliable. However data from both the logbook and sea sampling indicated relatively low discards in the otter trawl and scallop dredge fisheries. In addition, the SARC noted that discard survivorship is relatively high for winter flounder. A distribution plot using NEFSC autumn bottom trawl survey showed relatively little overlap between the winter flounder and scallop resource except inside Closed Area 2. This also suggests that discards in the scallop dredge fishery are relatively low. However, a significant overlap in the distribution for scallop and winter flounder occurs in Closed Area 2. The SARC expressed concern regarding the potential for an increase in winter flounder discards with the opening of Area 2 to the scallop dredge fishery.

The SARC questioned the lack of commercial and sea sampling data for winter flounder. There was some discussion on port and sea sampling procedures. A shift in sea sampling effort from offshore to inshore areas in recent years was noted.

The SARC noted that the spring Canadian survey gear had higher catchability for larger flat fish than the NEFSC survey. The Canadian survey is also sampling winter flounder during the spawning season when the fish tend to be aggregated.

The SARC requested a plot of the maximum, minimum, and mean lengths from the NEFSC survey. The SARC noted little change in the maximum and minimum sizes over the time series. The SARC speculated that maximum size could be increasing in recent years due to increased survival from the closed areas. A recommendation was made to use the 5^{th} and 95^{th} percentile instead of the maximum and minimum lengths.

The SARC questioned why F_{max} could not be estimated from the YPR analysis. A problem in estimating F_{max} was found in the YPR analysis due to the software identifying a local maximum at high f values. The problem was rectified and F_{max} was estimated at 0.42.

VPA run tuned with U.S. spring ages 1-7, U.S. autumn ages 2-7 and Canadian spring ages 2-7 was accepted by the SARC. Similar results in biomass are seen in both the VPA and the unconstrained surplus production model which included Canadian biomass indices. However the SARC was concerned about using NEFSC length-weight equation to estimate Canadian biomass indices since there is a two month difference between the surveys. There was also uncertainty in the estimate of B_{msy} from the surplus production model due to the small range in observed biomass over the time series in which no observation exceeded the estimate of B_{msy}. The number of iterations in the Bootstrap estimate which do not converge was also a point of concern.

Uncertainty in the reference point estimates from the surplus production model did not justify a change to the proposed overfishing definition.

There was some discussion on the addition of confidence intervals to the control rule figures but the SARC concluded that interpretation of 2-dimensional confidence intervals would be difficult. The SARC noted that the updated three year average exploitation index (1995-1997) declined considerably from the 1994-1996 estimate.

SOURCES OF UNCERTAINTY

1. Sampling of U.S. commercial landings was less than robust, particularly in the years since 1992. This leads to uncertainty in the age composition of landings in the catch at age matrix.

2. The exclusion of U.S. otter trawl and scallop dredge discards most likely results in an underestimation of fishery removals from the younger age classes (ages 0 to 3). Indications from both the sea sample and vessel trip record databases suggests that scallop dredge discards may have increased since the implementation of groundfish retention restrictions resulting in an underestimation of fishery removals of both younger and older age classes.

3. There is some uncertainty about the accuracy of reported Canadian landings because of the non-targeted nature of the Canadian fishery and the tendency to report landings some flatfish species including winter flounder as unclassified flounders.

4. The Canadian fishery has no formal sampling program to estimate the size and age composition of Canadian landings. This assessment assumed that the size and age

composition of Canadian landings was identical to the overall size and age composition in the U.S. fishery. This assumption is sensitive to the possibility that selectivity patterns may be different between the two species.

RESEARCH RECOMMENDATIONS

1. Increase the sampling of commercial landings through the port sampling program by highlighting the fact that trips fishing on Georges Bank proper (areas 522, 525 and east) are undersampled for several groundfish species.

2. Investigate approaches to improving information on winter flounder discards by:
   - requesting additional sea sampling coverage on scallop dredge and large mesh otter trawl trips on Georges Bank
   - examining reporting of discards in the vessel trip record database to determine patterns in the directivity of these trips
   - correlate discard ratios reported in logbooks on trips that were observed by the sea sampling program.

3. Investigate the potential for generating discard estimates and the sensitivity of excluding discards from the catch at age by:
   - assuming that all discards are smaller than the minimum size limit and adding to the landings based on average weights in the youngest age classes
   - developing survey-based approaches using the length frequency distributions from the Canadian survey to characterize the size distribution of the population

4. Examine the distribution of winter flounder resources in Stratum 23 and the prospects for splitting this stratum across the stock area boundary. This effort should be coordinated for all species where the stock boundary is split across the area 521/526 - 522/525 boundary, particularly yellowtail flounder.

5. Investigate the effects of the application of door correction coefficients to the U.S. research vessel survey data before 1985.

6. Obtain research vessel biomass indices (kg/tow) from the Department of Fisheries & Oceans, Canada for use in surplus production modeling.

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Table C 1. Landings (mt) of Georges Bank winter flounder from 1962-1997 by statistical area and country.

	522-525 561-562	5Z (521-543)				5ZE (521-526, 541-543)				Included in
	USA	USA	Canada	USSR	Total	USA	Canada	USSR	Total	Assessment
1962		6996	26		7022					
1963		6911	120	19	7050					
1964	1371	12656	146		12802					1517
1965	1176	10479	199	312	10990					1687
1966	1877	13807	164	156	14127					2197
1967	1917	10815	83	349	11247					2349
1968	1570		57			4346	59	372	4777	1999
1969	2167		116			6380		235	6615	2518
1970	2615		61			7020	64	40	7124	2716
1971	3092		62			1400	65	1029	15094	4183
1972	2805		8			1026	8	1699	11973	4512
1973	2269		14			4387	14	693	5094	2976
1974	2124		12			4508	12	82	4602	2218
1975	2409		13			4833	13	515	5361	2937
1976	1877		15			3732	11	1	3744	1893
1977	3572		15			5954	15	7	5976	3594
1978	3185		65			6378	65		6443	3250
1979	3045		19			6293	19		6312	3064
1980	3931		44			9941	44		9985	3975
1981	3993		19			9711	19		9730	4012
1982	2961		19			7347	19		7366	2980
1983	3894		14			8014	14		8028	3908
1984	3927		4			7574	4		7578	3931
1985	2151		12			4758	11		4769	2163
1986	1762		25							1787
1987	2637		32							2669
1988	2804		55							2859
1989	1880		11							1891
1990	1898		55							1953
1991	1814		14							1828
1992	1822		27							1849
1993	1662		21							1683
1994	907		65							972
1995	706		54							760
1996	1265		71							1336
1997	1287		143							1430

Table C 2. U.S. landings (mt) and percent of landings of Georges Bank winter flounder (U.S. statistical areas 522-525, 551-552, 561-562) by gear type from 1964 to 1993. U.S. general canvas landings are not included.

	Landings by Gear (mt)				Percent of Total Landings			
	Trawl	Scallop Dredge	Other	Total	Trawl	Scallop Dredge	Other	Total
1964	1360.2	–	11.2	1371.4	99.2	–	0.8	100.0
1965	1175.1	–	0.8	1176.0	99.9	–	0.1	100.0
1966	1851.3	–	25.8	1877.1	98.6	–	1.4	100.0
1967	1915.5	–	1.8	1917.3	99.9	–	0.1	100.0
1968	1565.3	–	4.6	1569.9	99.7	–	0.3	100.0
1969	2165.0	–	1.8	2166.8	99.9	–	0.1	100.0
1970	2610.6	–	4.4	2615.0	99.8	–	0.2	100.0
1971	3086.9	–	4..8	3091.7	99.8	–	0.2	100.0
1972	2796.6	–	7.9	2804.5	99.7	–	0.3	100.0
1973	2265.2	–	3.5	2268.8	99.8	–	0.2	100.0
1974	2116.5	–	7.7	2124.2	99.6	–	0.4	100.0
1975	2386.6	–	22.6	2409.2	99.1	–	0.9	100.0
1976	1874.7	–	2.6	1877.3	99.9	–	0.1	100.0
1977	3570.4	–	1.6	3571.9	100.0	–	<0.1	100.0
1978	3166.5	17.9	1.1	3185.5	99.4	0.6	<0.1	100.0
1979	3019.8	24.9	0	3044.6	99.2	0.8	<0.1	100.0
1980	3887.9	42.5	0.3	3930.8	98.9	1.1	<0.1	100.0
1981	3935.3	53.5	3.7	3992.5	98.6	1.3	0.1	100.0
1982	2919.5	41.2	0.1	2960.8	98.6	1.4	<0.1	100.0
1983	3864.0	25.4	7.2	3896.6	99.2	0.7	0.2	100.0
1984	3899.9	18.5	11.1	3929.5	99.2	0.5	0.3	100.0
1985	2146.3	3.1	3.2	2152.6	99.7	0.1	0.1	100.0
1986	1724.3	36.0	2.3	1762.6	97.8	2.0	0.1	100.0
1987	2560.6	77.6	0	2638.5	97.0	2.9	<0.1	100.0
1988	2699.5	106.5	0	2805.9	96.2	3.8	<0.1	100.0
1989	1761.7	119.7	0.1	1881.4	93.6	6.4	<0.1	100.0
1990	1779.6	118.2	1.6	1899.4	93.7	6.2	0.1	100.0
1991	1673.7	141.2	0.8	1815.6	92.2	7.8	<0.1	100.0
1992	1677.8	136.4	8.7	1822.9	92.0	7.5	0.5	100.0
1993	1535.2	115.5	12.4	1663.1	92.3	6.9	0.7	100.0
1994*	909.4	52.9	9.4	971.7	93.6	5.4	1.0	100.0
1995*	713.1	37.0	10.0	760.2	93.8	4.9	1.3	100.0
1996*	1243.8	71.2	20.6	1335.7	93.1	5.3	1.5	100.0
1997*	1337.9	80.0	11.9	1429.8	93.6	5.6	0.8	100.0

* includes Canadian landings from 1994 to 1997.

Table C 3. USA landings (mt) of Georges Bank winter flounder by tonnage class (TC2 = 5-50 GRT, TC3 = 51-150 GRT, TC4 = 151-500 GRT) for otter trawl and scallop dredge landings.

	Weighout Landings (mt)							Percentage of Total Landings						
	Otter Trawl Ton Class			Scallop Dredge Ton Class			All Others	Otter Trawl Ton Class			Scallop Dredge Ton Class			All Others
Year	2	3	4	2	3	4		2	3	4	2	3	4	
1964	74.0	927.8	358.4	0.0	0.0	0.0	11.2	5.4	67.7	26.1	0.0	0.0	0.0	0.8
1965	81.4	694.3	399.4	0.0	0.0	0.0	0.9	6.9	59.0	34.0	0.0	0.0	0.0	0.1
1966	54.2	1188.7	630.0	0.0	0.0	0.0	4.2	2.9	63.3	33.6	0.0	0.0	0.0	0.2
1967	46.4	1074.1	794.9	0.0	0.0	0.0	1.8	2.4	56.0	41.5	0.0	0.0	0.0	0.1
1968	34.4	1039.5	491.4	0.0	0.0	0.0	4.6	2.2	66.2	31.3	0.0	0.0	0.0	0.3
1969	6.6	1542.2	616.2	0.0	0.0	0.0	1.8	0.3	71.2	28.4	0.0	0.0	0.0	0.1
1970	16.2	2003.8	590.6	0.0	0.0	0.0	4.4	0.6	76.6	22.6	0.0	0.0	0.0	0.2
1971	66.8	2282.4	737.6	0.0	0.0	0.0	4.8	2.2	73.8	23.9	0.0	0.0	0.0	0.2
1972	36.4	2233.1	527.1	0.0	0.0	0.0	7.9	1.3	79.6	18.8	0.0	0.0	0.0	0.3
1973	22.0	1726.5	516.7	0.0	0.0	0.0	3.5	1.0	76.1	22.8	0.0	0.0	0.0	0.2
1974	15.8	1532.3	568.4	0.0	0.0	0.0	7.7	0.7	72.1	26.8	0.0	0.0	0.0	0.4
1975	9.5	1855.2	544.6	0.0	0.0	0.0	0.0	0.4	77.0	22.6	0.0	0.0	0.0	0.0
1976	2.2	1487.4	386.1	0.0	0.0	0.0	1.6	0.1	79.2	20.6	0.0	0.0	0.0	0.1
1977	33.2	2901.3	636.4	0.0	0.0	0.0	1.1	0.9	81.2	17.8	0.0	0.0	0.0	<0.1
1978	10.5	2541.3	615.7	0.0	7.6	10.3	0.2	0.3	79.8	19.3	0.0	0.2	0.3	<0.1
1979	34.7	2436.1	548.8	0.0	18.1	6.8	0.2	1.1	80.0	18.0	0.0	0.6	0.2	<0.1
1980	70.3	3112.3	705.3	2.9	19.6	20.1	0.4	1.8	79.2	17.9	<0.1	0.5	0.5	<0.1
1981	26.3	3087.7	822.5	0.0	19.0	34.5	2.5	0.7	77.3	20.6	0.0	0.5	0.9	0.1
1982	29.2	2194.6	693.4	0.0	26.9	14.2	2.5	1.0	74.1	23.4	0.0	0.9	0.5	0.1
1983	10.7	2641.1	1218.7	0.0	4.7	20.7	0.8	0.3	67.8	31.3	0.0	0.1	0.5	<0.1
1984	10.3	2551.1	1349.2	0.0	8.2	10.2	0.4	0.3	64.9	34.3	0.0	0.2	0.3	<0.1
1985	4.1	1316.3	829.0	0.0	1.8	1.4	0.0	0.2	61.2	38.5	0	0.1	0.1	0.0
1986	0.0	1222.5	504.2	0.1	6.6	29.3	0.0	0	69.4	28.6	<0.1	0.4	1.7	0.0
1987	0.4	1899.5	660.7	0.0	14.5	63.5	0.0	<0.1	72.0	25.0	0	0.5	2.4	<0.1
1988	2.6	1917.9	778.9	0.1	29.2	77.2	0.0	0.1	68.4	27.8	<0.1	1.0	2.8	<0.1
1989	0.0	1250.5	511.2	0.1	24.4	95.3	0.1	0.0	66.5	27.2	<0.1	1.3	5.1	<0.1
1990	0.3	1256.6	524.1	0.0	27.6	90.6	0.1	<0.1	66.2	27.6	<0.1	1.5	4.8	<0.1
1991	4.5	1225.1	444.8	0.7	22.7	117.9	0.0	0.2	67.5	24.5	<0.1	1.2	6.5	<0.1
1992	0.6	1221.1	464.7	0.1	29.8	106.5	0.0	<0.1	67.0	25.5	<0.1	1.6	5.8	<0.1
1993	0.0	1145.5	402.1	0.0	26.7	88.8	0.0	<0.1	68.9	24.2	0	1.6	5.3	0.0

Table C 4. U.S. landings (mt) of Georges Bank winter flounder (522-526, 551-552, 561-562) by market category from 1980 to 1997.

	Landings by Market Category (mt)								Landings by Market Category (percent)							
	1200 Unclassified	1201 Lemon Sole	1202 Large	1203 Small	1204 Extra Large	1205 Large/ Mixed	1206 Medium	1207 Peewee	1200 Unclassified	1201 Lemon Sole	1202 Large	1203 Small	1204 Extra Large	1205 Large/ Mixed	1206 Medium	1207 Peewee
1980	101	824	745	2257	0	0	0	0	2.6	21.0	19.0	57.4	0.0	0.0	0.0	0.0
1981	31	902	748	2310	0	0	0	0	0.8	22.6	18.7	57.9	0.0	0.0	0.0	0.0
1982	137	517	549	1666	33	10	47	1	4.6	17.5	18.5	56.3	1.1	0.3	1.6	<0.1
1983	68	1506	361	1758	160	25	14	1	1.7	38.6	9.3	45.1	4.1	0.6	0.4	<0.1
1984	154	370	2029	1231	6	4	28	108	3.9	9.4	51.6	31.3	0.2	0.1	0.7	2.7
1985	76	573	264	1076	110	46	2	3	3.5	26.6	12.3	50.0	5.1	2.1	0.1	0.1
1986	183	176	741	540	2	0	45	76	10.4	10.0	42.0	30.6	0.1	0.0	2.6	4.3
1987	118	241	1027	974	2	0	38	238	4.5	9.1	38.6	36.9	0.1	0.0	1.4	9.0
1988	149	164	995	1269	1	<1	34	194	5.3	5.8	35.5	45.2	<0.1	<0.1	1.2	6.9
1989	127	110	717	751	<1	<1	37	138	6.8	5.8	38.1	39.9	<0.1	<0.1	2.0	7.3
1990	112	71	629	882	<1	0	57	149	5.9	3.7	33.1	46.4	<0.1	0	3.0	7.8
1991	152	54	680	792	<1	0	46	92	8.4	3.0	37.5	43.6	<0.1	0	2.5	5.1
1992	151	64	673	767	<1	<1	26	140	8.3	3.5	36.9	42.1	<0.1	<0.1	1.4	7.7
1993	119	89	634	712	<1	<1	22	86	7.2	5.4	38.1	42.8	<0.1	0.1	1.3	5.2
1994	33	60	380	433	***	***	2	***	3.6	6.6	41.9	47.7	***	***	0.2	***
1995	70	40	245	351	***	***	<1	***	9.9	5.7	34.7	49.7	***	***	<0.1	***
1996	191	67	414	577	***	***	15	***	15.1	5.3	32.8	45.6	***	***	1.2	***
1997	424	45	453	215	0	1	91	58	32.9	3.5	35.2	16.7	0.0	<0.1	7.1	4.5

*** Prorated into other market categories.

Table C 5. USA port sampling of commercial winter flounder landings of length composition and commercial ages from Georges Bank (Statistical Areas 522-525, 551-562), 1980-1997. Total number of samples does not include 14 unclassified (market category 1200) samples from 1980 (1), 1981 (2), 1982 (4), 1985 (1), 1986 (1), 1990 (4), and 1991 (1).

				Number of Samples by Market Category, Area and Quarter															Annual Sampling Intensity No. mt landed/sample		
				Lemon Sole (1201) Extra-Large (1204)					Large (1202) and Large/Mixed (1205) Blackback					Small (1203), Medium (1206), and Pee-Wee (1207) Blackback					1201 1204	1202 1205	1203 1206 1207
	Total Samples	Total Measured	Total Aged	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Q1	Q2	Q3	Q4	Tot	Lemon	Large	Small
1980	8	863	226	0	0	1	0	1	2	2	1	0	5	1	0	1	0	2	445	217	—
1981	1	268	77	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	355	—	—
1982	26	2900	739	0	1	6	2	9	0	1	6	3	10	0	1	5	1	7	26	71	190
1983	36	4493	874	0	3	2	1	6	2	5	6	2	15	2	3	9	1	15	37	42	84
1984	24	2855	593	0	1	3	1	5	3	3	4	3	13	1	2	0	3	6	135	111	48
1985	38	3927	827	1	2	5	1	9	2	4	9	1	16	2	3	7	1	13	50	28	75
1986	29	2822	563	1	1	0	3	5	2	3	3	2	10	1	6	3	4	14	178	67	144
1987	33	3108	618	2	1	1	2	6	4	3	3	1	11	5	3	4	4	16	87	51	131
1988	34	2959	693	2	2	1	2	7	4	3	3	1	11	4	4	4	4	16	86	61	111
1989	16	1470	280	1	1	0	0	2	3	2	0	1	6	1	3	3	1	8	412	124	282
1990	34	3469	737	0	0	0	1	1	3	3	4	3	13	6	7	3	4	20	902	58	116
1991	35	3137	698	1	1	1	1	4	6	6	2	2	16	6	3	3	3	15	129	37	114
1992	35	3034	688	1	2	1	1	5	5	4	3	3	15	6	5	3	1	15	301	36	118
1993	16	1435	338	1	2	0	1	4	3	2	0	0	5	1	5	0	1	7	93	408	195
1994	17	1345	330	0	1	1	1	3	1	2	2	1	6	1	3	3	1	8	20	64	54
1995	14	1137	274	1	1	0	2	4	1	0	0	3	4	2	1	0	3	6	10	17	104
1996	11	1064	236	0	2	1	1	4	0	2	1	1	4	0	1	1	1	3	17	104	192
1997	15	1155	225	0	0	0	1	1	1	0	1	0	2	3	2	1	5	11	45	227	33

Table C 6. Data pooling procedures used to apply length frequency samples to landings by market category to estimat catch (numbers) at age of Georges Bank winter flounder from 1982 to 1997.

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Market Category Comments
1982	Pooled		X	X	1204 (Extra Large) pooled with 1201 Lemon Sole 1205 (Large/Mixed) pooled with 1202 (Large) 1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)
1983	Pooled		x	x	
1984	Pooled		Pooled		
1985	X	X	X	X	
1986	X	X	Pooled		
1987	X	X	X	X	
1988	X	X	X	X	
1989	X	X	Pooled		
1990	X	X	X	X	
1991	X	X	X	X	
1992	X	X	X	X	
1993	X	Pooled			
1994	Pooled		X	X	1201 (Lemon Sole) and 1204 (Extra Large) pooled with 1202 (Large) 1205 (Large/Mixed) pooled with 1202 (Large) 1206 (Medium) and 1207 (Peewee) pooled with 1203 (Small)
1995	X	X	Pooled		
1996	Pooled		X	X	
1997	X	X	Pooled		

Table C 7A. Estimated landings at age (thousands) of Georges Bank winter flounder from 1982 to 1997.

	Age									
	1	2	3	4	5	6	7	8	9	10+
1982	—	352.8	1707.2	1047.9	510.5	258.0	116.6	101.2	30.4	32.8
1983	10.1	787.0	2901.5	1453.8	551.2	206.0	220.8	133.7	46.9	127.0
1984	—	281.7	570.0	1370.9	1408.2	635.0	302.7	230.4	169.3	217.4
1985	19.6	804.6	693.0	811.6	490.7	111.5	50.7	21.6	19.7	8.2
1986	—	664.8	1327.7	235.2	228.6	130.7	48.7	23.4	7.3	8.8
1987	—	1293.7	1681.3	898.9	133.2	88.6	40.3	35.1	25.0	20.6
1988	—	835.3	2773.6	842.6	197.1	89.6	46.1	23.8	6.9	16.5
1989	—	1380.8	1222.0	509.3	147.2	106.7	28.9	22.0	5.7	3.9
1990	—	294.9	2031.5	668.1	184.5	45.5	7.5	6.5	0.2	2.5
1991	—	592.6	1270.0	950.6	135.8	37.8	29.9	18.0	8.6	3.9
1992	—	796.4	756.1	727.4	468.1	92.2	32.2	14.6	10.8	3.6
1993	37.1	300.5	1143.2	450.8	319.6	163.1	20.7	13.4	5.4	7.4
1994	—	532.8	582.2	246.0	67.3	56.7	34.4	9.3	4.3	3.0
1995	263.7	679.1	266.8	188.4	75.6	18.9	13.5	3.5	2.7	0.5
1996	—	736.5	567.3	240.3	156.7	104.0	38.0	28.8	10.1	6.4
1997	—	479.9	1114.9	589.6	131.8	34.8	11.3	7.1	2.0	13.3

Table C 7B. Estimated weight (mt) at age for Georges Bank winter flounder landed from 1982 to 1997.

	Age									
	1	2	3	4	5	6	7	8	9	10+
1982	—	99.6	760.6	817.5	531.4	317.0	160.5	164.2	61.1	68.1
1983	1.8	219.5	1308.2	971.4	495.3	204.0	252.5	168.5	69.1	217.6
1984	—	82.1	266.2	802.6	1048.5	566.2	317.8	272.1	221.4	353.7
1985	3.3	326.1	360.0	634.1	514.9	152.3	78.2	37.6	40.1	16.4
1986	—	264.4	809.7	182.5	235.2	155.6	68.9	37.0	12.7	20.5
1987	—	499.6	924.3	780.5	147.5	108.0	63.9	56.4	46.5	41.9
1988	—	292.4	1415.8	641.2	226.6	118.5	73.5	42.2	14.2	34.4
1989	—	498.1	565.1	421.7	158.8	142.2	44.0	39.6	12.2	9.5
1990	—	134.6	1035.2	505.4	183.1	60.9	14.9	12.4	0.5	6.0
1991	—	248.5	614.8	671.2	133.8	54.3	47.4	33.2	16.4	8.7
1992	—	309.9	373.2	541.3	424.7	109.6	42.8	24.1	16.8	6.2
1993	9.3	115.5	614.4	342.1	301.3	211.1	34.3	25.2	12.4	17.2
1994	—	201.0	318.0	218.0	75.3	75.9	51.6	17.3	8.2	6.4
1995	74.6	267.9	159.3	124.3	75.5	24.3	21.4	6.3	5.3	1.4
1996	—	304.2	348.2	217.1	171.7	150.0	60.1	51.4	20.0	12.9
1997	—	174.1	595.8	414.2	133.3	49.8	17.5	13.3	4.3	27.6

Table C 7C. Estimated mean length (cm) at age for Georges Bank winter flounder from the commercial landings at age.

	Age									
	1	2	3	4	5	6	7	8	9	10+
1982	–	30.68	35.36	42.42	46.54	49.11	50.91	53.68	57.46	58.03
1983	26.67	30.53	35.49	40.29	44.40	45.78	47.88	49.40	52.00	54.51
1984	–	31.05	36.05	38.72	41.75	44.31	46.61	48.42	50.00	53.61
1985	26.07	34.12	36.74	42.27	46.62	50.72	52.72	54.85	57.61	57.50
1986	–	33.99	39.13	42.18	46.12	48.37	51.04	53.37	55.08	60.42
1987	–	33.72	37.77	43.88	47.44	48.70	53.17	53.34	56.02	57.67
1988	–	32.77	36.76	41.95	48.01	50.16	53.28	55.15	57.79	58.16
1989	–	32.95	35.45	43.16	46.86	50.32	52.52	55.52	58.64	61.33
1990	–	35.72	36.93	41.91	45.74	50.39	57.26	56.46	62.00	60.83
1991	–	34.65	36.06	40.85	45.69	51.67	53.27	56.00	56.35	59.56
1992	–	33.90	36.53	41.71	44.37	48.43	49.74	53.89	52.20	54.73
1993	29.66	33.68	37.57	41.80	44.74	49.83	54.10	56.30	60.05	60.23
1994	—	33.53	37.75	44.09	47.56	50.36	52.13	56.16	56.64	58.48
1995	30.80	33.94	38.93	40.05	45.41	49.35	52.23	55.52	56.88	63.00
1996	—	34.65	39.32	44.42	47.08	51.64	53.20	55.39	57.29	57.53
1997	—	33.19	37.42	40.90	45.75	51.51	52.96	56.36	59.00	58.25

Table C 7D. Estimated mean weight (kg) at age for Georges Bank winter flounder from the commercial landings at age.

	Age									
	1	2	3	4	5	6	7	8	9	10+
1982	–	0.283	0.444	0.779	1.041	1.228	1.375	1.623	2.007	2.078
1983	0.181	0.279	0.451	0.668	0.899	0.991	1.144	1.261	1.475	1.713
1984	–	0.292	0.467	0.585	0.744	0.891	1.050	1.180	1.308	1.626
1985	0.168	0.405	0.522	0.782	1.050	1.366	1.541	1.743	2.035	2.011
1986	–	0.398	0.617	0.778	1.029	1.194	1.420	1.601	1.764	2.351
1987	–	0.385	0.549	0.868	1.107	1.217	1.582	1.605	1.861	2.038
1988	–	0.350	0.510	0.760	1.149	1.323	1.594	1.770	2.053	2.090
1989	–	0.359	0.459	0.826	1.076	1.332	1.522	1.804	2.131	2.450
1990	–	0.457	0.510	0.757	0.992	1.339	1.983	1.909	2.531	2.388
1991	–	0.418	0.479	0.702	0.985	1.438	1.582	1.853	1.897	2.250
1992	–	0.390	0.494	0.744	0.906	1.185	1.321	1.656	1.552	1.727
1993	0.250	0.384	0.537	0.758	0.941	1.294	1.657	1.880	2.299	2.324
1994	—	0.377	0.546	0.886	1.118	1.338	1.499	1.867	1.910	2.133
1995	0.283	0.394	0.597	0.660	0.999	1.287	1.582	1.798	1.941	2.662
1996	—	0.413	0.614	0.903	1.096	1.442	1.582	1.788	1.982	2.013
1997	—	0.363	0.534	0.702	1.011	1.429	1.555	1.879	2.167	2.092

Table C 8. Standardized, stratified abundance (numbers) and biomass (weight) indices for Georges Bank winter flounder from the U.S. NEFSC Spring and Autumn (NEFSC strata, and Canadian Spring research vessel bottom trawl surveys. U.S. survey strata 01130-01220; Canadian survey strata (5Z1-5Z8). Canadian biomass indices were estimated using the stratified mean number at length and the U.S. survey length-weight regression coefficients. Door standardization coefficients of 1.46 (numbers) and 1.39 (weight) applied to U.S. survey indices before 1985 to account for differences in catchability between survey doors (NEFSC 1991).

	U.S. Spring Survey		U.S. Autumn Survey		Canada Spring Survey	
	Number • tow^{-1}	Weight (kg) • tow^{-1}	Number • tow^{-1}	Weight (kg) • tow^{-1}	Number • tow^{-1}	Weight (kg) • tow^{-1}
1963			1.200	1.815		
1964			1.298	1.822		
1965			2.152	2.050		
1966			5.163	5.655		
1967	*Spring Survey initiated in 1968*		1.791	2.074		
1968	2.700	3.114	1.308	1.072		
1969	3.136	4.290	2.370	2.385		
1970	1.864	2.294	5.620	6.490		
1971	1.838	2.168	1.324	1.259		
1972	4.946	5.321	1.261	1.580		
1973	2.946	3.507	1.218	1.195		
1974	6.049	5.782	1.193	1.464		
1975	1.955	1.407	3.790	2.061		
1976	4.672	3.012	5.987	3.925		
1977	3.792	1.580	4.862	3.992		
1978	7.068	5.055	4.056	3.100		
1979	1.736	2.206	5.065	3.829		
1980	3.221	2.801	1.661	1.865		
1981	3.727	3.749	3.831	2.434		
1982	2.295	1.523	5.301	2.692		
1983	8.405	7.111	2.726	2.363		
1984	5.529	5.604	3.933	2.445		
1985	3.837	2.650	1.979	1.119		
1986	2.003	1.214	3.575	2.178	*Canadian Survey initiated in 1987*	
1987	2.803	1.247	0.762	0.889	3.73	2.83
1988	2.925	1.648	4.084	1.273	2.70	1.65
1989	1.299	0.757	1.560	1.051	3.48	1.88
1990	2.803	1.573	0.498	0.346	3.29	1.74
1991	2.403	1.319	0.268	0.136	1.43	0.97
1992	1.416	0.898	0.677	0.384	2.25	1.39
1993	1.018	0.570	1.166	0.663	2.78	1.45
1994	1.292	0.578	0.870	0.578	2.45	0.98
1995	2.613	1.489	2.357	1.337	3.10	1.17
1996	2.314	1.504	1.539	1.756	2.20	1.12
1997	1.610	1.192	1.744	1.534	2.80	1.77
1998	0.762	0.722	Unavailable		1.42	1.08

Table C 9A. Stratified mean catch per tow (numbers) of Georges Bank winter flounder (NEFSC strata 01130-01220) in the NEFSC offshore spring research vessel bottom trawl survey. Indices have been corrected to account for changes in catchability due to changes in trawl doors.

Spring	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1980	0.0000	0.1837	0.9630	0.6802	0.4244	0.5839	0.1930	0.0131	0.1448	0.0352	0.0000
1981	0.0000	0.1061	0.1891	1.3794	1.0334	0.2698	0.2045	0.4945	0.0266	0.0238	0.0000
1982	0.0000	0.0736	0.7878	0.3844	0.5957	0.1748	0.1497	0.0410	0.0175	0.0352	0.0352
1983	0.0000	0.0263	1.0262	3.1337	1.5819	0.6704	0.6969	0.5602	0.4195	0.1234	0.1669
1984	0.0000	0.0352	0.1418	1.9117	1.5371	0.4583	0.5456	0.4697	0.2622	0.0263	0.1418
1985	0.0000	0.0000	1.8507	0.6213	0.6285	0.3971	0.2206	0.0465	0.0241	0.0485	0.0000
1986	0.0000	0.2517	0.6618	0.7388	0.1159	0.1599	0.0748	0.0000	0.0000	0.0000	0.0000
1987	0.0000	0.1611	1.6488	0.5849	0.2939	0.0903	0.0000	0.0000	0.0240	0.0000	0.0000
1988	0.0000	0.0725	0.5354	1.4354	0.6799	0.1161	0.0412	0.0182	0.0000	0.0263	0.0000
1989	0.0000	0.0483	0.5312	0.2673	0.2258	0.1558	0.0180	0.0000	0.0526	0.0000	0.0000
1990	0.0000	0.1270	0.6108	1.5623	0.3320	0.0976	0.0733	0.0000	0.0000	0.0000	0.0000
1991	0.0000	0.2702	0.3446	0.8243	0.5802	0.2752	0.0361	0.0241	0.0000	0.0482	0.0000
1992	0.0000	0.0722	0.6000	0.2988	0.1391	0.1460	0.1094	0.0000	0.0240	0.0263	0.0000
1993	0.0000	0.1704	0.2727	0.3322	0.1540	0.0000	0.0463	0.0180	0.0241	0.0000	0.0000
1994	0.0000	0.1258	0.5753	0.4083	0.1021	0.0359	0.0443	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.1487	0.7817	1.2580	0.2935	0.1015	0.0292	0.0000	0.0000	0.0000	0.0000
1996	0.0000	0.0372	1.2191	0.4312	0.4888	0.0689	0.0263	0.0420	0.0000	0.0000	0.0000
1997	0.0000	0.0241	0.1923	0.5354	0.6689	0.1139	0.0241	0.0263	0.0000	0.0241	0.0000
1998	0.0000	0.0000	0.0233	0.1621	0.4265	0.1240	0.0000	0.0263	0.0000	0.0000	0.0000

Table C 9B. Stratified mean catch per tow (numbers) of Georges Bank winter flounder (NEFSC strata 01130-01220) in the NEFSC offshore autumn research vessel bottom trawl survey. Indices have been corrected to account for changes in catchability due to changes in trawl doors.

Autumn	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1980	0.0385	0.1218	0.4034	0.3881	0.2643	0.2251	0.1618	0.0000	0.0245	0.0077	0.0263
1981	0.0000	2.1322	0.5043	0.3922	0.4723	0.1313	0.0583	0.0701	0.0352	0.0175	0.0175
1982	0.2813	1.9636	2.1455	0.4383	0.3368	0.1216	0.0137	0.0000	0.0000	0.0000	0.0000
1983	0.0854	0.0689	0.5828	1.1333	0.4898	0.0572	0.1905	0.0842	0.0321	0.0000	0.0000
1984	0.2365	0.6602	0.9909	0.9156	0.8113	0.2304	0.0588	0.0139	0.0162	0.0000	0.0000
1985	0.1085	0.3235	0.9966	0.4172	0.0789	0.0270	0.0270	0.0000	0.0000	0.0000	0.0000
1986	0.2020	1.0945	1.5675	0.3660	0.2026	0.0479	0.0241	0.0232	0.0000	0.0000	0.0479
1987	0.0000	0.0526	0.2035	0.2181	0.1211	0.0000	0.0789	0.0611	0.0263	0.0000	0.0000
1988	0.0482	2.9253	0.6351	0.3860	0.0395	0.0000	0.0248	0.0248	0.0000	0.0000	0.0000
1989	0.0241	0.0963	1.0601	0.0722	0.1417	0.0725	0.0575	0.0094	0.0260	0.0000	0.0000
1990	0.0000	0.0840	0.0600	0.3026	0.0000	0.0510	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.1078	0.0456	0.0000	0.0620	0.0526	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0233	0.4610	0.1567	0.0094	0.0263	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.5901	0.1316	0.2461	0.1723	0.0263	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.1648	0.4288	0.1582	0.0850	0.0331	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0180	0.9675	0.8979	0.3596	0.0480	0.0478	0.0000	0.0000	0.0180	0.0000	0.0000
1996	0.0000	0.1226	0.3380	0.6241	0.2436	0.0550	0.0934	0.0620	0.0000	0.0000	0.0000
1997	0.0180	0.0782	0.6851	0.5741	0.2957	0.0615	0.0283	0.0031	0.0000	0.0000	0.0000
1998											

Table C9. Stratified mean catch per tow (numbers) of Georges Bank winter flounder (DFO strata 5Z1-5Z8)) in the Canadian Spring research vessel bottom trawl survey. Age keys were used from the corresponding U.S. spring survey for fish less than 40 cm, and from U.S. commercial age keys for fish greater than or equal to 40 cm. Commercial ages were unavailable for 1998 so only U.S. survey ages were used to partition the 1998 stratified mean length indices.

Autumn	Age										
Year	0	1	2	3	4	5	6	7	8	9	10+
1987	0.020	0.050	0.784	1.887	0.551	0.122	0.149	0.092	0.045	0.036	0.024
1988	0.000	0.786	1.256	0.234	0.258	0.083	0.033	0.019	0.011	0.026	0.000
1989	0.000	0.400	0.979	1.355	0.600	0.058	0.053	0.010	0.015	0.000	0.000
1990	0.000	0.150	0.753	1.983	0.250	0.113	0.017	0.005	0.005	0.000	0.000
1991	0.000	0.040	0.225	0.480	0.583	0.105	0..019	0.006	0.000	0.000	0.000
1992	0.000	0.020	0.610	1.018	0.323	0.191	0.038	0.018	0.001	0.002	0.013
1993	0.000	0.932	0.515	0.689	0.218	0.247	0.141	0.053	0.001	0.000	0.000
1994	0.000	0.007	1.600	0.562	0.202	0.055	0.011	0.014	0.010	0.000	0.000
1995	0.000	0.732	1.263	0.845	0.130	0.100	0.021	0.010	0.005	0.001	0.000
1996	0.000	0.301	0.932	0.414	0.323	0.117	0.053	0.029	0.019	0.007	0.003
1997	0.000	0.110	0.590	0.785	0.987	0.180	0.063	0.018	0.026	0.013	0.000
1998	0.002	0.080	0.120	0.492	0.526	0.132	0.011	0.015	0.000	0.000	0.000

Table C 10. Proportion mature at age for female winter flounder sampled by the NEFSC spring research vessel survey from 1982 to 1997. Logistic regression equations and age at 50% maturation are presented annually and for data pooled across the entire time series.

		Age					Logistic Regression Coefficients		
	N	1	2	3	4	5	a	b	A50
1982	23	0.00	0.44	1.00	1.00	1.00	18.30	9.04	2.02
1983	79	0.00	0.14	0.56	1.00	1.00	6.38	2.22	2.87
1984	54	0.00	0.80	1.00	0.93	0.93	17.70	9.54	1.85
1985	40	0.03	0.62	0.99	1.00	1.00	----	----	----
1986	39	0.00	1.00	1.00	1.00	1.00	19.83	13.59	1.46
1987	67	0.00	0.83	1.00	1.00	1.00	18.44	10.00	1.84
1988	42	0.00	0.13	0.95	1.00	1.00	11.88	4.96	2.39
1989	15	0.00	0.20	1.00	1.00	1.00	24.56	11.58	2.12
1990	43	0.00	0.44	1.00	1.00	1.00	23.80	11.79	2.02
1991	34	0.00	0.00	1.00	1.00	1.00	34.25	14.10	2.43
1992	31	0.00	0.54	0.78	1.00	1.00	3.28	1.64	2.00
1993	21	0.00	1.00	1.00	1.00	1.00	—	—	---
1994	30	0.00	0.79	0.86	1.00	1.00	3.49	2.16	1.62
1995	21	0.00	0.33	1.00	1.00	1.00	24.48	11.90	2.06
1996	43	0.00	0.76	1.00	1.00	1.00	18.23	9.70	1.88
1997	9	0.00	0.67		1.00	1.00	13.98	7.34	1.91
1998	10	0.00		1.00	1.00	1.00	—		---
1982-1998	**561**	**0.00**	**0.62**	**0.92**	**0.99**	**1.00**	**3.99**	**2.18**	**1.83**

Table C 11. VPA run descriptions including a summary of diagnostics and results.

Run 15 was accepted by the SAW/SARC.

VPA Run #	Run 4	Run 9	Run 8	Run 11	* *Run 15**
Inputs					
Estimated Ages	1 to 6	2 to 6	2 to 6	2 to 6	2 to 6
Tuning Indices					
US Spring 1-7	Ages 1-7	Ages 1-7	Ages 1-7	Ages 1-7	Ages 1-7
US Spring 1-5+	No	No	No	Yes	No
US Autumn 1	Ages 1-7	Ages 1-7	Ages 2-7	Ages 2-7	Ages 2-7
US Autumn 2-5+	No	No	No	Yes	No
Canada Spring	---	---	---	---	Ages 1-7
Diagnostics					
Sum of squares	142.42	142.42	135.47	114.36	189.26
Mean squared residuals	0.754	0.754	0.753	0.841	0.736
CV Age 1 Numbers	0.92	---	---	---	---
CV Age 2 Numbers	0.52	0.52	0.52	0.48	0.40
CV Age 3 Numbers	0.46	0.46	0.47	0.44	0.36
CV Age 4 Numbers	0.46	0.46	0.46	0.56	0.37
CV Age 5 Numbers	0.40	0.40	0.40	0.68	0.34
CV Age 6 Numbers	0.41	0.41	0.41	0.59	0.34
Min/Max CV q (US Spring)	0.22 - 0.28	0.22 - 0.28	0.22 - 0.28	0.23 - 0.24	0.21 - 0.28
Min/Max CV q (US Autumn)	0.22 - 0.29	0.22 - 0.29	0.22 - 0.27	0.23 - 0.24	0.21 - 0.26
Min/Max CV q (Canada Spring)	---	---	---	---	0.25 - 0.27
Standardized Residuals > 2	8	8	8	6	9
Maximum Partial Variance	2.026 US Autumn 7	2.010 US Autumn 7	2.016 US Autumn 7	2.081 US Autumn 2	2.421 Can Spring 1

Table C 11 (Cont). VPA run descriptions including a summary of diagnostics and results.

Run 15 was accepted by the SAW/SARC.

VPA Run #	Run 4	Run 9	Run 8	Run 11	**Run 15**
Terminal Year Results					
Stock Numbers	5991	5124	5346	5970	5688
1998 Age 1 Numbers	867	-----	-----	-----	---
1998 Age 2 Numbers	551	551	556	1302	774
1998 Age 3 Numbers	992	992	1190	2048	1568
1998 Age 4 Numbers	2026	2026	2044	1769	2097
1998 Age 5 Numbers	1008	1008	1006	311	797
1998 Age 6 Numbers	397	397	400	467	330
1998 Age 7 Numbers	151	151	151	73	122
Fishing Mortality					
1997 Age 2 F	0.36	0.36	0.31	0.19	0.24
1997 Age 3 F	0.40	0.40	0.40	0.45	0.39
1997 Age 4 F	0.42	0.42	0.43	1.00	0.51
1997 Age 5 F	0.26	0.26	0.26	0.23	0.31
1997 Age 6 F	0.34	0.34	0.34	0.61	0.41
1997 Average F (4-6,u)	0.34	0.34	0.34	0.61	0.41
Biomass					
1997 Mean Biomass	3913	3913	4008	3762	3943
1997 Jan 1 Biomass	4551	4551	4629	4261	4519
1997 SSB	3702	3702	3749	3129	3536

Table C 12. Stock numbers (thousands), fishing mortality, and spawning stock biomass (mt) at age of Georges Bank winter flounder estimated using an ADAPT calibration (Run 15).

STOCK NUMBERS

	1982	1983	1984	1985	1986	1987	1988	1989
1	4627	2725	6089	5963	8027	5307	9002	5243
2	8236	3788	2222	4986	4864	6572	4345	7370
3	6532	6424	2389	1564	3354	3381	4210	2802
4	3382	3803	2634	1441	654	1545	1247	937
5	1263	1821	1799	916	445	322	451	258
6	762	572	992	198	306	158	143	191
7	822	1453	1406	175	204	211	146	106
1+	25624	20586	17532	15243	17854	17496	19545	16908

	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	3327	4523	2441	2906	4813	6944	2987	946	00
2	4293	2724	3703	1998	2346	3940	5447	2445	774
3	4785	3248	1694	2311	1364	1439	2611	3793	1568
4	1188	2079	1510	703	858	590	936	1625	2097
5	307	368	842	578	167	480	313	549	797
6	78	84	179	266	184	76	324	114	330
7	28	133	117	75	164	81	258	110	122
1+	14005	13158	10485	8837	9896	13550	12876	9582	5688

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988	1989
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.05	0.26	0.15	0.20	0.16	0.25	0.24	0.23
3	0.34	0.69	0.31	0.67	0.58	0.80	1.30	0.66
4	0.42	0.55	0.86	0.97	0.51	1.03	1.37	0.92
5	0.59	0.41	2.00	0.90	0.84	0.61	0.66	0.99
6	0.47	0.51	1.23	0.97	0.64	0.97	1.17	0.96
7	0.47	0.51	1.23	0.97	0.64	0.97	1.17	0.96
4-6,u	0.49	0.49	1.36	0.95	0.66	0.87	1.07	0.96

	1990	1991	1992	1993	1994	1995	1996	1997
1	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00
2	0.08	0.28	0.27	0.18	0.29	0.21	0.16	0.24
3	0.63	0.57	0.68	0.79	0.64	0.23	0.27	0.39
4	0.97	0.70	0.76	1.23	0.38	0.44	0.33	0.51
5	1.09	0.52	0.95	0.94	0.59	0.19	0.81	0.31
6	1.03	0.69	0.84	1.13	0.42	0.32	0.44	0.41
7	1.03	0.69	0.84	1.13	0.42	0.32	0.44	0.41
4-6,u	1.03	0.64	0.85	1.10	0.46	0.32	0.53	0.41

Table C 12 (Continued). Stock numbers (thousands), fishing mortality, and spawning stock biomass (mt) at age of Georges Bank winter flounder estimated using an ADAPT calibration (Run 15).

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

	1982	1983	1984	1985	1986	1987	1988	1989
1	00	00	00	00	00	00	00	00
2	1083	505	295	814	726	1036	654	1127
3	1963	1765	717	471	1313	1192	1273	873
4	2172	1788	1096	688	360	879	589	487
5	1150	1350	816	577	324	254	380	184
6	754	504	667	158	289	140	132	188
7	1162	1689	1339	238	272	289	196	147
1+	8285	7601	4930	2947	3285	3790	3224	3006

	1990	1991	1992	1993	1994	1995	1996	1997
1	00	00	00	00	00	00	00	00
2	760	444	583	318	405	632	1074	373
3	1598	1205	595	797	486	576	1075	1457
4	556	1041	748	323	527	312	618	926
5	214	275	535	385	132	417	218	473
6	74	84	157	221	183	82	343	126
7	45	194	139	109	238	123	393	181
1+	3247	3243	2756	2152	1970	2143	3721	3536

Table C 13. Yield per recruit and SSB per recruit analysis for Georges Bank winter 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: 11-12-1998;  Time: 15:58:51.70
GB WINTER FLOUNDER - 15 Year, No Plus Group

Proportion of F before spawning:  .2000
Proportion of M before spawning:  .2000
Natural Mortality is Constant at:  .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:
==> gbwinfl.dat
```

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0000	1.0000	.0000	.221	.168
2	.5400	1.0000	.6200	.387	.300
3	.8600	1.0000	.9200	.573	.474
4	1.0000	1.0000	1.0000	.788	.670
5	1.0000	1.0000	1.0000	1.055	.917
6	1.0000	1.0000	1.0000	1.372	1.195
7	1.0000	1.0000	1.0000	1.521	1.428
8	1.0000	1.0000	1.0000	1.757	1.673
9	1.0000	1.0000	1.0000	1.894	1.827
10	1.0000	1.0000	1.0000	1.978	1.938
11	1.0000	1.0000	1.0000	2.080	2.024
12	1.0000	1.0000	1.0000	2.143	2.129
13	1.0000	1.0000	1.0000	2.204	2.165
14	1.0000	1.0000	1.0000	2.249	2.195
15	1.0000	1.0000	1.0000	2.265	2.251

```
Summary of Yield per Recruit Analysis for:
GB WINTER FLOUNDER - 15 Year, No Plus Group

 Slope of the Yield/Recruit Curve at F=0.00: -->    4.1119
   F level at slope=1/10 of the above slope (F0.1): ----->     .209
     Yield/Recruit corresponding to F0.1: ----->     .3361
   F level to produce Maximum Yield/Recruit (Fmax): ----->     .420
     Yield/Recruit corresponding to Fmax: ----->     .3652
   F level at 20 % of Max Spawning Potential (F20): ----->     .472
     SSB/Recruit corresponding to F20: -------->     .8073
```

Table C 13 (Cont). Yield per recruit and SSB per recruit analysis for Georges Bank winter flounder.

Listing of Yield per Recruit Results for:
GB WINTER FLOUNDER - 15 Year; No Plus Group

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.00	.00000	.00000	5.2420	4.4887	3.7252	4.0372	100.00
	.05	.14193	.15784	4.6694	3.5613	3.1478	3.1165	77.20
	.10	.24124	.24894	4.2444	2.9077	2.7205	2.4716	61.22
	.15	.31356	.30172	3.9207	2.4361	2.3959	2.0089	49.76
	.20	.36821	.33218	3.6682	2.0881	2.1430	1.6692	41.35
F0.1	.21	.37670	.33609	3.6284	2.0351	2.1032	1.6176	40.07
	.25	.41087	.34944	3.4668	1.8256	1.9416	1.4142	35.03
	.30	.44510	.35881	3.3030	1.6233	1.7779	1.2186	30.18
	.35	.47323	.36339	3.1673	1.4646	1.6424	1.0657	26.40
	.40	.49681	.36505	3.0531	1.3377	1.5285	.9439	23.38
Fmax	.42	.50538	.36517	3.0115	1.2931	1.4871	.9012	22.32
	.45	.51689	.36493	2.9557	1.2346	1.4314	.8453	20.94
F20%	.47	.52493	.36451	2.9168	1.1948	1.3926	.8073	20.00
	.50	.53424	.36374	2.8717	1.1497	1.3476	.7644	18.93
	.55	.54941	.36192	2.7983	1.0787	1.2746	.6970	17.26
	.60	.56280	.35973	2.7338	1.0188	1.2102	.6402	15.86
	.65	.57472	.35736	2.6764	.9675	1.1531	.5918	14.66
	.70	.58541	.35493	2.6251	.9233	1.1021	.5501	13.63
	.75	.59508	.35250	2.5790	.8848	1.0561	.5140	12.73
	.80	.60386	.35012	2.5372	.8510	1.0145	.4823	11.95
	.85	.61188	.34782	2.4992	.8212	.9766	.4545	11.26
	.90	.61924	.34561	2.4644	.7947	.9420	.4297	10.64
	.95	.62602	.34350	2.4325	.7709	.9102	.4076	10.10
	1.00	.63230	.34149	2.4030	.7495	.8808	.3877	9.60

Table C14. Results of an ASPIC surplus production model of Georges Bank winter flounder.

Georges Bank Winter Flounder -- ASPIC 3.6x -- Two Indices

01 Dec 1997 at 22:27

ASPIC -- A Surplus-Production Model Including Covariates (Ver. 3.64) FIT Mode

CONTROL PARAMETERS USED (FROM INPUT FILE)

Number of years analyzed:	34	Number of bootstrap trials:	0
Number of data series:	2	Lower bound on MSY:	1.000E+00
Objective function computed:	in EFFORT	Upper bound on MSY:	5.000E+02
Relative conv. criterion (simplex):	1.000E-08	Lower bound on r:	1.000E-01
Relative conv. criterion (restart):	3.000E-08	Upper bound on r:	1.000E+01
Relative conv. criterion (effort):	1.000E-04	Random number seed:	1964285
Maximum F allowed in fitting:	5.000	Monte Carlo search trials:	50000

PROGRAM STATUS INFORMATION (NON-BOOTSTRAPPED ANALYSIS) code 0

Normal convergence.

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2	3
1 USA Fall Survey	1.000		
	34		
2 USA Spring Survey (lagged)	0.252	1.000	
	31	31	
3 Canadian Survey (lagged)	0.636	0.157	1.00
	12	12	12

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title	Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1) SSE in yield	0.000E+00					
Loss(0) Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1) USA Fall Survey	1.098E+01	34	3.433E-01	1.000E+00	5.345E-01	0.323
Loss(2) USA Spring Survey (lagged)	7.131E+00	21	2.459E-01	1.000E+00	7.462E+00	0.273
Loss(3) Canadian Survey (lagged)	6.169E-01	12	6.169E-02	1.000E+00	2.974E+00	0.509

TOTAL OBJECTIVE FUNCTION:	1.87327825E+01
Number of restarts required for convergence:	28
Est. B-ratio coverage index (0 worst, 2 best):	0.8027
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1964	5.514E-01	1.000E+00	1	1
MSY .	Maximum sustainable yield	3.068E+00	2.500E+00	1	1
r	Intrinsic rate of increase	5.380E-01	4.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	USA Fall Survey	2.394E-01	2.410E-01	1	1
q(2)	USA Spring Survey (lagged)	3.125E-01	3.550E-01	1	1
q(3)	Canadian Survey (lagged)	3.881E-01	3.000E-01	1	1

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	3.068E+00	Kr/4	
K	Maximum stock biomass	2.281E+01		
Bmsy	Stock biomass at MSY	1.140E+01	K/2	
Fmsy	Fishing mortality at MSY	2.690E-01	r/2	
F(0.1)	Management benchmark	2.421E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	3.037E+00	0.99*MSY	
B-ratio	Ratio of B(1997) to Bmsy	3.756E-01		
F-ratio	Ratio of F(1996) to Fmsy	1.298E+00		
Y-ratio	Proportion of MSY avail in 1997	6.102E-01	2*Br-Br^2	Ye(1997) = 1.872E+00
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	USA Fall Survey	1.124E-01	r/2q(1)	f(0.1) = 1.011E-01

Table C 15. Results of short-term stochastic projections of landings (mt) in the 1999 and spawning stock biomass (mt) in 2000 for Georges Bank winter flounder. Landings in 1998 were assumed to be 1,107 mt based on projections by the NEFMC Multispecies Monitoring Committee and assumed Canadian landings, resulting in a realized F of 0.34 in 1998. Projected landings and spawning stock biomass estimates are provided for the 10th, 50th, and 90th percentiles for various levels of fishing mortality in 1999 including current and proposed biological reference points.

	Landings (mt) in 1999			Total Stock Biomass (mt) in 2000			Spawning Stock Biomass (mt) in 2000		
Fishing Mortality	10%	50%	90%	10%	50%	90%	10%	50%	90%
0.00	0	0	0	5,863	7,552	9,423	4,098	5,374	6,793
0.03 (F_{target})	124	163	207	5,695	7,342	9,170	3,986	5,228	6,613
0.04 ($F_{threshold}$)	164	215	273	5,641	7,274	9,088	3,948	5,181	6,552
0.21 ($F_{0.1}$)	707	932	1,185	4,804	6,244	7,848	3,377	4,446	5,639
0.34 (F_{1998})	888	1,172	1,487	4,275	5,596	7,068	3,004	3,967	5,046
0.47 ($F_{20\%}$)	1,164	1,537	1,951	3,823	5,042	6,406	2,676	3,550	4,529

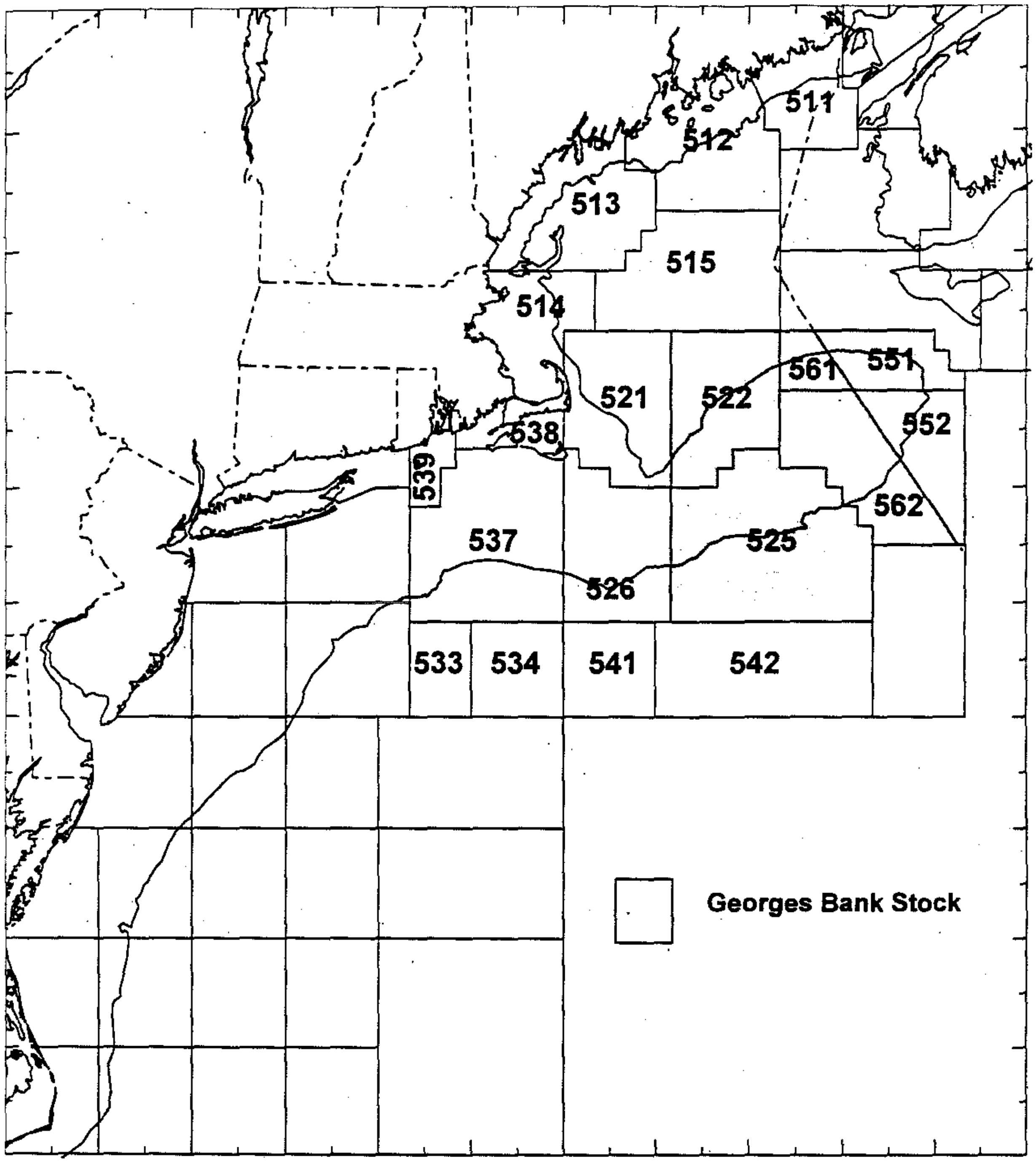

Figure C1. NEFSC statistical areas included in the Georges Bank winter flounder assessment.

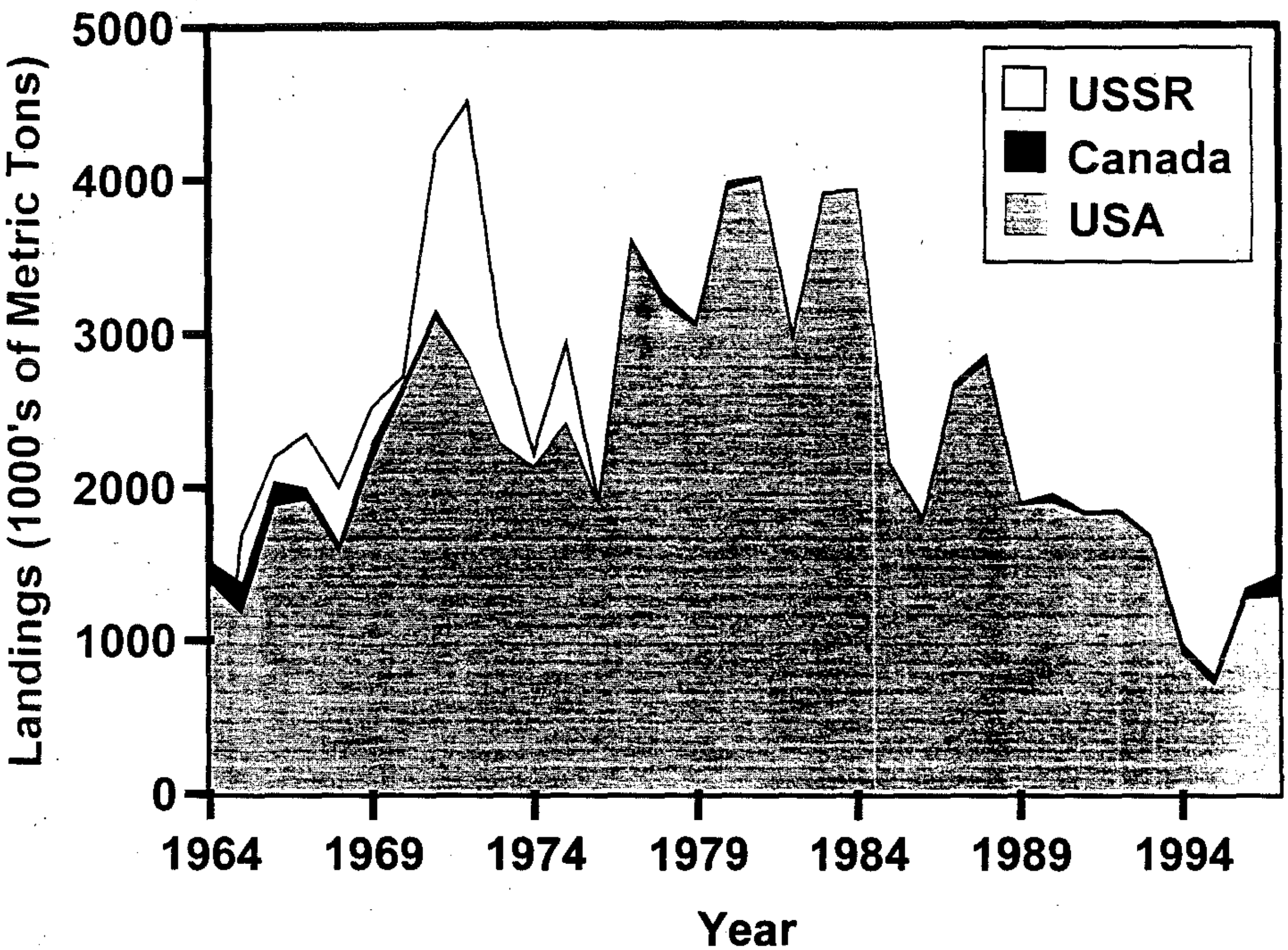

Figure C2. Total commercial landings (mt) of winter flounder from the Georges Bank stock (NEFSC areas 522-525, 551-562; NAFO areas 5Zh,j,m,n).

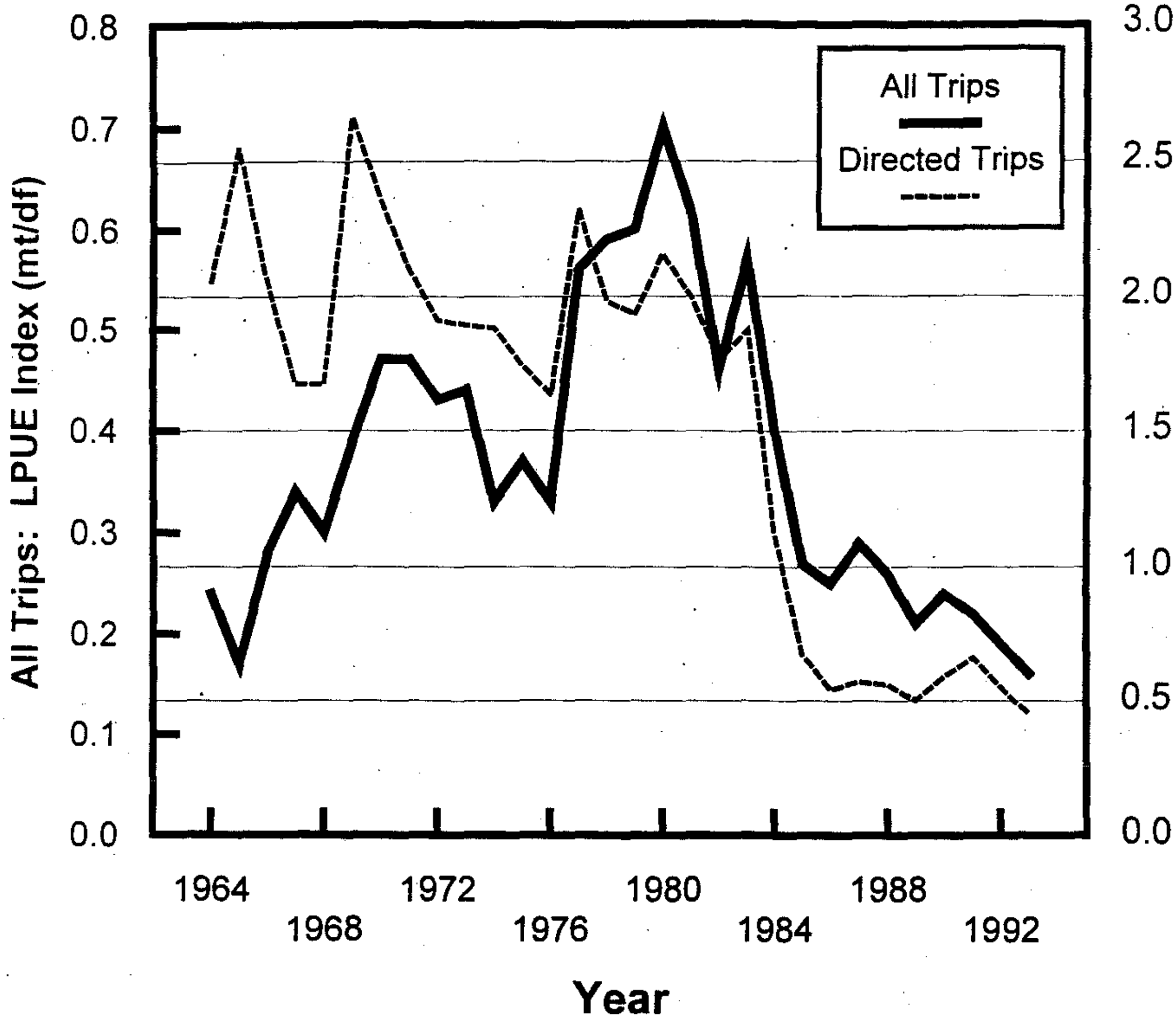

Figure C3. Unstandardized landings (mt) per unit effort (days fished) for all otter trawl trips landing winter flounder and for directed trips (trips where landings of winter flounder constitute 50% or more of the trip).

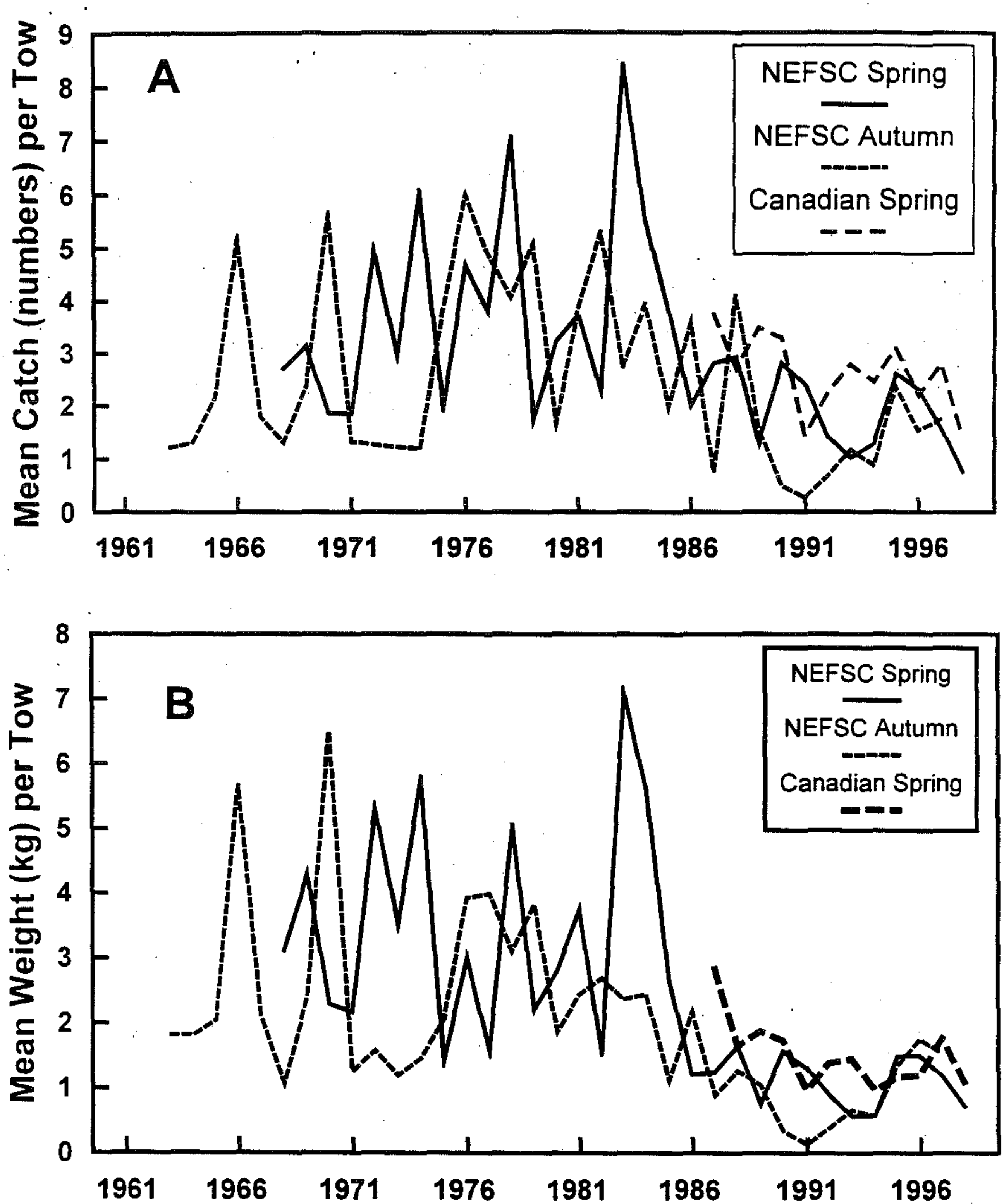

Figure C4. U.S. and Canadian research vessel bottom trawl survey abundance (number per tow; Panel A) and biomass (kg per tow; Panel B) for Georges Bank winter flounder, 1963-1998. Canadian weight per tow was estimated using the stratified mean number per tow at length and the U.S. survey length-weight regression equation.

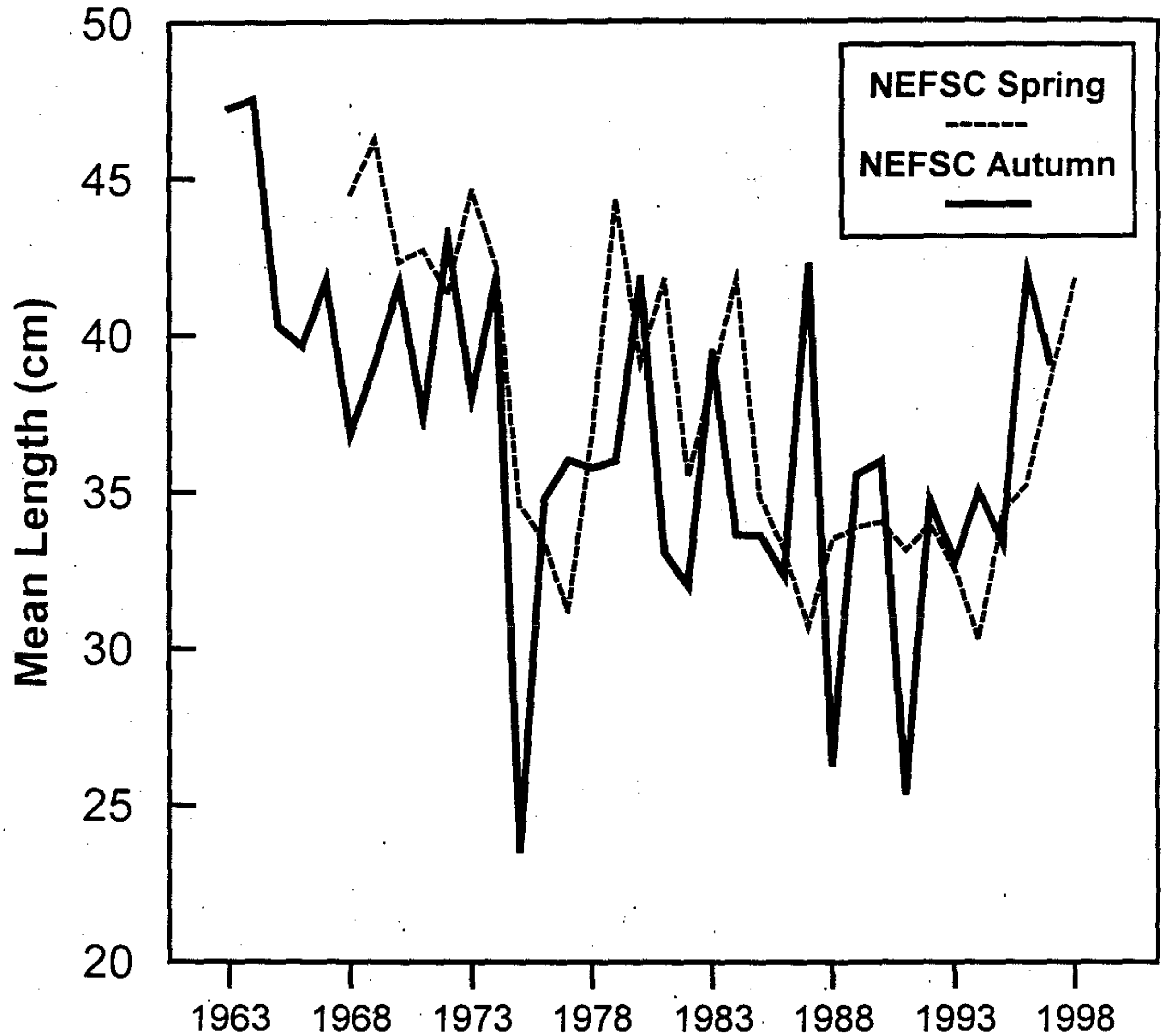

Figure C5. Stratified mean length of Georges Bank (NEFSC offshore strata 13-22) winter flounder from the NEFSC spring and auatumn research vessel surveys.

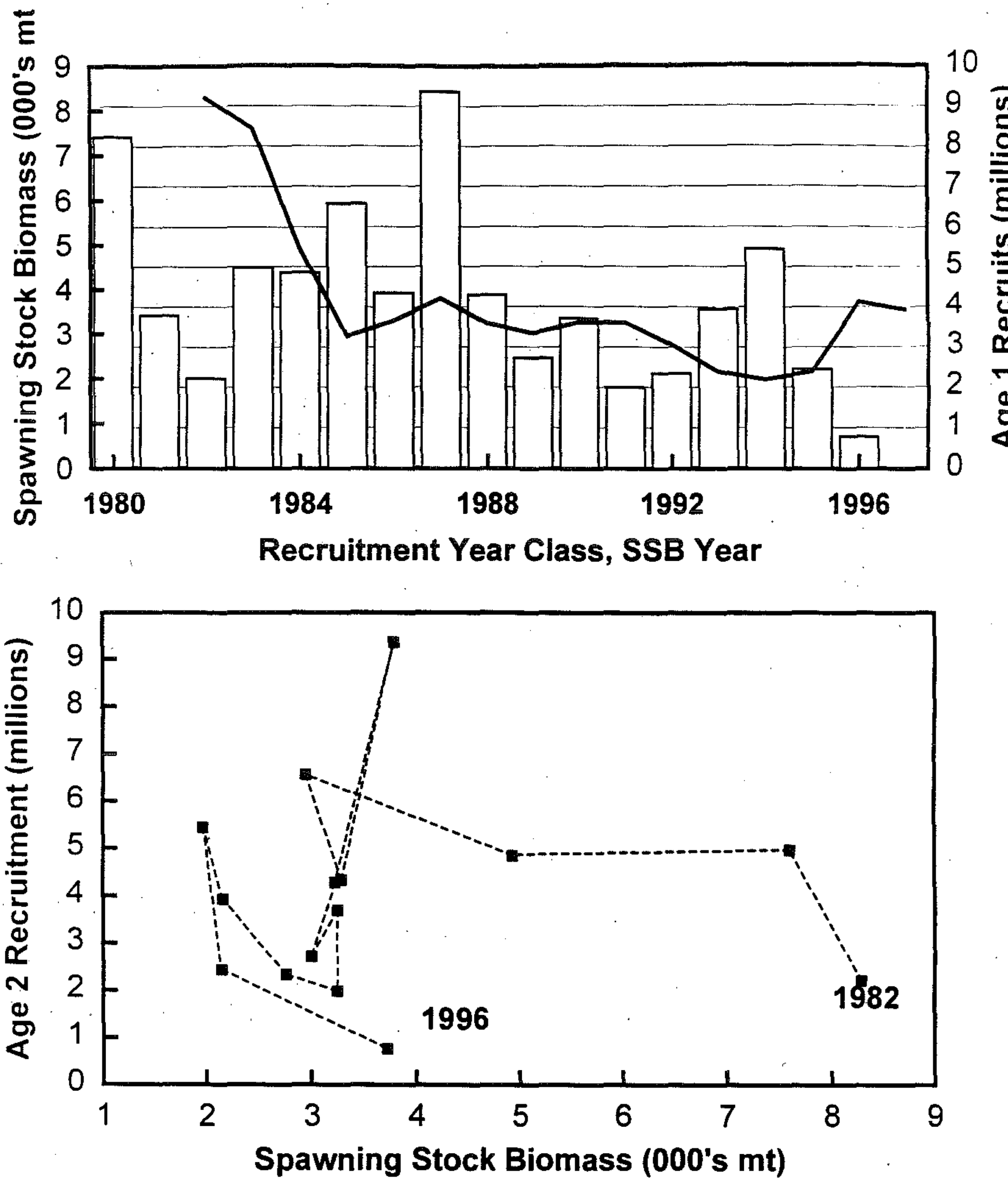

Figure C6. Trends in spawning stock biomass (line) and age 2 recruitment (bars) estimated from Virtual Population Analysis (Run 15) for Georges Bank winter flounder from 1980 to 1997.

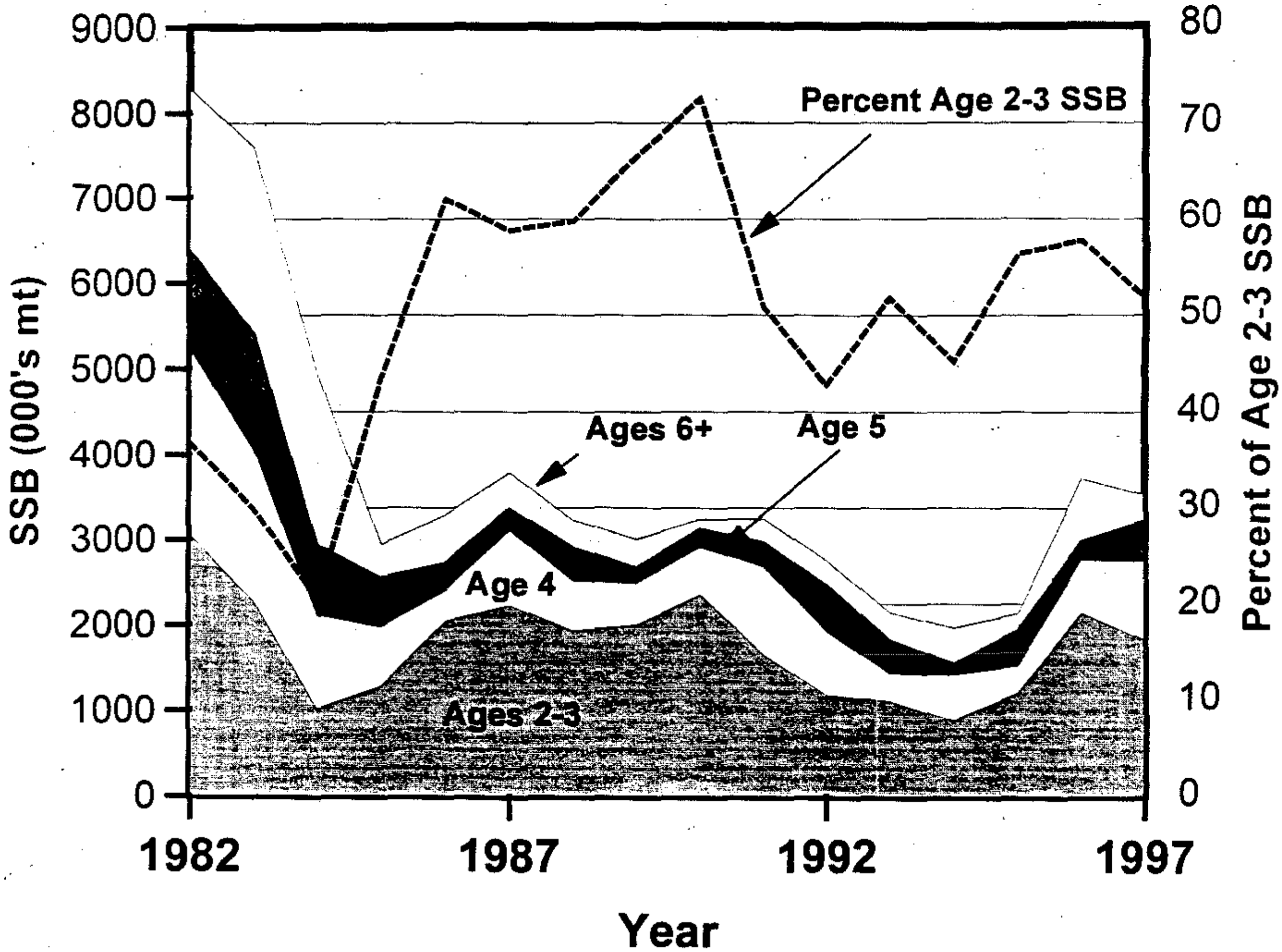

Figure C7. Age composition of the spawning stock biomass estimated from Virtual Population Analysis (Run 15) for Georges Bank winter flounder from 1982 to 1997.

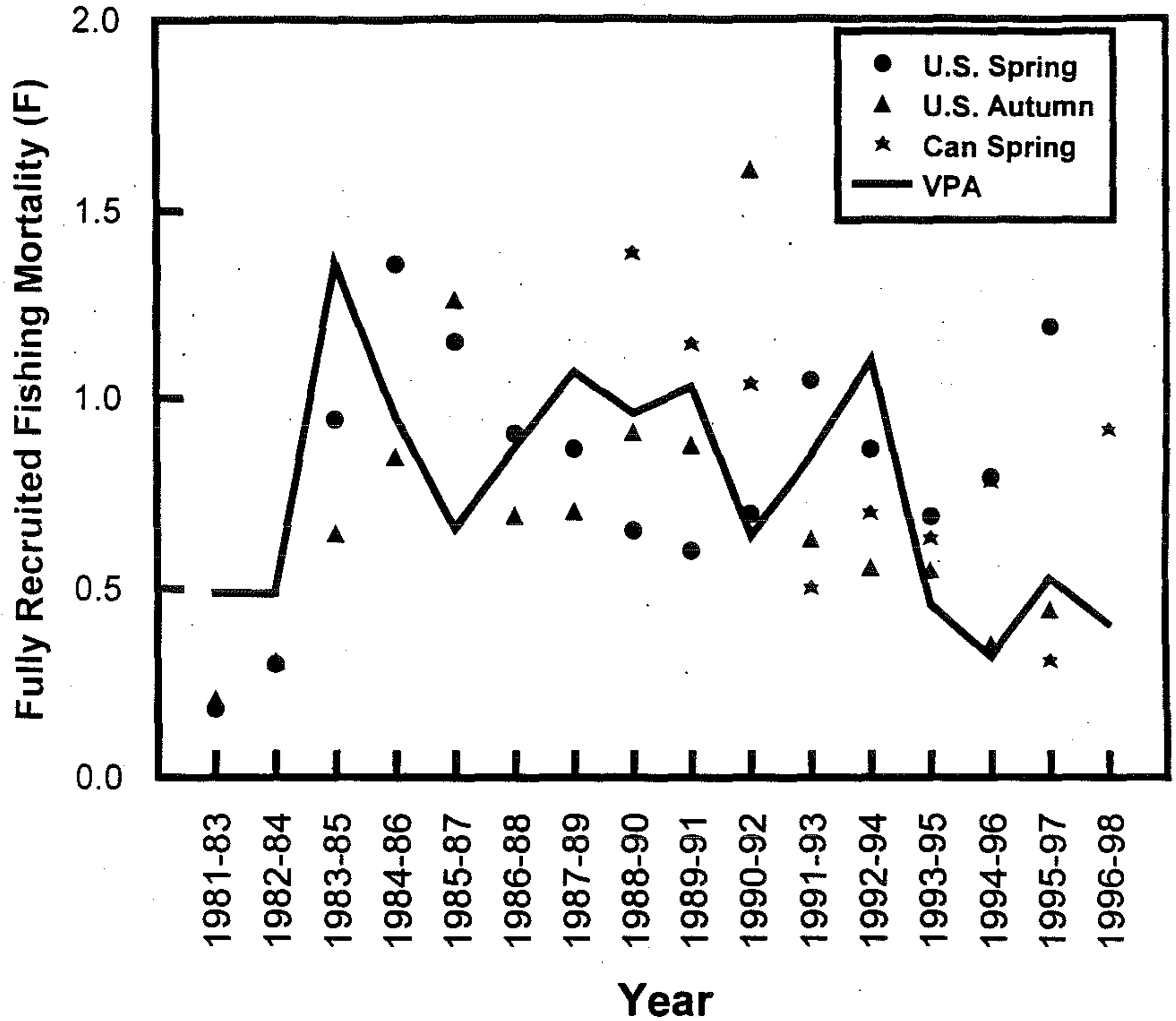

Figure C8. Comparison of estimated instantaneous fishing mortality rate estimated from NEFSC research vessel catch numbers at age with VPA estimates of average unweighted F for ages 4-6. The x-axis labels give the 3-year average used to generate the survey based estimates of F. The midpoint of this range (i.e., 1982 for the range 1981-83) corresponds to the VPA estimates of F.

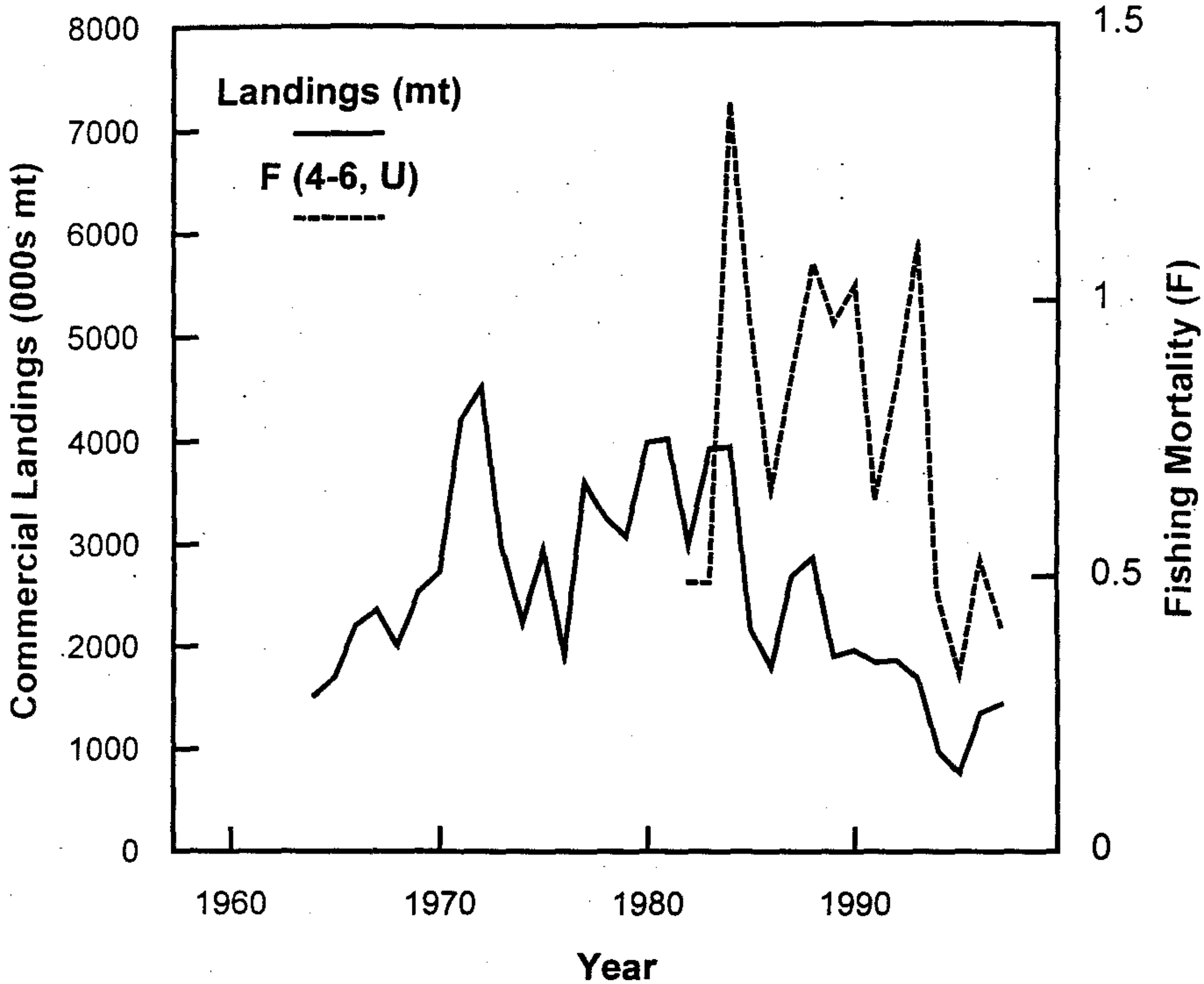

Figure C9. Trends in commercial landings (mt) and fully-recruited fishing mortality (F, 4-6, unweighted) estimated from Virtual Population Analysis (Run 15) for Georges Bank winter flounder from 1964 to 1997.

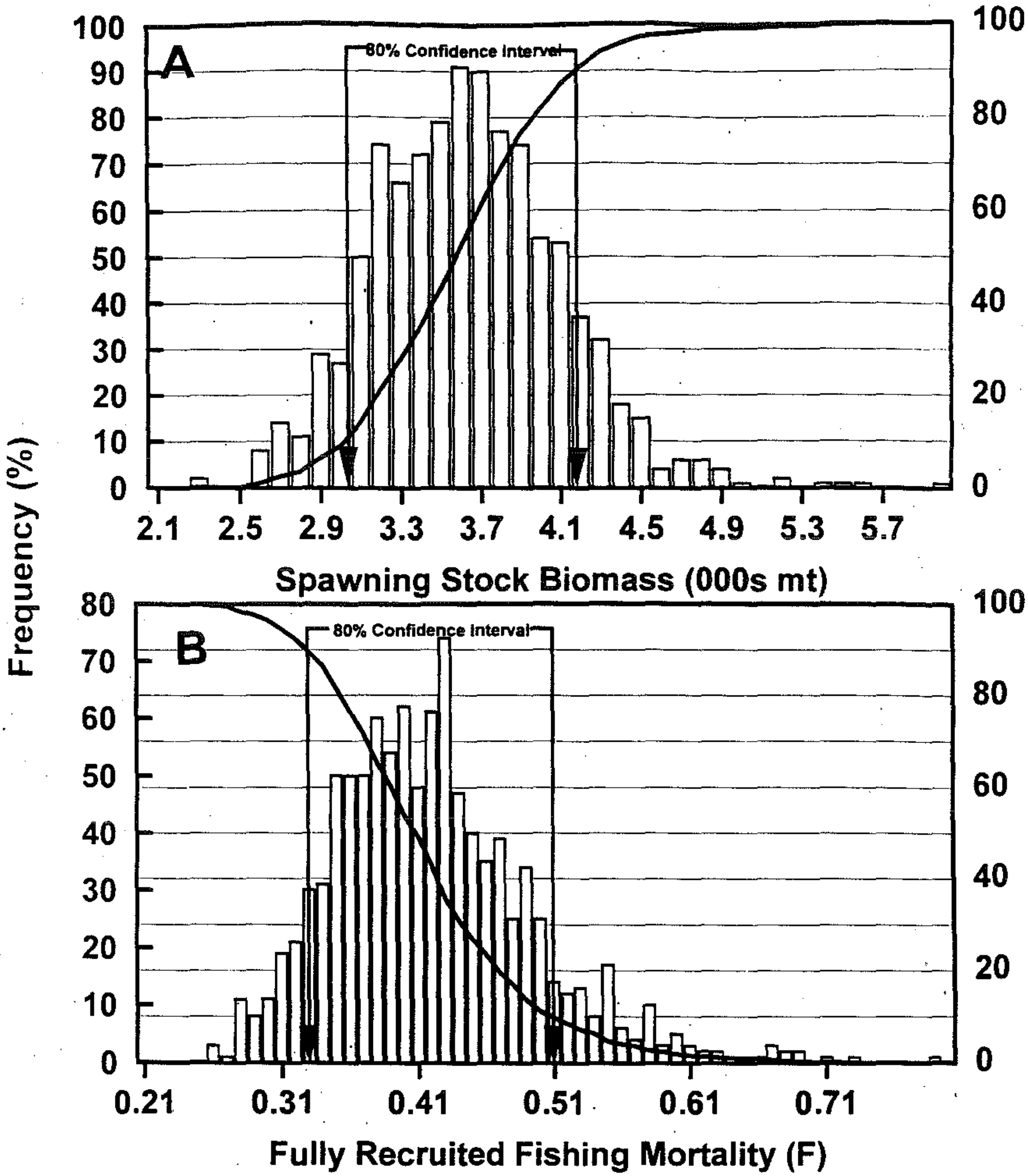

Figure C10. Precision of the estimates of spawning stock biomass (Panel A) at the beginning of the spawning season (April 1) and instantaneous rate of fishing mortality (Panel B) on the fully recruited ages (ages 4-6) in 1997 for Georges Bank winter flounder. The vertical bars display both the range of the estimator and the probability of individual values within the range. The solid line gives the probability of individual values within the range. The solid line gives the probability that F is greater than or SSB is less than the corresponding value on the X-axis. The solid arrows indicate the approximate 90% and 10% confidence levels for F and SSB. The precision estimates were derived from 1000 bootstrap replications of the final ADAPT VPA formulation (Run 15).

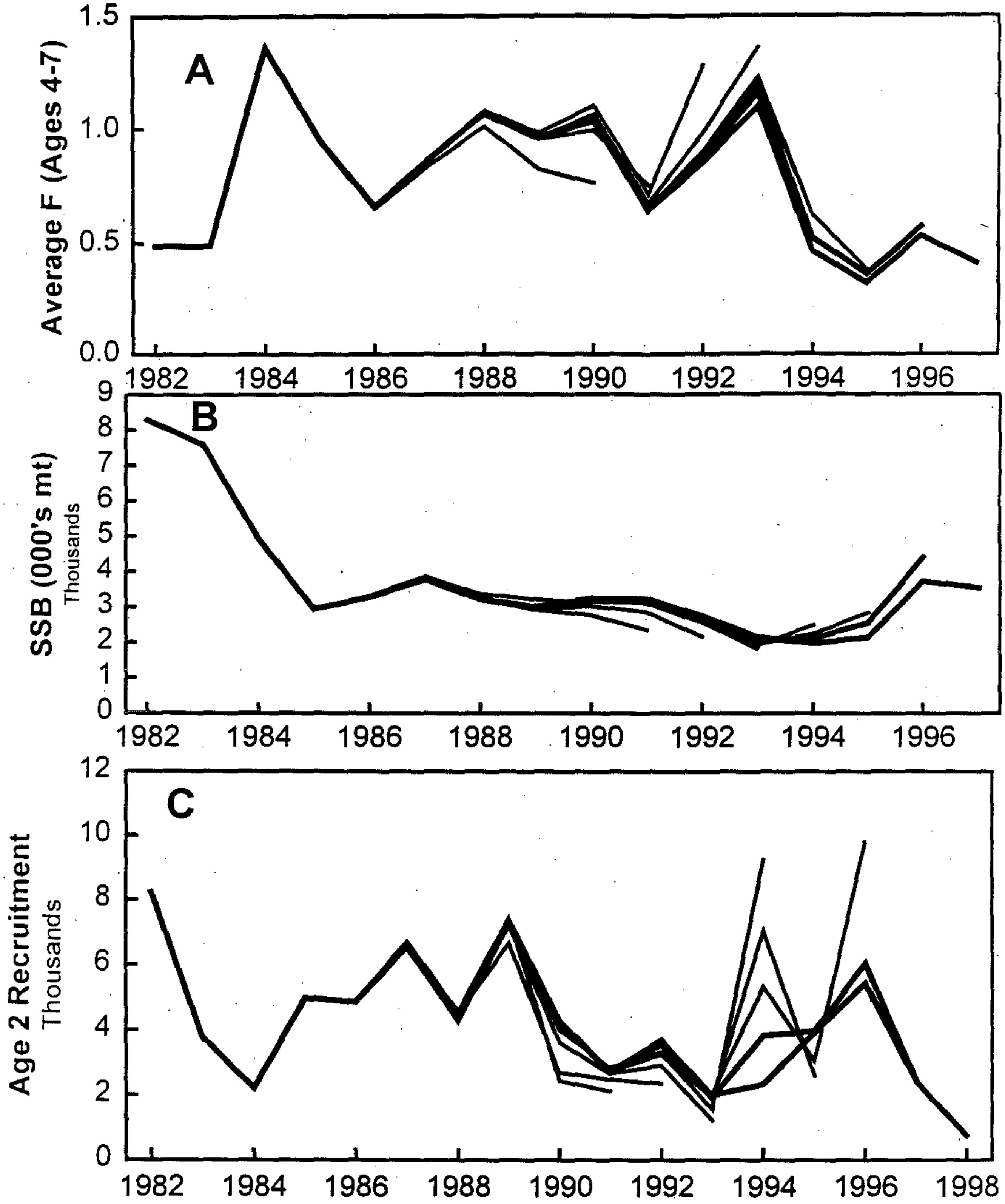

Figure C11. Retrospective analysis results of fishing mortality (Panel A) , spawning stock biomass (Panel B), and age 2 recruitment (Panel C) for the Georges Bank winter flounder assessment, 1997-1990.

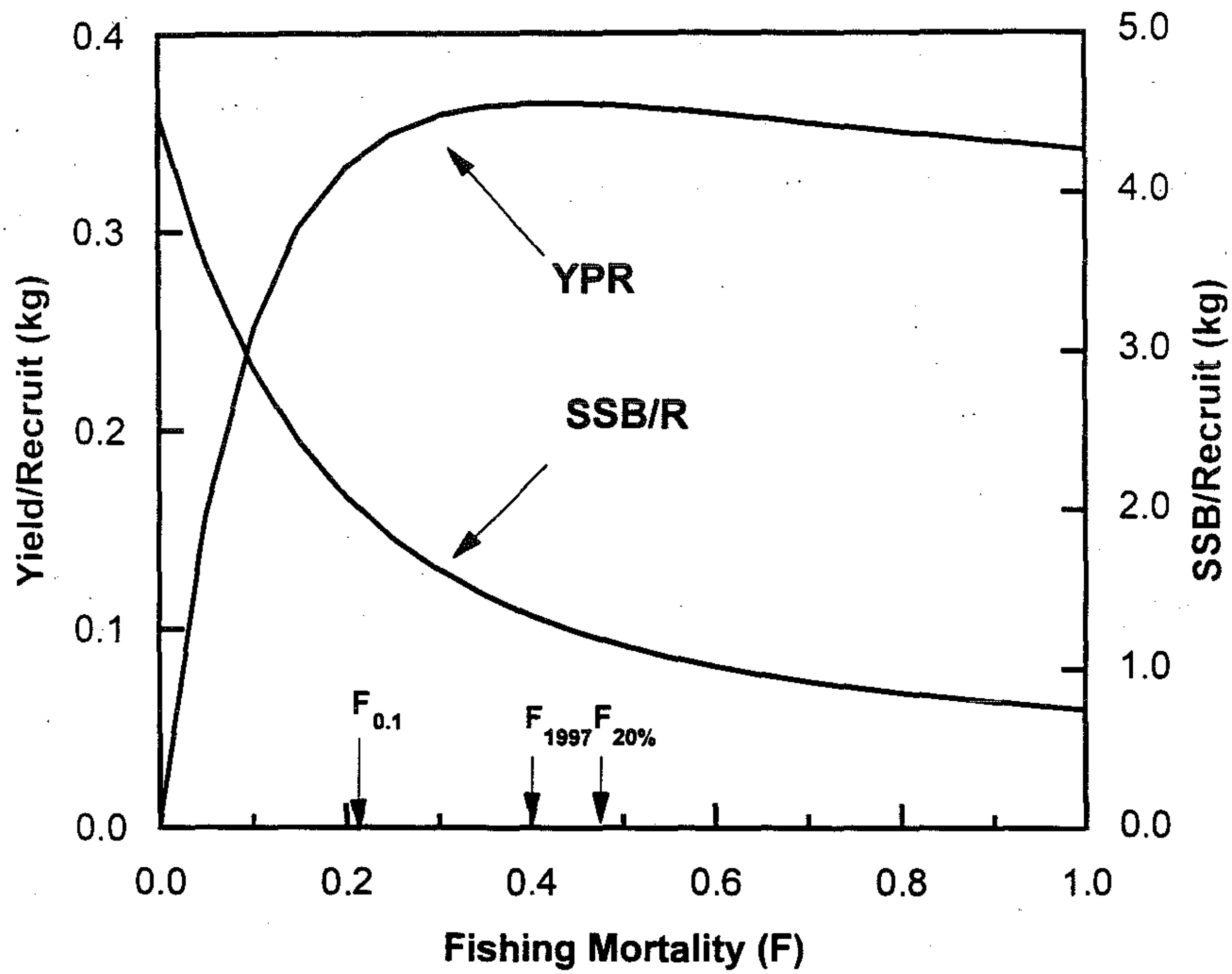

Figure C12. Yield (YPR) and spawning stock biomass (SSB/R) per recruit for Georges Bank winter flounder.

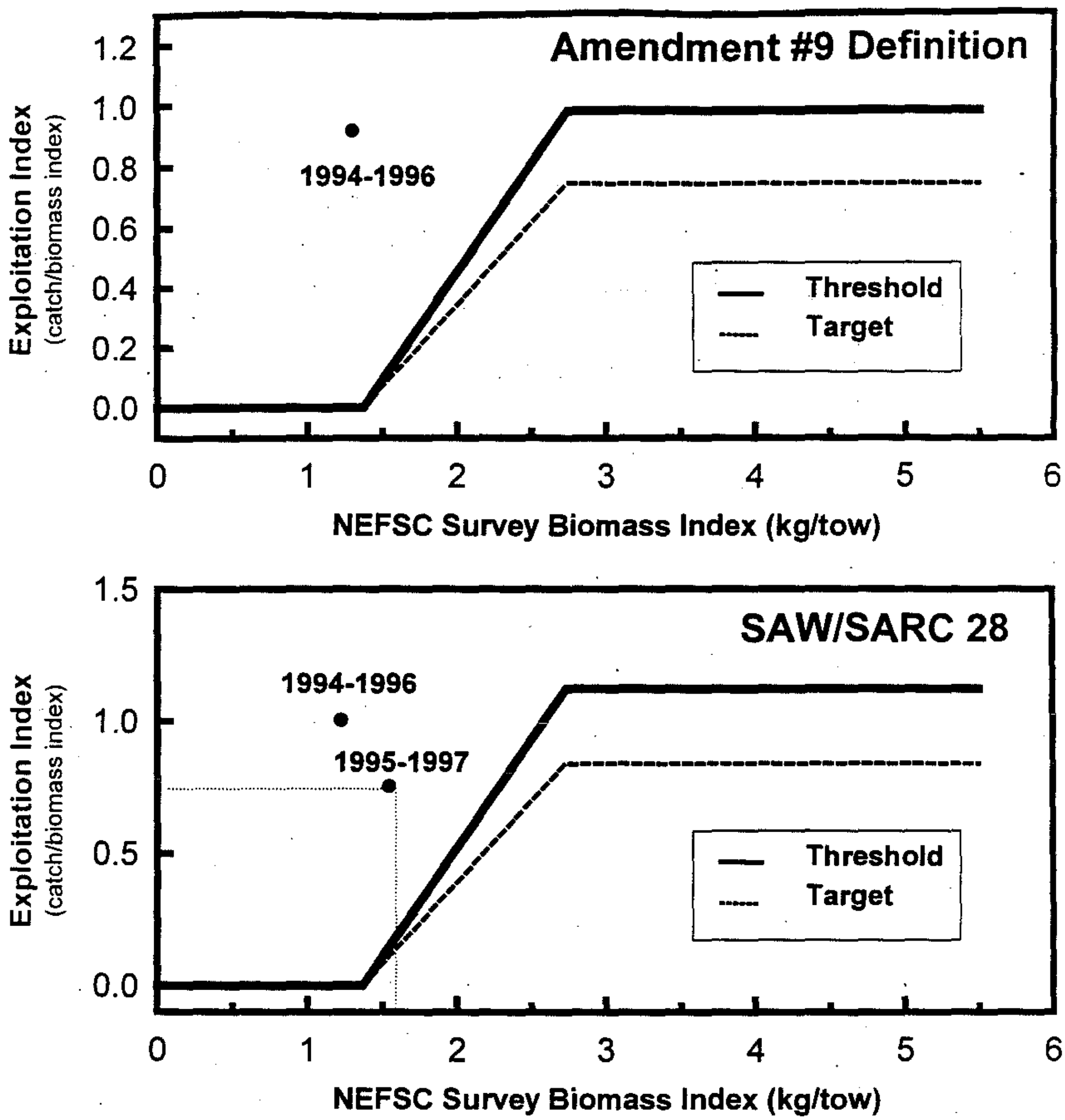

Figure C13. Proposed control rule for Georges Bank winter flounder based on survey equivalents of MSY-based reference points from the Overfishing Definition Review Panel Final Report (Applegate et al. 1998).

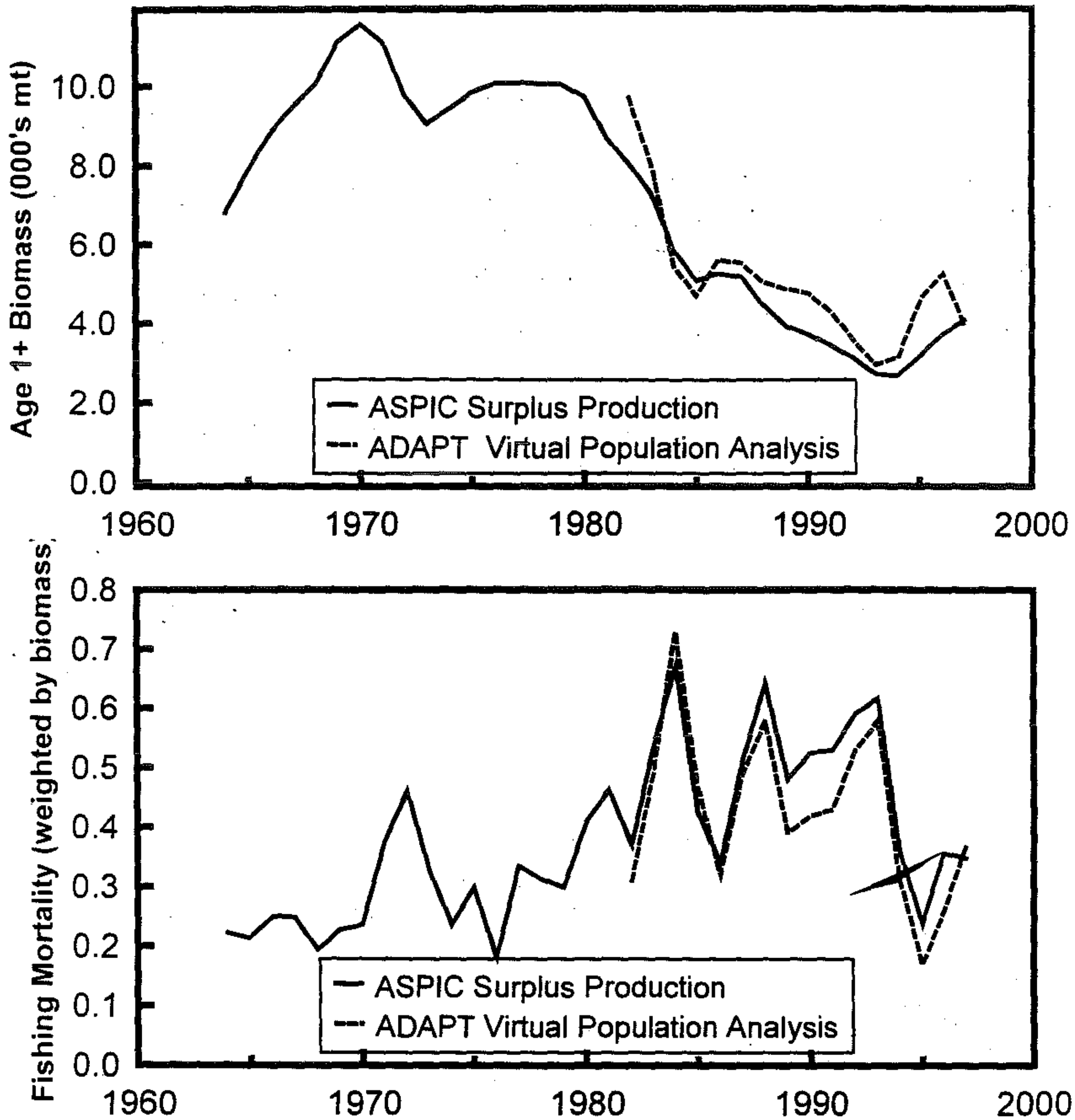

Figure C14. Comparison of estimated age 1+ biomass and fishing mortality (weighted by biomass) from an ASPIC surplus production model and an ADAPT virtual population analysis for Georges Bank winter flounder.

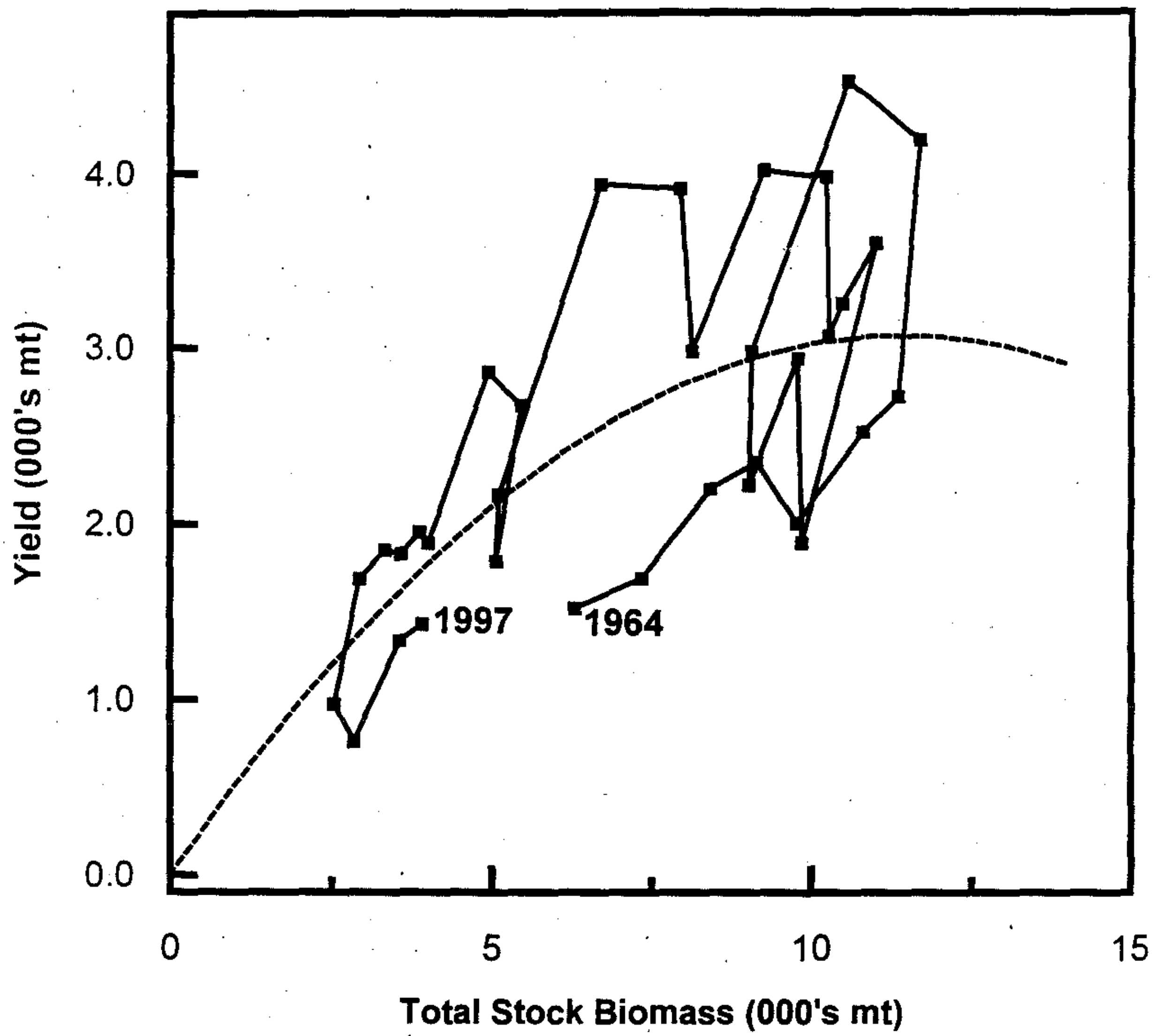

Figure C15. Time trajectory of fishery yield from the Georges Bank winter flounder stock relative to the surplus production curve estimated by ASPIC.

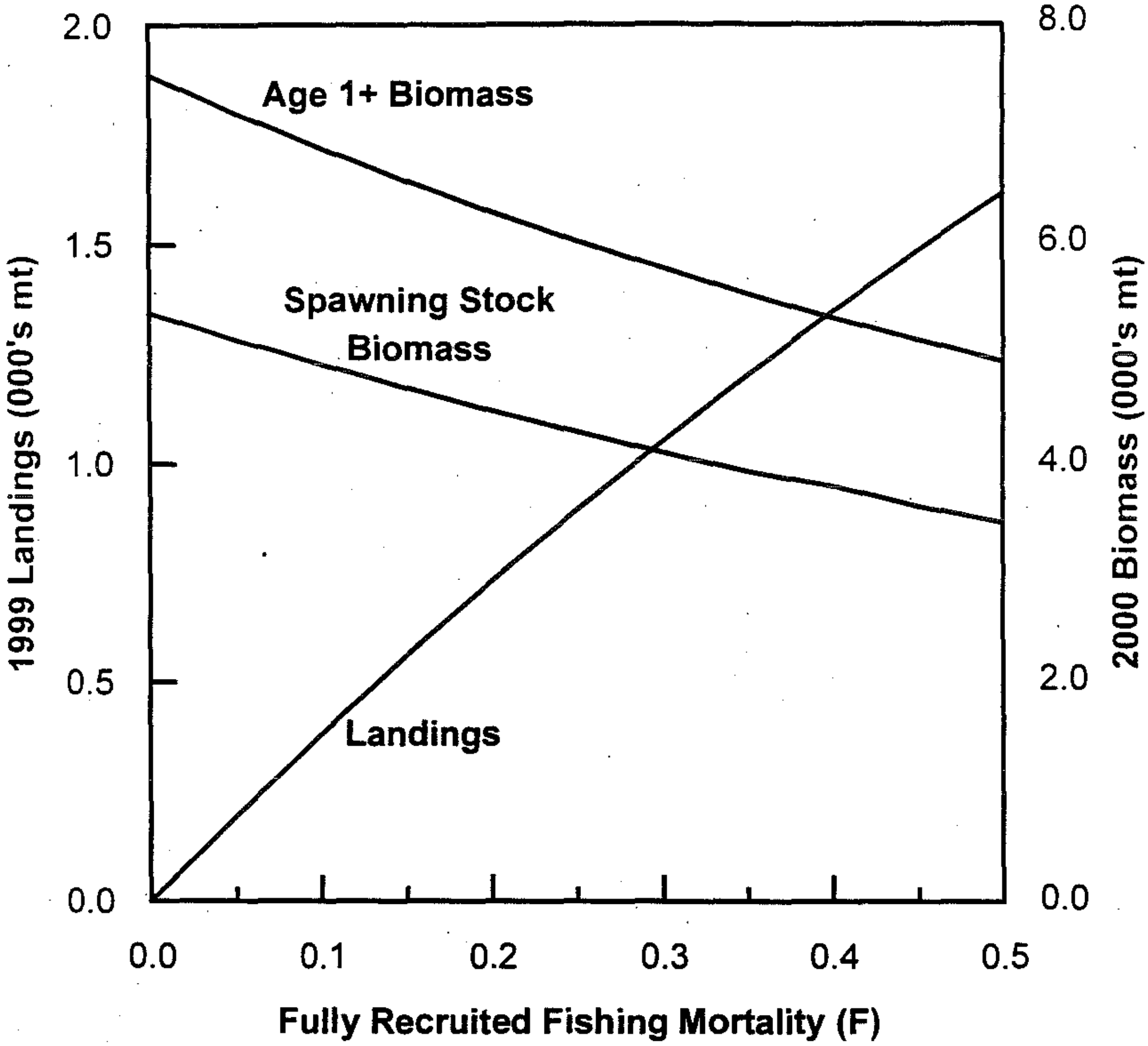

Figure C16. Results of short-term stochastic projections for the Georges Bank winter flounder stock. Projected landings of 1107 mt assumed in 1998. Winter flounder landings in 1999 and age 1+ biomass and spawning stock biomass in 2000 are shown as a function of fishing mortality in 2000.

D. GULF OF MAINE/GEORGES BANK AMERICAN PLAICE

Terms of Reference

a. Update the status of the Gulf of Maine - Georges Bank American plaice stock through 1997 and characterize the variability of estimates of stock size and fishing mortality.

b. On the basis of anticipated catches and abundance indicators in 1998,estimate stock size at the beginning of 1999 and provide projected estimates of catch and spawning stock biomass for 1999-2000 at various levels of F.

c. Comment on and revise, if necessary, the overfishing definition reference points for American plaice recommended by the Overfishing Definition Review Panel.

INTRODUCTION

American plaice, *Hippoglossoides platessoides*, is distributed along the continental shelf from southern Labrador to Montauk Point, New York. In U.S waters, plaice are most abundant in the deeper (> 50 m) waters of the Gulf of Maine and off the northern edge of Georges Bank (Appendix D1, Figure 1).

Spawning occurs in the spring from February to June, with peak spawning occurring in April and May. Median maturity for females occurs at 3.6 years and 26.8 cm, and for males at 3.0 years and 22.1 cm (O'Brien *et. al* 1992). The maximum age attained is between 24-30 years and the maximum size is 70-80 cm (Bigelow and Schroeder 1953). The growth rate for females is faster than that of males, after age four (Sullivan 1981).

The fishery for American plaice developed in the mid-seventies as other popular flounder stocks became less abundant or were being regulated under fishery management (Sullivan 1981). Historically, American plaice had either been discarded or used as bait (Lange and Lux 1979).

This report presents an updated and revised analytical assessment of the Gulf of Maine-Georges Bank American plaice stock for the period 1980-1997 based on analysis of commercial discards, landings and effort data, and research vessel survey data through 1997. The first analytical assessment was completed in 1992 (O'Brien *et al.* 1992).

THE FISHERY

Commercial Landings

Since 1960, US landings of American plaice have ranged from 1,309 mt (1960) to 15,126 mt (1982) (Table D1, Figure D1). Landings gradually increased as the fishery developed from an average of 2,280 mt during 1972-1976 to an average of 12,694 mt during 1979-1984. Subsequently, landings declined to 2,300 mt in 1989, then increased to 6,400 mt in 1992 and then gradually declined to 4,000 mt in 1997.

Otter trawl gear has accounted for the largest percentage of American plaice landings each year since 1980. In 1997, about 94% of the landings were caught by otter trawl and about 3% by gill net gear. The fishery occurs primarily during the second and third quarter of the year. Historically, the majority of the landings were in the large (large+jumbo) market category for all four quarters, however, in 1988, the majority of the landings shifted to the small category (small+peewee) in quarters 3 and 4. Since 1991 landings have been primarily in the small category in all four quarters (Table D2).

Commercial Fishery Sampling Intensity

The number of length and age samples taken are summarized for each year by quarter and market category in Table D3. The average number of metric tons landed per length frequency sample

(Table D3), by market category ranged from 34 mt 116 mt during 1985-1991. During 1992-1995, the sampling intensity decreased, ranging between 97 mt to 336 mt per sample. Sampling intensity has increased since 1996, ranging between 53 mt and 189 mt.

Commercial Landings Age Composition

Age-length keys

American plaice landings have been sampled for both length composition and age at length since about 1975. Commercial age samples had not been routinely aged, however, until recent years. Commercial age samples for 1985-1997, however, are now available and have been applied in this assessment. In this assessment the combined Gulf of Maine-Georges Bank age composition for 1980-1984 landings were taken from O'Brien *et al.* (1992).

A study by Esteves and Burnett (1993) concluded that there are significant growth differences between American plaice in the Gulf of Maine and Georges Bank based on analyses of 1988 samples from commercial landings and from NEFSC spring and autumn bottom trawl surveys.

In the current assessment, Fisher's exact test (Zar 1984, SAS 1990) was used to test the hypothesis of no difference in the proportion at age within a length class between Gulf of Maine and Georges Bank age length keys derived from commercial samples, by quarter for the combined 1985-1990 data. The hypothesis of no difference in the proportion at age within a length class between quarters 1&2 and between quarters 3&4 was also tested for each area.

Results indicate there are significant differences in the proportions at age within 2 cm length groups between Gulf of Maine samples and Georges Bank samples. For quarters 1-4 there were, respectively, 9 out of 21, 11 out of 21, 16 out of 24, and 4 out of 20 significant differences in the proportion at age within a length between the two areas. The number of significant differences is more than expected by chance, and are consecutive within the range of 28-58 cm. These results indicate that there is a difference in the age at length between the Gulf of Maine and Georges Bank American plaice.

Results of the Fisher's test for comparison of proportion at age within a length between quarters for each area indicated greater differences between quarters for the Gulf of Maine than for Georges Bank. For the Gulf of Maine, there were 5 out of 21, and 6 out of 22 significant differences between quarters 1&2, and 3&4, respectively. For Georges Bank, there were 4 out of 20 significant differences between quarter 1&2, and none for quarters 3&4. These results indicate some differences between quarters, but only within a narrow range of lengths, 36-46 cm.

Based on these results, the age composition of the 1985-1993 commercial landings were derived separately for the Gulf of Maine and Georges Bank area, only pooling areas when sampling was not adequate. The 1994-1997 data were pooled over the entire area because sampling by area was inadequate and due to the uncertainty in the spatial assignment of samples. Samples were generally applied on a quarterly basis, but when samples were not adequate, pooling to semi-annual or annual level was necessary.

Age composition

The pooled age composition of the 1980-1984 landings (Table D4) from the Gulf of Maine-Georges Bank region was estimated, by market category, from seasonal age-length keys derived from the NEFSC groundfish surveys and quarterly length compositions derived from the sampled commercial landings (O'Brien *et al.* 1992). The age composition of the 1985-1993 landings from the Gulf of Maine and from Georges Bank was estimated separately, by market category, from commercial length frequency and age samples, pooled by calendar quarter. The pooled age composition of the 1994-1997 landings from the Gulf of Maine-Georges Bank region was estimated, by market category, from commercial length frequency and age samples, pooled by calendar quarter. In quarters where the sampling was not adequate samples were pooled semi-annually or annually (Table D3). Due to the lack of adequate sampling in every market category for each area, the five market categories were collapsed to three: small + peewee, medium, and large + jumbo. Landed mean weights were estimated by applying the American plaice length weight equation (Lux 1969):

$$Weight(kg) = (2.4548 \times 10^{-6}) \times Length(cm)^{3.345},$$

to quarterly length frequencies, by market category. Total numbers landed by quarter were estimated by dividing the mean weights into quarterly landings, by market category and prorating according to the sample length frequency. Age-length keys were then applied to the quarterly numbers at length, by market category, to obtain the quarterly landings at age. For the 1980-1984 data, the spring NEFSC groundfish age samples were applied to the numbers at length distribution from quarters one and two, and the autumn NEFSC groundfish age samples were applied to the numbers at length distribution for quarters three and four (O'Brien *et al.* 1992). Numbers at age were summed over market category within each quarter and annual estimates of landings at age were obtained by summing over quarters. Numbers at age for the Gulf of Maine and for Georges Bank were combined to obtain the estimated annual numbers at age and were expanded to the total landings (Table D1) by the ratio of (total landings / Gulf of Maine-Georges Bank landings). The ratios varied between 1% and 12%.

Commercial Fishery Discards

Data for estimating discarded catch are available in the Sea Sampling Database (SSDBS; 1989-1997) and the Vessel Trip Log (VTR; 1994-1997) database. Only the sea sampling database was utilized in this assessment.

The quantity of American plaice discarded was estimated separately for the Northern shrimp fishery and the large mesh otter trawl fishery. No discard estimates were derived for the small mesh otter trawl fishery.

Northern Shrimp Fishery

Total numbers of American plaice discards at length in the Gulf of Maine northern shrimp fishery were derived based on the methodology described by Mayo *et. al* (1992). An indirect estimation of discards for 1980-1988 was derived from NEFSC bottom trawl data and a direct estimation of discards for 1989-1997 was calculated from NEFSC sea-sampling data. For both time periods discards were estimated for 2 fishing areas and two seasons. Fishing Areas 1 and 2 were defined, respectively, as north and south of 43 degrees 15 minutes latitude as described by Clark and Power (1991). The winter fishing season was defined by combining December of the previous year with January and February, and the spring season was defined by combining March, April, and May.

Discard estimates prior to implementation of the Sea Sampling Program in 1989 were derived using NEFSC length frequency data, a selectivity ogive for the shrimp otter trawl, and a sorting ogive. American plaice abundance indices by 2 cm length intervals (stratified mean number per tow) were computed from NEFSC spring and autumn bottom trawl survey data corresponding to the area of the shrimp fishery (NEFSC offshore survey strata 26, 27, 38, and 40). The original numbers per tow at length were then filtered through a 46 mm mesh selection ogive derived from analyses of the 99 mm mesh selection data for American plaice presented by Smolowitz (1983), and a sorting ogive based on the minimum plaice landing sizes observed in the landed component of the otter trawl catches (Mayo *et al.* 1992). The total number of plaice discarded at length by season was computed by raising the filtered survey indices by the catchability coefficients (q) determined from the sea sample data, and the total amount of shrimp fishing effort (number of trips) as described by Mayo *et al.* (1992). Age composition of the estimated discarded numbers at length was derived by applying seasonal age length keys from the NEFSC bottom trawl surveys.

Direct estimates of discard rates (lbs/trip) for 1989-1997 were obtained by summarizing total pounds discarded and number of trips by season. A geometric mean discard per trip was computed by exponentiating the mean of log discard per trip (Table D5). Discard rates (lbs/trip) for each year-season-area stratum were then raised to total discarded weight by the number of trips in each stratum. Discards were combined by area to obtain total discards (lbs) by season. The length-weight equation for American plaice (Lux 1969) was applied to the sea sample length frequency by season to obtain a sample mean weight. Total discard numbers by season were estimated by dividing the total discard weight by the sample mean weight. Total discards at length were derived by prorating the total numbers to the sampled length frequency. The age composition of the discard length frequency was derived by applying age samples obtained from sea sampling supplemented with seasonal age-length keys from the NEFSC surveys. The seasonal age compositions were summarized to obtain an annual age composition of discarded American plaice in the shrimp fishery (Table D6).

Large Mesh Otter Trawl

The total numbers of American plaice discards at length in the large mesh otter trawl fishery in the Gulf of Maine-Georges Bank region were derived based on the methodology described by Mayo *et. al* (1992). The model utilizes abundance of American plaice at length as indicated by NEFSC bottom trawl survey indices filtered through mesh size and sorting ogives to approximate the relative composition of the retained and discarded components of the catch. Mesh size increased over the time period from 130 mm to 140 mm to 155 mm diamond or square mesh as indicated by management regulations (Table D7). Mesh selection ogives applied in the present analysis were derived from studies by Walsh *et al.* (1992).

The retained portion of the survey length composition was compared to the estimated number landed at length, and coefficients relating landings and retained survey abundance of plaice were determined for each semi-annual period from 1980-1997. The coefficients were then applied to the discarded portion of the survey length composition for the same semi-annual periods to expand the indices at length to estimated numbers discarded.

The numbers discarded at length were adjusted by the proportion of total plaice landings caught by large mesh otter trawl gear (Table D7). The age composition of the discard length frequency was then derived by applying age length keys obtained from sea sampling supplemented with seasonal age-length keys from the NEFSC surveys. The semi-annual age compositions were summarized to obtain an annual age composition of discarded American plaice in the large mesh fishery (Table D8).

Total Commercial Fishery Age Composition and Mean Weight at Age

The catch in numbers and weight (mt) and the mean weight at age for the total commercial catch including landings and discards from the shrimp and large mesh otter trawl fishery are presented in Table D9 for the Gulf of Maine-Georges Bank region for 1980-1997. The most recent dominant year classes evident in the catch at age are the 1987 and 1992 year classes. The values for mean weight vary among years, however, there does not appear to be any trends over time. The variable mean weight in the older ages is likely due to poor sampling.

Commercial Catch Rates

The landings per day fished (L/DF) for otter trawl trips from the Gulf of Maine-Georges Bank area were estimated for 1964-1997. The L/DF were estimated for ton classes 2-4 for all trips that landed any amount of American plaice and for trips that landed 50% or more American plaice (50% trips).

The total L/DF was estimated by summing the individual ton class L/DF weighted by the percentage of the total landings. The total L/DF for 50% trips and for all trips landing American plaice generally declined from 1964 to 1972 then gradually increased to a record high in 1977 and gradually declined to a record low in 1988. Catch rates increased again until 1992, then declined and have been relatively stable in recent years (Figure D2). Nominal fishing effort (df) for all trips landing any amount of plaice increased between 1971-1985, remained relatively high between 1985 and 1992, but has declined since 1993 (Figure D3).

Research Survey Indices

Indices of abundance and biomass were estimated for American plaice from both the NEFSC and the Massachusetts Division of Marine Fisheries (MADMF) spring and autumn bottom trawl surveys. The NEFSC stratified mean number per tow by age and stratified mean weight per tow estimates, adjusted for differences in fishing power of the Albatross IV and the Delaware II are presented in Table D10 and Figures D4 and D5. Abundance indices were adjusted by 0.82 and biomass indices were adjusted by 0.69 if the survey was conducted by the Delaware II (NEFSC 1991). Indices of abundance from the NEFSC surveys indicate strong year classes occurring in 1978,1979,1981,1987 and 1992 (Table D10 and Figure D6). The MADMF survey indicates strong 1984,1987, and 1992 year classes (Table D11).

Mortality

Instantaneous natural mortality was assumed to be 0.2, based on studies of unexploited stocks by Pitt (1972). Mortality estimates were derived by combining all research surveys and calculating a 3 point moving average (Figure D7). Fishing mortality estimates are highly variable throughout the time series and appear to be lower in the latter half (1989-1997) of the time series.

ESTIMATES OF STOCK SIZE AND FISHING MORTALITY

Virtual Population Analysis Calibration

The ADAPT calibration method (Parrack 1986. Gavaris 1988, Conser and Powers 1990) was used to derive estimates of fishing mortality in 1997 and beginning year stock sizes in 1998. The catch-at-age used in the VPA consisted of combined USA commercial landings and estimates of discards from 1980-1997 for ages 1-8 with a 9+ age group. The indices of abundance used to calibrate the VPA included both the NEFSC 1980-1997 spring research survey abundance indices for ages 1-8 and the MADMF 1982-1997 spring research survey abundance indices for ages 1-5 , and the NEFSC 1980-1997 autumn research survey abundances for ages 2-8 and the MADMF 1982-1997 autumn research survey abundance indices for ages 2-6. The autumn survey indices were lagged forward one age and one year to match cohorts in the subsequent year. Results of preliminary VPA calibrations are presented in Table D12.

The final ADAPT formulation provided stock size estimates for ages 2-8 in 1998 and corresponding F estimates for ages 1-7 in 1997. Assuming full recruitment at age 5, the F on age 8 in the terminal year was estimated as the average of the F on ages 5 through 7. The F on age 8 in all years prior to the terminal year was derived from weighted estimates of Z for ages 5 through 7. For all years, the F on age 8 was applied to the 9+ age group. Spawning stock biomass estimates were derived by applying a constant ogive derived from O'Brien *et. al* (1992).

The final ADAPT calibration results are presented in Table D13 for estimates of F, stock size, and SSB at age. Estimates of stock size were more precise for ages 2-7 with CVs ranging from 0.18 to 0.29 than for age 8 (CV=0.35). The residual patterns of the indices did not show any strong trends for the four surveys (Figure D8).

Average fully recruited fishing mortality (ages 5-8) in 1997 was estimated at 0.47, an increase of 10% from 1996 (Table D13, Figure D9). The 1997 estimate of SSB was 13,500 mt, an increase of 11% from 1996 (Table D13, Figure D10). Since 1980, recruitment has ranged from 12 million (1984 year class) to 57 million (1992 year class). Recruitment since 1993 has been near record low values and the 1997 estimate is the lowest in the time series (Table D13, Figure D10).

The relationship of recruitment at age one to spawning stock biomass is presented in Figure D11.

Precision Estimates of F and SSB

A bootstrap procedure (Efron 1982) was used to evaluate the uncertainty associated with the estimates of fishing mortality and spawning stock biomass from the final VPA. One thousand bootstrap iterations were performed to estimate standard errors, coefficients of variation (CVs) and bias estimates for age 2-8 stock size estimates at the start of 1998, the catchability estimates (q) for each index of abundance used in calibrating the VPA, and ages 1-7 F's in 1997.

The bootstrap results indicate that stock sizes were well estimated for age 2-8 with coefficients of variation (CVs) varying between 0.16-0.33. The CVs for the catchability coefficients for all indices ranged between 0.13-0.15. The fully recruited F for ages 5+ was well estimated with a CV=0.15 . The bootstrap estimate of 0.485 was only slightly higher than the NLLS estimate. The distribution of the 1997 fully recruited average F estimates, derived from the 1000 bootstrap iterations, ranged from 0.32 to 0.79 (Figure D12). There is an 80% probability that the average F in 1997 is between 0.41 and 0.57 (Figure D12).

The bootstrap results indicate that spawning stock biomass was reasonably well estimated (CV=0.10) and slightly higher than the NLLS estimate of 13,454 mt. The distribution of the 1997 spawning stock biomass estimates, derived from the 1000 bootstrap iterations, ranged from 9,500 mt to 19,500 mt (Figure D13). There is an 80% probability that the 1997 SSB is between 12,000 mt and 15,000 mt (Figure D13).

Retrospective Analysis

A retrospective analysis was performed to evaluate how well the current ADAPT calibration would estimate spawning stock biomass, fishing mortality, and recruits at age 1 for the four years prior to the current assessment, 1993-1996. Convergence of the estimates generally occurs after about six years (Figures D14-D16). The retrospective analysis indicates a pattern of closely estimating or underestimating the recruits at age 1 (Figure D14). The exception to this is the estimates in 1993 and 1994 that were well below the 1995-1997 estimates. Estimates of spawning stock biomass (SSB) appear to be only slightly overestimated (Figure D15). Estimates of fishing mortality (F) are underestimated slightly for 1993-1995 and are almost equivalent for 1996 and 1997 (Figure D16).

BIOLOGICAL REFERENCE POINTS

Yield- and Spawning-Stock-Biomass per Recruit

Yield per recruit, total stock biomass per recruit, and spawning stock biomass per recruit were estimated using methodology of Thompson and Bell (1934). The estimates were derived based on arithmetic means of the 1994-1996 catch mean weight at age (Table D9) and stock mean weight at age. Proportion mature at age were obtained from O'Brien *et. al* (1992). A partial recruitment (PR) vector was calculated from the geometric mean of the 1994-1996 F estimates from the final VPA (Table D13), coinciding with the change in mesh regulations in 1994. The final exploitation pattern was derived by dividing the geometric mean F at age by the geometric mean of the unweighted average F for ages 5-8 and smoothed by applying full exploitation at ages 5 and older. The exploitation pattern of:

Age 1: 0.02, Age 2: 0.05, Age 3: 0.08, Ages 4: 0.42 Age 5: 1.00

reflects a decrease in the exploitation at age 3 and an increase at ages 4 and 5 compared to the previous assessment (O'Brien *et al.* 1992). Input values and results for the yield-per-recruit analysis are provided in Table D14 and Figure D17. The resulting biological reference points were $F_{0.1}$=.19, F_{max} =.35, and $F_{20\%}$=.40, compared to $F_{0.1}$=.18, F_{max} =.29, and $F_{20\%}$=.49 from the previous assessment.

Several other yield-per-recruit analyses were performed using catch mean weight at age disaggregated by landings, large mesh otter trawl discards, and shrimp fishery discards. The proportion of F for each of these components was also applied. The resulting biological reference points were $F_{0.1}$=.16 and F_{max} =.26, based on the landings per recruit.

An additional analysis was performed to address the recommendation of SAW 14 to simulate the effect of the removal of the shrimp fishery on stock status and biological reference points.

A yield per recruit analysis was performed using the average weight of the landings and large mesh discards combined, and a fishing mortality pattern that represented only the landings and large mesh fishery discards. Results indicate F would have to increase 15% (F_{max}=.40) to achieve a 4% increase in yield per recruit at F_{max}.

MSY Based Reference Points

Estimates of maximum sustainable yield (MSY) and SSB_{MSY} were derived using the long term average recruitment and current estimates of yield per recruit (Y/R) and spawning stock biomass per recruit (SSB/R) at $F_{0.1}$. MSY is estimated to be about 4,400 mt and SSB_{MSY} is estimated to be about 25,000 mt. These estimates differ for those provided by the Overfishing Definition Review Panel (Applegate *et al.* 1998) which appear to be incorrect.

The Panel recommended a control law with $F_{0.1}$ as the maximum fishing mortality threshold when the stock is greater than SSB_{MSY} then decreasing linearly to zero at 1/4 of SSB_{MSY}. Given our current estimate of $F_{0.1}$ (0.19) and SSB_{MSY} (25,000 mt) and the control law recommended by the Panel, the target F would be set at 60% of the $F_{0.1}$ (0.11) when SSB is above SSB_{MSY} and would decrease linearly to zero at ½ of SSB_{MSY} (12,500 mt) (Figure D18). The 1997 SSB estimate is 13,500 mt and the 1998 projected SSB is 10,800 mt.

PROJECTIONS

Short term, three year stochastic projections were performed to estimate landings and SSB during 1998-2000 under the F scenarios of F_{98} = 0.48, $F_{0.1}$ = 0.19, $F_{20\%}$ = 0.40, and F=0.0, with no fishing (Appendix D1 Tables 1-4). Data input are the same as described in the yield per recruit analysis (Table D14). In addition, recruitment in 1998 was derived from the distribution of geometric mean recruitment calculated from bootstrapped VPA estimates (1979-1996 year classes) and the recruitment for 1999 and 2000 was estimated as the median value of the observed 1980-1997 recruitment at age one (Table D13).

At a fishing mortality of 0.48, landings are projected to be about 3,000 mt in 1999, and decline to 2,200 mt in 2000 (Table 15, Figure D19). SSB decreases to about 8,600 mt in 1999 and declines further to 6,500 mt in 2000. Fishing at $F_{0.1}$= 0.19, landings will decline to 1,400 mt in 1999 and remain stable at about 1,300 mt in 2000. SSB at $F_{0.1}$ will decline in 1999 (9,100 mt) and continue to decline in 2000 (8,600 mt). If fishing mortality is reduced zero, SSB will decline in 1999 (9,500 mt) and only increase minimally in 2000 (10,400 mt) due to the below average recruitment in recent years (Table D15).

CONCLUSIONS

The Gulf of Maine-Georges Bank stock of American plaice is at a low biomass level, compared to the long term average mid-year biomass. Biomass indices derived from autumn research surveys indicate that the stock has been near or below the long term average since 1984. Fishing mortality increased rapidly from 1991 (0.43) to a record high in 1995 (0.75). Fishing mortality in 1997 was 0.47, more than one and half times $F_{0.1}$= 0.18. Spawning stock biomass declined steadily from 49,000 mt in 1980 to a record low value in 1990 (8,700 mt) , and increased to about 13,000 mt in 1997. Although the largest year class on record occurred in 1992, recruiting year classes (1994, 1995 ,1996) are among the record low, and well below the long term average.

Working Group Discussion

The working group noted that the VPA was relatively unstable when discard data were not included in some of the trial calibration runs. Exclusion of discards (primarily at younger ages) resulted in the same residual pattern noted for white hake (high positive residuals on the youngest age when not directly estimated) and unacceptable parameter estimates for older ages.

Inclusion of discards resulted in a very stable VPA under various trial formulations.

Discards represent an important component of the catch at age for this species and the working group considers further refinement of the discard estimates an important area for further investigation. In particular, the working group expressed concern for the estimates derived prior to the initiation of the NEFSC sea sampling program in 1989 and encourages further work to refine these estimates. Use of number of trips to characterize effort in the shrimp fishery may be too coarse, and the working group suggests that days fished be investigated as an effort multiplier. Further, the calculation of q from the relationship of filtered survey indices and estimated discards during the 1989-1997 period should be re-evaluated.

The working group noted that sea sample data collected by the state of Massachusetts could be used in conjunction with the NEFSC-sponsored sea sample program to better refine estimates of discards. The working group suggested that discards from large-mesh and small-mesh otter trawls (other than shrimp vessels) should be estimated separately. The working group noted that sea sample data for the otter trawl fishery are available in most years since 1989, and that these data should be evaluated as a source of discard estimates for the small-mesh finfish component of the otter trawl fishery. VTR (logbook) data also represent an additional source of information on discards, and these data should be evaluated for their utility for confirmatory calculations with respect to the sea sample data.

Overall, the working group notes that the final formulation of the VPA appears to be providing estimates of stock size and fishing mortality with considerable precision. Landings-at-age estimates from 1985-1997 have been completely revised in this assessment using recently-available commercial age/length keys. Further improvements should focus on refinements to the estimates of discards.

SARC Comments

Input Data

The SARC noted that the present VPA included landings at age derived from commercial length samples and commercial age/length keys rather than survey keys as was required in the previous assessment. However, a combination of direct (from sea sample data) and indirect (survey-based) methods was applied to estimate discards at age from the shrimp and large mesh trawl fisheries. Discard estimates from the shrimp fishery were expanded by effort (number of trips), and the SARC questioned where the effort was obtained for the period after 1993. The SARC was informed that number of trips is available from the dealer database, but some problems may arise in the interpretation of this field.

The SARC noted the rather high amounts of discarded plaice from the shrimp fishery after the Nordmore grate went into effect in 1992. It is likely that small plaice are passing through the grate and are retained in the codend. This hypothesis is consistent with the presence of relatively strong 1992 and 1993 year classes in the population.

The SARC detected an inconsistency in the estimation of plaice discards from the shrimp fishery during the 1995-1997 period when information from VTR records was used to determine the distribution of trips across the region. It was noted that most small vessel operators from Maine do not posses a groundfish license and are not obliged to fill out VTR reports. Therefore, no information on the spatial distribution of these trips are available to re-distribute the total number of trips derived from the dealer database. This may result in too many trips being assigned to the southern part of the region, thereby increasing the estimated discards. As well, the SARC speculated that sea sample trips are conducted primarily on larger vessels fishing in deeper water where discard of plaice may be highest, and the application of discard rates derived from these trips to all trips may inflate the estimates of discards. The SARC also noted that discard estimates from the shrimp fishery were dominated by the 1993 year class to an extent beyond their representation in the observed survey indices or in the estimated population matrix. It was noted that this year class as well as the 1992 year class appear relatively strong in the NEFSC surveys, but their dominance in the 1995 and 1996 shrimp fishery discard estimates may be affected by the length frequency samples available from the sea sample trips. *Noting this, the SARC recommended that discards emanating from the northern shrimp fishery be re-estimated, taking into account depth zone of the fishing trips, and, if possible, a more refined measure of fishing effort such as days fished.*

Some anomalous entries in the catch at age (e.g., 1995 age 4 numbers) appear to be related to poor sampling of the commercial catch during the mid 1990s. The SARC also noted a discontinuity in the relationship between the abundance indices in NEFSC spring and autumn surveys since 1990, but could offer no explanation for this change.

Stock Size and Fishing Mortality Rates

The SARC was presented with results from the final working group formulation of the VPA which appeared to have high precision on the estimates of N, little retrospective or residual patterns, and internally consistent estimates of F for all fully recruited ages (5 through 8) from 1993 through 1996. However, given the concern with regard to the possible over-estimation of discards from the shrimp fishery, and noting the sensitivity of recruitment estimates to the magnitude of discards in the catch at age, the SARC requested that sensitivity runs be conducted in which the 1994-1997 discard estimates from the shrimp fishery were reduced and expanded by 50%. Reduction of the discards resulted in slightly lower (~7%) estimates of the size of recent recruitment, particularly those of the 1992 and 1993 year classes. The impact on older ages and on estimates of fully recruited fishing mortality was minimal. Aside from this, results from these sensitivity runs were quite similar to the original base run and, noting this, the SARC agreed to accept the VPA as initially presented. The SARC requested that estimates of Z derived from NEFSC and MADMF surveys be presented. Although somewhat variable, estimates derived from surveys displayed no apparent trend, and agreed in magnitude with estimates derived from the VPA.

Biological Reference Points

The SARC reviewed yield and SSB per recruit analyses and noted that estimates of F0.1, Fmax and F20% were similar to those presented in the previous assessment. The SARC also examined a stock/recruitment plot for American plaice. Given that there appeared to be little or no S/R relationship for this stock, the SARC considered that calculating Bmsy and MSY proxies from the dynamic pool model results was appropriate. Consequently the SARC was presented estimates of MSY derived from the estimated yield per recruit and SSBmsy derived from the estimated SSB per recruit at F0.1. This resulted in a SSBmsy of 26,000 mt and an MSY of about 4,300 mt. These results were quite different from those derived from previous analyses.

Sources of Uncertainly

1. Effect of not including discards emanating from the small-mesh whiting fishery.

2. Effect of using number of trips as an effort multiplier *versus* a more refined measure such as days fished.

3. Effect of expanding discard estimates derived from the small segment covered in the sea sampling program to the whole fleet.

Research Recommendations.

1. The sea sample data used to estimate discards in the shrimp fishery could be further stratified to take account of variations in discard rates by depth.

2. Use of another effort measure of effort such as days fished should be evaluated as an effort multiplied in the survey-based method for calculating discards in the shrimp fishery.

3. Examine the feasibility of including Massachusetts sea sampling data and VTR data in the calculation of discards.

4. Examine the USSR data to determine if catches of American plaice may have been underestimated during the late 1960s.

5. Examine the available data to characterize the seasonality and spatial variability of spawning in the Gulf of Maine.

6. Derive estimates of discards for the small-mesh otter trawl component, particularly for the years 1980, 1981 and 1983.

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Table D1 Commerical landings (metric tons, live) of American plaice from the Gulf of Maine, Georges Bank, Southern New England and the Mid-Atlantic, 1960-1997.

Year	Gulf of Maine			Georges Bank					Southern New England				Mid - Atlantic			Grand Total		
	USA	Can	Total	USA	Can	SSR	Other	Total	USA	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689	-	-	-	689	-	-	-	0	-	-	0	1309	1	1310
1961	692	-	692	830	-	-	-	830	-	-	-	0	-	-	0	1522	0	1522
1962	694	-	694	1233	44	-	-	1277	-	-	-	0	-	-	0	1927	44	1971
1963	693	-	693	1489	127	24	-	1640	-	-	-	0	-	-	0	2182	151	2333
1964	811	-	811	2800	177	-	11	2988	-	-	-	0	-	-	0	3611	188	3799
1965	967	-	967	2376	180	112	-	2668	-	-	-	0	-	-	0	3343	292	3635
1966	955	2	957	2388	242	279	1	2910	-	-	-	0	-	-	0	3343	524	3867
1967	1066	6	1072	2166	203	1018	10	3397	-	-	-	0	4	-	4	3236	1237	4473
1968	904	5	909	1695	173	193	5	2066	637	145	-	782	18	2	20	3254	523	3777
1969	1059	7	1066	1738	71	63	17	1889	505	349	-	854	130	-	130	3432	507	3939
1970	895	-	895	1603	92	927	658	3280	88	18	40	146	8	-	8	2594	1735	4329
1971	648	5	653	1511	36	228	296	2071	11	112	206	329	6	2	8	2176	885	3061
1972	569	-	569	1222	22	358	-	1602	3	71	-	74	-	-	0	1794	451	2245
1973	687	-	687	910	38	289	-	1237	5	158	-	163	-	-	0	1602	485	2087
1974	945	2	947	1039	27	16	2	1084	92	4	-	96	-	-	0	2076	51	2127
1975	1507	-	1507	913	25	148	-	1086	3	-	-	3	-	-	0	2423	173	2596
1976	2550	-	2550	948	24	3	-	975	10	-	-	10	1	-	1	3509	27	3536
1977	5647	-	5647	1408	35	50	-	1493	6	78	-	84	7	-	7	7068	163	7231
1978	7287	30	7317	2193	77	-	-	2270	15	-	-	15	8	-	8	9503	107	9610
1979	8835	-	8835	2478	23	-	-	2501	13	-	7	20	4	-	4	11330	30	11360
1980	11139	-	11139	2399	43	-	5	2447	10	-	-	10	1	-	1	13549	48	13597
1981	10327	1	10328	2482	15	-	2	2499	26	-	2	28	46	-	46	12881	20	12901
1982	11147	-	11147	3935	27	-	1	3963	35	-	2	37	9	-	9	15126	30	15156
1983	9142	7	9149	3955	30	-	-	3985	40	-	-	40	4	-	4	13141	37	13178
1984	6833	2	6835	3277	6	-	-	3283	17	-	-	17	7	-	7	10134	8	10142
1985	4766	1	4767	2249	40	-	-	2289	12	-	-	12	2	-	2	7029	41	7070
1986	3319	-	3319	1146	34	-	-	1180	4	-	-	4	3	-	3	4472	34	4506
1987	2766	-	2766	1032	48	-	-	1080	2	-	-	2	1	-	1	3801	48	3849
1988	2271	-	2271	1097	108	-	-	1205	13	-	-	13	1	-	1	3382	108	3490
1989	1646	-	1646	703	68	-	-	771	1	-	-	1	3	-	3	2353	68	2421
1990	1802	-	1802	639	51	-	-	690	2	-	-	2	2	-	2	2445	51	2496
1991	2936	-	2936	1310	-	-	-	1310	15	-	-	15	0	-	0	4261	0	4261
1992	4564	2	4566	1838	-	-	-	1838	10	-	-	10	4	-	4	6416	2	6418
1993	3865	-	3865	1838	-	-	-	1838	11	-	-	11	4	-	4	5718	0	5718
1994	*3402*	29	3431	*1560*	2	-	-	1562	*21*	-	-	21	*83*	-	83	5066	31	5097
1995	*3123*	3	3126	*1486*	-	-	-	1486	*16*	-	-	16	*20*	-	20	4645	3	4648
1996	*2920*	2	2922	*1423*	-	-	-	1423	*39*	-	-	39	*14*	-	14	4396	2	4398
1997	*2331*	65	2396	*1560*	-	-	-	1560	*22*	-	-	22	*24*	-	24	3937	65	4002

**** 1994-1997 data are spatially distributed based on proportions of landings recorded by area in the VTR database and are considered provisional.**

Table D2. Landings by market category (Sm = small + peewee; Md=medium; Lg=large+jumbo; Un=unclassified) for statistical areas 511-515, 521-522, 525-526, 561-562 for American plaice, 1980-1997. (1994-1997 includes all areas).

	Quarter 1				Quarter 2				Quarter 3				Quarter 4				Total			
YEAR	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un	Sm	Md	Lg	Un
1980	565	0	1527	3	1398	0	3667	100	1026	0	2399	16	479	0	1488	1	3468	0	9081	120
1981	730	0	1775	26	1233	0	3557	253	993	0	2209	34	457	0	1532	2	3413	0	9073	315
1982	581	0	1468	11	1353	5	4350	318	1191	524	2643	131	571	299	1570	40	3696	827	10031	500
1983	580	356	1624	5	1488	713	3148	57	1027	497	1816	18	399	276	1090	3	3494	1843	7678	83
1984	431	247	1071	10	954	649	2355	27	812	479	1444	19	372	309	909	13	2568	1684	5779	70
1985	512	253	708	14	709	511	1548	22	503	369	1046	13	239	188	521	9	1963	1321	3823	59
1986	187	132	409	13	539	350	1014	33	342	201	536	11	202	146	349	6	1269	829	2308	63
1987	169	108	304	20	460	275	744	43	367	203	475	20	199	126	246	35	1195	711	1768	117
1988	203	94	279	39	447	244	529	75	433	186	303	47	155	88	143	36	1238	612	1254	197
1989	117	76	158	25	300	208	423	68	222	126	222	29	139	81	135	21	778	491	938	142
1990	101	66	142	19	269	194	317	49	323	196	273	20	190	118	146	19	883	573	879	107
1991	138	78	116	20	594	347	367	61	773	378	353	40	435	263	241	41	1939	1066	1077	162
1992	302	174	291	35	902	634	805	112	887	624	674	80	426	278	394	17	2517	1710	2164	244
1993	276	181	410	17	702	515	867	80	589	371	602	26	423	232	401	14	1990	1299	2280	137
1994	237	120	243	22	685	434	711	15	692	387	506	8	437	218	345	6	2051	1159	1805	51
1995	214	117	198	10	811	425	585	29	800	287	327	9	436	178	216	4	2261	1007	1326	52
1996	240	108	180	4	808	343	434	22	913	242	253	10	493	159	183	3	2454	852	1050	39
1997	322	99	158	2	696	390	360	56	550	406	245	16	321	176	139	2	1889	1071	902	76

Table D3 Sampling of commercial American plaice landings, by market category, for the Gulf of Maine and Georges Bank areas (NAFO Division 5Y and 5Z), 1985-1997. Outline indicates samples pooled to estimate landings at age.

		Small				Medium				Large				Number of tons landed / sample		
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Sm.	Med.	Lrg.
1985	GB	2	4	14	3	—	2	2	2	—	3	7	1			
	GM	2	5	5	5	3	1	9	5	1	10	6	5			
	total	4	9	19	8	3	3	11	7	1	13	13	6	49	55	116
1986	GB	3	6	5	3	2	4	3	2	1	4	3	2			
	GM	9	5	3	5	3	4	5	1	10	10	7	4			
	total	12	11	8	8	5	8	8	3	11	14	10	6	33	35	56
1987	GB	4	5	5	1	—	2	3	2	2	4	4	1			
	GM	2	6	5	3	1	5	2	3	3	3	6	5			
	total	6	11	10	4	1	7	5	5	5	7	10	6	39	40	63
1988	GB	3	7	4	2	1	3	4	2	4	5	2	4			
	GM	4	7	4	5	6	6	4	3	6	5	3	2			
	total	7	14	8	7	7	9	8	5	10	10	5	6	34	21	40
1989	GB	2	5	5	—	1	1	6	1	5	3	3	—			
	GM	1	3	3	3	1	—	4	3	2	1	—	1			
	total	3	8	8	3	2	1	10	4	7	4	3	1	35	29	63
1990	GB	—	5	6	—	2	1	2	2	—	2	5	—			
	GM	5	5	3	3	1	6	3	5	1	5	3	5			
	total	5	10	9	3	3	7	5	7	1	7	8	5	33	26	42
1991	GB	—	3	1	—	3	1	1	—	3	3	2	—			
	GM	5	3	7	6	3	1	4	3	—	1	5	2			
	total	5	6	8	6	6	2	5	3	3	4	7	2	78	67	67
1992	GB	—	4	1	—	—	1	1	—	—	2	2	1			
	GM	1	5	2	2	1	4	3	2	2	2	3	2			
	total	1	9	3	2	1	5	4	2	2	4	5	3	168	143	155
1993	GB	—	2	1	1	—	1	—	—	—	3	2	1			
	GM	2	4	4	1	—	2	2	—	—	1	2	—			
	total	2	6	5	2	0	3	2	0	0	4	4	1	133	260	253
1994	GB	—	—	—	—	—	—	1	1	—	1	—	1			
	GM	—	2	5	3	—	4	3	3	—	2	3	3			
	total	0	2	5	3	0	4	4	4	0	3	3	4	205	97	181
1995	GB	1	—	—	—	1	—	—	—	1	—	—	—			
	GM	1	3	—	2	—	2	—	—	—	2	—	1			
	total	2	3	0	2	1	2	0	0	1	2	0	1	323	336	332
1996	GB	—	2	2	1	—	1	4	—	—	2	1	1			
	GM	2	3	2	1	2	1	3	5	3	1	4	2			
	total	2	5	4	2	2	2	7	5	3	3	5	3	189	53	75
1997	GB	2	4	2	3	—	2	3	1	—	2	—	—			
	GM	4	4	3	1	2	3	3	—	1	5	3	2			
	total	6	8	5	4	2	5	6	1	1	7	3	2	82	77	69

Table D4. Landings at age (thousands of fish; metric tons), mean weight (kg), and mean length (cm) at age of commercial landings of American plaice from Gulf of Maine - Georges Bank, and South, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
							Landings in Numbers (000's) at Age									
1980	0	0	0	22	770	3129	3903	3629	1185	1139	850	323	155	215	687	16007
1981	0	0	587	1332	4331	5100	3618	2381	1573	645	440	196	146	45	234	20628
1982	0	0	113	2134	3495	4295	3481	3293	2038	1256	737	317	34	137	230	21558
1983	0	0	1	438	3735	4270	3809	2252	1271	697	450	455	230	59	168	17834
1984	0	0	3	253	1298	4819	2865	1913	577	274	307	65	57	0	647	13078
1985	0	0	0	60	786	2066	2787	2213	1081	438	267	79	54	19	30	9880.6
1986	0	0	1	198	1082	1502	1462	1307	631	255	105	51	26	7	15	6644
1987	0	0	15	343	486	1703	1271	891	541	187	62	26	15	14	5	5557
1988	0	0	1	446	1148	1456	1427	543	270	177	88	25	13	11	6	5612.5
1989	0	0	0	76	451	686	504	749	469	193	103	35	29	22	31	3345.7
1990	0	0	0	202	846	1049	500	290	349	193	96	74	42	16	29	3685.8
1991	0	0	0	23	1850	2818	1105	319	164	201	97	66	23	9	6	6682.4
1992	0	0	0	46	739	4871	2563	812	191	131	118	38	33	18	4	9564.4
1993	0	0	0	123	1028	2036	2452	1382	265	287	151	71	22	7	25	7847.8
1994	0	0	24	200	914	1903	1287	1178	608	239	153	64	49	26	157	6800.3
1995	0	0	0	141	717	2880	1745	646	582	212	53	26	16	0	8	7027.6
1996	0	0	101	175	2515	2396	1412	533	241	125	35	21	15	22	5	7598
1997	0	0	0	2	1275	2615	1558	620	184	86	67	48	19	11	41	6524.8
							Landings at Age (mt)									Total
1980	0	0	0	6	271	1387	2562	3008	1232	1347	1168	508	269	391	1448	13597
1981	0	0	78	276	1485	2318	2832	2122	1545	729	552	266	257	82	358	12898
1982	0	0	23	620	1166	1845	2007	3164	2320	1502	1144	551	65	224	524	15153
1983	0	0	0	149	1720	2484	2596	1864	1326	867	650	638	405	108	380	13187
1984	0	0	1	84	549	2913	1957	1713	688	310	421	134	93	0	1279	10142
1985	0	0	0	13	212	747	1516	1884	1263	603	445	158	115	42	73	7070
1986	0	0	0	53	349	616	864	1101	741	380	183	102	58	17	42	4506
1987	0	0	3	97	187	809	797	797	636	278	107	56	34	32	15	3849
1988	0	0	0	126	413	689	922	484	333	247	151	49	29	26	20	3490
1989	0	0	0	26	177	335	295	553	403	257	150	62	51	46	66	2421
1990	0	0	0	78	355	547	330	240	338	210	125	104	76	30	62	2496
1991	0	0	0	8	839	1532	790	307	191	256	150	107	46	18	17	4261
1992	0	0	0	22	314	2623	1895	774	237	173	193	72	63	40	13	6418
1993	0	0	0	51	463	1054	1591	1305	327	399	238	126	55	13	94	5718
1994	0	0	3	48	391	1008	807	938	659	308	217	106	92	54	466	5097
1995	0	0	0	51	301	1482	1141	531	652	283	112	51	28	0	17	4648
1996	0	0	17	59	1017	1236	918	490	290	172	55	41	33	57	13	4398
1997	0	0	0	0	541	1245	992	510	208	115	105	82	40	32	131	4002

Table D4. Landings at age (thousands of fish; metric tons), mean weight (kg), and mean length (cm) at age of commercial landings of American plaice
cont'd from Gulf of Maine - Georges Bank, and South, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
								Mean Weight at age (kg)								**Average**
1980	-----	-----	-----	0.285	0.352	0.443	0.656	0.829	1.039	1.183	1.374	1.573	1.732	1.815	2.109	0.849
1981	-----	-----	0.133	0.207	0.343	0.454	0.783	0.891	0.982	1.130	1.254	1.354	1.755	1.836	1.534	0.625
1982	-----	-----	0.200	0.291	0.334	0.429	0.577	0.961	1.138	1.196	1.552	1.737	1.944	1.636	2.281	0.703
1983	-----	-----	0.184	0.341	0.460	0.582	0.682	0.828	1.043	1.244	1.446	1.404	1.762	1.843	2.255	0.740
1984	-----	-----	0.180	0.331	0.423	0.605	0.683	0.895	1.192	1.133	1.369	2.058	1.628	0.000	1.977	0.775
1985	-----	-----	0.000	0.221	0.270	0.362	0.544	0.852	1.167	1.377	1.665	1.991	2.115	2.254	2.437	0.715
1986	-----	-----	0.191	0.267	0.322	0.410	0.591	0.842	1.174	1.491	1.747	2.002	2.207	2.344	2.751	0.678
1987	-----	-----	0.201	0.284	0.386	0.475	0.627	0.895	1.177	1.483	1.732	2.148	2.213	2.359	2.988	0.692
1988	-----	-----	0.151	0.282	0.360	0.473	0.646	0.893	1.231	1.396	1.717	1.991	2.265	2.278	3.074	0.622
1989	-----	-----	-----	0.339	0.393	0.489	0.586	0.739	0.858	1.334	1.463	1.789	1.780	2.106	2.142	0.724
1990	-----	-----	-----	0.384	0.420	0.522	0.660	0.826	0.968	1.089	1.305	1.409	1.811	1.881	2.154	0.678
1991	-----	-----	-----	0.333	0.453	0.543	0.715	0.963	1.161	1.276	1.541	1.618	2.012	2.050	2.837	0.639
1992	-----	-----	-----	0.473	0.424	0.538	0.739	0.953	1.240	1.319	1.640	1.902	1.928	2.151	2.884	0.671
1993	-----	-----	-----	0.416	0.451	0.518	0.649	0.945	1.234	1.394	1.577	1.784	2.468	1.989	3.750	0.729
1994	-----	-----	0.138	0.239	0.427	0.530	0.627	0.796	1.083	1.289	1.424	1.657	1.880	2.082	2.963	0.750
1995	-----	-----	0.000	0.359	0.420	0.517	0.685	0.914	1.168	1.099	2.105	1.934	1.757	0.000	2.213	0.517
1996	-----	-----	0.166	0.339	0.404	0.516	0.650	0.919	1.202	1.383	1.565	1.962	2.127	2.525	2.486	0.579
1997	-----	-----	-----	0.214	0.424	0.476	0.636	0.822	1.127	1.336	1.570	1.709	2.138	3.084	3.231	0.613
								Mean Length at age (cm)								**Average**
1980	-----	-----	-----	32.6	34.7	37.1	41.7	44.8	47.9	49.9	52.2	54.4	56.0	56.7	59.1	44.1
1981	-----	-----	25.8	28.8	34.0	36.9	43.3	45.2	46.7	48.8	50.3	51.8	55.6	57.0	53.8	39.4
1982	-----	-----	29.0	32.4	33.7	36.4	39.5	46.3	48.8	49.9	53.9	55.7	58.0	55.0	60.7	40.8
1983	-----	-----	28.7	34.2	37.2	39.8	41.9	44.2	47.5	50.2	52.9	52.2	56.1	56.9	60.1	42.2
1984	-----	-----	28.5	33.9	36.3	40.3	41.8	45.3	49.9	49.3	52.2	59.0	54.9	0.0	59.3	42.8
1985	-----	-----	-----	30.0	31.9	34.6	39.1	45.0	49.6	52.0	55.2	58.2	59.3	60.4	61.8	41.4
1986	-----	-----	29.0	31.9	33.6	36.0	40.1	44.6	49.5	53.3	56.0	58.4	60.0	61.1	64.2	40.7
1987	-----	-----	29.4	32.5	35.5	37.8	41.0	45.6	49.5	53.3	55.8	59.6	60.2	61.3	65.7	41.3
1988	-----	-----	27.0	32.4	34.8	37.6	41.4	45.6	50.4	52.3	55.7	58.3	60.6	60.6	66.4	39.9
1989	-----	-----	-----	34.3	35.8	38.2	40.2	43.0	44.6	51.5	52.9	56.2	56.2	59.2	59.4	41.9
1990	-----	-----	-----	35.6	36.5	38.9	41.6	44.5	46.7	48.3	51.1	52.3	56.6	57.3	59.5	41.3
1991	-----	-----	-----	34.2	37.4	39.4	42.6	46.6	49.3	50.6	53.9	54.5	58.5	58.6	64.8	40.8
1992	-----	-----	-----	38.0	36.7	39.2	43.1	46.4	50.5	51.4	54.9	57.5	57.7	59.6	65.2	41.5
1993	-----	-----	-----	36.5	37.3	38.8	41.4	46.6	50.5	52.4	54.4	56.5	62.2	58.3	70.4	42.3
1994	-----	-----	26.2	30.4	36.7	39.2	41.2	44.2	48.6	51.2	52.6	55.2	57.4	59.2	65.6	42.3
1995	-----	-----	0.0	35.0	36.6	38.8	41.6	44.6	49.0	51.7	59.4	57.9	56.1	-----	60.3	41.3
1996	-----	-----	27.7	34.1	36.2	38.8	41.4	46.1	50.0	52.1	54.3	58.1	59.5	62.6	62.1	39.5
1997	-----	-----	-----	30.0	36.7	37.9	41.3	44.5	49.0	51.7	54.2	55.6	59.6	66.5	66.9	40.2

Table D5. Discard rate (lbs/trip), number of trips and total discards (lbs) of American plaice in the Northern Shrimp fishery for Area I (N of 4315 degrees latitude) and Area 2 (S of 4315 degrees Latitude), by season, 1989-1997.

Year Season	AREA 1 (N of 4315 Degrees) Disc. Rate lbs / trip	No. Trips	Total Disc. lbs	AREA 2 (S <= of 4315 Degrees) Disc. Rate lbs / trip	No. Trips	Total Disc. lbs	Total Disc. lbs
1989							
Winter	8.17	2989	24420	33.12	2976	98565	122985
Spring	298.87	508	151826	9948	1282	127533	279359
December	109.95	343	37713	121.51	1016	123454	161167
Annual Total		3840	213959		5274	349553	563512
1990							
Winter	109.95	1951	214512	121.51	2417	293690	508202
Spring	99.48	1839	182944	81.45	1669	135940	318884
December	18.17	273	4960	73.7	820	60434	65394
Annual Total		4063	402417		4906	490064	892480
1991							
Winter	18.17	2061	37448	73.7	2421	178428	215876
Spring	12.18	867	10560	81.45	1307	106455	117015
December	6.69	235	1572	44.7	335	14975	16547
Annual Total		3163	49581		4063	299857	349438
1992							
Winter	6.69	4635	30989	44.7	378	16897	47886
Spring	5.47	969	5304	22.2	755	16759	22064
December	5.47	129	706	14.88	252	3750	4456
Annual Total		5733	37000		1385	37406	74406
1993							
Winter	5.47	2283	12497	14.88	1264	18808	31305
Spring	4.48	637	2855	16.44	1175	19322	22177
December	3.67	173	635	12.18	329	4008	4643
Annual Total		3093	15987		2768	42138	58125
1994							
Winter	3.67	2136	7838	12.18	1820	22172	30010
Spring	4.95	599	2967	3.67	741	2719	5686
December	24.53	271	6648	7.38	1633	12052	18699
Annual Total		3006	17452		4194	36943	54395
1995							
Winter	24.53	756	18545	7.38	4851	35800	54345
Spring	14.89	167	2487	54.6	2642	144253	146740
December	9.03	132	1192	24.53	1726	42339	43531
Annual Total		1055	22223		9219	222392	244616
1996							
Winter	9.03	848	7657	24.53	5822	142814	150471
Spring	81.45	366	29811	27.11	3024	81981	111791
December	7.39	113	835	18.17	2178	39574	40409
Annual Total		1327	38303		11024	264369	302672
1997							
Winter	7.39	527	3895	18.17	5162	93794	97688
Spring*	*81.45*	139	11322	29.96	4572	136977	148299
December*	*7.39*	28	207	*18.17*	1196	21731	21938
Annual Total		694	15423		10930	252502	267925

* Missing discard rates in 1997 are substitued values (in italics) from 1996.

Table D6. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the northern shrimp fishery in the Gulf of Maine region, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	
					Discards in Numbers (000's) at Age							Total
1980	0.0	5.6	84.5	105.4	79.9	19.9	0.0	0.0	0.0	0.0	0.0	295.4
1981	0.0	34.9	169.3	226.2	114.3	30.6	3.1	2.9	1.9	0.0	0.0	583.0
1982	0.0	55.9	310.4	244.2	326.3	33.5	33.6	0.0	0.0	0.0	0.0	1003.9
1983	0.1	15.1	427.8	399.1	449.9	178.2	22.5	1.1	0.0	0.0	0.0	1493.7
1984	0.7	50.3	214.8	308.0	297.1	88.6	29.1	0.0	0.0	0.0	0.0	988.6
1985	0.1	48.9	304.2	358.9	200.5	78.1	28.6	0.2	0.0	0.0	0.0	1019.5
1986	0.1	116.6	265.7	442.9	146.0	38.0	0.6	0.0	0.0	0.0	0.0	1010.0
1987	0.3	94.0	461.5	441.4	296.4	67.0	4.2	0.0	0.0	0.0	0.0	1364.9
1988	0.0	141.7	426.3	323.7	130.9	17.9	4.9	0.0	0.0	0.0	0.0	1045.4
1989	0.0	129.0	1458.3	1180.6	325.7	24.1	0.8	0.0	0.0	0.0	0.0	3118.4
1990	0.0	61.0	597.9	1965.4	1004.4	151.6	8.9	0.0	0.0	0.0	0.0	3789.2
1991	0.0	7.5	191.3	436.2	467.3	92.4	2.8	1.1	0.0	0.0	0.0	1198.7
1992	0.0	20.0	68.8	173.4	79.6	24.7	1.5	0.3	0.3	0.0	0.0	368.5
1993	0.0	81.9	95.8	113.2	85.2	22.7	4.3	0.0	0.0	0.2	0.0	403.4
1994	0.7	288.2	475.7	123.3	19.9	5.8	1.5	0.5	0.0	0.0	0.0	915.6
1995	1.1	518.3	1470.5	717.3	96.7	11.9	4.6	0.2	0.6	0.0	0.0	2821.1
1996	0.0	194.7	834.5	1041.0	359.3	53.4	19.9	6.9	0.1	0.0	0.0	2509.8
1997	0.0	158.0	1365.4	511.5	358.7	85.6	14.6	0.7	0.0	0.0	0.0	2494.5
					Discards at age (mt)							Total
1980	0.0	0.1	2.8	6.9	10.3	4.3	0.0	0.0	0.0	0.0	0.0	24.4
1981	0.0	0.5	5.6	14.9	14.7	6.7	0.9	1.0	0.6	0.0	0.0	44.7
1982	0.0	0.8	10.3	16.1	41.9	7.3	9.3	0.0	0.0	0.0	0.0	85.7
1983	0.0	0.2	14.2	26.2	57.8	38.8	6.2	0.4	0.0	0.0	0.0	143.8
1984	0.0	0.8	7.1	20.3	38.2	19.3	8.0	0.0	0.0	0.0	0.0	93.6
1985	0.0	0.7	10.1	23.6	25.7	17.0	7.9	0.1	0.0	0.0	0.0	85.1
1986	0.0	1.7	8.8	29.1	18.8	8.3	0.2	0.0	0.0	0.0	0.0	66.9
1987	0.0	1.4	15.3	29.0	38.1	14.6	1.2	0.0	0.0	0.0	0.0	99.5
1988	0.0	2.1	14.1	21.3	16.8	3.9	1.4	0.0	0.0	0.0	0.0	59.6
1989	0.0	1.6	55.5	124.8	51.1	5.5	0.2	0.0	0.0	0.0	0.0	238.6
1990	0.0	1.3	34.0	168.8	143.8	29.7	2.4	0.0	0.0	0.0	0.0	380.0
1991	0.0	0.1	8.8	39.5	75.4	24.6	1.0	0.4	0.0	0.0	0.0	149.8
1992	0.0	0.4	2.1	10.8	11.8	6.0	0.4	0.1	0.1	0.0	0.0	31.7
1993	0.0	1.3	3.6	4.9	8.5	5.0	1.2	0.0	0.0	0.1	0.0	24.6
1994	0.0	4.1	10.1	5.6	1.9	1.2	0.4	0.2	0.0	0.0	0.0	23.4
1995	0.0	6.4	37.5	40.1	13.0	3.0	1.2	0.1	0.2	0.0	0.0	101.4
1996	0.0	2.7	18.4	49.1	39.6	11.1	5.3	1.8	0.1	0.0	0.0	128.0
1997	0.0	2.1	27.5	28.6	38.2	12.4	2.8	0.3	0.0	0.0	0.0	111.9
					Mean weight at age (kg)							Average
1980	—	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.083
1981	—	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.077
1982	—	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.085
1983	0.001	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.096
1984	0.001	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.095
1985	0.001	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.084
1986	0.001	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.066
1987	0.001	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.073
1988	—	0.015	0.033	0.066	0.128	0.217	0.277	0.342	0.296	0.239	—	0.057
1989	—	0.012	0.038	0.106	0.157	0.227	0.313	—	—	—	—	0.077
1990	—	0.021	0.057	0.086	0.143	0.196	0.265	—	—	—	—	0.100
1991	—	0.013	0.046	0.091	0.161	0.266	0.370	0.359	0.000	—	—	0.125
1992	—	0.018	0.031	0.062	0.149	0.241	0.299	0.359	0.239	—	—	0.086
1993	—	0.016	0.037	0.044	0.100	0.221	0.278	—	0.000	0.239	—	0.061
1994	0.001	0.014	0.021	0.045	0.095	0.205	0.240	0.359	—	0.000	—	0.026
1995	0.001	0.012	0.026	0.056	0.134	0.248	0.266	0.359	0.289	0.000	—	0.036
1996	0.000	0.014	0.022	0.047	0.110	0.208	0.267	0.256	0.359	0.000	—	0.051
1997	0.000	0.014	0.020	0.056	0.107	0.145	0.191	0.361	—	0.000	—	0.045

Mean weights at age from 1980-1988 calculated as averages of 1989-1997.

Table D7. The percent of total American plaice landings caught by large mesh otter trawl gear (5.0", 5.1", and 6.0" mesh), 1980-1997.

Year	Mesh(inches)	Percent of total landings
1980	5.0	55.5
1981	5.0	63.2
1982	5.0	85.4
1983	5.5	62.3
1984	5.5	80.5
1985	5.5	84.9
1986	5.5	90.8
1987	5.5	97.8
1988	5.5	98.3
1989	5.5	95.6
1990	5.5	97.3
1991	5.5	95.7
1992	5.5	93.7
1993	5.5	91.7
1994	6.0	89.2
1995	6.0	88.4
1996	6.0	90.2
1997	6.0	88.3

Table D8. Discards at age (thousands of fish; metric tons) and mean weight (kg) at age of American plaice discarded in the large mesh fishery in the Gulf of Maine-Georges Bank region, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	Total
						Discards in Numbers (000's) at Age						
1980	0.0	5.2	98.9	935.7	1786.7	781.2	30.2	2.9	0.0	0.0	0.0	3640.8
1981	0.0	4.2	246.7	495.9	436.9	157.6	29.8	19.9	5.4	0.0	0.0	1396.4
1982	0.0	2.7	335.4	668.9	446.8	101.8	21.7	0.0	0.0	0.0	0.0	1577.3
1983	0.0	0.6	47.8	399.5	681.4	327.8	52.6	12.2	1.4	3.4	0.0	1526.6
1984	0.0	0.0	65.0	249.1	549.4	718.1	281.5	16.3	0.3	0.0	0.0	1879.8
1985	0.0	10.9	54.6	227.0	85.8	30.8	5.6	0.0	0.0	0.0	0.0	414.5
1986	0.0	5.6	85.9	139.6	268.3	65.7	4.4	0.1	0.0	0.0	0.0	569.6
1987	0.0	7.1	135.9	390.4	343.7	241.1	53.2	3.8	1.9	0.0	0.0	1177.1
1988	0.0	30.4	197.1	606.9	276.6	50.3	5.7	0.2	0.0	0.0	0.0	1167.0
1989	0.0	3.4	194.6	574.8	347.7	119.2	31.5	4.0	1.1	0.0	0.0	1276.3
1990	0.0	6.9	77.9	1221.4	814.0	168.3	22.1	1.0	0.1	0.0	0.0	2311.7
1991	0.0	5.6	132.1	541.9	2092.5	492.0	14.8	0.8	0.0	0.0	0.0	3279.7
1992	0.0	17.3	162.1	863.4	1403.5	1913.9	160.3	6.3	7.3	0.0	0.0	4533.9
1993	0.0	24.9	330.1	1795.9	3027.9	1523.5	683.4	20.9	0.0	0.0	0.0	7406.5
1994	0.0	0.0	6.9	299.6	1693.0	2550.8	414.3	110.4	0.0	0.5	0.0	5075.5
1995	0.0	0.0	17.6	1426.0	5689.0	1933.9	251.5	7.2	1.0	0.0	0.0	9326.3
1996	0.0	0.0	0.7	201.8	1568.8	508.8	38.9	8.7	8.8	0.0	0.0	2336.6
1997	0.0	0.0	9.7	289.5	1104.8	1219.2	128.2	97.0	45.6	42.5	21.9	2958.5
						Discards at age (mt)						
1980	0.0	0.2	7.5	147.2	423.8	218.3	9.4	1.1	0.0	0.0	0.0	807.6
1981	0.0	0.2	21.9	61.7	70.0	26.7	5.6	3.4	1.1	0.0	0.0	190.6
1982	0.0	0.1	42.1	98.8	69.3	18.6	3.8	0.0	0.0	0.0	0.0	232.6
1983	0.0	0.0	4.0	65.8	134.5	69.7	12.0	2.8	0.4	0.8	0.0	290.0
1984	0.0	0.0	6.7	40.2	112.4	172.8	71.3	5.2	0.1	0.0	0.0	408.7
1985	0.0	0.3	4.8	25.4	11.3	4.8	0.9	0.0	0.0	0.0	0.0	47.6
1986	0.0	0.2	6.2	17.9	44.7	12.4	0.7	0.0	0.0	0.0	0.0	82.2
1987	0.0	0.1	11.4	60.2	69.5	59.2	15.2	1.1	0.2	0.0	0.0	216.9
1988	0.0	0.6	13.5	100.1	53.5	11.3	1.5	0.1	0.0	0.0	0.0	180.5
1989	0.0	0.1	12.8	96.5	81.0	29.2	7.5	0.8	0.4	0.0	0.0	228.2
1990	0.0	0.1	5.2	222.8	207.9	45.5	6.6	0.4	0.0	0.0	0.0	488.4
1991	0.0	0.1	8.4	73.1	543.5	139.9	6.0	0.4	0.0	0.0	0.0	771.4
1992	0.0	0.7	12.8	139.9	375.4	674.6	60.0	1.8	1.7	0.0	0.0	1267.0
1993	0.0	0.4	29.5	374.4	787.5	496.6	259.9	7.7	0.0	0.0	0.0	1956.1
1994	0.0	0.0	0.7	67.4	470.7	856.4	153.7	45.8	0.0	0.3	0.0	1595.0
1995	0.0	0.0	2.7	373.2	1776.5	693.5	95.5	3.5	0.3	0.0	0.0	2945.3
1996	0.0	0.0	0.1	47.1	446.6	156.2	13.6	3.2	3.2	0.0	0.0	669.9
1997	0.0	0.0	1.7	59.9	285.8	319.5	36.0	25.2	10.9	12.5	6.5	758.0
						Mean weight at age (kg)						
1980	—	0.030	0.076	0.157	0.237	0.279	0.311	0.392	0.000	—	—	0.222
1981	—	0.037	0.089	0.124	0.160	0.169	0.189	0.171	0.209	—	—	0.133
1982	—	0.029	0.126	0.148	0.155	0.182	0.173	—	—	—	—	0.147
1983	0.007	0.024	0.083	0.165	0.197	0.213	0.228	0.234	0.308	0.229	—	0.190
1984	—	—	0.103	0.162	0.205	0.241	0.253	0.317	0.432	—	—	0.217
1985	—	0.030	0.088	0.112	0.132	0.155	0.168	0.000	0.000	—	—	0.115
1986	—	0.035	0.072	0.128	0.167	0.189	0.171	0.295	—	—	—	0.144
1987	—	0.020	0.084	0.154	0.202	0.246	0.286	0.295	0.116	—	—	0.184
1988	—	0.019	0.068	0.165	0.193	0.226	0.262	0.359	—	—	—	0.155
1989	—	0.017	0.066	0.168	0.233	0.245	0.239	0.209	0.369	—	—	0.179
1990	—	0.015	0.067	0.182	0.255	0.270	0.300	0.359	0.432	—	—	0.211
1991	—	0.019	0.063	0.135	0.260	0.284	0.406	0.515	—	—	—	0.235
1992	—	0.039	0.079	0.162	0.267	0.353	0.374	0.290	0.239	—	—	0.279
1993	—	0.017	0.090	0.208	0.260	0.326	0.380	0.371	—	—	—	0.264
1994	—	0.047	0.102	0.225	0.278	0.336	0.371	0.415	—	0.609	—	0.314
1995	—	—	0.156	0.262	0.312	0.359	0.380	0.489	0.295	0.000	—	0.316
1996	—	0.065	0.101	0.233	0.285	0.307	0.349	0.366	0.359	0.000	—	0.287
1997	—	0.065	0.170	0.207	0.259	0.262	0.281	0.260	0.239	0.295	0.295	0.256

Table D9 Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, and large mesh and northern shrimp fishery discards of American plaice from Gulf of Maine - Georges Bank, and South, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Catch in Numbers (000's) at Age																
1980	0	11	183	1063	2636	3930	3933	3632	1185	1139	850	323	155	215	687	19943
1981	0	39	1003	2054	4882	5288	3651	2404	1581	645	440	196	146	45	234	22607
1982	0	59	759	3047	4268	4431	3536	3293	2038	1256	737	317	34	137	230	24140
1983	0	16	476	1236	4866	4776	3884	2265	1272	701	450	455	230	59	168	20854
1984	1	50	283	810	2144	5625	3175	1930	577	274	307	65	57	0	647	15946
1985	0	60	359	645	1072	2175	2822	2214	1081	438	267	79	54	19	30	11315
1986	0	122	352	781	1497	1606	1467	1307	631	255	105	51	26	7	15	8224
1987	0	101	612	1174	1126	2011	1328	894	543	187	62	26	15	14	5	8099
1988	0	172	624	1377	1556	1524	1438	543	270	177	88	25	13	11	6	7825
1989	0	132	1653	1831	1125	829	536	753	471	193	103	35	29	22	31	7740
1990	0	68	676	3389	2664	1369	531	291	349	193	96	74	42	16	29	9787
1991	0	13	323	1001	4410	3403	1123	321	164	201	97	66	23	9	6	11161
1992	0	37	231	1083	2222	6810	2724	819	198	131	118	38	33	18	4	14467
1993	0	107	426	2032	4141	3583	3139	1403	265	287	151	71	22	7	25	15658
1994	1	288	506	623	2627	4459	1703	1288	608	240	153	64	49	26	157	12791
1995	1	518	1488	2285	6503	4826	2001	654	584	212	53	26	16	0	8	19175
1996	0	195	936	1418	4443	2958	1471	549	250	125	35	21	15	22	5	12444
1997	0	158	1375	803	2739	3919	1701	718	230	128	89	48	19	11	41	11978
Catch at Age (mt)																**Total**
1980	0	0	10	160	705	1609	2571	3009	1232	1347	1168	508	269	391	1448	14429
1981	0	1	106	353	1570	2351	2838	2126	1547	729	552	266	257	82	358	13134
1982	0	1	75	735	1277	1870	2020	3164	2320	1502	1144	551	65	224	524	15471
1983	0	1	16	179	1781	2527	2608	1872	1334	876	660	649	417	121	394	13436
1984	0	1	14	144	700	3105	2037	1719	688	310	421	134	93	0	1279	10644
1985	0	1	15	62	249	769	1525	1884	1263	603	445	158	115	42	73	7203
1986	0	2	15	100	412	637	865	1101	741	380	183	102	58	17	42	4655
1987	0	2	30	187	295	883	813	798	637	278	107	56	34	32	15	4165
1988	0	3	28	247	483	705	925	484	333	247	151	49	29	26	20	3730
1989	0	2	68	247	309	370	303	554	403	257	150	62	51	46	66	2888
1990	0	1	39	469	707	623	339	240	338	210	125	104	76	30	62	3364
1991	0	0	17	120	1458	1696	797	308	191	256	150	107	46	18	17	5182
1992	0	1	15	173	701	3304	1956	776	238	173	193	72	63	40	13	7717
1993	0	2	33	430	1259	1556	1852	1313	327	399	238	126	55	13	94	7699
1994	0	4	14	121	863	1866	961	984	659	309	217	106	92	54	466	6715
1995	0	6	40	464	2091	2178	1238	534	653	283	112	51	28	0	17	7695
1996	0	3	35	155	1503	1403	937	495	294	172	55	41	33	57	13	5196
1997	0	2	29	89	865	1577	1030	536	219	127	112	82	40	32	131	4872

Table D9 Catch at age (thousands of fish; metric tons) and mean weight (kg), of commercial landings, and large mesh and northern shrimp fishery
cont'd discards of American plaice from Gulf of Maine - Georges Bank, and South, 1980-1997.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
								Mean Weight at Age (kg)								**Average**
1980	----	0.022	0.056	0.151	0.267	0.409	0.653	0.829	1.039	1.183	1.374	1.573	1.732	1.815	2.109	0.723
1981	----	0.017	0.105	0.172	0.322	0.444	0.778	0.884	0.979	1.130	1.254	1.354	1.755	1.836	1.534	0.581
1982	----	0.016	0.099	0.241	0.300	0.422	0.572	0.961	1.138	1.196	1.552	1.737	1.944	1.636	2.281	0.641
1983	0.002	0.015	0.038	0.195	0.393	0.543	0.674	0.825	1.042	1.239	1.446	1.404	1.762	1.843	2.255	0.653
1984	0.001	0.015	0.051	0.178	0.326	0.552	0.641	0.890	1.192	1.133	1.369	2.058	1.628	2.014	1.977	0.667
1985	0.001	0.018	0.041	0.096	0.232	0.354	0.540	0.852	1.167	1.377	1.665	1.991	2.115	2.254	2.437	0.637
1986	0.001	0.016	0.043	0.128	0.276	0.397	0.589	0.842	1.174	1.491	1.747	2.002	2.207	2.344	2.751	0.566
1987	0.001	0.015	0.048	0.159	0.262	0.439	0.612	0.893	1.173	1.483	1.732	2.148	2.213	2.359	2.988	0.514
1988	----	0.016	0.044	0.180	0.311	0.462	0.643	0.892	1.231	1.396	1.717	1.991	2.265	2.278	3.074	0.477
1989	----	0.012	0.041	0.135	0.275	0.446	0.566	0.736	0.857	1.334	1.463	1.789	1.780	2.106	2.142	0.373
1990	----	0.021	0.058	0.138	0.265	0.455	0.639	0.824	0.968	1.089	1.305	1.409	1.811	1.881	2.154	0.344
1991	----	0.015	0.053	0.120	0.330	0.498	0.710	0.960	1.161	1.276	1.541	1.618	2.012	2.050	2.837	0.464
1992	----	0.028	0.065	0.159	0.315	0.485	0.717	0.948	1.202	1.319	1.640	1.902	1.928	2.151	2.884	0.533
1993	----	0.016	0.078	0.212	0.304	0.434	0.590	0.936	1.234	1.393	1.577	1.784	2.468	1.989	3.750	0.492
1994	0.001	0.014	0.028	0.194	0.328	0.418	0.564	0.763	1.083	1.287	1.424	1.657	1.880	2.082	2.963	0.525
1995	0.001	0.012	0.027	0.203	0.322	0.453	0.646	0.909	1.166	1.099	2.105	1.934	1.757	0.000	2.213	0.407
1996	----	0.014	0.038	0.110	0.338	0.474	0.637	0.902	1.172	1.383	1.565	1.962	2.127	2.525	2.486	0.418
1997	----	0.014	0.021	0.111	0.316	0.402	0.605	0.746	0.951	0.992	1.256	1.709	2.138	3.084	3.231	0.407

Table D10. Stratified mean number per tow by age and stratified mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys, adjusted for vessel differences, in the Gulf of Maine - Georges Bank[1] area, 1980-1997.

	AGE GROUP																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow	wt/tow
Spring																	
1980	0.00	0.57	3.55	4.49	3.00	2.89	1.60	1.12	0.25	0.31	0.23	0.04	0.02	0.02	0.04	18.34	4.78
1981	0.00	0.13	3.49	4.31	3.55	2.67	1.74	1.45	0.79	0.41	0.34	0.07	0.09	0.07	0.09	18.75	5.88
1982	0.00	0.06	1.04	1.79	3.17	2.13	1.34	0.92	0.49	0.35	0.19	0.07	0.01	0.04	0.02	11.601	3.80
1983	0.00	0.20	3.68	3.33	4.48	2.64	1.18	0.58	0.32	0.15	0.15	0.11	0.05	0.02	0.04	16.94	4.60
1984	0.00	0.02	0.35	0.57	0.90	1.30	0.58	0.22	0.10	0.01	0.02	0.01	0.01	0.00	0.03	4.10	1.42
1985	0.00	0.03	0.32	0.98	0.86	0.73	0.86	0.46	0.42	0.12	0.07	0.04	0.02	0.02	0.02	4.94	1.88
1986	0.00	0.01	0.46	0.34	1.01	0.59	0.29	0.21	0.10	0.04	0.04	0.00	0.00	0.00	0.00	3.09	0.92
1987	0.00	0.09	0.61	0.99	0.69	0.51	0.25	0.17	0.07	0.03	0.03	0.03	0.01	0.00	0.00	3.50	0.81
1988	0.00	0.20	0.99	0.84	0.76	0.31	0.23	0.12	0.01	0.09	0.01	0.01	0.00	0.00	0.00	3.58	0.84
1989	0.00	0.05	1.59	1.27	0.86	0.49	0.29	0.16	0.03	0.07	0.01	0.01	0.00	0.00	0.00	4.81	0.75
1990	0.00	0.00	0.57	2.65	1.02	0.54	0.17	0.06	0.04	0.05	0.00	0.00	0.00	0.00	0.00	5.09	0.75
1991	0.00	0.03	0.71	1.63	2.33	0.92	0.15	0.07	0.04	0.02	0.00	0.02	0.00	0.00	0.01	5.91	1.05
1992	0.00	0.06	0.34	1.15	0.88	1.07	0.43	0.11	0.04	0.02	0.01	0.00	0.01	0.00	0.00	4.11	1.36
1993	0.00	0.33	0.84	1.16	1.58	0.61	0.45	0.17	0.08	0.02	0.01	0.02	0.03	0.00	0.00	5.29	1.39
1994	0.00	0.03	1.43	1.14	1.12	0.75	0.23	0.10	0.03	0.01	0.00	0.01	0.01	0.01	0.01	4.88	0.85
1995	0.00	0.31	1.97	3.21	2.31	1.11	0.44	0.22	0.03	0.03	0.03	0.01	0.02	0.01	0.01	9.43	1.94
1996	0.00	0.02	0.47	1.94	3.30	1.31	0.53	0.20	0.05	0.02	0.00	0.00	0.00	0.00	0.00	7.83	1.69
1997	0.00	0.01	0.85	1.66	2.52	2.05	0.39	0.09	0.01	0.00	0.01	0.00	0.02	0.00	0.00	7.62	1.62
1998	0.00	0.06	0.19	1.02	1.12	1.22	0.68	0.16	0.06	0.01	0.01	0.003	0.01	0.00	0.00	4.52	1.11
Autumn																	
1980	0.00	1.58	2.22	2.72	2.85	1.53	1.03	0.93	0.57	0.31	0.20	0.11	0.04	0.07	0.08	14.24	5.12
1981	0.00	0.43	2.79	2.22	2.62	2.30	1.55	0.63	0.58	0.07	0.20	0.20	0.02	0.02	0.12	13.04	6.62
1982	0.00	0.20	0.91	1.65	1.27	0.57	0.48	0.30	0.17	0.19	0.08	0.03	0.00	0.00	0.02	5.88	2.49
1983	0.06	0.50	1.01	2.02	2.92	1.36	0.68	0.34	0.17	0.10	0.03	0.05	0.06	0.01	0.03	9.34	3.45
1984	0.02	0.22	2.24	1.56	1.21	1.07	0.51	0.12	0.10	0.00	0.03	0.01	0.02	0.00	0.01	7.12	2.02
1985	0.02	0.91	0.83	2.64	1.05	0.79	0.41	0.19	0.05	0.03	0.02	0.00	0.00	0.01	0.00	6.95	2.00
1986	0.10	0.51	1.48	0.89	1.45	0.47	0.43	0.16	0.12	0.04	0.01	0.02	0.01	0.00	0.00	5.61	1.56
1987	0.01	0.53	1.27	0.99	0.43	0.69	0.25	0.10	0.04	0.04	0.01	0.02	0.00	0.00	0.00	4.38	1.09
1988	0.00	2.84	2.97	2.39	0.78	0.47	0.10	0.07	0.00	0.03	0.00	0.02	0.00	0.00	0.00	9.69	1.46
1989	0.05	0.48	4.45	2.86	0.98	0.19	0.10	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.00	9.21	1.17
1990	0.01	1.52	2.26	7.49	2.89	0.59	0.25	0.11	0.07	0.02	0.02	0.01	0.01	0.00	0.01	15.46	2.90
1991	0.02	0.47	2.48	2.03	1.59	0.73	0.30	0.04	0.07	0.00	0.01	0.00	0.00	0.00	0.01	7.71	1.56
1992	0.02	0.65	1.23	1.85	1.28	0.78	0.30	0.07	0.05	0.03	0.02	0.00	0.02	0.00	0.00	6.31	1.78
1993	0.01	1.71	2.35	3.47	2.28	1.05	0.80	0.11	0.04	0.04	0.04	0.00	0.00	0.00	0.00	11.89	2.39
1994	0.04	3.83	7.53	2.81	1.71	1.30	0.04	0.25	0.13	0.01	0.03	0.02	0.00	0.00	0.00	18.07	2.67
1995	0.01	0.50	3.80	3.82	2.50	0.90	0.22	0.04	0.03	0.00	0.00	0.00	0.02	0.00	0.00	11.84	2.58
1996	0.01	0.54	0.81	2.00	2.74	0.93	0.39	0.07	0.04	0.03	0.00	0.00	0.02	0.00	0.02	7.58	2.23
1997	0.01	0.36	1.06	1.55	1.86	1.04	0.32	0.04	0.01	0.01	0.00	0.00	0.00	0.00	0.02	6.27	1.94

[1] Offshore strata 13-30, 36-40

Table D11 Stratified mean number per tow by age of American plaice in Massachusetts State spring and autumn bottom trawl surveys in Massachusetts Bay and Cape Cod Bay (Regions 4+5), 1982-1997.

Year Age	0	1	2	3	4	5	6	7	8	9	10	11
Spring												
1982	0.00	7.18	49.25	33.35	17.14	5.00	2.42	1.12	0.26	0.15	0.03	0.07
1983	0.00	1.93	18.76	22.42	21.46	10.22	2.37	0.73	0.20	0.19	0.06	0.10
1984	0.00	2.15	27.44	21.32	10.57	4.64	1.21	0.18	0.09	0.01	0.03	0.07
1985	0.00	21.56	17.16	24.22	9.50	3.77	2.24	0.65	0.76	0.12	0.04	0.03
1986	0.00	27.06	110.27	26.91	14.43	2.84	0.61	0.05	0.08	0.06	0.00	0.16
1987	0.00	34.36	17.26	15.79	3.90	1.76	0.51	0.10	0.02	0.00	0.00	0.00
1988	0.00	81.47	63.57	17.85	8.72	1.54	0.47	0.09	0.00	0.00	0.00	0.00
1989	0.00	8.07	127.26	44.97	11.99	3.03	1.31	0.20	0.03	0.03	0.00	0.05
1990	0.00	7.73	25.37	56.71	16.48	3.43	0.53	0.11	0.10	0.13	0.00	0.00
1991	0.00	2.10	19.98	34.77	18.98	3.24	0.18	0.07	0.01	0.00	0.00	0.00
1992	0.00	8.20	11.06	33.98	14.99	7.42	1.11	0.45	0.00	0.00	0.00	0.00
1993	0.00	11.60	18.98	16.08	9.16	3.45	0.81	0.04	0.02	0.00	0.00	0.00
1994	0.00	11.60	52.57	22.12	7.13	3.88	1.03	0.31	0.00	0.00	0.00	0.00
1995	0.00	0.54	34.65	49.64	10.32	3.16	0.62	0.17	0.03	0.05	0.02	0.00
1996	0.00	2.29	4.14	14.92	31.39	6.33	1.01	0.77	0.01	0.00	0.00	0.00
1997	0.00	1.55	7.96	13.95	17.24	12.21	2.41	0.21	0.00	0.00	0.00	0.00
Autumn												
1982	0.17	13.24	15.46	10.22	5.11	1.14	0.56	0.14	0.05	0.05	0.01	0.08
1983	1.29	52.17	18.98	10.02	8.30	1.39	0.32	0.15	0.05	0.06	0.00	0.01
1984	0.11	3.14	13.24	4.27	1.83	0.77	0.24	0.04	0.05	0.00	0.00	0.00
1985	0.00	60.97	9.45	14.21	1.56	0.14	0.03	0.02	0.00	0.00	0.00	0.00
1986	0.23	41.27	40.08	12.07	5.30	0.39	0.13	0.01	0.00	0.00	0.00	0.00
1987	0.24	46.36	14.60	3.00	0.52	0.23	0.07	0.01	0.04	0.00	0.00	0.00
1988	0.00	85.63	41.28	13.98	1.34	0.45	0.08	0.00	0.00	0.00	0.00	0.00
1989	0.03	57.56	122.25	31.03	2.33	0.13	0.01	0.01	0.00	0.00	0.00	0.00
1990	0.08	31.99	14.20	20.12	3.93	0.21	0.03	0.00	0.00	0.00	0.00	0.00
1991	0.04	24.07	90.36	40.05	11.51	1.17	0.14	0.00	0.00	0.00	0.00	0.00
1992	0.00	46.33	12.99	29.79	11.04	1.38	0.00	0.00	0.12	0.00	0.00	0.00
1993	0.00	76.21	36.80	17.59	6.85	1.71	0.69	0.00	0.00	0.00	0.00	0.00
1994	0.00	36.71	79.31	10.76	2.91	1.56	0.23	0.14	0.00	0.00	0.00	0.00
1995	0.00	11.84	44.22	24.93	4.21	0.91	0.08	0.00	0.00	0.00	0.00	0.00
1996	0.09	16.25	19.25	27.55	13.96	1.39	0.28	0.00	0.08	0.00	0.00	0.00
1997	0.00	13.61	28.08	17.91	10.29	1.46	0.19	0.01	0.00	0.00	0.00	0.00

Table D12 Results of preliminary formulations for VPA calibration of Gulf of Maine - Georges Bank American plaice.

Run Number	**41-BASE**	**48**
Ages Estimated	2 to 8	1 to 8
Indces used:		
US Spring	1 to 8	1 to 8
US Autumn	2 to 8	1 to 8
MA Spring	1 to 5	1 to 5
MA Autumn	2 to 6	1 to 6
Mean Square	0.36	0.41
CV on N	0.18 to 0.35	0.19 to 0.47
Stock Sizes:		
N1	0	12228
N2	6301	6933
N3	8660	8478
N4	7413	7995
N5	13123	12178
N6	12304	11660
Fishing Mortality		
F1	0.02	0.02
F2	0.13	0.14
F3	0.09	0.09
F4	0.17	0.19
F5	0.25	0.27
F6	0.49	0.53
Recruits:		
Year class 1992	56601	54850
Year class 1993	39386	37283
Year class 1994	16667	17727
Year class 1995	14990	14719
Year class 1996	7870	8643

Table D13. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) of Gulf of Maine-Georges Bank American plaice, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1980-1997.

Stock Numbers (Jan 1) in thousands

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	50702	23856	20595	21754	12745	12305	17694	36417	52580	26390	32391	30720	35205	56601	39386	16667	14990	7870	0
2	41263	41501	19497	16809	17796	10389	10020	14377	29724	42893	21487	26458	25139	28790	46244	31986	13177	12097	6301
3	35738	33618	33071	15276	13331	14314	8181	7885	11217	23771	33622	16980	21370	20373	23186	37404	24842	9942	8660
4	24117	28298	25665	24319	11388	10182	11136	5991	5394	7938	17806	24461	12997	16516	14842	18419	28556	19056	7413
5	21641	17360	18751	17151	15508	7384	7366	7763	3887	3008	5481	12167	16037	8630	9775	9774	9196	19360	13123
6	17355	14162	9428	11343	9721	7607	4077	4578	4536	1803	1713	3249	6883	6968	3824	3969	3636	4853	12304
7	11140	10650	8291	4520	5772	5086	3675	2011	2546	2413	991	922	1644	3170	2865	1590	1439	1646	2434
8	5135	5834	6545	3809	1651	2980	2160	1826	837	1593	1294	548	464	605	1326	1180	710	681	698
9+	14503	6248	8628	6117	3825	2420	1562	1031	987	1379	1656	1333	792	1268	1481	627	630	983	854
1 +	221593	181527	150471	121097	91738	72667	65873	81878	111708	111188	116440	116838	120529	142922	142929	121616	97175	76486	51786

Fishing Mortality

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0.01	0.01	0	0	0.01	0	0	0	0	0.01	0.03	0.01	0.02
2	0	0.03	0.04	0.03	0.02	0.04	0.04	0.05	0.02	0.04	0.04	0.01	0.01	0.02	0.01	0.05	0.08	0.13
3	0.03	0.07	0.11	0.09	0.07	0.05	0.11	0.18	0.15	0.09	0.12	0.07	0.06	0.12	0.03	0.07	0.07	0.09
4	0.13	0.21	0.2	0.25	0.23	0.12	0.16	0.23	0.38	0.17	0.18	0.22	0.21	0.32	0.22	0.49	0.19	0.17
5	0.22	0.41	0.3	0.37	0.51	0.39	0.28	0.34	0.57	0.36	0.32	0.37	0.63	0.61	0.7	0.79	0.44	0.25
6	0.29	0.34	0.54	0.48	0.45	0.53	0.51	0.39	0.43	0.4	0.42	0.48	0.58	0.69	0.68	0.81	0.59	0.49
7	0.45	0.29	0.58	0.81	0.46	0.66	0.5	0.68	0.27	0.42	0.39	0.49	0.8	0.67	0.69	0.61	0.55	0.66
8	0.29	0.36	0.42	0.46	0.49	0.51	0.39	0.4	0.44	0.4	0.35	0.4	0.64	0.66	0.71	0.79	0.49	0.47
9+	0.29	0.36	0.42	0.46	0.49	0.51	0.39	0.4	0.44	0.4	0.35	0.4	0.64	0.66	0.71	0.79	0.49	0.47
mn 5-8,	0.31	0.35	0.46	0.53	0.48	0.52	0.42	0.45	0.43	0.40	0.37	0.44	0.66	0.66	0.70	0.75	0.52	0.47

Table D13 continued. Estimates of beginning year stock size (thousands of fish), instantaneous fishing mortality (F) and spawning stock biomass (mt) of Gulf of Maine-Georges Bank American plaice, estimated from virtual population analysis (VPA), calibrated using the commercial catch at age ADAPT formulation, 1980-1997.

SSB at the start of the spawning season - males and females (mt)

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	50	75	30	16	19	10	11	15	29	42	21	33	30	51	37	23	10	8
3	833	739	1169	474	245	226	131	143	230	409	559	316	442	529	646	629	301	144
4	3311	4063	3793	4819	1854	1372	1194	708	745	1157	2203	3376	1639	2295	2541	2787	4888	2325
5	5492	4870	5797	5711	5745	2056	1883	2244	1060	923	1617	3639	4948	2475	2639	2792	2911	6059
6	8546	6917	3914	5055	4829	3428	1546	1929	2036	785	775	1541	3357	2955	1505	1585	1585	2167
7	7230	7157	5904	2414	3792	3034	2079	1171	1674	1421	584	608	1050	2088	1540	930	911	915
8	4211	4569	5614	3232	1379	2541	1864	1563	748	1200	951	461	404	527	1065	868	616	534
9+	19520	7150	10923	7670	5337	3277	2294	1498	1370	1826	1949	1696	1039	1684	2133	685	877	1302
Total	49194	35540	37144	29391	23200	15944	11002	9271	7893	7763	8660	11670	12908	12604	12105	10300	12100	13453

Percent Mature (females)

age	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
3	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24	24
4	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72	72
5	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95
6	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
7+	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table D14. Yield and Spawning Stock Biomass per recruit results for American plaice.

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: 24-11-1998; Time: 10:35:19.11
American plaice Gulf of Maine-Georges Bank - 1998

Proportion of F before spawning: .2500
Proportion of M before spawning: .2500
Natural Mortality is Constant at: .200
Initial age is: 1; Last age is: 9
Last age is a PLUS group;
Original age-specific PRs, Mats, and Mean Wts from file: ==> APYPR9.DAT

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Average Weights Stock
1	.0200	1.0000	.0000	.016	.010
2	.0500	1.0000	.0400	.052	.029
3	.0800	1.0000	.2400	.160	.092
4	.4200	1.0000	.7200	.305	.221
5	1.0000	1.0000	.9500	.449	.366
6	1.0000	1.0000	1.0000	.632	.534
7	1.0000	1.0000	1.0000	.866	.742
8	1.0000	1.0000	1.0000	1.107	.980
9+	1.0000	1.0000	1.0000	1.564	1.564

Summary of Yield per Recruit Analysis for:
American plaice Gulf of Maine-Georges Bank - 1998

Slope of the Yield/Recruit Curve at F=0.00: --> 2.5298
F level at slope=1/10 of the above slope (F0.1): -----> .185
Yield/Recruit corresponding to F0.1: -----> .1792
F level to produce Maximum Yield/Recruit (Fmax): -----> .346
Yield/Recruit corresponding to Fmax: -----> .1940
F level at 20 % of Max Spawning Potential (F20): -----> .397
SSB/Recruit corresponding to F20: --------> .5065

Listing of Yield per Recruit Results for:
American plaice Gulf of Maine-Georges Bank - 1998

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.5167	2.7847	2.8966	2.5330	100.00
	.050	.10278	.09231	5.0049	2.0916	2.3887	1.8518	73.11
	.100	.17196	.14135	4.6610	1.6510	2.0487	1.4214	56.12
	.150	.22193	.16810	4.4131	1.3517	1.8047	1.1308	44.64
F0.1	.185	.24967	.17920	4.2757	1.1945	1.6701	.9791	38.65
	.200	.25989	.18256	4.2251	1.1384	1.6207	.9251	36.52
	.250	.28983	.18996	4.0772	.9809	1.4766	.7741	30.56
	.300	.31416	.19320	3.9574	.8611	1.3607	.6601	26.06
Fmax	.346	.33281	.19396	3.8656	.7750	1.2725	.5785	22.84
	.350	.33439	.19395	3.8579	.7679	1.2651	.5719	22.58
F20%	.397	.35046	.19332	3.7790	.6984	1.1899	.5065	20.00
	.400	.35155	.19323	3.7737	.6939	1.1848	.5023	19.83
	.450	.36634	.19165	3.7013	.6341	1.1163	.4464	17.62
	.500	.37926	.18959	3.6382	.5851	1.0571	.4008	15.82
	.550	.39069	.18727	3.5825	.5443	1.0053	.3632	14.34
	.600	.40089	.18486	3.5329	.5100	.9596	.3317	13.10
	.650	.41009	.18243	3.4883	.4808	.9188	.3051	12.04
	.700	.41845	.18005	3.4478	.4557	.8822	.2823	11.14
	.750	.42609	.17775	3.4108	.4339	.8491	.2626	10.37
	.800	.43313	.17553	3.3768	.4148	.8190	.2456	9.69
	.850	.43964	.17341	3.3454	.3980	.7915	.2306	9.10
	.900	.44570	.17139	3.3163	.3831	.7662	.2173	8.58
	.950	.45136	.16947	3.2890	.3697	.7429	.2056	8.12
	1.000	.45668	.16764	3.2635	.3576	.7213	.1950	7.70

Table D15. Summary of stochastic projections for Gulf of Maine-Georges Bank American plaice for 1999-2000 fishing mortalities of F=0.0, $F_{0.1}$=0.19, and $F_{20\%}$=0.40 , and F_{98}= 0.48

Input for Projections:

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Catch	Stock	Discards
1	0.0200	1.000	0.0000	0.0160	0.0100	0.0160
2	0.0500	1.000	0.0400	0.0520	0.0290	0.0470
3	0.0800	1.000	0.2400	0.1600	0.0920	0.1260
4	0.4200	1.000	0.7200	0.3050	0.2210	0.2060
5	1.0000	1.000	0.9500	0.4490	0.3660	0.2580
6	1.0000	1.000	1.0000	0.6320	0.5340	0.2930
7	1.0000	1.000	1.0000	0.8660	0.7420	0.3280
8	1.0000	1.000	1.0000	1.1070	0.9800	0.3020
9	1.0000	1.000	1.0000	1.5640	1.5640	0.3430

Projection results:

Year	Recruitment	F	Median Landings	Median Discards	Median SSB
1998	26390	0.48	3597	889	10802
1999	23856	0.00	0	0	9514
2000	26390	0.00	0	0	10409
1998	26390	0.48	3597	889	10802
1999	23856	0.19	1387	263	9109
2000	26390	0.19	1299	252	8582
1998	26390	0.48	3597	889	10802
1999	23856	0.40	2656	515	8690
2000	26390	0.40	2071	449	6971
1998	26390	0.48	3597	889	10802
1999	23856	0.48	3027	592	8553
2000	26390	0.48	2220	501	6514

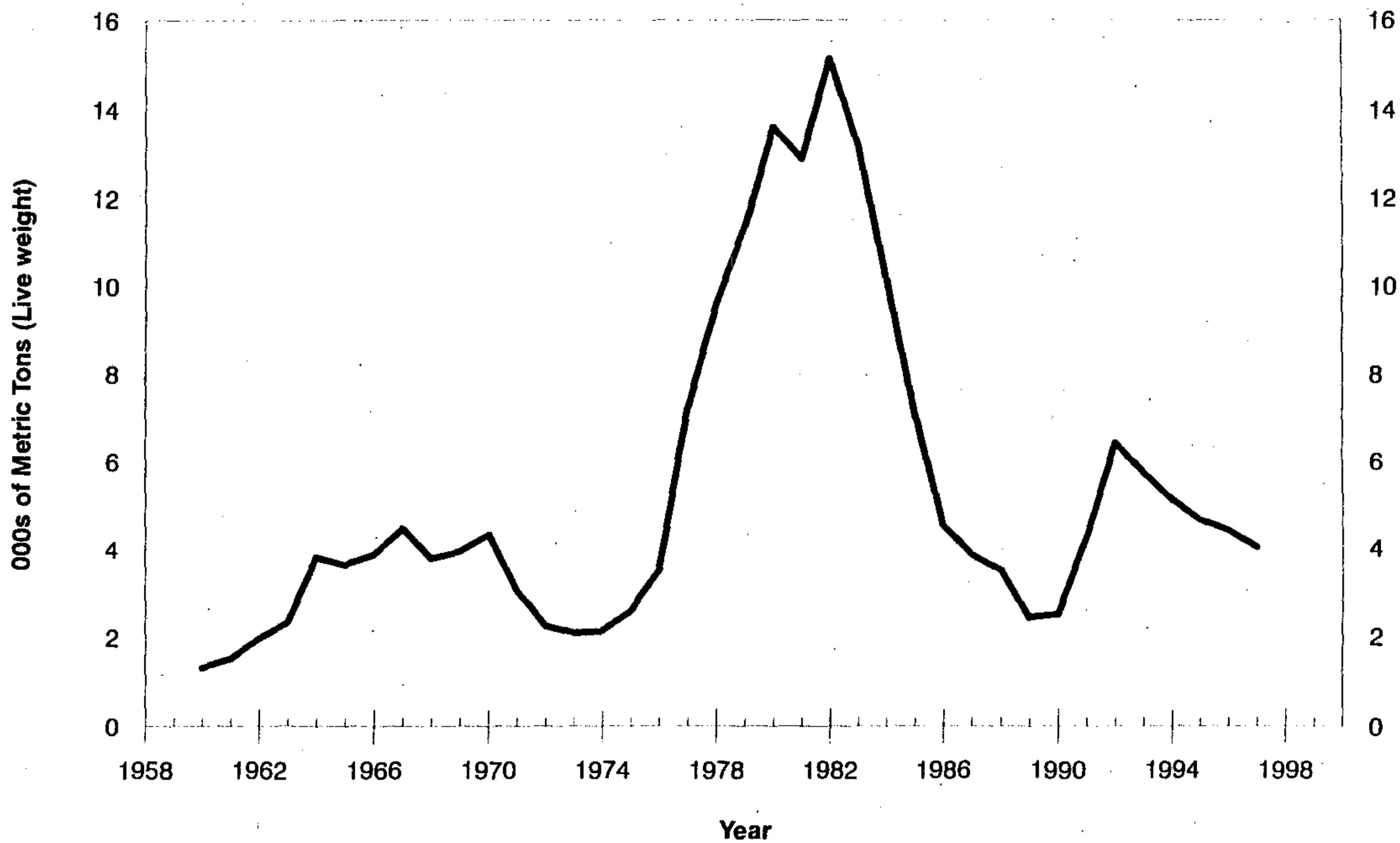


Figure D1. Total commercial landings of Gulf of Maine-Georges Bank American plaice (Division 5Zand 6), 1960-1997.

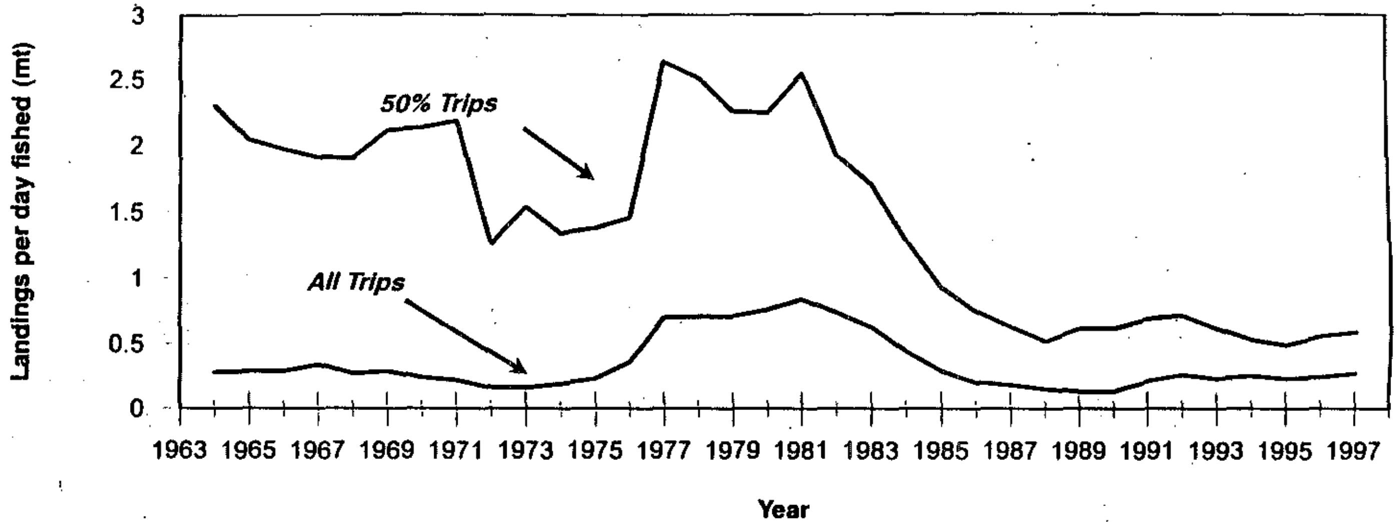


Figure D2. Trends in USA catch rates (landings (mt) per day) of Gulf of Maine-Georges Bank American plaice for all trips landing plaice and for trips with 50% or more of the landings comprised of plaice , 1964-1997.

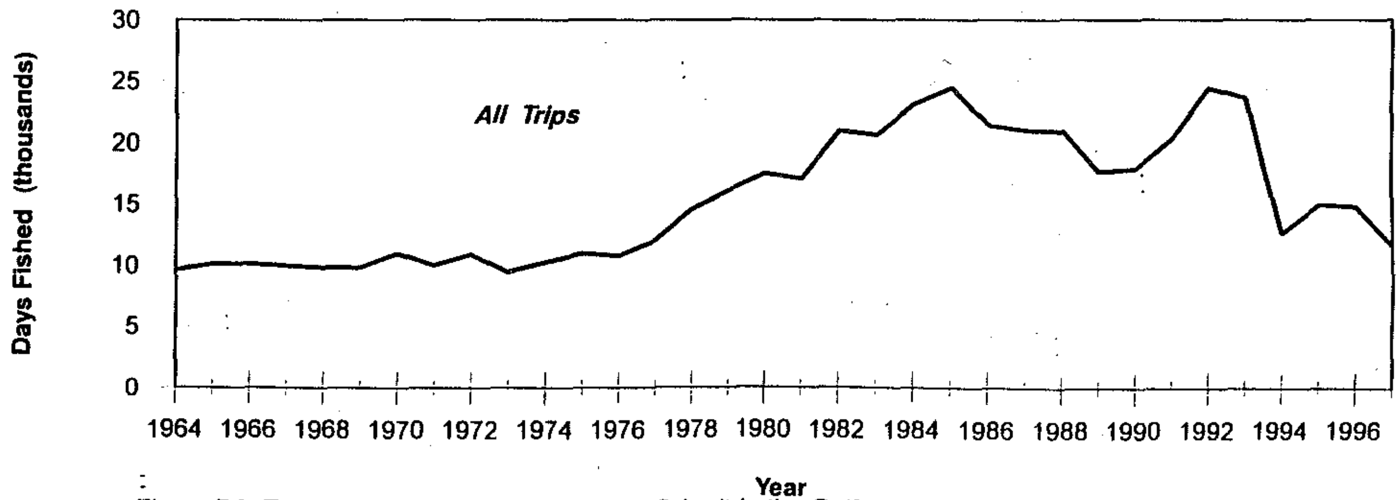


Figure D3. Trends in USA fishing effort (days fished) in the Gulf of Maine-Georges Bank region, 1964-1997. Nominal effort based on all otter trawl trips landing American plaice.

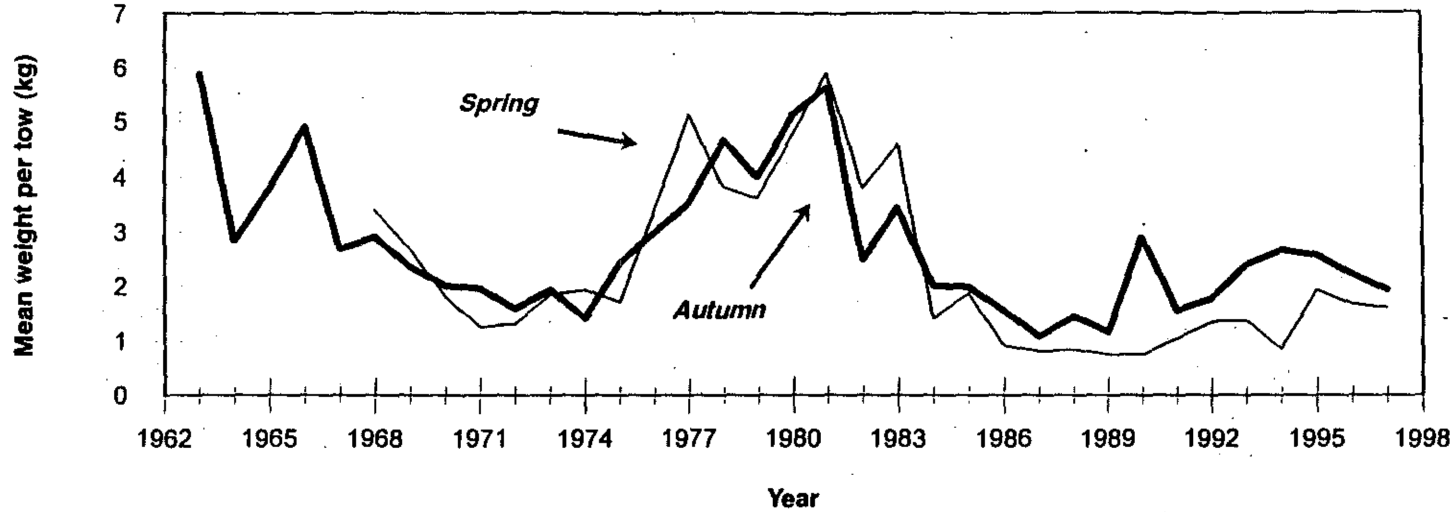


Figure D4. Standardized stratified mean catch per tow (kg) of American plaice in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963-1997.

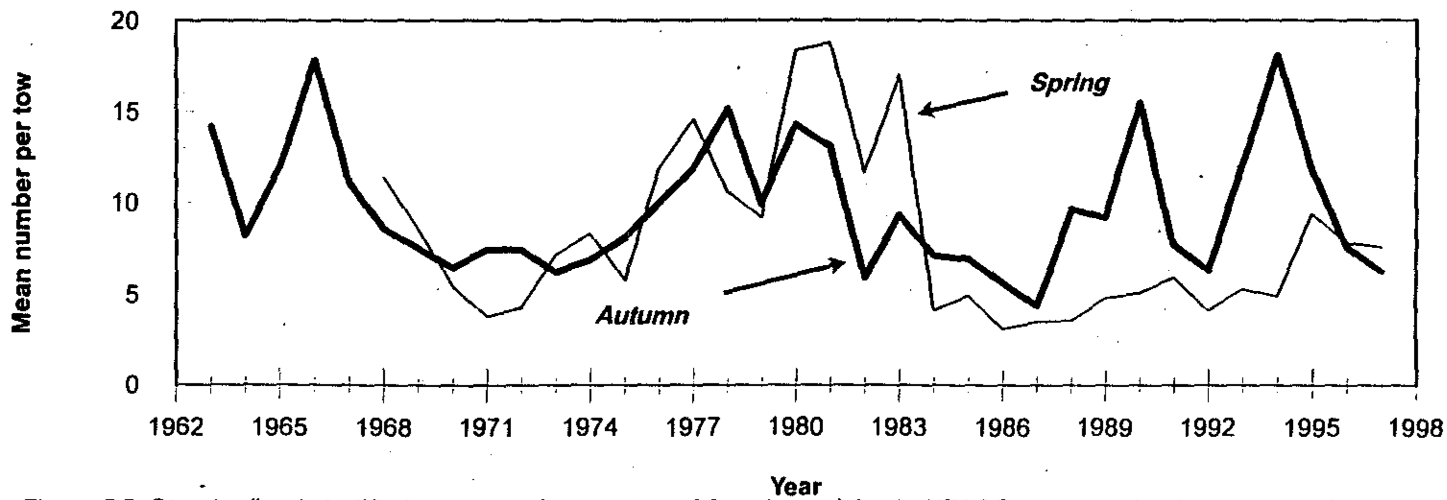


Figure D5. Standardized stratified mean number per tow of American plaice in NEFSC spring and autumn research vessel bottom trawl surveys in the Gulf of Maine-Georges Bank region, 1963 -1997.

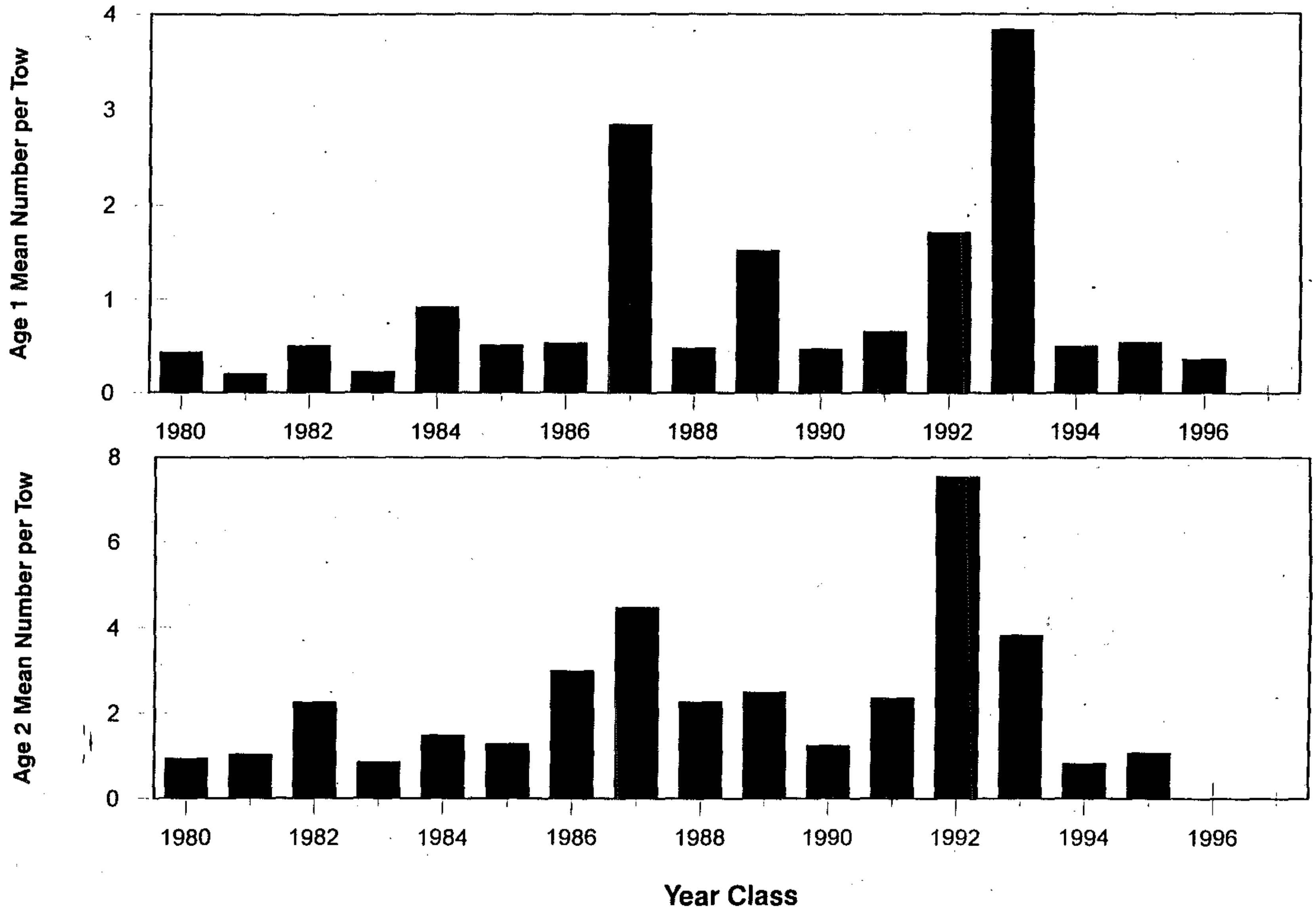


Figure D6. Relative year class strengths of Gulf of Maine-Georges Bank American plaice age 1 and age 2 based on standardized catch (number) per tow indices from NEFSC autumn research vessel bottom trawl surveys, 1980-1997.

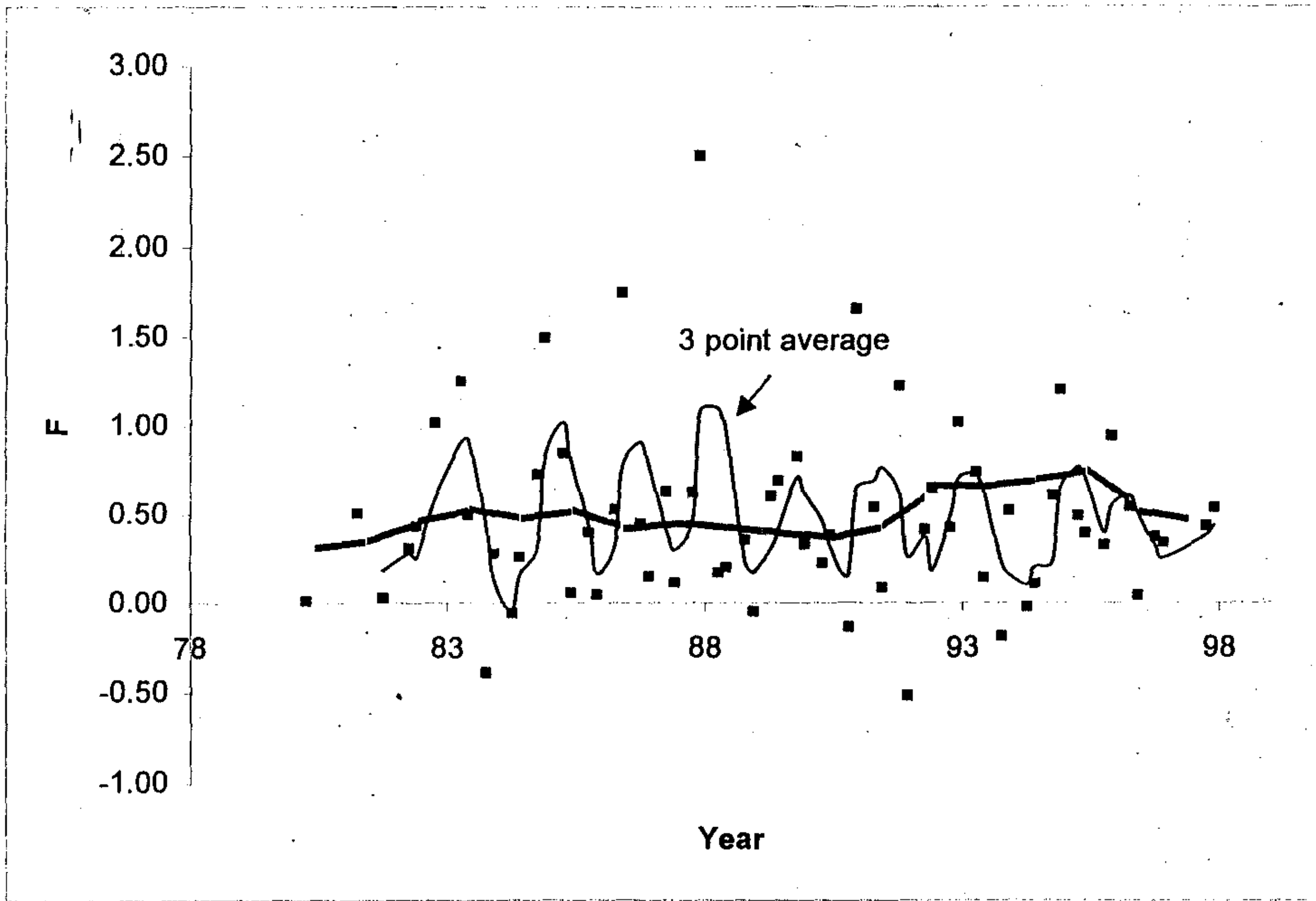


Figure D7. Mortality estimates from NEFSC and MADMF spring and autumn research bottom trawl surveys (solid squares) fitted with a smoothed 3 point running average, 1980-1997. The dashed line is the VPA estimate of mean F (ages 5-8, unweighted).

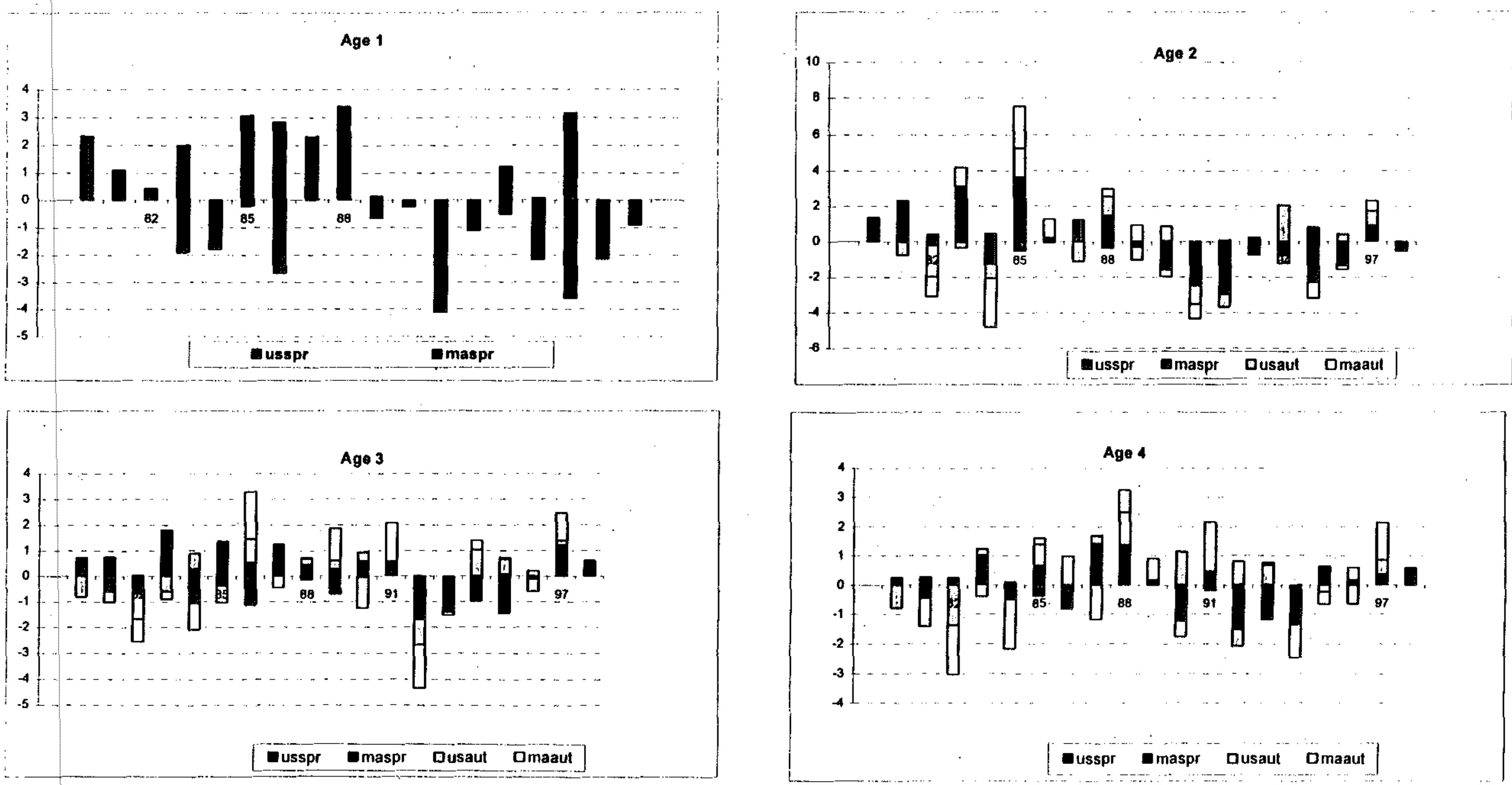


Figure D8. Residual plots (expected -observed) for ages 1-8 for the USA and ages 1-5 for the Massachusetts spring abundance indicies, and ages 2-8 for the USA and ages 2-6 for the Massachusetts autumn abundance indices.

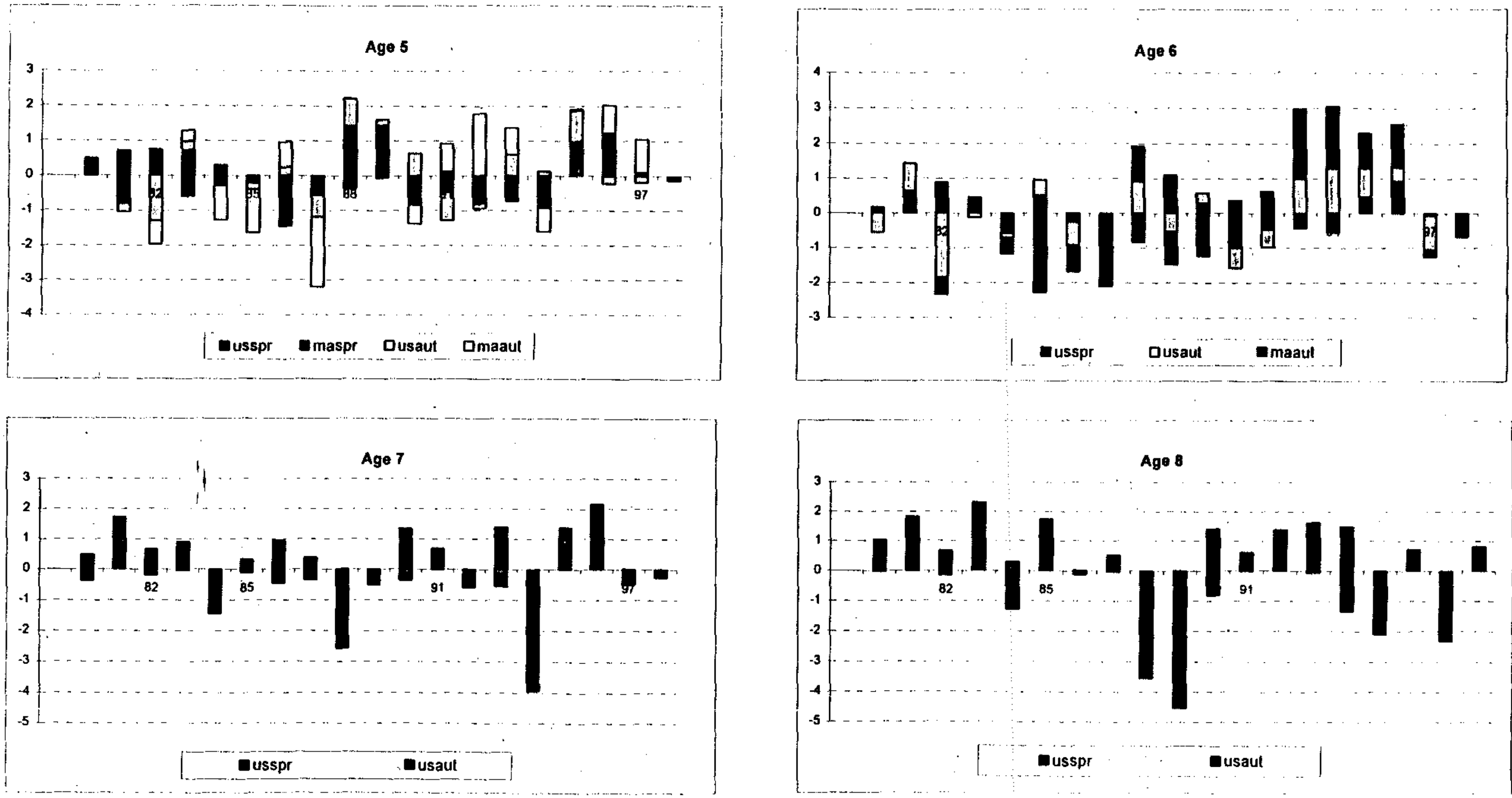


Figure D8. continued. Residual plots (expected -observed) for ages 1-8 for the USA and ages 1-5 for the Massachusetts spring abundance indicies, and ages 2-8 for the USA and ages 2-6 for the Massachusetts autumn abundance indices.

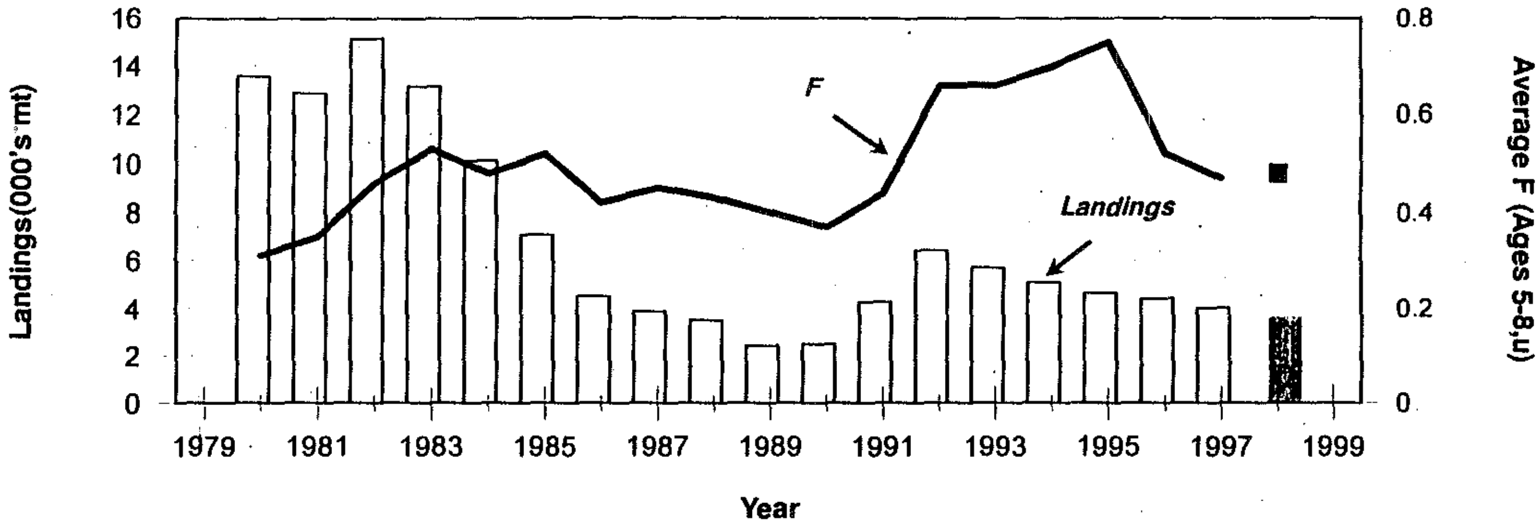


Figure D9. Trends in total commercial landings and fishing mortality for Gulf of Maine-Georges Bank American plaice, 1980 - 1997.

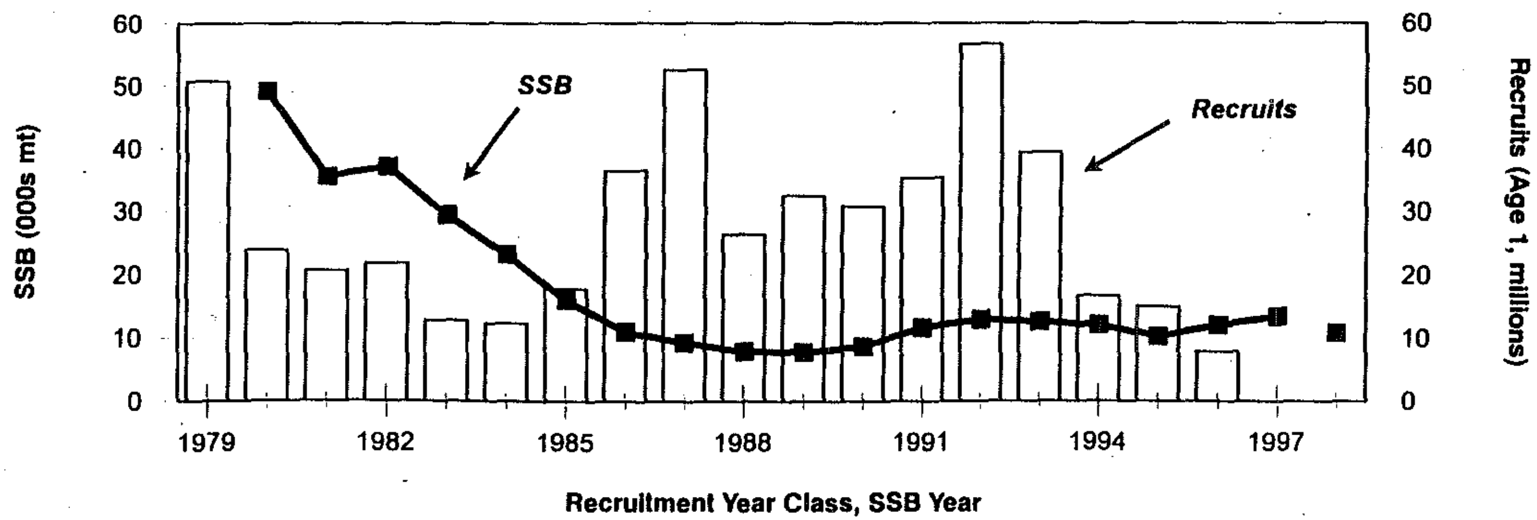


Figure D10. Trends in spawning stock biomass and recruitment for Gulf of Maine-Georges Bank American plaice, 1980-1997.

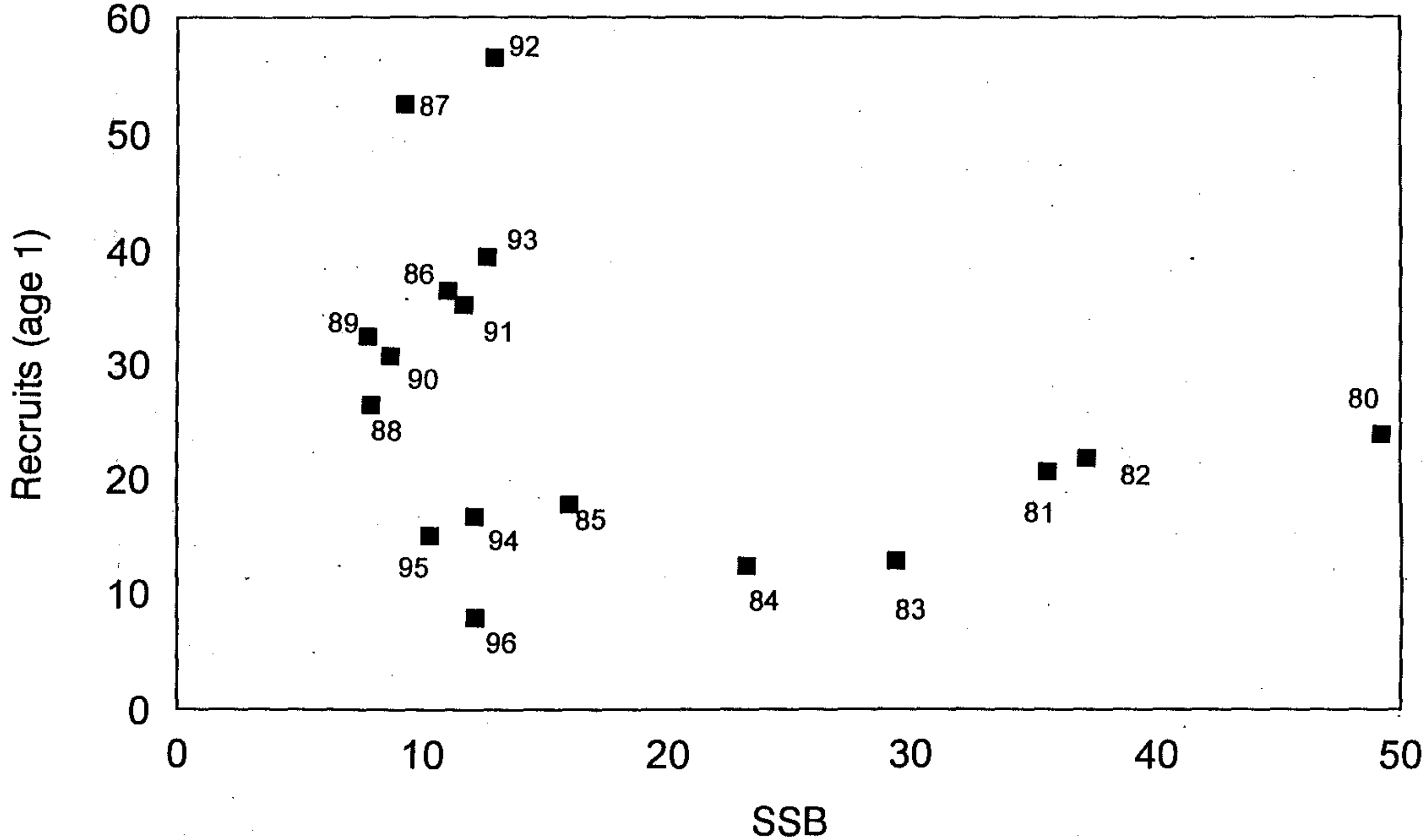


Figure D11. Spawning stock bioimass and recruits (age 1) for Gulf of Maine-Georges Bank American plaice.

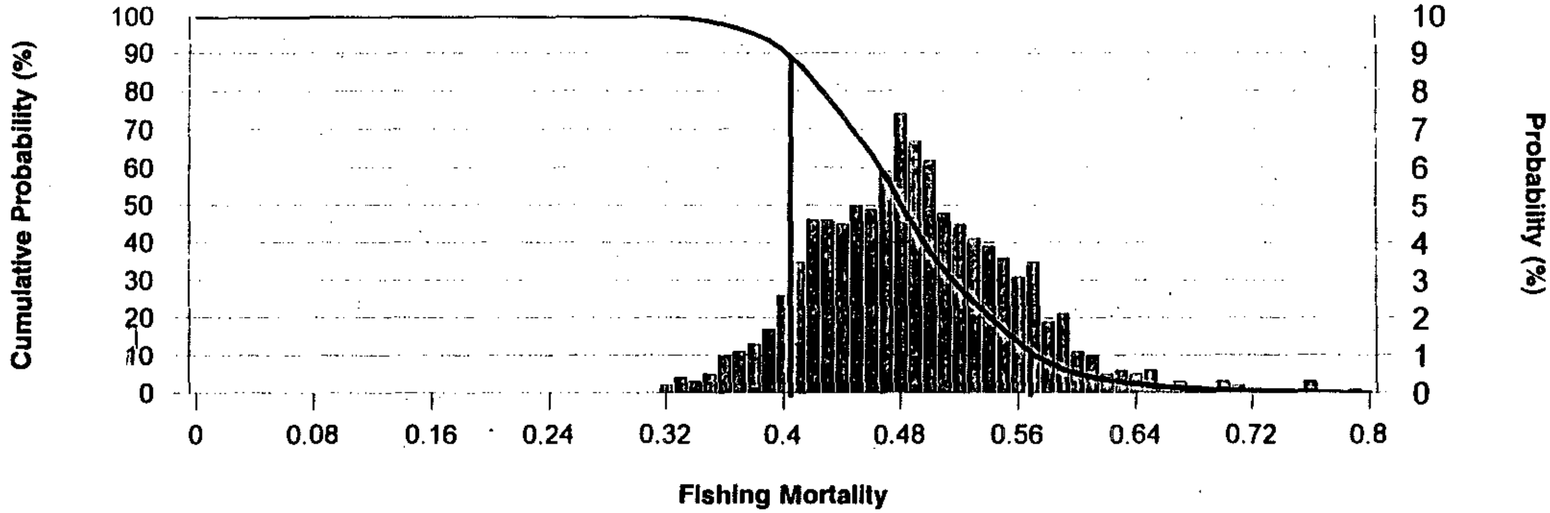


Figure D12. Precision of the estimates of the instantaneous rate of fishing (F) on the fully recruited ages (5+) in 1997 for Gulf of Maine-Georges Bank American plaice. The bar height indicates the probability of values within that range. The solid line gives the probability that F is greater than any selected value on the X-axis.

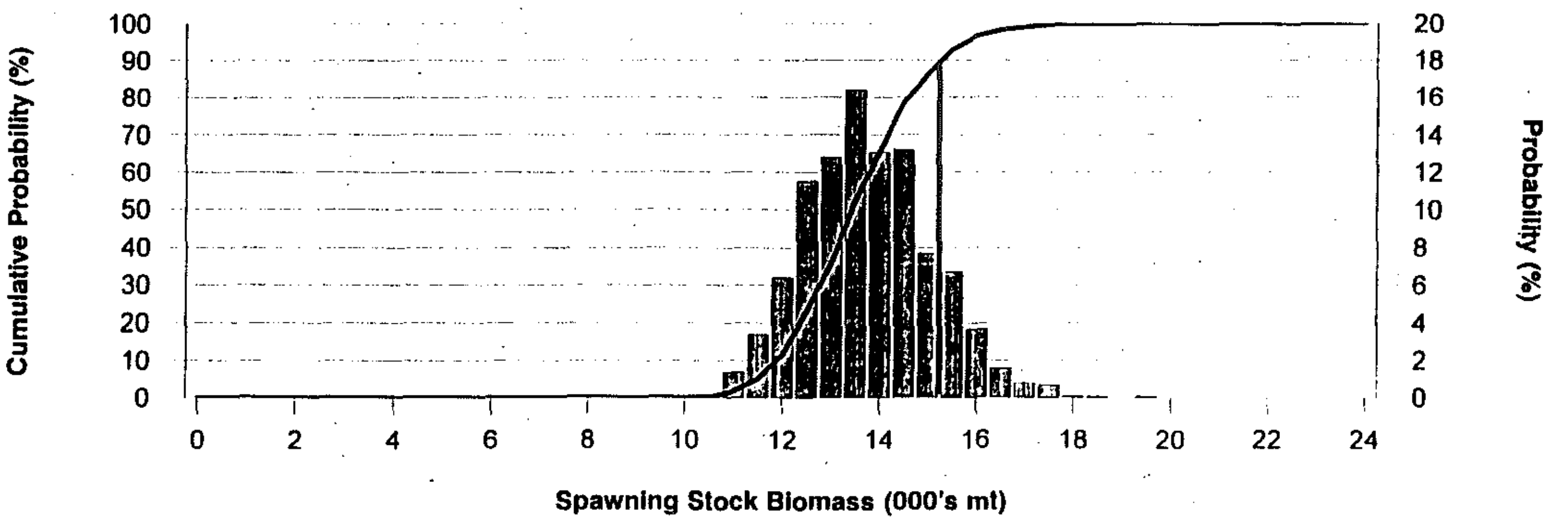


Figure D13. Precision of the estimates of spawning stock biomass (SSB) at the beginning of the spawning season for Gulf of Maine-Georges Bank American plaice, 1997. The bar height indicates the probability of values within that range. The solid line gives the probability that SSB is less than any selected value on the X-axis.

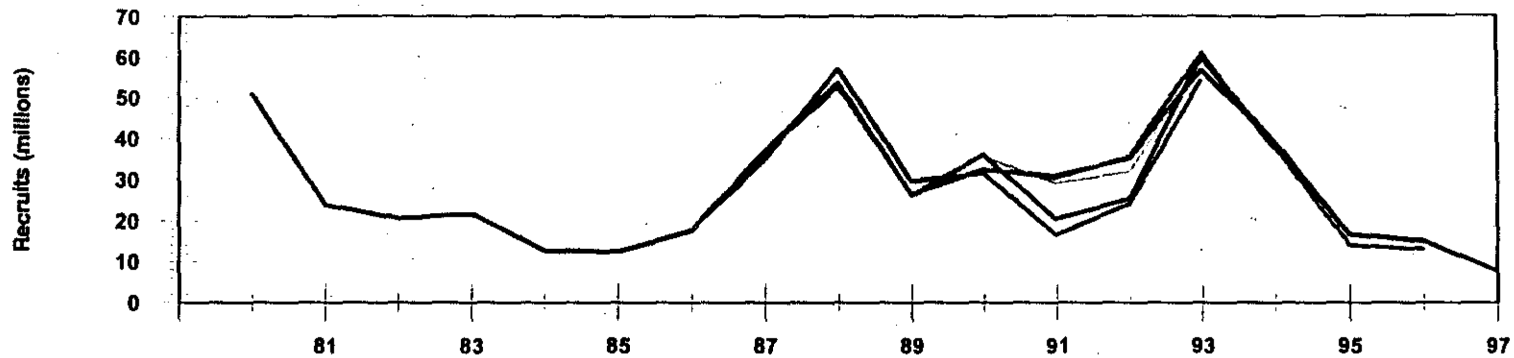


Figure D14.Retrospective analysis of Gulf of Maine--Georges Bank American plaice recruits at age 1 based on the final ADAPT VPA formulation, 1997-1993.

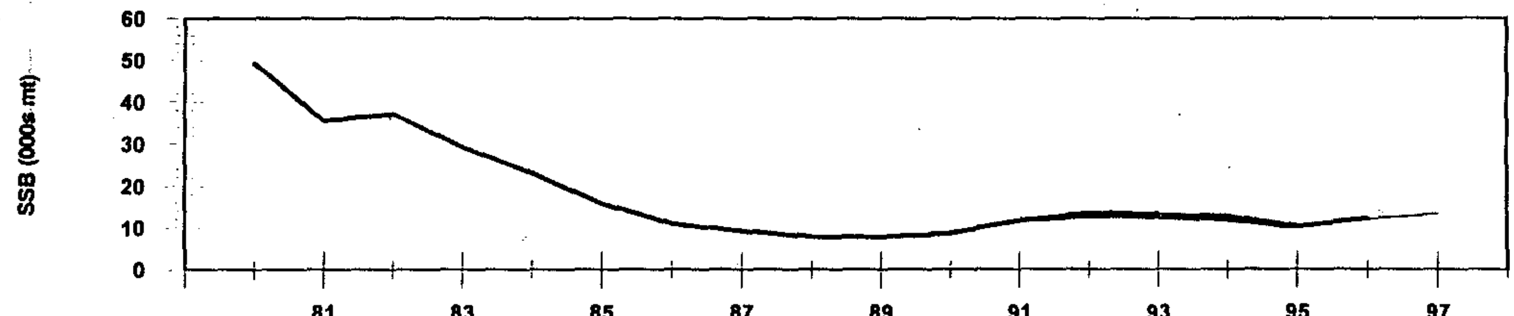


Figure D15. Retrospective analysis of Gulf of Maine--Georges Bank American plaice spawning stock biomass based on the final ADAPT VPA formulation, 1997-1993.

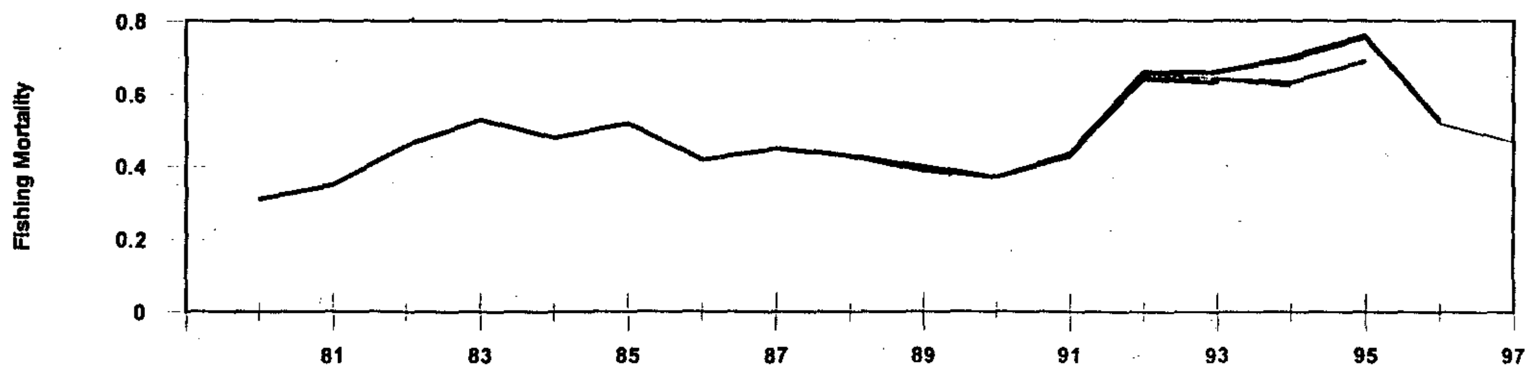


Figure D16. Retrospective analysis of Gulf of Maine--Georges Bank American plaice fishing mortality (average F, ages 5-8, unweighted) based on the final ADAPT VPA formulation, 1997-1993.

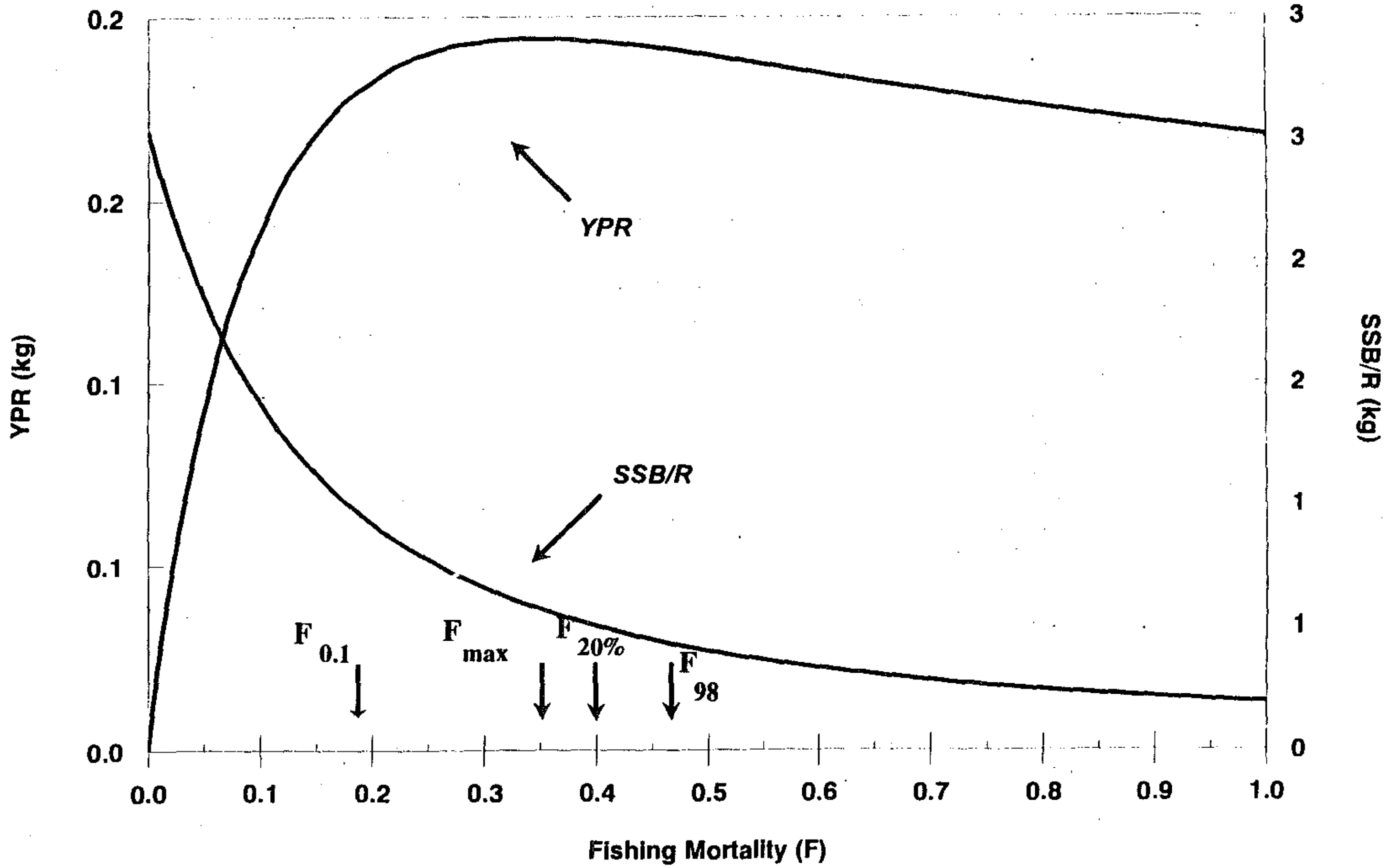


Figure D17. Yield per recruit (YPR) and spawning stock per recruit (SSB/R) for Gulf of Maine-Georges Bank American plaice.

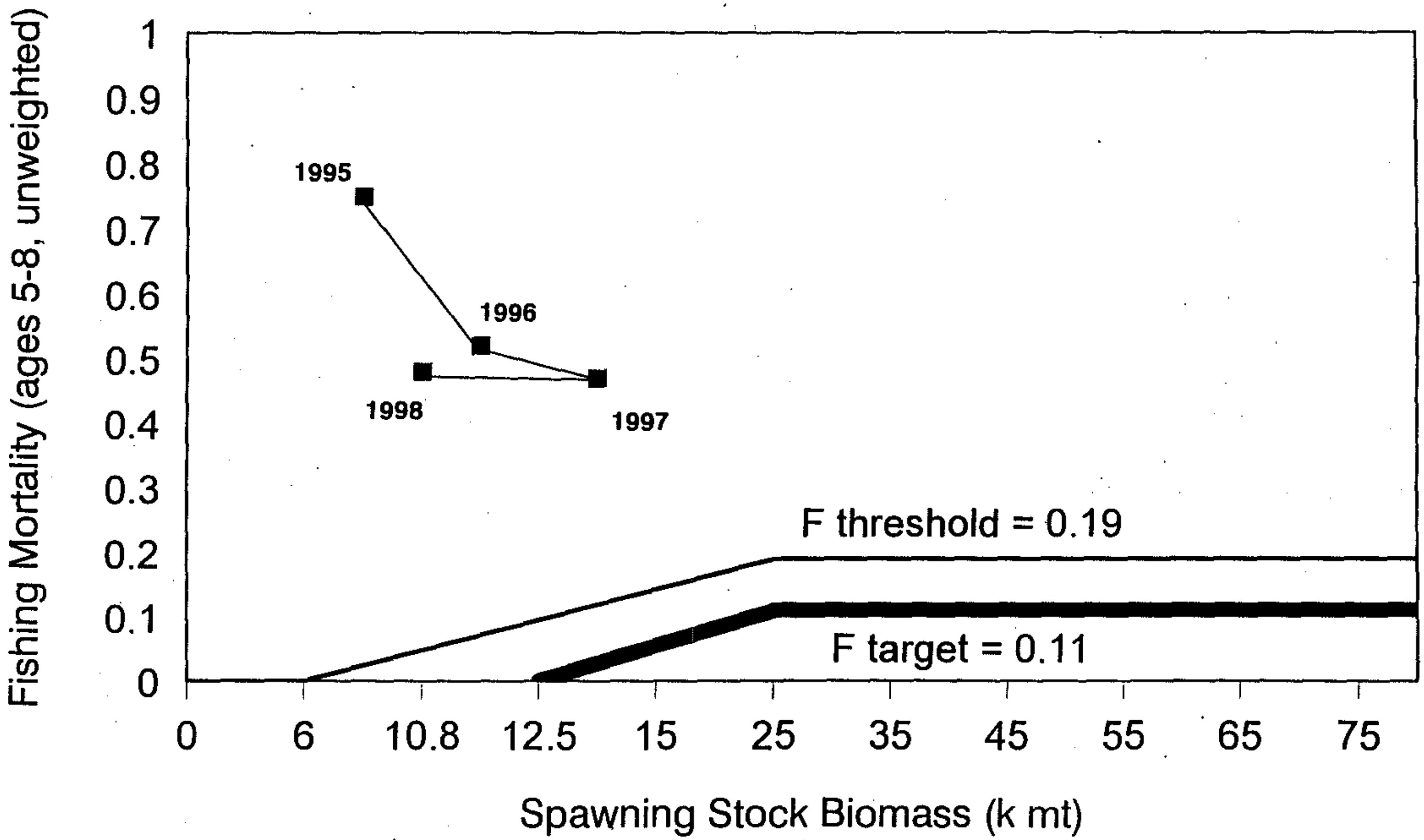


Figure D18. Proposed control rule and recent stock status for Gulf of Maine-Georges Bank American plaice.

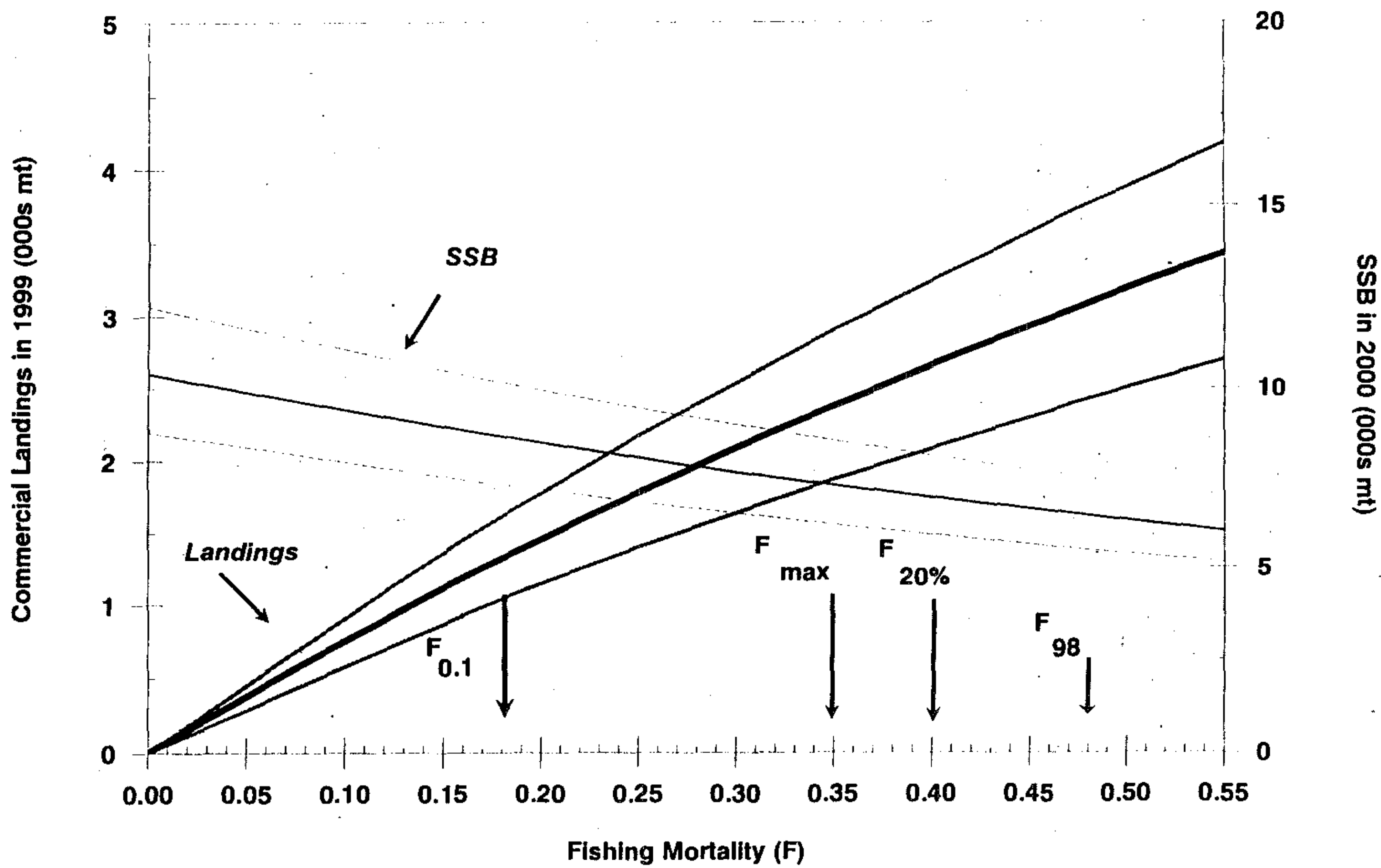
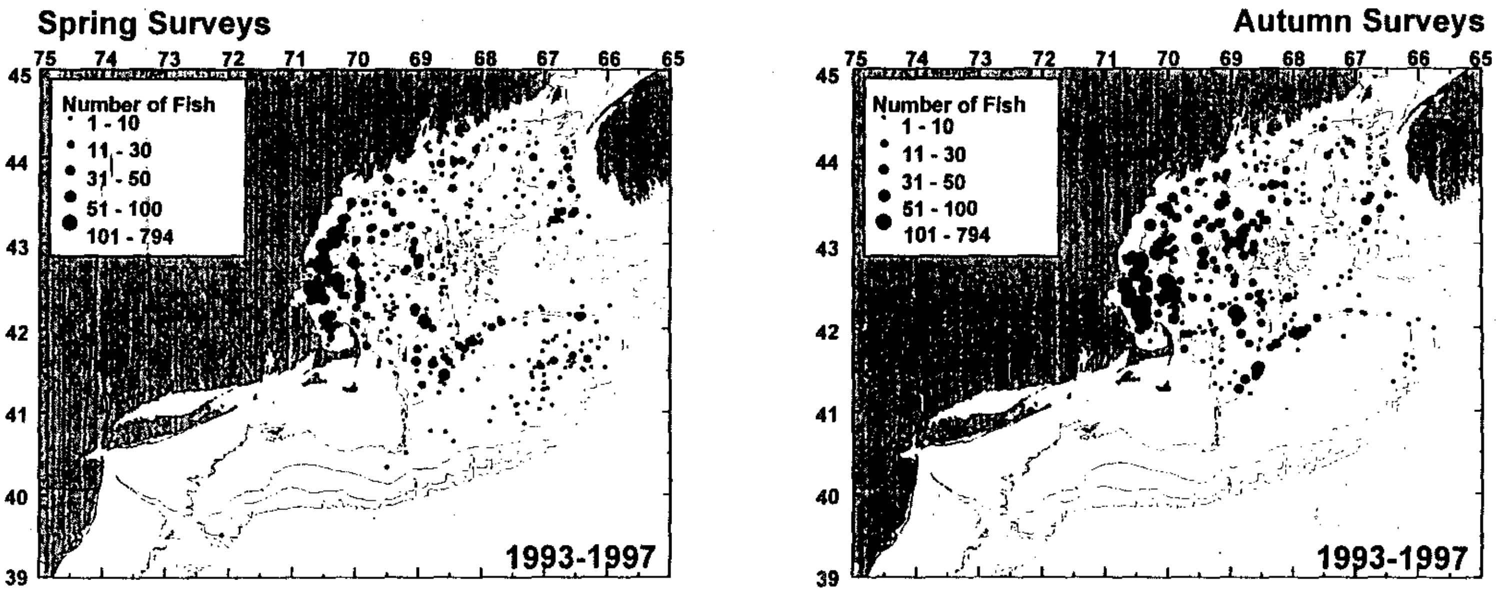


Figure D19. Predicted landings in 1999 and spawning stock biomasses in 2000 for Gulf of Maine-Georges Bank American plaice as a function of fishing mortality in 2000.



Appendix D1. Figure 1. Distribution of American plaice in the NEFSC spring and autumn bottom trawl surveys, 1993-1997.

Appendix D1. Table 1. Results of projections with F=0.0 in 1999-2000.

PROJECTION RUN: GM-GB American plaice 1998
INPUT FILE: apdis_0.in
OUTPUT FILE: apdis_0.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		3.597
1999	.000	
2000	.000	

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	10.802	1.499
1999	9.571	1.533
2000	10.487	1.428

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7.564	8.491	8.977	9.767	10.802	11.740	12.680	13.301	15.208
1999	6.185	7.170	7.671	8.490	9.514	10.508	11.462	12.157	13.612
2000	7.149	8.264	8.784	9.503	10.409	11.410	12.259	12.848	14.508

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.000000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	.693
1999	.380
2000	.625

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	28298.140	14176.900
1999	28204.640	14102.600
2000	28255.640	14180.830

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000
1999	7870.000	7870.000	12305.000	16667.000	23856.000	36417.000	52580.000	56601.000	56601.000
2000	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	3.601	.004
1999	.000	.000
2000	.000	.000

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.888	.081
1999	.000	.000
2000	.000	.000

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.711	.755	.780	.832	.889	.943	.989	1.019	1.079
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	.476	.082
1999	.000	.000
2000	.000	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.310	.358	.380	.421	.465	.524	.581	.623	.727
1999	.000	.000	.000	.000	.000	.000	.000	.000	.000
2000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Appendix D1. Table 2. Results of projections with $F_{0.1}$=0.19 (F threshold) in 1999-2000.

PROJECTION RUN: GM-GB American plaice 1998
INPUT FILE: apdis_19.in
OUTPUT FILE: apdis_19.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		3.597
1999	.190	
2000	.190	

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	10.802	1.499
1999	9.160	1.464
2000	8.630	1.150

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7.564	8.491	8.977	9.767	10.802	11.740	12.680	13.301	15.208
1999	5.933	6.863	7.351	8.123	9.109	10.057	10.960	11.634	13.027
2000	5.884	6.841	7.266	7.832	8.582	9.363	10.054	10.550	11.842

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.000000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	.693
1999	.268
2000	.105

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	28298.140	14176.900
1999	28204.640	14102.600
2000	28255.640	14180.830

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000
1999	7870.000	7870.000	12305.000	16667.000	23856.000	36417.000	52580.000	56601.000	56601.000
2000	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	3.601	.004
1999	1.389	.246
2000	1.309	.191

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597
1999	.865	1.008	1.091	1.219	1.387	1.542	1.695	1.799	2.082
2000	.872	1.007	1.078	1.173	1.299	1.431	1.544	1.624	1.831

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.888	.081
1999	.265	.033
2000	.253	.029

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.711	.755	.780	.832	.889	.943	.989	1.019	1.079
1999	.189	.214	.225	.242	.263	.286	.306	.319	.350
2000	.191	.208	.218	.233	.252	.271	.289	.303	.334

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	.476	.082
1999	.190	.000
2000	.190	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.310	.358	.380	.421	.465	.524	.581	.623	.727
1999	.190	.190	.190	.190	.190	.190	.190	.190	.190
2000	.190	.190	.190	.190	.190	.190	.190	.190	.190

Appendix D1. Table 3. Results of projection with $F_{20\%}$ = 0.40 in 1999-2000.

PROJECTION RUN: GM-GB American plaice 1998
INPUT FILE: apdis_40.in
OUTPUT FILE:
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		3.597
1999	.400	
2000	.400	

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	10.802	1.499
1999	8.728	1.391
2000	7.000	.910

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7.564	8.491	8.977	9.767	10.802	11.740	12.680	13.301	15.208
1999	5.668	6.540	7.013	7.742	8.690	9.582	10.432	11.082	12.411
2000	4.842	5.592	5.926	6.355	6.971	7.569	8.123	8.499	9.500

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.000000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	.693
1999	.165
2000	.004

RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	AVG RECRUITMENT	STD
1998	28298.140	14176.900
1999	28204.640	14102.600
2000	28255.640	14180.830

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH

BIRTH YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000
1999	7870.000	7870.000	12305.000	16667.000	23856.000	36417.000	52580.000	56601.000	56601.000
2000	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	3.601	.004
1999	2.661	.470
2000	2.086	.301

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597
1999	1.662	1.931	2.090	2.337	2.656	2.953	3.246	3.446	3.984
2000	1.390	1.619	1.724	1.873	2.071	2.285	2.458	2.575	2.906

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.888	.081
1999	.518	.064
2000	.451	.051

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.711	.755	.780	.832	.889	.943	.989	1.019	1.079
1999	.372	.420	.442	.475	.515	.560	.599	.625	.684
2000	.342	.372	.389	.417	.449	.483	.516	.540	.592

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	.476	.082
1999	.400	.000
2000	.400	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.310	.358	.380	.421	.465	.524	.581	.623	.727
1999	.400	.400	.400	.400	.400	.400	.400	.400	.400
2000	.400	.400	.400	.400	.400	.400	.400	.400	.400

Appendix D1. Table 4. Results of projections with F_{98}=0.48 in 1999-2000.

PROJECTION RUN: GM-GB American plaice 1998
INPUT FILE: apdis_48.in
OUTPUT FILE: apdis_48.out
RECRUITMENT MODEL: 3
NUMBER OF SIMULATIONS: 100

MIXTURE OF F AND QUOTA BASED CATCHES

YEAR	F	QUOTA (THOUSAND MT)
1998		3.597
1999	.480	
2000	.480	

SPAWNING STOCK BIOMASS (THOUSAND MT)

YEAR	AVG SSB (000 MT)	STD
1998	10.802	1.499
1999	8.589	1.367
2000	6.539	.843

PERCENTILES OF SPAWNING STOCK BIOMASS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7.564	8.491	8.977	9.767	10.802	11.740	12.680	13.301	15.208
1999	5.582	6.436	6.905	7.618	8.553	9.428	10.262	10.905	12.212
2000	4.546	5.238	5.545	5.944	6.514	7.067	7.578	7.917	8.849

ANNUAL PROBABILITY THAT SSB EXCEEDS THRESHOLD: 10.000000 THOUSAND MT

YEAR	Pr(SSB > Threshold Value)
1998	.693
1999	.140
2000	.000

RECRUITMENT UNITS ARE: 1000.000000 FISH
BIRTH

YEAR	AVG RECRUITMENT	STD
1998	28298.140	14176.900
1999	28204.640	14102.600
2000	28255.640	14180.830

PERCENTILES OF RECRUITMENT UNITS ARE: 1000.000000 FISH
BIRTH

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000
1999	7870.000	7870.000	12305.000	16667.000	23856.000	36417.000	52580.000	56601.000	56601.000
2000	7870.000	7870.000	12305.000	16667.000	26390.000	36417.000	52580.000	56601.000	56601.000

LANDINGS FOR F-BASED PROJECTIONS

YEAR	AVG LANDINGS (000 MT)	STD
1998	3.601	.004
1999	3.033	.535
2000	2.238	.321

PERCENTILES OF LANDINGS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597	3.597
1999	1.895	2.200	2.383	2.663	3.027	3.365	3.699	3.927	4.538
2000	1.491	1.745	1.851	2.012	2.220	2.447	2.630	2.757	3.112

DISCARDS FOR F-BASED PROJECTIONS

YEAR	AVG DISCARDS (000 MT)	STD
1998	.888	.081
1999	.595	.073
2000	.503	.057

PERCENTILES OF DISCARDS (000 MT)

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.711	.755	.780	.832	.889	.943	.989	1.019	1.079
1999	.428	.482	.507	.545	.592	.643	.688	.717	.785
2000	.382	.415	.433	.465	.501	.538	.576	.602	.660

REALIZED F SERIES FOR QUOTA-BASED PROJECTIONS

YEAR	AVG F	STD
1998	.476	.082
1999	.470	.000
2000	.470	.000

PERCENTILES OF REALIZED F SERIES

YEAR	1%	5%	10%	25%	50%	75%	90%	95%	99%
1998	.310	.358	.380	.421	.465	.524	.581	.623	.727
1999	.470	.470	.470	.470	.470	.470	.470	.470	.470
2000	.470	.470	.470	.470	.470	.470	.470	.470	.470

E. Southern New England / Mid-Atlantic Winter Flounder

TERMS OF REFERENCE

The following terms of reference were addressed for Southern New England/Mid Atlantic stock complex of winter flounder:

a. Update the status of the Southern New England winter flounder stock through 1997 and characterize the variability of estimates of stock size and fishing mortality.

b. On the basis of anticipated catches and abundance indicators in 1998, estimate stock size at the beginning of 1999 and provide projected estimates of catch and spawning stock biomass for 1999-2000 at various levels of F.

c. Comment on and revise, if necessary, the overfishing definition reference points for Southern New England winter flounder recommended by the Overfishing Definition Review Panel.

INTRODUCTION

The current assessment of the Southern New England/Mid-Atlantic stock complex of winter flounder is an update of the previous two assessments completed in 1995 at SARC 21 (NEFSC 1996) and in early 1998 by the Atlantic States Marine Fisheries Commission (ASMFC) Winter Flounder Technical Committee (ASMFC 1998). The SARC 21 assessment included catch through 1993, research survey abundance indices through 1995, catch at age analyzed by Virtual Population Analysis (VPA) for 1985-1993, and biological reference points based on yield and spawning stock biomass (SSB) per recruit analyses using partial recruitment and mean weight at age patterns from the VPA. The SARC 21 assessment concluded that the stock complex was over-exploited and at record low levels of spawning stock biomass. The ASMFC Technical Committee 1998 assessment used the ASPIC biomass dynamic (surplus production) model (Prager 1994, 1995) to assess the current status of the stock complex and estimate additional biological reference points. The ASMFC 1998 assessment concluded that fishing mortality in 1996 on the stock complex was substantially above the management target for 1996 of $F_{30\%}$. The current assessment updates landings and discard estimates, research survey abundance indices, and the VPA, yield per recruit, and ASPIC models through 1997-1998, as applicable. Finally, due to newly available NEFSC research survey and commercial fishery sample age data for 1980-1984, the survey and fishery catch at age series have been extended back to 1980 and 1981, respectively.

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. Winter flounder undergo migrations from estuaries where spawning occurs in the late winter and spring. Winter flounder reach a maximum size of around 2.25 kg (5 pounds; Bigelow and Schroeder, 1953) 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).

Management Summary

Current fishery management is coordinated by the ASMFC in state waters and the New England Fishery Management Council (NEFMC) in federal waters. Winter flounder fisheries in state waters are 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 1993-94, $F_{30\%}$ in 1995-98, and $F_{40\%}$ in 1999 through implementation of compatible, state-specific regulations.

Coastal states from New Jersey to New Hampshire having 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: 5 in for NJ and NY, 5.5 in for CT, 5 in for RI, and 6 in 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 primarily of the northeast U.S. EEZ. 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. Though the Plan 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. Days-at-sea controls were extended. Currently, any fishing by an EEZ-permitted vessel must be conducted with not less than 6 in diamond or square mesh in Southern New England east of 72° 30'. Winter flounder less than 12 in length may not be retained.

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 this and the previous two stock assessments, the definition of a separate Gulf of Maine complex has been maintained, based on results of tagging studies, and large differences in growth rates consistent with discrete oceanographic regimes between the Gulf of Maine and Southern New England (Howe and Coates, 1975). Additional analyses of life history characteristics and mixing within the Gulf of Maine may lead to future refinement of the complex's definition within the Gulf of Maine.

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. 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 (Figure 1).

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

DATA SOURCES

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 3,426 mt in 1997 (Table 1). During 1989-1993, an average of 42% 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 (21%) obtained from area 538 and divisions 61-62 (Table 2). Since 1993, an increasingly larger percentage of the commercial landings has been taken from area 521. For 1997, 69% of the landings were taken from area 521, 4% from area 526, 6 % from area 537, and 12% from area 539, with the remaining landings (9 %) obtained from area 538 and areas 611-622 (Table 2). Most landings are obtained from the EEZ (86%, 1989-1993 average) and the remainder from state waters. 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 such gears as handlines, pound nets, fyke nets, and gill nets each accounting for about 1% of total landings.

Recreational landings reached a peak in 1985 of 13.3 million fish (peak landed weight of 5,772 mt in 1984) but declined dramatically thereafter (Table 3). Landings from 1986 to 1996 averaged 3.3 million fish (1,497 mt) with the lowest estimated landings in 1992 of 0.8 million fish (393 mt). Landings in 1997 from the Southern New England/Mid Atlantic stock complex were 1.2 million fish (618 mt). The principal mode of fishing is private/rental boats. With the exception of 1986, 65 - 85% of recreational landings occurred from January to June (1986 division was 46%/54% spring to fall).

Sampling Intensity

Length samples of winter flounder are available from both commercial and recreational landings. In the commercial fishery, annual sampling intensity varied from 92 to 158 mt landed per 100 lengths measured during 1985-1993 (NEFSC 1996, Table 4). For 1981-1984, commercial sampling intensity varied from 50 to 264 mt per 100 lengths (Table 5). Supplementing port samples with sea samples in 1995 and 1996 resulted in overall sampling intensities of 63 mt per 100 lengths in 1995 and 138 mt per 100 lengths in 1996. Overall sampling intensity was 86 mt per 100 lengths in 1997 (Table 6).

In the recreational fishery, sampling intensity varied from 36 to 231 mt per 100 lengths during 1985-1993 (NEFSC 1996, Table 7). During 1981-1984, sampling intensity varied from 98 to 185 mt per 100 lengths (Table 8). During 1994-1997, sampling intensity varied from 63 to 86 mt per 100 lengths (Table 9).

Landed Age Compositions

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. Details of the analysis are presented in Howell (1996).

In the ASMFC 1998 assessment (ASMFC 1998), the Technical Committee attempted to construct 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 (Table 6). The Technical Committee concluded 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 work by the Technical Committee since the ASMFC 1998 assessment, commercial fishery port samples for 1995 and 1996 have been supplemented with commercial fishery sea sample length data for the second half of 1995 and 1996, in an attempt continue a reliable 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. In 1997, port sampling was adequate to develop the commercial fishery landings at age on a half-year, market category basis (Tables 6 and 12).

Also since the ASMFC 1998 assessment, archived NEFSC research survey and commercial fishery age samples have been 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. The commercial landings at age were compiled on the same market category, quarterly or half-year basis as the 1985-1997 landings.

The total fishery catch series was not extended back to 1980 because the recreational catch estimates for 1980 are not comparable to those in 1981 and later years, due to methodological changes.

Recreational landings at length were estimated seasonally and geographically. Spring landings were divided into 2 regions; 1) Massachusetts and Rhode Island and 2) Connecticut and south. 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, and the 1981-1984 period, which used NEFSC spring age-length keys to age both area length frequencies.. Age composition of fall recreational data was developed using the NEFSC autumn survey age-length keys for all areas combined. (Table 12).

Discard estimates and age compositions

In the SARC 21 assessment (NEFSC 1996), the Working Group and the SARC concluded that there were too few sea sampling trips in which winter flounder were caught to adequately characterize the overall ratio of discards to landings in the commercial fishery. The sea 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 sea 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 autumn) were smoothed using a three point moving average, then filtered through a mesh selection ogive (Simpson 1989) for 4.5 in mesh (1984-1989), 5 in mesh (1990-1992, fall 1993) or 5.5 in mesh (spring, 1993). The 5.5 in mesh selection curve was calculated using the 5 in curve adjusted to an L_{50} for 5.5 in 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 12 and 13). In this assessment, this same method using the 4.5 in 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 Technical Committee meetings since 1995, the group has considered the SARC 21 survey length-mesh selection method, NEFSC sea sample data, and NER Vessel Trip Report (VTR) data as sources of information to use in the estimation of commercial fishery discards for 1994-1997, with a focus on the latter two sources. The Committee examined the characteristics of both the sea sample 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 (Table 10). 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. The sea sample length frequency samples were judged adequate to directly characterize the proportion discarded at length (Table 11). 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 21 assessment, 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 per half-year. NEFSC Spring and Fall survey age-length keys were used to convert the discard length frequency to age (Table 12).

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 1995 of 69,000 fish.. In 1997, 84,000 fish were estimated to have been discarded (Table 3). If recreational discards are assumed to have the same average weight per fish as spring commercial discards during 1985-1993, the total weight of recreational discards ranged from 15 mt in 1992 to a high of 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 12 and 13; 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 this assessment. 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 in minimum 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. The SARC 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 (Tables 12 and 13).

Mean Weight at Age

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 1981-1997 are given in Table 13. 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 4,337 mt (8.3 million fish) in 1997. The SARC 21 assessment (NEFSC 1996) included catch at age from 1985-1993. In this assessment, the catch at age matrix has been updated through 1997 by supplementing commercial fishery port samples with sea sample data in 1995 and 1996, updating with 1997 data, and by extending the time series back to 1981 with the use of newly available research survey and commercial fishery age data. Total catch and mean weights at age as aggregated for input to the VPA (ages 1-7+) are presented in Table 14.

Research Survey Stock 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 autumn (1963-1997) and spring (1968-1998) NEFSC bottom trawl surveys. Indices from the spring and autumn 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.

Mean weight per tow and number per tow indices for the spring and autumn time series are presented in Table 15. Although the indices exhibit considerable year-to-year variability, both surveys follow a trend similar to commercial landings. 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 both survey series have generally increased since 1993 (Figure 2).

Massachusetts

The Massachusetts Division of Marine Fisheries (MADMF) spring survey from 1978-1998 was used to characterize abundance of winter flounder. Survey areas from east and south of Cape Cod were used in the analysis. The MADMF mean number per tow indices steadily declined from a high value of 53.61 in 1979 to a low of 10.57 in 1992, but have since increased to 30-40 fish per tow during 1995-1998. Mean weight per tow indices have varied in a similar manner over the time series (Tables 16 and 17, Figure 2).

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 1998 value was 0.16 fish per haul (Table 18).

Rhode Island

The Rhode Island Division of Fish, Wildlife and Estuarine Resources (RIDFW) has conducted a spring and autumn survey since 1979 based on a stratified random sampling design. Three major fishing grounds are considered in the spatial stratification, including Narragansett Bay, Rhode Island Sound and Block Island Sound.

Survey results are expressed as un-weighted catch per tow (Tables 16 and 17). Spring survey indices from 1979-1997 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 5.00 kg per tow and 19.22 fish per tow in 1998 (Figure 2).

A seine survey, conducted from June to October since 1986, 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 low levels of recruitment. The index of the 1998 year class is the lowest of the time series (Table 18).

Connecticut

The Connecticut Department of Environmental Protection (CTDEP) trawl survey program was initiated in May 1984 and encompasses both New York and Connecticut waters of Long Island Sound. Spring indices of mean catch per tow were used as indices of winter flounder abundance (Tables 16-18). CTDEP indices experienced several years between 1988 and 1991 of high values, declined through the 1990s, and have since increased during 1996-1997. A separate young of the year survey index shows above average recruitment during 1994-1996 (Table 18).

New York

The New York Department of Environmental Conservation (NYDEP) 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 17 and 18). 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 coastal waters of the state since 1988. Surveys are conducted bi-monthly from April to January, although the time sequence has undergone some modifications since 1988. Survey indices (mean number per tow in April) tended to decline between 1988 and 1994, and has been quite variable since 1994, with a time series low in 1996 and a time series high in 1997 (Table 17).

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 retransformed annual geometric means, presented in Table 18, indicate variable annual recruitment with a large year class in 1990. The 1994 index indicates above average recruitment.

Coherence among surveys

The surveys conducted by NEFSC and several states have each produced indices of winter flounder abundance. The coherence among surveys through 1998 was examined by correlation analysis. Surveys correlate best for ages 3-5, with poorest correlation among surveys for ages 1 and 7+. Since each of these surveys sample distinct geographical regions, it is possible that they provide indices for different components of the stock. NEFSC surveys present the most optimistic (increasing) trends in stock abundance, while RIDFW surveys are the most pessimistic. The performance of individual surveys in terms of tracking year class strength varies from survey to survey. This is a function of inter-annual differences in availability.

MORTALITY AND STOCK SIZE ESTIMATES

Natural Mortality

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 Working Group felt an M=0.2, which represents a maximum age of 15, was representative of the stock complex throughout its range.

Total Mortality from Mark and Recapture Data

Total mortality in two components of the stock were evaluated using most 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 has dropped to 0.37 in 1996-1997.

Virtual Population Analysis

Tuning

Total catch at age was calibrated using the NEFSC Woods Hole Assessment Toolbox (WHAT) version 1.05 of the ADAPT VPA (Conser and Powers 1990) with abundance at age indices (Tables 18-22) from several bottom trawl surveys: NEFSC spring bottom trawl ages 1-7+, NEFSC autumn ages 1-4 (advanced to tune January 1 abundance of ages 2-5), Massachusetts spring ages 1-7+, Rhode Island autumn age 0 (advanced to tune age-1), Rhode Island spring ages 1-7+, Connecticut spring ages 1-7+, New York ages 0-1, Massachusetts summer seine index of age-0 (advanced to tune age-1), and Delaware juvenile trawl survey age-0 (advanced to tune age-1). NEFSC autumn survey catch of ages 5+ were not used because there was little contrast in that series and poor correspondence with other indices. New Jersey trawl survey indices were excluded from calibration because the series began in 1992, although the survey may be useful in future assessments. New York indices were excluded from the final calibration because residuals in preliminary VPA runs were strongly trended and the survey covers a small geographic range.

Both 1981-1997 and 1985-1997 VPA runs were reviewed. There were initial concerns over the intensity of commercial fishery sampling in 1981 and 1984 and the extension of the commercial fishery discards by the survey/mesh retention method back to 1981, with regard to possible effects on the residual pattern and precision of the VPA. The precision of the terminal year estimates, estimated F, and estimated stock size for comparable time periods varied little, however, between VPA runs beginning in 1981 and 1985. No exceptional magnitude, unusual pattern, or significant correlation of residuals was evident in the longer run for the expanded 1981-1984 time period when compared to the 1985-1997 run. Given the better historical perspective of the longer run, encompassing a period of peak catches from the stock, the longer term 1981-1997 VPA was selected as the final calibration (Table 23).

Parameter estimates in the final calibration were moderately precise (initial coefficients of variation ranged from 0.25 at age-4 to 0.44 at age-1 and were not significantly correlated. As in the SARC 21 VPA there were, however, some moderate patterns in residuals. Nearly all surveys had years in which all observations deviated from predicted values in the same direction. For example, in 1987, all seven

NEFSC spring residuals were negative. Similar residual patterns existed for NEFSC autumn 1993, Massachusetts 1991 and 1994; Rhode Island 1986, 1987, 1991-94; and Connecticut 1985, 1986, and 1989-91. As illustrated by the correlation analysis of tuning indices, there are strong year effects in survey indices, due to annual distribution patterns or local recruitment events. However, in concert, the surveys appear to provide geographically balanced tuning. Although Connecticut age-1 residuals showed a negative trend over time, the index was included in the final calibration because it represented the Long Island Sound component of the stock complex. Iterative reweighting was not used because agreement with estimated catch at age was not necessarily assumed to be an accurate indication of survey performance.

Exploitation Pattern

The exploitation pattern has been variable from year to year, but with the exception of 1996, age-4 fish have been over 90% recruited since 1986. An average exploitation pattern for 1996-1997 was calculated as the ratio of the geometric mean fishing mortality rates at ages 1-3 to the geometric mean of the fishing mortality rates at age 4-6. The resulting pattern indicates 2% recruitment at age-1, 25% at age-2 and 61% at age-3, reflecting recent conditions in the fisheries. For purposes of yield-per-recruit calculations and catch and stock biomass projections, full (100%) recruitment was assumed at ages 4 and older.

Fishing Mortality

The fully recruited fishing mortality rate (F, averaged over ages 4-6) fluctuated between 0.45 and 1.38 during the 1981-1993, and has since declined to 0.31 in 1997. Fully recruited fishing mortality has been below 0.5 since 1993 (Figure 3). Total biomass F (weighted by mean stock-biomass over ages 1-7+) in 1997 was 0.24.

Stock Biomass

With maturity as estimated in O'Brien et al. (1993), spawning stock biomass (SSB) steadily declined over the period 1983 to 1994. SSB in 1994 was 3,420 mt, the lowest in the 1981-1997 VPA time series, and only 23% of the peak 1983 estimate of 14,765 mt. SSB has increased since 1994, reaching 8,558 mt in 1997 (Figures 4-6). Total stock biomass (TSB), estimated at mid-year using catch mean weights at age, peaked in 1984 at 34,061 mt. TSB steadily declined to 7,983 mt in 1992. Since then, TSB has increased to 17,928 mt in 1997 (Table 23, Figure 5).

Recruitment

Recruitment estimates, age 1 winter flounder in year i+1, followed a steady downward trend during 1981-1988, from 62.9 million fish in 1981 (1980 year class) to 8.8 million fish at the start of 1992 (1991 year class). The 1998 year class, as estimated from available survey indices and survey catchabilities estimated from tuning, is about 16.8 million fish. The 1981-1998 VPA time series geometric mean recruitment at age-1 is 23.5 million fish; the arithmetic mean is 27.6 million fish (Figures 4 and 6).

Retrospective analysis

A retrospective analysis of the VPA was conducted back to a terminal catch year of 1990. This analysis indicated a tendency for overestimation of fully recruited F in the unconverged portion of the VPA. Overestimation of F ranged from 66% for 1994 to 13% for 1996. The retrospective estimation of age-1 recruits indicated a tendency for overestimation during 1990 to 1993 and 1995, and a tendency for underestimation in 1994 and 1996 to 1997. The pattern for spawning stock biomass has been a tendency for overestimation since 1990 (Table 24, Figure 7).

Precision of Stock Size, F, and SSB estimates

The precision of the 1997 stock size, fully recruited F (ages 4-6), and SSB estimates from VPA was evaluated using bootstrap techniques (Efron 1982). Two 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 25. Bootstrap estimates of stock size at age indicate low bias (<10%) for ages 2-7+, and about 10% positive bias at age-1, suggesting that the abundance of the 1997 year class in 1998 at age-1 may be overestimated by the non-linear least squares (NLLS) point estimate from the VPA.

Bootstrapped estimates of spawning stock biomass indicate a CV of 12%, with low bias (bootstrap mean estimate of spawning stock biomass of 8,728 mt compared with VPA estimate of 8,559 mt). There is an 80% probability that spawning stock in 1997 was between 7,500 mt and 10,000 mt (Figure 8).

The bootstrap estimates of standard error associated with fully recruited fishing mortality rates indicate medium precision. Coefficients of variation for F estimates ranged from 20% at age 3 to 31% at age 1. There is an 80% probability that fully recruited F in 1997 was between 0.26 and 0.38 (Figure 8).

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit

Biological reference points were calculated using the Thompson and Bell (1934) yield per recruit model. Input parameters are summarized in Table 26. Natural mortality was constant at 0.2. The partial recruitment at age was determined from the 1996-1997 exploitation pattern observed in the VPA results as described above. The proportion mature was based on the maturity ogive from O'Brien et al., 1993. These proportions were intermediate among survey data from New Jersey, Connecticut, New York, Massachusetts, and NEFSC. Average stock and catch weights were based on the geometric mean weights at age from 1996-1997. Due to low sample sizes among older ages, a curve was fitted to the data set and the fitted mean weights at age were used for ages 10 and greater. The proportion of the fishing and natural mortality assumed to occur prior to spawning was equal to 20% of the annual total. The model was applied using a maximum true age of 15.

The calculated fishing mortality corresponding to maximum yield per recruit was $F_{max} = 0.71$; $F_{0.1} = 0.22$ (Table 26). At F_{max}, 12.2% of the maximum spawning potential is achieved. The $F_{40\%}$ target defined for 1999 in the ASMFC FMP occurs at $F_{40\%} = 0.20$; the target for 1997 = $F_{30\%} = 0.29$, the ASMFC overfishing definition of $F_{25\%} = 0.35$, and $F_{20\%} = 0.43$. At the 1997 fully recruited F of 0.31, the spawning stock biomass per recruit is 28% of the maximum potential (Figure 9).

ASPIC Surplus Production Model

The ASPIC model (A Surplus Production model Incorporating Covariates) (Prager 1994, 1995) was used in this assessment to estimate maximum sustainable yield reference points. ASPIC is a biomass dynamic model that assumes logistic growth, but does not require either age data or estimates of natural mortality. The model is non-equilibrium, and requires the use of fishery or survey biomass indices and catch. The model is based upon the Schaefer model:

$dB_t/dt = rB_t - (r/K)B_t^2 - C_t$, where
B_t = biomass in year t
r = intrinsic rate of growth
K = carrying capacity or maximum stock biomass
C_t = catch biomass in year t

ASPIC assumes that the following relationship exists between biomass and biomass indices:

$$b_{it} = q_i B_t e^{\delta},$$

where

b_{it} = the i^{th} biomass index in year t
q_i = the catchability of the i^{th} biomass index
B_t = population biomass in year t
e^{δ} = a lognormally distributed measurement error.

The model estimates the following parameters: ratio of starting biomass to the biomass that yields maximum sustainable yield (B1R), survey index catchability coefficients (q_i), maximum stock yield (MSY) and the intrinsic rate of growth (r). The intrinsic rate of growth (r) is a constant that incorporates growth, recruitment and non-fishing mortalities. The model calculates fishing mortality (F_{bio}= catch in biomass /average stock biomass), fishing mortality that achieves maximum sustainable yield (F_{msy}= r/2), biomass that yields maximum sustainable yield (B_{msy}= K/2) and the carrying capacity (K= 4MSY/r). The fishing mortality rate derived from this model is a biomass removal rate and is not directly comparable to ASMFC age-based $F_{40\%}$ reference point derived from the Thompson and Bell (1934) yield per recruit model. The model assumes that all biomass is fully exploitable. In the case of winter flounder, partially recruited age groups contribute to the biomass, thus the estimate of F_{bio} is sensitive to the contribution to biomass of cohorts before they fully recruit to the fishery.

Several sensitivity runs of the model were made using various combinations of surveys and re-weighting schemes. Total catch used in the model included commercial landings and discards and recreational landings and discards through 1997. Survey biomass indices that were available included the NEFSC spring and fall surveys, RIDFW spring and fall surveys, and MADMF spring survey. A biomass index was constructed for CTDEP survey by converting the number per tow at age to weight at age using mean weights at age. However, this index was negatively correlated with some of the indices and therefore could not be used in the model.

The SARC considered two run configurations that provided similar parameter estimates. The first run used the NEFSC spring and fall surveys, the RIDFW spring and fall surveys and the MADMF spring survey. This run provided estimates of MSY = 9,665 mt and r = 0.67. Correlation among some of the survey indices was low (ranging from 0.00 to 0.75), however, and some of the indices had very low R-squared values (ranging from -0.01 to 0.61). Furthermore, this run configuration proved to be very sensitive to starting conditions, occasionally converging to an unrealistic solution when started using various random seed, initial parameter, or initial penalty values. The second run configuration used only the NEFSC spring and fall survey series. This run provided estimates of MSY = 7,879 mt and r = 0.76. Correlation among the two surveys was high (0.68) and R-squared values were high (0.62 and 0.79). Although the second run provided a "better fit" and was more stable with respect to starting conditions and minor changes to the input data, the SARC felt that the run including all five surveys was potentially more useful in terms of reflecting local changes in stock abundance (i.e., in Southern New England bays and estuaries).

To increase the utility and reliability of the five index run configuration, the SARC elected to fix the survey catchability coefficients (q) to correspond to VPA biomass levels by regressing the individual survey biomass indices against VPA mean biomass estimates. The resulting regression coefficients then serve as fixed qs in the ASPIC model estimation of MSY and r. In this configuration, the ASPIC five survey run serves simply as a biological reference point estimation tool, analogous to a yield per recruit analysis, rather than as an independent stock assessment model. With fixed qs, bootstrap estimates of the variance of the estimated parameters will be biased low compared to unconstrained values. The variance estimated from 500 bootstrap trials of the unconstrained five index run was used to calculate the 10^{th} percentile of the point estimate of F_{msy} for calculation of the overfishing definition target fishing mortality rate for the stock as specified by the

NMFS Overfishing Definition Review Panel (Applegate et al. 1998).

The five index, fixed q run provided estimates of total stock biomass very similar to those from VPA (Figure 10), and estimates of MSY = 10,220 mt, r = 0.74, K = 55,600 mt, B_{msy} = 27,810 mt (the proposed overfishing definition biomass target), and F_{msy} = 0.37 (the proposed fishing mortality threshold; Table 27, Figure 11). For the current exploitation pattern estimated by VPA, F_{msy} = 0.37 corresponds to a fully recruited fishing mortality rate of F = 0.59. The proposed biomass based target fishing mortality to be used when stock biomass is greater than B_{msy} was estimated to be F_{target} = 0.24, corresponding to a fully recruited F = 0.33 (Figure 11). These values are about 10-25% higher than those estimated by the Overfishing Definition Review Panel (MSY = 8,200 mt, r = 0.64, K = 51,600 mt, B_{msy} = 25,800 mt, F_{msy} = 0.32, F_{target} = 0.19; Applegate et al. 1998), due to the inclusion of discarded catch and updated catch and survey data in the current analysis.

The SARC proposes that the Overfishing Definition Review Panel recommendations for SNE/MA Winter Flounder incorporated in NEFMC Amendment 9, as updated by the five index, fixed survey catchability run in this assessment, be adopted to meet SFA requirements. Stock biomass in 1997 was estimated to be 17,928 mt, 65% of B_{msy}, and fully recruited F was estimated to be 0.31 in 1997, equivalent to a total biomass F = 0.24, 65% of F_{msy} and equal to the total biomass fishing mortality target of F_{target} = 0.24 (Figure 11). The table below summarizes current and proposed reference points and current and projected fishing mortality rates and biomass for SNE/MA winter flounder estimated in this assessment:

Source	Fishing Mortality or Biomass	Biomass Based or Weighted	Fully Recruited
ASMFC Rebuilding Target for 1999	$F_{40\%}$	0.16	0.20
ASMFC Target for 1995-98	$F_{30\%}$	0.22	0.29
ASMFC Target for 1993-94	$F_{25\%}$	0.25	0.35
Certified NEFMC Amend. 9 Threshold Reference Point	F_{msy}	0.37	0.59
Certified NEFMC Amend. 9 5 Year Rebuilding Target Reference Point	$F_{target\ 5}$	0.21	0.28
Certified NEFMC Amend. 9 10 Year Rebuilding Target Reference Point	$F_{target\ 10}$	0.24	0.33
SARC 28 VPA	F_{97}	0.24	0.31
SARC 28 Projection	F_{98}	0.27	0.39
Certified NEFMC Amen. 9 Reference Point	B_{msy}	27,810 mt	
SARC 28 VPA	B_{97}	17,928 mt	
SARC 28 Projection	B_{98} at F_{98}	20,200 mt	

PROJECTIONS FOR 1998-2000

Stochastic projections were made based on 200 bootstrapped VPA realizations of numbers at age in 1998. Weights at age in the stock, landings, and discards were estimated as the weighted (by number landed) geometric mean weight at age from 1996-1997, to reflect recent conditions in the fisheries. Partial recruitment to the fishery and percentage discarded were similarly estimated as the geometric mean of VPA estimates for 1996-1997. Recruitment was treated as the median of the 1981-1998 estimates by resampling the VPA estimated recruitment at age-1 for that period (arithmetic mean = 27.6 million, geometric mean = 23.5 million, median of 200 bootstrap realizations = 23.5 million).

Based on the expected commercial fishery landings for 1998 of 3,719 mt and the relative proportions during 1996-1997 of commercial landings, commercial discard, recreational landings, and recreational discards, total landings in 1998 were projected to be 4,500 mt, about 94% of the total 1998 projected catch of 4,800 mt. This level of catch in 1998 is projected to result in a 1998 fully recruited fishing mortality of 0.39, corresponding to a total biomass F of 0.27 (Table 28). At this rate of fishing mortality in 1998, median spawning stock biomass is expected to increase to 10,200 mt, and median total biomass to 20,200 mt.

Applying the NEFMC FMP Amendment 9 five year rebuilding control rule to the 1998 total stock biomass (biomass between 0.5 B_{msy} and B_{msy}, rebuild to B_{msy} in 5 years) implies a target total biomass fishing mortality rate of $F_{target\ 5} = 0.21$ for 1999 (Figure 11), corresponding to a fully recruited fishing mortality of $F_{target\ 5} = 0.28$ for 1999. Applying the NEFMC FMP Amendment 9 ten year rebuilding control rule to the 1998 total stock biomass (biomass between 0.5 B_{msy} and B_{msy}, rebuild to B_{msy} in 10 years) implies a target total biomass fishing mortality rate of $F_{target\ 10} = 0.24$ for 1999 (Figure 11), corresponding to a fully recruited fishing mortality of $F_{target\ 10} = 0.33$ for 1999.

Applying the ASMFC FMP fully recruited fishing mortality rate target for 1999 implies a rate of $F_{40\%} = 0.20$ for 1999. Projections of landings, discards, and spawning stock biomass, and total stock biomass were estimated for five fully recruited fishing mortality rates during 1999-2000: $F_{40\%} = 0.20$, $F_{target\ 5} = 0.28$, $F_{target\ 10} = 0.33$, $F_{25\%} = 0.35$, and $F_{98} = 0.39$ (Table 28).

If fully recruited fishing mortality is reduced to $F_{40\%} = 0.20$ during 1999-2000, landings are expected to decrease in 1999 to 2,700 mt and then increase to 3,400 mt in 2000 (Table 28, Figure 12). At $F_{40\%} = 0.20$, spawning stock biomass is expected to increase to 11,800 mt in 1999 and to 14,300 mt in 2000, and total stock biomass is expected to increase to 23,000 mt in 1999 and to 27,500 mt in 2000.

If fully recruited fishing mortality is reduced to $F_{target\ 5} = 0.28$ during 1999-2000, landings are expected to decrease in 1999 to 3,600 mt and then increase to 4,300 mt in 2000. At $F_{target\ 5} = 0.28$, spawning stock biomass is expected to increase to 11,700 mt in 1999 and to 13,400 mt in 2000, and total stock biomass is expected to increase to 22,500 mt in 1999 and to 26,000 mt in 2000 (Table 28, Figure 12).

If fully recruited fishing mortality is reduced to $F_{target\ 10} = 0.33$ during 1999-2000, landings are expected to decrease in 1999 to 4,200 mt and then increase to 4,800 mt in 2000. At $F_{target\ 10} = 0.33$, spawning stock biomass is expected to increase to 11,600 mt in 1999 and to 12,800 mt in 2000, and total stock biomass is expected to increase to 22,100 mt in 1999 and to 25,100 mt in 2000 (Table 28, Figure 12).

If fully recruited fishing mortality is decreased to $F_{25\%} = 0.35$ during 1999-2000, landings are expected to remain stable in 1999 at 4,500 mt and then increase to 5,000 mt in 2000. At $F_{25\%} = 0.35$, spawning stock biomass is expected to increase to 11,500 mt in 1999 and to 12,500 mt in 2000, and total stock biomass is expected to increase to 22,000 mt in 1999 and to 24,700 mt in 2000 (Table 28, Figure 12).

If fully recruited fishing mortality is maintained at 0.39 in 1999-2000, landings are expected to increase in 1999 to 4,800 mt and then increase to 5,300 mt in 2000. At F_{98} = 0.39, spawning stock biomass is expected to increase to 11,400 mt in 1999 and to 12,100 mt in 2000, and total stock biomass is expected to increase to 21,700 mt in 1999 and to 24,100 mt in 2000 (Table 28, Figure 12).

SARC 28 CONCLUSIONS

The stock complex is at a medium level of biomass and is fully exploited. Reductions in fishing mortality, and to a lesser degree improvement in recent recruitment, have contributed to rebuilding of the stock (Figures 3 and 5). Total biomass in 1997 was estimated to be 17,900 mt, which is 64% of B_{msy} = 27,810 mt. Fully recruited fishing mortality in 1997 was 0.31 (exploitation rate = 24%), about equal to the ASMFC target for 1997 of $F_{30\%}$ = 0.29. The corresponding total biomass fishing mortality in 1997 was 0.24, below F_{msy} = 0.37.

Assuming a total catch of 4,800 mt in 1998, fully recruited fishing mortality in 1998 is projected to rise to 0.39 (exploitation rate = 29%), corresponding to a total biomass fishing mortality of 0.27. Total stock biomass is projected to increase to 20,200 mt in 1998, about 73% of B_{msy} = 27,810 mt (Figure 5). Relative to the NEFMC FMP Amendment 9 overfishing definition and associated control rules (Figure 11), the stock is not overfished (biomass in 1998 is above $B_{threshold}$) and overfishing is not occurring (biomass F in 1998 is below $F_{threshold}$). Relative to the ASMFC FMP overfishing definition of $F_{25\%}$ = 0.35 and target for 1999 of $F_{40\%}$ = 0.20, overfishing is occurring (Figure 9).

Applying the NEFMC FMP Amendment 9 ten year rebuilding control rule to the 1998 total stock biomass implies a target total biomass fishing mortality rate of $F_{target\ 10}$ = 0.24 for 1999, corresponding to a fully recruited fishing mortality of $F_{target\ 10}$ = 0.33 for 1999, and requires a 15% reduction in fully recruited fishing mortality from 1998. Applying the NEFMC FMP Amendment 9 five year rebuilding control rule to the 1998 total stock biomass implies a target total biomass fishing mortality rate of $F_{target\ 5}$ = 0.21 for 1999, corresponding to a fully recruited fishing mortality of $F_{target\ 5}$ = 0.28 for 1999, and requires a 28% reduction in fully recruited fishing mortality from 1998. Applying the ASMFC FMP fully recruited fishing mortality rate target of $F_{40\%}$ = 0.20 for 1999 requires a 49% reduction in fully recruited fishing mortality from 1998.

SARC 28 COMMENTS

The SARC accepted the results of the SNE/MA winter flounder assessment but noted some shortcomings which should be addressed in future assessments. One weakness of the input data lies with the geographic coverage of the commercial length samples by port. It was noted that the market categories differ by port, so applying samples by market category across ports may create bias in the results. Future assessments of coastal species would also benefit from a coordinated fisheries independent survey among states. The ASMFC Management and Science Committee has begun consideration of the logistics involved in such a survey series, but is many years away from contributing to stock assessments.

The use of large number of indices from several different state and federal sources in the VPA was discussed. An examination of the correlation among standardized indices and residuals at age was completed. The

SARC concluded that the increased information content provided by multiple surveys was worth the slight decrease in precision created in the results. Exploratory VPA runs were made during the SARC both a) without estimation of age-1 stock size in the last year, and b) by excluding all survey age-1 indices, in order to examine the effect on precision and residual patterns. There was some concern over the results in the retrospective pattern where both F and SSB tended to be over estimated in the terminal year. The probable reason was the influence of mature age 3 fish in the SSB which were not included in the estimate of fully recruited F.

The discussion of reference points centered around the calculation and terminology used in the control rule. The SARC concluded that the term F_{target} would be used to describe the current F necessary under the control rule. Similarly, $F_{threshold}$ is equal to F_{msy}. The SARC suggested that the maturity ogive used in the VPA and yield per recruit analyses be re-examined to incorporate any recent research.

RESEARCH RECOMMENDATIONS

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 et al. (1992) survey/mesh algorithm with those from VTR discard ratios for 1994-1997.

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

4. 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.

5. Re-examine the maturity ogive to incorporate andy recent research results.

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

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

8. Expand sea sampling for estimation of commercial discards.

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

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

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

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

13. Evaluate the utility of MA DMF sea sample data for winter flounder.

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Table E1. 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	3,426

Table E2. 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	68.7	3.9	5.9	0.7	11.7	6.0	0.6	2.1	0.4

Table E3. Estimated number (000's) and weight (mt) of winter flounder caught and discarded in recreational fishery, Southern Massachusetts to New Jersey.

	Number (000's)				Metric tons
	Catch A+B1+B2	Landed A+B1	Released B2	15% Release Mortality	Landed A+B1
1981	11006	8089	2916	437	3050
1982	10665	8392	2273	341	2457
1983	11010	8365	2645	397	2524
1984	17723	12756	4967	745	5772
1985	18056	13297	4759	714	5198
1986	9368	6995	2374	356	2940
1987	9213	6900	2313	347	3141
1988	10134	7358	2775	416	3423
1989	5919	3682	2236	335	1802
1990	3827	2486	1340	201	1063
1991	4325	2795	1530	230	1214
1992	1360	806	555	83	393
1993	2211	1180	1031	155	543
1994	1829	1209	620	93	598
1995	1850	1390	461	69	661
1996	2679	1554	1125	169	689
1997	1767	1204	563	84	618

Table E4. Winter flounder commercial fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1985-1993. Landings are in metric tons.

Year	Landings	Lengths measured	Metric tons per 100 lengths
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

Table E5. Winter flounder commercial fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1981-1984. Landings are in metric tons.

1981			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	782	415	0	491	1688
Port	Jul-Dec	1122	1127	0	293	2542
Total lengths used		1904	1542	0	784	4230
Landings		273	6025	0	4878	11176
Metric tons per 100 lengths						264

1982			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	281	1576	0	996	2853
Port	Jul-Dec	232	849	657	1205	2943
Total lengths used		513	2425	657	2201	5796
Landings		773	3799	1244	3622	9438
Metric tons per 100 lengths						163

1983			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	625	955	338	847	2765
Port	Jul-Dec	302	835	706	993	2836
Total lengths used		927	1790	1044	1840	5601
Landings		443	3835	1880	2501	2781
Metric tons per 100 lengths						50

Table E5 continued.

1984		Market Category				
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	274	689	0	604	1567
Port	Jul-Dec	277	482	637	734	2130
Total lengths used		551	1171	637	1338	3697
Landings		639	3687	2208	2348	8882
Metric tons per 100 lengths						240

Table E6. Winter flounder commercial fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1994-1997. Landings are in metric tons.

1994			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	0	472	242	332	1046
Port	Jul-Dec	142	620	574	211	1547
Total lengths used		142	1092	816	543	2593
Landings		550	867	285	458	2159
Metric tons per 100 lengths						83

1995			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	79	580	290	225	1174
Port	Jul-Dec	0	602	0	100	702
Sea Sample	Jul-Dec	2979	0	0	0	2979
Total lengths used		3058	580	290	225	4153
Landings		621	1377	194	442	2634
Metric tons per 100 lengths						63

1996			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	426	223	103	0	752
Sea Sample	Jan-Jun	55	0	0	0	55
Port	Jul-Dec	54	631	418	109	1212
Total lengths used		535	854	521	109	2019
Landings		409	1598	184	590	2781
Metric tons per 100 lengths						138

Table E6 continued.

1997			Market Category			
Sample Type	Season	Unclass.	Small	Medium	Large	Total
Port	Jan-Jun	0	553	776	843	2172
Port	Jul-Dec	201	774	400	458	1833
Total lengths used		201	1327	1176	1301	4005
Landings		542	1293	756	835	3426
Metric tons per 100 lengths						86

Table E7. Winter flounder recreational fishery landed sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1985-1993. Landings are in metric tons.

Year	Landings	Lengths measured	Metric tons per 100 lengths
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

Table E8. Winter flounder recreational fishery sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1981-1984. SNE = MA & RI; MA = CT and states south. Landings are in metric tons.

Season/area	1981	1982	1983	1984
Jan-Jun/SNE	229	394	1048	486
Jan-Jun/MA	279	228	604	1497
Jul-Dec/SNE	316	900	276	313
Jul-Dec/MA	901	449	659	827
Total lengths	1725	1971	2587	3123
Landings (A+B1)	3050	2457	2524	5772
Metric tons per 100 Lengths	177	125	98	185

Table E9. Winter flounder recreational fishery sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1994-1997. SNE = MA & RI; MA = CT and states south. Landings are in metric tons.

Season/area	1994	1995	1996	1997
Jan-Jun/SNE	544	578	664	421
Jan-Jun/MA	192	129	121	166
Jul-Dec/SNE	187	37	104	97
Jul-Dec/MA	25	23	47	68
Total lengths	948	767	936	752
Landings (A+B1)	598	661	689	618
Metric tons per 100 Lengths	63	86	74	82

Table E10. Winter flounder NEFSC Domestic Sea Sample Program (SS) and NER Vessel Trip Report (VTR) data: number of SS trips with landed winter flounder (to estimate discards to landings ratio), SS 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 only for 1994-1997.

Year	Half-year	SS trips	SS 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	0.320		
1994	Jan-Jun	13	0.304	1519	0.241
	Jul-Dec	12	2.840	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	0.050
1997	Jan-Jun	27	0.175	2138	0.145
	Jul-Dec	18	0.021	1766	0.160

Table E11. Winter flounder commercial fishery discard sample lengths (number of fish measured) used for Southern New England/Mid-Atlantic stock complex, 1994-1997. 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

Table E12. Winter flounder catch at age (number in 000s) for Southern New England/Mid-Atlantic stock complex. Note that 7+ totals only available for 1994-1996.

Commercial Landings

Year	Age 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

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

Table E12 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

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

Table E12 continued.

Total Landings

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1981	970	11208	12166	3492	665	182	70	32	0	0	9	0	0
1982	511	11132	11202	3538	610	213	91	59	21	17	7	7	0
1983	295	4425	11308	5659	1749	696	280	91	34	70	6	29	35
1984	294	8776	12591	4762	1770	875	396	158	67	86	27	33	37
1985	246	5521	9958	5610	2910	1839	982	32	352	52	5	2	0
1986	106	3886	6619	4003	1042	442	165	104	57	10	19	2	0
1987	16	3414	7201	2918	2694	755	122	135	78	89	2	0	0
1988	21	2775	6787	3684	1188	979	165	75	39	22	1	0	0
1989	99	2281	5000	2947	816	220	125	49	21	9	3	1	0
1990	7	1193	4791	2608	754	196	88	36	4	5	0	2	5
1991	13	1638	5879	3117	846	250	87	16	6	1	4	0	0
1992	3	607	3650	2431	659	161	38	11	3	0	0	0	0
1993	44	1118	2836	1666	579	157	91	17	4	2	2	0	1
1994	5	832	1044	705	311	163	99	0	0	0	0	0	0
1995	0	103	1805	885	415	291	211	0	0	0	0	0	0
1996	0	712	1347	1100	343	258	168	0	0	0	0	0	0
1997	1	1500	3071	1780	534	106	28	12	5	1	0	0	0

Total Discards

Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1981	392	2881	2186	101	0	0	0	0	0	0	0	0	0
1982	76	3125	1219	192	0	0	0	0	0	0	0	0	0
1983	322	2816	2000	467	45	0	0	0	0	0	0	0	0
1984	207	2799	1502	166	6	1	0	0	0	0	0	0	0
1985	31	1845	2878	444	43	4	0	0	0	0	0	0	0
1986	110	2441	2483	213	10	0	0	0	0	0	0	0	0
1987	58	1854	1797	173	10	0	0	0	0	0	0	0	0
1988	63	1166	2615	280	20	0	0	0	0	0	0	0	0
1989	364	2965	2175	556	33	2	1	0	0	0	0	0	0
1990	29	917	1484	324	14	0	1	0	0	0	0	0	0
1991	39	1389	1262	227	12	1	0	0	0	0	0	0	0
1992	22	896	806	151	14	1	0	0	0	0	0	0	0
1993	230	945	492	61	6	0	0	0	0	0	0	0	0
1994	56	265	108	8	0	0	0	0	0	0	0	0	0
1995	24	92	57	4	0	0	0	0	0	0	0	0	0
1996	32	174	104	7	1	0	0	0	0	0	0	0	0
1997	384	635	229	31	6	0	0	0	0	0	0	0	0

Table E12 continued.

Total Catch

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
	Age													
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

Table E13. 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	3,426	5,834	267	1,200	618	1,204	26	85	4,337	8,323	6.8	15.4

Table E14. Total fishery catch at age and mean weights at age used as input to Virtual Population Analysis for 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

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

Table E15. Winter flounder NEFSC survey index stratified mean number and mean weight (kgs) per tow for the Southern New England- Mid-Atlantic stock complex, strata set (offshore 1-12, 25, 69-76 ; inshore 1-29, 45-56).

	Spring		Fall	
YEAR	Number	Weight	Number	Weight
1963			8.554	3.283
1964			13.673	4.894
1965			15.537	4.435
1966			9.843	3.275
1967			9.109	2.745
1968	2.444	0.734	8.106	2.191
1969	5.640	3.414	6.842	1.939
1970	2.729	1.326	5.110	2.376
1971	2.035	0.756	3.862	1.232
1972	1.866	0.656	7.687	3.054
1973	7.459	2.013	2.691	0.776
1974	3.362	1.043	2.032	0.821
1975	1.136	0.354	2.358	0.742
1976	3.085	0.805	2.375	1.251
1977	4.186	1.190	4.722	1.735
1978	6.696	1.758	3.743	1.430
1979	2.965	1.069	10.058	2.606
1980	15.250	3.551	9.975	3.216
1981	18.234	4.762	9.899	3.109
1982	6.986	1.918	4.927	1.683
1983	6.262	2.469	8.757	2.691
1984	5.524	2.072	2.681	0.887
1985	5.360	1.983	2.727	0.991
1986	2.266	0.766	1.538	0.487
1987	1.763	0.568	1.167	0.419
1988	2.126	0.730	1.246	0.530
1989	2.485	0.582	1.435	0.341
1990	1.992	0.472	1.979	0.546
1991	2.473	0.692	1.950	0.708
1992	1.579	0.435	2.963	0.829
1993	0.961	0.219	1.382	0.392
1994	1.510	0.329	4.134	1.482
1995	2.097	0.592	2.253	0.626
1996	1.517	0.428	3.186	1.063
1997	1.436	0.399	7.893	2.583
1998	2.774	0.845		

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.

Table E16. SNE/MA winter flounder mean weight per tow for annual state surveys.

Year	MADMF spring	RIDFW spring	RIDFW fall	CTDEP
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	5.27	1.30	
1983	19.45	9.52	2.28	
1984	14.68	8.43	3.38	
1985	11.60	5.93	3.01	13.50
1986	10.42	6.61	2.91	10.28
1987	9.57	8.14	2.25	11.74
1988	6.46	6.02	1.45	18.28
1989	7.96	3.09	0.79	22.62
1990	5.38	3.07	0.71	29.00
1991	2.91	7.38	0.18	24.60
1992	7.99	0.95	0.42	11.94
1993	8.16	0.22	0.50	11.06
1994	12.59	1.67	0.33	12.29
1995	7.26	5.83	3.99	7.71
1996	9.78	5.34	0.91	20.98
1997	10.02	1.61	0.64	15.18
1998	7.98	5.00	0.31	

Note: MA DMF 1998 index is preliminary.

Table E17. Winter flounder mean number per tow for annual state surveys.

Year	MADMF spring	RIDFW spring	CTDEP	NYDEC (age 1)	NJDFW (April)
1978	51.50				
1979	53.61	83.76			
1980	38.92	63.10			
1981	46.05	87.93			
1982	40.23	31.42			
1983	56.39	58.85			
1984	36.64	41.69	110.76		
1985	38.36	34.97	83.26	1.96	
1986	36.51	41.80	63.74		
1987	37.84	56.21	79.83	1.64	
1988	27.57	34.41	137.63	1.32	
1989	24.42	20.89	148.18	3.01	25.60
1990	25.75	20.32	222.95	1.79	17.47
1991	10.57	42.00	150.28	3.38	22.17
1992	28.69	4.41	61.25	1.11	9.88
1993	46.92	2.90	63.58	5.42	20.13
1994	48.43	10.25	84.57	3.16	14.16
1995	33.35	31.78	50.16	1.72	30.04
1996	30.18	23.71	110.67	1.32	9.60
1997	39.31	11.31	71.31	3.15	36.24
1998	34.45	19.22			18.05

Note: MA DMF 1998 index is preliminary.

Table E18. 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	CTDEP	RIDFW	DEDFG	MADMF	NYDEC
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		29.00	0.17	0.32	
1987		11.60	0.09	0.27	0.97
1988	15.50	8.90	0.02	0.18	0.69
1989	1.90	21.40	0.29	0.42	1.67
1990	3.10	13.90	0.63	0.33	2.73
1991	5.80	12.40	0.03	0.27	2.48
1992	13.70	27.50	0.27	0.29	11.43
1993	6.00	5.70	0.04	0.07	4.66
1994	16.60	2.60	0.31	0.15	2.44
1995	12.50	3.50	0.10	0.16	0.91
1996	19.20	3.00	0.04	0.22	3.80
1997	7.47	3.63		0.39	
1998	9.38	1.97		0.16	

Table E19. NEFSC stratified mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex (strata set : offshore 1-12, 25, 69-76 ; inshore 1-29, 45-56).

NEFSC Spring

Year	AGE 1	2	3	4	5	6	7	8	9	10
1980	2.19	8.21	4.15	0.51	0.15	0.04				
1981	2.00	8.08	6.89	0.95	0.26	0.02	0.03			
1982	1.16	3.20	1.56	0.74	0.21	0.09	0.02	0.01		
1983	0.58	0.97	2.14	1.23	0.81	0.37	0.08	0.08		
1984	0.22	1.36	2.16	0.85	0.46	0.29	0.07	0.06	0.02	0.01
1985	0.41	1.21	2.16	0.72	0.51	0.20	0.14	0.01		
1986	0.10	0.49	1.14	0.31	0.15	0.05	0.01			0.02
1987	0.14	0.54	0.70	0.28	0.06	0.02		0.01	0.01	
1988	0.09	0.48	0.99	0.37	0.16	0.02	0.02			
1989	0.14	0.95	0.90	0.34	0.11	0.02	0.02	0.01		
1990	0.23	0.49	0.89	0.28	0.05	0.04	0.01			
1991	0.14	0.60	1.22	0.41	0.05	0.02	0.02	0.01		
1992	0.14	0.39	0.62	0.36	0.05	0.02				
1993	0.14	0.35	0.26	0.12	0.07	0.01	0.01			
1994	0.16	0.75	0.43	0.11	0.04	0.02	0.01			
1995	0.22	0.75	0.87	0.22	0.03		0.01			
1996	0.07	0.54	0.66	0.17	0.06	0.01	0.01			
1997	0.13	0.50	0.56	0.18	0.06	0.01				
1998	0.33	1.21	0.72	0.37	0.13	0.02				

NEFSC Autumn

Year	AGE 1	2	3	4	5	6	7	8	9	10
1980	1.76	4.62	2.74	0.44	0.01	0.01				
1981	2.06	5.06	2.30	0.31	0.06	0.08	0.03			
1982	0.76	2.21	1.34	0.47	0.12	0.02		0.01		
1983	1.63	3.82	2.06	0.62	0.35	0.11	0.07	0.08	0.02	
1984	0.17	1.04	1.17	0.26	0.03	0.01				
1985	0.16	1.18	0.99	0.30	0.09	0.01				
1986	0.22	0.90	0.36	0.03	0.01		0.01			
1987	0.03	0.64	0.36	0.12	0.02					
1988	0.03	0.29	0.63	0.22	0.04	0.01	0.01			
1989	0.28	0.82	0.26	0.05	0.01	0.01				
1990	0.07	0.88	0.84	0.15	0.01					
1991	0.06	1.02	0.73	0.12	0.01					
1992	0.15	1.74	0.79	0.26	0.03	0.01				
1993	0.42	0.50	0.34	0.08						
1994	0.44	2.22	1.08	0.30	0.04	0.03				
1995	0.58	0.93	0.63	0.09	0.01	0.01				
1996	0.62	1.40	0.80	0.31	0.06	0.01				
1997	1.48	3.58	2.20	0.55	0.08					

Table E20. MADMF spring trawl survey mean number per tow at age for winter flounder in the Southern New England/Mid-Atlantic stock complex.

Year	1	2	3	4	5	6	7	8	9+	Total
1978	9.90	9.70	15.71	9.31	3.14	1.09	1.33	0.51	0.81	51.50
1979	4.63	12.86	21.03	8.90	2.93	1.00	0.95	0.46	0.85	53.61
1980	1.63	8.21	14.48	9.13	3.01	0.96	0.79	0.28	0.43	38.92
1981	8.33	8.72	13.15	9.38	3.68	1.16	0.75	0.32	0.56	46.05
1982	2.68	6.23	15.98	9.22	3.32	1.00	0.83	0.41	0.56	40.23
1983	2.31	15.70	19.47	12.43	3.54	1.08	0.84	0.45	0.57	56.39
1984	1.23	6.92	14.12	10.14	2.64	0.72	0.51	0.17	0.19	36.64
1985	4.34	9.93	14.26	6.96	1.77	0.52	0.27	0.12	0.19	38.36
1986	3.62	8.07	17.42	5.37	1.21	0.35	0.27	0.08	0.12	36.51
1987	9.19	8.24	11.50	6.14	1.61	0.47	0.41	0.13	0.15	37.84
1988	2.91	7.06	13.71	3.05	0.53	0.15	0.08	0.02	0.06	27.57
1989	1.63	4.95	10.90	4.80	1.14	0.31	0.28	0.13	0.28	24.42
1990	4.18	10.66	7.60	2.87	0.30	0.02	0.10		0.02	25.75
1991	1.56	2.79	4.68	1.15	0.23	0.12	0.02		0.02	10.57
1992	7.78	7.55	6.68	4.16	1.64	0.59	0.07	0.08	0.14	28.69
1993	14.17	17.56	11.70	2.71	0.62	0.14	0.02			46.92
1994	11.37	16.12	14.65	4.66	0.61	0.58	0.37	0.05	0.02	48.43
1995	12.60	9.52	7.52	1.87	0.59	0.78	0.27	0.14	0.06	33.35
1996	4.81	9.73	7.61	2.84	1.99	1.45	0.84	0.29	0.63	30.19
1997	10.34	10.06	10.38	4.26	1.32	1.01	0.49	0.75	0.70	39.31

Table E21. CTDEP spring survey for winter flounder in the Southern New England-Mid Atlantic stock complex.

CTDEP Spring					AGE					
Year	1	2	3	4	5	6	7	8	9	10+
1984	8.13	43.09	31.40	20.90	4.41	1.24	0.65	0.73	0.04	0.04
1985	4.13	28.77	32.18	14.60	2.25	0.69	0.34	0.16	0.09	0.05
1986	6.62	26.12	15.75	12.18	2.00	0.49	0.24	0.23	0.09	0.03
1987	7.29	44.69	14.57	5.05	6.50	1.27	0.10	0.24	0.13	0.00
1988	14.64	71.88	39.10	8.60	1.84	1.49	0.17	0.04	0.02	0.02
1989	13.75	78.45	41.13	10.76	2.82	0.97	0.13	0.09	0.06	0.01
1990	11.31	131.46	64.93	9.00	4.08	1.96	0.20	0.05	0.00	0.02
1991	8.65	66.90	60.42	9.32	4.05	0.80	0.14	0.01	0.00	0.01
1992	6.78	31.24	12.76	8.96	1.10	0.36	0.05	0.00	0.00	0.00
1993	19.11	19.86	15.46	4.81	3.25	0.80	0.15	0.11	0.04	0.01
1994	9.56	64.16	5.90	3.06	1.15	0.50	0.17	0.06	0.01	0.01
1995	14.36	23.71	9.78	1.36	0.63	0.20	0.08	0.02	0.02	0.01
1996	11.47	59.10	24.18	14.42	0.97	0.29	0.14	0.06	0.04	0.01
1997	12.53	25.53	19.42	9.44	3.76	0.51	0.07	0.03	0.01	0.02

Table E22. RIDFW spring survey for winter flounder in the Southern New England-Mid Atlantic stock complex.

RIDFW spring

	AGE							
Year	1	2	3	4	5	6	7+	Total
1981	13.55	32.20	32.99	6.07	1.85	0.79	0.48	87.93
1982	6.82	8.42	9.61	4.02	1.45	0.63	0.47	31.42
1983	13.62	18.46	15.51	6.96	2.59	1.00	0.71	58.85
1984	2.96	18.20	11.91	5.58	2.21	0.62	0.21	41.69
1985	3.46	10.32	16.08	2.31	1.26	0.84	0.70	34.97
1986	7.06	10.41	9.70	10.95	2.05	0.71	0.92	41.80
1987	10.74	20.18	10.74	5.45	6.46	1.57	1.07	56.21
1988	7.23	10.92	9.82	3.34	2.07	0.62	0.41	34.41
1989	5.89	6.89	5.32	1.77	0.56	0.27	0.19	20.89
1990	5.31	6.00	5.73	2.11	0.73	0.28	0.16	20.32
1991	8.01	13.68	14.01	4.03	1.47	0.55	0.25	42.00
1992	2.38	1.49	0.31	0.18	0.03	0.01	0.01	4.41
1993	1.47	1.01	0.24	0.11	0.06	0.01	0.00	2.90
1994	0.78	5.44	2.33	1.38	0.25	0.05	0.02	10.25
1995	6.55	8.64	12.62	2.35	1.02	0.35	0.25	31.78
1996	1.52	9.24	7.18	4.79	0.62	0.24	0.12	23.71
1997	3.46	3.26	2.61	1.27	0.53	0.11	0.07	11.31
1998	1.52	3.21	8.67	4.17	1.40	0.17	0.08	19.22

Table E23. Virtual Population Analysis of winter flounder in the Southern New England/ Mid-Atlantic stock complex.

```
Natural mortality is  0.2
Oldest age (not in the plus group) is  6
For all years prior to the terminal year ( 1997 ), backcalculated
stock sizes for the following ages used to estimate
total mortality (Z) for age  6 : 4 5 6

 The Indices of abundance that will be used in this run are:

SURVEY           AGES
---------------------

NEFSC Spring    1 - 7
NEFSC Fall      1 - 4
MADMF Spring    1 - 7
RIDFW Spring    1 - 7
CTDEP Spring    1 - 7
RIDFW Fall      0
MADMF Spring    0
DEDFW Spring    0
```

Catch at age (thousands) - C:\Program Files\What105\wfl81.5

	1981	1982	1983	1984	1985	1986	1987
1	1362	587	617	501	277	215	73
2	14089	14257	7241	11575	7366	6327	5268
3	14352	12421	13308	14093	12836	9102	8999
4	3593	3730	6126	4928	6054	4216	3091
5	665	610	1794	1776	2953	1053	2703
6	182	213	696	876	1843	442	755
7	111	202	545	804	1424	357	426
1+	34354	32020	30327	34553	32753	21712	21315

	1988	1989	1990	1991	1992	1993	1994
1	84	463	36	53	25	274	61
2	3941	5246	2109	3027	1503	2062	1097
3	9402	7176	6275	7140	4457	3329	1152
4	3964	3503	2931	3344	2581	1728	713
5	1207	849	767	858	674	585	311
6	979	222	196	251	162	157	162
7	303	209	141	115	53	116	99
1+	19880	17668	12455	14788	9455	8251	3595

	1995	1996	1997
1	24	32	385
2	195	886	2135
3	1862	1450	3300
4	889	1107	1811
5	415	343	540
6	291	258	106
7	211	168	46
1+	3887	4244	8323

Table E23 continued.

Weight at age (mid year) in kg

	1981	1982	1983	1984	1985	1986	1987
1	0.130	0.090	0.195	0.146	0.111	0.129	0.046
2	0.276	0.261	0.237	0.258	0.282	0.292	0.287
3	0.478	0.438	0.353	0.366	0.364	0.398	0.384
4	0.802	0.694	0.516	0.542	0.482	0.480	0.551
5	1.065	1.048	0.774	0.693	0.522	0.685	0.475
6	1.243	1.253	1.046	0.913	0.467	0.879	0.564
7	1.202	1.837	1.552	1.282	0.613	0.961	0.853

	1988	1989	1990	1991	1992	1993	1994
1	0.039	0.118	0.082	0.093	0.079	0.169	0.156
2	0.279	0.258	0.295	0.317	0.287	0.334	0.347
3	0.351	0.378	0.394	0.420	0.427	0.460	0.448
4	0.508	0.508	0.525	0.534	0.599	0.592	0.597
5	0.634	0.660	0.672	0.603	0.802	0.689	0.741
6	0.517	0.716	0.808	0.823	0.945	0.878	0.692
7	0.827	1.073	0.990	1.168	1.395	1.167	0.818

	1995	1996	1997
1	0.167	0.193	0.093
2	0.323	0.407	0.369
3	0.449	0.507	0.510
4	0.578	0.569	0.659
5	0.714	0.705	0.806
6	0.763	0.826	1.071
7	0.780	0.853	1.511

SSB Weights

	1981	1982	1983	1984	1985	1986	1987
1	0.092	0.055	0.170	0.105	0.068	0.086	0.019
2	0.219	0.184	0.146	0.224	0.203	0.180	0.192
3	0.397	0.348	0.304	0.295	0.306	0.335	0.335
4	0.702	0.576	0.475	0.437	0.420	0.418	0.468
5	0.982	0.917	0.733	0.598	0.532	0.575	0.477
6	1.151	1.155	1.047	0.841	0.569	0.677	0.622
7	1.202	1.837	1.552	1.282	0.613	0.961	0.853

	1988	1989	1990	1991	1992	1993	1994
1	0.015	0.075	0.042	0.053	0.038	0.118	0.108
2	0.113	0.100	0.187	0.161	0.163	0.162	0.242
3	0.317	0.325	0.319	0.352	0.368	0.363	0.387
4	0.442	0.422	0.445	0.459	0.502	0.503	0.524
5	0.591	0.579	0.584	0.563	0.654	0.642	0.662
6	0.496	0.674	0.730	0.744	0.755	0.839	0.690
7	0.827	1.073	0.990	1.168	1.395	1.167	0.818

	1995	1996	1997
1	0.107	0.140	0.032
2	0.224	0.261	0.267
3	0.395	0.405	0.456
4	0.509	0.505	0.578
5	0.653	0.638	0.677
6	0.752	0.768	0.869
7	0.780	0.853	1.511

Table E23 continued.

Percent Mature (females)

	1981	1982	1983	1984	1985	1986	1987
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	53	53	53	53	53	53	53
4	95	95	95	95	95	95	95
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100

	1988	1989	1990	1991	1992	1993	1994
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	53	53	53	53	53	53	53
4	95	95	95	95	95	95	95
5	100	100	100	100	100	100	100
6	100	100	100	100	100	100	100
7	100	100	100	100	100	100	100

	1995	1996	1997
1	00	00	00
2	00	00	00
3	53	53	53
4	95	95	95
5	100	100	100
6	100	100	100
7	100	100	100

Sex Ratio (Percent Female)

	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1988	1989	1990	1991	1992	1993	1994
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
7	0.5	0.5	0.5	0.5	0.5	0.5	0.5

	1995	1996	1997
1	0.5	0.5	0.5
2	0.5	0.5	0.5
3	0.5	0.5	0.5
4	0.5	0.5	0.5
5	0.5	0.5	0.5
6	0.5	0.5	0.5
7	0.5	0.5	0.5

pF is 0.2
pM is 0.2

Table E23 continued.

RESULTS

Approximate Statistics Assuming Linearity Near Solution
Sum of Squares: 376.463583256854
Mean Square Residuals: 0.70367

	PAR. EST.	STD. ERR.	T-STATISTIC	C.V.
N 1	1.68E+04	7.35E+03	2.29E+00	0.44
N 2	1.69E+04	4.74E+03	3.56E+00	0.28
N 3	1.07E+04	2.74E+03	3.89E+00	0.26
N 4	9.12E+03	2.31E+03	3.95E+00	0.25
N 5	3.70E+03	9.80E+02	3.77E+00	0.27
N 6	1.33E+03	3.81E+02	3.49E+00	0.29
N 7	3.53E+02	1.13E+02	3.12E+00	0.32
q NEC_S1	2.59E-05	5.23E-06	4.94E+00	0.20
q NEC_S2	3.14E-05	6.29E-06	4.99E+00	0.20
q NEC_S3	5.16E-05	1.03E-05	5.00E+00	0.20
q NEC_S4	1.32E-04	2.64E-05	5.00E+00	0.20
q NEC_S5	2.93E-04	5.89E-05	4.98E+00	0.20
q NEC_S6	6.26E-04	1.30E-04	4.82E+00	0.21
q NEC_S7	1.10E-03	2.40E-04	4.58E+00	0.22
q NEC_F2	2.38E-05	4.77E-06	4.99E+00	0.20
q NEC_F3	5.25E-05	1.05E-05	5.00E+00	0.20
q NEC_F4	1.32E-04	2.65E-05	5.00E+00	0.20
q NEC_F5	3.60E-04	7.24E-05	4.98E+00	0.20
q MA_Spr1	3.14E-05	6.49E-06	4.84E+00	0.21
q MA_Spr2	4.34E-05	8.92E-06	4.86E+00	0.21
q MA_Spr3	6.47E-05	1.33E-05	4.87E+00	0.21
q MA_Spr4	1.42E-04	2.92E-05	4.87E+00	0.21
q MA_Spr5	3.66E-04	7.55E-05	4.85E+00	0.21
q MA_Spr6	9.51E-04	1.96E-04	4.85E+00	0.21
q MA_Spr7	1.25E-03	2.58E-04	4.85E+00	0.21
q RI_Spr1	3.16E-05	6.39E-06	4.94E+00	0.20
q RI_Spr2	3.51E-05	7.05E-06	4.99E+00	0.20
q RI_Spr3	4.41E-05	8.83E-06	5.00E+00	0.20
q RI_Spr4	1.10E-04	2.19E-05	5.00E+00	0.20
q RI_Spr5	2.76E-04	5.55E-05	4.98E+00	0.20
q RI_Spr6	7.34E-04	1.48E-04	4.95E+00	0.20
q RI_Spr7	1.22E-03	2.55E-04	4.78E+00	0.21
q CT_Spr1	4.57E-05	1.04E-05	4.39E+00	0.23
q CT_Spr2	4.86E-05	1.10E-05	4.41E+00	0.23
q CT_Spr3	6.46E-05	1.46E-05	4.42E+00	0.23
q CT_Spr4	1.58E-04	3.57E-05	4.41E+00	0.23
q CT_Spr5	4.25E-04	9.67E-05	4.40E+00	0.23
q CT_Spr6	1.13E-03	2.58E-04	4.39E+00	0.23
q CT_Spr7	1.67E-03	3.80E-04	4.39E+00	0.23
q RI_Fall1	4.11E-05	1.03E-05	4.00E+00	0.25
q MA_Spr1	3.87E-05	7.82E-06	4.94E+00	0.20
q DE_Spr1	3.37E-05	8.69E-06	3.88E+00	0.26

Table E23 continued.

STOCK NUMBERS (Jan 1) in thousands

	1981	1982	1983	1984	1985	1986	1987
1	62859	52021	56505	35618	34619	32806	26007
2	52566	50232	42060	45704	28708	28093	26665
3	27768	30289	28226	27884	26946	16839	17276
4	7146	9748	13560	11068	10077	10447	5551
5	1468	2600	4606	5559	4603	2773	4738
6	363	600	1577	2148	2944	1097	1317
7	218	564	1219	1949	2228	876	730
1+	152389	146054	147753	129930	110126	92930	82285

	1988	1989	1990	1991	1992	1993	1994
1	26822	23487	17999	12423	8834	12020	14601
2	21227	21884	18810	14704	10123	7210	9594
3	17065	13813	13170	13492	9300	6928	4037
4	6001	5464	4816	5105	4586	3581	2660
5	1748	1327	1304	1291	1154	1419	1368
6	1434	339	318	374	281	335	633
7	433	312	224	167	90	244	384
1+	74730	66626	56642	47556	34367	31737	33277

	1995	1996	1997	1998
1	23288	18806	21039	16837
2	11899	19045	15368	16877
3	6862	9566	14791	10651
4	2263	3933	6520	9124
5	1533	1048	2219	3699
6	839	879	548	1328
7	602	568	236	505
1+	47287	53846		

Table E23 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	0.00	0.00	0.03	0.00
2	0.23	0.31	0.13	0.26	0.18	0.38	0.14
3	0.94	0.85	0.75	0.88	0.75	0.76	0.38
4	1.31	1.23	1.12	1.29	0.97	0.76	0.35
5	1.44	1.23	1.05	1.33	1.04	0.61	0.29
6	1.41	1.29	1.14	1.36	1.02	0.73	0.33
7	1.41	1.29	1.14	1.36	1.02	0.73	0.33

	1995	1996	1997
1	0.00	0.00	0.02
2	0.02	0.05	0.17
3	0.36	0.18	0.28
4	0.57	0.37	0.37
5	0.36	0.45	0.31
6	0.48	0.39	0.24
7	0.48	0.39	0.24

Average F for 4,6

	1981	1982	1983	1984	1985	1986	1987
4,6	0.77	0.45	0.64	0.57	1.17	0.57	0.98

	1988	1989	1990	1991	1992	1993	1994
4,6	1.38	1.25	1.10	1.32	1.01	0.70	0.32

	1995	1996	1997
4,6	0.47	0.40	0.31

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	0.65	0.59	0.50	0.20

1995	1996	1997
0.18	0.14	0.24

Table E23 continued.

BACKCALCULATED 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	0.03	0.01
2	0.16	0.24	0.12	0.19	0.17	0.50	0.36
3	0.65	0.66	0.65	0.65	0.73	0.99	1.00
4	0.91	0.96	0.98	0.95	0.94	1.00	0.93
5	1.00	0.95	0.92	0.98	1.00	0.80	0.76
6	0.98	1.00	1.00	1.00	0.98	0.96	0.88
7	0.98	1.00	1.00	1.00	0.98	0.96	0.88

	1995	1996	1997
1	0.00	0.00	0.06
2	0.03	0.12	0.45
3	0.63	0.41	0.77
4	1.00	0.83	1.00
5	0.62	1.00	0.85
6	0.85	0.87	0.66
7	0.85	0.87	0.66

MEAN BIOMASS (using catch mean weights at age)

	1981	1982	1983	1984	1985	1986	1987
1	7320	4218	9928	4678	3468	3822	1083
2	11153	9965	8174	9160	6274	6496	6173
3	8228	9118	6470	6404	6338	4049	4095
4	3606	4760	4630	3994	2728	3466	1814
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	30157	21573	20421	15271

	1988	1989	1990	1991	1992	1993	1994
1	947	2485	1336	1045	632	1819	2060
2	4814	4427	4721	3739	2418	1827	2829
3	3576	3228	3353	3466	2559	2051	1373
4	1574	1475	1406	1419	1617	1362	1221
5	545	466	500	399	531	671	802
6	369	126	141	156	154	191	340
7	178	174	122	99	73	185	244
1+	12002	12382	11580	10323	7983	8106	8867

	1995	1996	1997
1	3523	3287	1756
2	3453	6849	4748
3	2363	4029	5983
4	912	1704	3280
5	840	544	1399
6	464	548	475
7	340	366	289
1+	11895	17326	17928

Table E23 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	4735	4753	3766	3551	3621	2395	2482
4	3891	4591	5124	3859	3106	3542	1960
5	1205	2157	2898	2927	1838	1373	1781
6	341	603	1387	1539	1272	634	644
7	214	900	1590	2129	1037	719	490
1+	10387	13004	14765	14006	10874	8662	7356

	1988	1989	1990	1991	1992	1993	1994
1	00	00	00	00	00	00	00
2	00	00	00	00	00	00	00
3	2286	1926	1841	2028	1498	1102	737
4	1862	1646	1566	1652	1728	1411	1186
5	744	577	593	535	590	776	822
6	515	170	178	203	166	233	393
7	260	249	170	143	99	236	282
1+	5667	4567	4348	4563	4081	3758	3420

	1995	1996	1997
1	00	00	00
2	00	00	00
3	1284	1900	3243
4	938	1684	3197
5	895	588	1356
6	550	600	436
7	410	430	327
1+	4078	5202	8558

Table E24. Retrospective analysis of virtual population analysis of winter flounder in the Southern New England/ Mid-Atlantic stock complex.

Fishing Mortality

Terminal Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1990	0.77	0.45	0.64	0.57	1.17	0.57	0.98	1.36	1.19	1.01							
1991	0.77	0.45	0.64	0.57	1.17	0.58	0.99	1.39	1.27	1.16	1.64						
1992	0.77	0.45	0.64	0.57	1.17	0.57	0.99	1.39	1.26	1.12	1.45	1.35					
1993	0.77	0.45	0.64	0.57	1.17	0.57	0.99	1.39	1.26	1.12	1.40	1.20	1.07				
1994	0.77	0.45	0.64	0.57	1.17	0.57	0.99	1.39	1.25	1.12	1.39	1.18	1.01	0.53			
1995	0.77	0.45	0.64	0.57	1.17	0.57	0.99	1.39	1.25	1.11	1.36	1.10	0.86	0.44	0.60		
1996	0.77	0.45	0.64	0.57	1.17	0.57	0.98	1.39	1.25	1.11	1.34	1.05	0.76	0.39	0.54	0.45	
1997	0.77	0.45	0.64	0.57	1.17	0.57	0.98	1.38	1.25	1.10	1.32	1.01	0.70	0.32	0.47	0.40	0.31

Spawning Stock Biomass

Terminal Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1990	10388	13005	14767	14010	10883	8677	7384	5728	4641	4389							
1991	10387	13003	14764	14004	10871	8658	7349	5647	4513	4139	3953						
1992	10387	13004	14764	14005	10873	8660	7353	5657	4544	4258	4243	3352					
1993	10387	13004	14765	14005	10873	8661	7354	5661	4548	4293	4363	3563	3232				
1994	10387	13004	14765	14005	10873	8661	7354	5661	4550	4300	4381	3619	3106	3340			
1995	10387	13004	14765	14005	10873	8662	7355	5664	4558	4320	4463	3808	3223	3067	5554		
1996	10387	13004	14765	14006	10874	8662	7356	5666	4562	4335	4509	3960	3483	3027	4506	6253	
1997	10387	13004	14765	14006	10874	8662	7356	5667	4567	4348	4563	4081	3758	3420	4078	5202	8558

Population Numbers Age: 1

Terminal Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1990	62864	52030	56538	35637	34719	32965	25954	26413	25862	31540	34106							
1991	62858	52018	56497	35611	34598	32724	25816	25735	22008	20794	21283	19118						
1992	62859	52020	56502	35614	34612	32755	25960	26298	22472	16177	16244	16447	32347					
1993	62859	52020	56502	35616	34611	32781	25933	26607	22674	16614	14203	15138	33946	13065				
1994	62859	52020	56502	35616	34612	32784	25939	26638	22723	16822	12489	13137	30009	17976	26681			
1995	62859	52020	56503	35617	34615	32793	25972	26703	23107	17145	11514	11065	23644	17759	28398	13484		
1996	62859	52021	56504	35618	34617	32801	25985	26780	23231	17796	11504	8975	17564	14890	23178	15760	16120	
1997	62859	52021	56505	35618	34619	32806	26007	26822	23487	17999	12423	8834	12020	14601	23288	18806	21039	16837

Age 2 + stock size (N)

Terminal Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1990	89534	94042	91262	94350	75554	60244	56504	48050	42914	40419	47648							
1991	89528	94031	91244	94302	75493	60096	56187	47678	42061	36548	35703	33278						
1992	89529	94033	91246	94308	75500	60113	56226	47827	42644	37408	32625	26625	26710					
1993	89529	94033	91247	94308	75502	60114	56249	47823	42894	37777	33290	25484	24809	40640				
1994	89529	94033	91247	94309	75503	60115	56252	47831	42926	37843	33514	24263	22178	35342	40402			
1995	89529	94033	91247	94310	75504	60119	56262	47866	43008	38225	34091	23938	20219	28580	34648	48104		
1996	89529	94033	91248	94311	75506	60121	56271	47884	43086	38390	34759	24475	18963	22562	27486	37691	39924	
1997	89530	94034	91248	94312	75507	60124	56277	47908	43139	38643	35133	25533	19717	18676	23998	35040	39683	42184

Table E25. Bootstrap analysis of virtual population analysis of winter flounder in the Southern New England/ Mid-Atlantic stock complex.

The number of bootstraps: 200

Bootstrap Output Variable: N t1

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	16836.8	18672.5	7480.2	0.4443
Age 2	16876.9	17063.3	4392.1	0.2602
Age 3	10650.9	10650.9	2566.1	0.2409
Age 4	9124.2	9558.6	2186.2	0.2396
Age 5	3699.5	3707.8	916.3	0.2477
Age 6	1328.2	1382.5	342.0	0.2575
Age 7	505.0	504.5	145.8	0.2887

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	1835.74	528.93	10.903	15001.02	0.50
Age 2	186.32	310.56	1.104	16690.62	0.26
Age 3	0.03	181.45	0.000	10650.88	0.24
Age 4	434.37	154.58	4.761	8689.82	0.25
Age 5	8.30	64.79	0.224	3691.15	0.25
Age 6	54.26	24.18	4.085	1273.94	0.27
Age 7	-0.50	10.31	-0.098	505.48	0.29

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0204	0.0216	0.0059	0.29
Age 2	0.1667	0.1749	0.0385	0.23
Age 3	0.2831	0.2829	0.0577	0.20
Age 4	0.3667	0.3830	0.0851	0.23
Age 5	0.3133	0.3172	0.0709	0.23
Age 6	0.2405	0.2584	0.0738	0.31
Age 7	0.2405	0.2584	0.0738	0.31

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	0.0011774	0.0004154	5.763	0.0192538	0.31
Age 2	0.0081751	0.0027248	4.905	0.1585054	0.24
Age 3	-0.0002322	0.0040799	-0.082	0.2833471	0.20
Age 4	0.0162824	0.0060203	4.440	0.3504046	0.24
Age 5	0.0039610	0.0050113	1.264	0.3092977	0.23
Age 6	0.0179349	0.0052190	7.457	0.2225707	0.33
Age 7	0.0179349	0.0052190	7.457	0.2225707	0.33

Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.3068	0.3195	0.0480	0.16

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
0.01273	0.00339	4.15	0.29409	0.16

Table E25 continued.

Bootstrap Output Variable: PR t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 1	0.0557	0.0551	0.0188	0.34
Age 2	0.4546	0.4444	0.1250	0.27
Age 3	0.7721	0.7149	0.1655	0.21
Age 4	1.0000	0.9447	0.1054	0.11
Age 5	0.8543	0.7962	0.1711	0.20
Age 6	0.6559	0.6497	0.1810	0.28
Age 7	0.6559	0.6497	0.1810	0.28

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
Age 1	-0.00063	0.001332	-1.14	0.05635138	0.33
Age 2	-0.01019	0.008836	-2.24	0.46475229	0.27
Age 3	-0.05723	0.011706	-7.41	0.82931976	0.20
Age 4	-0.05534	0.007456	-5.53	1.05533806	0.10
Age 5	-0.05807	0.012100	-6.80	0.91236634	0.19
Age 6	-0.00617	0.012800	-0.94	0.66206075	0.27
Age 7	-0.00617	0.012800	-0.94	0.66206075	0.27

Bootstrap Output Variable: B mean

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
17928.7497	18244.4718	2012.6084	0.11

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
315.7221	142.3129	1.76	17613.0276	0.11

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
8558.7036	8727.7027	969.9095	0.11

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE
169.00	68.58	1.97	8389.70	0.12

Table E26. Yield per recruit and spawning stock biomass per recruit for winter flounder in the Southern New England/Mid-Atlantic stock complex.

```
Proportion of F before spawning:  .2000
Proportion of M before spawning:  .2000
Natural Mortality is Constant at:  .200
Initial age is:  1; Last age is: 15
Last age is a TRUE Age;
```

Age-specific Input data for Yield per Recruit Analysis

Age	Fish Mort Pattern	Nat Mort Pattern	Proportion Mature	Average Weights Stock	Average Weights Catch
1	.0200	1.0000	.0000	.067	.134
2	.2500	1.0000	.0000	.264	.388
3	.6100	1.0000	.5300	.430	.508
4	1.0000	1.0000	.9500	.540	.612
5	1.0000	1.0000	1.0000	.657	.754
6	1.0000	1.0000	1.0000	.817	.941
7	1.0000	1.0000	1.0000	1.113	1.116
8	1.0000	1.0000	1.0000	1.372	1.423
9	1.0000	1.0000	1.0000	1.482	1.529
10	1.0000	1.0000	1.0000	1.691	1.730
11	1.0000	1.0000	1.0000	1.710	1.748
12	1.0000	1.0000	1.0000	1.821	1.855
13	1.0000	1.0000	1.0000	1.910	1.941
14	1.0000	1.0000	1.0000	1.983	2.011
15	1.0000	1.0000	1.0000	2.041	2.067

Summary of Yield per Recruit Analysis for:
SNE/MAB Winter Flounder - SARC 28 1996-97 PR, Mean Weights at Age

	FMORT	TOTCTHN	TOTCTHW	TOTSTKN	TOTSTKW	SPNSTKN	SPNSTKW	% MSP
	.000	.00000	.00000	5.2420	3.5937	2.9600	3.0363	100.00
	.050	.12794	.12208	4.7353	2.8875	2.4558	2.3374	76.98
	.100	.21808	.19385	4.3557	2.3866	2.0808	1.8455	60.78
	.150	.28408	.23661	4.0642	2.0236	1.7952	1.4916	49.12
	.200	.33417	.26243	3.8351	1.7545	1.5725	1.2312	40.55
F40%	**.204**	**.33748**	**.26392**	**3.8197**	**1.7370**	**1.5576**	**1.2143**	**39.99**
F0.1	.224	.35389	.27087	3.7431	1.6512	1.4836	1.1317	37.27
	.250	.37341	.27822	3.6511	1.5509	1.3951	1.0356	34.11
F30%	**.291**	**.39961**	**.28650**	**3.5264**	**1.4199**	**1.2759**	**.9106**	**29.99**
	.300	.40502	.28798	3.5005	1.3935	1.2512	.8855	29.16
	.350	.43111	.29407	3.3750	1.2695	1.1324	.7682	25.30
F25%	**.354**	**.43324**	**.29449**	**3.3647**	**1.2597**	**1.1228**	**.7590**	**25.00**
	.400	.45307	.29788	3.2687	1.1701	1.0328	.6749	22.23
	.450	.47186	.30027	3.1775	1.0889	.9482	.5994	19.74
	.500	.48818	.30175	3.0982	1.0218	.8755	.5374	17.70
	.550	.50253	.30264	3.0286	.9653	.8123	.4858	16.00
	.600	.51527	.30315	2.9668	.9173	.7569	.4423	14.57
	.650	.52668	.30341	2.9115	.8760	.7079	.4052	13.34
	.700	.53698	.30350	2.8617	.8400	.6643	.3732	12.29
Fmax	**.707**	**.53837**	**.30350**	**2.8550**	**.8353**	**.6584**	**.3691**	**12.16**
	.750	.54635	.30348	2.8165	.8085	.6252	.3455	11.38
	.800	.55492	.30339	2.7753	.7806	.5899	.3212	10.58
	.850	.56280	.30325	2.7374	.7556	.5580	.2997	9.87
	.900	.57008	.30307	2.7024	.7332	.5289	.2806	9.24
	.950	.57684	.30288	2.6701	.7129	.5023	.2635	8.68
	1.000	.58314	.30266	2.6400	.6945	.4779	.2482	8.17

Table E27. Surplus production model analysis (ASPIC) of winter flounder in the Southern New England/Mid-Atlantic stock complex.

SNE Winter Flounder -- ASPIC 3.6x -- Five Indices, Fixed qs

CORRELATION AMONG INPUT SERIES EXPRESSED AS CPUE (NUMBER OF PAIRWISE OBSERVATIONS BELOW)

	1	2	3	4	5
1 NEFSC Fall Survey	1.000				
	17				
2 NEFSC Spring Survey	0.675	1.000			
	17	17			
3 Mass. Spring Survey	0.703	0.695	1.000		
	17	17	17		
4 RI Spring Survey	0.355	0.754	0:451	1.000	
	17	17	17	17	
5 RI Fall Survey	0.000	0.403	0.374	0.596	1.000
	17	17	17	17	17

GOODNESS-OF-FIT AND WEIGHTING FOR NON-BOOTSTRAPPED ANALYSIS

Loss component number and title		Weighted SSE	N	Weighted MSE	Current weight	Suggested weight	R-squared in CPUE
Loss(-1)	SSE in yield	0.000E+00					
Loss(0)	Penalty for B1R > 2	0.000E+00	1	N/A	1.000E+00	N/A	
Loss(1)	NEFSC Fall Survey	4.474E+00	17	2.983E-01	1.000E+00	9.442E-01	0.528
Loss(2)	NEFSC Spring Survey	2.573E+00	17	1.715E-01	1.000E+00	1.642E+00	0.585
Loss(3)	Mass. Spring Survey	2.892E+00	17	1.928E-01	1.000E+00	1.461E+00	0.198
Loss(4)	RI Spring Survey	9.631E+00	17	6.421E-01	1.000E+00	4.387E-01	0.457
Loss(5)	RI Fall Survey	8.219E+00	17	5.479E-01	1.000E+00	5.141E-01	0.070

TOTAL OBJECTIVE FUNCTION: 2.77890784E+01

Number of restarts required for convergence:	11
Est. B-ratio coverage index (0 worst, 2 best):	1.1283
Est. B-ratio nearness index (0 worst, 1 best):	1.0000

MODEL PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Starting guess	Estimated	User guess
B1R	Starting biomass ratio, year 1981	1.366E+00	1.000E+00	1	1
MSY	Maximum sustainable yield	1.022E+01	8.000E+00	1	1
r	Intrinsic rate of increase	7.350E-01	5.000E-01	1	1
....	Catchability coefficients by fishery:				
q(1)	NEFSC Fall Survey	6.600E-02	6.600E-02	0	1
q(2)	NEFSC Spring Survey	5.586E-02	5.586E-02	0	1
q(3)	Mass. Spring Survey	6.348E-01	6.348E-01	0	1
q(4)	RI Spring Survey	3.056E-01	3.056E-01	0	1
q(5)	RI Fall Survey	9.148E-02	9.148E-02	0	1

Table E27 continued.

MANAGEMENT PARAMETER ESTIMATES (NON-BOOTSTRAPPED)

Parameter		Estimate	Formula	
MSY	Maximum sustainable yield	1.022E+01	Kr/4	
K	Maximum stock biomass	5.561E+01		
Bmsy	Stock biomass at MSY	2.781E+01	K/2	
Fmsy	Fishing mortality at MSY	3.675E-01	r/2	
F(0.1)	Management benchmark	3.307E-01	0.9*Fmsy	
Y(0.1)	Equilibrium yield at F(0.1)	1.012E+01	0.99*MSY	
B-ratio	Ratio of B(1998) to Bmsy	7.033E-01		
F-ratio	Ratio of F(1997) to Fmsy	6.805E-01		
Y-ratio	Proportion of MSY avail in 1998	9.120E-01	2*Br-Br^2	Ye(1998) = 9.319E+00
....	Fishing effort at MSY in units of each fishery:			
fmsy(1)	NEFSC Fall Survey	5.568E+00	r/2q(1)	f(0.1) = 5.011E+00

ESTIMATED POPULATION TRAJECTORY (NON-BOOTSTRAPPED)

Obs	Year or ID	Estimated total F mort	Estimated starting biomass	Estimated average biomass	Observed total yield	Model total yield	Estimated surplus production	Ratio of F mort to Fmsy	Ratio of biomass to Bmsy
1	1981	0.452	3.799E+01	3.462E+01	1.566E+01	1.566E+01	9.564E+00	1.231E+00	1.366E+00
2	1982	0.433	3.190E+01	3.028E+01	1.311E+01	1.311E+01	1.013E+01	1.178E+00	1.147E+00
3	1983	0.457	2.891E+01	2.762E+01	1.262E+01	1.262E+01	1.021E+01	1.243E+00	1.040E+00
4	1984	0.678	2.651E+01	2.330E+01	1.579E+01	1.579E+01	9.912E+00	1.844E+00	9.533E-01
5	1985	0.786	2.063E+01	1.784E+01	1.401E+01	1.401E+01	8.877E+00	2.138E+00	7.420E-01
6	1986	0.619	1.549E+01	1.486E+01	9.208E+00	9.208E+00	8.004E+00	1.686E+00	5.572E-01
7	1987	0.701	1.429E+01	1.329E+01	9.324E+00	9.324E+00	7.431E+00	1.909E+00	5.139E-01
8	1988	0.771	1.240E+01	1.129E+01	8.708E+00	8.708E+00	6.608E+00	2.099E+00	4.459E-01
9	1989	0.708	1.030E+01	9.777E+00	6.925E+00	6.925E+00	5.921E+00	1.927E+00	3.703E-01
10	1990	0.661	9.295E+00	9.082E+00	5.999E+00	5.999E+00	5.585E+00	1.798E+00	3.343E-01
11	1991	0.873	8.880E+00	7.870E+00	6.872E+00	6.872E+00	4.962E+00	2.376E+00	3.194E-01
12	1992	0.698	6.970E+00	6.788E+00	4.735E+00	4.735E+00	4.380E+00	1.898E+00	2.506E-01
13	1993	0.596	6.615E+00	6.784E+00	4.041E+00	4.041E+00	4.378E+00	1.621E+00	2.379E-01
14	1994	0.394	6.952E+00	7.862E+00	3.095E+00	3.095E+00	4.958E+00	1.071E+00	2.500E-01
15	1995	0.340	8.815E+00	1.010E+01	3.439E+00	3.439E+00	6.068E+00	9.264E-01	3.170E-01
16	1996	0.280	1.144E+01	1.326E+01	3.707E+00	3.707E+00	7.408E+00	7.606E-01	4.116E-01
17	1997	0.250	1.514E+01	1.734E+01	4.337E+00	4.337E+00	8.750E+00	6.805E-01	5.446E-01
18	1998		1.956E+01						7.033E-01

Table E28. Input parameters and short term 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, 1998 are as estimated by SARC 28 VPA. Age-1 recruitment levels in 1999-2000 are estimated as the median of 200 random estimates (23.5 million fish) selected from VPA estimated numbers at age-1 during 1981-1998. Fishing mortality was apportioned among landings and discard based on the proportion landed at age during 1996-1997. Mean weights at age (kg; spawning stock, mean stock biomass, landings, and discards) are weighted (by fishery) geometric means of 1996-97 values. F98 is the F realized for projected fishery landings and discards in 1998, based on January-August 1998 commercial landings and proportions in fishery components for 1996-1997 (commercial landings = 3,719 mt; commercial discards = 265 mt; recreational landings = 780 mt; recreational discards = 53 mt; total catch = 4,817 mt). Proportion of F, M before spawning = 0.20 (spawning peak on 1 March).

Age	Stock Size on 1 Jan 1998 (000s)	Fishing Mortality Pattern	Proportion Landed	Proportion Mature	Mean Weights Spawning Stock	Mean Weights Mean Biomass	Mean Weights Landings	Mean Weights Discards
1	16837	0.02	0.01	0.00	0.067	0.134	0.204	0.134
2	16877	0.25	0.73	0.00	0.264	0.388	0.427	0.277
3	10651	0.61	0.93	0.53	0.430	0.508	0.520	0.350
4	9124	1.00	0.99	0.95	0.540	0.612	0.615	0.445
5	3699	1.00	0.99	1.00	0.657	0.754	0.755	0.617
6	1328	1.00	1.00	1.00	0.817	0.941	0.941	-----
7+	505	1.00	1.00	1.00	1.113	1.135	1.135	-----

Forecast Medians (50% probability level)

000s Metric tons

1998 F	1998 Land	1998 Disc	1998 SSB	1998 Biom	1999 F	1999 Land	1999 Disc	1999 SSB	1999 Biom	2000 F	2000 Land	2000 Disc	2000 SSB	2000 Biom
0.39	4.5	0.3	10.2	20.2	F40%=0.20	2.7	0.1	11.8	23.0	F40%=0.20	3.4	0.1	14.3	27.5
					Ftarget 5=0.28	3.6	0.2	11.7	22.5	Ftarget 5=0.28	4.3	0.1	13.4	26.0
					Ftarget 10=0.33	4.2	0.2	11.6	22.1	Ftarget 10=0.33	4.8	0.1	12.8	25.1
					F25%=0.35	4.5	0.2	11.5	22.0	F25%=0.35	5.0	0.2	12.5	24.7
					F98=0.39	4.8	0.3	11.4	21.7	F98=0.39	5.3	0.3	12.1	24.1

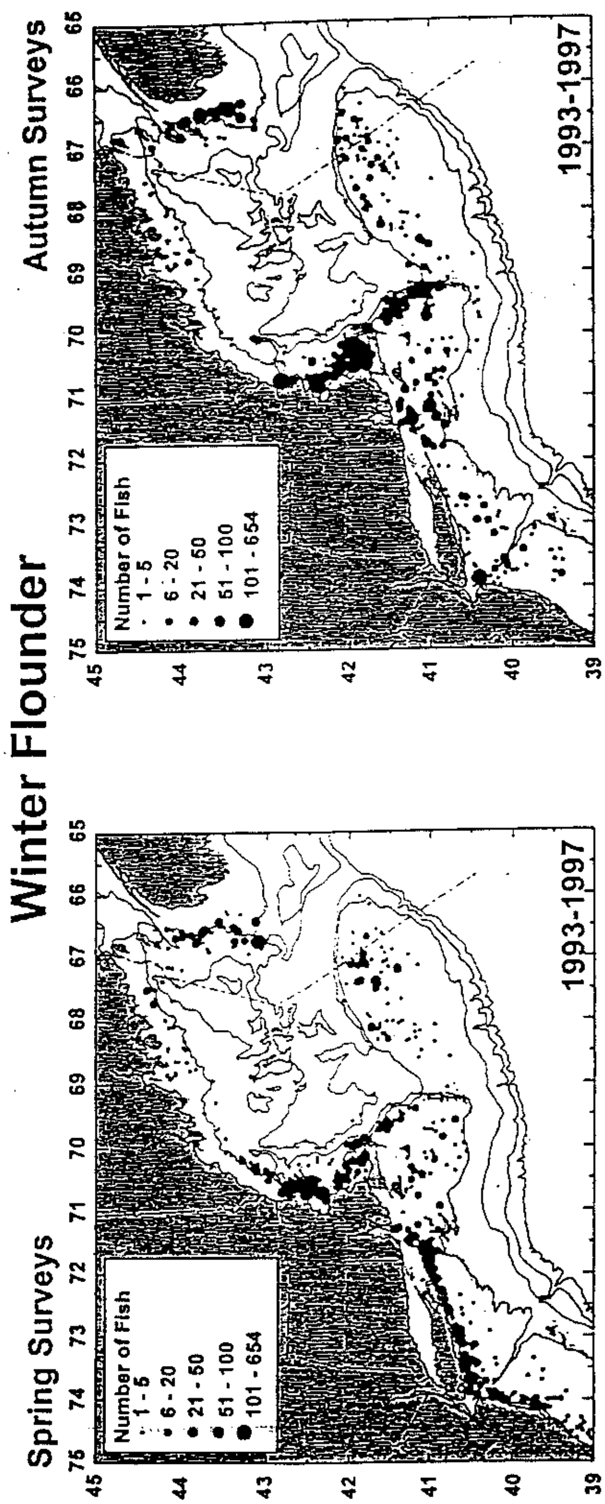

Figure E.1. Distribution of winter flounder sampled in NEFSC Spring and Autumn trawl surveys, 1993-1997. The Southern New England/Mid-Atlantic stock complex extends from the waters of outer Cape Cod to the south and west.

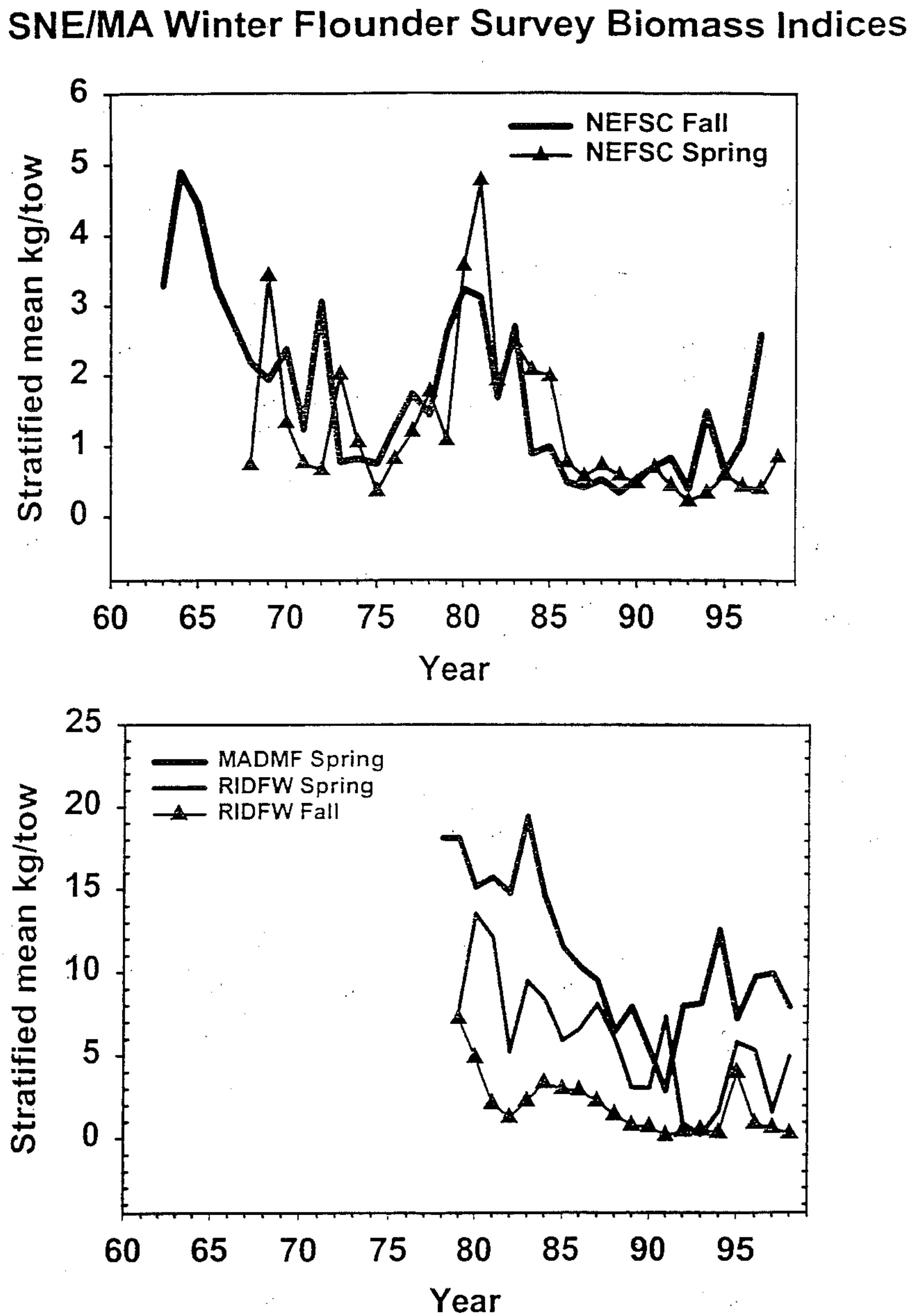

Figure E.2. Survey biomass indices (kg/tow) for SNE/MA winter flounder from NEFSC spring and fall research vessel surveys (top), and MA DMF spring and fall and RI DFW fall trawl surveys.

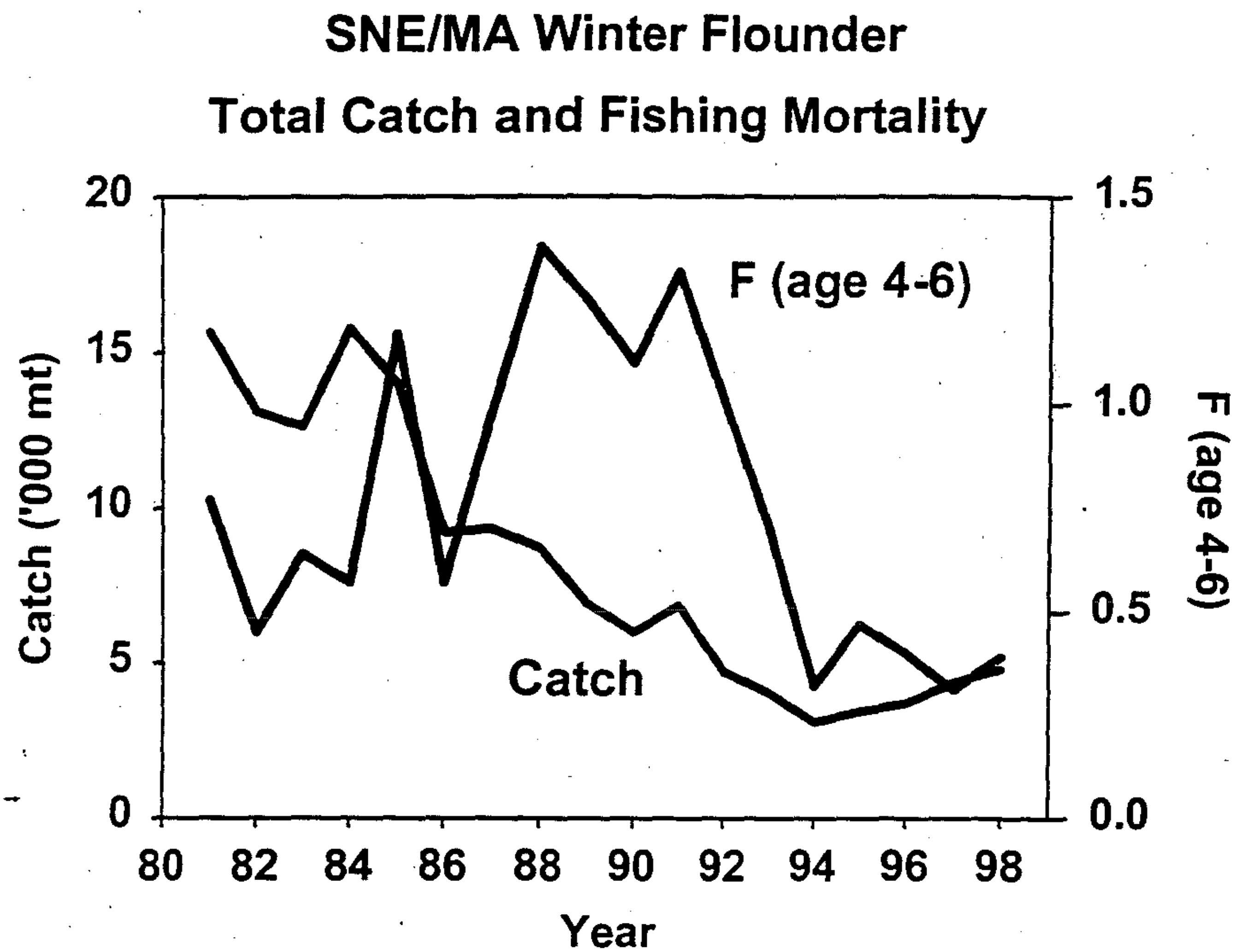

Figure E.3. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (fully recruited F, ages 4-6) for SNE/MA winter flounder.

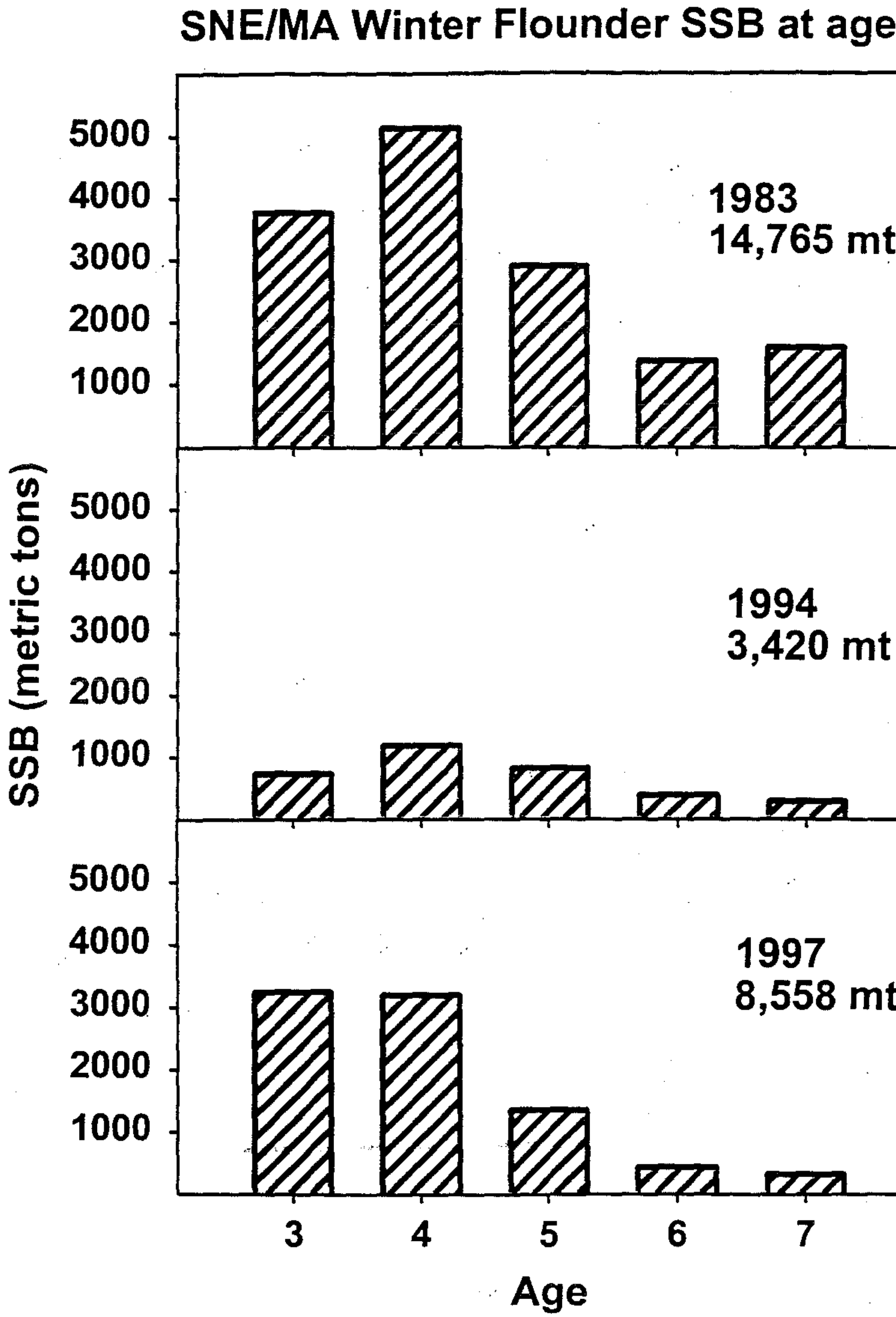

Figure E.4. Spawning stock biomass (SSB ages 3 to 7+, thousands of metric tons) and recruitment (millions of fish at age-1) for SNE/MA winter flounder.

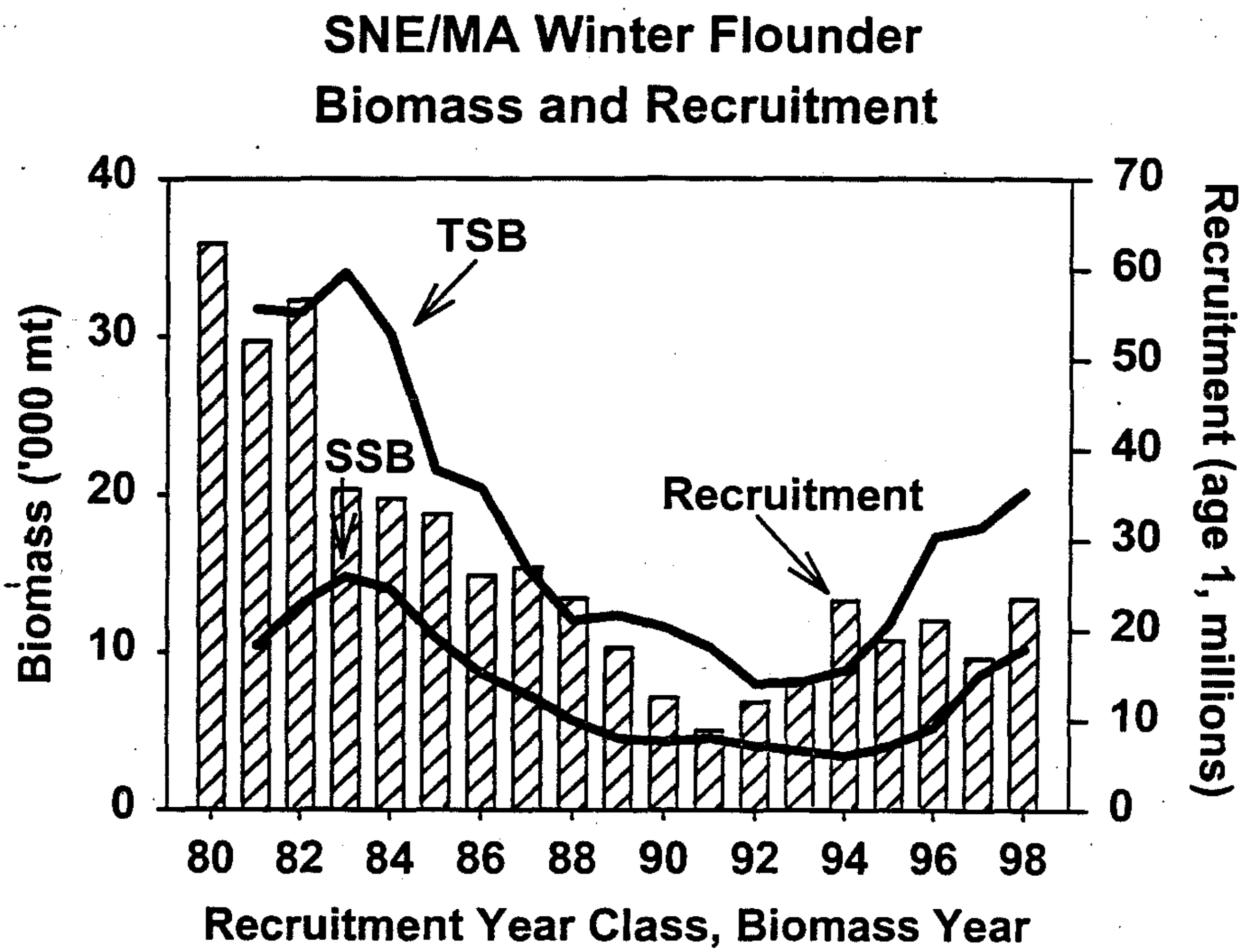

Figure E.5. Spawning stock biomass at age for SNE/MA winter flounder during peak (1983), minimum (1994), and 1997 abundance.

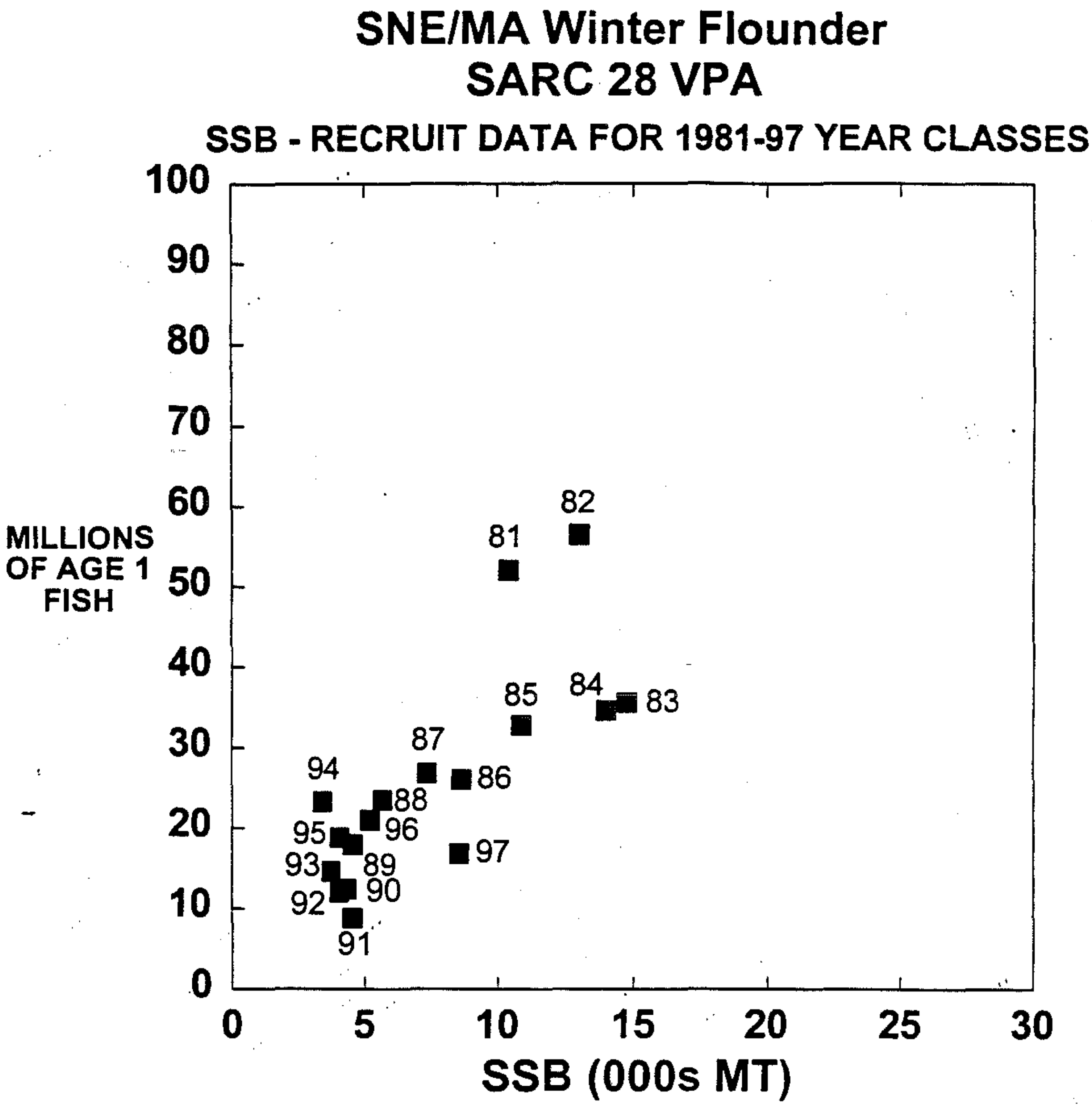

Figure E.6. SNE/MA winter flounder SARC 28 VPA SSB and recruit data for the 1981-97 year classes.

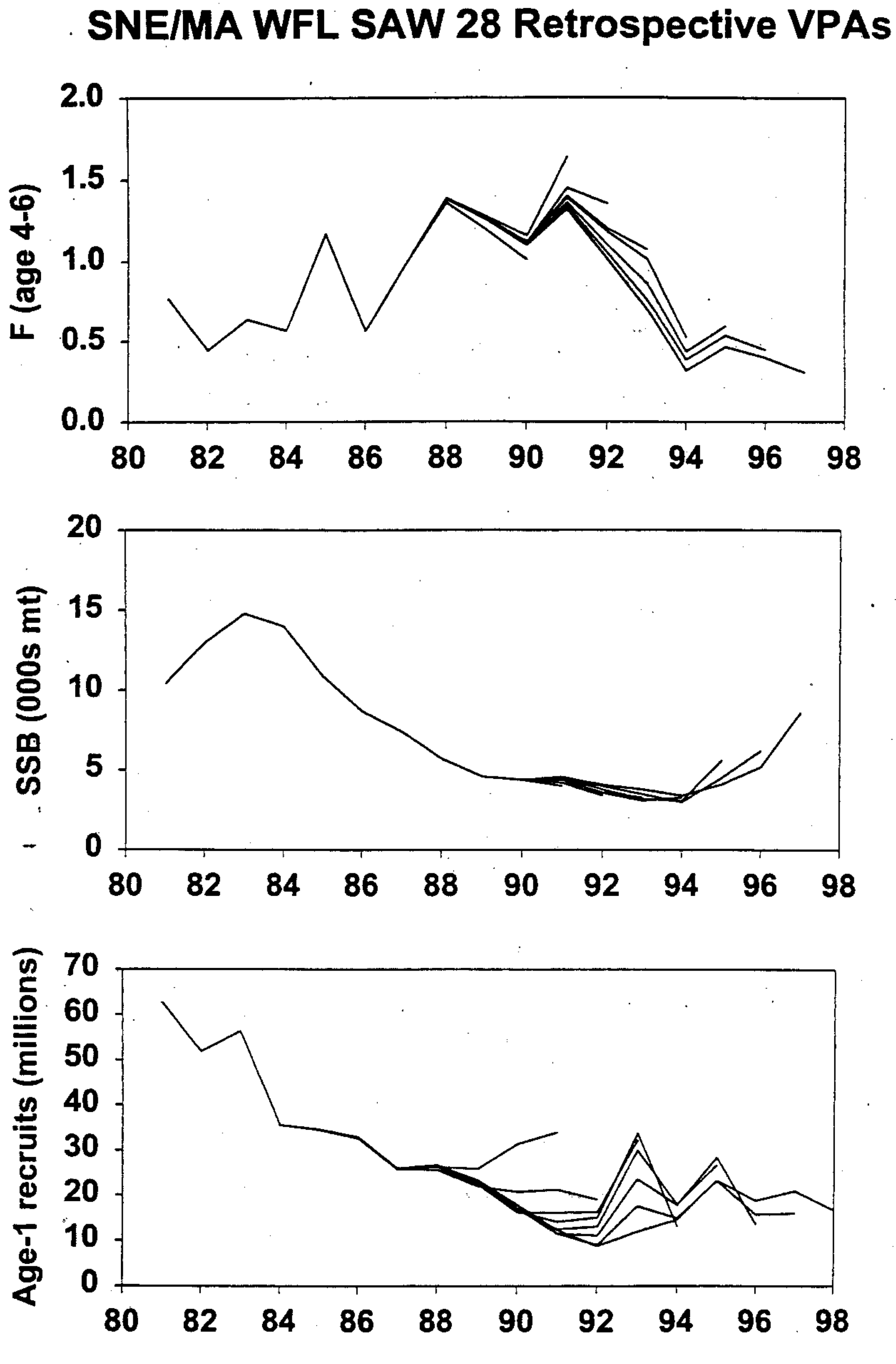

Figure E. 7. SNE/MA winter flounder SARC 28 retrospective virtual population analyses (VPAs).

SNE/MA Winter Flounder

Precision of 1997 Estimates for SSB and F

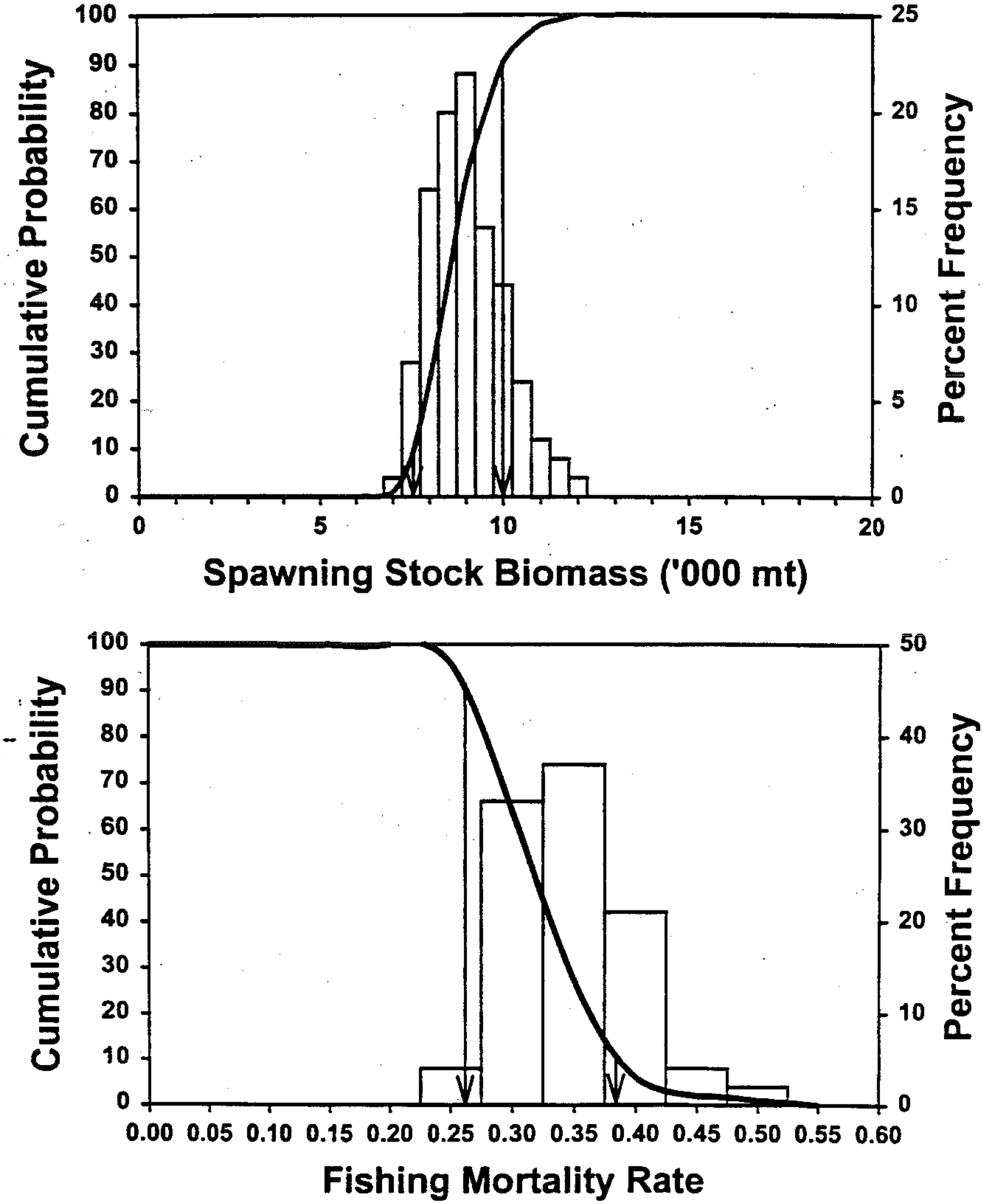

Figure E.8. Precision of estimates of spawning stock biomass and fishing mortality rate in 1997 for SNE/MA winter flounder. Vertical bars display the range of the bootstrap estimates and the probability of individual values in the range. The solid curve gives the probability of SSB that is less or fishing mortality that is greater than any value along the X axis.

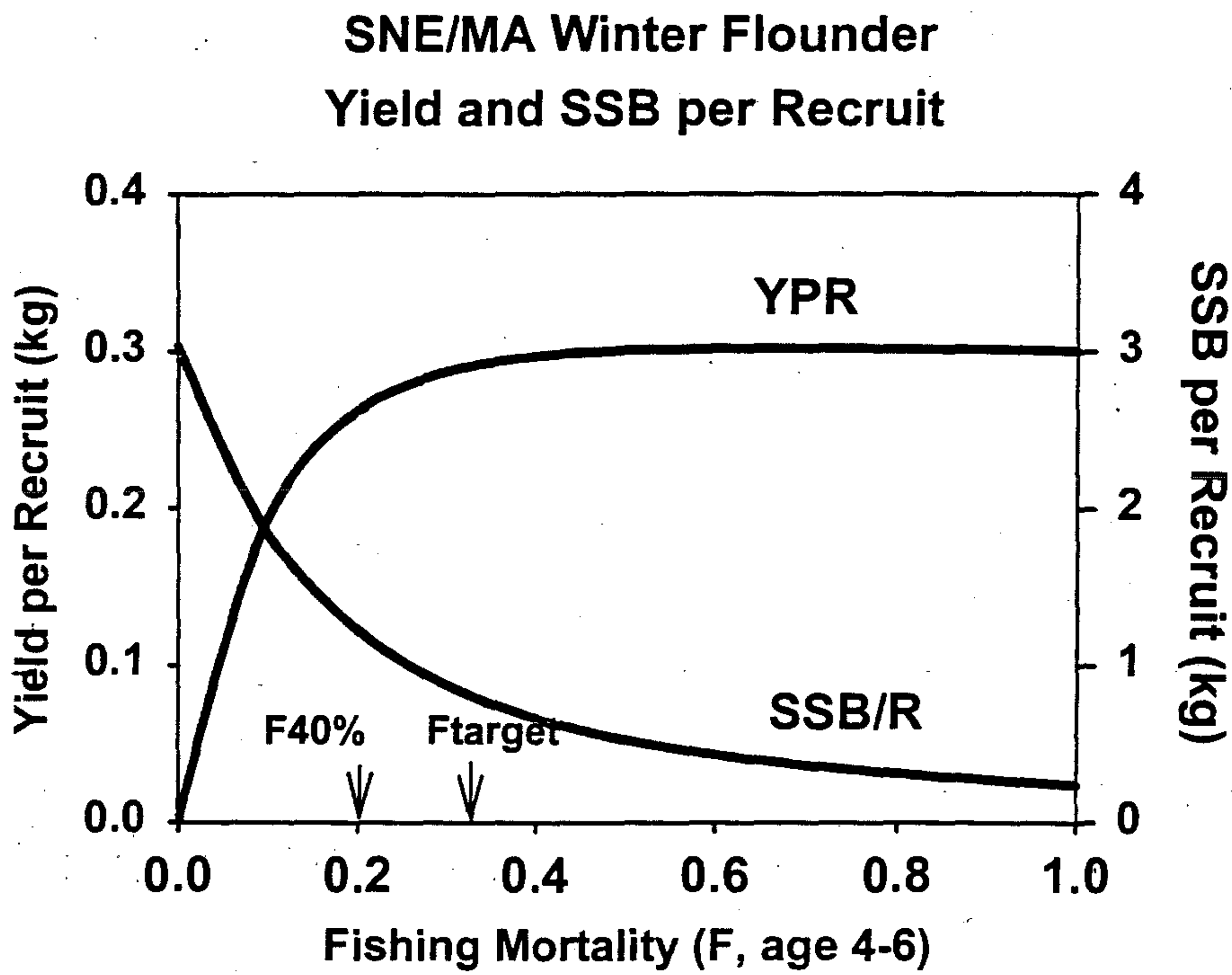

Figure E.9. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R) for SNE/MA winter flounder.

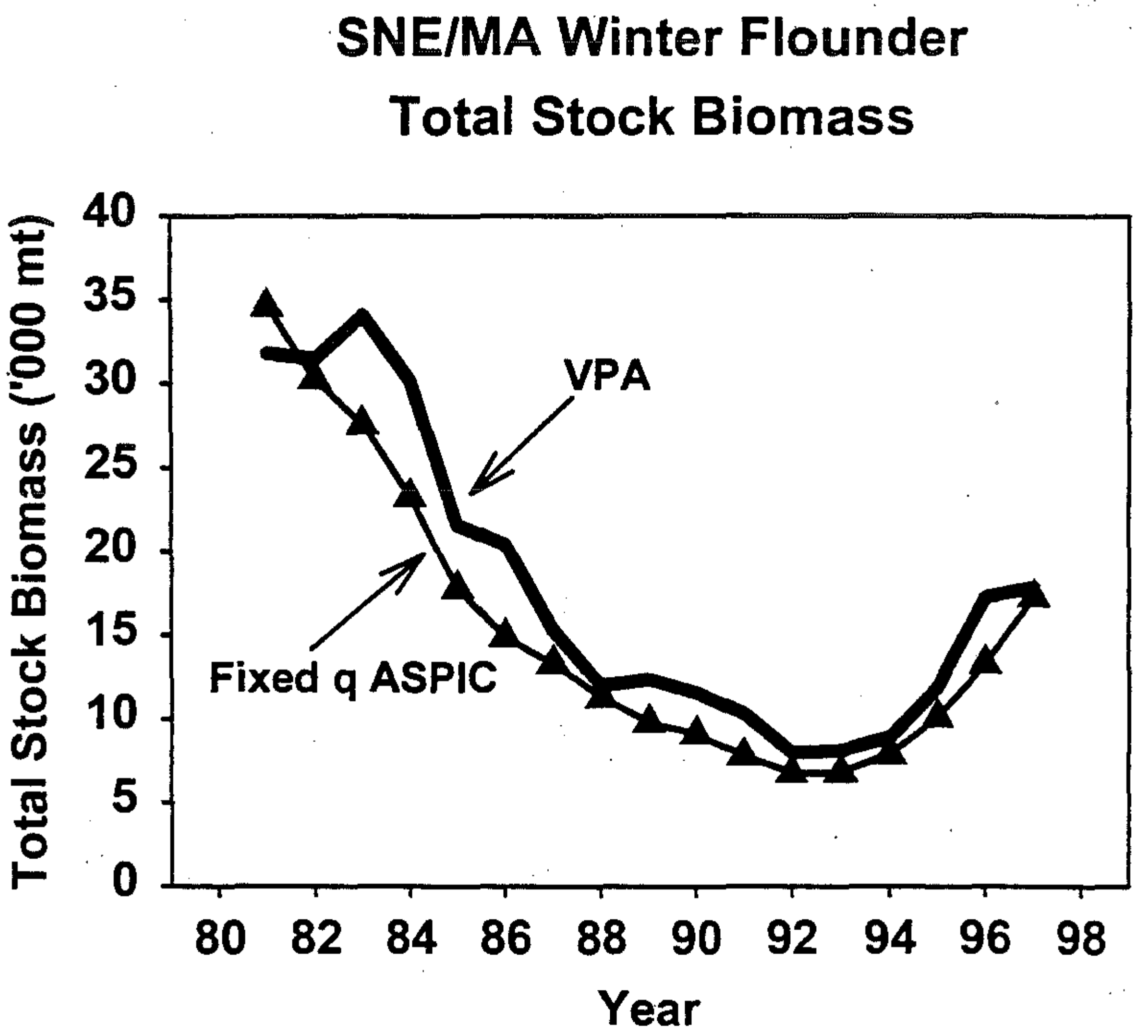

Figure E.10. SNE/MA winter flounder total stock biomass as estimated by VPA and by ASPIC with catchability (q) fixed to correspond to VPA estimates.

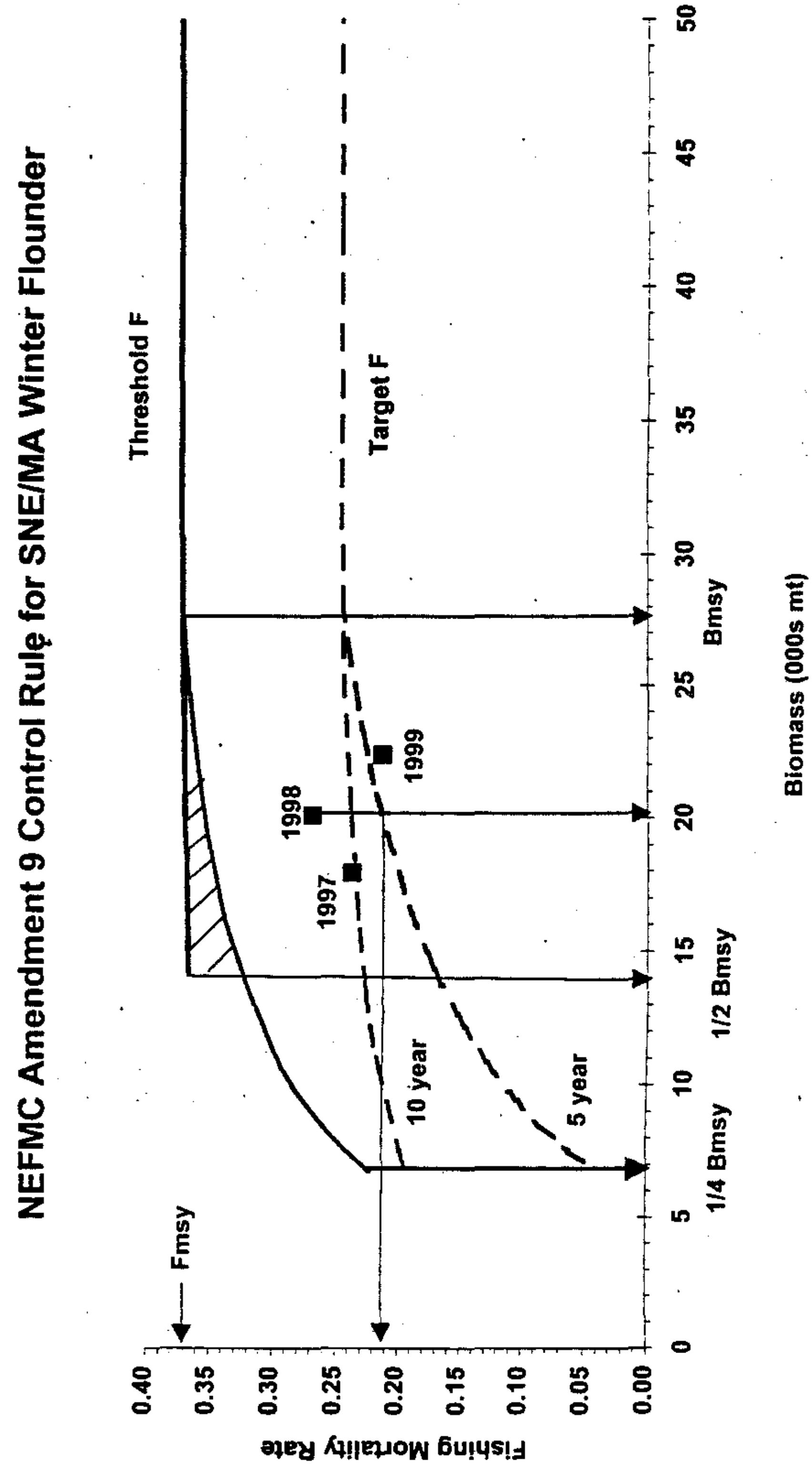

Figure E.11. NEFMC Amendment 9 control rule for SNE/MA winter flounder for rebuilding to Bmsy, with 1997-1999 estimates of biomass weighted F and total stock biomass.

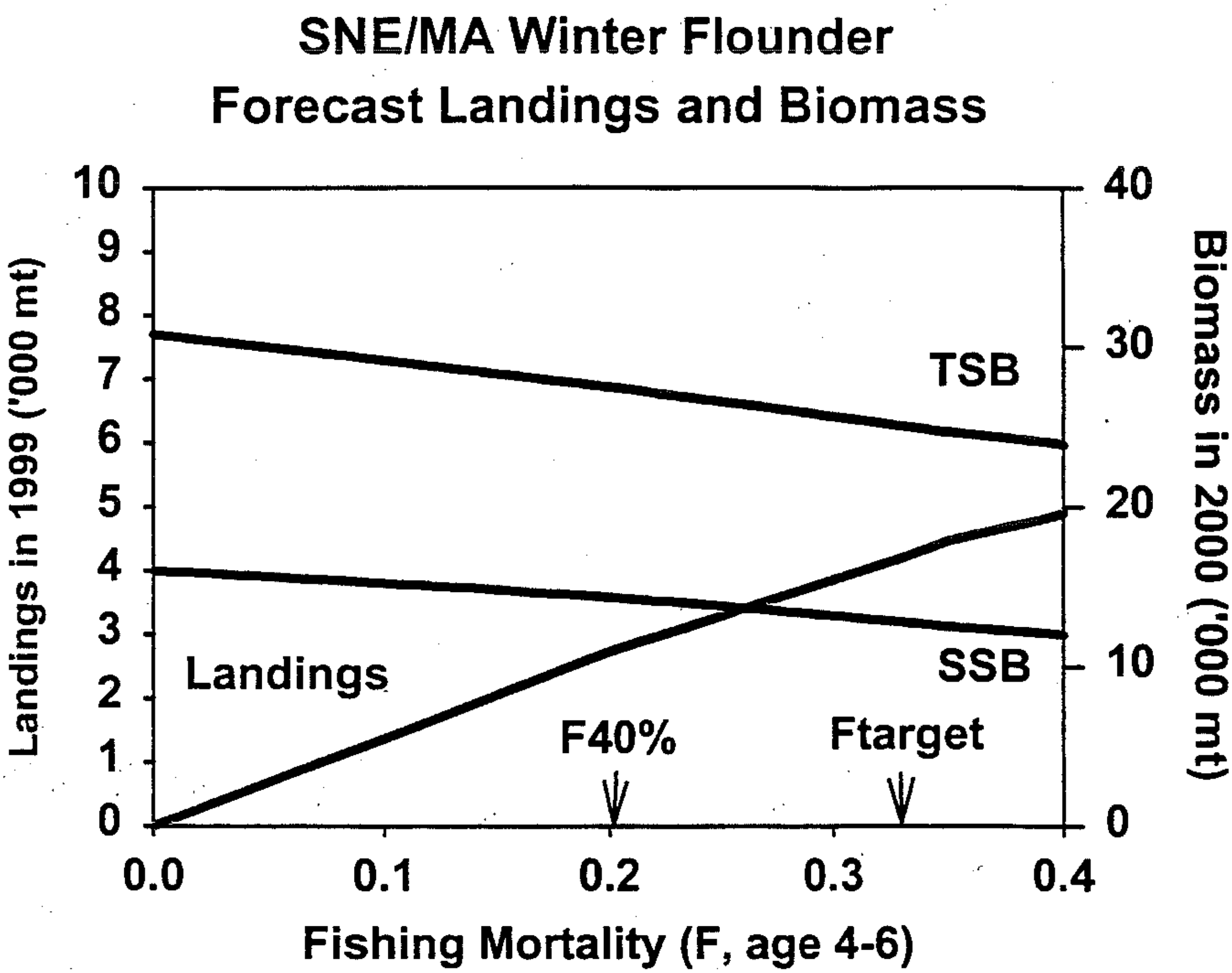

Figure E.12. Projected landings and SSB in 1999 for SNE/MA winter flounder over a range of fishing mortality from F=0.0 to F=0.40.