Northeast Fisheries Science Center Reference Document 02-14

35th Northeast Regional Stock Assessment Workshop (35th SAW)

Stock Assessment Review Committee (SARC) Consensus Summary of Assessments

September 2002

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02-11 **Status of the Northeast U.S. Continental Shelf Ecosystem: A Report of the Northeast Fisheries Science Center's Ecosystem Status Working Group**. By J.S. Link and J.K.T. Brodziak, editors, with contributions from (listed alphabetically) J.K.T. Brodziak, D.D. Dow, S.F. Edwards, M.C. Fabrizio, M.J. Fogarty, D. Hart, J.W. Jossi, J. Kane, K.L. Lang, C.M. Legault, J.S. Link, S.A. MacLean, D.G. Mountain, J. Olson, W.J. Overholtz, D.L. Palka, and T.D. Smith. August 2002.

02-12 **Proceedings of the Fifth Meeting of the Transboundary Resources Assessment Committee (TRAC), Woods Hole, Massachusetts, February 5-8, 2002.** By R.N. O'Boyle and W.J. Overholtz, TRAC co-chairmen. [A report of Transboundary Resources Assessment Committee Meeting No. 5]. September 2002.

02-13 **Report of the 35th Northeast Regional Stock Assessment Workshop (35th SAW): Public Review Workshop.** [By Northeast Regional Stock Assessment Workshop No. 35.] September 2002.

Northeast Fisheries Science Center Reference Document 02-14

A Report of the 35th Northeast Regional Stock Assessment Workshop

35th Northeast Regional Stock Assessment Workshop (35th 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

September 2002

Northeast Fisheries Science Center Reference Documents

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D. SILVER HAKE STOCK IDENTIFICATION

MEETING OVERVIEW

The Stock Assessment Review Committee (SARC) meeting of the 35th Northeast Regional Stock Assessment Workshop (35th SAW) was held in the Aquarium Conference Room of the Northeast Fisheries Science Center's Woods Hole Laboratory, Woods Hole, MA during 24-28 June, 2002. The SARC Chairman was Dr. Norman Hall, Centre for Fish and Fisheries Research, Murdoch University, Western Australia. Members of the SARC included scientists from the NEFSC, the Mid-Atlantic Fishery Management Council (MAFMC), Atlantic States Marine Fisheries Commission (ASMFC), the States of Maine and North Carolina, NYU School of Medicine, Marine Institute of Ireland, and the Centro Nacional Patagonico of Argentina (Table 1). In addition, 27 other persons attended some or all of the meeting (Table 2). The meeting agenda is presented in Table 3.

Table 1. SAW-35th SARC Composition.

Chairman
Norman G. Hall
(Murdoch University, Perth, Western Australia) (CIE)

Northeast Fishery Science Center:
Steven Cadrin
Devora Hart
James Weinberg
Susan Wigley

Regional Fishery Management Councils:
Chris Moore, MAFMC

Atlantic States Marine Fisheries Commission/States:
John Carmichael, NC
Matthew Cieri, ME
Joseph Defosse, ASMFC

Other experts:
Ciaran Kelly, Marine Institute of Ireland
Ana Parma, Centro Nacional Patagonico of Argentina (CIE)
Isaac Wirgin, NYU School of Medicine

Opening

Dr. Terrence Smith, Stock Assessment Workshop (SAW) Chairman, welcomed the meeting participants and briefly reviewed the overall SAW process. Dr. Hall reviewed the agenda and discussed the conduct of the meeting.

Table 2. List of Participants.

NMFS, Northeast Fisheries Science Center
Steve Murawski
Fred Serchuk
Frank Almeida
Wendy Gabriel
Josef Idoine
Paul Nitschke
Loretta O'Brien
William Overholtz
Paul Rago
Gary Shepherd
Vaughn Silva
Pie Smith
Terry Smith
Katherine Sosebee
Michele Thompson

MAFMC/ASMFC/States/Industry
Michael Armstrong, MA
Stephen Brown, NMFS
Eleanor Bochenek, Rutgers
Paul Caruso, MA
Steven Correira, MA
James Fletcher, Industry
Laura Lee, ASMFC
Michael Lewis, ASMFC
Jim Lovgren, MAFMC
Bill Phoel, Industry
John Sheppard, MA
Pete Straub, Richard Stockton College
Marla Trollan, MAFMC
Bonnie VanPelt, NERO

Table 3. Agenda of the 35th Northeast Regional Stock Assessment Workshop (SAW-35) Stock Assessment Review Committee (SARC) Meeting

Aquarium Conference Room - NEFSC Woods Hole Laboratory
Woods Hole, Massachusetts
24-28 June, 2002

AGENDA

TOPIC	WORKING GROUP & PRESENTER(S)	SARC LEADER	RAPPORTEUR
MONDAY, 24 June (1:00 - 5:00 PM)........			
Opening			
Welcome	Terry Smith, SAW Chairman		P. Smith
Introduction	Norm Hall, SARC Chairman		
Summer flounder (A)	Southern Demersal Working Group		
	Mark Terceiro	C. Moore	P. Nitschke
TUESDAY, 25 June (8:30 AM - 6:00 PM)........			
Scup (B)	Scup Assessment Subcommittee		
	ASMFC Scup Technical Team		
	Laura Lee	C. Kelly	M. Lewis
Informal reception (**6:00 PM**) at SWOPE Building (Marine Biological Laboratory)			
WEDNESDAY, 26 June (8:30 AM - 5:00 PM)........			
8:30 AM			
Methods Working Group (C)	Methods Working Group		
	Paul Rago	A. Parma	K. Sosebee
1:00 PM			
Whiting Stock Identification (D)	Undersea Research Foundation		
	Bill Phoel	S. Cadrin	
THURSDAY, 27 June (8:30 AM - 5:00 PM)........			
Review Advisory Reports and Consensus Summary Sections for the SARC Report			
FRIDAY, 28 June (8:30 AM - 5:00 PM)........			
SARC comments, research recommendations, and 2nd drafts of Advisory Reports			
Other business		P. Smith	

* = To be determined by SARC Chairman

The Process

The Northeast Regional Coordinating Council (NRCC) guides the SAW process and is composed of the chief executives of the five partner organizations (NMFS/NEFSC, NMFS/NER, NEFMC, MAFMC, ASMFC). Working groups assemble the data for assessments, decide on methodology, and prepare documents for SARC review. Assessments for SARC review were prepared at meetings listed in Table 4.

Agenda and Reports

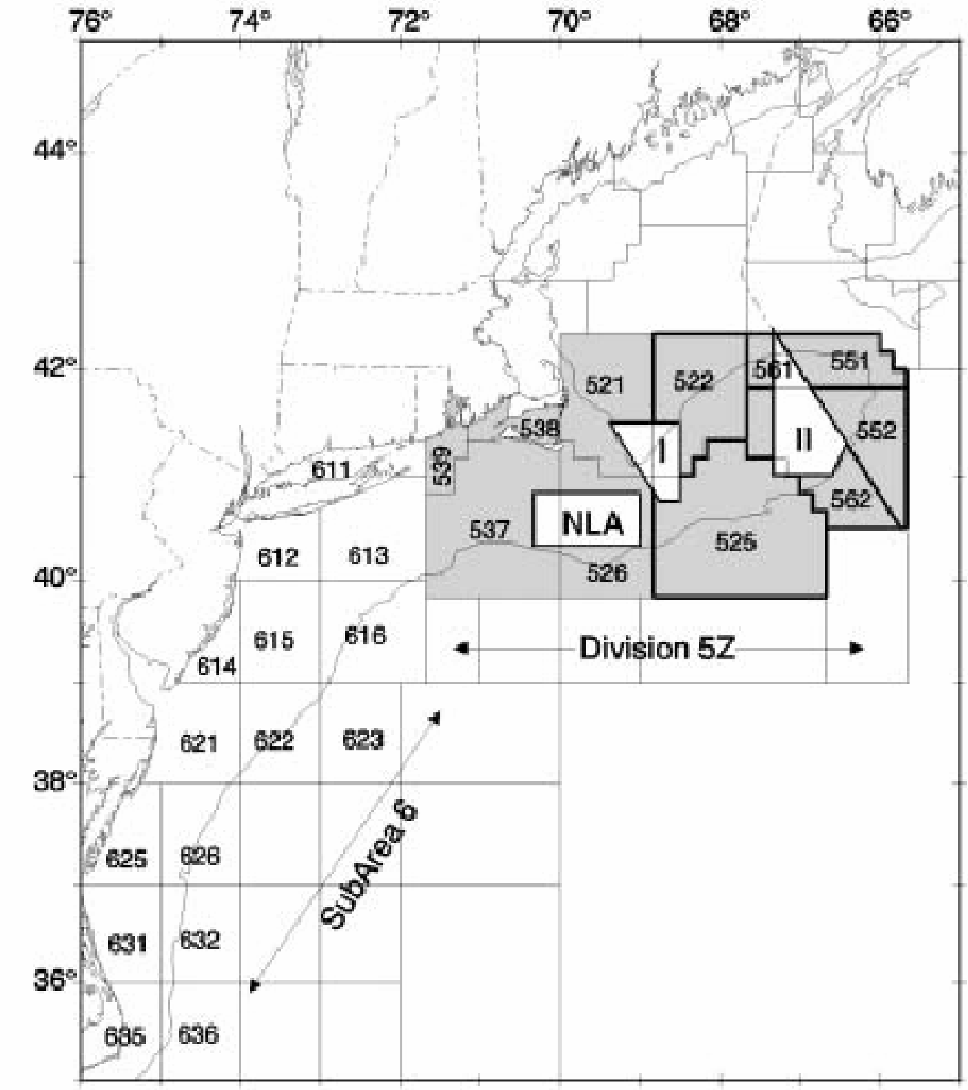
The SAW-35 SARC agenda (Table 3) included presentations on assessments for summer flounder, scup, a review by the SAW Methods Group, and a review of preliminary results from a research study concerning silver hake (whiting). A chart of US commercial statistical areas used to report landings in the Northwest 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 (SARC Consensus Summary), and another produced in a standard format which includes the status of stocks and management advice (SARC Advisory Report). The draft reports were made available at a SAW-35 Public Review Workshop held during a joint MAFMC and ASMFC meeting (6-8 August, Philadelphia). Following the Public Review Workshop, the documents are finalized and published in the NEFSC Reference Document series as the *35th SARC Consensus Summary of Assessments* (this document) and the 35th *SAW Public Review Workshop Report* (the latter document includes the final version of the Advisory Report).

Table 4. SAW-35 Working Group meetings and participants.

Working Group and Participants	Meeting Date	Stock/Species
SAW Southern Demersal	20-21 May, 2002	**Summer flounder**
J. Bancroft, DEDFW		
P. Caruso, MADMF		
C. Legault, NEFSC		
A. Mooney, NYDEC		
C. Moore, MAFMC		
P. Nitschke, NEFSC		
R. Pearson, NERO		
E. Powell, Rutgers University		
M. Terceiro, NEFSC (Chair)		
SSC Overfishing Definition Meeting	July 31 - August 1, 2001	**Summer flounder**
J. Armstrong, MADMF		
B. Beal, MAFMC		
E. Bochanek, Rutgers		
D. Conover, MAFMC		
V. Crecco, MADMF		
W. Gabriel, NEFSC		
M. Gibson, RI DEM		
J. Hightower		
J. Hoenig		
M. Holliday, NMFS		
E. Houde		
C. Jones		
M. Lewis, MAFMC		
T. Miller		
C. Moore, MAFMC (Chair)		
R. Pearson, NMFS		
ASMFC Scup Assessment Subcommittee	April 16, 2002	**Scup**
P. Caruso, MA DMF	May 17, 29	
V. Crecco, CT DEP	June 4, 2002	
L. Lee, ASMFC		
M. Lewis, ASMFC (Chair)		
C. Moore, MAFMC		
B. Murphy, RI DEM		
M. Terceiro, NEFSC		
SAW Methods Working Group		
P. Rago, NEFSC (Chair)		

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



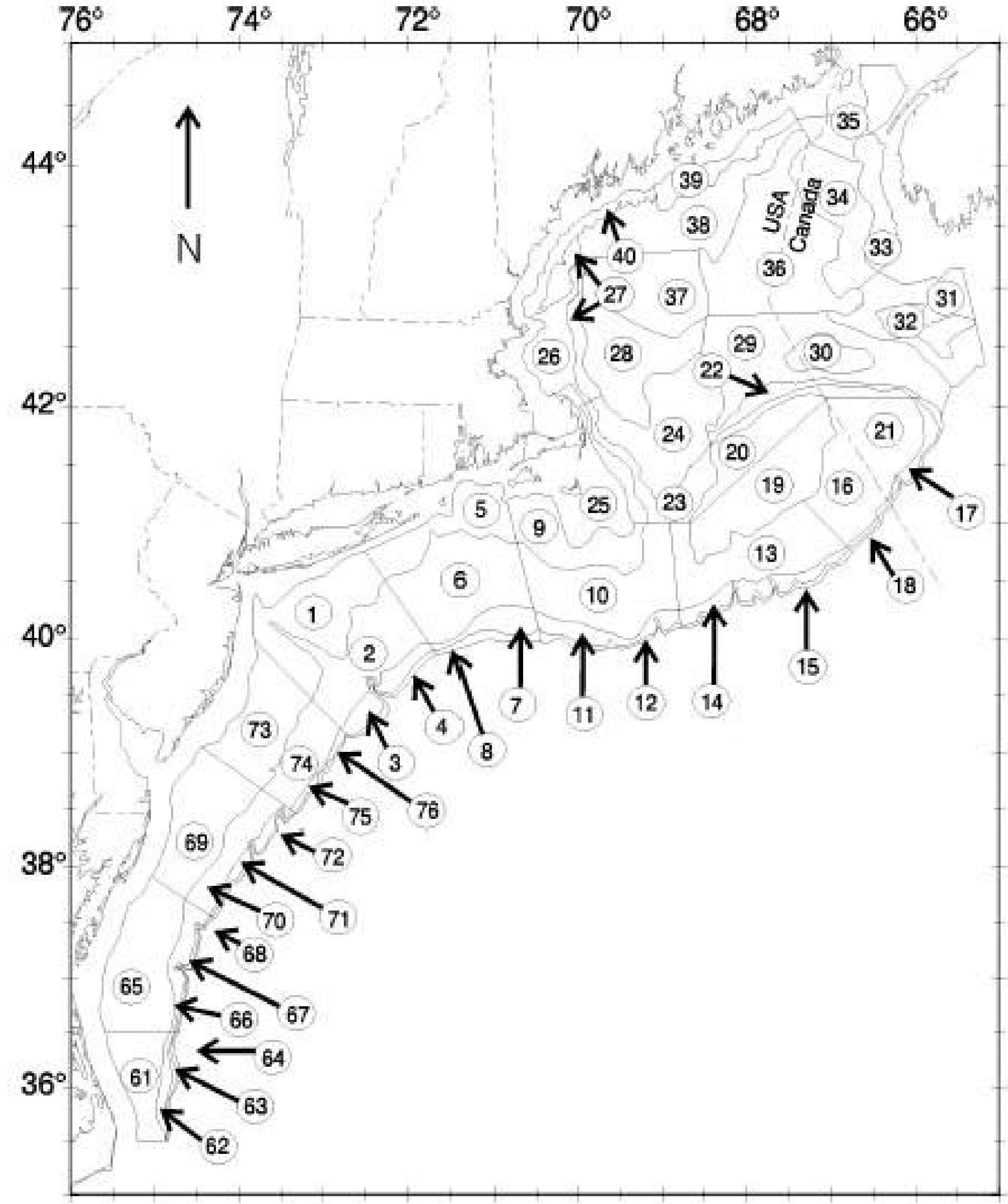


Figure 2. Offshore sampling strata used in NEFSC bottom trawl surveys.

A. SUMMER FLOUNDER

TERMS OF REFERENCE

The following terms of reference were addressed for summer flounder:

1. Characterize the commercial and recreational catch including landings and discards.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates.

3. Evaluate and either update or re-estimate biological reference points as appropriate.

4. Where appropriate, estimate a TAC and/or TAL based on stock status and target mortality rate for the year following the terminal assessment year.

5. If stock projections are possible,

   a. provide short term projections (2-3 years) of stock status under various TAC/F strategies and
   b. evaluate current and projected stock status against existing rebuilding or recovery schedules, as appropriate.

INTRODUCTION

For assessment purposes, the previous definition of Wilk *et al*. (1980) of a unit stock extending from Cape Hatteras north to New England has been accepted. The joint Mid-Atlantic Fishery Management Council (MAFMC) Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan (FMP) for summer flounder has as a management unit all summer flounder from the southern border of North Carolina, northeast to the U.S.-Canadian border. A recent summer flounder genetics study (Jones and Quattro, 1999) revealed no significant population subdivision centered around Cape Hatteras.

Amendment 1 to the FMP in 1990 established the overfishing definition for summer flounder as fishing mortality rate equal to $F_{max,}$ initially estimated as 0.23 (NEFC 1990). Amendment 2 in 1992 set target fishing mortality rates for summer flounder for 1993-1995 (F = 0.53) and 1996 and beyond (F_{max} = 0.23). Major regulations enacted under Amendment 2 to meet those fishing mortality rate targets included: 1) an annual fishery landings quota, with 60% allocated to the commercial fishery and 40% to the recreational fishery, based on the historical (1980-1989) division of landings, with the commercial allocation further distributed among the states based on their share of commercial landings during 1980-1989, 2) commercial minimum landed fish size limit at 13 in (33 cm), as established in the original FMP, 3) a minimum mesh size of 5.5 in (140 mm) diamond or 6.0 in (152 mm) square for commercial vessels using otter trawls that possess 100 lb (45 kg) or more of summer flounder, with exemptions for the flynet fishery and vessels fishing in an exempted area off southern New England (the Northeast Exemption Area) during 1 November to 30 April, 4) permit requirements for the sale and purchase of summer flounder, and 5) annually adjustable regulations for the recreational fishery, including seasons, a 14 in (36 cm) minimum landed fish size, and possession limits.

Amendment 3 to the FMP revised the western boundary of the Northeast Exemption Area to $72^0$30'W (west of Hudson Canyon), increased the large mesh net possession threshold to 200 lbs during 1 November to 30 April, and stipulated that only 100 lbs could be retained before using a large mesh net during 1 May to 31 October. Amendment 4 adjusted Connecticut's commercial landings of summer flounder and revised the state-specific shares of the commercial quota accordingly. Amendment 5 allowed states to transfer or combine the commercial quota. Amendment 6 allowed multiple nets on board commercial fishing vessels if properly stowed, and changes the deadline for publication of overall catch limits and annual commercial management measures to 15 October and the recreational management measures to 15 February.

The results of previous assessments indicated that summer flounder abundance was not increasing as rapidly as projected when Amendment 2 regulations were implemented. In anticipation of the need to drastically reduce fishery quotas in 1996 to meet the management target of F_{max}, the MAFMC and ASMFC modified the fishing mortality rate reduction schedule in 1995 to allow for more stable landings from year to year while slowing the rate of stock rebuilding. Amendment 7 to the FMP set target fishing mortality rates of 0.41 for 1996 and 0.30 for 1997, with a target of F_{max} = 0.23 for 1998 and beyond. Total landings were to be capped at 8,400 mt (18.51 million lbs) in 1996-1997, unless a higher quota in those years provided a realized F of 0.23. Amendment 12 in 1999 defined overfishing for summer flounder to occur when the fishing mortality rate exceeds the threshold fishing mortality rate of F_{MSY}. Since F_{MSY} could not be reliably estimated for summer flounder, F_{max} = 0.24 was used as a proxy for F_{MSY}, and was also defined as the target fishing mortality rate. The stock was defined to be overfished when the total stock biomass falls below the minimum biomass threshold of one-half of the biomass target, B_{MSY}. Because B_{MSY} could not be reliably estimated, the biomass target was defined as the product of total biomass per recruit and contemporary (1982-1996) median recruitment, estimated to be 153,350 mt (338 million lbs), with the biomass threshold defined as 76,650 mt (169 million lbs). In a recent stock assessment (Terceiro 1999), those references points were updated using recent estimates of median recruitment (1982-1998) and mean weights at age (1997-1998), providing a biomass target of 106,444 mt (235 million lbs) and biomass threshold of 53,222 mt (118 million lbs). The Terceiro (1999) reference points were retained in the 2000 and 2001 stock assessments (NEFSC 2000, MAFMC 2001a) because of the stability of the input data. Concurrent with the development of the 2001 assessment, the MAFMC and ASMFC convened the ASMFC Summer Flounder Overfishing Definition Review Committee to review the reference points. The work of the Committee was reviewed by the MAFMC Scientific and Statistical Committee (SSC) in August 2001. The SSC recommended that the F_{MSY} proxy of F_{max} = 0.26 remain for 2002, and endorsed the recommendation of SARC 31

(NEFSC 2000) which stated that "...the use of F_{max} as a proxy for F_{MSY} should be reconsidered as more information on the dynamics of growth in relation to biomass and the shape of the stock recruitment function become available (MAFMC 2001b).

The 2001 stock assessment (MAFMC 2001a) found that the fishing mortality rate had declined from 1.32 in 1994 to 0.30 in 2000, about 15% higher than the FMP overfishing definition. Total stock biomass in 2000 was estimated to be 46,400 mt, 13% below the FMP biomass threshold. Therefore, the stock was found to be overfished and overfishing was occurring relative to the FMP reference points.

FISHERY DATA

Commercial Fishery Landings

Total U.S. commercial landings of summer flounder from Maine to North Carolina peaked in 1979 at nearly 18,000 mt (40 million lbs, Table A1). The reported landings in 2001 of 4,916 mt (about 10.8 million lbs) were about 1% over the adjusted 2001 quota of 4,875 mt (10.7 million lbs). Since 1980, 70% of the commercial landings of summer flounder have come from the Exclusive Economic Zone (EEZ; greater than 3 miles from shore). The percentage of landings attributable to the EEZ was lowest in 1983 and 1990 at 63% and was highest in 1989 at 77%. Large variability in summer flounder landings exist among the states, over time, and the percent of total summer flounder landings taken from the EEZ has varied widely among the states.

Northeast Region Commercial Fishery Landings

Annual commercial landings data for summer flounder in years prior to 1994 were obtained from trip-level detailed landings records contained in master data files maintained by the NEFSC (the weighout system; 1963-1993) and from summary reports of the Bureau of Commercial Fisheries and its predecessor the U.S. Fish Commission (1940-1962). Beginning in 1994, landings estimates were derived from mandatory dealer reports under the current NMFS Northeast Region (NER) summer flounder quota monitoring system.

Prior to 1994, summer flounder commercial landings were allocated to NEFSC 3-digit statistical area according to interview data (Burns *et al. In* Doubleday and Rivard 1983). For 1994-2001, dealer landings were allocated to statistical area using fishing Vessel Trip Reports (VTR data) according to the general procedures developed by Wigley *et al.* (1997), in which a matched set of dealer and VTR data is used as a sample to characterize the statistical area distribution of monthly state landings. Since the implementation of the annual commercial landings quota in 1993, the commercial landings have become concentrated during the first calender quarter of the year, with about 46% of the landings taken during the first quarter in 2001.

The distribution of 1992-2001 landings by three-digit statistical area is presented in Table A2. Areas 537-539 (Southern New England), areas 611-616 (New York Bight), areas 621, 622, 625, and 626 (Delmarva region), and areas 631 and 632 (Norfolk Canyon area) have generally accounted for over 80% of the NER commercial landings. In 2001, these areas accounted for 95% of the NER commercial landings. A summary of length and age sampling of summer flounder landings collected by the NEFSC commercial fishery port agent system in the NER is presented in Table A3. For comparability with the manner in which length frequency sampling in the recreational fishery has been evaluated, sampling intensity is expressed in terms of metric tons of landings (mt) per 100 fish lengths measured. The sampling is proportionally stratified by market category (jumbo, large, medium, small, and unclassified), with the sampling distribution generally reflecting the distribution of commercial landings by market category. Overall sampling intensity has improved markedly since 1995, from 165 mt per 100 lengths to 30-40 mt per 100 lengths, and temporal and geographic coverage has generally improved as well.

The age composition of the NER commercial landings for 1994-2001 was generally estimated semiannually by market category and (usually) 1-digit statistical area (e.g., area 5 or area 6), using standard NEFSC procedures (market category length frequency samples converted to mean weights by length-weight relationships; mean weights in turn divided into landings to calculate numbers landed by market category; market category numbers at length apportioned to age by application of age-length keys, on semiannual area basis). For 2000 and 2001, sampling was generally sufficient to make quarterly estimates of the age composition in area 6 (in some cases, by division) for the large and medium market categories.

NER landed numbers at age were raised to total NER (general canvas) commercial landings when necessary by assuming that landings not accounted for in the weighout/mandatory reporting system had the same age composition as that sampled, as follows: calculate proportion at age by weight; apply proportions at age by weight to total NER commercial landings to derive total NER commercial catch at age by weight; divide by mean weights at age to derive total NER commercial landed numbers at age (Table A4). The proportion of large and jumbo market category fish in the NER landings has increased since 1996, while the proportion of small market category landings has become very small. The mean size of fish landed in the NER commercial fishery has been increasing since 1993, and was about 1.01 kg (2.2 lbs) in 2001, typical of an age 3 summer flounder (Table A5).

North Carolina Commercial Fishery Landings

The North Carolina winter trawl fishery accounts for about 99% of summer flounder commercial landings in North Carolina. A separate landings at age matrix for this component of the commercial fishery was developed from North Carolina Division of Marine Fisheries (NCDMF) length and age frequency sampling data. The NCDMF program samples about 10% of the winter trawl fishery landings annually, at a rate of between 53 and 5 mt of landings per 100 lengths measured (Table A6). All length frequency data used in construction of the North Carolina winter trawl fishery landings at age matrix were collected in the NCDMF program; age-length keys from NEFSC commercial data and NEFSC spring survey data (1982-1987) and NCDMF commercial fishery data (1988-2001) were combined by appropriate statistical area and semiannual period to resolve lengths to age. Fishery regulations in North Carolina also changed between 1987 and 1988, with increases in both the minimum mesh size of the codend and minimum landed fish size taking effect. It is not clear whether the change in regulations or the change in keys, or some combination, is responsible for the decreases in the numbers of age-0 and age-1 fish estimated in the North Carolina commercial fishery landings since 1987. Landed numbers at age and mean weights at age from this fishery are shown in Tables A7-A8.

Commercial Fishery Discards

In a previous assessment, analysis of variance of the fishery observer data for summer flounder was used to identify stratification variables for an expansion procedure to estimate total landings and discards from fishery observer data kept and discard rates (weight per day fished) in the commercial fishery. Initial models included year, quarter, fisheries statistical division (2-digit area), area (divisions north and south of Delaware Bay), and tonnage class as main effects, with quarter and division emerging (along with year) as consistently significant main effects without significant interaction with the year (NEFSC 1993). The estimation procedure expands transformation bias-corrected geometric mean catch (landings and discards) rates in year, quarter, and division strata by total days fished (days fished on trips landing any summer flounder by any mobile gear, including fish trawls and scallop dredges) to estimate fishery landings and discards. The use of fishery effort as the multiplier (raising factor) allows estimation of landings from the fishery observer data for comparison with dealer reported landings, to help judge the potential accuracy of the procedure and/or sample data.

For strata with no fishery observer sampling, catch rates from adjacent or comparable strata were substituted as appropriate (except for Division 51, which generally has very low catch rates and negligible catch). Estimates of discard are stratified by 2 gear types (scallop dredge and trawl and others) for years when data are adequate (1992-2001). Estimates at length and age are stratified by gear only for 1994-2000, again due to sample size considerations. Only 11 fish were sampled from the sea scallop dredge fishery 2001, and so the scallop dredge discards were assumed to have the same length and age composition as the trawl fishery discards in 2001.

While estimates of catch rates from the NER fishery observer data are used in this assessment to estimate total discards, information on catch rate is also reported in the VTR data. A comparison of discard to total catch ratios for the fishery observer and VTR data sets for trawl and scallop dredge gear indicated similar discard rates in the trawl fishery from the two data sources, while discard rates in the scallop dredge fishery were often higher in the fishery observer data. Overall fishery observer and VTR discard to total catch ratios for 1994-2000 were generally within 10% of each other; 2001 was an exception, with an overall discard to total catch ratio of 45% in the fishery observer data and 29% in the VTR data (Tables A9-A10).

The change from the interview/weighout data reporting system to the VTR/mandatory dealer report system required a change in the estimation of effort (days fished) used as a multiplier with the fishery observer geometric mean discard rate in the procedure used to estimate total discard for 1994-2001. An initial examination of days fished and catch per unit effort (CPUE; landings per day fished) for cod conducted at SAW 24 (NEFSC 1997a) compared these quantities as reported in the full weighout and VTR data sets (DeLong *et al.*, 1997). This comparison indicated a shift to a higher frequency of short trips (trips with one or two days fished reported), and to a mode at a lower rate of CPUE. It was not clear at SAW 24 if these changes were due to the change in reporting system (units reported not comparable), or real changes in the fishery, and so effort data reported by the VTR system were not used quantitatively in the SAW 24 assessments. In the SAW 25 assessment for summer flounder (NEFSC 1997a), a slightly different comparison was made. The port agent interview data for 1991-93 and merged dealer/VTR data for 1994-1996 (the matched set data), which under each system serve as the "sample" to characterize the total commercial landings, were compared in relative terms (percent frequency). For summer flounder, the percent frequency of short trips (lower number of days fished per trip) increased during 1991-1996, but not to the degree observed for cod, and the mode of CPUE rates for summer flounder increased in spite of lower effort per trip. For the summer flounder fishery, these may reflect actual changes in the fishery, due to increasing restrictions of allowable landings per trip (trip landings limits might lead to shorter trips) and increasing stock size (higher CPUE). As for cod, however, the influence of each of these changes (reporting system, management changes, stock size changes) has not been quantified. Total days fished in the summer flounder fishery were comparable between 1989-1993 period and 1994. With increasing restrictions on the fishery in 1995-2001 (lower landings quota, higher stock size, and thus increasing impact of trips limits and closures), total days fished declined relative to the early 1990s. Questions will remain about the accuracy of the VTR data . However, because the effort measure is critical to the estimation of discards for summer flounder, the VTR data were used as the best data source to estimate summer flounder fishery days fished for 1994-2001.

Two adjustments were made to the dealer/VTR matched data subset days fished estimates to fully accounted for summer flounder fishery effort during 1994-2001. First, the landings to days fished relationship in the matched set was assumed to be the same for unmatched trips, and so the days fished total in each discard estimation stratum (2-digit area and quarter) was raised by the dealer to matched set landings ratio. This step in the estimation accounted for days fished associated with trips landing summer flounder, and provided an estimate of discard for trips landing summer flounder.

Given the restrictions on the fishery however, there is fishing activity which results in summer flounder discard, but no landings, especially in the scallop dredge fishery. The days fished associated with these trips was accounted for by raising strata discard estimates by the ratio of the total days fished on trips catching any summer flounder (trips with landings and discard, plus trips with discard only) to the days fished on trips landing summer flounder (trips with landings and discard), for VTR trips reporting discard of any species (DeLong *et al.* 1997). For this step, it is necessary to assume that the discard rate (as indicated by the fishery observer data, which includes trips with discard but no landings, and which is used in previous estimation procedure steps) is the same for trips with only discard as for trips which both land and discard.

The expansion procedure provided fishery observer data estimates of landings ranging from +35% (1996) to -69% (2001) of the reported landings in the fisheries, with discard ranging from 41% (1990) to 6% (1995) of the reported landings. Total discards estimated for 2000 and 2001 were 18% and 16% of the reported landings. Scallop dredge fishery discard to landed ratios are much higher than trawl fishery ratios, purportedly because of closures and trip limits. Thus, although the scallop dredge landings are less than 5% of the total, the discard is of the same order of magnitude as that in the trawl fishery.

These discard estimates were based only on the days fished data for ports in the NER during

1989-1996, and so it was necessary to raise the discard estimate to account for discarding which occurs in components of the commercial fishery outside the NER reporting system (i.e., NER state reporting systems such as Connecticut and Virginia, and North Carolina) for those years. To determine the proper raising factor, landings accounted for by the NER reporting system (which result from the fishing effort on which the fishery observer discard estimate is based) were compared with total NER landings, plus that portion of North Carolina landings removed from the EEZ (it is assumed that only the North Carolina fishery in the EEZ would experience significant discard, as mesh regulations in state waters have resulted in very low discards in state waters since implementation of the regulation in 1989; R. Monaghan, pers. comm.). Since 1996, all states' landings and are included in the NER dealer reporting system, so no raising is necessary to account for missing landings. As recommended by SAW 16 (NEFSC 1993), a commercial fishery discard mortality rate of 80% was assumed to develop the final estimate of discard mortality (Table A11).

Existing fishery observer data were used to develop estimates of commercial fishery discard for 1989-2001. However, adequate data (e.g., interviewed trip data, survey data) are not available for summer flounder to develop discard estimates for 1982-1988. Discard numbers were assumed to be very small relative to landings during 1982-1988 (because of the lack of a minimum size limit in the EEZ), but to have increased since 1989 with the implementation of fishery regulations under the FMP. It is recognized that not accounting directly for commercial fishery discards would result in an underestimation of fishing mortality and population sizes in 1982-1988.

NEFSC fishery observer length frequency samples were converted to sample numbers at age and sample weight at age frequencies by application of NEFSC survey length-weight relationships and fishery observer, commercial fishery, and survey age-length keys. Sample weight proportions at age were next applied to the raised fishery discard estimates to derive fishery total discard weight at age. Fishery discard weights at age were then divided by fishery observer mean weights at age to derive fishery discard numbers at age. Classification to age for 1989-1993 was done by semiannual (quarters 1 and 2 pooled, quarters 3 and 4 pooled) periods using NEFSC fishery observer age-length keys, except for 1989, when first period lengths were aged using combined commercial (quarters 1 and 2) and NEFSC spring survey age-length keys. For 1994-2001, only NEFSC winter, spring, and fall survey age-length keys were used. Fishery observer sampling intensity is summarized in Table A11. Estimates of discarded numbers at age, mean length and mean weight at age are summarized in Tables A12-A14.

The reason for discarding in the trawl and scallop dredge fisheries has been changing over time. During 1989 to 1995, the minimum size regulation was recorded as the reason for discarding summer flounder for over 90% of the observed trawl and scallop dredge tows. In 1999, the minimum size regulation was provided as the reason for discarding for 61% of the observed trawl tows, with quota or trip limits given as the discard reason for 26% of the observed tows, and high-grading for 11% of the observed tows. In the scallop fishery in 1999, quota or trip limits was given as the discard reason for over 90% of the observed tows. During 2000-2001, minimum size regulations were identified as the discard reason for 40-45% of the observed trawl tows, quota or trip limits for 25-30% of the tows, and high grading for 3-8%. In the scallop fishery during 2000-2001, quota or trip limits was given as the discard reason for over 99% of the observed tows. As a result of the increasing impact of trip limits, fishery closures, and high grading as the reasons for discarding, the age structure of the summer flounder discards has also changed, with more older fish being discarded (Table A12).

Recreational Fishery Landings

Summary landings statistics for the recreational fishery (catch type A+B1) as estimated by the National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Survey (MRFSS) are presented in Tables A15-A16. Recreational fishery landings decreased 29% by number and 26% by weight from 2000 to 2001, although the fishery still landed 162% (5,250 mt, 11.6 million lbs) of the 3,250 mt (7.2 million lbs) harvest limit established for 2001.

The length frequency sampling intensity for the recreational fishery for summer flounder was calculated by MRFSS subregions (North - Maine to Connecticut; Mid - New York to Virginia; South - North Carolina) on a metric tons of landings per hundred lengths measured basis (Burns *et al. In* Doubleday and Rivard, 1983). For 2001, aggregate sampling intensity averaged 123 mt of landings per 100 fish measured, an improvement over 2000 (Table A17).

MRFSS sample length frequency data, NEFSC commercial age-length data, and NEFSC survey age-length data were examined in terms of number of fish measured/aged on various temporal and geographical bases. Correspondences were made between MRFSS intercept date (quarter), commercial quarter, and survey season (spring and summer/fall) on temporal bases, and between MRFSS subregion, commercial statistical areas, and survey depth strata on geographic bases in order to integrate data from the different sources. Based on the number, size range, and distribution of lengths and ages, a semiannual (quarters 1 and 2, quarters 3 and 4), subregional basis of aggregation was adopted for matching of commercial and survey age-length keys with recreational length frequency distributions for conversion of the lengths to ages.

The recreational landings historically have been dominated by relatively young fish. Over the 1982-1996 period, age 1 fish accounted for an average of over 50% of the landings by number; summer flounder of ages 0 to 4 accounted for an average of over 99% of landings by number. No fish from the recreational landings were determined to be older than age 7. With increases in the minimum size during 1997-2001 (to 14.5 in [37 cm] in 1997, 15 in [38 cm] in 1998-1999, generally 15.5 in [39 cm] in 2000, and various state minimum sizes from 15.5 [38 cm] to 17.5 in [44 cm] in 2001), reductions in fishing mortality, and patterns in recruitment to the stock, the age composition of the recreational landings now includes mainly fish at ages 2 and 3. The number of summer flounder of ages 4 and older landed by the recreational fishery in 2000 (11% of the landings by number) and 2001 (13%) was the highest since 1983 (Table A18).

Small MRFSS intercept length sample sizes for larger fish resulted in a high degree of variability in mean length for older fish, especially at ages 5 and older. Attempts to estimate length-weight relationships from MRFSS biological sample data for use in estimating weight at age provided unsatisfactory results. As a result, quarterly length (mm) to weight (g) relationships from Lux and Porter (1966), which are employed in the conversion of length to weight in NEFSC compilation of commercial fishery statistics for summer flounder, were used to calculate annual mean weights at age from the estimated age-length frequency distribution of the landings.

Recreational Fishery Discards

MRFSS catch estimates were aggregated on a subregional basis for calculation of the proportion of live discard (catch type B2) to total catch (catch types A+B1+B2) in the recreational fishery for summer flounder. Examination of catch data in this manner shows that the live discard has varied from about 18% (1985) to about 81% (1999, 2001) of the total catch (Table A19).

To account for all removals from the summer flounder stock by the recreational fishery, some assumptions about the biological characteristics and hooking mortality rate of the recreational live discard needed to be made, because no biological samples are taken from MRFSS catch type B2. In previous assessments, data available from New York Department of Environmental Conservation (NYDEC) surveys (1988-92) of New York party boats suggested the following for this component (Mid-Atlantic subregion, anglers fishing from boats) of the recreational fishery: 1) nearly all (>95%) of the fish released alive were below the minimum regulated size (during 1988-92, 14 in [36 cm] in New York state waters), 2) nearly all of these fish were age 0 and age 1 summer flounder, and 3) age 0 and 1 summer flounder occurred in approximately the same proportions in the live discard as in the landings. It was assumed that all B2 catch would be of lengths below regulated size limits, and so either age 0 or age 1 in all three subregions during 1982-1996. Catch type B2 was therefore allocated on a subregional basis in the same ratio as the annual age 0 to age 1 proportion observed in the landings during 1982-1996. Mean weights at age were assumed to be the same as in the landings during 1982-1996.

The minimum landed size in federal and most state waters increased to 14.5 in (37 cm) in 1997, to 15.0 in (38 cm) in 1998-1999, and to 15.5 in (39 cm) in 2000. Applying the same logic employed to classify the 1982-1996 recreational released catch to size and age for 1997-2000 implied that the recreational fishery released catch included fish of ages 2 and 3. Investigation of data from the CTDEP Volunteer Angler Survey (VAS, 1997-1999) and American Littoral Society (ALS, 1999), comparing the length frequency of released fish in those programs with the MRFSS data on the length frequency of landed fish less than the minimum size, suggested this assumption was valid for 1997-1999 (MAFMC 2001a). The CTDEP VAS and ALS data, along with data from the NYDEC Party Boat Survey (PBS) was used to validate this assumption for 2000. For 1997-2000 it was therefore assumed that all B2 catch would be of lengths below regulated size limits, and so of ages 0 to 3. Catch type B2 was therefore allocated on a sub-regional basis in the same ratio as the annual age 0 to age 3 proportions observed in the landings at lengths less than 37 cm in 1997, 38 cm in 1998-1999, and 39 cm in 2000 (Table A20).

In 2001, many states adopted different combinations of minimum size and possession limits to meet management requirements. As a result, minimum sizes for summer flounder ranged from 15.5 in (39 cm) in Federal, VA, and NC waters, 16 in (41 cm) in NJ, 16.5 in (42 cm) in MA, 17 in (43 cm) in MD and NY, to 17.5 in (44 cm) in CT, RI, and DE. Examination of data provided by MD sport fishing clubs, the CTDEP VAS, the ALS, and the NYDEP PBS indicated that the basic assumption that fish released are those smaller than the minimum size remained valid. Thus for 2001, catch type B2 was characterized by the same proportion at length as the landed catch less than the minimum size in the respective states. Due to sample size considerations, lengths and B2 catch were aggregated to semi-annual, subregional strata to calculate the expanded discards at length. The number of age 1 fish discarded in the recreational fishery in 2001 was the most since 1996 (Table A20).

Studies conducted cooperatively by NEFSC and the state of Massachusetts to estimate hooking mortality for striped bass and black sea bass suggest a hooking mortality rate of 8% for striped bass (Diodati and Richards 1996) and 5% for black sea bass (Bugley and Shepherd, 1991). Work by the states of Washington and Oregon with Pacific halibut (a potentially much larger flatfish species, but otherwise morphologically similar to summer flounder) found "average hooking mortality...between eight and 24 percent" (IPHC, 1988). An unpublished tagging study by the NYDEC (Weber MS 1984) on survival of released sublegal summer flounder caught by hook-and-line suggested a total, non-fishing mortality rate of 53%, which included hooking plus tagging mortality as well as deaths by natural causes (i.e., predation, disease, senescence). Assuming deaths by natural causes to be about 18%, (an instantaneous rate of 0.20), an annual hooking plus tagging mortality rate of about 35% can be derived from the NYDEC results. In the SARC 25 (NEFSC 1997b) and earlier assessments of summer flounder, a 25% hooking mortality rate was assumed reasonable for summer flounder released alive by anglers.

Two more recent investigations of summer flounder recreational fishery release mortality suggest that a lower release mortality rate is appropriate. Lucy and Holton (1998) used field trials and tank experiments to investigate the release mortality rate for summer flounder in Virginia, and found rates ranging from 6% (field trials) to 11% (tank experiments). Malchoff and Lucy (1998) used field cages to hold fish angled in New York and Virginia during 1997 and 1998, and found a mean short term mortality rate of 14% across all trials. Given the results of these release mortality studies conducted specifically for summer flounder, a 10% release mortality rate was adopted in the Terceiro (1999) and has been retained in subsequent assessments (NEFSC 2000, MAFMC 2001a).

Ten percent of the total B2 catch at age is added to estimates of summer flounder landings at age to provide estimates of summer flounder recreational fishery discard at age (Table A20), total recreational fishery catch at age in numbers (Table A21) and mean weights at age (Table A22). The number of fish discarded and assumed dead in the recreational fishery (2.3 million fish, 1,184 mt) was 43% by number and 23% by weight of the total landed (5.2 million fish, 5,250 mt) in the recreational fishery in 2001.

Total Catch Composition

NER total commercial fishery landings and discards at age, North Carolina winter trawl fishery landings and discards at age, and MRFSS recreational fishery landings and discards at age totals were summed to provide a total fishery catch at age matrix for 1982-2001 (Table A23; Figure A1). The percentage of age-3 and older fish in the total catch in numbers has increased in recent years from only 4% in 1993, to about 40% during 1998-2001. Overall mean lengths and weights at age for the total catch were calculated as weighted means (by number in the catch at age) of the respective mean values at age from the NER commercial (Maine to Virginia), North Carolina commercial, and recreational (Maine to North Carolina) fisheries (Tables A24-A25; Figure A2). The recreational fishery share of the total summer flounder catch has increased since 1995 (Figure A3).

BIOLOGICAL DATA

<u>Aging</u>

Work performed for the SAW 22 assessment (NEFSC 1996b) indicated a major expansion in the size range of 1-year old summer flounder collected during the 1995 and 1996 NEFSC winter bottom trawl surveys, and brought to light differences between ages determined by the NEFSC and NCDMF fishery biology staffs. Age structure (scale) exchanges were performed after the SAW 22 assessment to explore these aspects of summer flounder biology. The results of the first two exchanges, which were reported at SAW 22 (NEFSC 1996b), indicated low levels of agreement between age readers at the NEFSC and NC DMF (31 and 46%). In 1996, research was conducted to determine inter-annular distances and to back-calculate mean length at age from scale samples collected on all NEFSC bottom trawl surveys (winter, spring and fall) in order to compare with NCDMF samples. While mean length at age remained relatively constant from year to year, inter-annular distances increased sharply in the samples from the 1995-1996 winter surveys, and increased to a lesser degree in samples from other 1995-1996 surveys as well. As a result, further exchanges were suspended pending the resolution of an apparent aging problem.

Age data from the winter 1997 bottom trawl survey, aged utilizing both scales and otoliths by only by one reader, indicated a similar pattern as the previous two winter surveys (i.e., several large age 1 individuals) from scale readings, and some disagreement between scale and otolith ages obtained from the same fish. Because of these problems, a team of five experienced NEFSC readers was formed to re-examine the scales aged from the winter survey. After examining several hundred scales, the team determined that re-aging all samples from 1995-1997, including all winter, spring, and fall samples from the NEFSC and MA DMF bottom trawl surveys and all samples from the commercial fishery, would be appropriate. The age determination criteria used remained the same as developed at the 1990 summer flounder workshop (Almeida *et al.* 1992) and described in the standard aging manual utilized by NEFSC staff (Dery 1997). Only those fish for which a 100% consensus of all group members could be reached were included in the revised database, however. The data from the re-aged database were used in analyses in the SAW 25 assessment (NEFSC 1997b).

A third summer flounder aging workshop was held at NEFSC in February, 1999, to continue the exchange of age structures and review of aging protocols for summer flounder (Bolz *et al.* 2000). The participants of the latest workshop concluded that the majority of aging disagreements in recent NEFSC-NCDMF exchanges arose from the interpretation of marginal scale increments due to highly variable timing of annulus formation, and from the interpretation of first year growth patterns and first annulus selection. The workshop recommended regular samples exchanges between NEFSC and NCDMF, and further analyses of first year growth.

Maturity

The maturity schedule for summer flounder used in the 1990 SAW 11 and subsequent stock assessments through 1999 was developed by the SAW 11 Working Group using NEFSC Fall Survey maturity data for 1978-1989 and mean lengths at age from the NEFSC fall survey (G. Shepherd, NEFSC, personal communication; NEFC 1990; Terceiro 1999). The SAW 11 work indicated that the median length at maturity (50th percentile, L_{50}) was 25.7 cm for male summer flounder and 27.6 cm for female summer flounder, and 25.9 cm for the sexes combined. Under the aging convention used in the SAW 11 and subsequent assessments (Smith *et al.* 1981, Almeida *et al.* 1992, Szedlmayer and Able 1992, Bolz *et al.* 2000), the median age of maturity (50th percentile, A_{50}) for summer flounder was determined to be 1.0 years for males and 1.5 years for females. Combined maturities indicated that 38% of age-0 fish are mature, 72% of age-1 fish are mature, 90% of age-2 fish are mature, 97% of age-3 fish are mature, 99% of age-4 fish are mature, and 100% of age-5 and older fish are mature at peak spawning time in the autumn. The maturities for age-3 and older were rounded to 100% in the SAW 11 and subsequent assessments.

In the series of summer flounder assessments, it has been noted that the maturity schedules have been based on simple gross morphological examination of the gonads and therefore may not accurately reflect (i.e., may overestimate) the true spawning potential of the summer flounder stock (especially for age-0 and age-1 fish). It should also be noted, however, that spawning stock biomass (SSB) estimates based on age-2 and older fish show the same long term trends in SSB as estimates which include age 0 and 1 fish in the spawning stock. A research recommendation that the true spawning contribution of young summer flounder to the SSB be investigation has been included in summer flounder stock assessments since 1993 (NEFSC 1993). In light of the completion of a URI study to address this research recommendation, the maturity data for summer flounder for 1982-1998 were examined in the 2000 assessment (NEFSC 2000) to determine if changes in the maturity schedule were warranted.

The research at the University of Rhode Island (URI) by Drs. Jennifer Specker and Rebecca Rand Merson (hereafter referred to collectively as the “URI 1999" study) attempted to address the issue of the true contribution of young summer flounder to the spawning stock. The URI 1999 study examined the histological and biochemical characteristics of female summer flounder oocytes (1) to determine if age-0 and age-1 female summer flounder produce viable eggs, and (2) to develop an improved guide for classifying the maturity of summer flounder collected in NEFSC surveys (Specker *et al.* 1999, Merson *et al.* In press, Merson *et al.* In review). The URI study examined 333 female summer flounder (321 aged fish) sampled during the NEFSC Winter 1997 Bottom Trawl Survey (February 1997) and 227 female summer flounder (210 aged fish) sampled during the NEFSC Autumn 1997 Bottom Trawl Survey (September 1997), using radioimmunoassays to quantify the biochemical cell components characteristic of mature fish.

To provide an increased sampled size for the calculation of length- and age-based maturity schedules, the fish in the URI study sampled from the NEFSC Winter and Autumn 1997 Surveys were combined, with the ages of the fish from the Winter Survey reduced by 1 year to reflect their age at spawning during the previous (1996) autumn. For this combined sample, the NEFSC and URI maturity criteria disagreed for 13% of the aged fish, with most (10%) of the disagreement due to

NEFSC mature fish classified as immature by the URI histological and biochemical criteria. Of the 531 female summer flounder in the combined age sample, the URI criteria indicated that 15% of the age-0 fish were mature, 82% of the age-1 fish were mature, 97% of the age-2 fish were mature, and 100% of the age 3 and older fish were mature. When the proportions of fish mature at length and age were estimated by probit analysis, the URI 1999 criteria a median length at maturity (50^{th} percentile, L_{50}) of 34.7 cm for female summer flounder, with proportions mature at age of age-0: 30%, age-1: 68%, age-2: 92%, age-3: 98%, age-4: 100%., with a median age of maturity (50^{th} percentile, A_{50}) of about 0.5 years.

SARC 31 (NEFSC 2000) considered 5 options for the summer flounder maturity schedule for the 2000 stock assessment:

1) No change, use the maturity schedule for combined sexes as in the SAW 11 and subsequent assessments (the schedule presented below is rounded to 0.38, 0.72, 0.90, 1.00, 1.00, and 1.00 as in the SAW 25 and Terceiro (1999) assessment analyses).

2) Consider only age-2 and older fish of both sexes in the SSB.

3) Knife edged, age-1 and older maturity for both sexes. This would eliminate age-0 fish of both sexes from the SSB, and assume that the proportions mature at age-1 “round” to 100%.

4) NEFSC 1982-1989, 1990-1998 for both sexes, assuming a 1:1 sex ratio to average proportions for a combined schedule.

5) NEFSC 1982-1989, 1990-1998 for males, URI 1999 for females, assuming a 1:1 sex ratio to average proportions for a combined schedule.

SARC 31 concluded that some contribution to spawning from ages 0 and 1 should be included, eliminating options 2 and 3. The differences among remaining options 1, 4, and 5 were considered to be relatively minor, and so the SAW 11 schedule (Option 1) was retained for the 2000 (NEFSC 2000), 2001 (MAFMC 2001a), and current (2002) assessment. SARC 31 recommended that more biochemical and histological work, for both male and female summer flounder, should be done for additional years to determine if the results of the URI 1999 study will be applicable over the full VPA time series. SARC 31 also noted the need for research to explore whether the viability of eggs produced by young, first time spawning summer flounder is comparable to the viability of eggs produced by older, repeat spawning summer flounder.

RESEARCH SURVEY ABUNDANCE AND BIOMASS INDICES

NEFSC Spring

Long-term trends in summer flounder abundance were derived from a stratified random bottom trawl survey conducted in spring by NEFSC between Cape Hatteras and Nova Scotia since

1968 (Clark 1978). NEFSC spring survey indices (Tables A26-A27) suggest that total stock biomass last peaked during 1976-1977, and in 2002 was now about 15% above that peak, and at a new historical high (Figure A4). Age composition data from the NEFSC spring survey indicate a substantial reduction in the number of ages in the stock between 1976-1990 (Table A27). Between 1976-1981, fish of ages 5-8 were captured regularly in the survey, with the oldest individuals aged 8-10 years. Between 1982-1986, fish aged 5 and older were only occasionally observed in the survey, and by 1986, the oldest fish observed in the survey were age 5. In 1990 and 1991, only three ages were observed in the survey catch, and there was an indication that the 1988 year class was very weak. Since 1991, the survey age composition has expanded significantly. There is strong evidence in the 1998-2002 NEFSC spring surveys of increasing abundance of age-3 and older fish, due to increased survival of the 1994 and subsequent year classes (Table A27). Mean lengths at age in the NEFSC spring survey are presented in Table A28.

NEFSC Autumn

Summer flounder are caught frequently in the NEFSC autumn survey at stations in the inshore strata (< 27 meters = 15 fathoms = 90 feet) and in the band of offshore strata of 27-55 meters depth (15-30 fathoms, 90-180 feet), at about the same magnitude as in the spring survey (Table A26). Furthermore, the autumn survey catches age-0 summer flounder in abundance, providing an index of summer flounder recruitment (Tables A29 & A48, Figure A7). Fall survey indices suggest improved recruitment since the late 1980s, and evidence of an increase in abundance at age-2 and older since 1995. The NEFSC autumn surveys indicate that the 1995 year class of summer flounder was the most abundant in recent years, and that subsequent, weaker year classes are experiencing increased survival (Table A29). Mean lengths at age in the NEFSC autumn survey are presented in Table A30.

NEFSC Winter

A new series of NEFSC winter trawl surveys was begun in February 1992 specifically to provide improved indices of abundance for flatfish, including summer flounder. This survey targets flatfish during the winter when they are concentrated offshore. A modified 36 Yankee trawl is used in the winter survey that differs from the standard trawl employed during the spring and autumn surveys in that 1) long trawl sweeps (wires) are added before the trawl doors, to better herd fish to the mouth of the net, and 2) the large rollers used on the standard gear are absent, and only a chain "tickler" and small spacing "cookies" are present on the footrope.

Based on a comparison of summer flounder catches during the winter surveys with recent spring and autumn surveys, the design and conduct of the winter survey (timing, strata sampled, and the use of the modified 36 Yankee trawl gear) has resulted in greater catchability of summer flounder compared to the other surveys. Most fish have been taken in survey strata 61-76 (27-110 meters; 15-60 fathoms), off the Delmarva and North Carolina coasts . Other concentrations of fish are found in strata 1-12, south of the New York and Rhode Island coasts, in slightly deeper waters. Significant numbers of large summer flounder are often captured along the southern flank of Georges Bank (strata 13-18).

Indices of summer flounder abundance from the winter survey indicated stable stock size during 1992-1995, with indices of stratified mean catch per tow in number ranging from 10.9 in

1995 to 13.6 in 1993. The NEFSC winter survey index for 1996 increased by 290% over the 1995 value, from 10.8 to 31.2 fish per tow. The largest increases in 1996 catch per tow occurred in the Mid-Atlantic Bight region (offshore strata 61-76), where increases in catch per tow of up to an order of magnitude over the 1995 level occurred in several strata, with the largest increases in strata 61,62, and 63, off the northern coast of North Carolina. Most of the increased catch in 1996 consisted of age-1 summer flounder from the 1995 year class. In 1997, the index dropped to 10.3 fish per tow, due to the lower numbers of age-1 (1996 year class) fish caught. The Winter 2002 survey kg per tow index is the highest of the 1992-2002 series (Tables A26 & A31, Figure A4). As with the other two NEFSC surveys, there is strong evidence in recent winter surveys of increased abundance of age-3 and older fish relative to earlier years in the time series, due to the abundance of the 1995 year class and increased survival of subsequent year classes (Table A32). Mean lengths at age in the NEFSC winter survey are presented in Table A33.

Massachusetts DMF

Spring and fall bottom trawl surveys conducted by the Massachusetts Division of Marine Fisheries (MADMF) show a decline in abundance in numbers of summer flounder from recent high levels in 1986 to record lows in 1990 (MADMF fall survey), and 1991 (MADMF spring survey). In 1994, the MADMF survey indices increased to values last observed during 1982-1986, but then declined substantially in 1995, although the indices remain higher than the levels observed in the late 1980s . Since 1996, both the MADMF spring and fall indices have increased substantially to values last observed during 1982-1986 (Tables A34-A35, Figure A5). The MADMF also captures a small number of age-0 summer flounder in a seine survey of estuaries, and these data are available as an index of recruitment (Tables A36 & A48, Figure A9).

Connecticut DEP

Spring and fall bottom trawl surveys are conducted by the Connecticut Department of Environmental Protection (CTDEP). The CTDEP surveys show a decline in abundance in numbers of summer flounder from high levels in 1986 to record lows in 1989. The CTDEP surveys indicate recovery since 1989, and evidence of increased abundance at ages 2 and older since 1995. The 2000 and 2001 spring indices were the highest of the 16 year time series, and the 2001 autumn index was the highest of the series (Tables A37-A38, Figure A6). An index of recruitment from the autumn series is available (Tables A38 & A48, Figure A7).

Rhode Island DFW

A standardized bottom trawl survey has been conducted during the spring and fall months in Narragansett Bay and state waters of Rhode Island Sound by the Rhode Island Department of Fish and Wildlife (RIDFW) since 1979. Indices of abundance at age for summer flounder have been developed from the autumn survey data using NEFSC autumn survey age-length keys. The 1988 and 1991 year classes are the weakest in recent years in this time series, and the index shows the 1984-1987, 1999, and 2000 year classes to have been the strongest. The autumn survey was at or near a time-series high during 1999-2000 (Table A39, Figure A5). A new series of indices was developed from a set of fixed stations sampled monthly during 1990-2000. Age-1 indices from this series indicate that strong year classes recruited to the stock in1996, 1999, and 2000, with age 2+ abundance peaking in 2000 (Table A40). Recruitment indices are available from both the autumn and monthly fixed station surveys (Table A39-A40 & A48, Figure A9).

New Jersey BMF

The New Jersey Bureau of Marine Fisheries (NJBMF) has conducted a standardized bottom trawl survey since 1988. Indices of abundance for summer flounder incorporate data collected from April through October. NJBMF supplied annual total mean number per tow indices and associated annual length frequency distributions; lengths were converted to age using the corresponding annual NEFSC combined spring and fall survey age-length keys. Indices of the 1995 year class at age-0 and at older ages in subsequent years through 1999 indicate that it is the strongest of the 1988-2001 time series. Indices of the 1996-2001 year classes are below the time series average. The NJBMF survey indices show evidence of increased abundance at age-2 and older in the 1995-2000 surveys, but a decline in 2001 (Table A41, Figure A6). Recruitment indices are available from the NJBMF survey (Tables A41 & A48, Figure A7).

Delaware DFW

The Delaware Division of Fish and Wildlife (DEDFW) has conducted a standardized bottom trawl survey with a 16 foot headrope trawl since 1980, and with a 30 foot headrope trawl since 1991. Recruitment indices (age 0 fish; one index from the Delaware estuary proper, one from the inland bays) have been developed from the 16 foot trawl survey data for the 1980 to 2001 year classes. Indices for age-0 to age-4 and older summer flounder have been compiled from the 30 foot headrope survey. The indices incorporate data collected from June through October (arithmetic mean number per tow), with age 0 summer flounder separated from older fish by visual inspection of the length frequency. The 16 foot headrope survey indices suggest poor recruitment in 1988 and 1993, and improved recruitment in 1994-1995 (Tables A42-A43 & A48). The 16-foot trawl Estuary index indicates below average recruitment since 1995, except for 2000 (Figure A9). The 16-foot trawl Inland Bays index indicates above average recruitment during 1998-2000, and poor recruitment in 2001. The 30 foot headrope survey indices suggest stable stock sizes over the 1991-2001 time series, with strong recruitment in 1991, 1994, 1995, and 2000 (Table A44, Figure A6).

Maryland DNR

The Maryland Department of Natural Resources (MDDNR) has conducted a standardized trawl survey in the seaside bays and estuaries around Ocean City, MD since 1972. Samples collected during May to October with a 16 foot bottom trawl have been used to develop a recruitment index for summer flounder for the period 1972-2001. This index suggests that weakest year class in the time series recruited to the stock in 1988, and the strongest in 1972, 1983, 1986, and 1994. The 2000 and 2001 indices were about average (Tables A45 & A48, Figure A8).

Virginia Institute of Marine Science

The Virginia Institute of Marine Science (VIMS) conducts a juvenile fish survey using trawl gear in Virginia rivers and the mainstem of Chesapeake Bay. The time series for the rivers extends from 1979-2001. With the Bay included, the series is available only since 1988, but many more stations are included. Trends in the two time series are very similar. An index of recruitment developed from the rivers only series suggests weak year classes recruited to the stock in 1987 and 1999, with strongest year classes recruiting during 1980-1984, and 1990. Recruitment indices since

1990 have been below the time series average (Tables A46 & A48, Figure A8).

North Carolina DMF

The NCDMF has conducted a stratified random trawl survey using two 30 foot headrope nets with 3/4" mesh codend in Pamlico Sound since 1987. An index of recruitment developed from these data suggests weak year classes in 1988 and 2000, and strongest year classes in 1987, 1992, and 1996, and 2001 (Tables A47-A48, Figure A8). The survey normally takes place in mid-June, but in 1999 was delayed until mid-July. The 1999 index therefore inconsistent with the other indices in the time series, and the 1999 value was excluded from the VPA calibration in the SARC 31 assessment (NEFSC 2000).

ESTIMATES OF MORTALITY AND STOCK SIZE

Natural Mortality Rate

The instantaneous natural mortality rate (M) for summer flounder was assumed to be 0.2 in all analyses, although alternative estimates of M were considered in the SAW 20 assessment (NEFSC 1996a). In the SAW 20 work, estimates were derived with the methods described by 1) Pauly (1980) using growth parameters derived from NCDMF age-length data and a mean annual bottom temperature (17.5^{o}C) from NC coastal waters, 2) Hoenig (1983) using a maximum age for summer flounder of 15 years, and 3) consideration of age structure expected in unexploited populations (5% rule, 3/M rule, e.g., Anthony 1982). SAW 20 (NEFSC 1996a) concluded that M = 0.2 was a reasonable value given the mean (0.23) and range (0.15-0.28) obtained from the various analyses, and that value for M has been used in all subsequent assessments.

ASPIC Model

The non-equilibrium surplus production model incorporating covariates (ASPIC; Prager 1994, 1995) can be used to estimate maximum sustainable yield (MSY) and other management benchmarks. An ASPIC analysis applied to summer flounder using various state and federal agency survey biomass indices (the 1998 analysis) was previously reviewed by the NEFMC Overfishing Review Panel (Applegate *et al.* 1998). Based on total weighted mean squared error (MSE), the NEFSC spring and autumn biomass indices gave the best fit to the data in that analysis. However, the Overfishing Review Panel concluded that biological reference points estimated in the 1998 analysis for summer flounder were unreliable, due to the short time series of reliable catch estimates and lack of dynamic range in the input data (Applegate *et al.* 1998).

An ASPIC analysis using projected catch and NEFSC survey biomass indices through 1999 was reviewed in the 1999 assessment (Terceiro 1999). Model results were examined for sensitivity by employing the Monte Carlo search routine and by initializing the values of MSY (10,000 to 50,000 mt) and the intrinsic rate of increase ® ; 0.12 to 1.25) over a broad range, with the ratio of initial to current biomass (B1 ratio) assigned a starting value of 0.50. Overall, the 1999 ASPIC model results for summer flounder were sensitive and suggested the possibility of numerous local minima in the sums of squared errors (SSE) response surface. The Monte Carlo search algorithm was employed in an attempt to provide a better search of the SSE response surface, and the this procedure with restarts gave a range of estimates of MSY from 19,000 mt to 58,000 mt and of r from 0.49 to 1.08. Due to the number of restarts to reach convergence (>25) and the probable number of local minima, these results also appeared to be sensitive. Due to the unstable nature of the results, biological reference points for summer flounder estimated by the 1999 ASPIC analysis were considered to be unreliable, and the ASPIC analysis has not been repeated in this assessment.

Virtual Population Analysis and Tuning

Fishing mortality rates in 2001 and stock sizes in 2002 were estimated using the ADAPT method for calibration of the VPA (Parrack 1986, Gavaris 1988, Conser and Powers 1990) as implemented in the NEFSC FACT version 1.50 VPA. As recommended by the MAFMC S&S Committee during the review of the Terceiro (1999) assessment, and by the recent National Research Council review of the summer flounder assessment (NRC 2000), ages 0-6 were included in the analysis as true ages, with ages 7 and older combined as a plus group. An instantaneous natural mortality rate of M = 0.2 was assumed for all ages in all years, as noted earlier. Maturities at age for all years were 38% for age-0, 72% for age-1, 90% for age-2, and 100% for ages 3 and older, as noted earlier. Stock sizes in 2002 were directly estimated for ages 1-6, while the age 7+ group was calculated from Fs estimated in 2001. Fishing mortality on the oldest true age (6) in the years prior to the terminal year was estimated from back-calculated stock sizes for ages 3-6. Fishing mortality on the age 7+ group was assumed equal to the fishing mortality for age 6. Winter, spring, and mid-year (e.g., RIDFW monthly fixed station, DEDFW, and NJBMF) survey indices and all survey recruitment (age-0) indices were compared to population numbers of the same age at the beginning of the same year. Fall survey indices were compared to population numbers one year older at the beginning of the next year. Tuning indices were unweighted.

A number of exploratory VPA runs using different combinations of research survey tuning indices were considered to examine the sensitivity of the summer flounder VPA. The inclusion of each index was considered based on a pre-calibration correlation analysis among all indices, a post-calibration correlation analysis among the indices and resulting VPA estimates of stock size, and an examination of the VPA diagnostics including the partial variance accounted for by each index, patterns in residuals, and the mean squared residual (MSR) of the calibrated solution. Survey indices with trends that did not reasonably match corresponding patterns in abundance as estimated by other indices and/or the VPA, as evidenced by poor correlation, high partial variance in tuning diagnostics, or patterns in residuals, were eliminated from the VPA tuning configuration.

The run chosen as final (run F35_2) includes more indices (n=41) than were used in the 2000 (NEFSC 2000) and 2001 (MAFMC 2001a) assessments (n= 35). The MADMF seine survey recruitment index, MADMF spring survey age 2 index, RIDFW fall survey age 2 and age 3 indices (tuned to ages 3 and 4), the RIDFW fall and monthly fixed station survey age 0 indices, and the DEDFW 16 foot trawl Estuary age 0 indices that were excluded from the previous assessments are included in the current VPA based on consideration of the above analyses and criteria. One index which was included in the last VPA calibration, the RIDFW monthly fixed station survey age 1 index, was excluded this time.

A summary of the input catch and comparison with VPA estimated catch biomass is presented in Table A49. The final 2002 assessment VPA (run F35_2), including input data and assumptions, solution statistics, residuals, and estimates of F at age, stock number, and biomass at age is presented in Table A50.

VPA Estimates of Fishing Mortality Rates

The annual partial recruitment of age-1 fish decreased from near 0.50 during the first half of the VPA time series to less than 0.30 since 1994; the partial recruitment of age-2 fish has decreased from 1.00 in 1993 to 0.78 during 1999-2001 (Table A50). These decreases in partial recruitment at age are in line with expectations given recent changes in commercial and recreational fishery regulations. For these reasons, summer flounder are currently considered to be fully recruited to the fisheries at age 3, and fully recruited fishing mortality is expressed as the unweighted average of fishing mortality at age for ages 3 to 5.

Fishing mortality on fully recruited ages 3-5 summer flounder was high for most of the VPA time series, varying between 0.9 and 2.2 during 1982-1998 (55%-83% exploitation), far in excess of the current overfishing definition, $F_{threshold} = F_{target} = F_{max} = 0.26$ (21% exploitation). The fishing mortality rate has declined substantially since 1998 and was estimated to be 0.27 (22% exploitation) in 2001, marginally above the overfishing definition (Table A50, Figure A10).

VPA Estimates of Stock Abundance

Summer flounder spawn in the late autumn and into early winter (peak spawning on November 1), and age 0 fish recruit to the fishery the autumn after they are spawned. For example, summer flounder spawned in autumn 1987 (from the November 1, 1987 spawning stock biomass) recruit to the fishery in autumn 1988, and appear in VPA tables as age 0 fish in 1988. This assessment indicates that the 1982 and 1983 year classes were the largest of the VPA series, at 74 and 80 million fish, respectively. The 1988 year class was the smallest of the series, at only 13 million fish. The 2000 year class is estimated at 39 million fish, above the 1982-2001 median of 36 million. The 2001 year class is currently estimated to be below average, at 27 million fish (Table A50, Figure A11).

Total stock biomass has increased substantially since 1989, and in 2001 total stock biomass was estimated to be 42,900 mt, the highest since 1983, but still 19% below the current biomass threshold (Table A50, Figure A11). Spawning stock biomass (SSB; Age 0+) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has increased seven-fold, with improved recruitment and decreased fishing mortality, to 38,200 mt in 2001 (Table A50, Figure A11). In general, the abundance of summer flounder of ages 2 and older has increased substantially since the early 1990s (Figure A12). The age structure of the spawning stock has thus also expanded, with 72% at ages 2 and older, and 14% at ages 5 and older. Under equilibrium conditions at F_{max}, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older (Figure A13). Recent recruitment per unit of SSB has been lower than that observed during the early 1980s (Figure A14).

Precision of VPA Estimates

A bootstrap procedure (Efron 1982) was used to evaluate the precision of the final VPA estimates with respect to random variation in tuning data (survey abundance indices). The procedure does not reflect uncertainty in the catch-at-age data. Five hundred bootstrap iterations were used to generate distributions of the 2001 fishing mortality rate and total stock biomass. Histogram plots of the distribution of the terminal year VPA estimates indicate the amount of uncertainty by visually depicting variability. The cumulative probability can be used to evaluate the risk of making a management decision based on the estimated value. It expresses the probability (chance) that the fishing mortality rate was greater than a given level when measurement errors are considered (e.g., some target fishing mortality rate). For stock biomass, the cumulative plot indicates the probability that it was less than a given level (e.g., some desired minimum stock biomass).

The precision and bias of the 2001 fishing mortality rates, 1 January 2002 stock sizes, 1 November 2001 spawning stock biomass, and 1 January 2001 total stock biomass estimates are presented in Table A51. Bias was less than 5% for all parameters estimated. The bootstrap estimate of the 2001 total stock biomass was relatively precise, with a corrected CV of 7%. The bootstrap mean (43,160 mt) was slightly higher than the VPA point estimate (42,875 mt). The bootstrap results suggest a high probability (>90%) that total stock biomass in 2001 was at least 39,300 mt, reflecting only variability in survey observations (Table A51, Figure A15).

The corrected coefficients of variation for the Fs in 2001 on individual ages were 21% for age 0, 17% for age 1, 15% for age 2, 14% for age 3, 20% for age 4, 28% for age 5, 12% for age 6, and 12% for ages 7 and older. The distribution of bootstrap Fs was not strongly skewed, resulting in the bootstrap mean F for 2001 (0. 2804) being about equal to the point estimate from the VPA (0.2734). There is a 80% chance that F in 2001 was between about 0.24 and 0.32, given variability in survey observations (Table A51, Figure A15).

<u>Retrospective Analysis of VPA</u>

Retrospective analysis of the summer flounder VPA was carried out for terminal catch years 1996-2001. In the retrospective configuration, only the NEFSC surveys and MADMF, RIDFW, and CTDEP fall surveys are included in the calibration of terminal year + 1 stock size estimates, to duplicate the 2002 assessment. Expansion of the catch at age to ages 7 and older caused convergence problems for retrospective VPA configurations in the years 1996-1997. In order to account for the very low stock sizes at ages 5-7+ as indicated by survey indices during 1996-1997, given the estimates of catch at those ages, the VPA estimates unreasonable fishing mortality rates for age 5 in 1996 and ages 5-7+ in 1997 (Table A52, Figure A16). There were no convergence problems for the years 1982-1995, or for the 1998-2001 terminal years.

The retrospective analysis indicates a pattern of underestimation of fully recruited F (ages 3-5) for 1998-2000, following the pattern observed in the last two assessments (NEFSC 2000, MAFMC 2001a). Fishing mortality was underestimated by 31% for 1998, by 45% for 1999, and by 23% for 2000, relative to the current VPA estimates. Spawning stock biomass has been overestimated since 1996, ranging from 5% for 1998 to 23% for 1997. Summer flounder recruitment at age-0 has been underestimated since 1996, ranging from 8% for 1996 to 40% for 1997 (Table A52, Figure A16).

BIOLOGICAL REFERENCE POINTS

The calculation of biological reference points based on yield per recruit for summer flounder using the Thompson and Bell (1934) model was detailed in the 1990 SAW 11 assessment (NEFC 1990). The 1990 analysis estimated $F_{max} = 0.23$. In the 1997 SAW 25 assessment (NEFSC 1997b), an updated yield per recruit analysis reflecting the partial recruitment pattern and mean weights at age for 1995-1996 estimated that $F_{max} = 0.24$. The analysis in the Terceiro (1999) assessment, reflecting partial recruitment and mean weights at age for 1997-1998, estimated that Fmax = 0.263 (Figure A17).

The Overfishing Definition Review Panel (Applegate *et al.* 1998) recommended that the MAFMC base MSY proxy reference points on yield per recruit analysis, and this recommendation was adopted in formulating the current, FMP Amendment 12 reference points (see Introduction), based on the 1999 assessment (Terceiro 1999). The 1999 assessment yield per recruit analysis indicated that $F_{threshold} = F_{target} = F_{max} = 0.263$, yield per recruit (YPR) at F_{max} was 0.55219 kg/recruit, and January 1 biomass per recruit (BPR) at Fmax was 2.8127 kg/recruit. The median number of summer flounder recruits estimated from the 1999 VPA for the 1982-1998 period was 37.844 million fish. Based on this recruitment, maximum sustainable yield (MSY) was estimated to be 20,897 mt (46 million lbs) at a biomass (B_{MSY}) of 106,444 mt (235 million lbs). The biomass threshold, one-half B_{MSY}, was therefore estimated to be 53,222 mt (118 million lbs). Based on the stability of the input data, the SARC concluded that an update of the summer flounder biological reference points was not warranted at this time, and so the Terceiro (1999) estimates have been retained in this assessment.

PROJECTIONS

Stochastic projections were made to provide forecasts of stock size and catches in 2002-2004 consistent with target reference points established in the FMP. The projections assume that recent patterns of discarding will continue over the time span of the projections. Different patterns that could develop in the future due to further trip and bag limits and fishery closures have not been evaluated. The partial recruitment pattern (including discards) used in the projections was estimated as the geometric mean of F at age for 1999-2001, to reflect recent conditions in the fisheries. Mean weights at age were estimated as the geometric means of 1999-2001 values. Separate mean weight at age vectors were developed for the January 1 biomass, landings, and discards.

One hundred projections were made for each of the 500 bootstrapped realizations of 2002 stock sizes from the final 2002 VPA, using algorithms and software described by Brodziak and Rago (MS 1994) as implemented in FACT 1.50. Recruitment during 2002-2004 was generated randomly from a cumulative frequency distribution of VPA recruitment series for 1982-2001 (median recruitment = 35.613 million fish). Other input parameters were as in Table A53; uncertainty in partial recruitment patterns, discard rates, or components other than survey variability was not reflected.

Stochastic projections which assume the adjusted 2002 quota of 10,991 mt will be landed estimate a median (50% probability) F = 0.32 and a median total stock biomass on January 1, 2003 of 57,600 mt, above the current biomass threshold of one-half B_{MSY} = 53,222 mt. (Table A53, Figures A18-A19). There is a 95% probability that the target F for 2002 (i.e., F_{max} = 0.26) will be exceeded. Landings of 10,580 mt and discards of 1,508 mt in 2003 provide a median F = 0.26 and a median total stock biomass level on January 1, 2004 of 65,600 mt (Table A53, Figures A18-A19). Landings of 12,179 mt (26.9 million lbs) and discards of 1,692 mt (3.7 million lbs) in 2004 provide a median F in 2004 = 0.26 (Table A53, Figure A19.)**.**

CONCLUSIONS

Assessment Results

The summer flounder stock is overfished and overfishing is occurring relative to the current biological reference points. The fishing mortality rate has declined from 1.32 in 1994 to 0.27 in 2001 (Figure A10) marginally above the current overfishing definition reference point ($F_{threshold}$ = F_{target} = F_{max} = 0.26; Figure A19). There is an 80% chance that the 2001 F was between 0.24 and 0.32 (Figure A15). The estimate of F for 2001 may understate the actual fishing mortality; retrospective analysis shows that the current assessment method tends to underestimate recent fishing mortality rates (e.g., by about 1/3 over the last three years).

Total stock biomass has increased substantially since 1989, and in 2001 was estimated to be 42,900 mt, 19% below the current biomass threshold (53,200 mt) (Figures A11 & A19). There is an 80% chance that total stock biomass in 2001 was between 39,300 and 46,900 mt (Figure A15). Spawning stock biomass (SSB; Age 0+) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has increased seven-fold, with improved recruitment and decreased fishing mortality, to 38,200 mt in 2001 (Figure A11). Comparison with previous assessments shows a tendency to slightly overestimate the SSB in recent years. The age structure of the spawning stock has expanded, with 72% at ages 2 and older, and 14% at ages 5 and older (Figure A13). Under equilibrium conditions at F_{max}, about 85% of the spawning stock biomass would be expected to be ages 2 and older, with 50% at ages 5 and older.

The arithmetic average recruitment from 1982 to 2001 is 40 million fish at age 0, with a median of 36 million fish. The 2000 year class is estimated at 39 million fish. The 2001 year class is currently estimated to be below average, at 27 million fish (Figure A11). It should be noted that retrospective analysis shows that the current assessment method tends to underestimate the abundance of age 0 fish (e.g., by about 20% over the last three years). Recent recruitment per unit of SSB has been lower than that observed during the early 1980s (Figure A14).

Stochastic forecasts only incorporate uncertainty in 2002 stock sizes due to survey variability and assume current discard to landings proportions. If landings in 2002 are 10,991 mt (24.2 million lbs) and discards are 1,700 mt (3.7 million lbs), the forecast estimates a median (50% probability) F in 2002 = 0.32 and a median total stock biomass on January 1, 2003 (equivalent to December 31, 2002) of 57,600 mt, above the biomass threshold of ½ B_{MSY} = 53,200 mt. (Figure A19). Landings of 10,580 mt (23.3 million lbs) and discards of 1,508 mt (3.3 million lbs) in 2003 provide a median

F in 2003 = 0.26 and a median total stock biomass level on January 1, 2004 of 65,600 mt (Table A53, Figures A18-A19). Landings of 12,179 mt (26.9 million lbs) and discards of 1,692 mt (3.7 million lbs) in 2004 provide a median F in 2004 = 0.26 (Table A53, Figure A19.).

During each of the past six years the recreational fishery has exceeded its harvest limit and, for the entire period, exceeded the limit by 58%. During the same period the commercial fishery exceeded its harvest limit by 5%. These excesses result in a fishing mortality that exceeds the target. Given that there is a persistent retrospective underestimation of fishing mortality, managers should consider adopting a lower TAL than that implied by the current overfishing threshold.

SARC COMMENTS

The SARC discussed the procedure for selecting survey indices used in the summer flounder VPA. The use of state surveys, which cover only a small component of the stock, was questioned. It was noted that YOY surveys may be variable due to the low numbers of fish caught per tow. The SARC requested that the standard error also be shown with the survey indices in the future. Whether differences in state surveys truly measure different trends in different components of the stock or whether differences are simply due to variation among surveys was questioned. It was noted that the F on age 2 fish in recent years was higher than the average F for ages 3-5.

The SARC commented on the presence of a retrospective pattern in the VPA. Discussion focused on whether removals were underestimated in either the commercial discard estimates or by an underestimation of the discard mortality rate in the commercial and/or recreational sectors. The SARC concluded that the tendency for F to be underestimated in the retrospective pattern should not be quantitatively adjusted in the assessment but rather stated as a qualitative concern in the management advice.

The SARC discussed whether the use of an assumption of 10% discard mortality for the recreational catch was appropriate. The discard mortality rate may vary spatially, and may not represent longer term mortality associated with capture and release.

The SARC questioned the appropriateness of setting the F target equal to the threshold. Under these circumstances, when the estimate of F is equal to the target, there is a 50% chance that the threshold is exceeded. With the retrospective pattern in this stock the current F is thus likely to be above the target. However the SARC noted that changing the F_{MSY} proxy and threshold was not a term of reference for this meeting. The proxy used for biological reference points will be re-evaluated for all stocks by a formal committee in the near future. The SARC discussed whether new information exists to warrant updating the values of the biological reference points. It was noted that the combined effect of increases in partial recruitment and decreases in the mean weight at ages 0 and 1 in recent years resulted in no change in F_{max}. However, decreases in biomass per recruit combined with a decrease in the median recruitment would decrease the B_{MSY} proxy by 16%. The SARC questioned the decrease in mean weights at age 0 and the appropriateness of using catch mean weights for estimating B_{MSY}. The SARC pointed out that the apparent decrease in catch mean weights at age was likely due to changes in the fishery, and not reflective of real changes in the population since survey mean weights do not show the same decrease. Therefore the SARC concluded that changes in input data to the yield per recruit analysis did not justify a change in the reference points at this time.

The SARC was questioned on how to handle late data such as survey indices which are provided after the working group has met and developed an assessment for SARC review. The SARC agreed that data provided after the working group meeting should not be given special consideration and should be excluded from the assessment. The working group meeting is the appropriate place for anyone to contribute data and suggestions to the assessment, thereby allowing appropriate consideration and review by the SARC.

RESEARCH RECOMMENDATIONS

The SARC made the following recommendations:

1) Expand the NEFSC fishery observer program for summer flounder, with special emphasis on a) comprehensive areal and temporal coverage, b) adequate length and age sampling, and c) continued sampling after commercial fishery areal and seasonal quotas are reached and fisheries are limited or closed, and d) sampling of summer flounder discard in the scallop dredge fishery. Maintaining adequate observer coverage will be especially important in order to monitor a) the effects of implementation of gear and closed/exempted area regulations, both in terms of the response of the stock and the fishermen, b) potential continuing changes in "directivity" in the summer flounder fishery, as a results of changes in stock levels and regulations, and c) discards of summer flounder in the commercial fishery once quota levels have been attained and the summer flounder fishery is closed or restricted by trip limits.

2) Evaluate the amount of observer data needed to reliably estimate discards of summer flounder in all components of the fishery.

3) Conduct further research to better determine the discard mortality rate of recreational and commercial fishery summer flounder discards.

4) Develop a program to annually sample the length and age frequency of summer flounder discards from the recreational fishery.

5) RIDFW monthly fixed station survey length frequencies are currently converted to age using length cut-offs points. Investigate the utility of applying the appropriate NEFSC or MADMF age-length keys to convert the RIDFW monthly fixed station survey lengths to age.

6) Explore the possibility of weighting survey indices used in VPA calibration by the areal coverage (e.g., in square kilometers) of the respective seasonal surveys.

7) Explore the sensitivity of the VPA calibration to the addition of 1 and/or a small constant to values of survey series with "true zeros."

8) Statistically analyze changes in mean weights at age in the catch and NEFSC surveys. Determine if using mean weights at age in the survey are more appropriate for estimating the B_{MSY} proxy. Explore the sensitivity of the mean weights of the catch and partial recruitment pattern from a longer time series (1997 to 2001) to the re-estimated B_{MSY} proxy.) As the NEFSC fall survey age structure expands, investigate the use of survey mean weights at age for stock weights at age in yield per recruit, VPA, and projection analyses.

9) Monitor changes in life history (growth and maturity) as the stock rebuilds.

10) Evaluate use of a forward calculating age-structured model for comparison with VPA. Forward models would facilitate use of expanding age/sex structure and allow inclusion of historical data. If sex-specific assessments are explored, the implications on YPR should also be investigated.

11) Explore the sensitivity of the VPA results to separating the summer flounder stock into multiple components.

12) Evaluate trends in the regional components of the NEFSC surveys and contrast with the state surveys that potentially index components of the stock.

<u>Major Sources of Assessment Uncertainty</u>

The SARC identified the following major sources of uncertainty in the summer flounder assessment:

1) The landings from the commercial fisheries used in this assessment assume no under reporting of summer flounder landings. Therefore, reported landings from the commercial fisheries should be considered minimal estimates.

2) The recreational fishery landings and discards used in the assessment are estimates developed from the Marine Recreational Fishery Statistics Survey (MRFSS). While the estimates of summer flounder catch are considered to be among the most reliable produced by the MRFSS, they are subject to possible error. The proportional standard error (PSE) of estimates of summer flounder total landings in numbers has averaged 7%, ranging from 26% in 1982 to 3% in 1996, during 1982-2001.

3) The intensity of fishery observer sampling of the commercial scallop dredge fishery (outside of exempted area fisheries) was particularly low in 2001. This level of observer coverage likely was insufficient to accurately characterize summer flounder discards.

4) The length and age composition of the recreational discards are based on data from a limited geographic area (Long Island, New York, 1988-1992; Connecticut, 1997-2001, New York party boats 2000-2001, ALS releases focused in New York and New Jersey, 1999-2001). Sampling of recreational fishery discards on a annual, synoptic basis is needed.

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Table A1. Summer Flounder Commercial Landings by State (thousands of lb) and coastwide (thousands of pounds ('000 lbs), metric tons (mt)).

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total '000 lbs	Total mt
1940	0	0	2847	258	149	1814	3554	3	444	1247	498	10814	4905
1941	na	na	na	na	na	na	na	na	183	764	na	947	430
1942	0	0	193	235	126	1286	987	2	143	475	498	3945	1789
1943	0	0	122	202	220	1607	2224	11	143	475	498	5502	2496
1944	0	0	719	414	437	2151	3159	8	197	2629	498	10212	4632
1945	0	0	1730	467	270	3182	3102	2	460	1652	1204	12297	5578
1946	0	0	1579	625	478	3494	3310	22	704	2889	1204	14305	6489
1947	0	0	1467	333	813	2695	2302	46	532	1754	1204	11146	5056
1948	0	0	2370	406	518	2308	3044	15	472	1882	1204	12219	5542
1949	0	0	1787	470	372	3560	3025	8	783	2361	1204	13570	6155
1950	0	0	3614	1036	270	3838	2515	25	543	1761	1840	15442	7004
1951	0	0	4506	1189	441	2636	2865	20	327	2006	1479	15469	7017
1952	0	0	4898	1336	627	3680	4721	69	467	1671	2156	19625	8902
1953	0	0	3836	1043	396	2910	7117	53	1176	1838	1844	20213	9168
1954	0	0	3363	2374	213	3683	6577	21	1090	2257	1645	21223	9627
1955	0	0	5407	2152	385	2608	5208	26	1108	1706	1126	19726	8948
1956	0	0	5469	1604	322	4260	6357	60	1049	2168	1002	22291	10111
1957	0	0	5991	1486	677	3488	5059	48	1171	1692	1236	20848	9456
1958	0	0	4172	950	360	2341	8109	209	1452	2039	892	20524	9310
1959	0	0	4524	1070	320	2809	6294	95	1334	3255	1529	21230	9630
1960	0	0	5583	1278	321	2512	6355	44	1028	2730	1236	21087	9565
1961	0	0	5240	948	155	2324	6031	76	539	2193	1897	19403	8801
1962	0	0	3795	676	124	1590	4749	24	715	1914	1876	15463	7014
1963	0	0	2296	512	98	1306	4444	17	550	1720	2674	13617	6177
1964	0	0	1384	678	136	1854	3670	16	557	1492	2450	12237	5551
1965	0	0	431	499	106	2451	3620	25	734	1977	272	10115	4588
1966	0	0	264	456	90	2466	3830	13	630	2343	4017	14109	6400
1967	0	0	447	706	48	1964	3035	0	439	1900	4391	12930	5865
1968	0	0	163	384	35	1216	2139	0	350	2164	2602	9053	4106
1969	0	0	78	267	23	574	1276	0	203	1508	2766	6695	3037

* = less than 500 lb; na = not available; + = NMFS did not identify flounders to species prior to 1978 for NC and 1957 for both MD and VA and thus the numbers represent all unclassified flounders.
Sources: 1940-1977 USDC 1984; 1978-1979 unpublished NMFS General Canvas data

Table A1 continued.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total '000 lb	Total mt
1970	0	0	41	259	23	900	1958	0	371	2146	3163	8861	4019
1971	0	0	89	275	34	1090	1850	0	296	1707	4011	9352	4242
1972	0	0	93	275	7	1101	1852	0	277	1857	3761	9223	4183
1973	0	0	506	640	52	1826	3091	*	495	3232	6314	16156	7328
1974	*	0	1689	2552	26	2487	3499	0	709	3111	10028	22581	10243
1975	0	0	1768	3093	39	3233	4314	5	893	3428	9539	26311	11934
1976	*	0	4019	6790	79	3203	5647	3	697	3303	9627	33368	15135
1977	0	0	1477	4058	64	2147	6566	5	739	4540	10332	29927	13575
1978	0	0	1439	2238	111	1948	5414	1	676	5940	10820	28586	12966
1979	5	0	1175	2825	30	1427	6279	6	1712	10019	16084	39561	17945
1980	4	0	367	1277	48	1246	4805	1	1324	8504	13643	31216	14159
1981	3	0	598	2861	81	1985	4008	7	403	3652	7459	21056	9551
1982	18	*	1665	3983	64	1865	4318	8	360	4332	6315	22928	10400
1983	84	0	2341	4599	129	1435	4826	5	937	8134	7057	29548	13403
1984	2	*	1488	4479	131	2295	6364	9	813	9673	12510	37765	17130
1985	3	*	2249	7533	183	2517	5634	4	577	5037	8614	32352	14675
1986	0	*	2954	7042	160	2738	4017	4	316	3712	5924	26866	12186
1987	8	*	3327	4774	609	2641	4451	4	319	5791	5128	27052	12271
1988	5	0	2421	4719	741	3439	6006	7	514	7756	6770	32377	14686
1989	9	0	1878	3083	513	1464	2865	3	204	3689	4206	17913	8125
1990	3	0	628	1408	343	405	1458	2	138	2144	2728	9257	4199
1991	0	0	1124	1672	399	719	2341	4	232	3715	3516	13722	6224
1992	*	*	1383	2532	495	1239	2871	12	319	5172	2576	16599	7529
1993	6	0	903	1942	225	849	2466	6	254	3052	2894	12599	5715
1994	4	0	1031	2649	371	1269	2356	4	179	3091	3571	14525	6588
1995	5	0	1128	2325	319	1248	2319	4	174	3304	4555	15381	6977
1996	8	0	780	1664	266	928	2345	7	225	2280	4218	12721	5770
1997	3	0	745	1566	257	823	1321	5	215	2370	1501	8806	3994
1998	6	0	709	1716	263	823	1863	11	224	2616	2967	11199	5080
1999	6	0	813	1637	245	804	1918	8	201	2196	2801	10627	4820
2000	7	0	789	1703	240	800	1848	12	252	2206	3354	11211	5085
2001	22	0	694	1800	205	751	1745	7	223	2660	2730	10838	4916

* = less than 500 lb; na = not available; Sources: 1980-2001 State and Federal reporting systems, 1995-98 NC DMF Trip Ticket System

Table A2. Distribution of Northeast Region (ME-VA) commercial fishery landings by statistical area.

Area	1992	1993	1994	1995	1996	1997	1998	1999
511	0	0	0	0	1	0	0	0
512	0	0	0	0	1	1	0	0
513	0	3	0	0	2	0	0	2
514	9	11	10	12	3	15	17	11
515	0	0	0	0	0	0	0	0
521	8	3	14	4	16	2	9	2
522	8	8	7	6	13	6	2	3
561	2	1	0	0	1	1	3	2
562	6	4	5	10	1	1	0	3
525	22	35	26	85	137	16	27	28
526	294	242	193	128	44	22	33	17
533	0	0	0	0	6	2	3	5
537	916	557	707	770	539	449	418	354
538	228	255	341	332	267	270	229	275
539	217	157	223	258	242	284	374	418
611	117	35	181	283	166	141	204	230
612	404	393	169	221	344	297	317	403
613	237	167	280	242	184	194	128	171
614	81	97	141	129	18	41	41	13
615	61	15	49	99	20	37	41	44
616	532	476	743	730	462	245	280	122
621	1028	526	258	279	318	266	286	304
622	299	363	323	522	258	53	141	301
623	0	6	0	14	28	0	1	0
625	289	227	122	118	276	227	142	91
626	743	601	821	347	385	94	503	415
631	655	98	219	220	21	174	258	140
632	160	77	60	43	73	30	41	79
635	45	45	77	55	29	418	228	97
636	0	0	0	4	2	27	8	20
Total	6361	4402	4969	4911	3857	3313	3734	3550

Table A2 continued.

Area	2000	2001
511	1	0
512	1	0
513	0	1
514	2	1
515	0	0
521	4	15
522	6	5
561	4	7
562	8	3
525	41	29
526	16	23
533	10	2
537	326	337
538	260	214
539	455	437
611	142	157
612	308	379
613	170	162
614	3	11
615	70	115
616	384	281
621	208	274
622	101	234
623	8	18
625	60	129
626	697	442
631	185	142
632	39	41
635	54	212
636	1	7
Total	3564	3678

Table A3. Summary of NEFSC sampling of commercial fishery for summer flounder, ME-VA[1].

Year	Lengths	Ages	NER Landings (MT)	Sampling Intensity (mt/100 lengths)
1982	8,194	2,288	7,536	92
1983	6,893	1,347	10,202	148
1984	5,340	1,794	11,455	215
1985	6,473	1,611	10,767	166
1986	7,840	1,967	9,499	121
1987	6,605	1,788	9,945	151
1988	9,048	2,302	11,615	128
1989	8,411	1,325	6,217	74
1990	3,419	853	2,962	87
1991	4,627	1,089	4,626	100
1992	3,385	899	6,361	188
1993	3,638	844	4,402	121
1994	3,950	956	4,969	126
1995	2,982	682	4,911	165
1996	4,580	1,235	3,857	84
1997	8,855	2,332	3,313	37
1998	10,055	2,641	3,734	37
1999	10,460	3,244	3,550	34
2000	10,956	3,307	3,564	33
2001	9,521	2,838	3,678	39

1 Does not include unclassified market category landings for 1982-93.

Table A4. Commercial landings at age of summer flounder ('000), ME-VA. Does not include discards, assumes catch not sampled by NEFSC has same biological characteristics as port sampled catch.

	AGE										
Year	0	1	2	3	4	5	6	7	8	9+	Total
1982	1,441	6,879	5,630	232	61	97	57	22	2	0	14,421
1983	1,956	12,119	4,352	554	30	62	13	17	4	2	19,109
1984	1,403	10,706	6,734	1,618	575	72	3	5	1	4	21,121
1985	840	6,441	10,068	956	263	169	25	4	2	1	18,769
1986	407	7,041	6,374	2,215	158	93	29	7	2	0	16,326
1987	332	8,908	7,456	935	337	23	24	27	11	0	18,053
1988	305	11,116	8,992	1,280	327	79	18	9	5	0	22,131
1989	96	2,491	4,829	841	152	16	3	1	1	0	8,430
1990	0	2,670	861	459	81	18	6	1	1	0	4,096
1991	0	3,755	3,256	142	61	11	1	1	0	0	7,227
1992	114	5,760	3,575	338	19	22	0	1	0	0	9,829
1993	151	4,308	2,340	174	29	43	19	2	1	0	7,067
1994	119	3,698	3,692	272	64	12	6	0	5	0	7,868
1995	46	2,566	4,280	241	40	8	0	1	0	0	7,182
1996	0	1,401	3,187	798	156	15	3	0	1	0	5,559
1997	0	380	2,442	1,214	261	69	10	4	0	0	4,381
1998	0	196	1,719	2,022	437	72	15	1	0	0	4,462
1999	0	123	1,570	1,522	585	160	26	8	0	0	3,994
2000	0	212	1,934	1,083	449	119	47	15	6	2	3,867
2001	0	713	1,402	980	324	155	59	16	4	3	3,656

Table A5. Mean weight (kg) at age of summer flounder landed in the commercial fishery, ME-VA.

	AGE										
Year	0	1	2	3	4	5	6	7	8	9+	ALL
1982	0.26	0.42	0.62	1.84	2.33	2.94	2.71	4.04	5.99		0.55
1983	0.31	0.46	0.80	1.40	2.35	1.85	2.76	3.30	4.17	4.37	0.56
1984	0.28	0.39	0.60	0.11	1.43	2.16	3.21	3.62	4.64	4.03	0.54
1985	0.33	0.44	0.59	1.08	1.73	2.22	2.59	4.71	4.78	4.80	0.59
1986	0.30	0.44	0.63	1.11	1.76	1.89	3.14	2.96	4.81		0.63
1987	0.27	0.45	0.62	1.06	2.00	2.85	3.08	3.02	4.14		0.59
1988	0.36	0.46	0.60	1.21	2.07	2.88	3.98	3.91	4.50		0.60
1989	0.36	0.55	0.74	1.06	1.83	2.47	3.57	3.59	2.25		0.74
1990		0.52	0.86	1.37	1.84	2.13	3.21	3.92	5.03		0.72
1991		0.48	0.75	1.54	2.26	3.01	3.91	3.87			0.64
1992	0.34	0.50	0.82	1.88	2.68	3.09		4.59			0.67
1993	0.35	0.49	0.75	1.63	2.10	1.79	2.81	4.14	5.20		0.62
1994	0.39	0.55	0.62	1.43	2.27	3.08	3.32		3.70		0.63
1995	0.33	0.54	0.70	1.54	2.37	2.92		4.09			0.68
1996		0.54	0.58	1.14	1.88	2.85	3.78		4.76		0.69
1997		0.54	0.63	0.84	1.31	2.10	2.56	3.43			0.76
1998		0.55	0.64	0.85	1.39	2.31	2.52	3.98			0.84
1999		0.52	0.62	0.86	1.36	1.93	2.84	3.62			0.89
2000		0.57	0.68	0.97	1.46	2.13	2.51	2.60	3.30	3.53	0.92
2001		0.59	0.76	1.03	1.73	2.39	2.86	3.57	3.90	4.94	1.01

Table A6. Summary of North Carolina Division of Marine Fisheries (NCDMF) sampling of the commercial winter trawl fishery for summer flounder.

Year	Lengths	Ages	Total Landings (MT)	Total MT per 100 lengths
1982	5,403	0	2,864	53
1983	8,491	0	3,201	38
1984	14,920	0	5,674	38
1985	13,787	0	3,907	28
1986	15,754	0	2,687	17
1987	12,126	0	2,326	19
1988	13,377	189	3,071	23
1989	15,785	106	1,908	12
1990	15,787	191	1,238	8
1991	24,590	534	1,582	6
1992	14,321	364	1,168	8
1993	18,019	442	1,313	7
1994	21,858	548	1,620	7
1995	18,410	548	2,066	11
1996	17,745	477	1,913	11
1997	12,802	388	681	5
1998	21,477	476	1,346	6
1999	11,703	412	1,271	11
2000	24,177	568	1,521	6
2001	19,655	499	1,263	6

Table A7. Number ('000) of summer flounder at age landed in the North Carolina commercial winter trawl fishery. The 1982-1987 NCDMF length samples were aged using NEFSC age-lengths keys for comparable times and areas (i.e., same quarter and statistical areas). Since 1987, the NCDMF length samples have been aged using NCDMF age-lengths keys.

	AGE									
Year	0	1	2	3	4	5	6	7	8+	Total
1982	981	3,463	1,021	142	52	19	6	4	2	5,691
1983	492	3,778	1,581	287	135	41	3	3	<1	6,321
1984	907	5,658	3,889	550	107	18	<1	0	0	11,130
1985	196	2,974	3,529	338	85	24	5	<1	0	7,152
1986	216	2,478	1,897	479	29	32	1	1	<1	5,134
1987	233	2,420	1,299	265	28	1	0	0	0	4,243
1988	0	2,917	2,225	471	227	39	1	6	<1	5,887
1989	2	49	1,437	716	185	37	1	2	0	2,429
1990	2	142	730	418	117	12	1	<1	0	1,424
1991	0	382	1,641	521	116	20	2	<1	0	2,682
1992	0	36	795	697	131	21	2	<1	0	1,682
1993	0	515	1,101	252	44	1	<1	0	0	1,913
1994	6	258	1,262	503	115	14	3	<1	0	2,161
1995	<1	181	1,391	859	331	53	2	<1	0	2,817
1996	0	580	2,187	554	132	56	13	<1	2	3,526
1997	0	17	625	378	18	3	<1	0	0	1,041
1998	18	548	694	230	28	3	<1	0	0	1,520
1999	1	70	504	579	152	88	6	3	<1	1,403
2000	0	50	398	906	345	55	18	1	2	1,775
2001	0	79	408	556	334	63	18	5	<1	1,463

Table A8. Mean weight (kg) at age of summer flounder landed in the North Carolina commercial winter trawl fishery.

	AGE									
Year	0	1	2	3	4	5	6	7	8+	ALL
1982	0.34	0.46	0.76	1.28	1.66	2.05	2.12	2.23	2.58	0.53
1983	0.32	0.45	0.75	1.14	1.26	1.49	1.73	2.43	2.70	0.57
1984	0.33	0.48	0.70	1.06	1.50	2.17	3.48			0.59
1985	0.38	0.46	0.66	1.20	1.66	2.49	3.07	4.57		0.62
1986	0.36	0.51	0.67	1.09	1.62	1.96	3.40	3.23	3.63	0.64
1987	0.33	0.51	0.66	1.09	1.88	2.94				0.59
1988		0.41	0.60	0.93	1.19	1.70	2.24	2.98	3.41	0.57
1989	0.12	0.38	0.60	0.99	1.16	2.10	3.09	2.50		0.78
1990	0.08	0.48	0.66	0.87	1.31	2.10	1.90	3.97		0.77
1991		0.45	0.66	1.07	1.73	2.25	2.51	3.13	4.10	0.77
1992		0.36	0.50	0.85	1.20	1.46	2.30			0.71
1993		0.49	0.61	1.13	1.37	2.95	3.41			0.66
1994	0.27	0.45	0.62	1.27	2.04	2.44	2.89	5.78		0.84
1995	0.04	0.21	0.46	0.85	1.47	2.49	3.79	3.82		0.72
1996		0.42	0.47	0.73	1.35	1.72	2.29	3.20	2.86	0.56
1997		0.41	0.62	0.76	1.32	2.07	3.25			0.68
1998	0.41	0.71	0.89	1.24	1.49	2.80	3.38			0.89
1999	0.14	0.58	0.73	0.92	1.40	1.68	2.61	3.06	3.90	0.95
2000		0.56	0.66	0.80	1.20	1.96	2.59	3.31	3.52	0.90
2001		0.59	0.67	0.76	1.07	1.72	2.39	3.07	4.24	0.87

Table A9. Summary NER fishery observer data for trips catching summer flounder. Total trips (trips are not split for multiple areas), observed tows, total summer flounder catch (lb), total summer flounder kept (lb), and total summer flounder discard (lb), and percentage of summer flounder discard (lb) to summer flounder catch (lb).

Year	Gear	Trips	Obs Tows	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1989	All	57	413	53,714	48,406	5,308	9.9
1990	All	61	463	47,954	35,972	11,982	25.0
1991	All	82	635	61,650	50,410	11,240	18.2
1992	Trawl	66	643	136,632	118,026	18,606	13.6
	Scallop	8	178	1,477	767	710	48.1
	All	74	821	138,109	118,793	19,316	14.0
1993	Trawl	37	410	74,982	67,603	7,379	9.8
	Scallop	15	671	2,967	1,158	1,809	61.0
	All	52	1,081	77,949	68,761	9,188	11.8
1994	Trawl	51	574	174,347	163,734	10,612	6.1
	Scallop	14	651	5,811	435	5,376	92.5
	All	65	1,225	180,158	164,169	15,988	8.9
1995	Trawl	134	1,004	242,784	235,011	7,773	3.2
	Scallop	19	1,051	10,044	2,247	7,778	77.4
	All	153	2,055	252,828	237,258	15,551	6.2
1996	Trawl	111	653	101,389	90,789	10,600	10.5
	Scallop	24	1,083	9,575	1,345	8,230	86.0
	All	135	1,736	110,964	92,134	18,830	17.0
1997	Trawl	59	334	31,707	26,475	5,232	16.5
	Scallop	23	835	5,721	583	5,138	89.8
	All	82	1,169	37,428	27,058	10,370	27.7

Table A9 continued.

Year	Gear	Trips	Obs Tows	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1998	Trawl	53	329	72,396	65,507	6,889	9.5
	Scallop	22	359	1,962	652	1,310	66.8
	All	75	688	74,358	66,159	8,199	11.0
1999	Trawl	56	374	60,733	45,987	14,746	24.3
	Scallop	10	247	3,199	458	2,741	85.7
	All	66	621	63,932	46,445	17,487	27.4
2000	Trawl	115	688	162,015	144,752	17,263	10.7
	Scallop	23	608	8,457	501	7,956	94.1
	All	138	1,296	170,472	145,253	25,219	14.8
2001	Trawl	132	581	109,285	61,497	47,789	53.9
	Scallop	4	176	1,835	6	1,830	99.7
	All	136	757	111,120	61,503	49,619	44.7

Table A10. Summary NER Vessel Trip Report (VTR) data for trips reporting discard of any species and catching summer flounder. Total trips, total summer flounder catch (lb), total summer flounder kept (lb), total summer flounder discard (lb), and percentage of summer flounder discard (lb) to summer flounder catch (lb).

Year	Gear	Trips	Total Catch	Total Kept	Total Discard	Discard: Total (%)
1994	Trawl	4,267	2,149,332	2,015,296	134,036	6.2
	Scallop	85	70,353	22,877	47,476	67.5
	All	4,352	2,219,685	2,038,173	181,512	8.2
1995	Trawl	3,733	2,444,231	2,332,516	111,715	4.6
	Scallop	113	78,758	25,084	53,674	68.2
	All	3,846	2,522,989	2,357,600	165,389	6.6
1996	Trawl	2,990	1,662,313	1,459,155	203,158	12.2
	Scallop	79	69,557	16,657	52,900	76.1
	All	3,069	1,731,870	1,475,812	256,058	14.8
1997	Trawl	3,044	988,599	851,090	137,509	13.9
	Scallop	51	21,553	4,665	16,888	78.4
	All	3,095	1,010,152	855,755	154,397	15.3
1998	Trawl	3,004	1,128,578	868,706	259,872	23.0
	Scallop	62	23,538	10,323	13,215	56.1
	All	3,066	1,152,116	879,029	273,087	23.7
1999	Trawl	2,884	959,275	772,924	186,351	19.4
	Scallop	41	26,334	14,324	12,010	45.6
	All	2,925	985,609	787,248	198,361	20.1
2000	Trawl	3,140	1,048,791	786,576	262,215	25.0
	Scallop	41	12,183	3,798	8,385	68.8
	All	3,181	1,060,974	790,374	270,600	25.5
2001	Trawl	3,035	1,086,331	783,900	307,156	28.3
	Scallop	69	14,592	1,349	13,243	90.8
	All	3,104	1,100,923	785,249	320,399	29.1

Table A11. Summary of Northeast Region fishery observer data to estimate summer flounder discard at age in the commercial fishery. Estimates developed using fishery observer length samples, age-length data, and estimates of total discard in mt. An 80% discard mortality rate is assumed. 1995-2001 lengths converted to age using 1995-2001 NEFSC trawl survey ages; n/a = not available.

Year	Gear	Lengths	Ages	Fishery Observer Discard Estimate (mt)	Sampling Intensity (mt per 100 lengths)	Raised Discard Estimate (mt)	Raised Estimate with 80% mortality rate (mt)
1989	All	2,337	54	642	27	886	709
1990	All	3,891	453	1,121	29	1,517	1,214
1991	All	5,326	190	993	19	1,315	1,052
1992	All	9,626	331	755	8	862	690
1993	All	3,410	406	817	24	1,057	846
1994	Trawl	2,338	---	429	18	542	434
	Scallop	660	---	590	89	590	472
	All	2,998	354	1,019	34	1,132	906
1995	Trawl	1,822	---	130	7	173	138
	Scallop	731	---	212	29	212	170
	All	2,553	n/a	342	13	385	308
1996	Trawl	1,873	---	319	17	444	355
	Scallop	854	---	135	16	135	108
	All	2,727	n/a	454	17	579	463
1997	Trawl	839		299	36	299	239
	Scallop	556		108	19	108	86
	All	1,395	n/a	407	29	407	326

Table A11 continued.

Year	Gear	Lengths	Ages	Fishery Observer Discard Estimate (mt)	Sampling Intensity (mt per 100 lengths)	Raised Discard Estimate (mt)	Raised Estimate with 80% mortality rate (mt)
1998	Trawl	721		318	44	318	254
	Scallop	150		169	113	169	135
	All	871	n/a	487	56	487	389
1999	Trawl	1,145		1,476	129	1,476	1,181
	Scallop	216		459	213	459	367
	All	1,361	n/a	1,935	142	1,935	1,548
2000	Trawl	1,470		740	50	740	592
	Scallop	2,611		167	6	167	134
	All	4,081	n/a	907	22	907	726
2001	Trawl	1,394		284	20	284	227
	Scallop	11		515	4,682	515	412
	All	1,405	n/a	799	57	799	639

Table A12. Estimated summer flounder discard at age in the in the commercial fishery. 1995-2001 lengths converted to age using 1995-2001 NEFSC trawl survey ages. Includes an assumed 80% discard mortality rate.

Discard numbers at age (000s)

Year	Gear	0	1	2	3+	Total
1989	All	775	1,628	94	0	2,497
1990	All	1,441	2,755	67	0	4,263
1991	All	891	3,424	<1	0	4,315
1992	All	1,155	1,544	36	3	2,738
1993	All	1,041	1,532	179	1	2,753
1994	Trawl	571	1,014	95	0	1,680
	Scallop	0	663	398	36	1,098
	All	571	1,677	493	36	2,778
1995	Trawl	141	294	58	2	495
	Scallop	0	114	148	20	282
	All	141	408	206	22	777
1996	Trawl	23	417	167	56	663
	Scallop	<1	221	72	5	298
	All	23	638	239	61	961
1997	Trawl	8	215	203	50	476
	Scallop	0	34	98	22	154
	All	8	249	301	72	630
1998	Trawl	26	132	146	95	399
	Scallop	1	42	73	52	168
	All	27	174	219	157	567
1999	Trawl	95	1,159	1,012	255	2,521
	Scallop	1	64	239	176	479
	All	96	1,223	1,251	431	3,001
2000	Trawl	20	118	378	303	819
	Scallop	2	46	82	49	179
	All	22	164	460	352	998
2001	All	51	176	198	363	788

Table A13. Estimated summer flounder discard mean length at age in the commercial fishery. 1995-2001 lengths converted to age using 1995-2001 NEFSC trawl survey ages.

Discard mean length (cm) at age

Year	Gear	0	1	2	3+	All
1989	All	25.9	31.5	44.2		30.2
1990	All	29.0	31.7	38.9		30.9
1991	All	24.0	30.9	37.0		29.5
1992	All	29.3	30.0	36.6	51.2	29.8
1993	All	30.0	32.5	34.8	55.0	31.7
1994	Trawl	26.0	31.3	34.5		29.7
	Scallop		30.8	38.2	52.1	34.2
	All	26.0	31.1	37.5	52.1	31.5
1995	Trawl	29.6	29.4	37.0	50.9	30.4
	Scallop		30.7	40.6	52.4	37.4
	All	29.6	29.8	39.6	52.5	33.0
1996	Trawl	28.9	32.0	38.1	55.8	35.5
	Scallop	31.4	30.7	38.2	48.5	32.8
	All	29.0	31.6	38.1	55.2	34.7
1997	Trawl	26.9	32.1	37.8	46.6	36.0
	Scallop		32.5	37.2	45.9	37.5
	All	26.9	32.2	37.6	46.3	36.4
1998	Trawl	26.0	32.5	37.5	48.3	37.7
	Scallop	30.0	35.0	39.7	48.9	41.3
	All	26.1	33.1	38.2	48.5	38.8
1999	Trawl	25.8	32.0	35.9	48.5	34.9
	Scallop	31.0	33.2	36.3	48.8	40.5
	All	25.9	32.1	36.0	48.6	35.9
2000	Trawl	17.2	32.6	37.7	46.3	39.5
	Scallop	26.8	34.4	39.5	47.6	40.3
	All	18.1	33.2	38.0	46.5	39.6
2001	All	21.1	32.9	39.2	47.7	40.3

Table A14. Estimated summer flounder discard mean weight at age in the in the commercial fishery. 1995- 2001 lengths converted to age using 1995-2001 NEFSC trawl survey ages.

Discard mean weight (kg) at age

Year	Gear	0	1	2	3+	All
1989	All	0.182	0.296	0.909		0.284
1990	All	0.235	0.304	0.559		0.285
1991	All	0.124	0.275	0.491		0.244
1992	All	0.238	0.256	0.498	1.450	0.252
1993	All	0.253	0.332	0.413		0.307
1994	Trawl	0.177	0.291	0.392		0.258
	Scallop		0.287	0.565	1.565	0.430
	All	0.177	0.289	0.532	1.565	0.326
1995	Trawl	0.244	0.242	0.522	1.505	0.280
	Scallop		0.281	0.702	1.604	0.595
	All	0.244	0.253	0.651	1.597	0.395
1996	Trawl	0.226	0.312	0.586	2.004	0.521
	Scallop	0.305	0.274	0.572	1.254	0.363
	All	0.227	0.299	0.582	1.937	0.472
1997	Trawl	0.178	0.327	0.560	1.088	0.504
	Scallop		0.331	0.553	1.044	0.558
	All	0.178	0.328	0.558	1.075	0.517
1998	Trawl	0.158	0.332	0.533	1.346	0.637
	Scallop	0.247	0.421	0.651	1.357	0.808
	All	0.161	0.353	0.572	1.350	0.688
1999	Trawl	0.156	0.317	0.462	1.300	0.468
	Scallop	0.275	0.355	0.478	1.310	0.767
	All	0.157	0.319	0.465	1.304	0.516
2000	Trawl	0.055	0.355	0.555	1.114	0.722
	Scallop	0.174	0.412	0.643	1.023	0.741
	All	0.066	0.371	0.571	1.138	0.725
2001	All	0.084	0.356	0.622	1.207	0.797

Table A15. Estimated total landings (catch types A + B1, [000s]) of summer flounder by recreational fishermen. SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats.

	YEAR										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
North											
Shore	167	144	62	10	70	39	42	4	16	9	26
P/C Boat	138	201	5	3	48	7	1	1	1	8	1
P/R Boat	1,293	747	568	382	2,562	648	379	137	99	173	211
TOTAL	1,598	1,092	635	395	2,680	694	422	142	116	190	238
Mid											
Shore	682	3,296	977	272	478	251	594	84	96	505	200
P/C Boat	5,745	3,321	2,381	1,068	1,541	1,143	1,164	141	412	589	374
P/R Boat	5,731	12,345	11,764	8,454	5,924	5,499	7,271	1,141	2,658	4,573	3,983
TOTAL	12,158	18,962	15,122	9,794	7,943	6,893	9,029	1,366	3,166	5,667	4,557
South											
Shore	272	523	316	504	689	115	306	91	150	51	50
P/C Boat	53	52	110	81	20	1	1	1	1	1	1
P/R Boat	1,392	367	1,292	292	289	162	355	117	361	159	156
TOTAL	1,717	942	1,718	877	998	278	662	209	512	211	207
All											
Shore	1,121	3,963	1,355	786	1,237	405	942	179	262	565	276
P/C Boat	5,936	3,574	2,496	1,152	1,609	1,151	1,166	143	414	598	376
P/R Boat	8,416	13,459	13,624	9,128	8,775	6,309	8,005	1,395	3,118	4,905	4,350
TOTAL	15,473	20,996	17,475	11,066	11,621	7,865	10,113	1,717	3,794	6,068	5,002

Table A15 continued.

	YEAR								
	1993	1994	1995	1996	1997	1998	1999	2000	2001
North									
Shore	36	49	19	22	27	44	34	57	4
P/C Boat	10	24	6	7	22	26	19	45	13
P/R Boat	250	596	449	717	669	970	769	1,355	539
TOTAL	296	669	474	746	718	1,040	822	1,457	556
Mid									
Shore	176	195	175	137	195	243	157	445	195
P/C Boat	872	773	267	1,167	907	333	281	557	311
P/R Boat	3,969	4,372	2,312	4,999	5,059	4,972	2,610	4,565	3,849
TOTAL	5,017	5,340	2,754	6,303	6,161	5,548	3,048	5,567	4,355
South									
Shore	113	180	48	46	32	30	23	38	23
P/C Boat	1	2	1	5	2	2	<1	1	<1
P/R Boat	236	197	100	274	247	360	214	312	302
TOTAL	350	379	149	325	281	391	237	351	325
All									
Shore	325	424	242	205	254	317	214	540	222
P/C Boat	883	799	274	1,179	931	361	301	603	325
P/R Boat	4,455	5,165	2,861	5,990	5,975	6,302	3,593	6,232	4,690
TOTAL	5,663	6,388	3,377	7,374	7,160	6,979	4,107	7,375	5,236

Table A16. Estimated total landings (catch types A + B1, [mt]) of summer flounder by recreational fishermen. SHORE mode includes fish taken from beach/bank and man-made structures. P/C indicates catch taken from party/charter boats, while P/R indicates fish taken from private/rental boats.

	YEAR										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
North											
Shore	87	59	17	7	25	21	32	2	16	6	20
P/C Boat	85	87	4	2	45	4	<1	<1	<1	6	<1
P/R Boat	875	454	388	328	2,597	582	289	141	89	150	175
TOTAL	1,047	600	409	337	2,667	607	322	144	106	162	196
Mid											
Shore	295	1,254	399	140	293	129	329	52	56	306	126
P/C Boat	3,112	2,196	1,426	609	1,093	1,098	799	125	264	364	267
P/R Boat	3,085	8,389	5,686	4,187	3,521	3,596	5,003	985	1,665	2,673	2,536
TOTAL	6,492	11,839	7,511	4,936	4,907	4,823	6,131	1,162	1,985	3,343	2,929
South											
Shore	87	134	98	230	425	34	113	57	76	25	25
P/C Boat	12	12	23	20	7	1	<1	<1	<1	<1	<1
P/R Boat	629	102	471	142	96	54	166	71	161	80	91
TOTAL	728	248	592	392	528	89	280	129	238	106	117
All											
Shore	469	1,447	514	377	743	184	474	111	148	337	171
P/C Boat	3,209	2,295	1,453	631	1,145	1,103	801	127	266	371	269
P/R Boat	4,589	8,945	6,545	4,657	6,214	4,232	5,458	1,197	1,915	2,903	2,802
TOTAL	8,267	12,687	8,512	5,665	8,102	5,519	6,733	1,435	2,329	3,611	3,242

Table A16 continued.

	YEAR								
	1993	1994	1995	1996	1997	1998	1999	2000	2001
North									
Shore	25	30	14	15	17	56	27	69	6
P/C Boat	7	14	5	13	17	22	18	40	16
P/R Boat	181	424	371	531	445	833	738	1,454	698
TOTAL	213	468	390	559	479	911	783	1,563	720
Mid									
Shore	88	112	108	80	127	160	136	346	182
P/C Boat	534	478	185	746	712	274	286	611	344
P/R Boat	2,453	2,849	1,699	3,155	3,898	4,096	2,461	4,373	3,822
TOTAL	3,075	3,439	1,992	3,981	4,737	4,530	2,883	5,330	4,348
South									
Shore	59	100	29	24	18	18	13	22	15
P/C Boat	<1	1	<1	2	1	1	<1	<1	<1
P/R Boat	136	103	84	138	143	199	115	174	167
TOTAL	196	204	114	164	162	218	129	197	182
All									
Shore	172	242	151	119	162	234	176	437	203
P/C Boat	542	493	191	761	730	297	305	652	361
P/R Boat	2,770	3,376	2,154	3,824	4,486	5,128	3,314	6,001	4,687
TOTAL	3,484	4,111	2,496	4,704	5,378	5,659	3,795	7,090	5,250

Table A17. Recreational fishery sampling intensity for summer flounder by subregion.

Year	Subregion	Landings (A+B1; mt)	Number of Summer Flounder Measured	mt/100 Lengths
1982	North	1,047	231	453
	Mid	6,492	2,896	224
	South	728	576	126
	TOTAL	8,267	3,703	223
1983	North	600	311	192
	Mid	11,839	4,712	251
	South	248	170	146
	TOTAL	12,687	5,193	244
1984	North	409	168	243
	Mid	7,511	2,195	342
	South	592	283	209
	TOTAL	8,512	2,646	322
1985	North	337	78	432
	Mid	4,936	1,934	255
	South	392	274	143
	TOTAL	5,665	2,286	248
1986	North	2,667	266	1,003
	Mid	4,907	1,808	271
	South	528	288	183
	TOTAL	8,102	2,362	343
1987	North	607	217	280
	Mid	4,823	1,897	254
	South	89	445	20
	TOTAL	5,519	2,559	216

Table A17 continued.

Year	Subregion	Landings (A+B1; mt)	Number of Summer Flounder Measured	mt/100 Lengths
1988	North	322	310	104
	Mid	6,131	2,865	214
	South	280	743	38
	TOTAL	6,733	3,918	172
1989	North	144	107	135
	Mid	1,162	1,582	73
	South	129	358	36
	TOTAL	1,435	2,047	70
1990	North	106	110	96
	Mid	1,985	2,667	74
	South	238	1,293	18
	TOTAL	2,329	4,070	57
1991	North	162	189	86
	Mid	3,343	4,648	72
	South	106	820	13
	TOTAL	3,611	5,657	64
1992	North	196	425	46
	Mid	2,929	4,504	65
	South	117	566	21
	TOTAL	3,242	5,495	59
1993	North	213	338	63
	Mid	3,075	4,174	74
	South	196	995	20
	TOTAL	3,484	5,507	63
1994	North	468	621	75
	Mid	3,439	3,834	90
	South	204	1,467	14
	TOTAL	4,111	5,922	69

Table A17 continued.

Year	Subregion	Landings (A+B1; mt)	Number of Summer Flounder Measured	mt/100 Lengths
1995	North	390	501	78
	Mid	1,992	1,470	136
	South	114	485	24
	TOTAL	2,496	2,456	102
1996	North	559	919	61
	Mid	3,981	3,373	118
	South	164	1,188	14
	TOTAL	4,704	5,480	86
1997	North	480	786	61
	Mid	4,736	2,988	159
	South	162	1,026	16
	TOTAL	5,378	4,800	112
1998	North	911	857	106
	Mid	4,530	3,205	141
	South	218	1,259	17
	TOTAL	5,659	5,321	106
1999	North	783	442	177
	Mid	2,883	1,584	182
	South	129	564	23
	TOTAL	3,795	2,590	147
2000	North	1,563	707	221
	Mid	5,330	1,892	282
	South	197	722	27
	TOTAL	7,090	3,321	213
2001	North	720	351	205
	Mid	4,348	2,965	147
	South	182	953	19
	TOTAL	5,250	4,269	123

Table A18. Estimated recreational landings at age of summer flounder (000s), (catch type A + B1).

					AGE					
Year	0	1	2	3	4	5	6	7	8+	Total
1982	2,750	8,445	3,498	561	215	<1	4	0	0	15,473
1983	2,302	11,612	4,978	1,340	528	220	0	16	0	20,996
1984	2,282	9,198	4,831	1,012	147	5	<1	0	0	17,745
1985	1,002	5,002	4,382	473	148	59	0	0	0	11,066
1986	1,169	6,404	2,784	1,088	129	15	28	0	0	11,621
1987	466	4,674	2,083	448	182	1	5	0	0	7,865
1988	434	5,855	3,345	386	90	3	0	0	0	10,113
1989	74	539	946	135	16	2	5	0	0	1,717
1990	353	2,770	529	118	23	<1	1	0	0	3,794
1991	86	3,611	2,251	79	40	1	0	0	0	6,068
1992	82	3,183	1,620	90	<1	27	0	0	0	5,002
1993	71	3,470	1,981	139	<1	2	0	0	0	5,663
1994	765	3,872	1,549	171	26	<1	5	0	0	6,388
1995	235	1,557	1,426	117	26	16	<1	0	0	3,377
1996	115	3,093	3,664	372	129	1	0	0	0	7,374
1997	4	1,147	4,183	1,464	274	88	0	0	0	7,160
1998	0	768	2,915	2,714	515	63	3	0	0	6,979
1999	0	201	1,982	1,520	325	60	19	0	0	4,107
2000	0	544	3,897	2,161	609	160	4	0	0	7,375
2001	0	838	1,960	1,751	529	119	35	4	0	5,236

Table A19. Estimated summer flounder landings (catch types A + B1), live discard (catch type B2), and total catch (catch types A + B1 + B2) in numbers (000s), and live discard (catch type B2) as a proportion of total catch.

Year	A+B1	B2	A+B1+B2	B2 / (A+B1+B2)
1982	15,473	8,089	23,562	0.343
1983	20,996	11,066	32,062	0.345
1984	17,475	12,310	29,785	0.413
1985	11,066	2,460	13,526	0.182
1986	11,621	13,672	25,293	0.541
1987	7,865	13,159	21,024	0.626
1988	10,113	7,249	17,362	0.418
1989	1,717	960	2,677	0.359
1990	3,794	5,307	9,101	0.583
1991	6,068	10,007	16,075	0.623
1992	5,002	6,907	11,909	0.580
1993	5,663	14,321	19,984	0.717
1994	6,388	10,345	16,733	0.618
1995	3,377	12,860	16,237	0.792
1996	7,374	12,368	19,742	0.626
1997	7,160	12,860	20,020	0.642
1998	6,979	15,107	22,086	0.684
1999	4,107	17,271	21,378	0.808
2000	7,375	16,712	24,087	0.694
2001	5,236	22,561	27,797	0.812

Table A20. Estimated recreational fishery discard at age of summer flounder (catch type B2). Discards during 1982-1996 allocated to age groups in same relative proportions as ages 0 and 1 in the subregional catch. Discards during 1997-2000 allocated to age groups in same relative proportions as fish less than the annual EEZ minimum size in the subregional catch. Discards in 2001 allocated to age groups in the same relative proportion as fish less than the minimum size in the respective state catch. All years assume 10% release mortality.

	Numbers at age					Metric Tons at age				
Year	0	1	2	3+	Total	0	1	2	3+	Total
1982	172	636	0	0	808	39	257	0	0	296
1983	175	932	0	0	1,107	31	345	0	0	376
1984	210	1,020	0	0	1,230	43	372	0	0	415
1985	40	206	0	0	246	10	82	0	0	92
1986	150	1,217	0	0	1,367	34	544	0	0	578
1987	106	1,210	0	0	1,316	24	498	0	0	522
1988	56	669	0	0	725	16	326	0	0	342
1989	13	83	0	0	96	3	42	0	0	45
1990	60	470	0	0	530	18	216	0	0	234
1991	24	977	0	0	1,001	6	423	0	0	429
1992	17	674	0	0	691	4	340	0	0	344
1993	22	1,410	0	0	1,432	6	730	0	0	736
1994	177	857	0	0	1,034	77	500	0	0	577
1995	170	1,116	0	0	1,286	72	642	0	0	714
1996	24	1,213	0	0	1,237	8	645	0	0	653
1997	18	752	495	21	1,286	4	296	206	9	515
1998	0	548	833	130	1,511	0	129	330	58	517
1999	84	569	954	122	1,729	11	215	407	55	688
2000	0	510	1,001	161	1,672	0	244	524	87	855
2001	0	1,171	864	221	2,256	0	553	483	148	1,184

Table A21. Estimated recreational catch at age of summer flounder ('000; catch type A + B1 + B2). Includes catch type B2 (fish released alive) with 10% release mortality.

	AGE									
Year	0	1	2	3	4	5	6	7	8+	Total
1982	2,922	9,081	3,498	561	215	<1	4	0	0	16,281
1983	2,477	12,544	4,978	1,340	528	220	0	16	0	22,103
1984	2,492	10,218	4,831	1,012	147	5	<1	0	0	18,705
1985	1,042	5,208	4,382	473	148	59	0	0	0	11,312
1986	1,319	7,621	2,784	1,088	129	15	28	4	0	12,988
1987	572	5,884	2,083	448	182	1	5	6	0	9,181
1988	490	6,524	3,345	386	90	3	0	0	0	10,838
1989	87	622	946	135	16	2	5	0	0	1,813
1990	413	3,240	529	118	23	<1	1	0	0	4,324
1991	110	4,588	2,251	79	40	1	0	0	0	7,069
1992	99	3,857	1,620	90	<1	27	0	0	0	5,693
1993	93	4,880	1,981	139	<1	2	0	0	0	7,095
1994	942	4,729	1,549	171	26	<1	5	0	0	7,422
1995	405	2,673	1,426	117	26	16	<1	0	0	4,664
1996	139	4,306	3,664	372	129	1	0	0	0	8,611
1997	22	1,899	4,678	1,485	274	88	0	0	0	8,446
1998	0	1,316	3,748	2,844	515	63	4	0	0	8,490
1999	84	769	2,935	1,642	325	60	19	0	0	5,834
2000	0	1,054	4,898	2,322	609	160	4	0	0	9,047
2001	0	2,009	2,824	1,963	538	119	35	4	0	7,492

Table A22. Mean weight (kg) at age of summer flounder catch in the recreational fishery.

	AGE									
Year	0	1	2	3	4	5	6	7	8+	ALL
1982	0.22	0.40	0.57	1.33	1.84	1.89	2.98			0.46
1983	0.18	0.37	0.63	0.93	1.19	1.40				0.47
1984	0.21	0.36	0.62	0.97	1.77	2.20	4.17			0.45
1985	0.24	0.40	0.63	1.10	1.75	2.44				0.53
1986	0.23	0.45	0.75	1.29	1.74	2.72	3.48	5.96		0.58
1987	0.23	0.41	0.76	1.34	1.84	3.05	4.81	4.64		0.56
1988	0.29	0.49	0.71	1.11	1.92	2.32				0.58
1989	0.26	0.51	0.81	1.23	1.78	3.33	1.58			0.73
1990	0.30	0.46	0.97	1.44	1.68	2.90	6.46			0.54
1991	0.27	0.43	0.67	1.31	1.37	2.45				0.52
1992	0.23	0.50	0.72	1.62	2.28	3.34				0.59
1993	0.25	0.52	0.72	1.87	2.44	3.03				0.60
1994	0.44	0.58	0.69	1.44	1.92	2.83	3.90			0.61
1995	0.43	0.58	0.82	1.46	2.60	2.93	3.54			0.68
1996	0.34	0.53	0.62	1.34	1.34	2.36				0.61
1997	0.23	0.45	0.65	0.90	1.15	2.38				0.68
1998		0.41	0.61	0.81	1.26	2.51	2.79			0.70
1999	0.13	0.41	0.62	0.91	1.55	2.33	2.60			0.74
2000		0.52	0.71	0.95	1.31	2.39	3.48			0.83
2001		0.53	0.78	1.00	1.53	2.09	2.30	3.75		0.86

Table A23. Total catch at age of summer flounder (000s), ME-NC.

	AGE										
Year	0	1	2	3	4	5	6	7	8	9+	Total
1982	5,344	19,423	10,149	935	328	116	67	26	4	0	36,392
1983	4,925	28,441	10,911	2,181	693	323	16	36	5	2	47,533
1984	4,802	26,582	15,454	3,180	829	95	4	5	1	4	50,956
1985	2,078	14,623	17,979	1,767	496	252	30	5	2	1	37,233
1986	1,942	17,140	11,055	3,782	316	140	58	12	3	0	34,448
1987	1,137	17,212	10,838	1,648	544	25	29	33	11	0	31,477
1988	795	20,557	14,562	2,137	644	121	19	15	6	0	38,856
1989	960	4,790	7,306	1,692	353	55	9	3	1	0	15,169
1990	1,856	8,808	2,187	995	221	30	8	2	1	0	14,108
1991	1,001	12,149	7,148	742	217	32	3	1	0	0	21,293
1992	1,368	11,197	6,026	1,125	151	70	2	1	0	0	19,940
1993	1,285	11,235	5,601	566	73	45	20	2	1	0	18,828
1994	1,638	10,362	6,996	982	205	26	14	0	5	0	20,227
1995	592	5,828	7,303	1,239	397	77	2	1	0	0	15,440
1996	162	6,925	9,278	1,785	417	71	16	1	3	0	18,658
1997	30	2,545	8,046	3,149	553	160	11	4	0	0	14,498
1998	45	2,233	6,380	5,243	980	138	19	1	0	0	15,039
1999	181	2,185	6,260	4,018	1,161	358	55	14	0	0	14,232
2000	22	1,480	7,690	4,538	1,495	360	73	19	8	2	15,687
2001	51	2,977	4,832	3,736	1,282	365	121	28	4	3	13,399

Table A24. Mean length (cm) at age of summer flounder catch, ME-NC.

	AGE										
Year	0	1	2	3	4	5	6	7	8	9+	ALL
1982	29.4	34.5	38.8	50.7	55.3	61.0	60.7	68.0	71.2		35.7
1983	28.8	34.5	40.9	46.5	48.8	51.6	60.7	60.9	69.3	72.0	36.3
1984	29.4	33.8	39.1	45.9	51.3	57.9	66.8	68.4	74.0	70.7	36.1
1985	30.6	34.8	38.8	46.8	53.9	58.6	61.5	74.5	73.3	75.0	37.5
1986	29.7	35.6	39.9	47.5	54.0	56.2	65.8	66.4	72.8		38.2
1987	29.9	35.3	39.7	46.9	55.8	63.3	65.9	63.2	73.5		37.7
1988	32.4	35.8	39.1	46.6	53.1	60.2	69.6	68.5	72.7		37.9
1989	27.1	35.7	40.8	45.5	50.6	58.5	59.1	63.1	59.0		39.1
1990	29.6	35.1	41.9	46.8	51.4	57.4	66.4	71.7	75.2		36.6
1991	24.8	34.5	40.4	47.1	54.3	61.0	61.7	68.1			36.7
1992	29.6	36.0	41.2	46.9	49.7	61.0	58.8	72.2			37.9
1993	30.3	36.5	40.6	50.4	52.9	54.7	62.6	70.6	75.5		37.9
1994	32.2	37.1	39.3	49.6	57.3	63.4	66.3		68.5		38.3
1995	33.7	37.1	39.9	44.9	52.4	62.2	70.5	71.9			39.4
1996	32.6	36.9	38.3	45.7	51.3	54.4	58.5	63.0	66.0		38.8
1997	28.5	36.2	39.8	43.4	48.3	58.1	60.8	66.3			40.4
1998	28.7	37.2	40.0	43.4	49.5	59.3	60.9	71.1			41.6
1999	25.3	33.6	38.8	43.9	50.7	55.5	62.2	67.1	67.0		40.8
2000	18.1	37.2	40.9	44.2	49.3	58.0	60.8	60.3	66.1	67.7	42.8
2001	21.1	37.7	41.8	45.0	50.4	57.3	60.5	66.1	68.9	71.8	43.2

Table A25. Mean weight (kg) at age of summer flounder catch, ME-NC.

	AGE										
Year	0	1	2	3	4	5	6	7	8	9+	ALL
1982	0.255	0.419	0.616	1.447	1.907	2.795	2.673	3.758	4.408	4.370	0.504
1983	0.243	0.419	0.716	1.075	1.257	1.495	2.572	2.594	3.849	4.030	0.521
1984	0.251	0.398	0.632	1.046	1.500	2.163	3.302	3.620	4.640	4.800	0.518
1985	0.290	0.429	0.613	1.109	1.726	2.297	2.671	4.682	4.780		0.575
1986	0.256	0.453	0.668	1.160	1.739	1.994	3.311	4.000	4.432		0.613
1987	0.263	0.446	0.651	1.140	1.941	2.855	3.326	3.314	4.140		0.581
1988	0.319	0.462	0.624	1.130	1.739	2.485	3.888	3.545	4.316		0.588
1989	0.207	0.459	0.723	1.044	1.479	2.249	2.399	2.861	2.251		0.668
1990	0.250	0.429	0.810	1.169	1.538	2.121	3.461	3.951	5.029		0.540
1991	0.140	0.404	0.702	1.186	1.811	2.527	2.837	3.586			0.537
1992	0.246	0.467	0.749	1.222	1.390	2.696	2.302	4.479			0.595
1993	0.264	0.480	0.699	1.461	1.659	1.859	2.816	4.136	5.199		0.571
1994	0.342	0.521	0.628	1.353	2.096	2.736	3.437		3.703		0.605
1995	0.375	0.527	0.678	1.056	1.639	2.628	3.750	4.047			0.675
1996	0.327	0.504	0.570	1.080	1.545	1.957	2.546	3.200	3.164		0.621
1997	0.212	0.452	0.639	0.866	1.233	2.252	2.572	3.429			0.697
1998	0.259	0.490	0.648	0.859	1.321	2.410	2.577	3.983			0.759
1999	0.143	0.371	0.594	0.896	1.439	1.998	2.716	3.496	3.904		0.755
2000	0.066	0.509	0.692	0.924	1.331	2.214	2.586	2.728	3.359	3.532	0.850
2001	0.084	0.538	0.760	0.968	1.451	2.154	2.586	3.418	3.914	4.532	0.894

Table A26. NEFSC research trawl survey indices of abundance. Indices are stratified mean numbers (n) and weight (kg) per tow. Spring indices are for offshore strata 1-12 61-76; autumn indices are for offshore strata 1-2, 5-6, 9-10, 61, 65, 69, and 73. Winter indices (1992 and later) are for NEFSC offshore strata 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, and 73-75. n/a = not available due to incomplete coverage. **Note that 2002 indices are from preliminary, unaudited data.**

Year	Spring (n)	Spring (kg)	Autumn (n)	Autumn (kg)
1967	n/a	n/a	1.35	1.25
1968	0.15	0.16	1.10	1.00
1969	0.19	0.16	0.59	0.61
1970	0.09	0.09	0.15	0.13
1971	0.22	0.28	0.42	0.27
1972	0.47	0.21	0.39	0.27
1973	0.76	0.54	0.87	0.63
1974	1.37	1.26	1.70	1.86
1975	1.97	1.61	3.00	2.48
1976	2.83	2.00	1.14	0.85
1977	2.84	1.74	2.17	1.75
1978	2.62	1.43	0.32	0.40
1979	0.40	0.35	1.17	0.94
1980	1.30	0.78	0.94	0.57
1981	1.50	0.80	0.91	0.72
1982	2.27	1.11	1.57	0.90
1983	0.95	0.53	0.90	0.47
1984	0.66	0.38	0.99	0.65
1985	2.38	1.20	1.24	0.87
1986	2.14	0.82	0.68	0.45
1987	0.93	0.38	0.26	0.28
1988	1.47	0.68	0.11	0.11
1989	0.32	0.24	0.20	0.08
1990	0.72	0.27	0.27	0.19
1991	1.08	0.35	0.51	0.17

Table A26 continued.

Year	Winter (n)	Winter (kg)	Spring (n)	Spring (kg)	Autumn (n)	Autumn (kg)
1992	12.30	4.90	1.20	0.46	0.85	0.49
1993	13.60	5.50	1.27	0.48	0.11	0.04
1994	12.05	6.03	0.93	0.46	0.60	0.35
1995	10.93	4.81	1.09	0.46	1.13	0.83
1996	31.25	12.35	1.76	0.67	0.71	0.45
1997	10.28	5.54	1.06	0.61	1.32	0.92
1998	7.76	5.13	1.19	0.76	2.32	1.58
1999	11.06	7.99	1.60	1.01	2.42	1.66
2000	16.01	12.74	2.14	1.70	1.90	1.82
2001	18.59	15.68	2.69	2.16	1.60	1.61
2002	22.55	18.71	2.47	2.29		

Table A27. NEFSC spring trawl survey (offshore strata 1-12, 61-76) stratified mean number of summer flounder per tow at age. **Note that 2002 indices are from preliminary, unaudited data.**

	AGE										
Year	1	2	3	4	5	6	7	8	9	10+	ALL
1976	0.03	1.77	0.71	0.29	0.01	0.01	0.01				2.83
1977	0.61	1.31	0.71	0.10	0.09	0.01		0.01			2.84
1978	0.68	0.93	0.64	0.19	0.04	0.03	0.03			0.01	2.55
1979	0.06	0.18	0.08	0.04	0.03			0.01			0.40
1980	0.01	0.70	0.31	0.14	0.02	0.06	0.03	0.02		0.01	1.30
1981	0.60	0.54	0.17	0.08	0.05	0.03	0.02	0.01			1.50
1982	0.70	1.43	0.12	0.02							2.27
1983	0.32	0.39	0.19	0.03	0.01				0.01		0.95
1984	0.17	0.33	0.09	0.05		0.01	0.01				0.66
1985	0.55	1.56	0.21	0.04	0.02						2.38
1986	1.48	0.43	0.20	0.02	0.01						2.14
1987	0.47	0.43	0.02	0.01							0.93
1988	0.60	0.81	0.07	0.02							1.50
1989	0.06	0.23	0.02	0.01							0.32
1990	0.63	0.03	0.06								0.72
1991	0.79	0.27		0.02							1.08
1992	0.77	0.41	0.01		0.01						1.20
1993	0.73	0.50	0.04								1.27
1994	0.35	0.53	0.04	0.01							0.93
1995	0.79	0.27	0.02				0.01				1.09
1996	1.08	0.56	0.12								1.76
1997	0.29	0.67	0.09	0.01							1.06
1998	0.27	0.52	0.32	0.06	0.01	0.01					1.19
1999	0.22	0.74	0.48	0.13	0.02	0.01					1.60
2000	0.19	1.03	0.63	0.12	0.15	0.02					2.14
2001	0.48	0.89	1.02	0.20	0.05	0.04	0.01				2.69
2002	0.35	0.87	0.75	0.31	0.09	0.05	0.02	0.01	0.01	0.01	2.47
Mean	0.49	0.68	0.27	0.09	0.04	0.03	0.02	0.01	0.01	0.01	1.55

Table A28. NEFSC spring trawl survey (offshore strata 1-12, 61-76) summer flounder mean length (cm) at age. **Note that 2002 indices are from preliminary, unaudited data.**

	AGE											
Year	1	2	3	4	5	6	7	8	9	10	11	12
1976	25.9	36.0	43.1	53.5	60.8	70.0	72.0					
1977	25.2	35.0	43.4	51.7	59.6	63.0		74.0				
1978	27.3	34.8	40.9	46.9	53.3	59.5	64.0				65.0	75.0
1979	25.1	37.0	43.2	51.5	54.8			77.0				
1980	29.0	28.8	38.1	44.2	51.1	53.0	67.7	77.0		81.0		
1981	25.3	32.2	39.8	48.9	55.7	62.9	67.8	74.0				
1982	28.6	36.2	47.3	46.7								
1983	25.5	37.7	43.4	53.3	61.4				77.0			
1984	27.1	33.9	41.8	56.7		63.0	56.0					
1985	26.8	36.1	42.8	57.2	54.5							
1986	28.6	36.3	46.0	56.0	63.0							
1987	27.8	37.7	47.3	58.0								
1988	27.7	36.3	47.8	45.0								
1989	30.4	39.2	51.5	60.0								
1990	28.3	47.7	48.6									
1991	27.0	38.8		42.1								
1992	27.9	37.7	57.0		72.0							
1993	27.5	37.9	51.9									
1994	33.0	36.8	48.0	53.1								
1995	29.4	40.0	46.4				72.0					
1996	29.8	36.2	47.2									
1997	29.4	38.3	49.4	54.1								
1998	27.6	39.1	42.7	50.5	50.0	60.0						
1999	28.5	35.8	42.9	49.1	57.7	64.0						
2000	29.5	37.9	44.3	49.4	55.4	60.5						
2001	29.6	39.1	44.9	53.4	60.5	63.8	55.0					
2002	29.7	39.3	45.8	52.7	58.1	63.5	62.1	66.0	54.0	68.0		
Mean	28.1	37.1	45.6	51.5	57.9	62.1	64.6	73.6	65.5	74.5	65.0	75.0

Table A29. NEFSC autumn trawl survey (inshore strata 1-61, offshore strata <= 55 m (1,5,9,61,65,69,73)) mean number of summer flounder per tow at age.

	AGE								
Year	0	1	2	3	4	5	6	7	ALL
1982	0.55	1.52	0.40	0.03					2.50
1983	0.96	1.46	0.34	0.12	0.01	0.01			2.90
1984	0.18	1.39	0.43	0.07	0.01	0.01	<0.01		2.09
1985	0.59	0.80	0.46	0.05		0.02			1.92
1986	0.39	0.83	0.11	0.11		<0.01			1.44
1987	0.07	0.58	0.20	0.03	0.02				0.90
1988	0.06	0.62	0.18	0.03					0.89
1989	0.31	0.21	0.05						0.57
1990	0.44	0.38	0.03	0.04		<0.01			0.89
1991	0.76	0.84	0.09		0.01	<0.01	<0.01		1.70
1992	0.99	1.04	0.25	0.03	0.01	<0.01			2.32
1993	0.23	0.80	0.03	0.01			<0.01		1.07
1994	0.75	0.67	0.09	0.01	0.01				1.53
1995	0.93	1.16	0.28	0.02	0.01				2.40
1996	0.11	1.24	0.57	0.04					1.96
1997	0.17	1.29	1.14	0.29	0.02	0.01	0.01	<0.01	2.93
1998	0.38	2.13	1.63	0.33	0.04	0.01			4.52
1999	0.21	1.73	1.49	0.31	0.04	0.01			3.79
2000	0.22	1.20	1.22	0.40	0.15	0.06	0.03	0.04	3.32
2001	0.08	1.36	0.93	0.39	0.11	0.11	0.01	0.01	3.00
Mean	0.42	1.06	0.50	0.13	0.04	0.02	0.01	0.02	2.13

Table A30. NEFSC autumn trawl survey (inshore strata 1-61, offshore strata <= 55 m (1,5,9,61,65,69,73)) summer flounder mean length (cm) at age.

	AGE							
Year	0	1	2	3	4	5	6	7
1982	28.2	35.1	43.3	47.1				
1983	24.5	33.5	42.7	52.3	60.0	58.0		
1984	23.5	33.6	41.1	46.5	62.6	65.0	70.0	
1985	25.5	35.4	43.1	53.0		63.0		
1986	23.1	35.7	40.8	53.5		57.0		
1987	27.4	34.4	46.0	53.6	47.7			
1988	30.1	35.9	43.4	61.7				
1989	25.8	35.8	48.2	60.0				
1990	24.8	36.0	45.2	54.9	60.0	68.0		
1991	23.2	34.7	43.7	59.0	61.2	67.0	69.0	
1992	25.3	34.4	42.7	51.3	58.8	68.0		
1993	29.9	35.1	44.0	58.1	59.0		70.0	
1994	27.5	38.0	44.3	61.5	57.0			
1995	26.5	36.7	47.4	59.0	65.0			
1996	26.6	35.4	41.6	56.1				
1997	28.4	35.1	40.3	46.5	51.7	59.3	56.0	63.0
1998	24.0	34.7	42.6	50.2	58.2	68.6		
1999	24.1	34.7	40.0	48.5	55.6	56.8		
2000	25.2	35.7	42.1	48.6	53.5	59.9	68.0	66.5
2001	22.9	36.3	42.5	50.0	54.1	62.1	56.0	67.0
Mean	25.8	35.3	43.3	53.6	57.5	62.7	64.8	65.5

Table A31. NEFSC Winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms): 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras): mean number and mean weight (kg) per tow. **Note that 2002 indices are from preliminary, unaudited data.**

Year	Stratified mean number per tow	Coefficient of variation	Stratified mean weight (kg) per tow	Coefficient of variation
1992	12.295	15.6	4.898	15.4
1993	13.604	15.2	5.497	11.9
1994	12.051	17.8	6.033	16.1
1995	10.930	12.0	4.808	11.6
1996	31.246	24.2	12.351	22.0
1997	10.283	24.0	5.544	16.6
1998	7.756	20.7	5.131	16.6
1999	11.055	13.3	7.987	11.4
2000	15.759	13.0	12.593	12.8
2001	18.589	11.4	15.682	13.2
2002	22.550	15.6	18.705	15.7

Table A32. NEFSC Winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms): 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras) : mean number at age per tow. **Note that 2002 indices are from preliminary, unaudited data.**

Year	AGE											
	1	2	3	4	5	6	7	8	9	10	11	12+	Total
1992	7.15	4.74	0.33	0.04	0.01	0.03							12.29
1993	6.50	6.70	0.31	0.05	0.02	0.02							13.60
1994	3.76	7.20	0.82	0.26			0.01						12.05
1995	6.07	4.59	0.25	0.02									10.93
1996	22.17	8.33	0.60	0.12	0.03								31.25
1997	3.86	4.80	1.04	0.43	0.11	0.04							10.28
1998	1.68	3.25	2.29	0.42	0.10	0.01				0.01			7.76
1999	2.11	4.80	2.90	0.84	0.28	0.06	0.04	0.02		0.01			11.06
2000	0.70	6.52	4.96	2.51	0.78	0.17	0.08	0.04	0.01				15.76
2001	3.06	5.36	6.40	2.44	0.80	0.37	0.09	0.05	0.01		0.01	0.01	18.57
2002	2.77	10.65	5.57	2.25	0.84	0.33	0.12	0.02	0.02				22.55
Mean	5.41	6.06	2.35	0.85	0.33	0.13	0.07	0.03	0.01	0.01	0.01	0.01	15.09

Table A33. NEFSC Winter trawl survey (offshore strata from 27-185 meters (15-100 fathoms): 1-3, 5-7, 9-11, 13-14, 16-17, 61-63, 65-67, 69-71, 73-75; Southern Georges Bank to Cape Hatteras): summer flounder mean length (cm) at age. **Note that 2002 indices are from preliminary, unaudited data.**

	AGE											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1992	28.0	38.4	48.8	60.0	70.0	69.0						
1993	27.9	37.3	49.4	58.7	58.5	65.0						
1994	28.0	37.5	46.1	56.4			69.0					
1995	27.4	40.2	50.8	59.6								
1996	30.9	38.2	51.4	61.2	63.6							
1997	29.2	37.8	44.5	50.0	57.3	62.5						
1998	28.4	38.0	43.3	52.2	59.7	66.3				64.0		
1999	28.4	36.9	44.5	51.6	59.2	64.1	70.2	68.8		78.0		
2000	28.2	35.9	41.4	49.0	56.3	62.2	68.2	67.1	77.0			
2001	28.3	37.3	43.6	50.2	56.3	61.0	65.3	69.4	58.6		70.0	74.0
2002	30.0	38.5	44.5	51.4	58.1	62.2	66.4	62.7	75.0			
Mean	28.6	37.8	46.2	54.6	59.9	64.0	67.8	67.0	70.2	71.0	70.0	74.0

Table A34. MADMF Spring survey cruises: stratified mean number per tow at age.

Year					Age					
	0	1	2	3	4	5	6	7	8+	Total
1978		0.097	0.520	0.274	0.221		0.042			1.154
1979			0.084	0.087	0.147	0.048	0.011			0.377
1980		0.055	0.061	0.052	0.075	0.053	0.055	0.011		0.362
1981		0.405	0.558	0.074	0.031	0.043	0.060		0.031	1.202
1982		0.376	1.424	0.118	0.084	0.020		0.010		2.032
1983		0.241	1.304	0.544	0.021	0.009	0.003			2.122
1984		0.042	0.073	0.063	0.111	0.010				0.299
1985		0.142	1.191	0.034	0.042					1.409
1986		0.966	0.528	0.140	0.008					1.642
1987		0.615	0.583	0.012			0.011			1.221
1988		0.153	0.966	0.109	0.012					1.240
1989			0.338	0.079			0.010			0.427
1990		0.247	0.021	0.079	0.012					0.359
1991		0.029	0.048	0.010						0.087
1992		0.274	0.320	0.080		0.011	0.011			0.696
1993		0.120	0.470	0.060	0.010		0.020			0.680
1994		1.770	1.160	0.050	0.020		0.020			3.020
1995		0.089	1.245	0.050						1.384
1996		0.072	0.641	0.110	0.012					0.835
1997		0.512	1.212	0.169	0.109		0.005			2.007
1998		0.137	1.144	0.630	0.041	0.047				1.999
1999		0.073	0.814	1.042	0.286	0.028		0.015		2.258
2000		0.224	1.566	1.137	0.296	0.202	0.049		0.012	3.486
2001		0.172	0.963	0.687	0.216	0.054				2.092
Mean		0.310	0.718	0.237	0.092	0.048	0.025	0.012	0.022	1.350

Table A35. MADMF Autumn survey cruises: stratified mean number per tow at age.

Year	Age									
	0	1	2	3	4	5	6	7	8+	Total
1978		0.011	0.124	0.024		0.007				0.166
1979			0.047	0.101		0.019				0.167
1980		0.114	0.326	0.020	0.020	0.010				0.490
1981	0.009	0.362	0.367	0.011						0.749
1982		0.255	1.741	0.016						2.012
1983		0.026	0.583	0.140	0.004					0.753
1984	0.033	0.453	0.249	0.120	0.008					0.863
1985	0.051	0.108	1.662	0.033						1.854
1986	0.128	2.149	0.488	0.128						2.893
1987		1.159	0.598	0.010	0.004					1.771
1988		0.441	0.414	0.018						0.873
1989			0.286	0.024						0.310
1990		0.108		0.012						0.120
1991	0.021	0.493	0.262	0.010						0.786
1992		1.110	0.170							1.280
1993	0.010	0.300	0.430	0.020	0.020					0.780
1994	0.050	2.130	0.070							2.250
1995	0.032	0.401	0.323	0.013						0.769
1996	0.020	0.709	1.165	0.082	0.039	0.004				2.019
1997		0.462	1.399	0.323	0.018	0.030				2.232
1998		0.011	0.553	0.248	0.016	0.011				0.839
1999	0.058	0.325	0.878	0.359	0.035					1.655
2000	0.071	1.300	2.129	0.443	0.085	0.084	0.012	0.015		4.139
2001	0.011	1.166	1.000	0.271	0.025	0.000	0.010	0.012		2.494
Mean	0.041	0.618	0.664	0.110	0.025	0.021	0.011	0.013		1.344

Table A36. MADMF seine survey: total catch of age-0 summer flounder.

Year	Total catch
1982	3
1983	3
1984	1
1985	19
1986	5
1987	5
1988	2
1989	3
1990	11
1991	4
1992	0
1993	2
1994	1
1995	13
1996	7
1997	0
1998	12
1999	13
2000	10
2001	1
Mean	6

Table A37. CTDEP spring trawl survey: summer flounder index of abundance, geometric mean number per tow at age.

Year	Age								
	0	1	2	3	4	5	6	7	Total
1984	0.000	0.314	0.271	0.044	0.000	0.000	0.000	0.000	0.629
1985	0.000	0.015	0.325	0.040	0.058	0.003	0.000	0.000	0.441
1986	0.000	0.753	0.100	0.082	0.008	0.006	0.000	0.000	0.949
1987	0.000	0.951	0.086	0.014	0.004	0.001	0.000	0.001	1.057
1988	0.000	0.232	0.223	0.035	0.009	0.001	0.000	0.000	0.500
1989	0.000	0.013	0.049	0.024	0.016	0.000	0.000	0.000	0.102
1990	0.000	0.304	0.022	0.013	0.006	0.001	0.000	0.001	0.347
1991	0.000	0.392	0.189	0.029	0.028	0.001	0.000	0.000	0.639
1992	0.000	0.319	0.188	0.021	0.004	0.023	0.000	0.000	0.555
1993	0.000	0.320	0.151	0.015	0.018	0.003	0.000	0.001	0.508
1994	0.000	0.496	0.314	0.025	0.018	0.005	0.000	0.002	0.860
1995	0.000	0.199	0.051	0.020	0.005	0.000	0.000	0.006	0.281
1996	0.000	0.578	0.266	0.086	0.023	0.004	0.000	0.004	0.961
1997	0.000	0.391	0.507	0.057	0.036	0.004	0.002	0.002	0.999
1998	0.000	0.064	0.594	0.503	0.116	0.006	0.025	0.002	1.310
1999	0.000	0.245	0.593	0.385	0.139	0.053	0.025	0.000	1.440
2000	0.000	0.321	0.726	0.524	0.074	0.111	0.034	0.000	1.790
2001	0.000	0.841	0.340	0.365	0.120	0.043	0.032	0.007	1.748
Mean	0.000	0.347	0.274	0.113	0.033	0.013	0.005	0.001	0.786

Table A38. CTDEP autumn trawl survey: summer flounder index of abundance, geometric mean number per tow at age.

Year	Age								
	0	1	2	3	4	5	6	7	Total
1984	0.000	0.571	0.331	0.072	0.014	0.004	0.004	0.003	0.999
1985	0.240	0.339	0.528	0.075	0.001	0.008	0.000	0.000	1.191
1986	0.172	1.170	0.298	0.072	0.006	0.001	0.000	0.000	1.719
1987	0.075	1.067	0.223	0.033	0.003	0.000	0.000	0.000	1.401
1988	0.015	0.884	0.481	0.037	0.002	0.001	0.000	0.000	1.420
1989	0.000	0.029	0.095	0.015	0.001	0.000	0.000	0.000	0.140
1990	0.032	0.674	0.110	0.042	0.007	0.005	0.000	0.000	0.870
1991	0.036	0.826	0.340	0.036	0.013	0.005	0.004	0.000	1.260
1992	0.013	0.570	0.366	0.046	0.016	0.009	0.000	0.000	1.020
1993	0.084	0.827	0.152	0.039	0.003	0.001	0.002	0.001	1.109
1994	0.132	0.300	0.085	0.024	0.009	0.000	0.000	0.000	0.550
1995	0.023	0.384	0.117	0.012	0.002	0.001	0.000	0.002	0.541
1996	0.069	0.887	1.188	0.042	0.005	0.000	0.000	0.000	2.191
1997	0.033	0.681	1.373	0.373	0.021	0.014	0.004	0.001	2.500
1998	0.000	0.269	1.054	0.321	0.054	0.021	0.000	0.000	1.719
1999	0.044	0.679	1.484	0.346	0.114	0.011	0.002	0.000	2.680
2000	0.112	0.395	0.871	0.341	0.124	0.043	0.011	0.013	1.910
2001	0.021	2.689	1.137	0.436	0.110	0.018	0.005	0.001	4.417
Mean	0.064	0.621	0.535	0.113	0.023	0.007	0.002	0.001	1.366

Table A39. RIDFW autumn trawl survey summer flounder index of abundance. RIDFW lengths aged with NEFSC autumn trawl survey age-length keys.

Year	Age										
	0	1	2	3	4	5	6	7	8	9	Total
1980	0.131	0.203	0.392	0.074	0.013	0.000	0.000	0.000	0.000	0.000	0.813
1981	0.304	0.971	1.740	0.199	0.013	0.003	0.002	0.002	0.001	0.001	3.236
1982	0.024	0.209	0.516	0.071	0.005	0.000	0.000	0.000	0.000	0.001	0.826
1983	0.030	0.135	0.420	0.110	0.014	0.001	0.000	0.001	0.000	0.001	0.712
1984	0.122	0.424	0.701	0.092	0.013	0.003	0.000	0.000	0.000	0.000	1.355
1985	0.342	0.218	0.338	0.048	0.004	0.001	0.000	0.001	0.000	0.000	0.952
1986	0.547	1.183	1.518	0.179	0.012	0.000	0.002	0.001	0.001	0.001	3.444
1987	0.135	0.503	0.579	0.121	0.014	0.001	0.003	0.003	0.001	0.000	1.360
1988	0.014	0.167	0.351	0.036	0.003	0.000	0.000	0.000	0.000	0.000	0.571
1989	0.000	0.001	0.037	0.030	0.003	0.000	0.000	0.000	0.000	0.000	0.071
1990	0.051	0.262	0.475	0.042	0.003	0.000	0.000	0.000	0.000	0.000	0.833
1991	0.002	0.060	0.128	0.034	0.007	0.000	0.000	0.000	0.000	0.000	0.231
1992	0.065	0.394	0.685	0.185	0.033	0.003	0.004	0.001	0.001	0.000	1.371
1993	0.024	0.152	0.396	0.139	0.021	0.002	0.000	0.001	0.000	0.000	0.735
1994	0.005	0.045	0.126	0.013	0.001	0.000	0.000	0.000	0.000	0.000	0.190
1995	0.031	0.175	0.393	0.140	0.013	0.005	0.000	0.004	0.000	0.001	0.762
1996	0.193	0.704	1.346	0.171	0.012	0.001	0.000	0.001	0.000	0.001	2.429
1997	0.080	0.557	1.053	0.174	0.012	0.003	0.000	0.002	0.000	0.000	1.881
1998	0.008	0.087	0.359	0.087	0.004	0.001	0.000	0.001	0.000	0.001	0.548
1999	0.241	0.931	1.888	0.254	0.020	0.005	0.000	0.002	0.000	0.000	3.341
2000	0.365	0.506	1.305	0.654	0.054	0.035	0.000	0.000	0.000	0.000	2.919
2001											
Mean	0.129	0.376	0.702	0.136	0.013	0.003	0.001	0.001	0.000	0.000	1.361

Table A40. RIDFW monthly fixed station trawl survey summer flounder index of abundance.

Year	Mean number/tow	Mean kg/tow	Mean age 0 number/tow	Mean age 1 number/tow	Mean age 2+ number/tow
1990	0.655	0.630	0.000	0.328	0.328
1991	0.111	0.100	0.000	0.037	0.074
1992	0.692	0.680	0.019	0.269	0.404
1993	0.419	0.580	0.016	0.065	0.339
1994	0.317	0.270	0.016	0.143	0.159
1995	0.891	0.810	0.000	0.359	0.531
1996	2.353	1.790	0.137	1.059	1.157
1997	1.633	1.390	0.033	0.700	0.900
1998	0.952	0.890	0.000	0.270	0.683
1999	2.038	1.600	0.135	0.962	0.942
2000	5.420	4.350	0.260	2.140	3.020
2001					
Mean	1.407	1.190	0.056	0.576	0.776

Age 0: Proportion of catch < 30 cm
Age 1: Proportion of 30 cm ≤ catch ≤ 39 cm
Age 2+: Proportion of fish > 39 cm

Table A41. NJBMF trawl survey, April - October: index of summer flounder abundance.

Year	Age					
	0	1	2	3	4+	Total
1988	0.29	4.22	1.19	0.01	0.00	5.71
1989	1.25	0.54	0.40	0.01	0.01	2.21
1990	1.88	1.89	0.15	0.05	0.00	3.97
1991	1.50	3.11	0.32	0.02	0.01	4.96
1992	1.34	3.76	0.76	0.08	0.05	5.99
1993	3.52	6.95	0.27	0.04	0.02	10.80
1994	2.22	1.46	0.13	0.01	0.03	3.85
1995	4.95	2.93	0.28	0.05	0.16	8.37
1996	1.65	5.16	2.71	0.18	0.05	9.75
1997	1.64	8.25	5.25	1.02	0.18	16.34
1998	0.67	5.80	2.67	0.29	0.03	9.46
1999	1.03	6.12	3.46	0.65	0.18	11.44
2000	0.95	3.91	1.82	0.45	0.22	7.35
2001	0.62	3.32	1.18	0.41	0.14	5.67
Mean	1.68	4.10	1.47	0.23	0.08	7.56

Table A42. DEDFW 16 foot trawl survey: index of summer flounder recruitment at age-0 in the Delaware Estuary.

Year	Geometric Mean number per tow
1980	0.12
1981	0.06
1982	0.11
1983	0.03
1984	0.08
1985	0.06
1986	0.10
1987	0.14
1988	0.01
1989	0.12
1990	0.23
1991	0.07
1992	0.31
1993	0.02
1994	0.29
1995	0.17
1996	0.03
1997	0.02
1998	0.03
1999	0.05
2000	0.18
2001	0.07
Mean	0.10

Table A43. DEDFW 16 foot trawl survey: index of summer flounder recruitment at age-0 in the Delaware Inland Bays.

Year	Geometric Mean number per tow
1986	0.01
1987	0.00
1988	0.00
1989	0.15
1990	0.02
1991	0.94
1992	0.06
1993	0.04
1994	0.70
1995	0.23
1996	0.05
1997	0.33
1998	0.99
1999	0.62
2000	0.70
2001	0.05
Mean	0.31

Table A44. DEDFW Delaware Bay 30 foot trawl survey: index of summer flounder abundance.

Year	Age					
	0	1	2	3	4+	Total
1991	1.44	1.13	0.18	0.04	0.00	2.79
1992	0.47	0.28	0.08	0.00	0.00	0.83
1993	0.04	1.56	0.73	0.07	0.00	2.40
1994	2.28	0.14	0.22	0.08	0.00	2.72
1995	0.94	1.00	0.28	0.10	0.09	2.41
1996	0.46	0.73	0.48	0.10	0.02	1.79
1997	0.03	0.12	0.49	0.47	0.16	1.27
1998	0.11	0.31	0.83	0.29	0.12	1.66
1999	0.20	0.06	0.77	0.47	0.19	1.69
2000	0.79	0.24	0.30	0.28	0.23	1.84
2001	0.34	1.55	0.49	0.26	0.13	2.77
Mean	0.65	0.65	0.44	0.20	0.09	2.02

Table A45. MD DNR Coastal Bays trawl survey: index of summer flounder recruitment at age-0.

Year	Geometric mean	Lower 95% CI	Upper 95% CI
1972	12.3	6.5	21.8
1973	4.2	3.0	5.7
1974	5.1	3.9	6.6
1975	2.1	1.6	2.6
1976	1.9	1.4	2.6
1977	2.4	1.8	3.2
1978	3.2	2.4	4.1
1979	2.9	2.0	4.1
1980	4.2	2.6	6.2
1981	3.9	2.6	5.4
1982	2.0	0.8	3.7
1983	10.6	6.0	17.9
1984	5.4	3.1	8.7
1985	5.6	3.6	8.1
1986	16.2	10.1	25.2
1987	4.6	2.4	7.8
1988	0.5	0.3	0.8
1989	1.3	0.9	1.9
1990	2.1	1.6	2.7
1991	3.1	2.4	3.9
1992	3.5	2.5	4.7
1993	1.6	1.2	2.1
1994	8.2	6.5	10.3
1995	5.0	4.0	6.2
1996	2.6	2.0	3.2
1997	3.3	2.5	4.3
1998	5.2	4.2	6.6
1999	3.4	2.6	4.2
2000	4.1	3.1	5.2
2001	5.3	4.1	6.9
Mean	4.5		

Table A46. VIMS juvenile fish trawl survey, VA rivers: index of summer flounder recruitment at age-0.

Year	Geometric mean catch per trawl	Lower 95% confidence limit	Upper 95% confidence limit	Number of samples
1979	1.0	0.6	1.6	48
1980	7.6	5.0	11.3	58
1981	5.1	3.5	7.3	61
1982	4.3	2.8	6.4	60
1983	5.2	3.7	7.1	62
1984	1.9	1.2	2.9	45
1985	1.1	0.6	1.9	27
1986	1.3	0.8	1.8	53
1987	0.4	0.2	0.8	52
1988	0.5	0.2	1.0	36
1989	1.0	0.6	1.4	36
1990	2.6	1.7	3.8	36
1991	1.4	0.9	2.1	36
1992	0.5	0.2	0.8	36
1993	0.5	0.3	0.8	36
1994	1.1	0.5	1.9	36
1995	0.7	0.4	1.2	36
1996	0.6	0.3	1.0	36
1997	0.7	0.4	1.1	36
1998	0.2	0.0	0.3	36
1999	0.4	0.2	0.6	36
2000	0.5	0.2	0.9	36
2001	0.5	0.2	0.9	36
Mean	1.7			

Table A47. North Carolina Division of Marine Fisheries (NCDMF) Pamlico Sound trawl survey: June index of summer flounder recruitment at age-0.

Year	Mean number per tow
1987	19.86
1988	2.61
1989	6.63
1990	4.27
1991	5.85
1992	9.14
1993	5.13
1994	8.17
1995	5.59
1996	30.67
1997	14.14
1998	9.96
1999	n/a
2000	3.94
2001	22.03
Mean	10.57

Table A48. Summary of age-0 summer flounder recruitment indices from NEFSC and state surveys, Massachusetts to North Carolina.

	YEAR CLASS																					
Survey	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
CT					0.00	0.24	0.17	0.08	0.02	0.00	0.03	0.04	0.01	0.08	0.13	0.02	0.07	0.03	0.00	0.04	0.11	0.02
RI Autumn	0.13	0.31	0.02	0.03	0.12	0.34	0.55	0.14	0.01	0.00	0.05	0.01	0.07	0.02	0.01	0.03	0.17	0.08	0.01	0.24	0.37	
RI											0.00	0.00	0.02	0.02	0.02	0.00	0.14	0.03	0.00	0.14	0.26	
MA Seine			3	3	1	19	5	5	2	3	11	4	0	2	1	13	7	0	12	13	10	1
NJ Trawl									0.29	1.25	1.88	1.50	1.34	3.52	2.22	4.95	1.65	1.64	0.67	1.03	0.95	0.62
DE: 16 ft	0.12	0.06	0.11	0.03	0.08	0.06	0.10	0.14	0.01	0.12	0.23	0.07	0.31	0.02	0.29	0.17	0.03	0.02	0.03	0.05	0.18	0.07
DE: 16 ft							0.01	0.00	0.00	0.15	0.02	0.94	0.06	0.04	0.70	0.23	0.05	0.33	0.99	0.62	0.70	0.05
DE: 30ft												1.44	0.47	0.04	2.28	0.94	0.46	0.03	0.11	0.20	0.79	0.34
MD	4.2	3.9	2.0	10.6	5.4	5.6	16.2	4.6	0.5	1.3	2.1	3.1	3.5	1.6	8.2	5.0	2.6	3.3	5.2	3.4	4.1	5.3
VIMS	7.6	5.1	4.3	5.2	1.9	1.1	1.3	0.4	0.5	1.0	2.6	1.4	0.5	0.5	1.1	0.7	0.6	0.7	0.2	0.4	0.5	0.5
NC								19.86	2.61	6.63	4.27	5.85	9.14	5.13	8.17	5.59	30.67	14.14	9.96	n/a	3.94	22.03
NEFSC			0.55	0.96	0.18	0.59	0.39	0.07	0.06	0.31	0.44	0.76	0.99	0.23	0.75	0.93	0.11	0.17	0.38	0.21	0.22	0.08

Table A49. Commercial and recreational fishery landings, estimated discard, and total catch statistics (metric tons) as used in the assessment of summer flounder, Maine to North Carolina, compared with VPA estimates of total catch biomass.

	Commercial			Recreational			Total				
Year	Landings	Discard	Catch	Landings	Discard	Catch	Landings	Discard	Catch	VPA Catch	VPA:Catch ratio
1982	10,400	n/a	10,400	8,267	296	8,563	18,667	296	18,963	18,602	0.981
1983	13,403	n/a	13,403	12,687	376	13,063	26,090	376	26,466	25,142	0.950
1984	17,130	n/a	17,130	8,512	415	8,927	25,642	415	26,057	26,874	1.031
1985	14,675	n/a	14,675	5,665	92	5,757	20,340	92	20,432	21,828	1.068
1986	12,186	n/a	12,186	8,102	578	8,680	20,288	578	20,866	21,561	1.033
1987	12,271	n/a	12,271	5,519	522	6,041	17,790	522	18,312	18,551	1.013
1988	14,686	n/a	14,686	6,733	342	7,075	21,419	342	21,761	23,442	1.077
1989	8,125	709	8,834	1,435	45	1,480	9,560	754	10,314	10,388	1.007
1990	4,199	1,214	5,413	2,329	234	2,563	6,528	1,448	7,976	7,759	0.973
1991	6,224	1,052	7,276	3,611	429	4,040	9,835	1,481	11,316	11,730	1.037
1992	7,529	690	8,219	3,242	344	3,586	10,771	1,034	11,805	12,167	1.031
1993	5,715	846	6,561	3,484	736	4,220	9,199	1,582	10,781	10,992	1.020
1994	6,588	906	7,494	4,111	577	4,688	10,699	1,483	12,182	12,542	1.030
1995	6,977	308	7,285	2,496	714	3,210	9,473	1,022	10,495	10,648	1.015
1996	5,770	463	6,233	4,704	615	5,319	10,474	1,078	11,552	11,794	1.021
1997	3,994	326	4,320	5,378	627	6,005	9,372	953	10,325	10,240	0.992
1998	5,080	389	5,469	5,659	517	6,176	10,739	906	11,645	11,575	0.994
1999	4,820	1,548	6,368	3,795	688	4,483	8,615	2,236	10,851	10,847	1.000
2000	5,085	726	5,811	7,090	855	7,945	12,175	1,581	13,756	13,446	0.977
2001	4,916	639	5,555	5,250	1,184	6,434	10,166	1,823	11,989	12,058	1.006
Mean	8,489	755	8,979	5,403	509	5,913	13,892	1,000	14,892	15,109	1.013

Table A50. Virtual Population Analysis (VPA) for summer flounder, 1982-2001.

```
Fisheries Assessment Toolbox  Summer flounder: 2002  Run Number F35-2
 5/20/2002   6:46:32 PM
FACT Version 1.5.0
Summer flounder 2002:  1982 - 2001
Input Parameters and Options Selected
---------------------------------------
Natural mortality is 0.2 for all ages and years; Oldest age (not in the plus
group) is 6; For all years prior to the terminal year ( 19 ), back calculated
stock sizes for the following ages used to estimate total mortality (Z) for age
6 : 3 4 5 6.  Stock size of the  7 + group is then calculated using the following
method:  CATCH EQUATION

 Partial recruitment estimate for  2002
 0             0.01
 1             0.2
 2             0.8
 3             1
 4             1
 5             1
 6             1

 The Indices that will be used in this run are:
 1            NEC_W1
 2            NEC_W2
 3            NEC_W3
 4            NEC_W4
 5            NEC_W5:7
 6            NEC_S1
 7            NEC_S2
 8            NEC_S3
 9            NEC_S4
 10           NEC_S5:7
 11           NEC_F2
 12           NEC_F3
 13           NEC_F4
 14           MA_S2
 15           MA_S3
 16           MA_F3
 17           MA_F4
 18           CT_S2
 19           CT_S3
 20           CT_S4
 21           CT_F2
 22           CT_F3
 23           CT_F4
 24           CT_F5:7
 25           RI_F3
 26           RI_F4
 27           RI_X2
 28           NJ1
 29           NJ2
 30           DE2
 31           DE3
 32           CT_Y0
 33           VA_RY0
 34           NC_Y0
 35           MD_Y0
 36           NJ_Y0
 37           NEC_Y0
 38           MA_Y0
 39           RI_Y0
 40           DE_EY0
 41           RI_XY0
```

Table A50 continued.

STOCK NUMBERS (Jan 1) in thousands

	1982	1983	1984	1985	1986	1987	1988
0	74269	80323	48380	48579	53444	43921	13033
1	42907	55970	61306	35265	37893	41999	34931
2	16205	17555	20090	26141	15641	15515	18812
3	2203	4085	4500	2465	5134	2803	2896
4	807	957	1371	807	419	782	804
5	161	364	157	372	212	57	148
6	152	27	06	42	77	47	24
7	67	70	14	11	19	69	26
0+	136771	159350	135824	113683	112840	105194	70674
	1989	1990	1991	1992	1993	1994	1995
0	27270	30353	28687	32322	33258	35480	39619
1	9951	21458	23172	22581	25225	26067	27566
2	9998	3813	9599	7979	8357	10487	11966
3	2226	1575	1143	1391	1080	1774	2256
4	438	291	389	264	121	372	564
5	75	39	38	122	80	33	119
6	11	12	05	03	37	25	03
7	05	04	02	01	05	09	02
0+	49974	57546	63035	64664	68163	74245	82095
	1996	1997	1998	1999	2000	2001	2002
0	32864	35613	39817	30766	39455	26594	n/a
1	31902	26760	29130	32559	25026	32283	21727
2	17296	19853	19607	21829	24680	19150	23737
3	3189	5766	8974	10280	12208	13248	11307
4	726	996	1871	2603	4781	5889	7466
5	102	217	315	645	1081	2561	3662
6	28	20	33	133	204	559	1767
7	05	07	02	33	80	161	448
0+	86111	89231	99748	98849	107514	100445	n/a

Table A50 continued.

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988
0	0.08	0.07	0.12	0.05	0.04	0.03	0.07
1	0.69	0.82	0.65	0.61	0.69	0.60	1.05
2	1.18	1.16	1.90	1.43	1.52	1.48	1.93
3	0.63	0.89	1.52	1.57	1.68	1.05	1.69
4	0.60	1.61	1.10	1.14	1.79	1.47	2.17
5	1.60	3.95	1.11	1.38	1.31	0.65	2.36
6	0.67	1.10	1.47	1.52	1.80	1.16	1.96
7	0.67	1.10	1.47	1.52	1.80	1.16	1.96

	1989	1990	1991	1992	1993	1994	1995
0	0.04	0.07	0.04	0.05	0.04	0.05	0.02
1	0.76	0.60	0.87	0.79	0.68	0.58	0.27
2	1.65	1.00	1.73	1.80	1.35	1.34	1.12
3	1.83	1.20	1.26	2.24	0.87	0.95	0.93
4	2.22	1.82	0.96	1.00	1.10	0.94	1.51
5	1.64	1.92	2.51	1.00	0.97	2.08	1.26
6	2.07	1.34	1.24	1.98	0.92	0.98	1.07
7	2.07	1.34	1.24	1.98	0.92	0.98	1.07

	1996	1997	1998	1999	2000	2001
0	0.01	0.00	0.00	0.01	0.00	0.00
1	0.27	0.11	0.09	0.08	0.07	0.11
2	0.90	0.59	0.45	0.38	0.42	0.33
3	0.96	0.93	1.04	0.57	0.53	0.37
4	1.01	0.95	0.86	0.68	0.42	0.28
5	1.46	1.69	0.66	0.95	0.46	0.17
6	1.01	0.97	1.03	0.61	0.50	0.27
7	1.01	0.97	1.03	0.61	0.50	0.27

Average F for 3,5

	1982	1983	1984	1985	1986	1987	1988
3,5	0.94	2.15	1.24	1.36	1.59	1.06	2.07

	1989	1990	1991	1992	1993	1994	1995
3,5	1.90	1.65	1.58	1.41	0.98	1.32	1.23

	1996	1997	1998	1999	2000	2001
3,5	1.14	1.19	0.86	0.73	0.47	0.27

BACK CALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988
0	0.05	0.02	0.06	0.03	0.02	0.02	0.03
1	0.43	0.21	0.34	0.39	0.38	0.41	0.44
2	0.74	0.29	1.00	0.91	0.84	1.00	0.82
3	0.40	0.23	0.80	1.00	0.93	0.71	0.72
4	0.37	0.41	0.58	0.72	0.99	0.99	0.92
5	1.00	1.00	0.58	0.88	0.73	0.44	1.00
6	0.42	0.28	0.78	0.97	1.00	0.78	0.83
7	0.42	0.28	0.78	0.97	1.00	0.78	0.83

	1989	1990	1991	1992	1993	1994	1995
0	0.02	0.04	0.02	0.02	0.03	0.03	0.01
1	0.34	0.31	0.35	0.35	0.50	0.28	0.18
2	0.74	0.52	0.69	0.80	1.00	0.64	0.75
3	0.83	0.62	0.50	1.00	0.64	0.46	0.62
4	1.00	0.95	0.38	0.44	0.82	0.45	1.00
5	0.74	1.00	1.00	0.45	0.72	1.00	0.83
6	0.93	0.70	0.50	0.88	0.68	0.47	0.71
7	0.93	0.70	0.50	0.88	0.68	0.47	0.71

	1996	1997	1998	1999	2000	2001
0	0.00	0.00	0.00	0.01	0.00	0.01
1	0.19	0.07	0.09	0.08	0.13	0.29
2	0.62	0.35	0.43	0.40	0.80	0.88
3	0.66	0.55	1.00	0.60	1.00	1.00
4	0.69	0.56	0.83	0.71	0.80	0.74
5	1.00	1.00	0.64	1.00	0.87	0.46
6	0.70	0.58	0.99	0.64	0.95	0.73
7	0.70	0.58	0.99	0.64	0.95	0.73

Catch BIOMASS (using catch mean weights)

	1982	1983	1984	1985	1986	1987	1988
0	1362	1185	1195	602	493	295	252
1	8226	12042	10658	6333	7867	7697	9698
2	6383	7974	10077	11295	7578	7236	9380
3	1369	2383	3413	2013	4513	1914	2484
4	633	895	1268	874	566	1083	1160
5	333	510	210	593	286	72	312
6	181	42	14	82	198	99	76
7	116	112	39	38	61	155	79
0+	18602	25142	26874	21828	21561	18551	23442

	1989	1990	1991	1992	1993	1994	1995
0	200	469	146	336	340	583	231
1	2235	3841	5024	5341	5531	5533	3149
2	5431	1804	5165	4651	4008	4496	5051
3	1821	1188	900	1425	840	1352	1331
4	541	350	400	214	124	437	668
5	127	66	84	192	85	74	207
6	22	28	09	05	57	49	08
7	11	13	04	05	07	19	04
0+	10388	7759	11730	12167	10992	12542	10648

	1996	1997	1998	1999	2000	2001
0	54	06	12	26	02	04
1	3554	1154	1098	813	755	1607
2	5376	5201	4172	3748	5368	3699
3	1962	2773	4588	3640	4237	3645
4	656	694	1315	1692	2007	1872
5	143	371	337	728	805	790
6	42	29	50	151	191	315
7	09	12	04	49	82	126
0+	11794	10240	11575	10847	13446	12058

Table A50 continued.

Jan 1 BIOMASS (using Jan 1 mean weights)

	1982	1983	1984	1985	1986	1987	1988
0	14705	15020	9144	11222	10208	8521	3415
1	13687	18190	18882	11497	13717	14028	12086
2	7552	9602	10306	12888	8368	8425	9876
3	3421	3325	3892	2063	4328	2447	2485
4	1738	1292	1741	1084	583	1173	1132
5	468	614	259	691	393	128	324
6	416	71	13	102	212	121	82
7	259	182	55	52	79	244	98
0+	42246	48297	44292	39598	37887	35086	29498

	1989	1990	1991	1992	1993	1994	1995
0	3927	6010	2324	5624	6219	10254	13510
1	3791	6416	7415	5894	8703	9723	12046
2	5789	2326	5279	4404	4788	5789	7156
3	1796	1448	1120	1288	1130	1724	1836
4	566	369	566	340	172	651	839
5	149	69	76	270	128	70	279
6	28	33	11	06	102	63	11
7	13	19	05	06	14	32	07
0+	16059	16690	16797	17832	21255	28305	35684

	1996	1997	1998	1999	2000	2001
0	9268	4950	8601	2338	908	984
1	14228	10330	9380	10093	6757	6069
2	9565	11336	10607	11766	12513	11911
3	2730	4053	6650	7833	9046	10837
4	927	1149	2002	2895	5221	6820
5	183	404	543	1048	1929	4336
6	72	44	79	340	464	1338
7	15	21	07	117	227	579
0+	36987	32287	37868	36431	37064	42875

Table A50 continued.

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

	1982	1983	1984	1985	1986	1987	1988
0	5668	5854	3507	4341	4207	3574	1251
1	6150	7180	8615	5534	5890	6863	4123
2	2862	3655	2003	3735	2257	2257	1797
3	1596	1774	1130	629	1248	1133	682
4	795	268	697	459	140	380	196
5	101	17	115	230	120	81	44
6	198	23	05	27	48	50	16
7	126	62	14	12	15	79	16
0+	17497	18833	16086	14968	13926	14418	8124

	1989	1990	1991	1992	1993	1994	1995
0	1767	2323	1296	2450	2726	3882	4905
1	1487	3415	2803	3349	4260	5193	7239
2	1403	1023	1220	1023	1452	1655	2436
3	430	577	402	224	651	927	929
4	87	84	270	136	68	303	224
5	37	14	10	122	56	14	93
6	04	11	04	01	41	32	04
7	02	05	02	01	05	12	02
0+	5216	7453	6007	7304	9260	12017	15834

	1996	1997	1998	1999	2000	2001
0	3475	2428	3316	1408	1777	872
1	7902	6727	8089	6910	7345	9688
2	3565	5907	6691	7204	9171	8458
3	1311	1962	2760	4879	6159	7967
4	411	472	1021	1806	3791	5760
5	51	102	371	496	1385	4054
6	26	19	31	184	295	976
7	06	08	02	60	127	391
0+	16746	17625	22280	22948	30050	38166

Table A51. VPA Bootstrap results: precision of estimates.

The number of bootstraps: 500
Bootstrap Output Variable: N hat

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP Std Error	C.V. FOR NLLS SOLN
N 1	21727	22185	4399	0.20
N 2	23737	24038	4018	0.17
N 3	11307	11396	1904	0.17
N 4	7466	7510	1213	0.16
N 5	3662	3681	798	0.22
N 6	1767	1804	471	0.27

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
N 1	458	197	2.11	21270	0.206828	16216	27505
N 2	300	180	1.27	23437	0.171459	19087	29100
N 3	90	85	0.79	11217	0.169766	9103	13864
N 4	44	54	0.59	7422	0.163492	5895	9064
N 5	20	36	0.54	3642	0.219021	2868	4959
N 6	37	21	2.10	1730	0.272477	1148	2305

Table A51 continued.

Bootstrap Output Variable: F t

	NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
Age 0	0.0021	0.0022	0.0004	0.21
Age 1	0.1075	0.1090	0.0177	0.17
Age 2	0.3269	0.3316	0.0487	0.15
Age 3	0.3735	0.3786	0.0519	0.14
Age 4	0.2752	0.2839	0.0544	0.20
Age 5	0.1714	0.1788	0.0475	0.28
Age 6	0.2734	0.2804	0.0315	0.12
Age 7	0.2734	0.2804	0.0315	0.12

	BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
Age 0	0.0000396	0.0000197	1.865	0.0020821	0.21	0.0017	0.0028
Age 1	0.0014651	0.0007932	1.363	0.1060253	0.17	0.0884	0.1316
Age 2	0.0046466	0.0021784	1.421	0.3222752	0.15	0.2726	0.3892
Age 3	0.0051271	0.0023231	1.373	0.3683516	0.14	0.3160	0.4516
Age 4	0.0086827	0.0024324	3.155	0.2665285	0.20	0.2095	0.3390
Age 5	0.0074158	0.0021235	4.327	0.1639547	0.29	0.1335	0.2521
Age 6	0.0070752	0.0014103	2.588	0.2662783	0.12	0.2370	0.3162
Age 7	0.0070752	0.0014103	2.588	0.2662783	0.12	0.2370	0.3162

Bootstrap Output Variable: F full t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
0.2734	0.2804	0.0315	0.12

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
0.00708	0.00141	2.59	0.26628	0.12	0.2370	0.3162

Table A51 continued.

Bootstrap Output Variable: SSB spawn t

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
38166.3196	38502.5412	3309.9183	0.09

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
336.22	148.02	0.88	37830.10	0.09	34164.5520	42579.9361

Bootstrap Output Variable: Jan 1 biomass

NLLS ESTIMATE	BOOTSTRAP MEAN	BOOTSTRAP StdError	C.V. FOR NLLS SOLN
42874.5306	43159.7457	2973.0448	0.07

BIAS ESTIMATE	BIAS STD ERROR	PERCENT BIAS	NLLS EST CORRECTED FOR BIAS	C.V. FOR CORRECTED ESTIMATE	LOWER 80%CI	UPPER 80%CI
285.22	132.96	0.67	42589.32	0.07	39279.15	46922.42

Table A52. VPA Retrospective analysis for summer flounder.

Fishing Mortality (F)

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1996	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.42	0.99	1.37	1.41	1.99					
1997	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.33	1.25	1.26	5.99				
1998	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.32	1.22	1.09	1.02	0.59			
1999	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.32	1.21	1.08	1.03	0.60	0.40		
2000	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.32	1.23	1.12	1.12	0.72	0.57	0.36	
2001	0.94	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.32	1.23	1.14	1.19	0.86	0.73	0.47	0.27

Spawning Stock Biomass (SSB)

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1996	17497	18833	16086	14968	13926	14418	8124	5215	7449	5997	7254	9101	12187	17674	19516					
1997	17497	18833	16086	14968	13926	14418	8124	5216	7453	6007	7293	9289	12754	18770	20969	21782				
1998	17497	18833	16086	14968	13926	14418	8124	5216	7453	6008	7311	9277	12251	17226	19430	20710	23482			
1999	17497	18833	16086	14968	13926	14418	8124	5216	7453	6008	7310	9287	12271	16844	18640	20262	24795	25243		
2000	17497	18833	16086	14968	13926	14418	8124	5216	7453	6007	7307	9271	12066	16372	17793	19111	24456	25644	32657	
2001	17497	18833	16086	14968	13926	14418	8124	5216	7453	6007	7304	9260	12017	15834	16746	17625	22280	22948	30050	38166

Population numbers: Age-0

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1996	74269	80323	48380	48579	53444	43920	13031	27269	30329	28630	32028	32749	39614	48642	30368					
1997	74269	80323	48380	48579	53444	43922	13033	27270	30361	28663	32213	33965	40689	50289	29383	21451				
1998	74269	80323	48380	48579	53444	43921	13033	27270	30354	28697	32370	33269	37292	46534	35898	25251	26377			
1999	74269	80323	48380	48579	53444	43921	13033	27270	30356	28697	32351	33429	37139	43414	35712	34444	30853	26064		
2000	74269	80323	48380	48579	53444	43921	13033	27270	30354	28689	32343	33318	35689	43181	33101	37245	40276	27233	35822	
2001	74269	80323	48380	48579	53444	43921	13033	27270	30353	28687	32322	33258	35480	39619	32864	35613	39817	30766	39455	26594

Table A53. Input parameters and short term stochastic projection results for summer flounder. Starting stock sizes on January 1, 2002 are as estimated by VPA bootstrap procedure. Age-0 recruitment levels in 2002-2004 are estimated as the median of 500 random estimates selected from VPA estimated numbers at age 0 (000s) during 1982-2001. Fishing mortality was apportioned among landings and discard based on the proportion of F associated with landings and discards at age during 1999-2001. Mean weights at age (landings and discards) are weighted (by fishery) geometric means of 1999-2001 values. Total stock biomass is the product of January 1 numbers at age and January 1 mean weights at age estimated from total catch (landings plus discards) weights. Proportion of F and M before spawning = 0.83 (spawning peak at 1 November).

Age	Median Stock Size in 2002	Fishing Mortality Pattern	Proportion Landed	Proportion Mature	Mean Weights January 1 Total Biomass	Mean Weights Landings	Mean Weights Discards
0	35613	0.01	0.00	0.38	0.040	0.144	0.093
1	23156	0.18	0.43	0.72	0.251	0.536	0.425
2	26637	0.78	0.75	0.90	0.554	0.709	0.586
3	12957	1.00	0.90	1.00	0.773	0.933	0.890
4	6741	1.00	0.97	1.00	1.120	1.403	1.386
5	2861	1.00	0.97	1.00	1.700	2.103	2.099
6	2083	1.00	0.97	1.00	2.405	2.655	2.410
7+	395	1.00	0.97	1.00	3.291	3.135	2.972

2002 Landings = 10,991 mt; 2002-2004 median recruitment from 1982-2001 VPA estimates (35.6 million)

Forecast medians (50% probability level) (landings, discards, and total stock biomass (B) in '000 mt)

2002				2003				2004			
F	Land.	Disc.	B	F	Land.	Disc.	B	F	Land.	Disc.	B
0.32	**11.0**	**1.7**	**51.4**	**0.26**	**10.6**	**1.5**	**57.6**	**0.26**	**12.2**	**1.7**	**65.6**

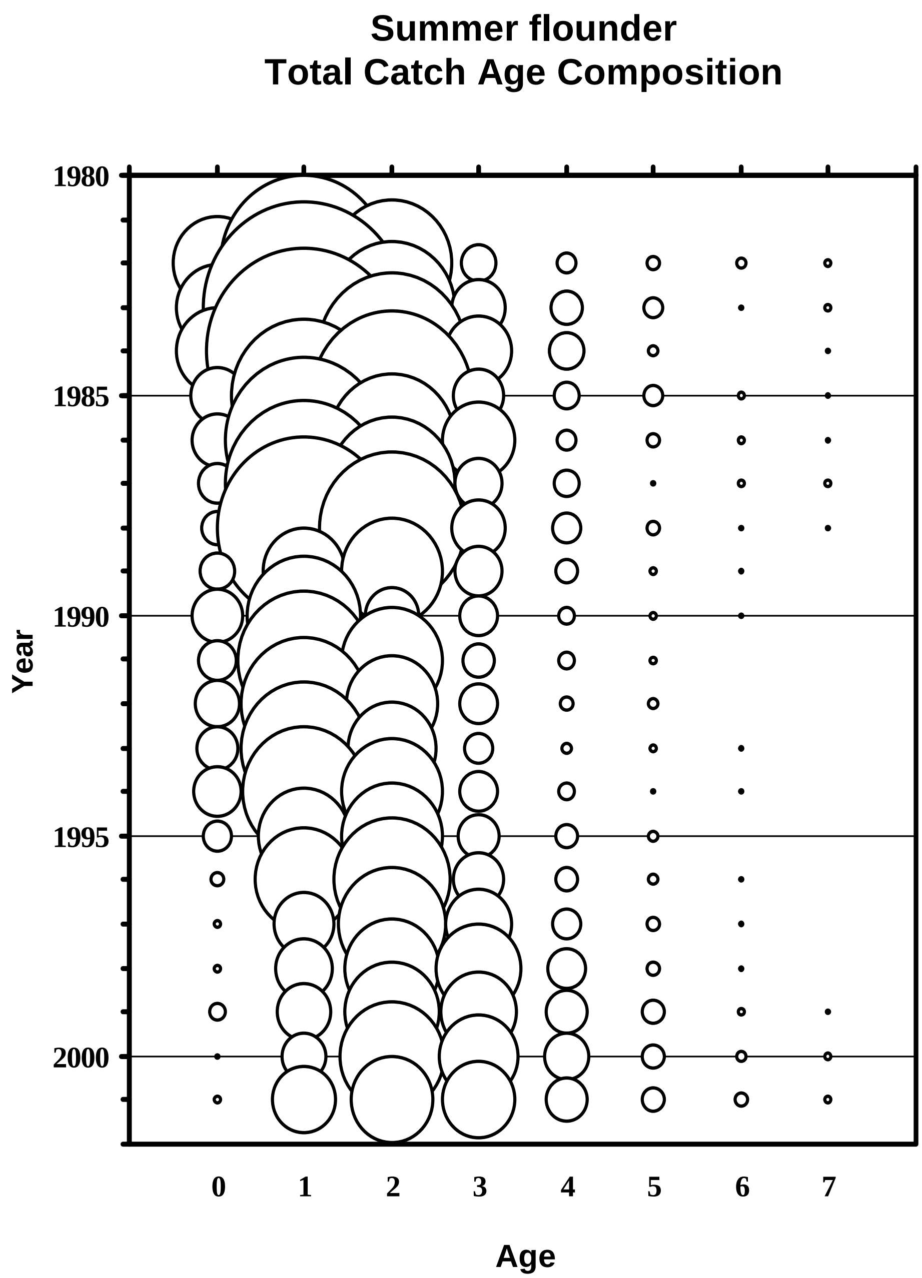

Figure A1. Total catch age composition for summer flounder: 1982-2001

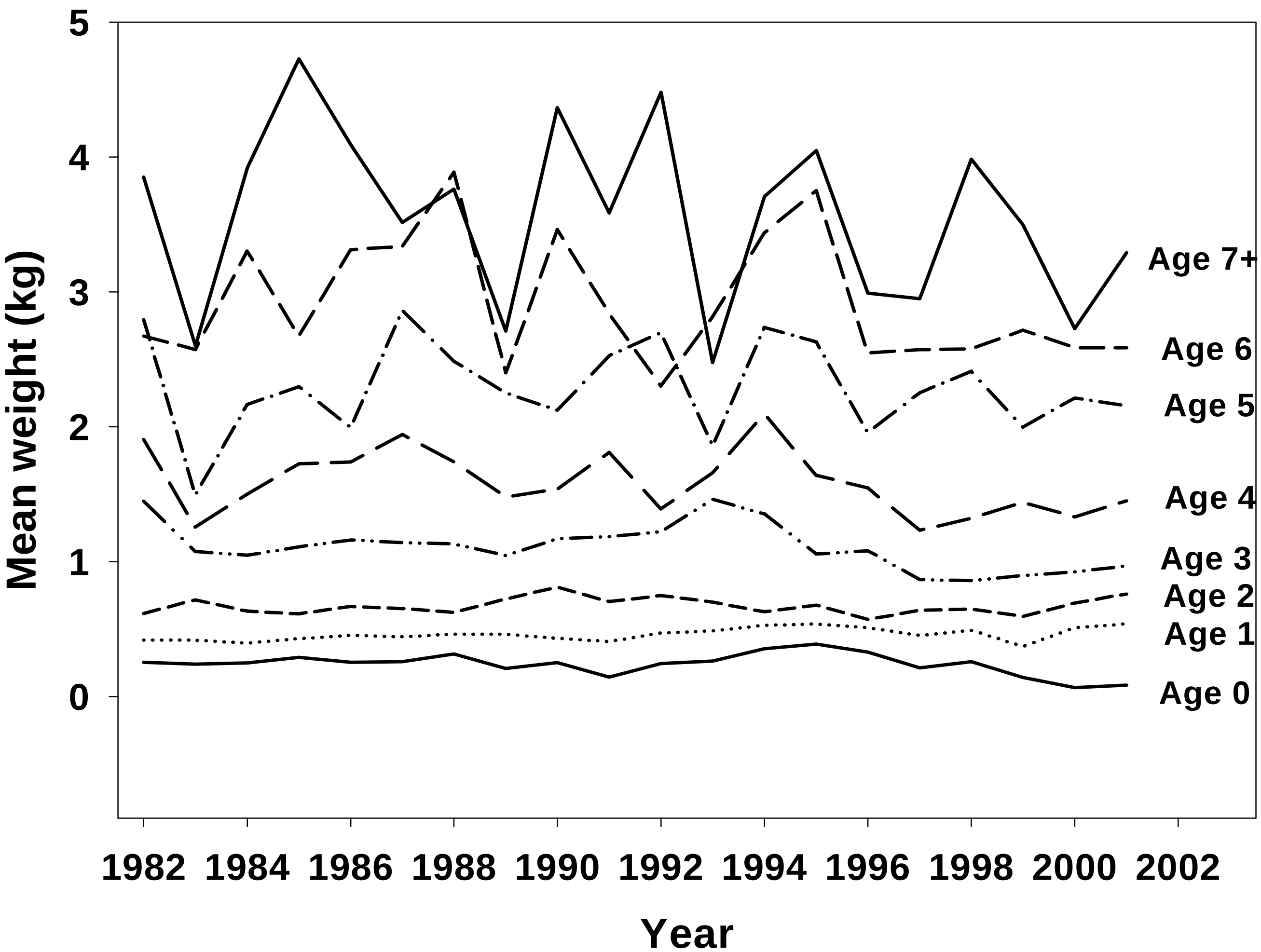

Figure A2. Trends in mean weight at age in the total catch of summer flounder.

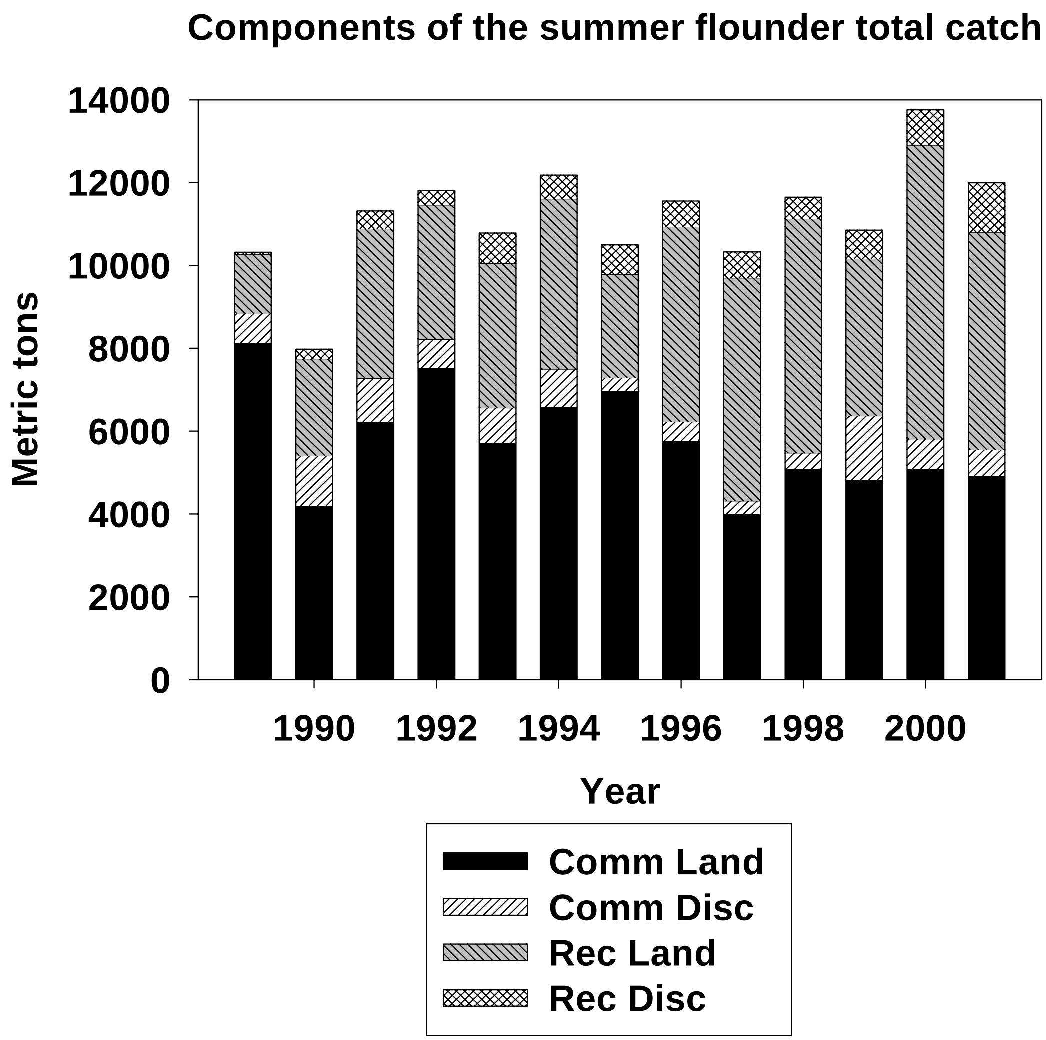

Figure A3. Components of the summer flounder total catch.

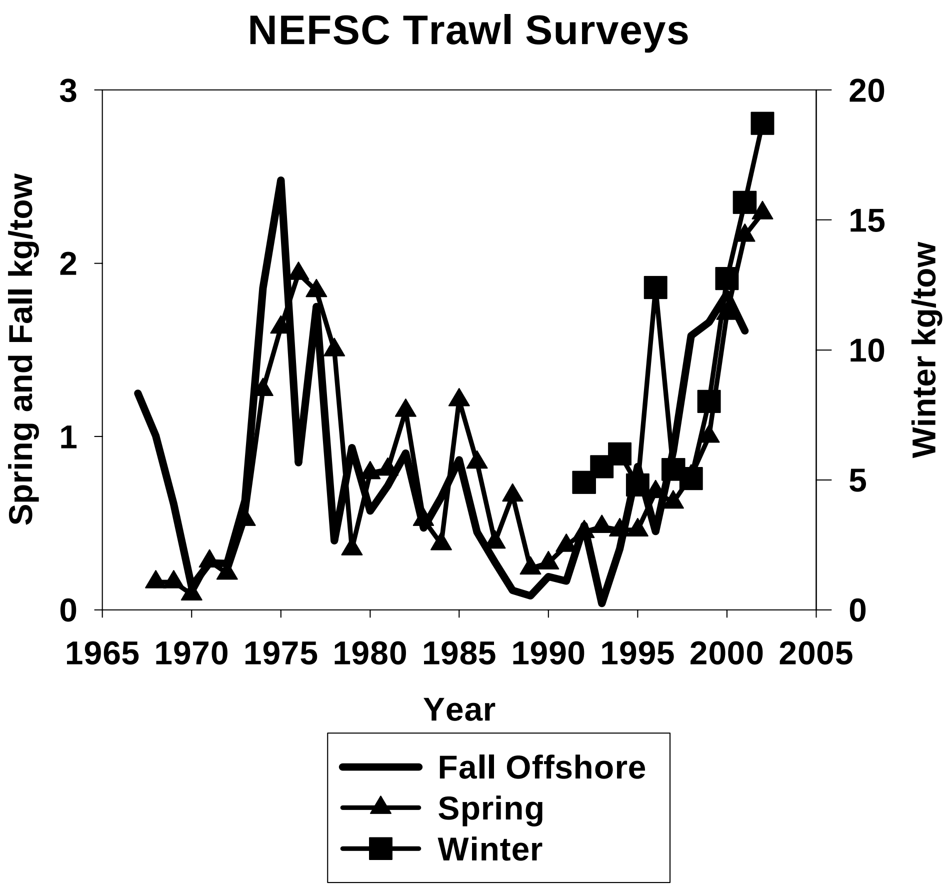

Figure A4. Trends in NEFSC trawl survey biomass indices for summer flounder.

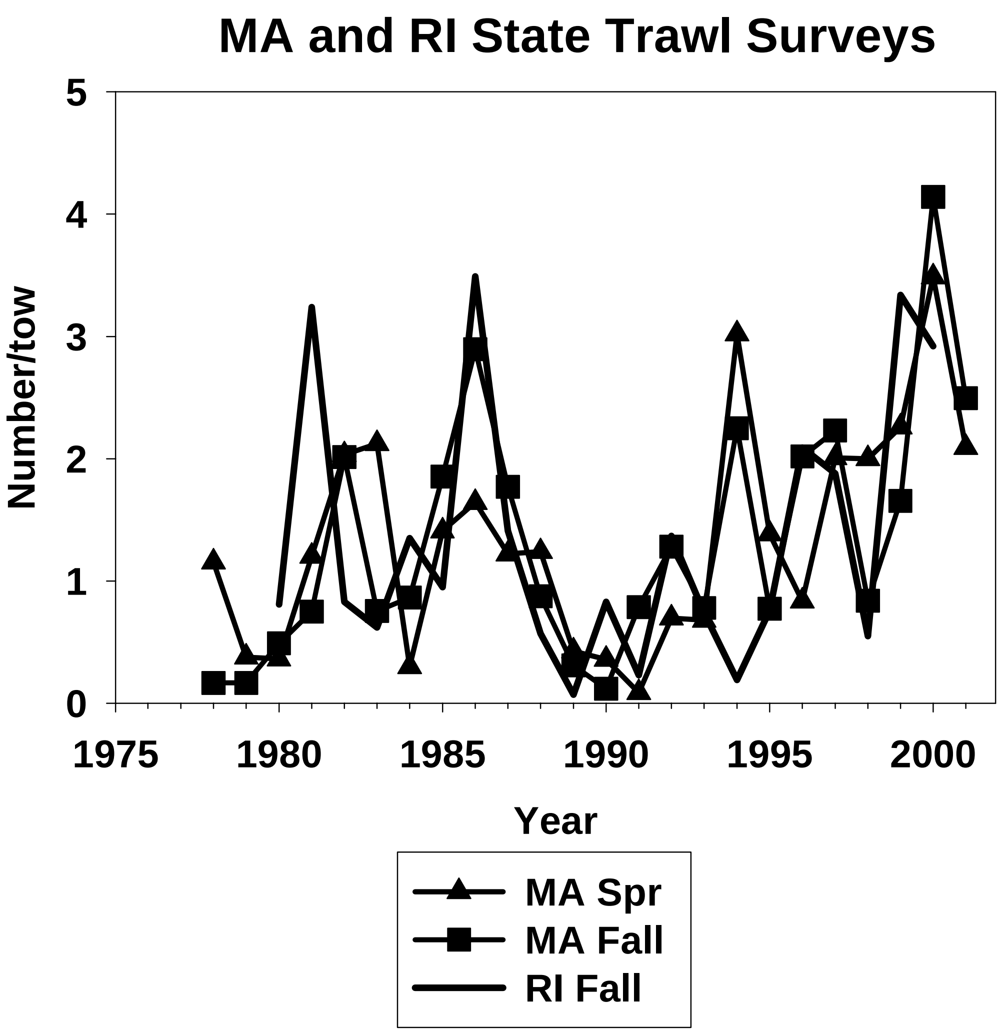

Figure A5. Trends in MA and RI trawl survey abundance indices for summer flounder.

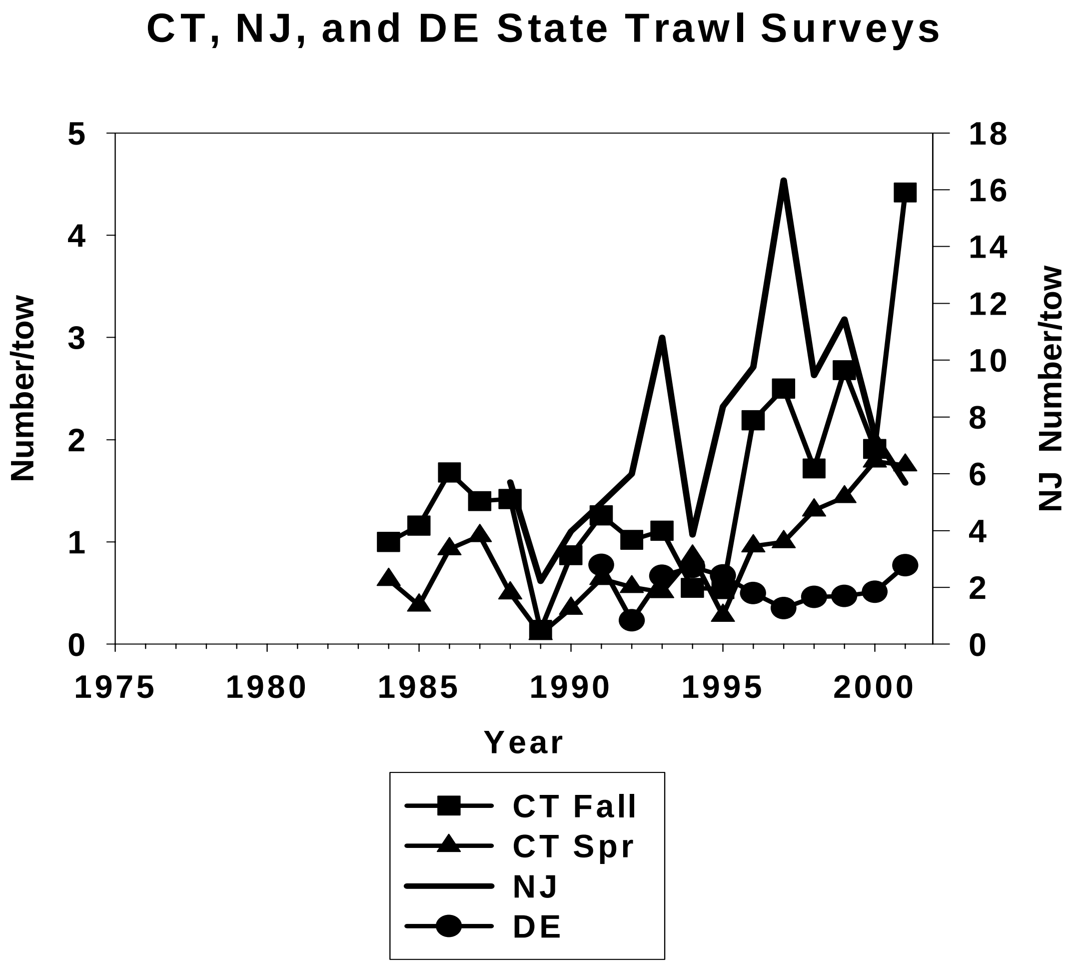

Figure A6. Trends in CT, NJ, and DE trawl survey abundance indices for summer flounder

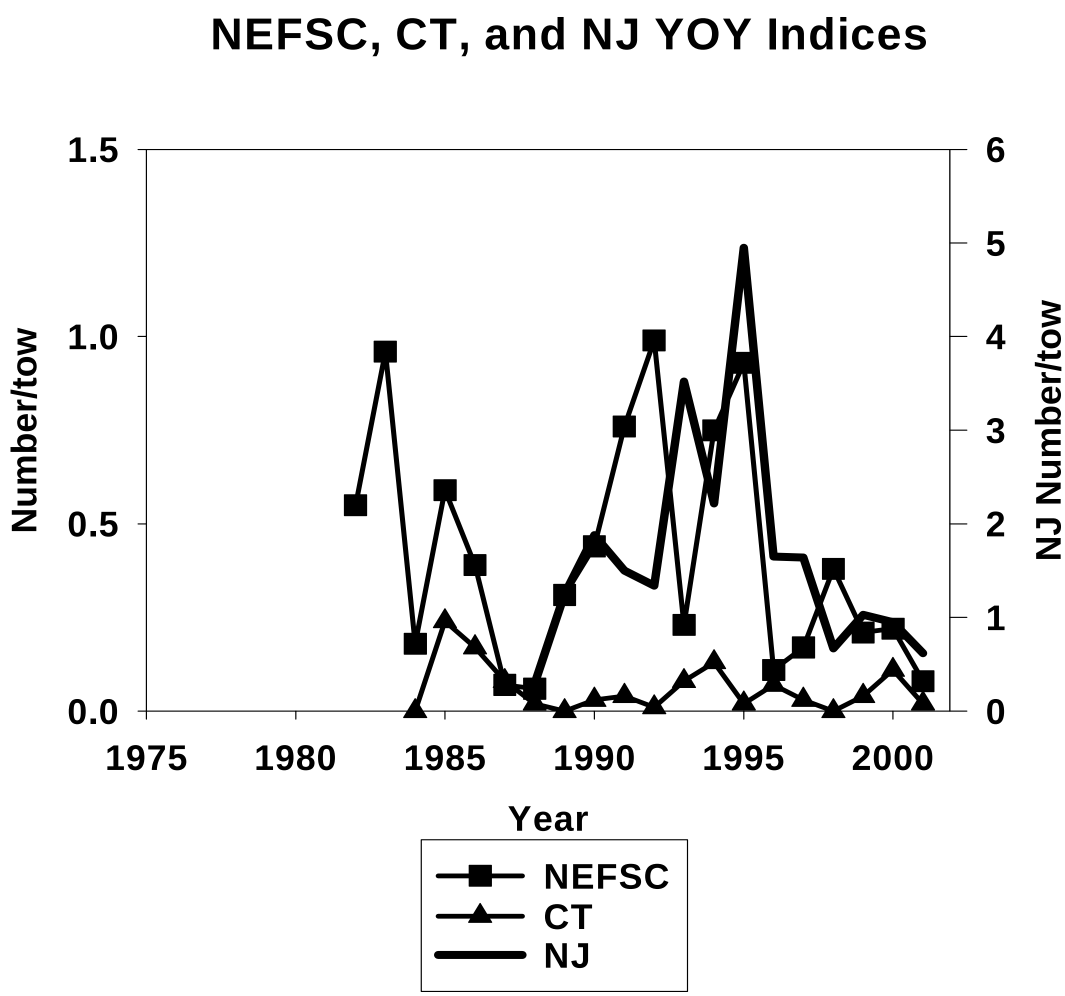

Figure A7. Trends in NEFSC, CT, and NJ trawl survey recruitment indices for summer flounder

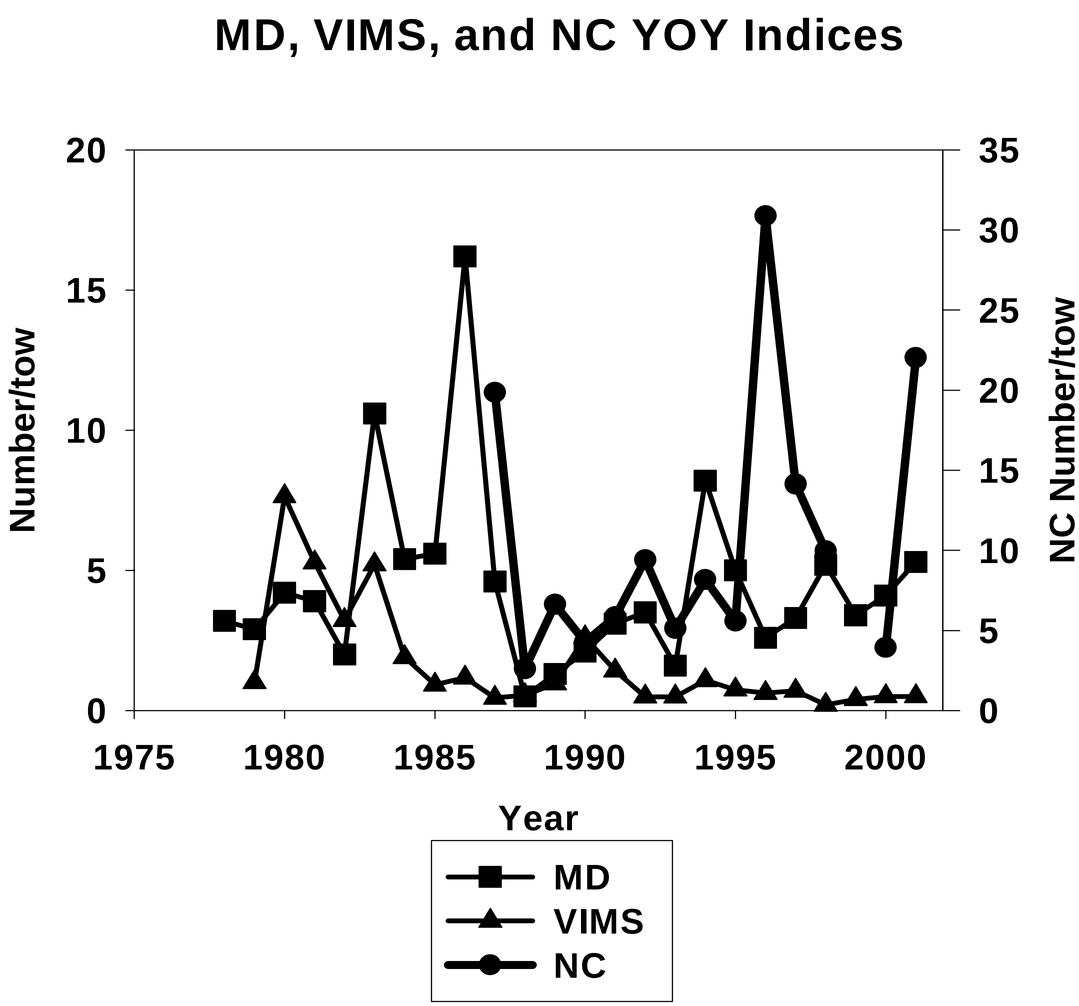

Figure A8. Trends in MD, VIMS, and NC trawl survey recruitment indices for summer flounder.

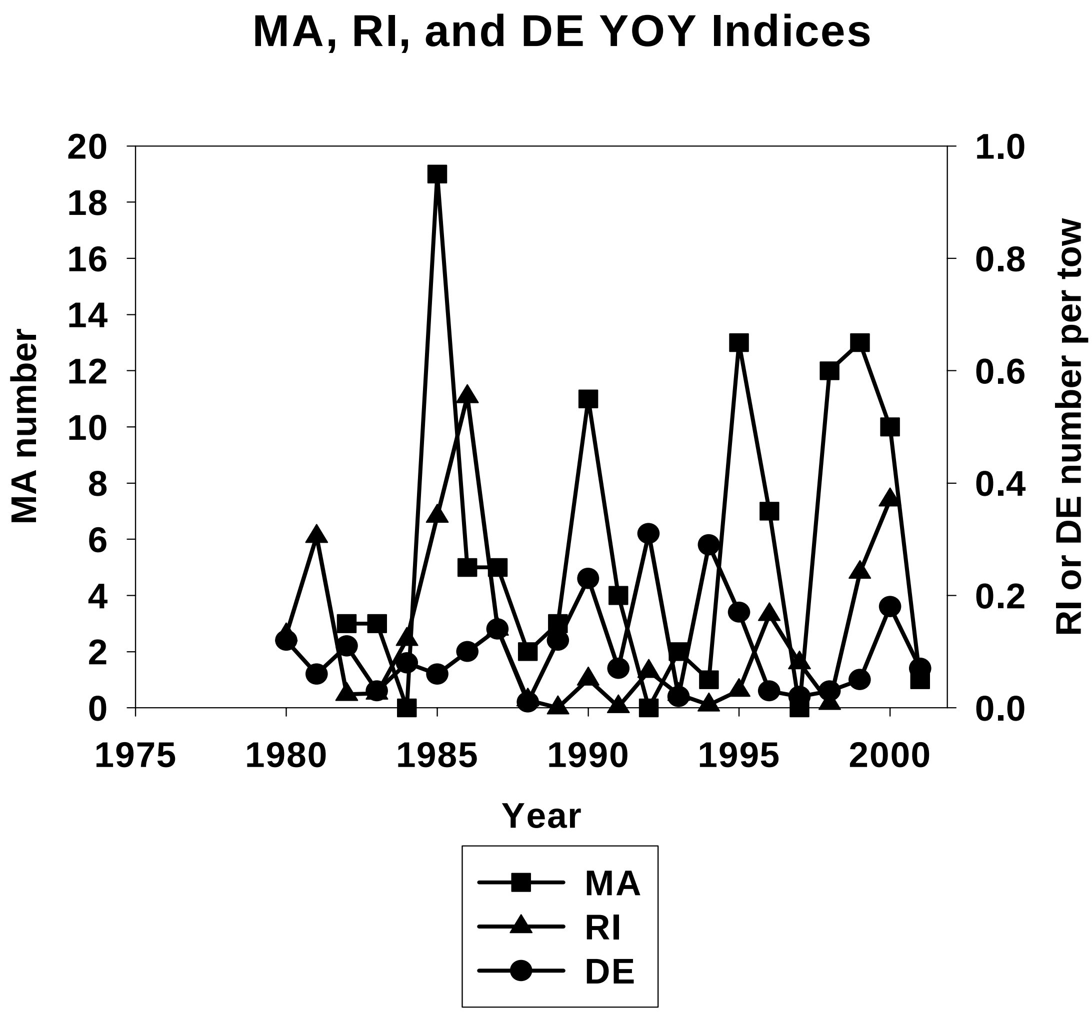

Figure A9. Trends in MA, RI, and DE survey recruitment indices for summer flounder.

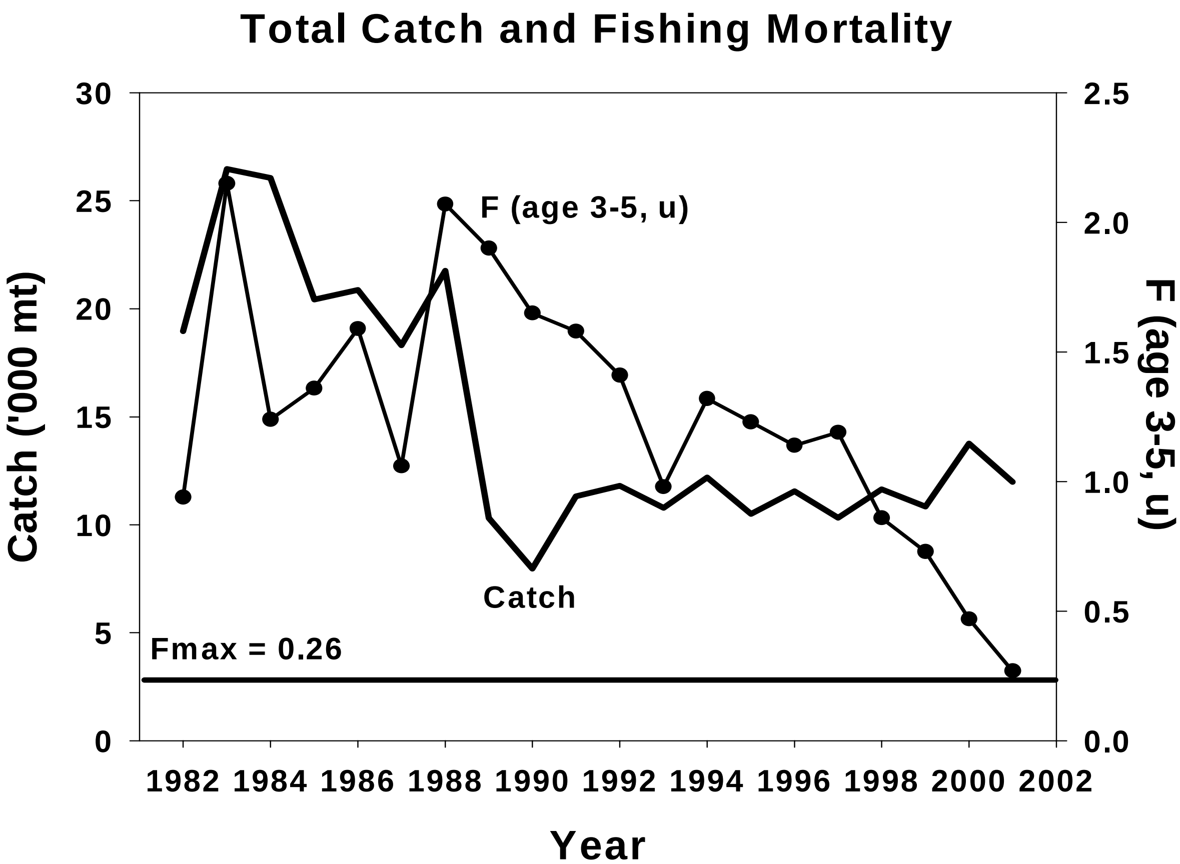

Figure A10. Total catch (landings and discards, thousands of metric tons) and fishing mortality rate (F, ages 3-5, unweighted) for summer flounder.

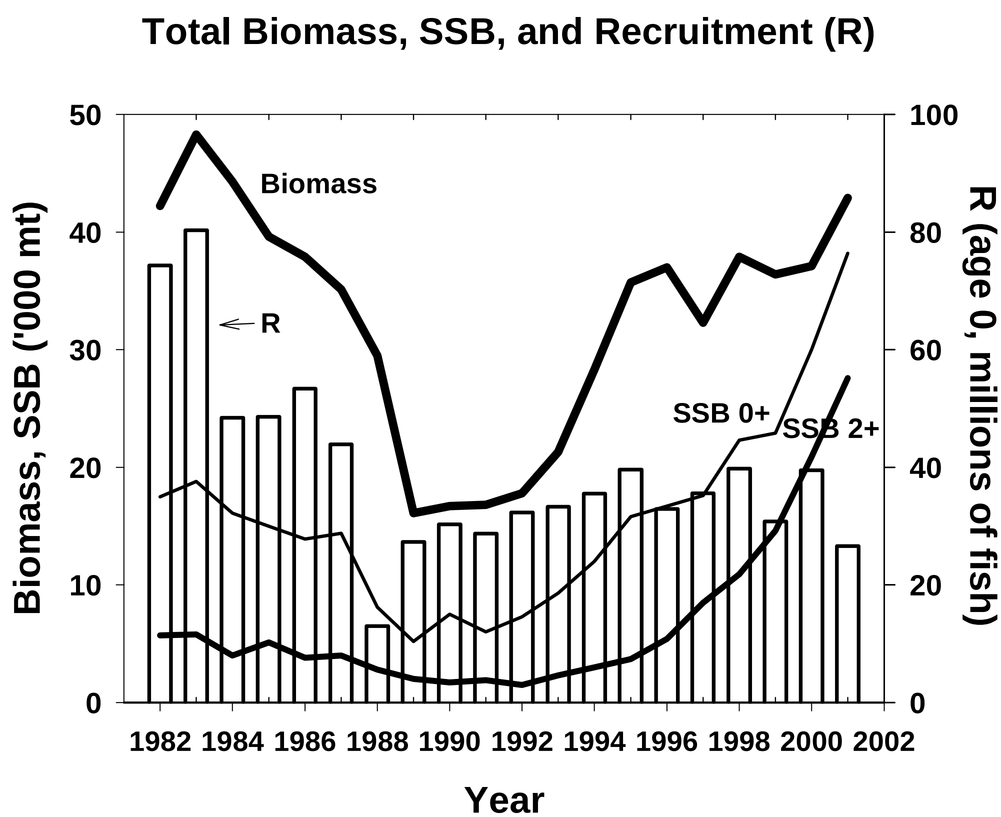

Figure A11. Total stock biomass ('000 mt), spawning stock biomass (SSB ages 0-7+ and 2-7+, '000 mt), and recruitment (millions of fish at age-0) for summer flounder.

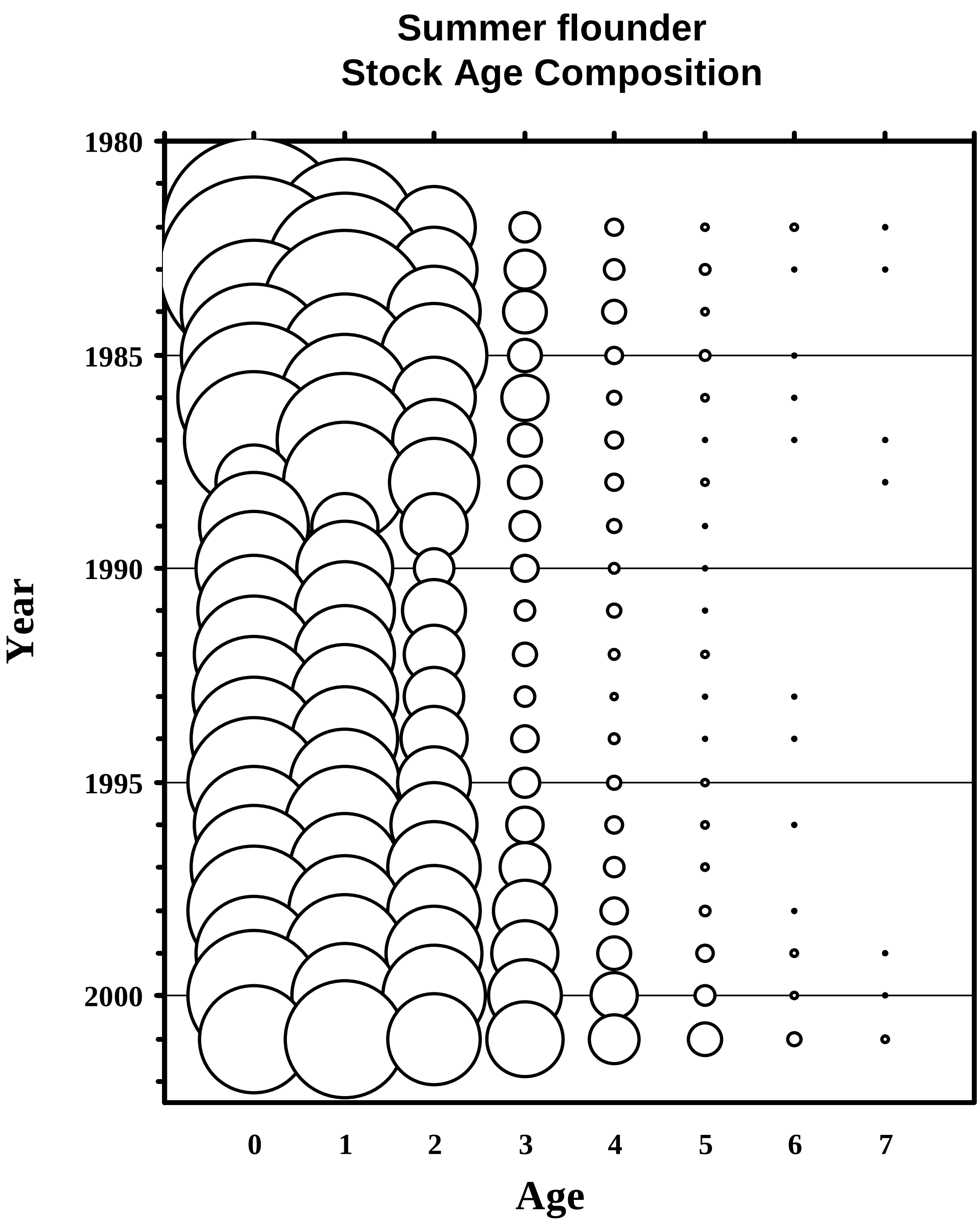

Figure A12. Stock age composition for summer flounder: 1982-2001

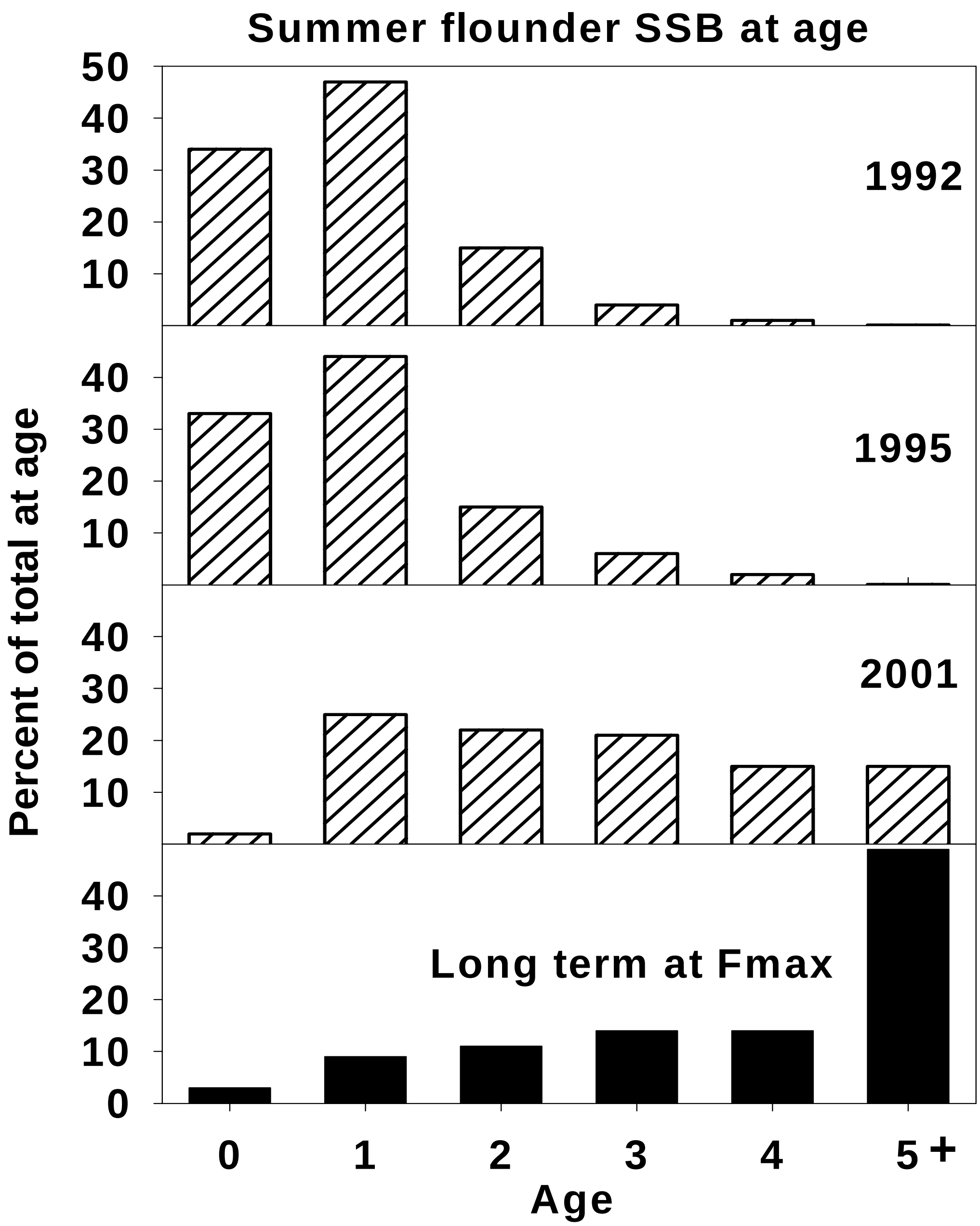

Figure A13. Spawning stock biomass for summer flounder: percent of total at age.

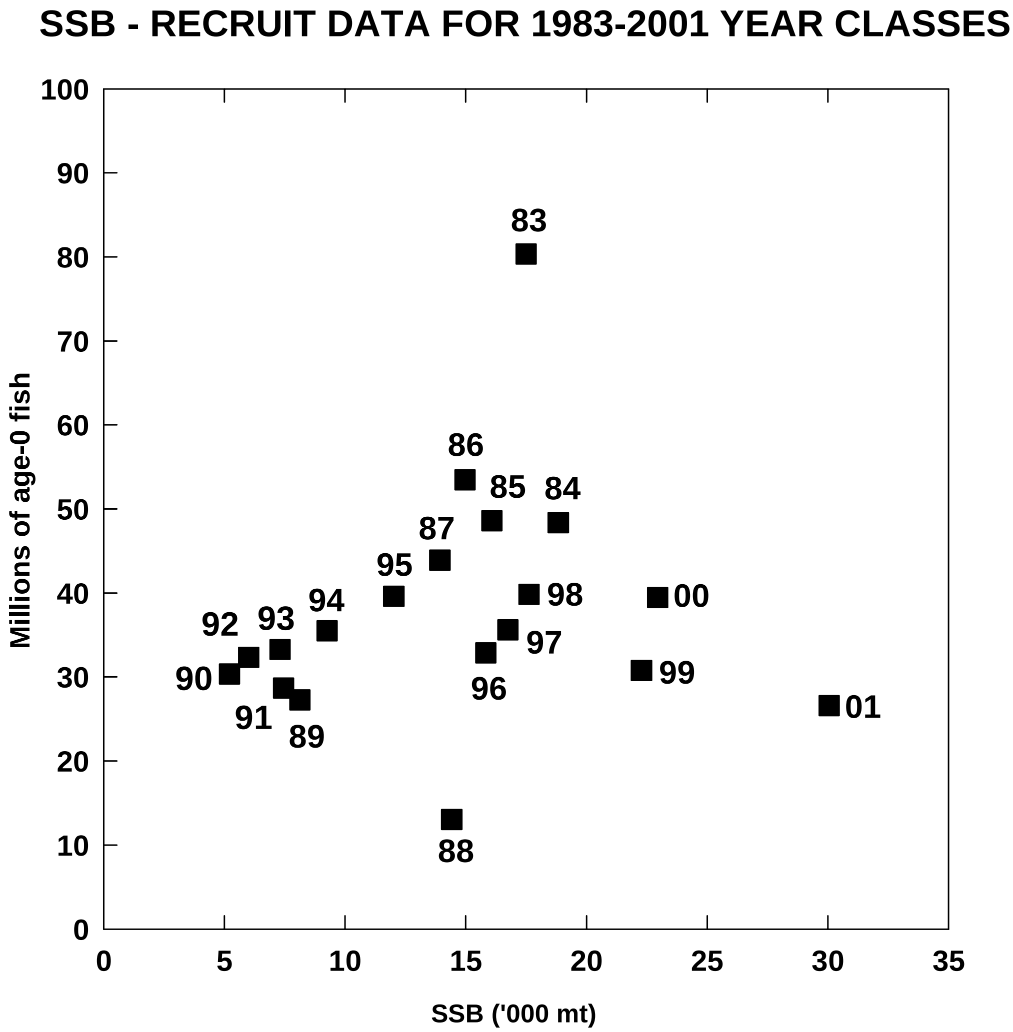

Figure A14. VPA spawning stock biomass and recruitment estimates for summer flounder.

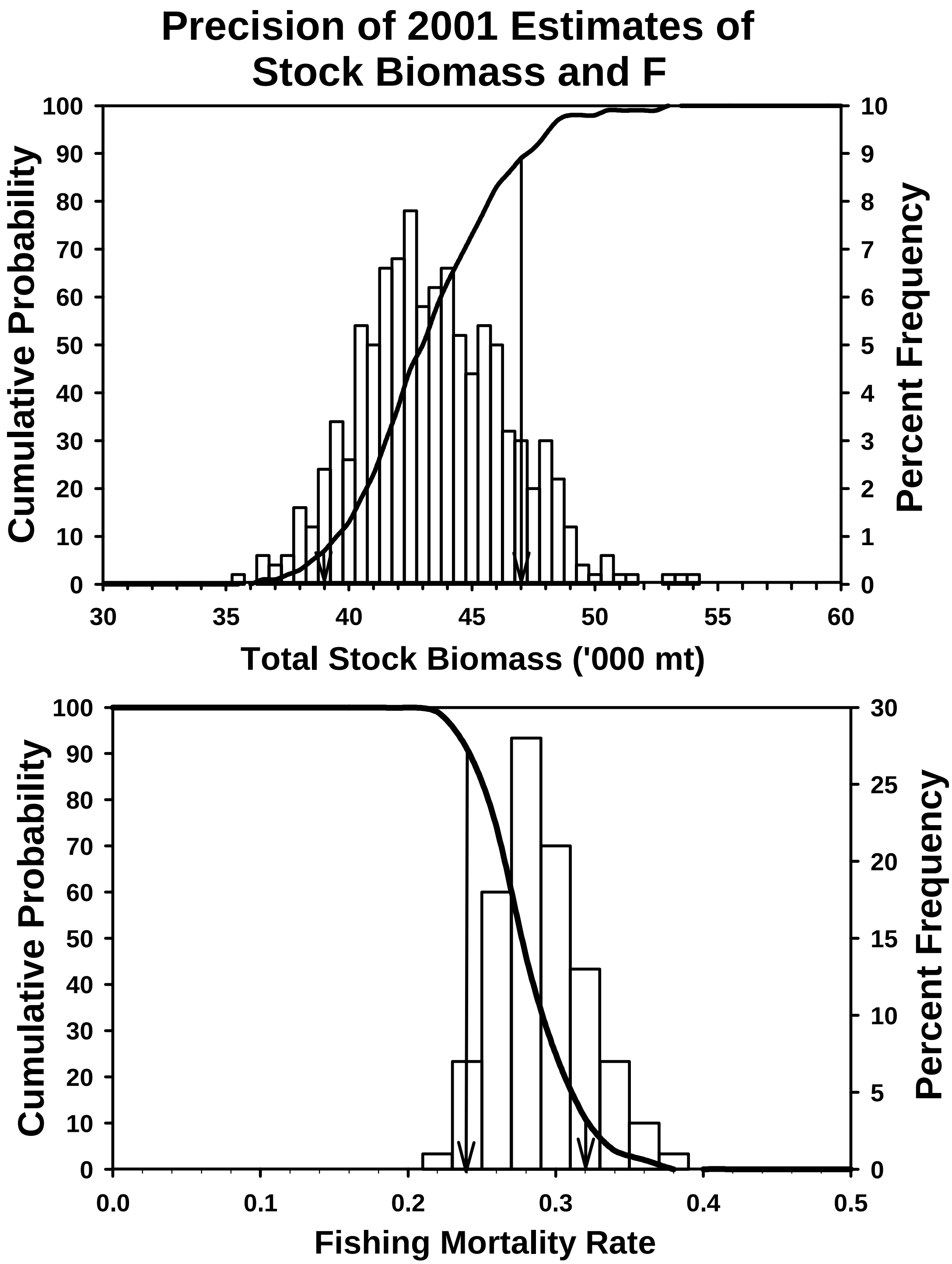

Figure A15. Precision of the estimates of January 1, 2001 total stock biomass (B) and fully recruited fishing mortality on age 3-5 (F) in 2001 for summer flounder.

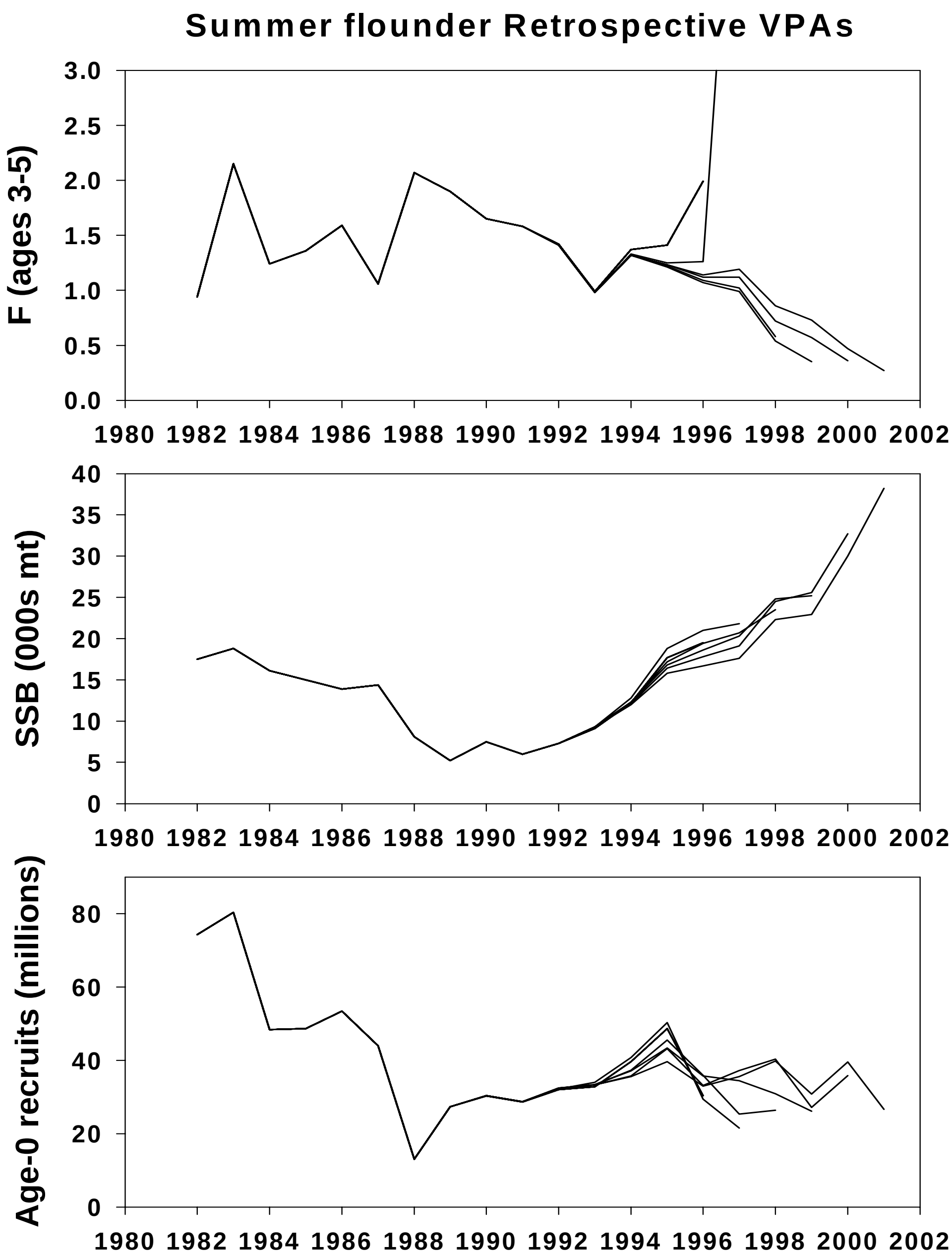

Figure A16. Retrospective VPAs for summer flounder.

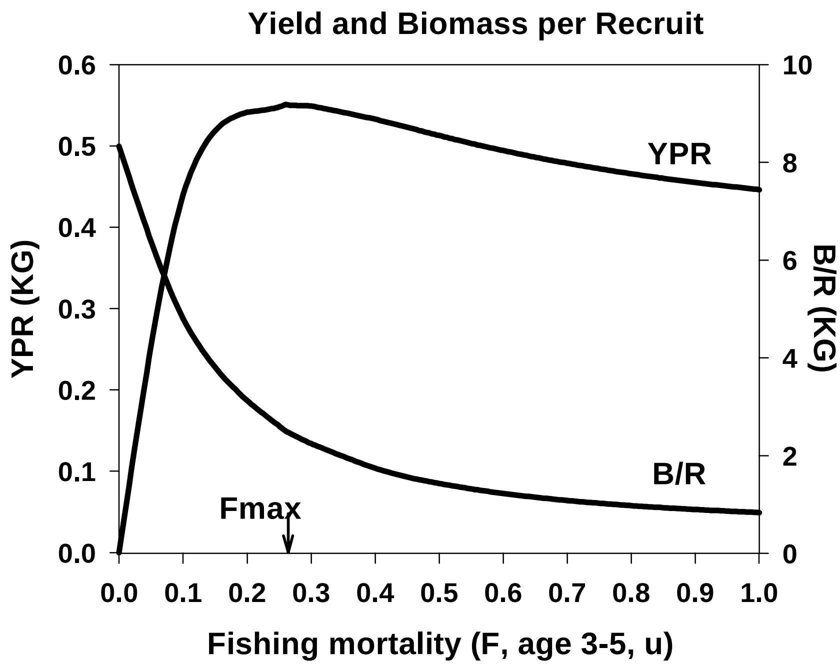

Figure A17. Yield per recruit (YPR) and biomass per recruit (B/R).

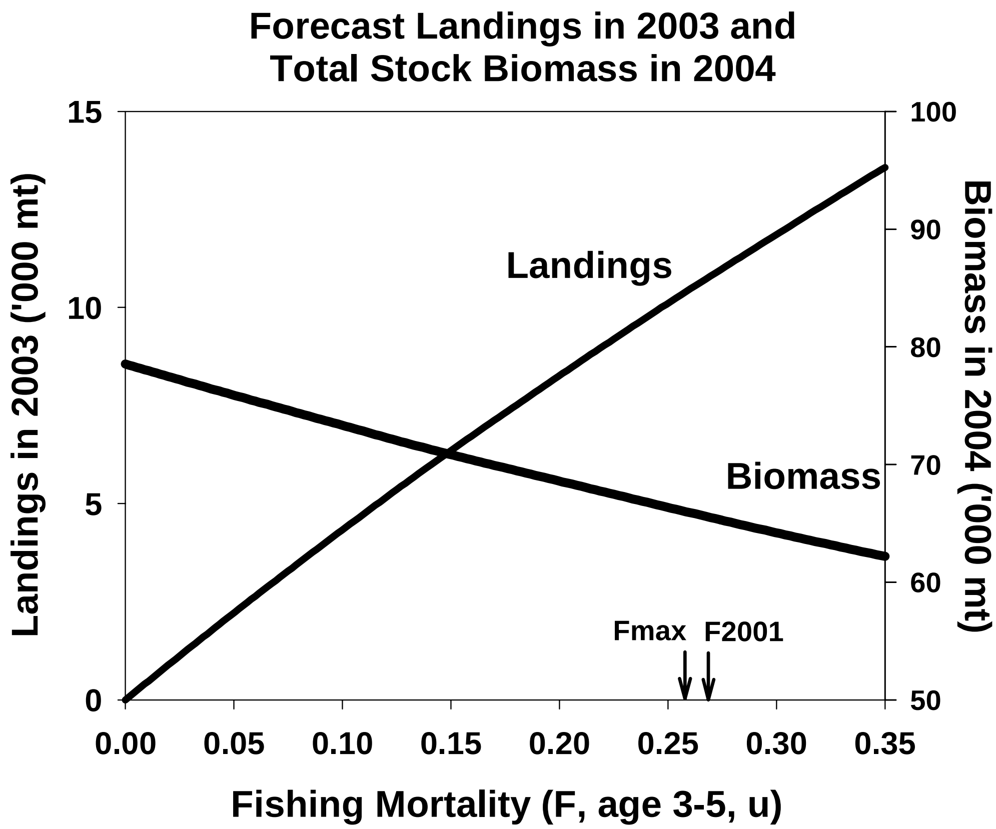

Figure A18. Forecast landings in 2003 and total stock biomass on Jan.1, 2004 over a range of fishing mortalities in 2003.

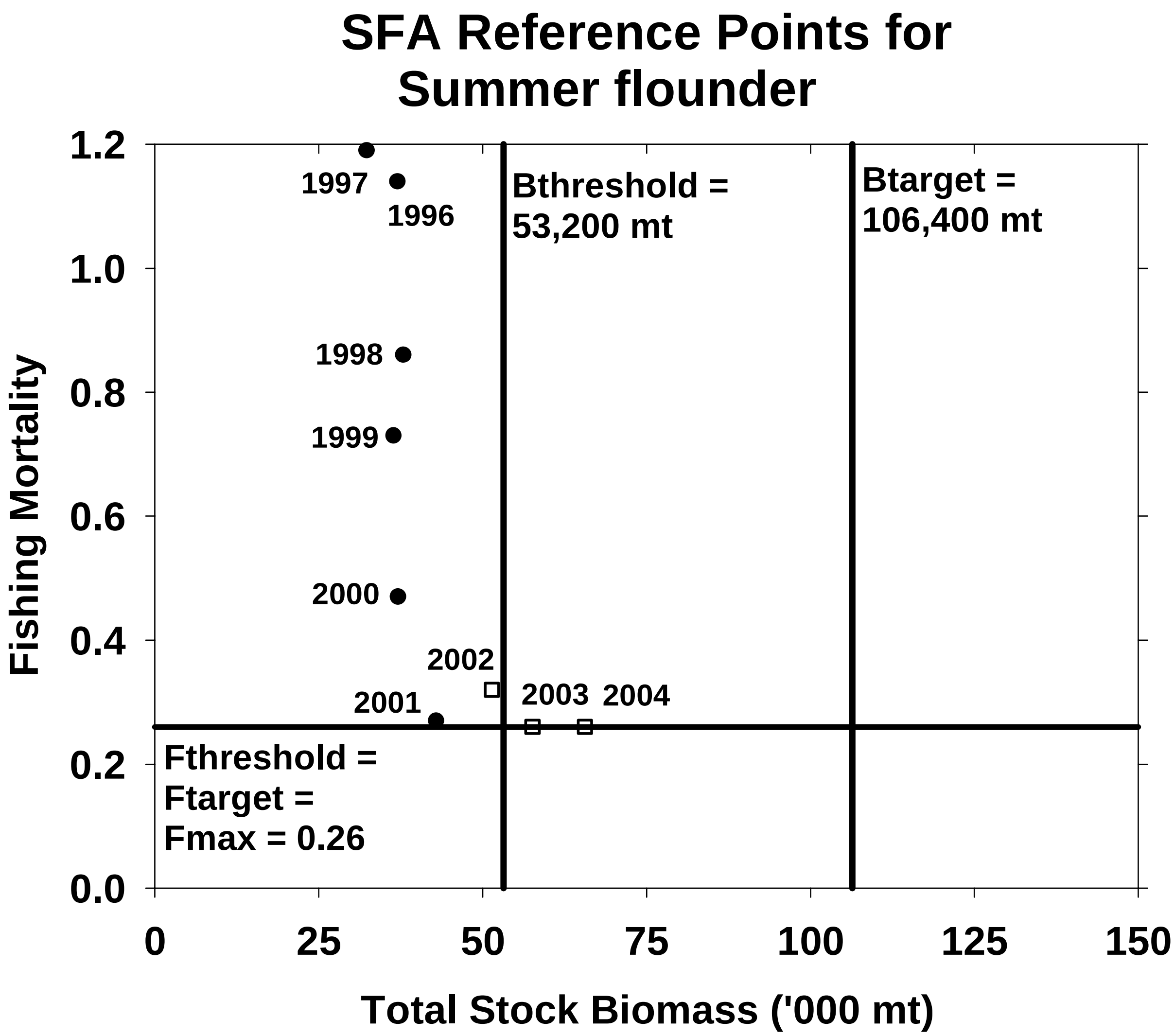

Figure A19. MAFMC FMP Amendment 12 SFA reference points for summer flounder, with 1996-2001 VPA estimates of F and total stock biomass, and forecast estimates of F and total stock biomass for 2002-2004.

B. SCUP

TERMS OF REFERENCE

1. Characterize the commercial and recreational catch including landings and discards.

2. Estimate fishing mortality, spawning stock biomass, and total stock biomass for the current year and characterize the uncertainty of those estimates.

3. Evaluate and either update or re-estimate biological reference points as appropriate.

4. Where appropriate, estimate a TAC and/or TAL based on stock status and target mortality rate for the year following the terminal assessment year.

5. If stock projections are possible, provide short term projections (2-3 years) of stock status under various TAC/F strategies and evaluate current and projected stock status against existing rebuilding or recovery schedules, as appropriate.

INTRODUCTION

Scup***, Stenotomus chrysops,*** are a schooling, continental shelf species of the Northwest Atlantic, distributed primarily between Cape Cod, MA and Cape Hatteras, NC (Morse 1978). Scup undertake extensive migrations between coastal waters in summer and offshore waters in winter. Scup migrate north and inshore to spawn in spring. Larger scup (0.7-1.8 kg) tend to arrive in spring first, followed by smaller scup (Neville and Talbot 1964; Sisson 1974). Larger scup are found during summer near the mouth of larger bays and in the ocean within the 20-fathom contour; smaller scup are found in shallow areas of bays (Morse 1978). Scup migrate south and offshore in autumn as the water temperature decreases, arriving in offshore wintering areas by December (Hamer 1970; Morse 1978).

Spawning occurs from May through August and peaks in June. About 50% of age-2 scup are sexually mature (about 17 cm total length; NEFSC 1993). Scup can attain a maximum length of about 40 cm and a maximum age of about 20 years (Dery and Rearden 1979). Crecco *et al.* (1981) have characterized scup as slow-growing and relatively long-lived fish.

Tagging studies (e.g., Neville and Talbot 1964; Cogswell 1960, 1961; Hamer 1970, 1979) have indicated the possibility of two stocks of scup, one in Southern New England and another extending south from New Jersey. However, a lack of definitive tag return data coupled with distributional data from the NEFSC bottom trawl surveys support the concept of a single unit stock extending from Cape Hatteras north to New England (Mayo 1982).

The Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) manage scup under Amendment 8 to the Summer Flounder, Scup, and Black Sea Bass Fishery Management Plan (FMP). The FMP defines the management unit as scup in US waters from Cape Hatteras northward to the US-Canadian border. Exploitation rates were to be reduced to 47% (F=0.72) in 1997-1999, to 33% (F=0.45) in 2000-2001, and to 21% (F=0.26) in 2002 through coast-wide commercial quotas and recreational season, size and possession limits that are established on an annual basis. Amendment 12 to the FMP established a biomass threshold for scup based on the maximum value of the 3-year moving average of the NEFSC spring bottom trawl survey index of spawning stock biomass - 2.77 kg per tow, 1977-1979. The scup stock is overfished when the spawning stock biomass index falls below this value. Amendment 12 defined overfishing for scup to occur when the fishing mortality rate exceeds the threshold fishing mortality of F_{max}=0.26.

The Total Allowable Catch (TAC) of 9.11 million lbs (4,132 mt) established in 1997 included a commercial fishery quota of 6.00 million lbs (2,722 mt), a recreational fishery harvest limit of 1.95 million lbs (885 mt), and projected total discards of 1.16 million lbs (528 mt). The TAC decreased steadily to a low of 5.92 million lbs in 1999 and 2000 followed by a significant increase in 2001 to 8.37 million lbs (3797 mt). The 2002 TAC increased further to 12.92 million lbs with a commercial quota of 8 million lbs (3629 mt), a recreational harvest limit of 2.77 million lbs (1257 mt) and projected total discards of 2.15 million pounds (975 mt).

For 2002, the Board and Council implemented minimum mesh size regulations that vary according to net size. Large nets may have up to 25 meshes of 4.5@ in the codend, with at least 100 meshes of 5@ forward of the 4.5@ mesh. Small nets, defined as those with codends smaller than 125 meshes including extension, must have 4.5@ mesh throughout. Vessels using nets with smaller mesh may possess 500 lbs. of scup from November through April and 100 lbs. from May through October. The minimum size for scup caught by any net in the commercial fishery remains at 9@.

The ASMFC Summer Flounder, Scup, and Black Sea Bass Management Board approved Addenda V and VII on February 21, 2002 to more effectively manage the scup fishery. Addendum V was enacted to set state-by-state summer period allocations for the summer period scup fishery during 2002 and until action is taken to modify them. The quota was reallocated using 1983-1992 as the base period with updated landings data from Massachusetts.

Addendum VII was implemented to create a state-by-state conservation equivalency system for the 2002 scup recreational fishery. Under this addendum, each state from North Carolina through New Jersey (inclusive) was assigned size, bag and season regulations, while those states from Massachusetts through New York (inclusive) were required to modify their fishing effort based on the performance of their regulations in previous years. Calculations of the state specific effort necessary to achieve the 2002 harvest limit were based on the average number of fish landed from 1998-2000. The addendum also permitted individual states to separate the management of the Party and Charter Boat sector from the remainder of the recreational fishery, provided that the estimated landings for each mode had a percent standard error not greater than 30%.

THE FISHERY

Commercial Landings

US commercial landings averaged over 18,000 mt per year from 1950 to 1966 (peaking at over 22,000 mt in 1960) and declined to about 4,000 mt per year in the early 1970s (Figure B1). Landings fluctuated between 7,000 and 10,000 mt from 1974 to 1986 and have since declined to less than 2,000 mt. Landings in 2001 were 1,729 mt (3.8 million pounds) - less than 8% of the 48.5 million pound peak observed in 1960 (Table B1).

Dealers reported commercial landings in 1994-2001 by market category and not by area of catch. Procedures developed by Wigley *et al.* (1997) were used to allocate landings by market category to statistical area, based on information collected under the Vessel Trip Report (VTR) system. A monthly set of landings, which are reported in both dealer and VTR databases, are used to characterize the distribution of dealer-reported landings by statistical area. This prorating procedure contributes to uncertainty in the attribution of market category landings by area, especially if vessels that are not participating in any fishery with mandatory VTR requirements land scup from different areas than those that produce landings for participating vessels. Other sources of uncertainty include unreported landings by dealers.

About two-thirds of the commercial landings of scup for the period 1979-2001 were in Rhode Island (37%) and New Jersey (28%) (Table B2). Landings in New York composed an average of 15% of the total. Scup landings reported for Massachusetts were revised for the 31st SARC assessment for 1986-1996, increasing an average of 92% or 218 mt per year (range, 182 to 268 mt and 40 to 216%) (NEFSC 2000). MADMF staff obtained affidavits from several major scup dealers detailing previously unreported landings of scup in Massachusetts for the years 1986-1997. Most of this increase was from previously unreported landings in the hand-line gear category, generally employed from vessels of displacement less than 5 gross registered tons. These records are now included in the NMFS NER dealer landings database.

The otter trawl is the principal commercial fishing gear, accounting for an average of 74% of the total catch in 1979-2001 (Table B3). The remainder of the commercial landings is taken by floating trap (12%) and hand lines (6%), with paired trawl, pound nets, and pots and traps each contributing 2-3%.

The intensity of NER commercial fishery biological sampling in 1979-2001 is summarized in Table B4. Annual sampling intensity varied from 25-640 mt per 100 lengths. Overall sampling exceeded the informal criterion of 100 lengths sampled per 200 mt in 17 of the last 23 years. However, this alone does not indicate adequate sampling because many of these strata have substantial landings but lack samples. Commercial landings at age were not estimated for 1998-2001 because an analytical assessment was determined to be unreliable by SAW 27 (NEFSC 1998) due to concerns about commercial landings sampling and estimation of commercial discards in recent years. Estimation of commercial landings at length using the available sample data indicated that most fish in the 1997-2001 commercial landings were age-3 fish of their respective year classes (Figures B2, B3).

Commercial Discards

Estimates

The NEFSC sea sampling program has collected information on landings and discards in the commercial fishery for 1989-2001. NER discard estimates were raised to account for North Carolina landings. A discard mortality rate of 100% was assumed because there are no published estimates of scup discard mortality rates. This assumption is based on limited observations and is a point of some contention between scientists and fishermen. Past SAW panels have recommended that research be conducted to better characterize the mortality of scup in different gear types in order to more accurately assess discard mortality (NEFSC 1995, 1997, 1998, 2000). The number of trips in which scup were landed and/or discarded is tabulated in Table B5. The NEFSC sea sampling program sampled from 7 to 91 otter trawl trips per year in which scup were landed or discarded. The number of sampled trips was especially low in 1994 and 1995 when only 7 and 18 otter trawl trips were sampled. Sample size in 2000 (72 trips) was the largest since 1992, but the number dropped to 28 sampled trips in 2001 (Table B5).

Quantifying discards from the commercial fishery is necessary for a reliable stock assessment, but low sample sizes have resulted in questionable estimates. Concern regarding the poorly estimated discards due to inadequate sampling has been addressed in at least four previous SAW meetings (NEFSC 1995, 1997, 1998, 2000). Members of these previous SARC panels commented that the uncertainty associated with the discards prevents reliable estimates of discard at age in the commercial fishery and seriously impedes the development of a reliable analytic assessment as well as forecasts of catch and stock biomass for the stock. Previous SAW panels have given recommendations for significant improvement in the precision of discard estimates. The most recent SARC that evaluated scup was especially concerned and did not consider an analytical assessment due to uncertainties in the input data, especially discard estimates (NEFSC 2000). Despite the uncertainty of the discard data, the SAW 31 panel concluded that the limited available information suggested that discarding of scup has been high throughout the time series (1989-1999), approaching or exceeding landings. The panel stated that continued unreliability in discard estimates would prevent the use of VPA and production models for producing a reliable assessment.

Given the difficulty associated with estimating commercial discards for scup, the sub-committee considered three different approaches for calculating estimates:

1. Geometric Mean Discards-to-Landings Ratio (GMDL): In previous assessments (e.g., SAW 25 (NEFSC 1997)), ratios of discards to landings by landings level (for trip landings < 300 kg (661 lbs) or => 300 kg) and half year were calculated (uncorrected geometric mean by cell) and multiplied by corresponding observed landings levels from the weigh-out database to provide estimates of discards for use as guidance in setting TAC levels for management (Table B6). Only trips with both non-zero landings and discards could be used. Geometric mean rates (retransformed, mean ln-transformed D/L per trip) were used because the distributions of landings and discards and the ratio of discards to landings on a per-trip basis in the scup fishery are highly variable and positively skewed. N is the number of sea sample trips with both scup landings and discard, which were used to calculate the per trip discard to

landings ratios. Corresponding dealer landings are from the NEFSC database.

The number of trawl gear trips used to calculate geometric mean discard-to-landings ratios (GMDL) by half year for 1997-2001 ranged from 1 to 17 for trips < 300 kg and from 1 to 4 for trips => 300 kg (Table B6). No trawl gear trips were available for half year two in 1997 and 1999 for trips < 300 kg and for half year two in 1997-2001 for trips => 300 kg. The GMDL calculated for half year one was used to estimate discards for half year two when no trawl gear trips were available in half year two. The GMDL ratios ranged from 0.46 in 2001 (half year two, trips < 300 kg) to 121.71 in 1998 (half year one, trips => 300 kg). The large 1998 estimate was based on one trawl gear trip. About 93% of the discard from that trip was attributable to a single tow in which an estimated 68.2 mt (150,000 lbs.) of scup were captured. This tow was not lifted from the water and the captain from the vessel estimated the weight. There has been debate concerning the validity of the tow weight estimate and whether or not it is representative of other vessels in the fishery. However, the observation was reported and was therefore included in the calculation of the GMDL. Estimates for 2001 were relatively low B 0.89 for half year one and 0.46 for half year two for trips < 300 kg (the latter of these was based on only two trawl gear trips) and 0.92 for half year one for trips => 300 kg.

2. Aggregate Discards-to-Landings Ratio (AGDL): The second approach for estimating discards considered aggregate discards to landings ratios (summed D/summed L for all trips in stratum). As in the GMDL method, trips are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips in the stratum used to calculate the aggregate ratio (Table B7). The number of trawl gear trips used to calculate AGDL by half year for 1997-2001 ranged from 14 to 37 for trips < 300 kg and from 1 to 4 for trips => 300 kg. There are more trips available for calculation for trips < 300 kg than in the GMDL approach. The lowest AGDL ratio calculated was 0.69 in 2000(half year one, trips => 300 kg). The largest AGDL was 121.71 in 1998 (half year one, trips => 300 kg) B the same as that calculated in the GMDL method.

3. Mean Differences between Landings and Discards (DELTA): Mean differences (kg) between landings and discard (D = landings - discard, per trip) were also calculated using the same strata as the previous methods - stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips in the stratum used to calculate the mean difference in stratum, which was then applied to the landings of every trip in the NEFSC dealer database to calculate a discard for each trip (discard = landings - (D)). Calculating differences allows use of trips that had discards but no landings, whereas D/L ratios cannot be calculated in these situations (i.e. zero in the denominator). When discards exceed landings, DELTA values will be negative. As the magnitude of discards is of primary interest, the absolute values will be considered.

The number of trawl gear trips used in the DELTA method calculations ranged from 6 to 37 for trips < 300 kg and from 1 to 4 for trips => 300 kg (Table B8). The magnitude of the DELTA values ranged from 10.7 in 2001 (half year two, trips < 300 kg) to 72707 in 1998 (half year one, trips => 300 kg). As before, this large discarding event is the result of one large discarding event that was discussed above.

Comparison of Methods

A summary of landings, discards, and aggregate discards to landings ratios from the three alternative methods of discard calculation are presented in Table B9. The year-to-year trends among the different approaches differed in magnitude but followed similar trends. D/L ratios in 1997 and 2001 were relatively low for all methods within each series. The large discard event in 1998 affected calculations from each method, resulting in relatively high D/L values in 1998 for each approach. The DELTA method yielded estimates that were fairly consistent with the GMDL ratios, while the AGDL estimates exhibited more variability. The working group felt most confident in the estimates produced using the GMDL approach and felt the estimates were supported by the DELTA ratios. The GMDL estimates were used for all modeling approached considered.

Estimates of GMDL from sea sampling were compared to estimates from vessel trip reports (VTR) for 1994-2001 (Table B10). VTR data were selected to include only trawl trips that reported some discard of any species. In contrast to black sea bass and New England groundfish discard data, GM D/L for scup for 1994-2001 sea sample data were 2 to 44 times greater than GM D/L for VTR data, with a single exception in 1996 for trips landing => 300 kg.

Length-frequency

The intensity of length frequency sampling of discarded scup from the sea sampling declined in 1992-1995 relative to 1989-1991 (Table B5). Sampling intensity ranged from 496 to 334 mt/100 lengths sampled in 1992-1995, failing to meet the informal criterion of 200 mt/100 lengths sampled. Sampling intensity improved to 100 mt/100 lengths in 1996, but then declined to about 240 mt/100 lengths in 1997 and 1999 and 1,071 mt/100 lengths in 1998. In 2000, sampling intensity dramatically improved to 50 mt/100 lengths. Mean weight was estimated from length frequency data and a length-weight equation, total numbers were estimated by dividing total weight by mean weight, and numbers at length were then calculated from the length-frequency distribution. Discards were dominated by fish aged 0, 1, or 2, depending on the year under consideration. There is some evidence for discarding of a strong 1994 year class based on the changes in length and age composition of discards from 1995 and 1996 (Figure B4); however, poor sampling in those years adds uncertainty to this assertion. The 1997 discard estimate is dominated by age-2 fish from the 1995 year class, probably as a result of minimum size and mesh regulations implemented in late 1996 and early 1997 (Figure B4). The 1998 and 1999 discard length samples suggest high discarding of the 1997 year class at age 1 in 1998 and at age-2 in 1999 (Figure B5). The usual discarding of age-2 fish was also high in 1998 (1996 year class) (Figure B4). The discarding of age-1 scup was lower in 1999 (1998 year class) compared to 1998 (1997 year class), which is likely a result of lower recruitment in the 1998 year class (Figure B5). The 2000 discard estimate is dominated by age-1 fish (1999 year class), suggesting high recruitment in 1999 (Figure B5). Evidence for discarding of a strong 1999 year class is further demonstrated in the 2001 discard estimates (Figure B6).

Recreational Catch

Scup is an important recreational species, with the greatest proportions of catch taken in the Southern New England states and New York. Estimates of the recreational catch in numbers were obtained from the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) for 1979-2000. These estimates were available for three categories: type A - fish landed and available for sampling, type B1 - fish landed but not available for sampling, and type B2 - fish caught and released. The estimated recreational landings (types A and B1) in weight for 1979-2000 averaged 2,018 mt per year (Table B1). The MRFSS data indicated that recreational landings have composed about 27% of the commercial and recreational total since 1979 (Figure B1). The 1998 estimate of 395 mt is the lowest of the 1979-2001 time series, and about 56% of the available 1998 harvest limit. Recreational landings in 2001 were 1,933 mt, similar to the time series average.

No length frequency distribution data on scup discards were collected in the MRFSS program. Mortality attributable to discarding in the recreational fishery has been reported to range from 0-15% (Howell and Simpson 1985) and from 0-13.8% (NEFSC 2000). Howell and Simpson (1985) found mortality rates to be positively correlated with size because of the tendency for larger fish to take the hook deep in the esophagus or gills. Williams more clearly demonstrated increased mortality with depth of hook location, as well as handling time, but found no association between mortality rate and fish size. Discard mortality from 5 to 15% in the recreational fishery appears reasonable based on these studies. Previous assessments have assumed a recreational fishery discard mortality rate of 15% (NEFSC 1995, 1997, 1998, 2000).

Sampling intensity for lengths varied from 48 to 451 mt/100 lengths in the recreational fishery (Table B4). Sampling in all years except one from 1979 - 1987 failed to satisfy the informal criterion of 200 mt/100 lengths. This criterion was met from 1988 - 1998 when sampling intensity varied from 193 to 48 mt/100 lengths. Sampling did not meet the criteria in 1999 - 2001 with intensities ranging from 323 to 451 mt/100 lengths. Numbers at length for recreational landings were determined based on available recreational fishery length-frequency samples pooled by half years over all regions and fishing modes. The 1998-2001 recreational length frequencies were not converted to age because no age-structured analyses were included in recent assessment work as a result of inadequate commercial fishery sampling. Almost all of the recreational catch is estimated to be above the 7 in (18 cm) recreational fishery minimum size limit (Figures B7, B8).

Total Catch

Estimates of total catch are given in Table B11. These estimates include commercial and recreational landings and discards. The earliest catches in the 1960-2002 time series are the least reliable due to uncertainty about the level of distant water fleet (DWF) catch, recreational catch (50% reduction from interpolations made in Mayo 1982 for 1960-1978), and commercial fishery discard (GM D/L ratio from 1989-2001 applied to all earlier years). Commercial discards for 1989-2001 were estimated using the GMDL ratio method. The working group expressed some uncertainty regarding the magnitude of the 1998 GMDL ratio, so an average of the 1997 and 1999 GMDL ratios was calculated and applied to the 1998 estimated landings to generate a discard estimate for 1998.

For years in which no discard data were collected (prior to 1989), commercial landings were raised by the GMDL ratios for 1989-2001. A discard mortality rate of 100% was assumed since there are no published estimates of commercial discard mortality rates for scup. Recreational discard estimates by weight for 1981-2001 were based on the assumptions that discarded scup occurred in the same relative proportions as illegally landed fish and that 15% of recreational discards die of hooking mortality (Howell and Simpson 1985, NEFSC 1995, 1997, 1998, 2000). Because discard lengths and weights are not collected in the MRFSS program, mean weight at size/age in the discards was set equal to mean weight at size/age of the illegal landings. Indirect estimates (by ratio to commercial landings) of recreational catch and commercial fishery discards extended the catch series back to 1960 (NEFSC 1998).

STOCK ABUNDANCE AND BIOMASS INDICES

Research Vessel Survey Indices

The fishery-independent surveys provide information about relative abundance and biomass. Indices of scup abundance and biomass have been calculated from catch-per-tow data from research vessel surveys by the Northeast Fisheries Science Center (NEFSC), Massachusetts Division of Marine Fisheries (MADMF), Rhode Island Division of Fish and Wildlife (RIDFW), Connecticut Department of Environmental Protection (CTDEP), New York Department of Environmental Conservation (NYDEC), New Jersey Bureau of Marine Fisheries (NJBMF), and the Virginia Institute of Marine Science (VIMS). Details on the methods employed in the state surveys are given in historical assessment documentation (NEFSC 1997, 1998, 2000).

NEFSC Surveys

The NEFSC spring and fall surveys provide the longest time series of fishery-independent indices for scup. NEFSC spring and fall abundance and biomass indices exhibit considerable year-to-year variability (Table B12). While biomass levels from 1979 through 2001 have been much lower than in earlier years, the 2002 spring index is the largest in the time series (Figure B9). The 2002 spring biomass index (13.46 kg/tow) is almost three times the second highest spring index, which was observed in 1978 (4.56 kg/tow). The spring abundance indices are similar; in 2002, the estimated index of spring abundance is the highest observed in the series (167.93 number/tow), about twice the 1970 index (78.50 number/tow). These dramatic increases are evident across all ages in the estimated spring numbers at age (Table B13). Though the winter survey only started in 1992, the estimated 2002 abundance and biomass indices are the largest within the series (Table B15; Figure B11). Similar to the spring estimates, numbers at age estimated for the 2002 winter survey are also exceptionally large (Table B15). Though the NEFSC fall indices have shown improvement in recent years, the 2001 fall abundance and biomass indices are much smaller than those observed in 1999 and 2000 (Table B12; Figure B10). Fall estimates of numbers at age in 2001 do not reflect relatively large values from which corresponding 2002 spring numbers at age might be expected to derive (Table B13; Figure B10).

Indices of scup spawning stock biomass per tow (SSB kg/tow) were developed from the NEFSC spring offshore strata series for use as minimum biomass indices for stock rebuilding in response to Sustainable Fisheries Act (SFA) considerations (NEFSC 1998). SAW 27 selected a 3-year moving average of the NEFSC spring SSB index as a representative measure of scup SSB based on the characteristics of the survey age structure and the magnitude of the survey catch. FMP Amendment 12 defined the threshold biomass index as the maximum observed value of this 3-year moving average - 2.77 SSB kg/tow (Table B12; Figure B12). The most recent average SSB index (2000-2002) is 3.20 SSB kg/tow, which exceeds this threshold.

<u>MADMF Survey</u>

The MADMF spring survey catches are characterized by scup age-1 and older. The spring biomass and abundance indices have dropped sharply from a high in the early 1980s to relatively low levels through the remainder of the time series, with the exception of spikes in 1990 and 2000 (Table B16; Figure B13). The 2001 spring index shows a decline to levels seen prior to the year 2000 increase. The MADMF fall indices are more variable than the spring indices, but also exhibit a decreasing trend in abundance and biomass over time (Table B16; Figure B14). The fall index is dominated by age-0 scup and does not reveal a strong 1997 year-class, but does indicate a strong 1999 year-class.

<u>RIDFW Survey</u>

The RIDFW spring survey typically catches scup age-1 and older. The spring indices show nominal levels of scup abundance through 1999 followed by a dramatic peak in 2000 (Table B17; Figure B15). The 2001 spring index exhibits a decline in abundance, though it is still larger than any other index in the time series prior to 2000. The spring biomass indices demonstrate very low scup biomass through 1999, but a significant increase is seen in 2000 and has continued to rise through 2001. The RIDFW fall survey is dominated by the presence of age-0 scup. Fall abundance indices show a general increase to its 1993 peak, followed by a steep decline in 1994 (Table B17; Figure B16). The fall survey gives evidence of a steady rise in abundance since that drop. The fall biomass trends are similar to the RI abundance patterns, giving evidence to a recent increase in biomass.

<u>CTDEP Survey</u>

The CTDEP spring survey is largely composed of age-1 scup, similar to the other surveys. The spring abundance indices exhibit relatively low levels through the survey period, with the exception of a dramatic peak in 2000, similar to the RIDFW spring abundance index (Table B18; Figure B17). The 2001 spring abundance and biomass indices for scup are 7.2 fish/tow and 2.85 kg/tow, respectively. Both values are lower than in 2000, but still substantially larger than any index prior to 2000. The CTDEP spring survey actually caught twice as much by weight in 2001 compared to 2000 (4,250.2 kg/120 tows in 2001 vs 2263.1 kg/120 tows in 2000; D. Simpson, pers. comm.). Numbers caught were 28,119 fish in 2001 and 36,531 fish in 2000 so the index dropped a lot more than indicated by the total catch. This is likely a result of the schooling behavior of scup, which allowed for several 'big hits' in 2001. The scup were more spread out in 2000 although there were still a few 'big hits'. Another indication of the tighter aggregation seen in the 2001 CTDEP spring survey is the % of tows where scup were present: 72% in 2000 and only 49% in 2001. The CTDEP fall survey, which is dominated by age-0 scup, indicates that scup numbers were relatively stable during the survey period, except for relatively large values in 1991, 1999, and 2000 (Table B19; Figure B18). As with the spring indices, the increases seen in 1999 and 2000 did not persist through

2001.

<u>NJBMF Survey</u>

The NJBMF abundance and biomass indices exhibit variable patterns over the time series. Relatively high values were observed from 1989 to 1993, lower values from 1994 to 1996/97, a peak in 1999, and a gradual decline in recent years. (Table B20; Figure B19).

<u>VIMS Survey</u>

The VIMS age-0 scup survey shows a general decline in abundance from relatively high levels peaking in 1990 and 1993 to relatively low levels from 1994 to 2000 (Table B21; Figure B20). The VIMS 2001 index suggests a potentially large increase in abundance.

<u>NYDEC Survey</u>

NYDEC provides both yearling (June-Aug) and young-of-year (Aug-Oct) indices for scup abundance. The yearling indices are generally low throughout the time series (Table B22; Figure B21A - note scale). Within the yearling series, there are three distinct peaks in relative abundance seen in 1989, 1985, and most recently in 2000. The 2000 index is the highest within the yearling indices. The YOY index shows fairly low levels over the survey periods, with periods of slightly elevated abundance levels evident in the early and late 1990s and a dramatic peak in 2000, which is the highest in the series (Table B22; Figure B21B).

<u>Coherence Among Surveys</u>

Previous assessment have been concerned with the conflicting pieces of evidence presented by the fishery-independent survey indices. The various indices have been inconsistent in their portrayal of relative population trends. For that reason, coherence among survey indices was evaluated in historical assessments of scup (NEFSC 1987, 1995, 1997). Correlation analyses yielded no consistent trends or patterns. Any significant correlations detected were sporadic and inconsistent between ages. The most recent SARC workshops abandoned formal correlation analyses and concluded that the various surveys likely measure different spatial and temporal components of the stock and those differences are reflected in the survey indices (NEFSC 1998, 2000). Correlation analyses were revisited in 2001 and results were similar to those found in previous assessment work (ASMFC 2001). The addition of one year of data (2001) is not expected to improve results from the correlation analyses, and so the analyses were not updated this year.

The spring indices are indicative of trends in adult biomass (age-1 and older) as indexed by mean weight per tow. Perhaps the most interesting trend is the dramatic increase observed in the 2002 NEFSC spring and winter abundance and biomass indices (Figures B9, B11). Estimates for 2002 are not yet available from the remaining surveys, but RIDFW spring biomass indices reflect a substantial increase in 2000 that continues through 2001 (Figures B15). The VIMS YOY indices also hint at an upward trend for 2001 (Figure B20). The remaining spring survey indices do not suggest an increase in scup biomass in 2001. The fall survey indices are mostly representative of age-0 fish and exhibit considerable inter-annual variability. Overall, fall indices appear to show evidence of strong recruitment in the 1999-2001 time period, which is also demonstrated in the YOY indices (VIMS and NYDEC). However, the NEFSC fall, CTDEP fall, and NYDEC YOY indices suggest

2001 recruitment was much lower than recent highs.

Spatial Patterns

Patterns in the spatial distribution of NEFSC spring survey catches were investigated to identify potential factors that may have influenced the marked increase in the 2002 NEFSC spring survey biomass and catch-at-age indices (Tables B12,B13; Figure B9). In previous years scup have been aggregated in deep water towards the northern end of their range (Figure B22). The 2001 NEFSC spring survey results exhibited a distribution similar to the historically observed patterns (Figure B23). This year, however, scup were also found in shallower water and spread from the Hudson Canyon to the mouth of the Chesapeake Bay (Figure B24). This same pattern was evident in the 2002 winter survey, though it was not as extreme. The magnitude of the 2002 spring survey catches ranged from 0.1 to 505.1 kg/tow in the 26 tows that observed scup (Figure B25). In contrast, the 2001 spring survey observed 15 positive scup tows ranging from 0.1 to 34 kg/tow. The 2002 spring survey also saw a greater number of larger scup than in most previous years, a trend reflected in many recent state surveys. The observed changes in distribution and relative biomass are attributable to changes in annual availability to the survey gear and variations in environmental conditions. Such factors have likely influenced the short-lived peaks and troughs observed in almost all of the state survey indices.

MORTALITY AND STOCK SIZE ESTIMATES

Natural Mortality

Instantaneous natural mortality (M) for scup was assumed to be 0.20 (Crecco *et al.* 1981, Simpson *et al.* 1990).

Catch Curve Analyses

In SAW 27, catch curve analyses based on the NEFSC autumn and spring surveys were used to estimate total mortality for scup (NEFSC 2000). These estimates were variable and considered imprecise. The fishery-independent surveys are thought to under-sample larger fish and so catch curve analyses based on these surveys will tend to overestimate Z. The absence of older scup from the survey catches may be due to a lack of availability and/or selectivity. The SAW 27 panel recommended research to investigate factors affecting size-specific availability to research surveys.

In 2001, both Massachusetts and Rhode Island initiated programs to age scup from commercial samples. Though the lack of a time series makes it difficult to incorporate this information into an analysis, catch curve analyses were applied to provide a general indication of current fishing mortality. The Rhode Island samples were taken from commercial fish traps. Sampled fish ranged from 1 to 8 years of age and most were age-3. Catch curve analysis yielded an estimated Z of 1.12, which corresponds to an F of 0.92 if M is assumed to be 0.20. Massachusetts provided scup age samples summarized over all fisheries and market categories. Estimates of Z ranged from 0.99 to 1.22 (F ~ 0.79 to 1.00) depending on the ages used to fit the catch curve.

Relative Exploitation Index

A relative exploitation index based on landings and spawning stock biomass was constructed to identify trends in exploitation rates. The index used total landings (1,000=s of lbs.) and the NEFSC spring SSB survey (kg/tow; three-year average) as a proxy for biomass. Relative exploitation was equal to landings divided by the SSB index and scaled by dividing by 1,000. This index reflected the mortality on age 2 and older scup because landings and catch in the SSB survey generally comprised scup ages 2 and older. Total catch and spring survey results were not used to derive an exploitation index because of the uncertainty associated with the discard estimates. To confirm observed trends in exploitation, an additional index was calculated based on total landings (1,000s of lbs.) and the NEFSC fall survey (kg/tow; three-year average).

The relative exploitation index indicated that the exploitation of scup was relatively low in the 1980=s and high in the 1990=s (Table B23; Figure B26). The low exploitation rates in the early 1980=s were consistent with Mayo=s 1983 assessment of scup. There was a general increasing trend in exploitation through the mid-1990s followed by a steady decline through 2001, the lowest observed value in the time series. Relative exploitation based on the 3-year moving average of the fall survey index also suggested a declining trend in relative exploitation since the mid-1990s, though there is evidence of a slight increase in 2000 (Figure B27).

BIOLOGICAL REFERENCE POINTS

FMP Amendment 12 defined overfishing for scup to occur when the fishing mortality rate exceeded the threshold fishing mortality rate of F_{MSY}. F_{MAX} was used as a proxy for F_{MSY} because F_{MSY} could not be reliably estimated for scup. F_{MAX} was most recently estimated to be 0.26 in SAW 27 (NEFSC 1998).

FMP Amendment 12 defined a threshold biomass index for stock rebuilding as the maximum value of a 3-year moving average of the NEFSC spring survey catch per tow of spawning stock biomass (1977-1979 = 2.77 SSB kg/tow). The most recent estimate of the average SSB index exceeds this threshold (3.20 SSB kg/tow, 2000-2002).

STOCK REBUILDING SCHEDULES

Long-Term Projections

According to the Sustainable Fisheries Act, the stock is to be rebuilt to a target biomass, which is greater than the biomass threshold, in ten years. Stock projections to assess projected stock status against existing rebuilding schedules were performed in the SAW 31 assessment using the NEFSC spring survey catch per tow at age estimates for 2000 (NEFSC 2000). The inability to estimate the absolute magnitude of F prevented an update of the previous forecast method for evaluating the SSB relative to the current biomass threshold. However, long-term projections of relative biomass were performed to get a sense of how exploitation may affect long-term population trends. The projections were based on the average of 2000-2002 NEFSC spring survey catch per tow at age estimates, offshore strata only (Table B24). The survey catch per tow at age values were projected into the next respective age in each time step, with an assumed M=0.20 and yearly recruitment at age 1 assumed equal to the long-term median catch per tow at age 1, NEFSC spring survey offshore strata (1977-2002 median = 5.15). The projections assumed different intrinsic rates of fishing mortality: F=0.00, F=0.26 (target for 2002), F=0.45 (target for 2000-2001), F=0.72 (target for 1997-1999), F=1.00, and F=2.00. Relative biomass was estimated by multiplying catch per tow at age by a partial recruitment vector and a weight at age vector (NEFSC 1995). Recruitment to the spawning stock was 13% at age 1, 75% at age 2, 99% at age 3, and 100% at ages 4 and older (NEFSC 1995). Projections were for 15 years.

Projections of relative biomass trends were dependent on the assumed fishing mortality rate (Figure B28). At F=0.00, trends in scup stock biomass showed a steady increase in the first eight years followed by a moderate decline. Long-term projections based on an assumed F=0.26 showed a moderate increase in the early years and gradually decreased to a level equivalent to approximately 40% of the peak predicted relative biomass within the time series. When fishing mortality was assumed F=0.45 or higher, relative biomass demonstrated a long-term decline.

Note that these projections were made solely to explore estimated trends in long-term relative biomass. The difficulties in estimating current fishing mortality precluded the application of reliable stock projections. Additionally, these projections assumed constant recruitment for all years. Realistically, recruitment will exhibit inter-annual variability that will affect predictions of SSB relative to the biomass threshold at a given F. Catchability differences between age groups as well as annual variability in catchability have not been accounted for in these projections. As such, consideration should be given to potential fluctuations in recruitment, changes in catchability, and environmental variation when interpreting stock projections.

CONCLUSIONS

The stock is not overfished, but stock status with respect to overfishing cannot currently be evaluated. The 2001 estimate of spawning stock biomass (2000-2002 average=3.20 SSB kg/tow), based on the 3-year moving average of the NEFSC SSB spring survey, exceeds the established biomass index threshold (2.77 SSB kg/tow). The change in stock status results from the extremely high survey observation in 2002 and it=s contribution to the calculation of the moving average. The spring survey index for 2002 is highly uncertain since the abundance of all age groups in the survey increased substantially as compared with the 2001 results. Though the relative exploitation rates have declined in recent years, the absolute value of F cannot be determined. Survey observations indicate strong recruitment and some rebuilding of age structure.

Management should continue efforts to further reduce fishing mortality rates and minimize fishery discards to rebuild the stock.

The stock can likely sustain modest increases in catches, but managers should do so with due consideration of high uncertainty in stock status determination.

Major uncertainties in estimating total catch continue to preclude an analytical stock assessment for scup. As such, the SARC concluded that a quantitative analysis of the population would be inappropriate as the basis for management decisions for scup at this time. The SARC panel expressed concerns about the failure to collect sufficient catch information that has impeded the development of scup assessments in the past. Several previous SARC panels (SAW 25, 27, 31) have concluded that new or enhanced data reporting or sampling are required to produce a reliable assessment. Members of the current panel emphasized that an analytical formulation for scup will not be feasible until the quality and quantity of the input data (biological sampling and estimates of all components of catches) are significantly improved for an adequate time series.

SARC COMMENTS

The SARC commented on possible explanations for the marked increase in the 2002 spring survey indices. In previous years scup have been aggregated in deep water towards the northern end of their range. This year, however, they were also found in shallower water and distributed from the Hudson canyon to the mouth of the Chesapeake. This same pattern was evident in the winter survey, though it was not as extreme. The 2002 spring survey also saw a greater number of larger scup than in most previous years, a trend reflected in many recent state surveys. The SARC had difficulty interpreting the spring 2002 survey results due to potential changes in the availability of the fish, performance of the gear and/or sampling variability. Availability to the survey gear and variations in environmental conditions were recognized as potential factors in the high survey values and additional analyses were recommended to evaluate their potential effects. In addition, the SARC agreed that the standard error for the survey indices should be included in the current document. Future assessments should include confidence intervals generated using stratified bootstraps.

Estimates of recreational and commercial discards were discussed at length. A number of methods were reviewed, but a consensus opinion on a satisfactory option could not be reached due to the absence of sufficiently reliable data. As a result, the SARC determined that while the document should include discards for the commercial and recreational fisheries, there was insufficient confidence in the estimates to support a production model. The SARC recognized the ongoing problems associated with discard estimates and recommended that the Scup Stock Assessment Working Group design a sampling program that would provide enough information to determine discard estimates in the future. Future documents should also include a description of the statistical properties of each method used to estimate discards to help determine which is most appropriate.

The SARC reviewed a method of estimating relative exploitation rate, fishing mortality and stock biomass using CPUE from the recreational private boat fishery. Though it was recognized as having potential for providing useful information on trends, the SARC concluded that it needed further development (e.g., consistency in the fishing mortality metric and the effort information used in CPUE indices) prior to being included in an advisory document and used as a management tool.

The SARC discussed the stock projections provided by the Scup Stock Assessment Working

Group. The age structure and recruitment rate, both derived from 2002 estimates, were determined to be inappropriate. The SARC recommended that the average age structure from 2000, 2001 and 2002 and the median recruitment rate from 1977 through 2002 be used to eliminate the bias associated with single year estimates. The SARC considered that this method of projection should be treated with caution especially beyond year one, due to uncertainties in input information.

The SARC discussed the possibility of recommending revised reference points, possibly including a revised biomass threshold or a biomass target. It was determined that, as confidence in the data used in the analytical assessment was very low, there was insufficient basis for forwarding revised reference points to the Council.

SOURCES OF UNCERTAINTY

The majority of the uncertainty pertaining to the population assessment of scup is related to biological sampling and estimates of all components of catches for scup. The main concerns include:

- NER commercial fishery biological sampling
  Inadequate sampling of strata (market categories and statistical areas) that have substantial landings of scup

- Dealer / VTR databases
  Uncertainty with method of allocation of landings by market category to statistical area
  Unreported landings by dealers

- NEFSC sea sampling
  Inadequate for developing reliable estimates of scup discards (limited sample size and questionable as to representative nature of sea sampling data for scup)
  Intensity of length frequency sampling may not be representative of discards

- Historical catch estimation
  Uncertainty about the level of distant water fleet (DWF) catch (1963-1981), recreational catch (MRFSS data not available prior to 1979), and commercial fishery discards (no sea sampling for discards prior to 1989)

- Assumption of 100% commercial discard mortality

RESEARCH RECOMMENDATIONS

1. The SARC discussed some of the reasons why the research recommendations from previous SARCs had not been adequately addressed. There is currently no mechanism for accountability, resulting in other research needs taking priority. It was suggested that summaries of research recommendations be forwarded to the NRCC for review and comment, followed by a feasibility analysis. At that point a list of priorities and perhaps assignments for research could be made. The SARC recommends that a working group be developed to assess what group would be best suited to address each research need.

2. Increased and more representative sea and port sampling of the various fisheries in which scup are landed and discarded is needed to adequately characterize the length composition of both landings and discards. The current level of sampling, particularly of the discards, seriously impedes the development of analytic assessment and forecasts of catch and stock biomass for this stock. A pilot study to develop a sampling program to estimate discards should be implemented. Expanded age sampling of scup from commercial and recreational catches is required, with special emphasis on the acquisition of large specimens.

3. Commercial discard mortality had previously been assumed to be 100% for all gear types. The committee recommends that studies be conducted to better characterize the mortality of scup in different gear types to more accurately assess discard mortality.

4. Additional information on compliance with regulations (e.g. length limits) and hooking mortality is needed to interpret recreational discard data.

5. Biological studies to investigate factors affecting annual availability of scup to research surveys and maturity schedules.

6. Investigate the statistical properties of the three commercial discard estimation approaches presented for consideration in future analyses.

7. Quantify the percentage of commercial fishery trips that had discards, but no landings, and evaluate how such trips contribute to the total commercial fishery discard estimate.

8. Continue exploration of relative biomass and relative exploitation calculations based on CPUE data from the recreational private boat fishery.

9. Explore other approaches for analyzing survey data, including bootstrap resampling methods to generate approximate confidence intervals around the survey index point estimates.

10. In the absence of reliable estimates of the catch, consideration should be given to simple forward projection models that rely on trends from the survey indices in the absence of catch information.

11. Design an optimal sampling plan that would be considered for implementation by the fishery observer sampling, recreational and commercial port sampling program.

12. Explore alternative biomass indices for development of biomass proxies for reference point determination based on multiple survey indices.

13. Evaluate the current biomass reference point and consider alternative proxy reference points such as B_{MAX} (the relative biomass associated with F_{MAX}).

14. Surveys should be evaluated to test the assumption of equal catchability at age in projections (i.e. through forward projection methods).

15. Explore alternative decision support methodologies for updating TALs directly from relative trends in abundance without relying on direct estimates of F.

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Table B1. Landings (mt) of scup from Maine through North Carolina. Landings include revised Massachusetts landings for 1986-1997.

Year	Commercial	Recreational	Total
1979	8,585	1,198	9,783
1980	8,424	3,109	11,533
1981	9,856	2,636	12,492
1982	8,704	2,361	11,065
1983	7,794	2,836	10,630
1984	7,769	1,096	8,865
1985	6,727	2,764	9,491
1986	7,176	5,264	12,440
1987	6,276	2,806	9,082
1988	5,943	1,936	7,879
1989	3,984	2,521	6,505
1990	4,571	1,878	6,449
1991	7,081	3,668	10,749
1992	6,259	2,001	8,260
1993	4,726	1,450	6,176
1994	4,392	1,192	5,584
1995	3,073	596	3,669
1996	2,945	1,016	3,961
1997	2,188	543	2,731
1998	1,896	395	2,291
1999	1,505	855	2,360
2000	1,207	2,365	3,572
2001	1,729	1,933	3,662
mean	5,340	2,018	7,358

Table B2. Commercial landings (mt) of scup by state. One mt was landed in DE in 1995, included with MD 1995 total. Landings include revised Massachusetts landings for 1986-1997.

Year	ME	MA	RI	CT	NY	NJ	MD	VA	NC	Total
1979		782	3,123	92	1,422	2,159	21	397	589	8,585
1980	1	706	2,934	17	1,294	2,310	32	531	599	8,424
1981		523	2,959	44	1,595	2,990	9	1,054	682	9,856
1982		545	3,203	25	1,473	1,746	2	1,042	668	8,704
1983		672	2,583	49	1,103	2,536	13	536	302	7,794
1984		540	2,919	32	904	2,217	6	673	478	7,769
1985		387	3,583	41	861	1,493	17	74	271	6,727
1986		875	2,987	67	893	1,895	14	273	172	7,176
1987	5	735	2,162	301	911	1,817		232	113	6,276
1988	9	536	2,832	359	687	1,334	1	127	58	5,943
1989	32	579	1,401	89	603	1,219	1	45	15	3,984
1990	4	696	1,786	165	755	1,005	4	75	81	4,571
1991	16	553	2,902	287	1,223	1,960	15	56	69	7,081
1992		655	2,676	193	1,043	1,475	17	73	127	6,259
1993		556	1,332	148	729	1,822	10	76	53	4,726
1994		354	1,514	142	688	1,456	7	92	139	4,392
1995		310	1,045	90	511	1,084	2	20	11	3,073
1996		436	773	99	377	1,141	20	72	27	2,945
1997		676	486	50	376	596	1	2	1	2,188
1998		435	361	44	282	758	5	4	7	1,896
1999		300	581	44	206	361		13		1,505
2000		161	461	65	287	232		1		1,207
2001		149	734	45	297	479	1	24		1,729
mean	11	529	1,971	108	805	1,482	10	239	223	5,340

Table B3. Commercial landings (mt) of scup by major gear types. All North Carolina landings in 1990-2001 are assumed to be obtained by otter trawls. Mid-water paired trawl landings are combined with other gears during 1994 and later. Landings include revised Massachusetts landings for 1986-1997.

Year	Otter trawl	Paired trawl	Floating trap	Pound net	Pots and traps	Hand lines	Other gear	Total mt
1979	6,387	146	1,305	429	26	215	77	8,585
1980	6,192	160	1,559	194	8	303	8	8,424
1981	7,836	79	1,291	246	49	306	49	9,856
1982	6,563	104	1,514	244	9	226	44	8,704
1983	5,861	398	850	390	8	265	22	7,794
1984	5,617	272	1,266	295	8	287	24	7,769
1985	4,856	417	1,022	229	5	182	16	6,727
1986	5,163	540	629	332	9	493	10	7,176
1987	4,607	237	590	193	213	423	13	6,276
1988	4,142	166	1,052	53	44	396	90	5,943
1989	3,174	89	193	74	104	334	16	3,984
1990	3,205	200	505	60	239	340	22	4,571
1991	5,217	152	988	40	258	395	31	7,081
1992	4,371	94	934	67	303	450	40	6,259
1993	3,865	46	166	25	202	402	20	4,726
1994	3,416		331	79	76	340	150	4,392
1995	2,204		331	42	57	215	224	3,073
1996	2,196		229	8	120	374	18	2,945
1997	1,491		86	12	104	489	6	2,188
1998	1,379		11	4	98	390	14	1,896
1999	1,005		140	30	77	184	69	1,505
2000	773		56		78	205	95	1,207
2001	1,088		229	65	52	215	80	1,729
mean	3,939	207	664	141	93	323	49	5,340

Table B4. Summary of the sampling intensity for scup in the NER (ME-VA) commercial and coastal recreational fisheries.

	NER Commercial fishery				Coastal Recreational fishery		
Year	No. of samples	No. of lengths	NER Landings (mt)	Sampling intensity (mt/100 lengths)	No. of lengths	Estimated landings (A + B1) (mt)	Sampling intensity (mt/100 lengths)
1979	10	1,250	7,996	640	322	1,198	372
1980	26	3,478	7,825	225	1,263	3,109	246
1981	16	2,005	9,174	458	642	2,068	322
1982	81	9,896	8,036	81	1,057	3,100	293
1983	72	7,860	7,492	95	1,384	3,432	248
1984	60	6,303	7,291	116	943	1,434	152
1985	31	3,058	6,456	211	741	3,282	443
1986	54	5,467	7,004	128	2,580	5,908	229
1987	61	6,491	6,163	95	777	2,980	384
1988	85	8,691	5,885	68	2,156	2,414	112
1989	46	4,806	3,969	83	4,111	3,248	79
1990	46	4,736	4,490	95	2,698	2,007	74
1991	31	3,150	7,012	223	4,230	3,634	86
1992	33	3,260	6,163	189	4,419	2,110	48
1993	23	2,287	4,673	204	2,206	1,341	61
1994	22	2,163	4,253	197	1,374	1,188	86
1995	22	2,487	3,062	123	822	595	72
1996	61	6,544	2,918	45	526	1,016	193
1997	37	3,732	2,187	59	399	543	136
1998	41	4,022	1,889	47	286	395	138
1999	56	6,040	1,505	25	265	855	323
2000	22	2,245	1,207	54	524	2,365	451
2001	40	3,934	1,729	44	1,038	1,933	186

Table B5. Summary of sampling for scup in the Northeast Region sea sampling program. OT= number of trips sampled in which otter trawl gear was used. H1 = first half year; H2 = second half year. SS discard reflects the estimate of discard based on applying ratios of discards to landings by trip, stratified by landings level (< 300 kg per trip, = > 300 kg per trip) to reported weighout landings. Estimates of tonnage reflecting potential discard in the entire fishery are from the method used in the SARC 27 assessment. (Eleven length measurements from scallop dredges were not used in 1995.)

Year	Trips		Lengths			SS Discard	Intensity
	All	OT	H1	H2	Total	(mt)	(mt/100 lengths)
1989	63	61	4,449	2,910	7,359	2,173	30
1990	52	52	2,582	781	3,363	3,877	115
1991	104	91	1,237	1,780	3,017	3,535	117
1992	106	53	1,158	0	1,158	5,749	496
1993	64	29	275	154	429	1,434	334
1994	7	7	99	119	218	773	355
1995	20	18	162	383	556	2,046	368
1996	32	27	1,093	435	1,528	1,522	100
1997	58	45	750	1	751		
1998	41	33	618	64	682		
1999	40	35	586	89	675		
2000	72	62	3,981	762	4,743		
2001	67	67	1,473	401	1,874		

Table B6. GMDL . Summary NEFSC Domestic Sea Sampling program data for scup during 1997-2001. Geometric mean discards to landings ratios (retransformed, mean ln-transformed D/L per trip) are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips with both scup landings and discard, which are used to calculate the per trip discard to landings ratios. Corresponding dealer landings are from the NEFSC database.

1997		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.8957	17	258	231	0.8221	4	1,244	1,023
HY 2	0.8957	0	279	250	0.8221	0	413	340
Total			537	481			1,657	1,362

1998		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	2.401	7	196	471	121.71	1	920	111,973
HY 2	3.126	10	281	878	121.71	0	496	60,368
Total			477	1,349			1,416	172,341

1999		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	1.742	6	245	427	3.766	2	785	2,956
HY 2	1.742	0	178	310	3.766	0	299	1,126
Total			423	737			1,084	4,082

Table B6. GMDL continued .

2000		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	4.5818	13	196	898	0.6018	2	655	394
HY 2	3.5001	1	292	1,022	0.6018	0	63	38
Total		14	488	1,920		2	718	432

2001		Trips <300 kg				Trips =>300 kg		
Period	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	GM D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	0.8916	10	180	160	0.9185	4	1,013	930
HY 2	0.4606	2	307	141	0.9185	0	290	266
Total		14	487	302		4	1,303	1,197

Table B7. AGDL . Summary NEFSC Domestic Sea Sampling program data for scup during 1997-2001. Aggregate discards to landings ratios (summed D/summed L for all trips in stratum) are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips in the stratum which are used to calculate the aggregate ratio. Corresponding dealer landings are from the NEFSC database.

1997		Trips <300 kg				Trips =>300 kg		
Period	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	6.45	29	258	1,664	0.92	4	1,244	1,144
HY 2	6.45	0	279	1,800	0.92	0	413	380
Total			537	3,464			1,657	1,524

1998		Trips <300 kg				Trips =>300 kg		
Period	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	9.77	16	196	1,915	121.71	1	920	111,973
HY 2	5.80	16	281	1,630	121.71	0	496	60,368
Total			477	3,545			1,416	172,341

1999		Trips <300 kg				Trips =>300 kg		
Period	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	20.59	14	245	5,045	3.77	2	785	2,959
HY 2	20.59	0	178	3,665	3.77	0	299	1,127
Total			423	8,710			1,084	4,087

2000		Trips <300 kg				Trips =>300 kg		
Period	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	12.36	31	196	2,423	0.69	2	655	452
HY 2	26.13	29	292	7,630	0.69	0	63	43
Total			488	10,053			718	495

2001		Trips <300 kg				Trips =>300 kg		
Period	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)	AG D/L	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	4.79	37	180	862	1.44	4	1,013	1,459
HY 2	10.82	22	307	3,322	0.00	4	290	0
Total			487	4,184			1,303	1,459

Table B8. DELTA. Summary NEFSC Domestic Sea Sampling program data for scup during 1997-2001. Mean differences (kg) between landings and discard (D = landings - discard, per trip) are stratified by half-year period (HY1, HY2) and trip landings level (< 300 kg, => 300 kg). N is number of sea sample trips in the stratum which are used to calculate the mean difference in stratum, which is then applied to the landings of every trip in the NEFSC dealer database to calculate a discard for each trip (discard = landings - (D)).

1997		Trips <300 kg				Trips =>300 kg		
Period	D	N	Dealer Landings (mt)	Estimated Discard (mt)	D	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	-49.4	29	258	624	167.7	4	1,244	1,118
HY 2	-18.6	6	279	477	167.7	0	413	355
Total			537	1,101			1,657	1,473

1998		Trips <300 kg				Trips =>300 kg		
Period	D	N	Dealer Landings (mt)	Estimated Discard (mt)	D	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	-53.2	16	196	544	-72707	1	920	45,857
HY 2	-46.1	16	281	846	-72707	0	496	37,140
Total			477	1,390			1,416	82,997

1999		Trips <300 kg				Trips =>300 kg		
Period	D	N	Dealer Landings (mt)	Estimated Discard (mt)	D	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	-97.1	14	245	978	-3271	2	785	2,660
HY 2	-11.9	19	178	242	-3271	0	299	1,494
Total			423	1,220			1,084	4,154

2000		Trips <300 kg				Trips =>300 kg		
Period	D	N	Dealer Landings (mt)	Estimated Discard (mt)	D	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	-194.6	31	196	1,143	1062	2	655	148
HY 2	-39.3	29	292	804	1062	0	63	44
Total			488	1,947			718	192

2001		Trips <300 kg				Trips =>300 kg		
Period	D	N	Dealer Landings (mt)	Estimated Discard (mt)	D	N	Dealer Landings (mt)	Estimated Discard (mt)
HY 1	-34.5	37	180	161	-1868.5	4	1,013	931
HY 2	-10.7	22	307	142	998	4	290	0
Total			487	303			1,303	931

Table B9. SUMMARY. A summary of landings, discards, and aggregate discards to landings ratio (D:L) from the three alternative methods of discard calculation.

Year	Landings (mt)	GMDL Discards (mt)	GMDL D:L ratio	AGDL Discards (mt)	AGDL D:L ratio	Delta Discards (mt)	Delta D:L ratio
1997	2,194	1,843	0.84	4,988	2.27	2,574	1.17
1998	1,893	173,690	91.75	175,886	92.91	84,387	44.58
1999	1,507	4,819	3.20	12,797	8.49	5,374	3.57
2000	1,206	2,352	1.95	10,548	8.75	2,139	1.77
2001	1,790	1,499	0.84	5,643	3.15	1,234	0.69

Table B10. Comp. Comparison of Sea Sampled (SS) and Vessel Trip Report (VTR) trawl gear geometric mean discard ratios for scup (Re-transformed mean of the natural log of discard to landed ratio on trips catching scup. In VTR, data was subset to include only trawl trips that reported some discard of any species). Values in bold were substituted for inadequate data in discard calculation (i.e., missing or unrepresentative SS trips; see report text).

		Trip Landings < 300 kg		Trip Landings => 300 kg	
Year	Reporting System	Half-year 1	Half-year 2	Half-year 1	Half-year 2
1994	SS	0.81	0.74	0.11	0.18
	VTR	0.11	0.10	0.05	0.03
1995	SS	1.62	1.77	**0.48**	**0.48**
	VTR	0.14	0.23	0.05	0.04
1996	SS	0.74	0.91	**0.48**	**0.48**
	VTR	0.44	0.23	0.89	0.05
1997	SS	0.90	**0.90**	0.82	**0.82**
	VTR	0.14	0.37	0.04	0.05
1998	SS	0.88	1.14	4.81	n/a
	VTR	0.28	0.64	0.11	0.05
1999	SS	0.55	n/a	1.33	n/a
	VTR	0.25	0.43	0.04	0.05
2000	SS	4.58	3.50	0.60	n/a
	VTR	1.19	0.86	0.04	n/a
2001	SS	0.89	0.46	0.92	n/a
	VTR	0.64	0.27	0.06	0.08

Table B11. Total catch (mt) of scup from Maine through North Carolina, 1960 – 2001.

	Commercial		DWF	Recreational		Total
Year	Landings	Discards	Landings	Landings	Discards	Catch
1960	22236	11198	0	3689	75	37199
1961	20944	10548	0	3642	74	35208
1962	20831	10491	0	3593	73	34988
1963	18884	9510	5863	3457	71	37785
1964	17204	8664	459	3274	67	29668
1965	15785	7950	2089	3200	65	29089
1966	11960	6023	823	2425	49	21280
1967	8748	4406	896	1841	38	15928
1968	6630	3339	2251	1443	29	13692
1969	5149	2593	485	1085	22	9334
1970	4493	2263	288	982	20	8046
1971	3974	2001	889	836	17	7717
1972	4203	2117	1647	780	16	8763
1973	5024	2530	1783	1095	22	10455
1974	7106	3579	958	1360	28	13031
1975	7623	3839	685	1375	28	13550
1976	7302	3677	87	1159	24	12249
1977	8330	4195	28	1370	28	13951
1978	8936	4500	3	1230	25	14695
1979	8585	4324	0	1198	24	14130
1980	8424	4242	16	3109	62	15854
1981	9856	4964	1	2636	53	17510
1982	8704	4383	0	2361	47	15496
1983	7794	3925	0	2836	57	14612
1984	7769	2158	0	1096	30	11053
1985	6727	4184	0	2764	54	13729
1986	7176	2005	0	5264	87	14532
1987	6276	2537	0	2806	38	11657
1988	5943	1657	0	1936	31	9567
1989	3984	2173	0	2521	39	8717
1990	4571	3877	0	1878	38	10364
1991	7081	3535	0	3668	78	14362
1992	6259	5749	0	2001	47	14056
1993	4726	1434	0	1450	28	7638
1994	4392	773	0	1192	37	6394
1995	3073	2046	0	596	33	5748
1996	2945	1522	0	1016	47	5530
1997	2188	1843	0	543	25	4599
1998	1896	3830	0	395	8	6129
1999	1505	4819	0	855	17	7196
2000	1207	2352	0	2365	50	5974
2001	1729	1499	0	1933	85	5246

Table B12. NEFSC spring and autumn trawl survey indices for scup. Strata set includes only offshore Strata 1-12, 23, 25, and 61-76 for consistency over entire time series. Strata set excludes inshore strata 1-61 that are included in the 1984 and later indices at age in later tables. **Note that Spring 2002 indices are preliminary.**

Year	Spring No./tow	Spring Kg/tow	Spring SSB kg/tow	Spring SSB 3-yr avg	Autumn No./tow	Autumn Kg/tow
1963					2.12	1.21
1964					118.70	2.23
1965					3.84	0.62
1966					2.00	0.41
1967					29.38	1.46
1968	59.21	2.25	0.94		14.35	0.54
1969	2.26	0.40	0.39	0.88	99.41	4.48
1970	78.50	3.01	1.30	1.09	10.34	0.22
1971	70.91	2.41	1.57	1.28	7.730	0.25
1972	49.80	2.30	0.98	1.21	40.56	2.34
1973	3.62	1.19	1.09	1.38	22.82	0.93
1974	30.28	3.24	2.06	1.92	9.94	1.01
1975	14.01	3.12	2.61	1.73	52.21	3.40
1976	4.09	0.63	0.53	2.50	161.14	7.35
1977	42.46	4.48	4.35	2.49	32.64	1.71
1978	39.85	3.49	2.59	2.77	12.17	1.32
1979	22.42	1.95	1.38	1.69	15.77	0.61
1980	9.31	1.31	1.09	1.12	11.05	0.92
1981	14.72	1.16	0.90	1.00	67.14	3.01
1982	7.88	1.16	1.02	0.65	25.47	1.17
1983	0.80	0.29	0.03	0.46	4.59	0.34
1984	8.52	0.51	0.33	0.24	24.03	1.22
1985	14.67	0.80	0.37	0.68	68.30	3.56
1986	11.74	1.30	1.33	0.98	46.19	1.66
1987	10.82	1.21	1.24	1.10	5.76	0.15
1988	25.41	1.26	0.73	0.66	5.75	0.09
1989	1.63	0.12	0.00	0.35	5.70	0.30
1990	1.17	0.39	0.31	0.26	16.53	0.83
1991	12.61	0.75	0.45	0.32	9.52	0.43
1992	6.79	0.40	0.21	0.32	16.19	1.12
1993	2.93	0.33	0.31	0.18	0.43	0.04
1994	1.54	0.09	0.03	0.15	3.59	0.11
1995	2.90	0.22	0.12	0.06	24.72	0.91
1996	0.53	0.03	0.02	0.08	4.46	0.23
1997	0.91	0.11	0.11	0.06	16.92	0.88
1998	40.04	0.87	0.05	0.08	25.35	0.69
1999	1.70	0.12	0.09	0.08	85.23	2.07
2000	6.71	0.33	0.11	0.25	99.33	4.79
2001	13.03	0.80	0.54	3.20	20.28	1.11
2002	167.93	13.46	8.94			

Table B13. NEFSC spring trawl survey stratified mean number of scup per tow at age. Strata set includes offshore strata 1-12, 23, 25, 61-76, and inshore strata 1-61. **Note that Spring 2002 indices are preliminary.**

Spring Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	age 2+	age 3+
1984		4.95	1.55	0.18	0.10	0.02							6.88	1.85	0.30
1985		9.84	1.65	0.17	0.01								11.98	1.83	0.18
1986		0.84	8.06	0.19									9.47	8.25	0.19
1987		3.76	2.96	1.49	0.61	0.03	0.02	0.02	0.01			0.01	8.90	5.15	2.19
1988		13.66	6.90	0.14	0.02		0.02	0.05					20.98	7.13	0.23
1989		0.66	0.42	0.08	0.01								1.36	0.51	0.09
1990		0.14	0.24	0.25	0.15	0.08	0.11	0.03					1.01	0.86	0.62
1991		8.26	0.42	0.89	0.16								10.17	1.47	1.05
1992		4.60	0.71	0.06	0.04	0.05	0.10						5.46	0.96	0.25
1993		0.50	1.62	0.14	0.09	0.02							2.37	1.87	0.25
1994		1.07	0.08	0.03									1.24	0.11	0.03
1995		1.84	0.36	0.08	0.04								2.35	0.48	0.12
1996		0.35	0.04	0.02	0.01								0.42	0.07	0.03
1997		0.27	0.52	0.08									0.87	0.60	0.08
1998		32.15	0.08	0.01									32.24	0.09	0.01
1999		0.82	0.54	0.01									1.37	0.55	0.01
2000		4.78	0.58	0.06									5.42	0.64	0.06
2001		6.38	4.07	0.06		0.02							10.53	4.15	0.08
2002		97.91	12.78	21.47	2.64	0.25							135.05	37.14	24.36

Table B14. NEFSC autumn trawl survey stratified mean number of scup per tow at age. Strata set includes offshore strata 1-12, 23, 25, 61-76, and inshore strata 1-61.

Autumn Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	age 2+	age 3+
1984	47.64	9.20	0.34	0.03	0.01		0.01						59.96	0.39	0.05
1985	61.22	11.53	1.10	0.26	0.06	0.05							74.71	1.47	0.37
1986	70.19	6.58	0.57		0.01								77.36	0.58	0.01
1987	49.93	29.85	0.46	0.01									80.45	0.47	0.01
1988	47.44	15.95	0.67	0.10									64.22	0.77	0.10
1989	176.37	25.92	0.66	0.03									202.99	0.69	0.03
1990	77.45	9.21	0.75	0.04									87.46	0.79	0.04
1991	151.62	12.51	0.07	0.02									164.24	0.09	0.02
1992	25.92	14.51	1.66	0.04	0.02								42.15	1.72	0.06
1993	46.78	9.76	0.32										56.86	0.32	0.00
1994	39.54	3.92	0.04	0.01									43.52	0.05	0.01
1995	33.04	2.61	0.08	0.01									35.74	0.09	0.01
1996	24.42	2.86	0.43	0.01									27.73	0.44	0.01
1997	46.91	0.61	0.02		0.01								47.66	0.03	0.01
1998	57.73	9.64	0.09	0.03	0.01								67.50	0.13	0.04
1999	96.06	9.77	1.37	0.07	0.01								107.28	1.45	0.08
2000	98.72	20.60	3.14	0.48	0.11	0.07							123.12	3.80	0.66
2001	91.84	10.32	1.82	0.12	0.04	0.01							104.15	1.99	0.17

Table B15. NEFSC Winter trawl survey indices of abundance for scup, offshore survey strata 1-12 and 61-76. The 1992, 1993, and 1996 lengths are aged with the corresponding annual spring survey age-length key. **Note that Winter 2002 indices are preliminary.**

Year	Mean number per tow	Mean kg per tow
1992	63.18	2.76
1993	25.71	2.73
1994	17.09	0.66
1995	67.01	2.18
1996	18.29	1.19
1997	13.90	0.32
1998	46.92	1.20
1999	15.04	0.71
2000	24.21	1.33
2001	55.49	1.58
2002	259.51	7.49

Winter					Age							
Year	0	1	2	3	4	5	6	7	8	Total	age 2+	age 3+
1992		57.61	4.75	0.19	0.09	0.10	0.45			63.18	5.57	0.82
1993		2.51	22.05	0.56	0.57	0.02				25.71	23.19	1.15
1994		16.31	0.73	0.02	0.02	0.01				17.09	0.78	0.05
1995		64.94	1.87	0.15	0.01	0.01	0.02	0.01		67.01	2.07	0.20
1996		12.95	5.31	0.03	0.01					18.29	5.34	0.04
1997		13.27	0.52	0.11						13.90	0.64	0.11
1998		45.62	0.75	0.22	0.21	0.08	0.03	0.01		46.92	1.30	0.55
1999		12.48	2.41	0.12	0.02	0.01				15.04	2.56	0.15
2000		20.28	3.21	0.68	0.03			0.01		24.21	3.93	0.72
2001		48.54	6.48	0.36	0.09	0.02				55.49	6.95	0.47
2002		248.54	7.66	2.96	0.33	0.01	0.01			259.51	10.97	3.31

Table B16. MADMF trawl surveys' mean number of scup per tow and total mean weight(kg) per tow for spring (survey regions 1-3) and fall (all survey regions).

	Spring		Fall	
Year	No./Tow	Kg/Tow	No./Tow	Kg/Tow
1978	88.20	31.11	1765.90	14.01
1979	74.48	17.64	1088.60	11.38
1980	191.91	42.05	1112.20	11.77
1981	292.37	17.40	911.20	13.51
1982	10.37	0.97	2012.70	8.61
1983	24.42	3.40	1536.60	12.22
1984	17.80	6.50	907.20	11.54
1985	65.85	3.33	605.70	11.41
1986	43.76	7.28	727.60	8.57
1987	6.01	1.36	530.40	7.29
1988	13.98	2.08	1325.90	13.37
1989	13.05	1.97	555.00	7.34
1990	141.74	21.21	1054.40	6.76
1991	28.62	6.04	1088.90	9.67
1992	14.26	2.47	2307.80	10.90
1993	18.41	4.08	957.40	9.94
1994	9.60	2.82	781.10	9.35
1995	48.30	2.72	481.70	3.88
1996	5.04	0.66	965.00	8.65
1997	3.21	0.71	874.10	6.88
1998	1.26	0.19	670.90	6.55
1999	11.26	1.87	1152.20	17.11
2000	266.94	15.49	821.56	10.97
2001	7.20	2.34	1143.78	9.39

Table B17. RIDFW spring and fall trawl survey mean number of scup per tow and mean weight (kg) of scup per tow.

	Spring		Fall	
Year	No./Tow	Kg/Tow	No./Tow	Kg/Tow
1981	12.49	0.40	196.22	2.54
1982	0.43	0.04	63.87	0.70
1983	3.59	0.32	173.63	2.75
1984	13.24	0.88	589.68	10.57
1985	8.30	0.41	74.27	1.51
1986	1.78	0.33	340.06	4.20
1987	0.04	0.01	314.20	4.73
1988	0.23	0.04	804.00	7.10
1989	0.17	0.04	326.86	6.62
1990	0.64	0.15	527.31	5.66
1991	2.93	0.57	655.69	16.62
1992	1.88	0.61	1105.51	9.10
1993	1.12	0.06	1246.35	8.90
1994	2.08	0.53	236.12	3.66
1995	4.33	0.53	423.02	5.03
1996	0.52	0.07	184.73	3.83
1997	1.93	0.15	597.90	6.04
1998	0.15	0.03	150.38	1.89
1999	0.38	0.07	832.22	12.39
2000	84.05	3.54	588.73	9.11
2001	29.68	5.08	1139.17	11.07

Table B18. CTDEP spring trawl survey mean number of scup per tow at age, total mean number per tow, and total mean weight (kg) per tow.

	Age														Total	Total	Age
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	No./Tow	Kg/Tow	2+
1984	0.49	1.31	0.59	0.30	0.08	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	2.80	0.64	2.31
1985	2.94	2.00	0.33	0.24	0.05	0.02	0.05	0.00	0.00	0.01	0.00	0.00	0.00	0.00	5.61	1.22	2.71
1986	4.44	1.65	0.99	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	0.78	2.79
1987	0.43	1.65	0.07	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.37	1.76
1988	1.18	0.30	0.51	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.32	0.88
1989	5.63	0.56	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.77	0.63	0.62
1990	2.56	2.06	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.25	0.61	2.30
1991	4.25	1.44	1.26	0.09	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09	0.94	2.80
1992	0.39	1.21	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.48	1.36
1993	0.04	2.29	0.19	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.49	2.49
1994	0.81	2.03	0.93	0.10	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88	0.58	3.09
1995	12.94	0.39	0.20	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.24	0.65	0.64
1996	5.20	2.48	0.07	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.25	0.73	2.56
1997	3.16	2.61	1.68	0.06	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	0.75	4.39
1998	10.07	0.58	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.25	0.75	0.76
1999	2.71	1.75	0.16	0.07	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.22	0.56	2.02
2000	124.51	17.18	4.24	0.20	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.46	4.56	21.71
2001	1.65	18.99	1.57	0.25	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20	2.85	20.84

Table B19. CTDEP fall trawl survey mean number of scup per tow at age, total mean number per tow, and total mean weight (kg) per tow.

	Age											Total	Total	Age
Year	0	1	2	3	4	5	6	7	8	9	10	No./Tow	Kg/Tow	2+
1984	7.99	1.04	0.78	0.52	0.28	0.09	0.02	0.00	0.00	0.00	0.00	10.72	1.36	1.69
1985	25.01	4.71	0.40	0.59	0.19	0.04	0.03	0.00	0.00	0.00	0.00	30.97	2.50	1.26
1986	13.06	9.98	2.50	0.19	0.01	0.01	0.01	0.00	0.00	0.00	0.00	25.76	2.95	2.71
1987	12.47	4.17	1.25	0.58	0.06	0.01	0.01	0.00	0.00	0.00	0.00	18.54	1.79	1.91
1988	31.89	5.71	1.82	0.24	0.03	0.00	0.00	0.00	0.00	0.00	0.00	39.70	2.27	2.10
1989	40.88	22.60	1.51	0.08	0.01	0.00	0.00	0.00	0.00	0.00	0.00	65.09	3.65	1.61
1990	54.34	7.74	6.95	0.40	0.03	0.01	0.01	0.00	0.00	0.01	0.00	69.48	5.00	7.40
1991	291.58	17.03	1.76	1.04	0.15	0.01	0.00	0.00	0.00	0.00	0.00	311.57	8.30	2.95
1992	50.91	26.58	5.54	0.40	0.29	0.01	0.01	0.00	0.00	0.00	0.00	83.73	4.96	6.24
1993	74.06	1.83	1.02	0.12	0.01	0.01	0.00	0.00	0.00	0.00	0.00	77.06	3.72	1.16
1994	90.76	1.12	0.46	0.18	0.01	0.00	0.00	0.00	0.00	0.00	0.00	92.54	3.33	0.66
1995	32.46	26.52	0.14	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.14	4.63	0.15
1996	51.50	8.56	1.37	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	61.46	3.68	1.40
1997	31.79	8.68	0.63	0.17	0.01	0.00	0.00	0.00	0.00	0.00	0.00	41.28	2.49	0.81
1998	90.40	12.24	0.54	0.07	0.02	0.00	0.00	0.00	0.00	0.00	0.00	103.27	4.50	0.63
1999	498.18	30.93	8.35	0.19	0.02	0.01	0.00	0.00	0.00	0.00	0.00	537.68	22.72	8.57
2000	250.39	261.45	8.32	0.79	0.14	0.01	0.00	0.00	0.00	0.00	0.00	521.10	30.76	9.27
2001	140.51	16.90	18.42	1.61	0.19	0.03	0.00	0.00	0.00	0.00	0.00	177.64	11.28	20.24

Table B20. NJBMF trawl survey mean number of scup per tow and mean weight (kg) per tow.

Year	No./Tow	Kg/Tow
1988	475.82	14.62
1989	67.90	3.11
1990	67.39	4.12
1991	196.13	6.91
1992	224.11	7.56
1993	216.50	6.60
1994	80.15	3.18
1995	39.79	2.53
1996	30.33	0.95
1997	62.78	4.65
1998	209.50	5.72
1999	279.43	11.33
2000	206.94	6.78
2001	155.58	5.44

Table B21. VIMS age-0 scup index of abundance for Chesapeake Bay (geometric mean catch per tow, June-September).

Year	No./Tow	Lower CL	Upper CL	n
1988	2.07	1.24	3.21	92
1989	3.07	2.05	4.41	112
1990	4.92	3.14	7.45	112
1991	1.90	1.11	2.99	103
1992	0.65	0.41	0.93	104
1993	3.36	2.16	5.01	104
1994	0.90	0.53	1.35	104
1995	0.39	0.21	0.59	104
1996	0.54	0.29	0.83	104
1997	0.21	0.09	0.35	104
1998	0.50	0.28	0.76	79
1999	0.27	0.06	0.52	88
2000	0.13	0.02	0.25	107
2001	1.34	0.88	1.90	111

Table B22. NYDEC yearling (June-August) and young-of-the-year (August-September) \
scup indices (geometric mean catch per station).

	No./Tow	
Year	Yearling	YOY
1987	1.58	0.22
1988	0.80	0.50
1989	3.06	0.40
1990	0.37	1.97
1991	1.02	4.39
1992	0.66	3.76
1993	0.30	0.19
1994	0.18	1.77
1995	2.95	0.38
1996	0.41	0.26
1997	0.34	4.65
1998	0.37	10.42
1999	0.72	5.81
2000	5.58	61.66
2001	1.04	36.04

Table B23. Relative exploitation index for scup for 1981-2001. Landings are 1,000's of lbs. and SSB index values are kg/tow.

Year	Landings	Spring SSB (3-year average)	Relative Exploitation Index
1981	27,540	1.00	27.5
1982	24,394	0.65	37.5
1983	23,435	0.46	50.9
1984	19,544	0.24	81.4
1985	20,924	0.68	30.8
1986	27,425	0.98	28.0
1987	20,022	1.10	18.2
1988	17,370	0.66	26.3
1989	14,341	0.35	41.0
1990	14,218	0.26	54.7
1991	23,697	0.32	74.1
1992	18,210	0.32	56.9
1993	13,616	0.18	75.6
1994	12,311	0.15	82.1
1995	8,089	0.06	134.8
1996	8,732	0.08	109.2
1997	6,021	0.06	100.3
1998	5,051	0.08	63.1
1999	5,203	0.08	65.0
2000	7,875	0.25	31.5
2001	8,073	3.2	2.5

Table B24. NEFSC spring trawl survey stratified mean number of scup per tow at age. Strata set includes offshore strata 1-12, 23, 25, 61-76. **Note that Spring 2002 indices are preliminary.**

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11	Total
1977	6.62	32.08	3.54	0.16	0.04	0.01	0.01					42.46
1978	26.90	4.67	6.50	1.31	0.32	0.12	0.03					39.85
1979	15.63	4.04	0.88	1.28	0.37	0.06	0.13	0.02	0.01			22.42
1980	2.39	5.61	0.57	0.17	0.25	0.15	0.08	0.08	0.01			9.31
1981	10.78	2.16	1.15	0.17	0.14	0.05	0.15	0.12				14.72
1982	3.80	1.77	1.39	0.38	0.17	0.13	0.07	0.07	0.10			7.88
1983	0.70	0.03	0.06				0.01					0.80
1984	6.14	1.97	0.22	0.12	0.07							8.52
1985	12.11	2.32	0.20	0.04								14.67
1986	1.05	10.26	0.43									11.74
1987	4.57	3.60	1.81	0.74	0.04	0.02	0.03	0.01				10.82
1988	16.74	8.36	0.17	0.03	0.01	0.03	0.07					25.41
1989	0.79	0.74	0.09	0.01								1.63
1990	0.12	0.30	0.30	0.18	0.09	0.13	0.05					1.17
1991	10.61	0.70	1.11	0.19								12.61
1992	5.72	0.88	0.07	0.05	0.06	0.01						6.79
1993	0.61	2.02	0.17	0.11	0.02							2.93
1994	1.34	0.16	0.04									1.54
1995	2.29	0.44	0.11	0.05	0.01							2.90
1996	0.44	0.05	0.03	0.01								0.53
1997	0.17	0.64	0.10									0.91
1998	39.90	0.12	0.02									40.04
1999	1.03	0.67										1.70
2000	5.93	0.71	0.07									6.71
2001	7.90	5.03	0.08		0.02							13.03
2002	121.75	15.89	26.70	3.28	0.31							167.93

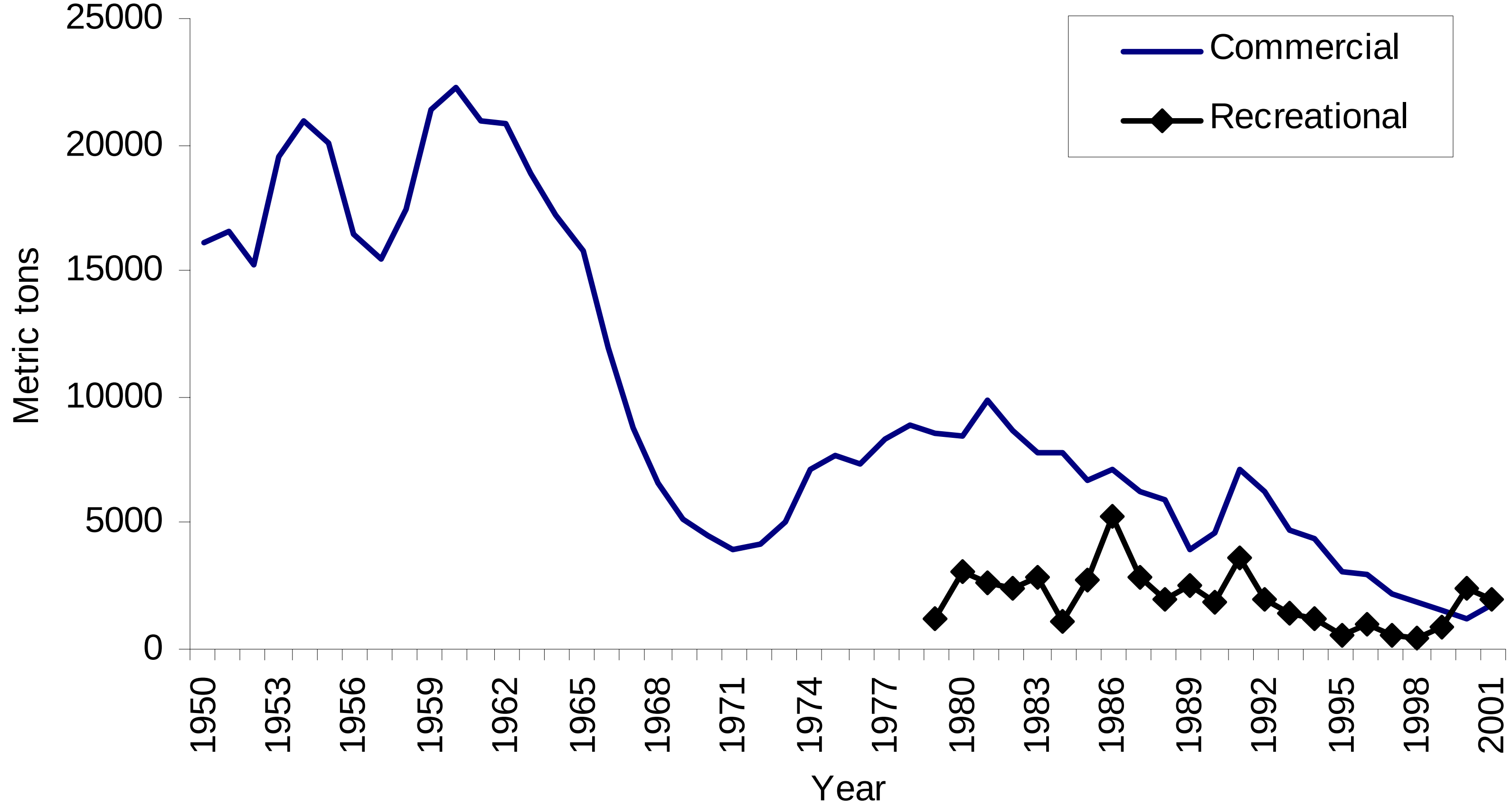


Figure B1. Landings of scup from Maine through North Carolina, including US commercial and recreational landings (1950-2001).

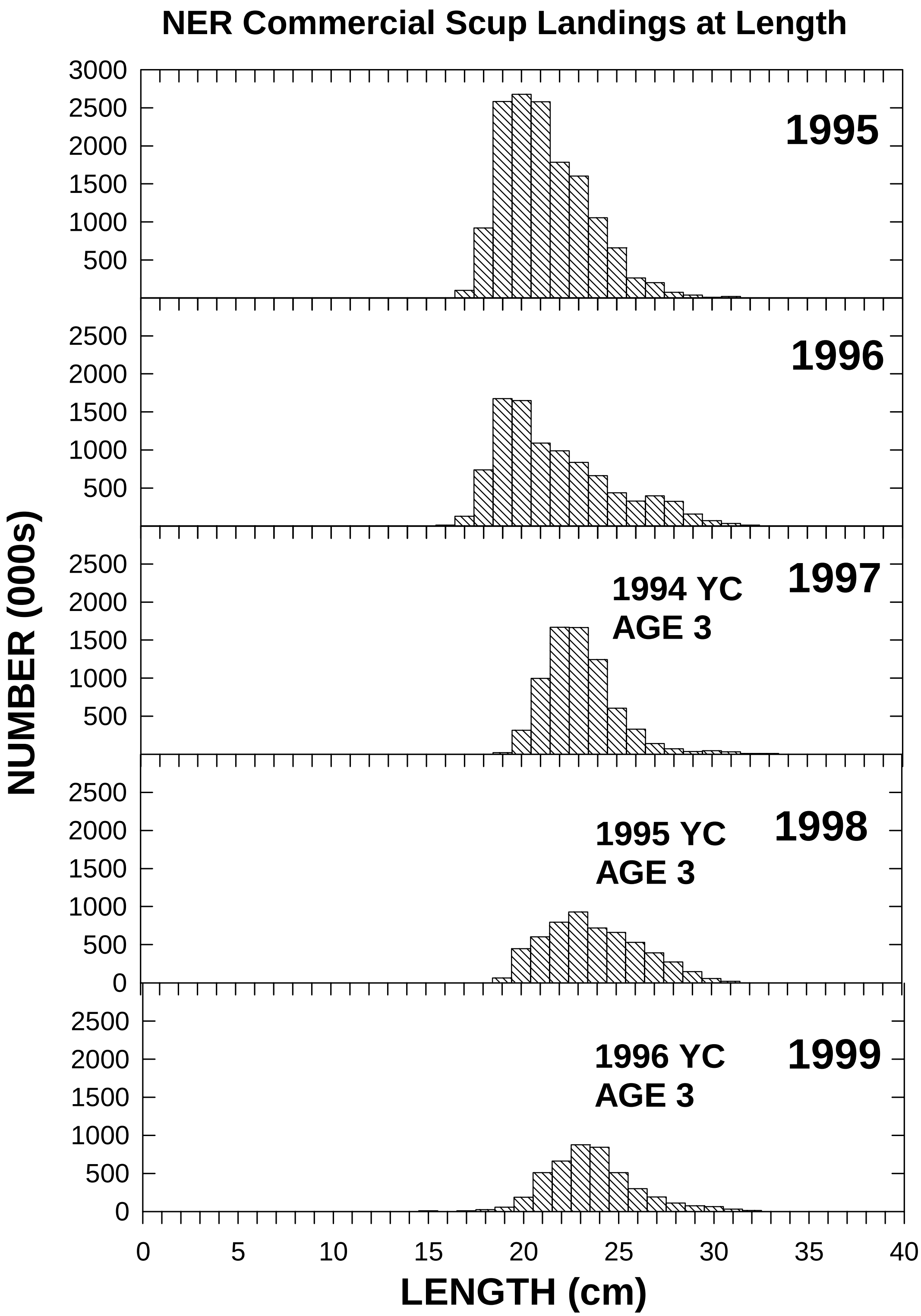


Figure B2. Northeast Region (NER; ME to VA) commercial fishery estimates of scup landings at length (fork length, cm) for 1995 to 1999.

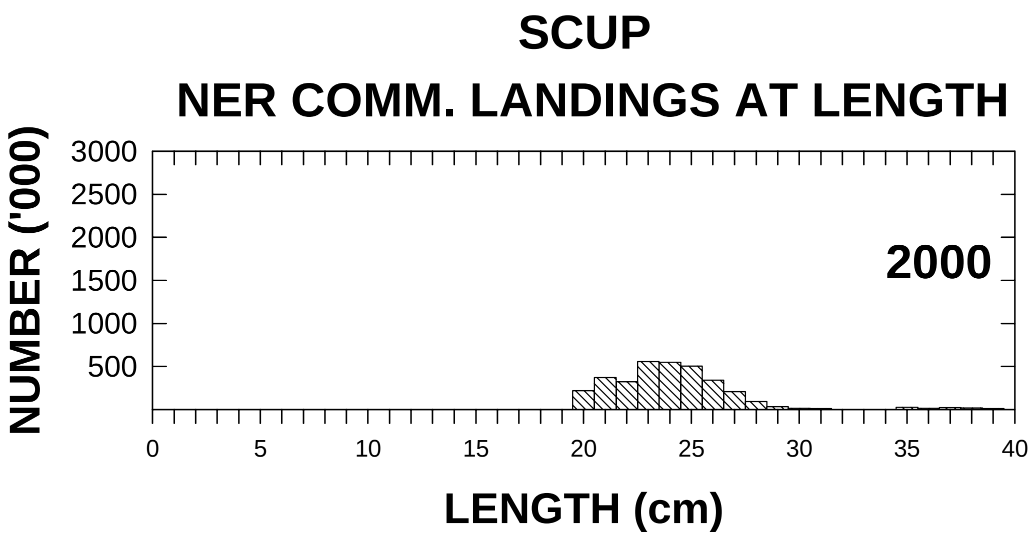


Figure B3. Northeast Region (NER; ME to VA) commercial fishery estimates of scup landings at length (fork length, cm) for 2000.

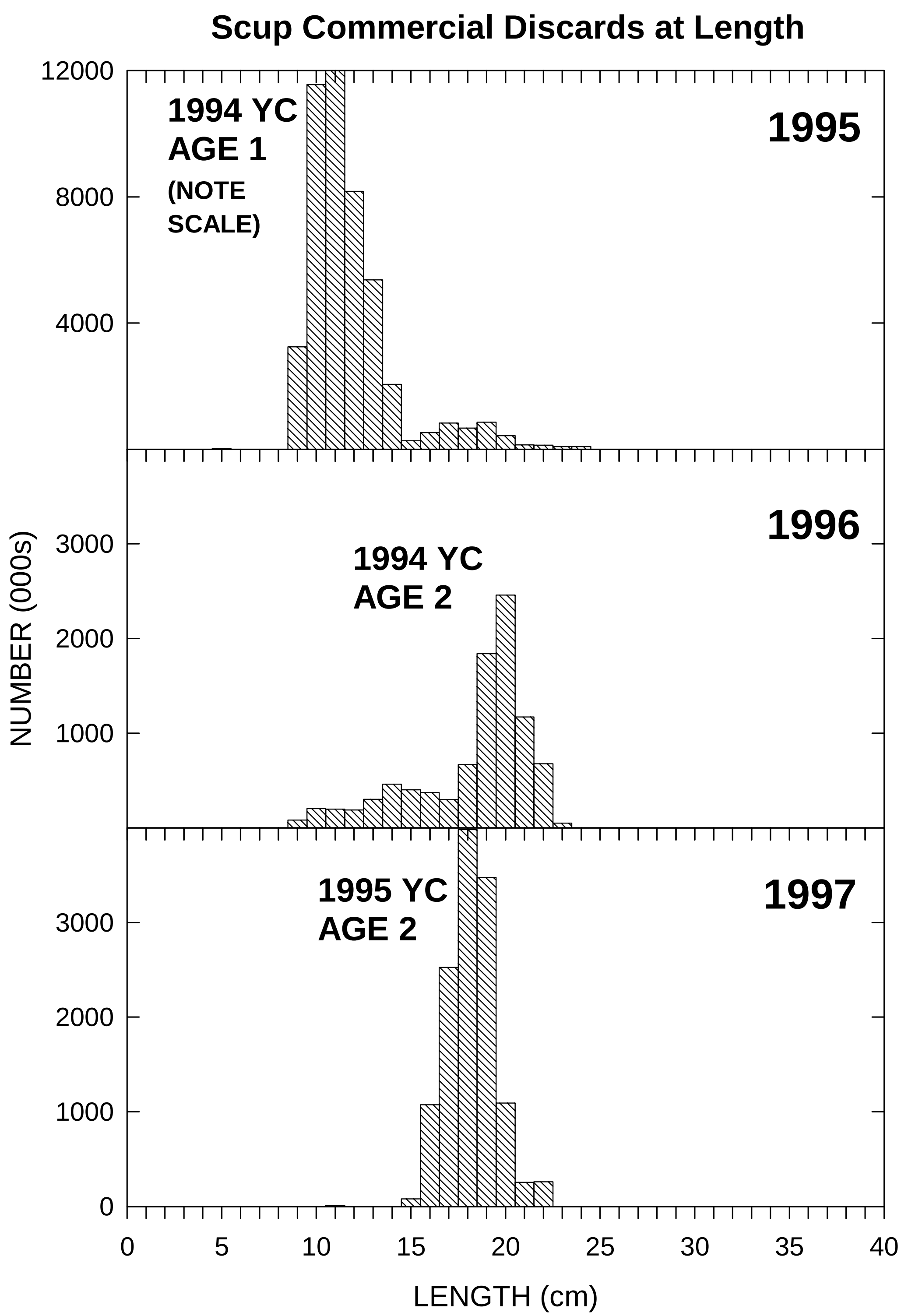


Figure B4. Northeast Region (NER; ME to VA) commercial fishery estimates of scup discards at length (fork length, cm) for 1995-1997.

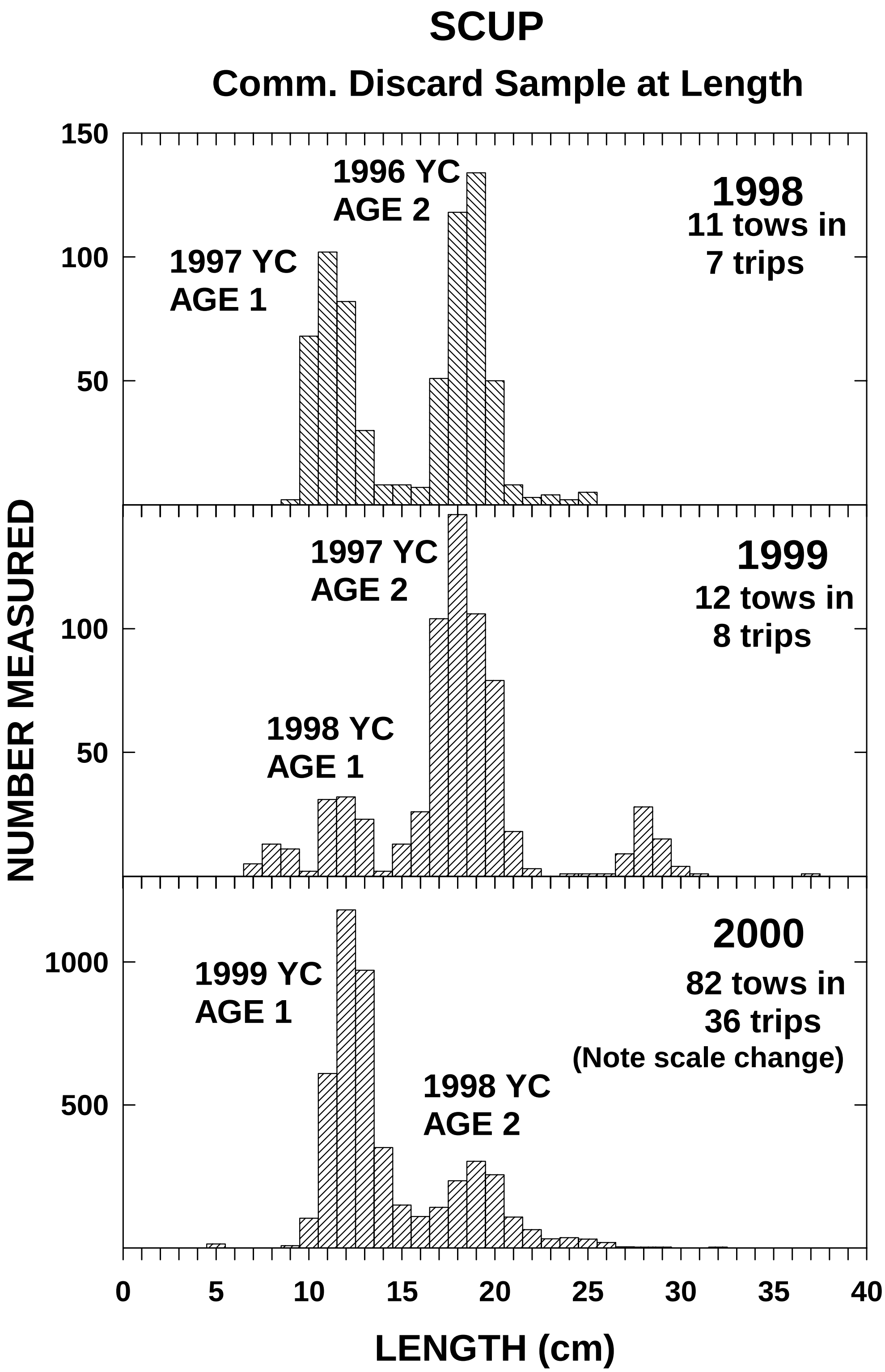


Figure B5. Northeast Region (NER; ME to VA) commercial fishery estimates of scup discards at length (fork length, cm) for 1998-2000.

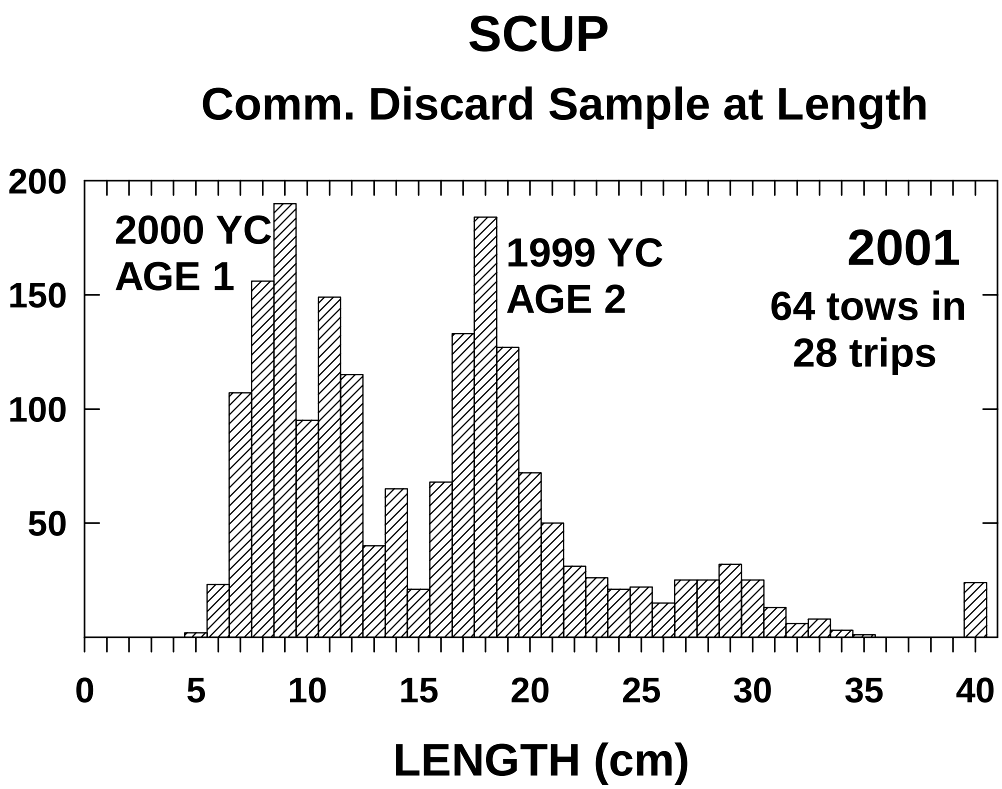


Figure B6. Northeast Region (NER; ME to VA) commercial fisher estimates of scup discards at length (fork length, cm) for 2001.

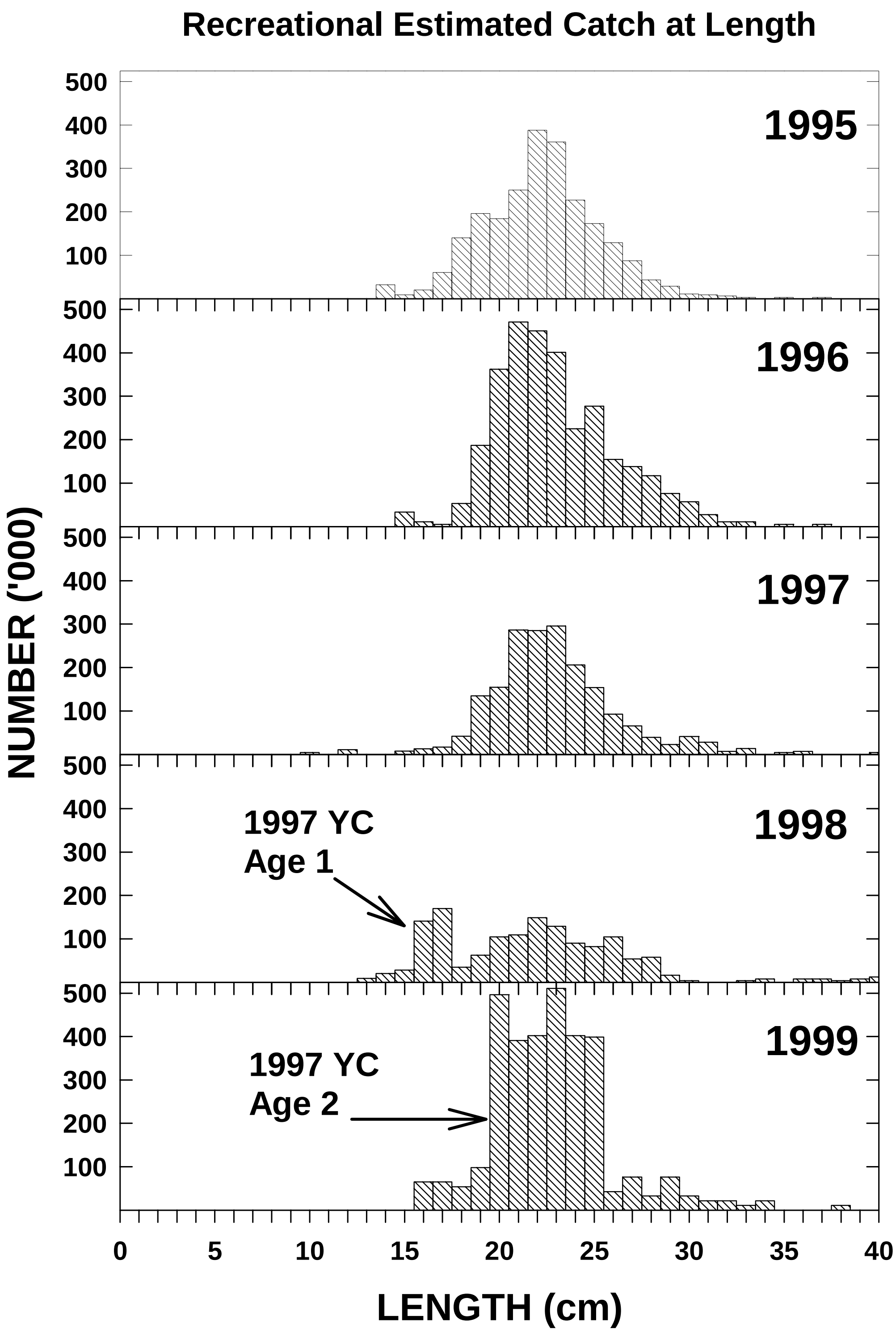


Figure B7. Coastal recreational fishery estimates of scup catch at length (fork length, cm; ME to NC) for 1995 to 1999.

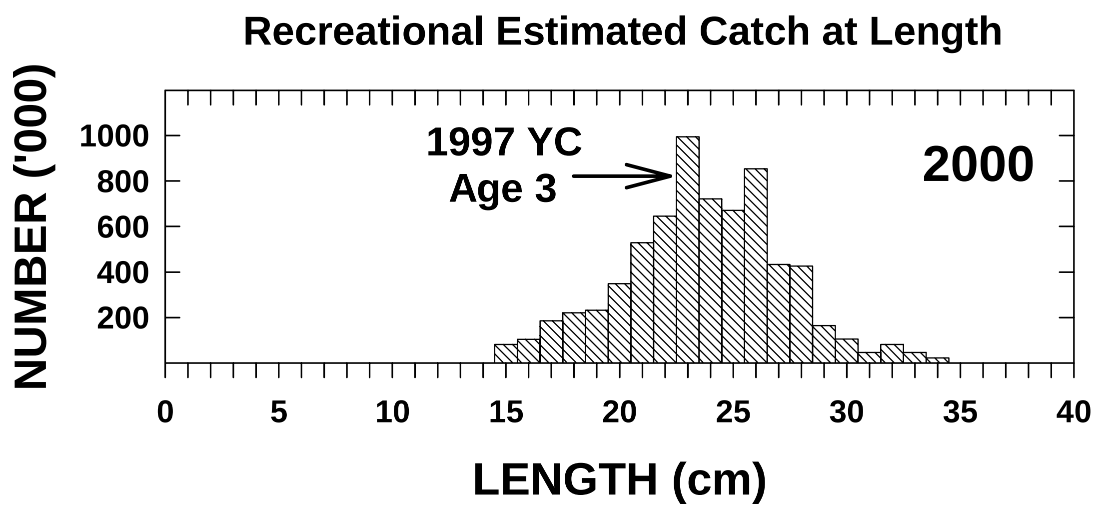


Figure B8. Coastal recreational fishery estimates of scup catch at length (fork length, cm; ME to NC) for 2000.

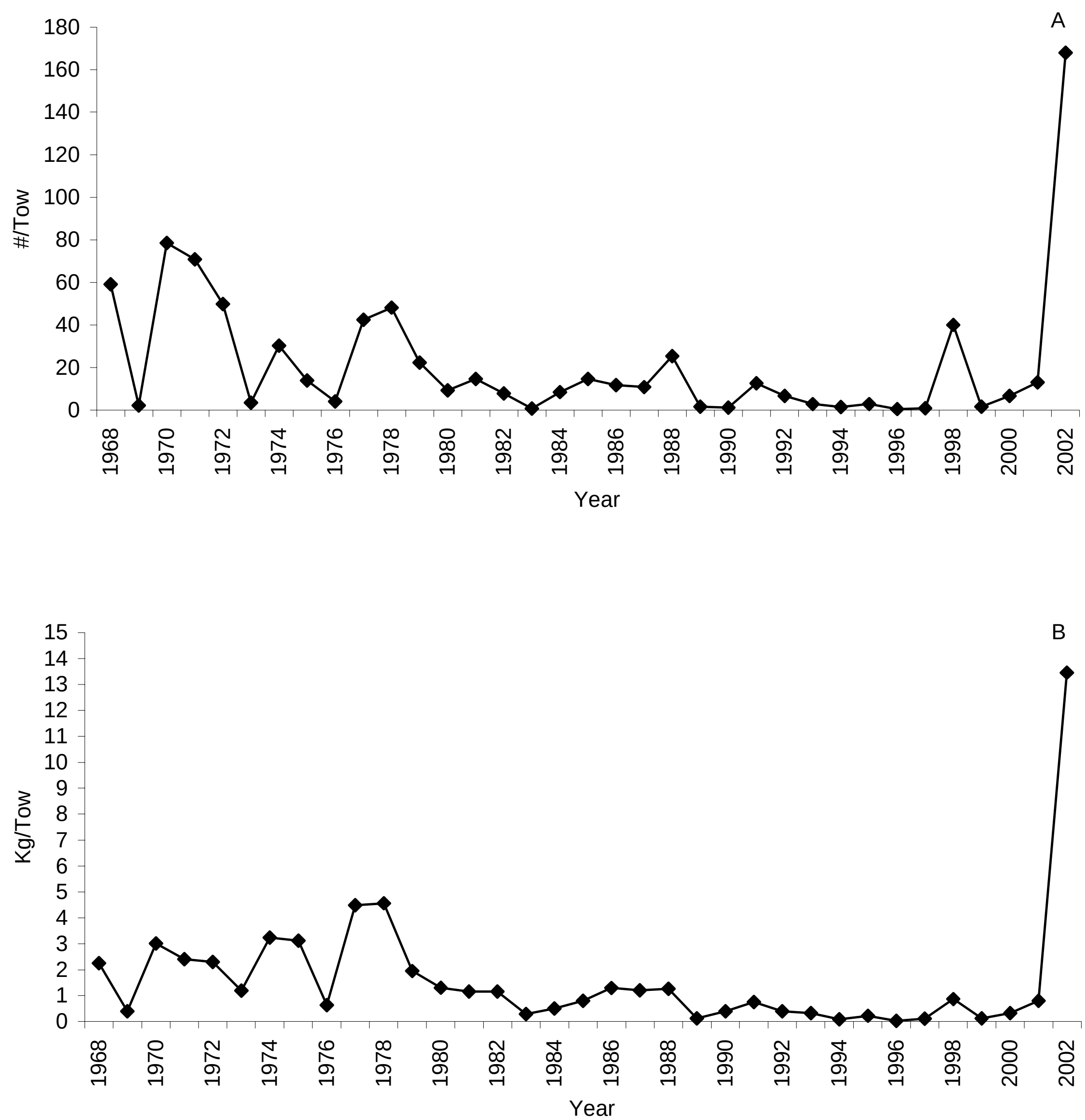


Figure B9. NEFSC spring research vessel survey (1968-2002) indices for scup abundance (A) and biomass (B) based on offshore strata 1-12, 23, 25, and 61-76. **Note that 2002 indices are preliminary**.

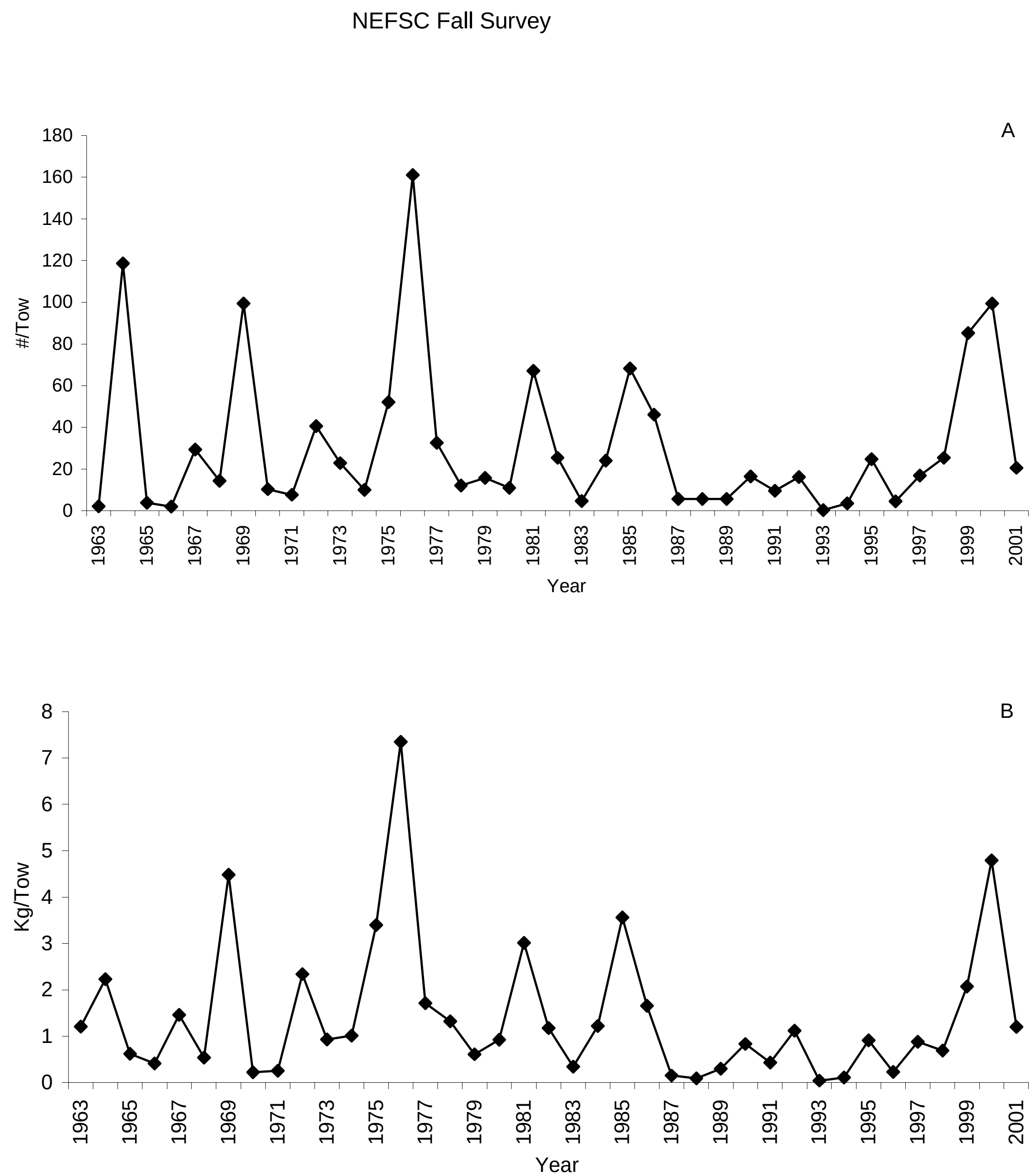
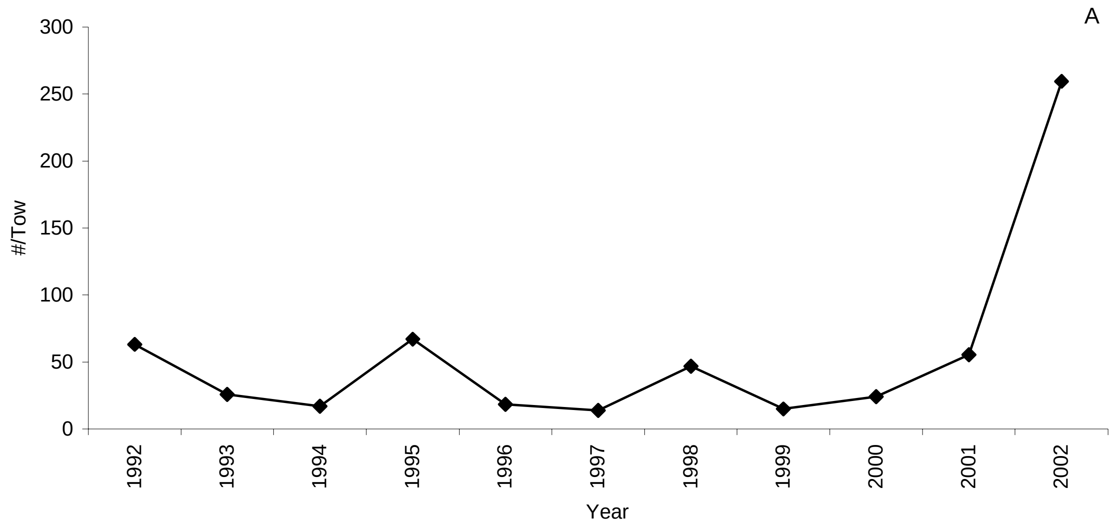


Figure B10. NEFSC fall research vessel survey (1963-2001) indices for scup abundance (A) and biomass (B) based on offshore strata 1-12, 23, 25, and 61-76.



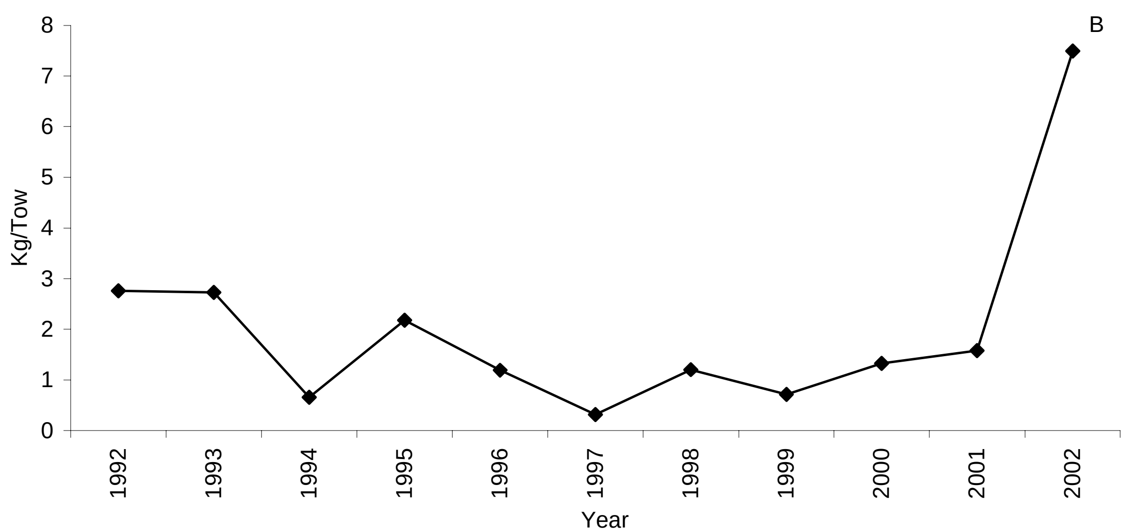


Figure B11. NEFSC winter research vessel survey (1992-2002) indices for scup abundance (A) and biomass (B) based on offshore strata 1-12 and 61-76. **Note that Winter 2002 indices are preliminary.**

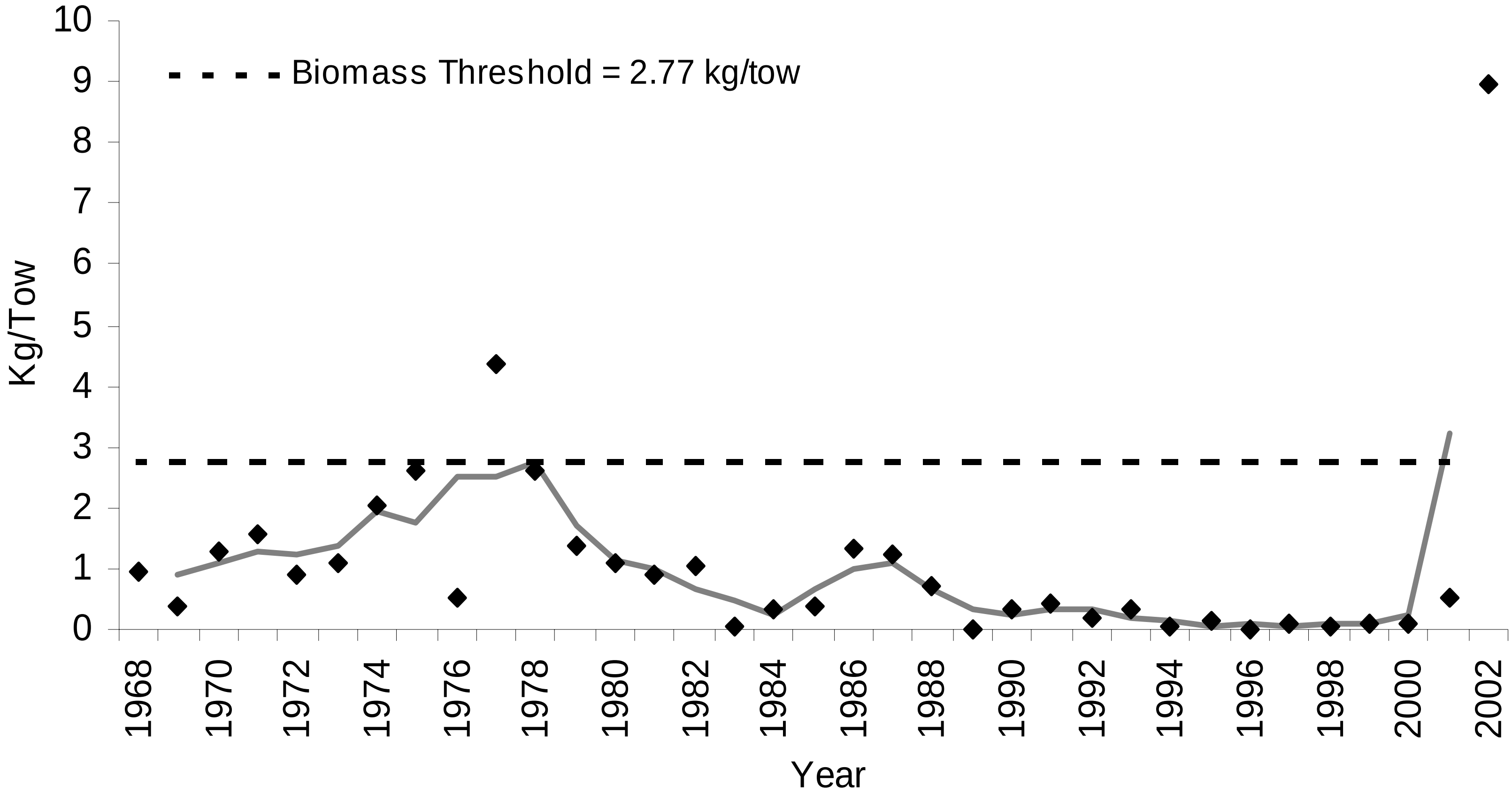


Figure B12. Scup spawning stock biomass per tow (SSB kg/tow) index (points). The solid line represents the 3-year moving average of the SSB. The dotted line represents the biomass threshold adopted for scup in Amendment 12 to the FMP. This threshold is based on the maximum value of the SSB index (2.77 kg/tow, 1977-1979).

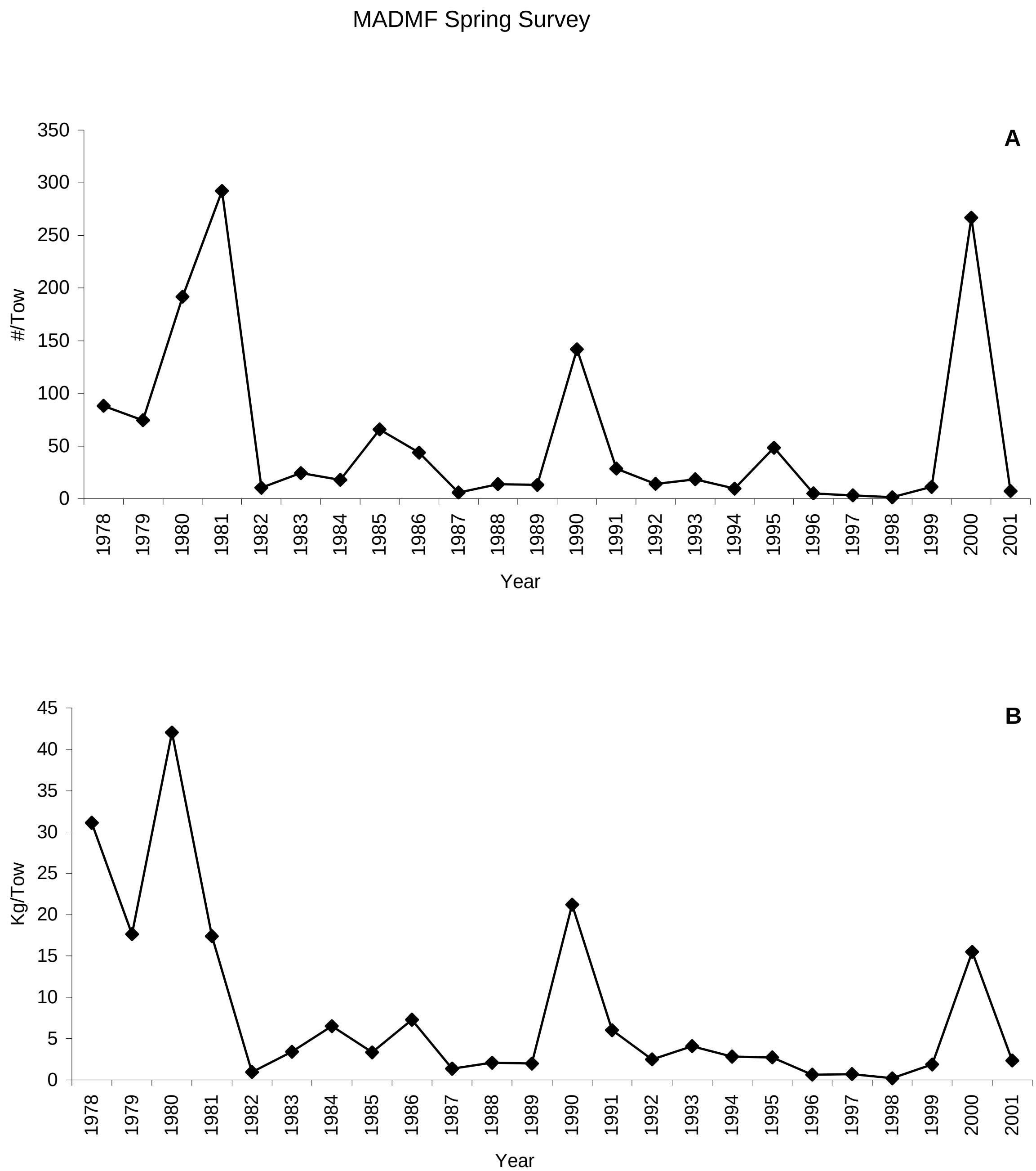


Figure B13. MADMF spring survey (1978-2001) indices for scup abundance (A) and biomass (B) based on survey regions 1, 2, and 3.

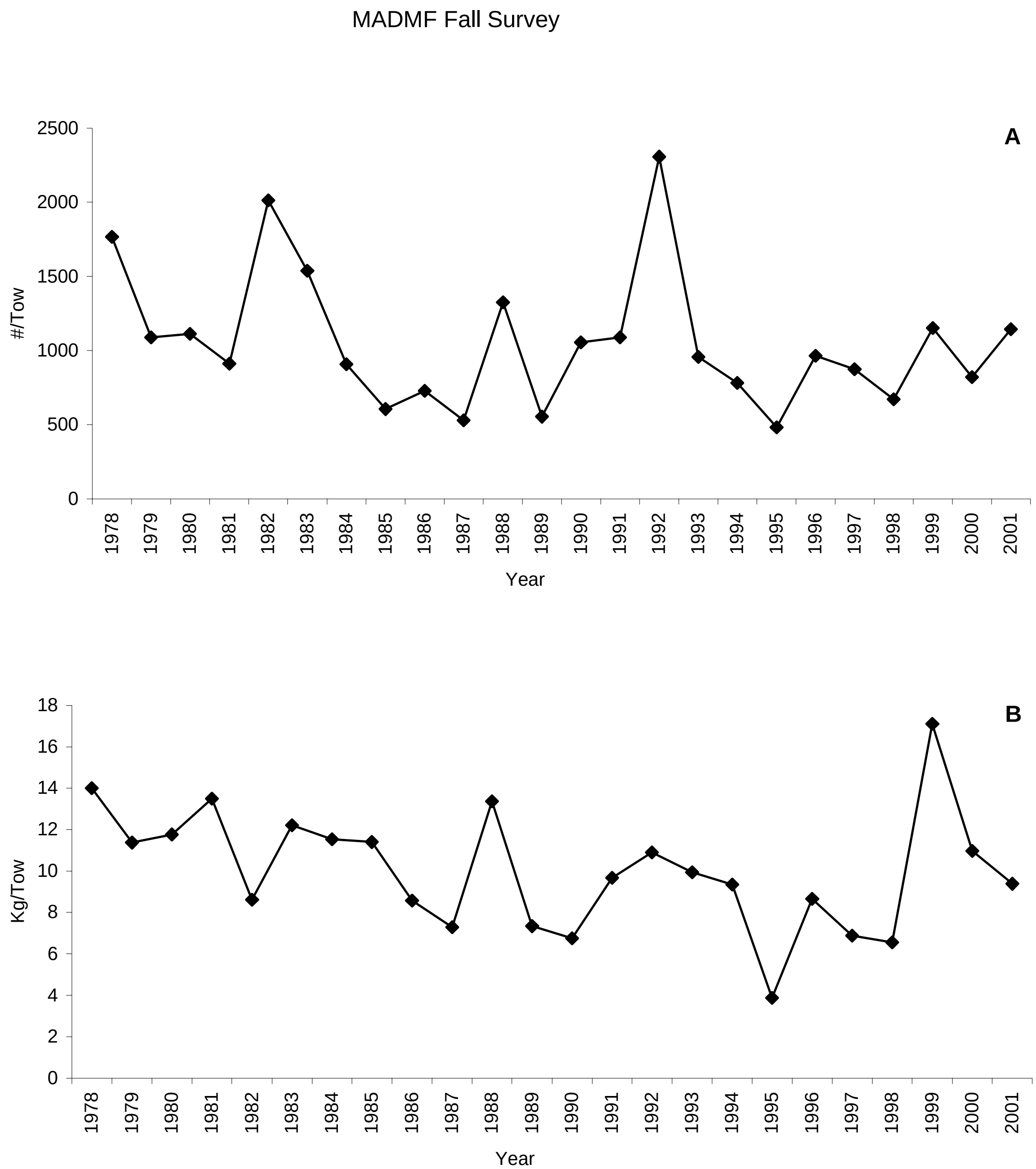


Figure B14. MADMF fall survey (1978-2001) indices for scup abundance (A) and biomass (B) based on all survey regions.

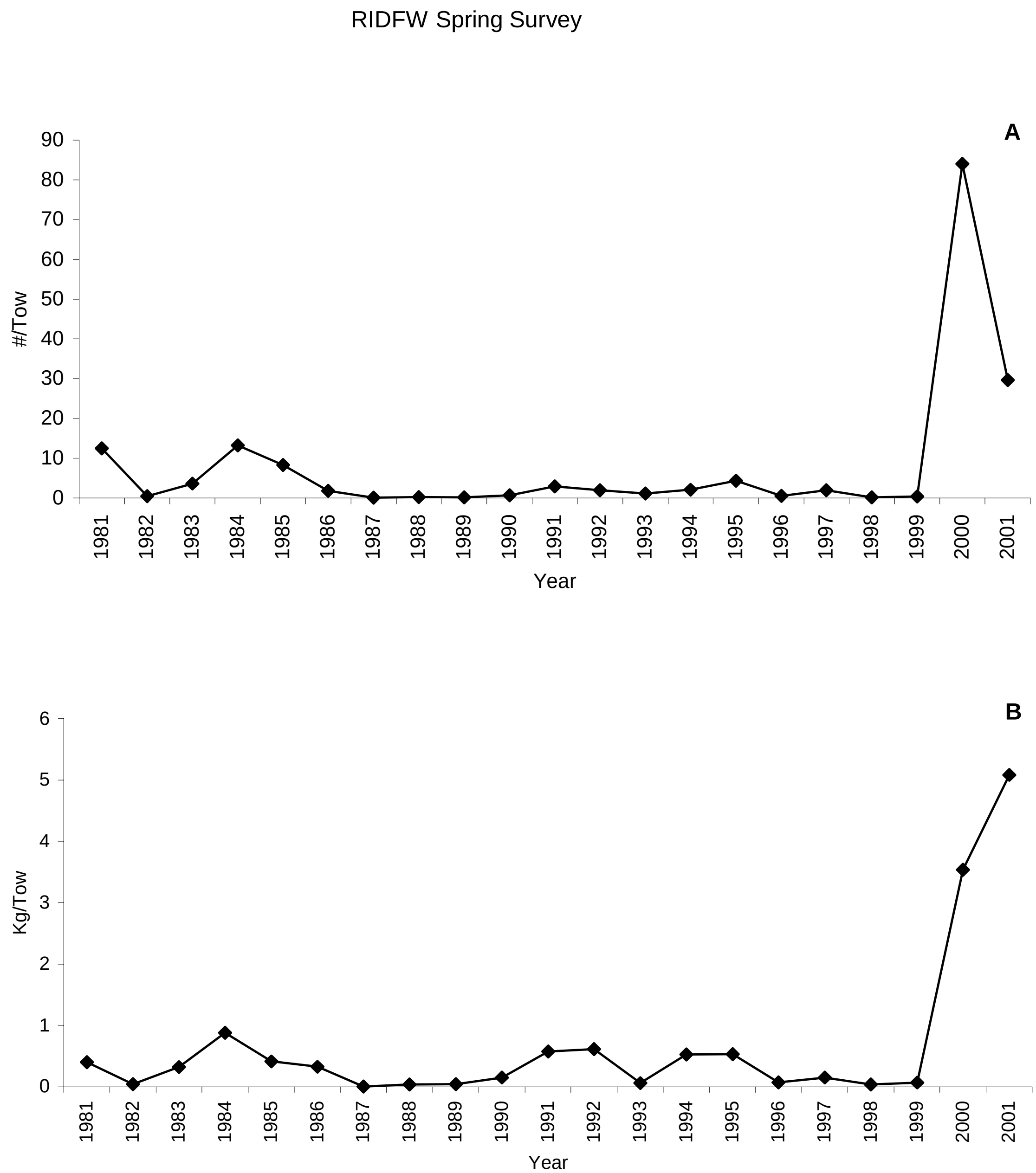
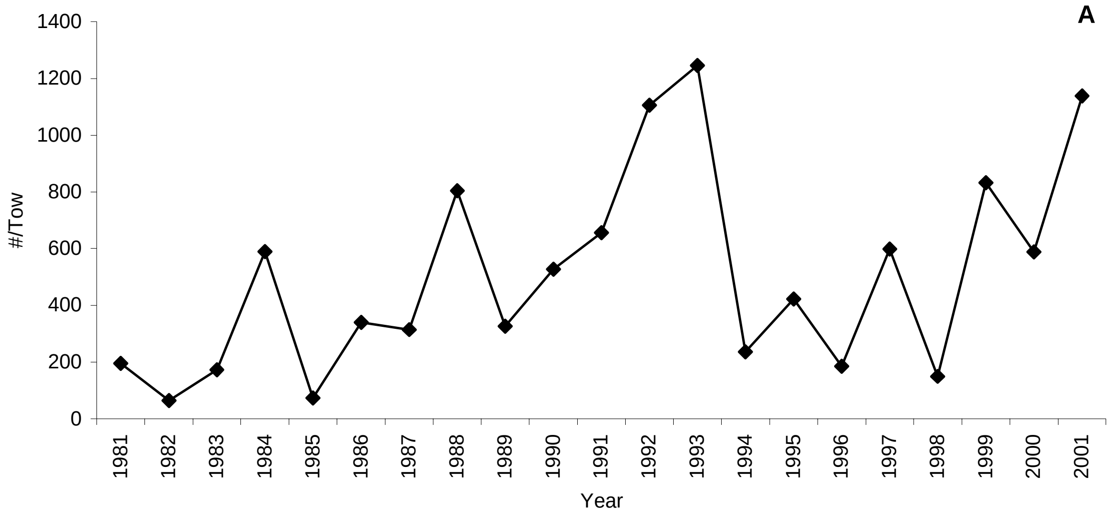


Figure B15. RIDFW spring survey (1981-2001) indices for scup abundance (A) and biomass (B).

RIDFW Fall Survey



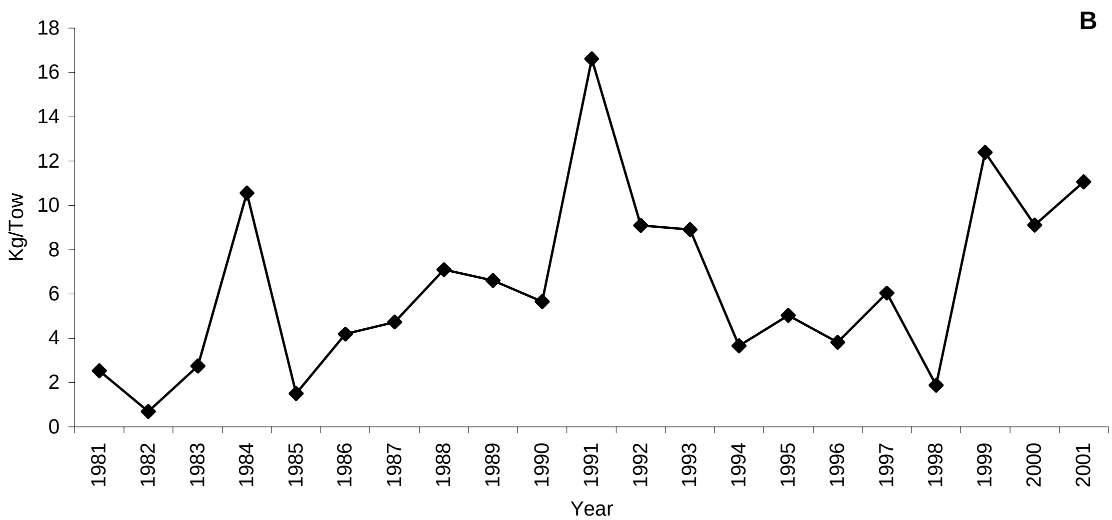


Figure B16. RIDFW fall survey (1981-2001) indices for scup abundance (A) and biomass (B).

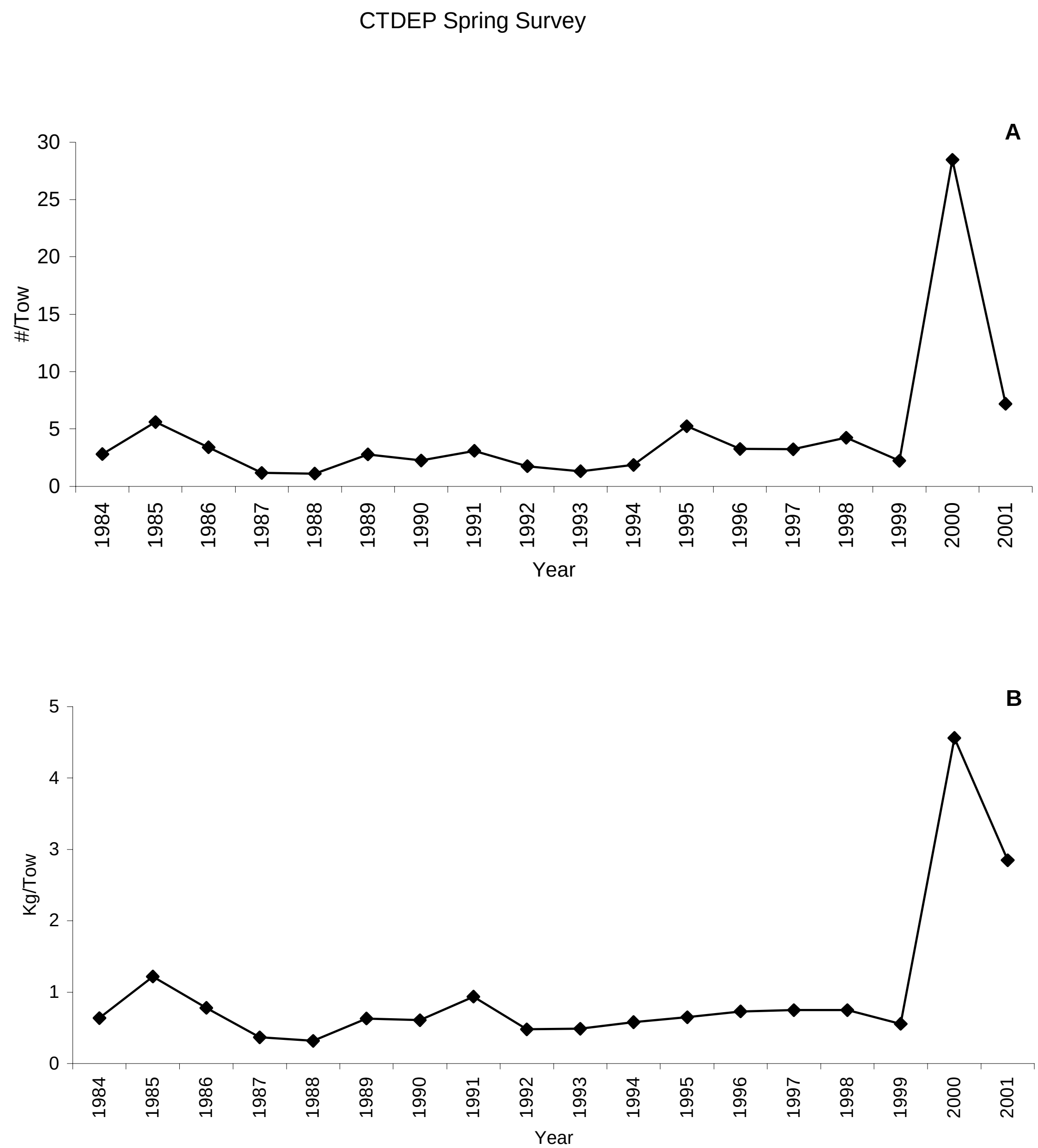


Figure B17. CTDEP spring survey (1984-2001) indices for scup abundance (A) and biomass (B).

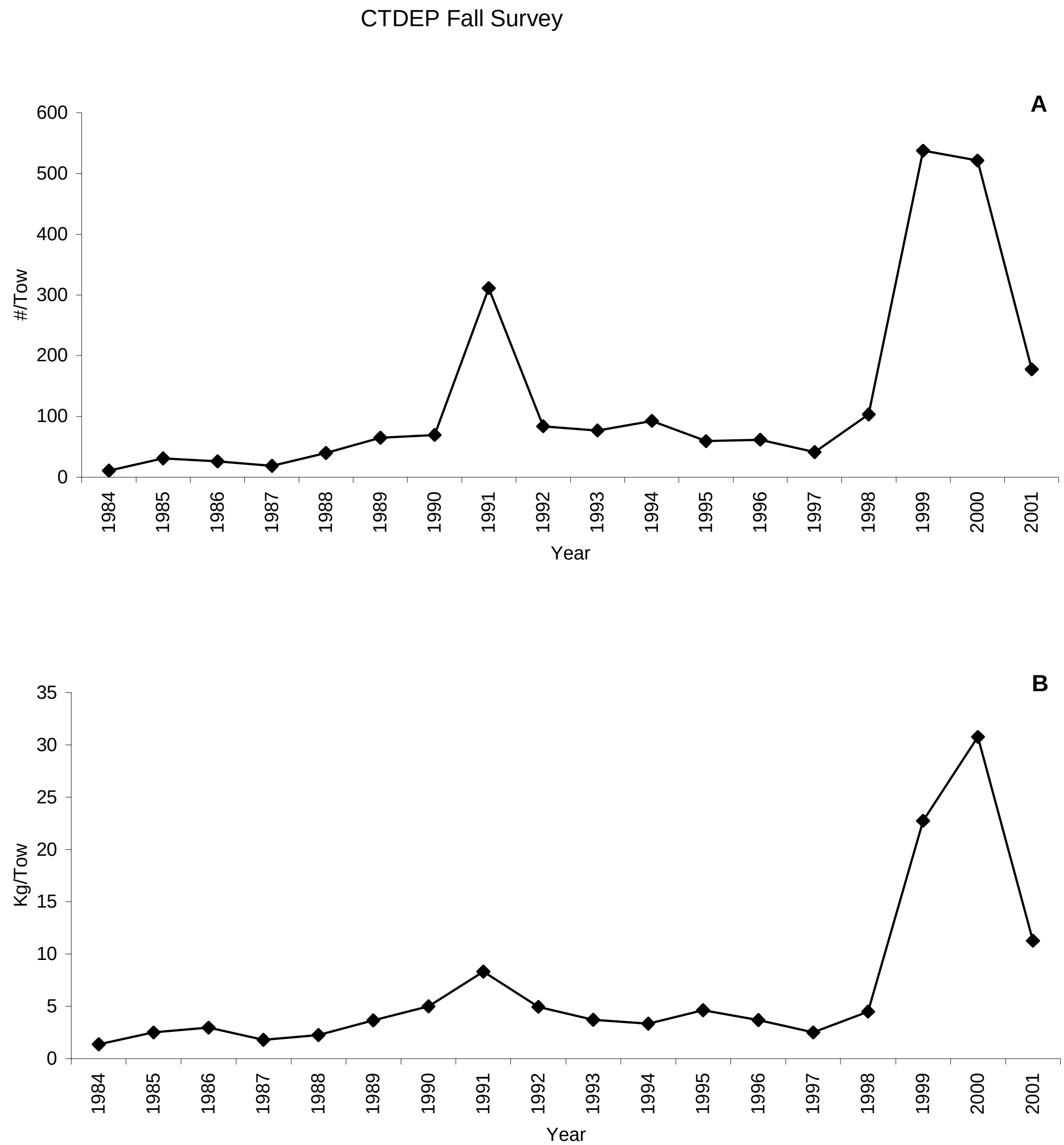


Figure B18. CTDEP fall survey (1984-2001) indices for scup abundance (A) and biomass (B).

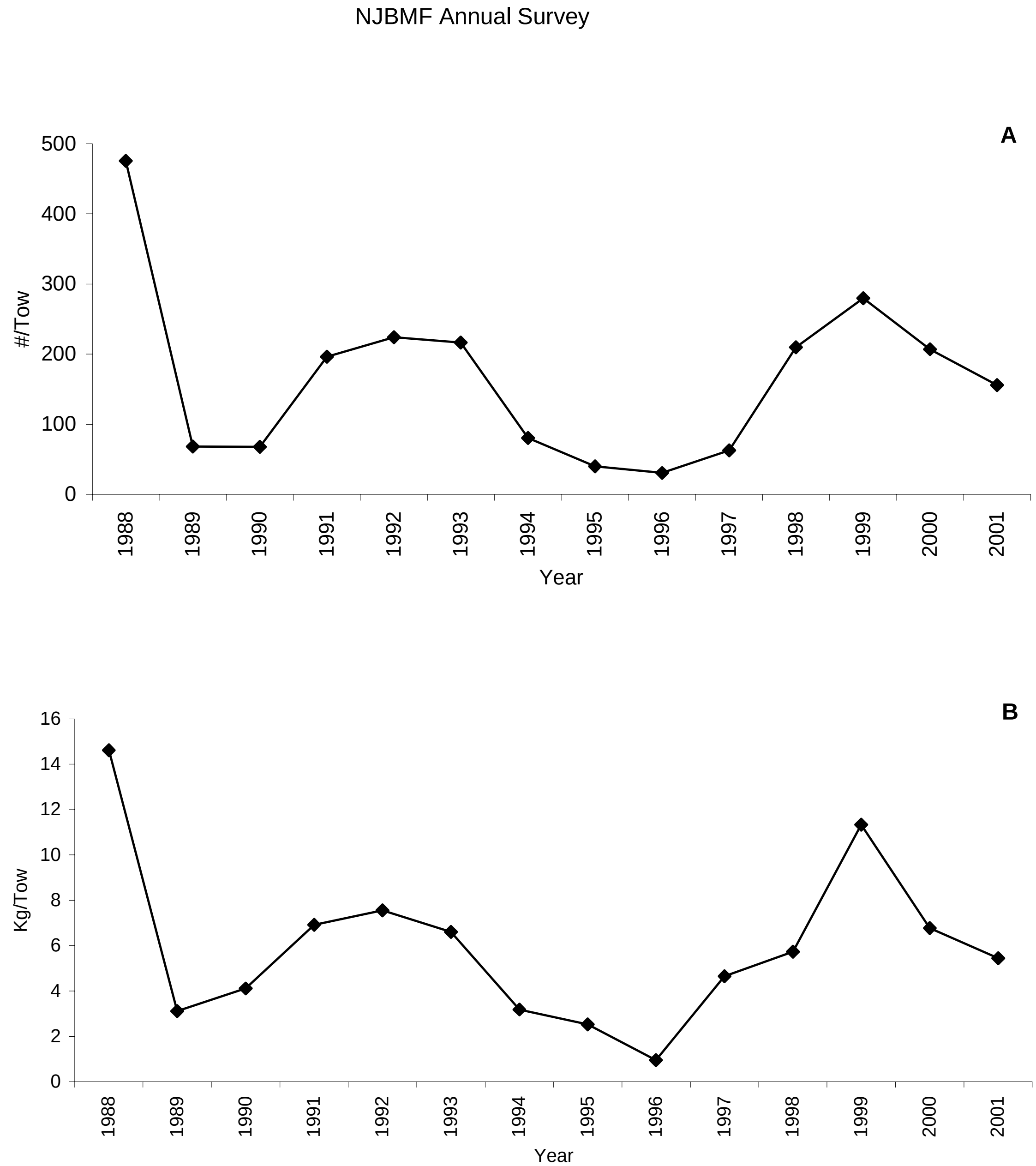


Figure B19. NJBMF survey (1988-2001) indices for scup abundance (A) and biomass (B).

Figure B20. VIMS survey (June – September; 1988-2001) indices for young-of-the-year scup abundance.

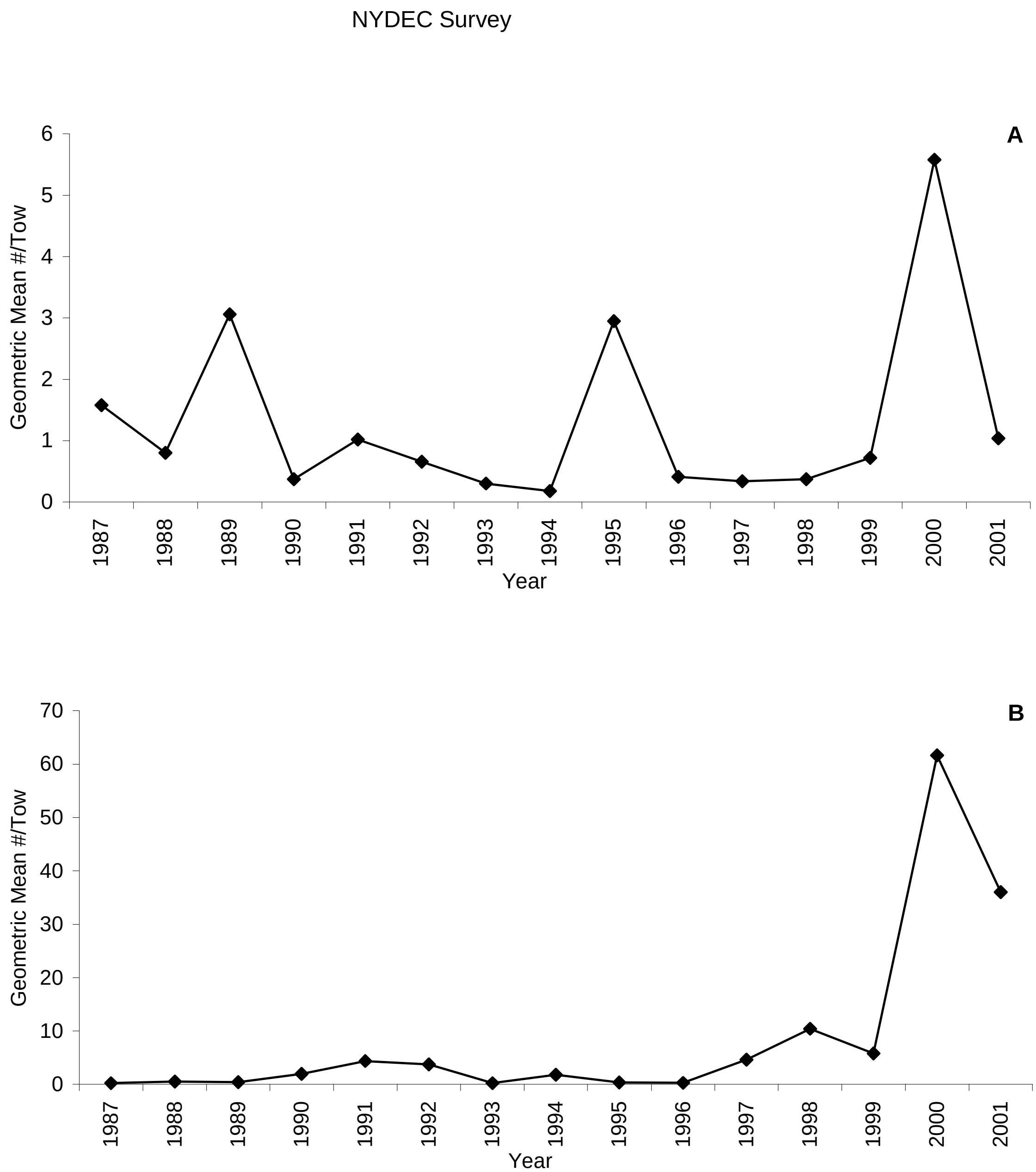


Figure B21. Yearling (A; June-August) and young-of-the-year (B; August-September) scup recruitment indices from the NYDEC survey (1985-2001).

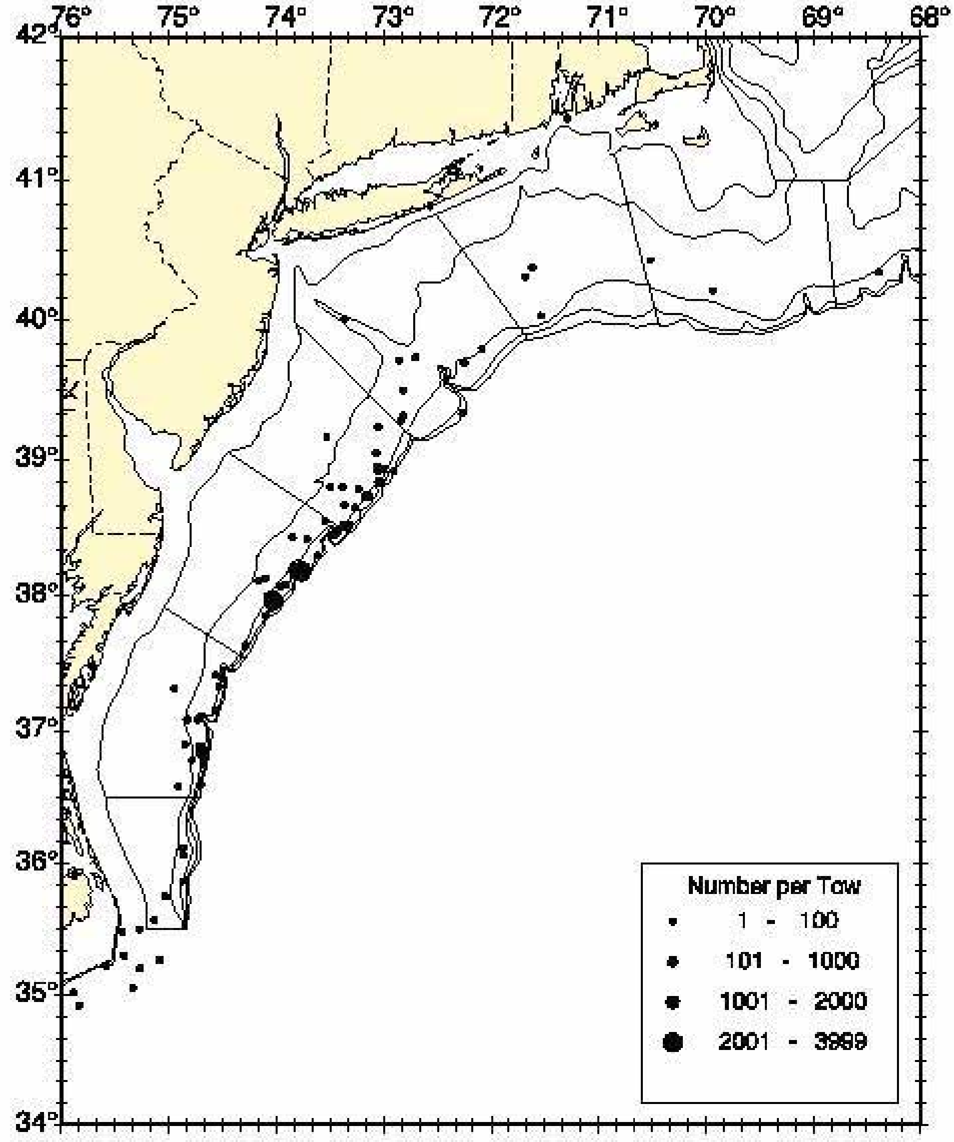


Figure B22. Distribution of scup during NEFSC 1992-1998 spring bottom trawl survey.

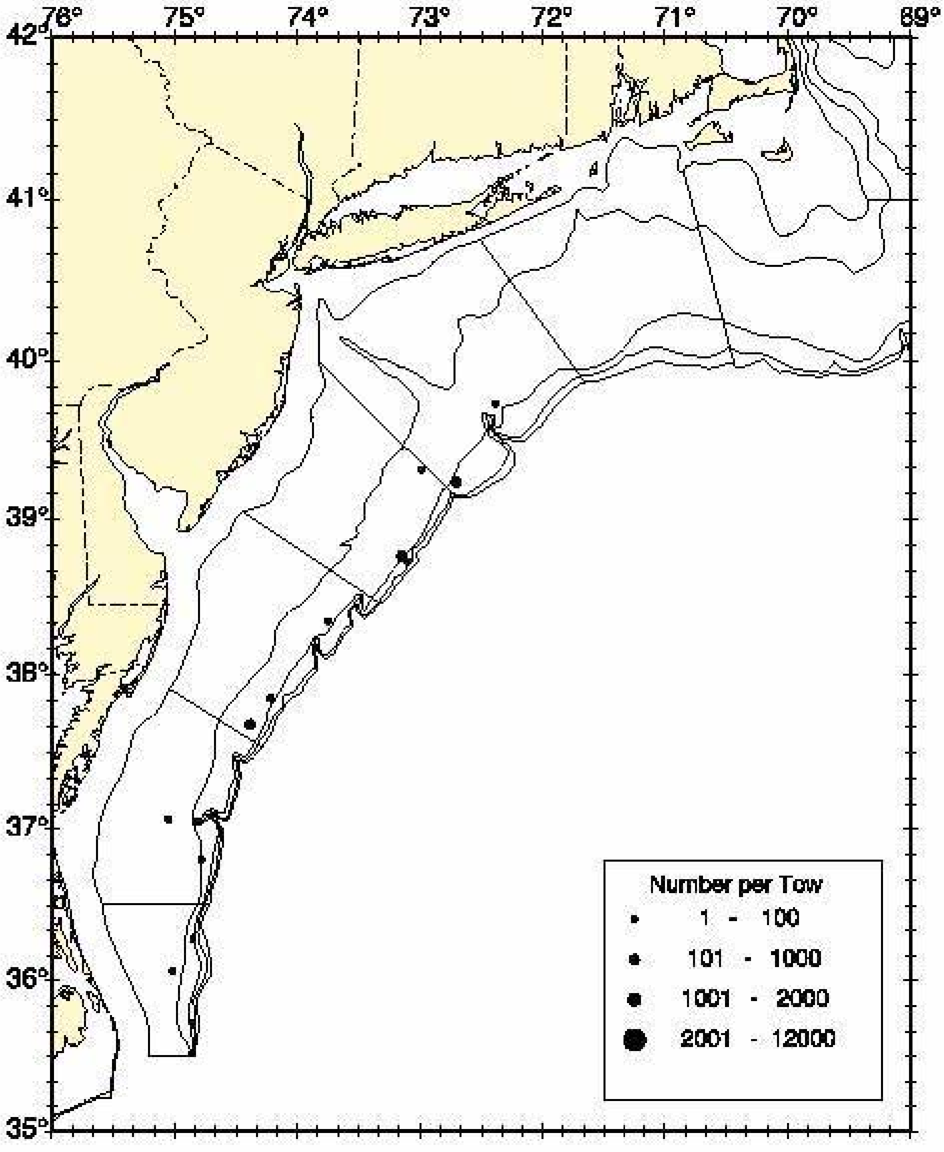


Figure B23. Distribution of scup during NEFSC 2001 spring bottom trawl survey.

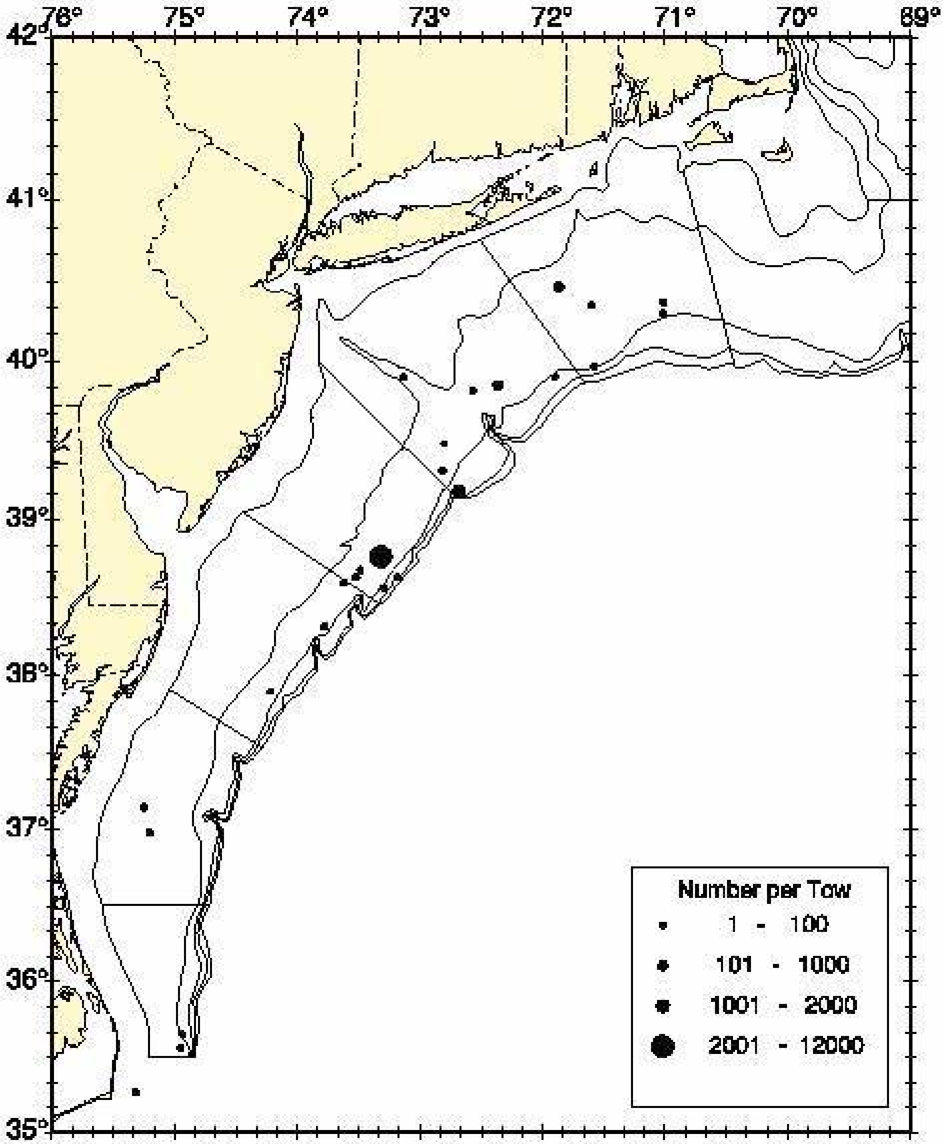


Figure B24. Distribution of scup during NEFSC 2002 spring bottom trawl survey.

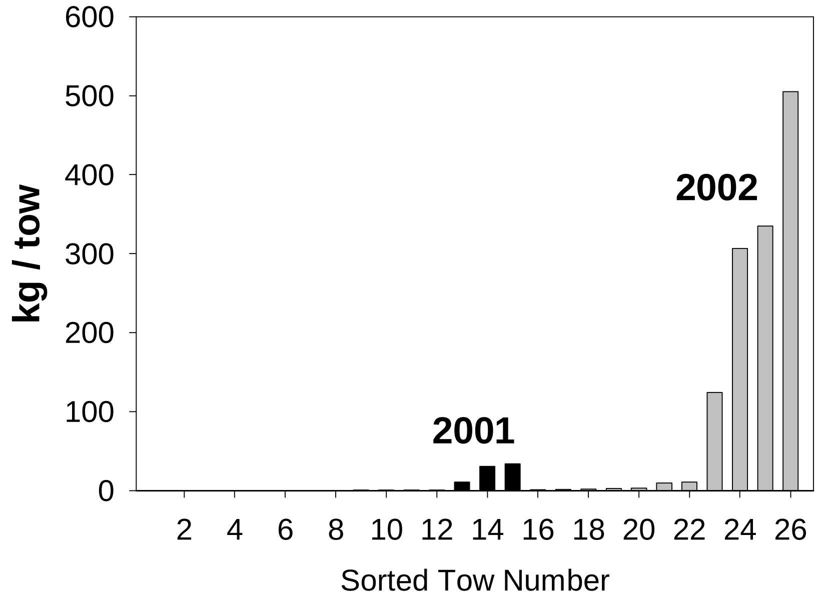


Figure B25. Comparison of the occurrence of positive scup tows and the associated magnitude as observed in the NEFSC 2001 and 2002 spring survey.

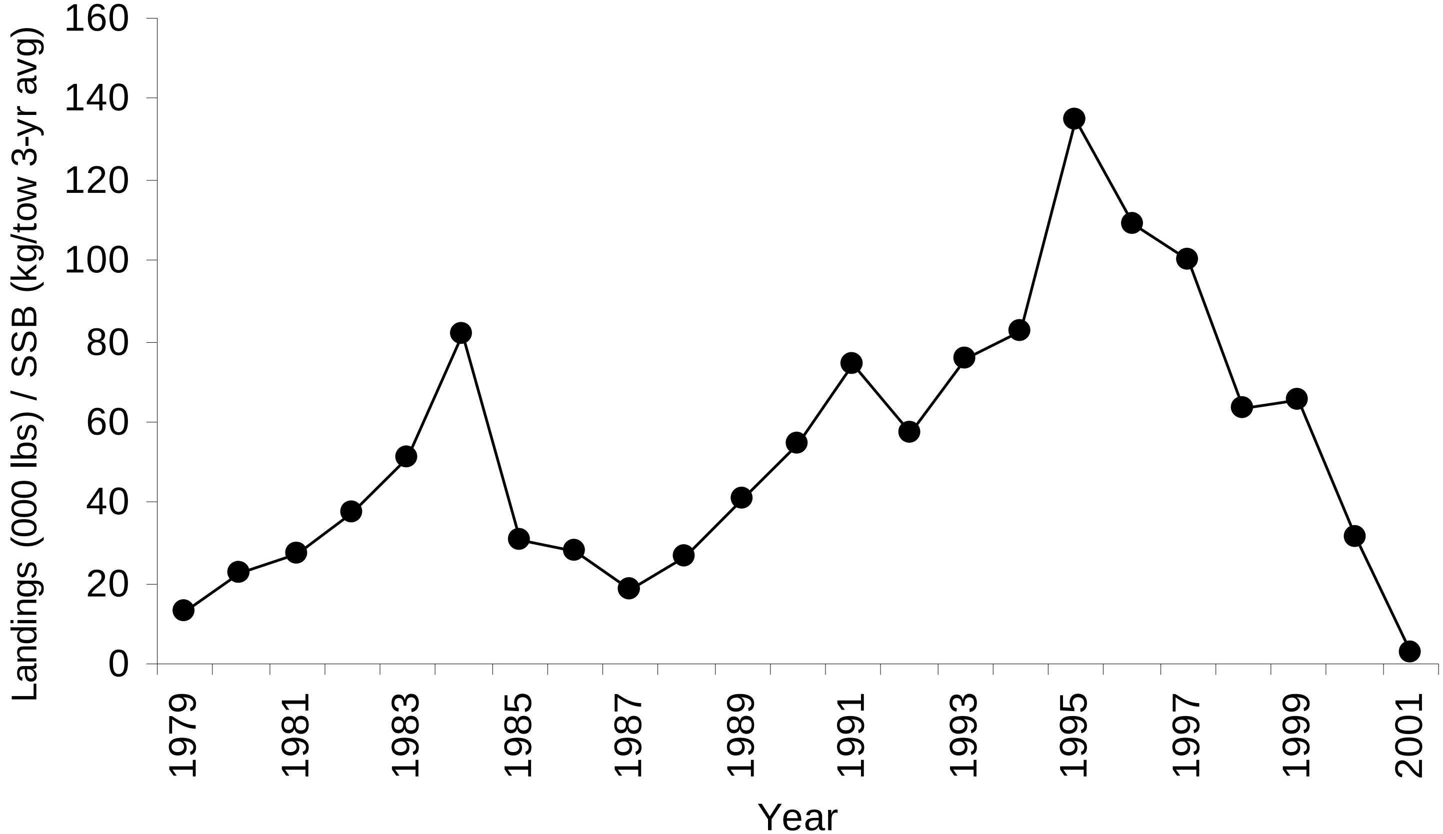


Figure B26. Estimated relative exploitation index based on total landings (1,000's of lbs.) and the NEFSC spring SSB survey (kg/tow; three-year average).

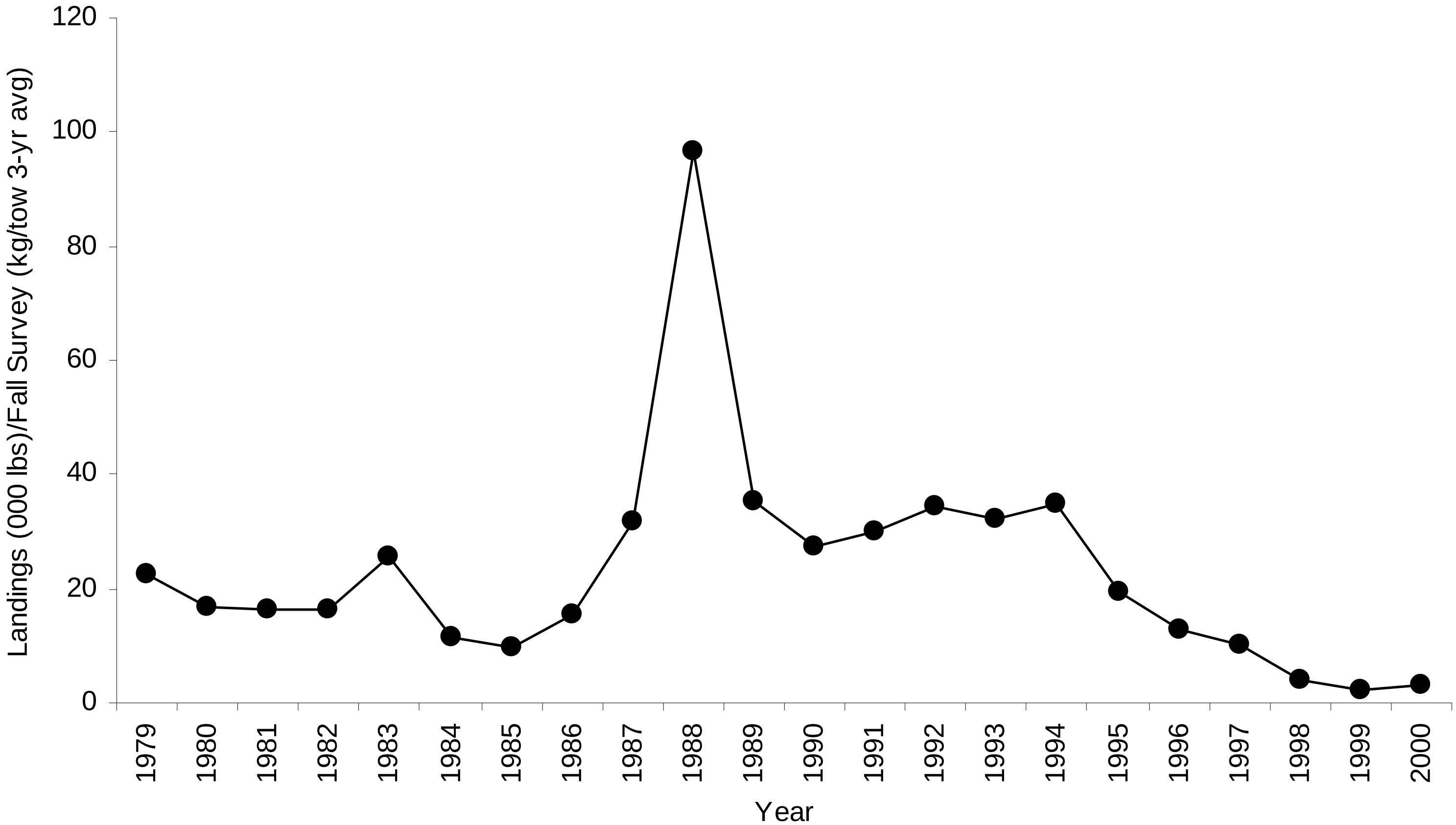


Figure B27. Estimated relative exploitation index based on total landings (1,000's of lbs.) and the NEFSC fall survey (kg/tow; three-year average).

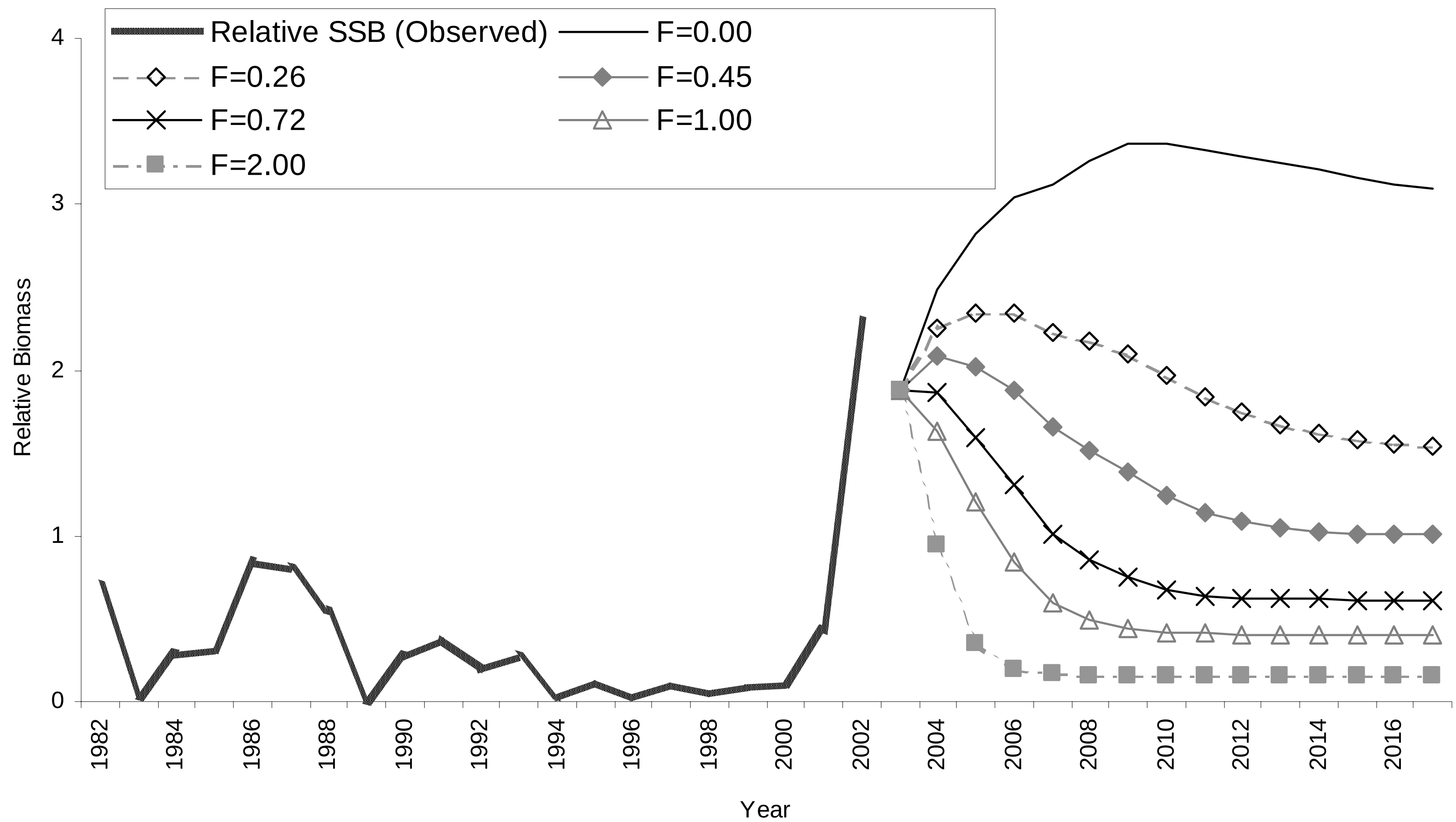


Figure B28. Observed trends in relative SSB (ln+1) and projections of scup relative biomass starting with average of 2000-2002 NEFSC spring survey catch per tow, offshore strata only. Yearly recruitment is assumed equal to the long-term median catch per tow at age 1 (1977-2002). Projections are for F values of 0.00, 0.26, 0.45, 0.72, F=1.00, and F=2.00.

C. Application of Index Methods: Catch and Fishery Independent Abundance Surveys

OVERVIEW

Despite an unmatched time series of synoptic research vessel-based surveys, the ability to apply age-based assessment models to marine finfish stocks in the Northeast USA is limited by the number of years for which age samples are available. Typically this means that such assessments are restricted to time periods beginning in the late 1970's or early 1980's. In many instances, severe overfishing of the resource has already occurred, and the information content of the available series may be problematic for the establishment of biomass reference points. In these situations, it is desirable to apply methods that can incorporate historical catch information, thereby avoiding a myopic perspective on resource conditions. In this report, a number of index-based approaches are developed to more fully utilize the data sets from the surveys and historical landings. The methods are technically simple but are based on linear population models, modern graphical methods, and robust statistical models. The concept of a replacement ratio is introduced here as an analytical tool for examining the historical behavior of a population and any potential influence of removals due to fishing activities.

To test these concepts and to facilitate comparisons, the analyses were applied to both the aged and un-aged stocks. Index-based methods for reference point estimation were considered in light of the specific goal of identifying the limit relative fishing mortality rate (relF) that is associated with stock replacement, in the long term. The replacement ratio method was applied to revise estimates of F proxies for six stocks: Gulf of Maine haddock, Mid-Atlantic yellowtail flounder, pollock, northern and southern windowpane, and ocean pout. In some cases, biomass proxies and MSY values were also updated for these stocks. Catch forecasts are developed for all of the 19 stocks considered as part of the Northeast multispecies groundfish complex. For a limited number of stocks, index-based forecasts are compared to age-based estimates. The proposed methodology was applied to summer flounder and scup as an adjunct to the analyses prepared by the respective subcommittees for these species for SARC 35.

Index-based approaches can be viewed as important tools for the identification and development of parametric models of stock dynamics. Additional simulation work is necessary to support the theoretical basis for the method and the limits of its applicability.

INTRODUCTION

One of the core problems in fisheries science is the estimation of the scaling factor between estimates of relative abundance and true population size. This scaling factor is generally called the catchability coefficient. Assessment models that rely on VPA utilize the record of age-specific catches to approximate the virtual population. The utility of the virtual population as a means of estimating catchability rests on assumptions that the losses due to fishing are both known and large relative to natural mortality.

Age-structured assessments are data intensive and their scope is restricted to years in which both catch and abundance indices can be aged. Such restrictions can greatly reduce the number of the number of years available for analyses. For Northeast USA stocks this often precludes consideration of large-scale reductions in abundance coincident with the presence of distant water fleets in the 1960's and early 1970's.

Reduced-parameter models are often used to analyze non-age structured models. The most common example is the surplus production model (see Prager 1994 for review and modern approaches) but the Collie-Sissenwine model (Collie and Sissenwine 1983), and delay-difference models (Schnute 1985) are also candidates. Even these simple models may fail when the dynamic range of population responses and/or fishing mortality rates is small (Hilborn and Walters 1993). For example, a time series characterized by continuously declining abundance indices contains relatively little information about the productive capacity of that stock. Under these circumstances the maximum population biomass (K) is estimable only if it assumed that the initial population size represents an unfished stock. This assumption is rarely tenable for Northwest Atlantic stocks that have been fished for hundreds of years and monitored since 1960.

The Collie-Sissenwine model replaces a structural model for biomass dynamics with a sequence of recruitment estimates and simple mass balance equation. The increased parameterization may lead to instability in the catchability coefficient and therefore, population estimates. As in delay-difference models, poorly specified growth parameters and sampling variability can greatly influence the ability to estimate abundance. Even the simplest parametric models may be difficult to fit to data characterized by large observation errors.

In this report we explore the general trends in abundance and fishing mortality deducible from a time series of catch (or landings for some species) and survey indices. For all stocks, only the total catch (mt) and autumn and spring research trawl survey indices (kg/tow) are utilized. We explore the relative fishing mortality rate, defined as the ratio of catch to survey index, and relate it to what we call the replacement ratio. The replacement ratio is introduced here as an analytical tool for examining the historical behavior of a population and any potential influence of removals due to fishing activities. To test these concepts and to facilitate comparisons, the analyses were applied to both the aged and un-aged stocks.

REPLACEMENT RATIO THEORY

The replacement ratio draws from the ideas underlying the Sissenwine-Shepherd model, delay-difference models, life-history theory, Collie-Sissenwine model, and statistical smoothing (Simonoff 1996). We begin by defining $\mathbf{I}_{j,s,t}$ as the j-th relative abundance index for species-stock unit s at time t and $\mathbf{C}_{s,t}$ as the catch (or landings) of species-stock unit s at time t. The simple relative fishing mortality rate with respect to index type j, stock s and time t is defined as the ratio of $\mathbf{C}_{s,t}$ to $\mathbf{Ij}_{s,t}$. This ratio can be noisy, owing to imprecision of survey estimates, and the variation can be damped by writing the relative F as a ratio of the catch to some average of the underlying indices. Following the recommendation of the previous reference point panel review team (Applegate et al. 1998), relative F is defined as the ratio of catch in year t to a centered 3-yr average of the survey indices:

$$relF_{j,s,t} = \frac{C_{s,t}}{\left(\frac{I_{j,s,t-1}+I_{j,s,t}+I_{j,s,t+1}}{3}\right)} \qquad (1)$$

Note that under this definition, the estimates of relative F for the first and last years of a time series are based on only 2 years of data.

Noise in the survey indices also affects the ability to relate inter-annual changes in abundance estimates to removal from fishing. The general approach of averaging adjacent years to estimate current stock size underlies statistical smoothing procedures (e.g., LOWESS) as well as formal time series models (e.g., ARIMA methods). One of the difficulties of applying such approaches in the present context, is that the derived parameters, if any, are unrelated to the species' biology or any aspect of the fishery. Moreover, we are interested in a basic questions of whether the current stock is replacing itself and whether the current level of catch is too high or low. Population dynamics models usually come to the rescue and allow approximate answers to these questions. However, if age-structure models cannot be applied, and more importantly, if the recent history of the fishery is uninformative, then most mathematical models will fail. The underlying reasons for model failure may not be immediately obvious from analysis of standard diagnostic measures. Of greater concern is the issue of the model mis-specification, wherein an inappropriate model adequately fits the data but leads to deductions inconsistent with basic biology and the fishery. The proposed replacement ratio is a "data-based" technique relying on fewer assumptions. No technique however, can fully compensate for model mis-specification errors.

If we assume that the survival from eggs to the juvenile stage is largely independent of stock size, then the number of recruits will be proportional to stock size. Locally, (i.e, in the neighborhood of a given stock size) this assumption holds for any stock-recruitment function. Since a population is a weighted sum of recruitment events, the interannual change in total stock size tends to be small relative to the total range of stock sizes (at least in the Northeast USA). Recruitment in any year is likely to be small relative to the biomass of the total population. Thus, the change in total biomass is likely to be small relative to the change in annual recruitment. Although the mathematics are more complicated than this ,the argument is based on the premise that if Var(x/1) = F^2 then Var(Ex/n) F^2 /n. Of course, the magnitude of such changes depends on the variation of recruitment and the magnitude of fishing mortality.

Using the linearity assumption defined above, we can employ basic life history theory to write abundance at time t as a function of the biomasses in previous time periods. The number of recruits at time t (**R_t**) is assumed to be proportional to the biomass at time t (**B_t**). More formally,

$$R_t = S_o \, Egg \, B_t \qquad (2)$$

where **Egg** is the number of eggs produced per unit of biomass, and **S_o** is the survival rate between the egg and recruit stages. Survival for recruited age groups at age a and time t (**$S_{a,t}$**) is defined as

$$S_{a,t} = e^{-F_{a,t} - M_{a,t}} \qquad (3)$$

where F and M refer to the instantaneous rates of fishing and natural mortality, respectively. We also need to consider the weight at age a and time t (**$W_{a,t}$**) and the average longevity (A) of the species
Using these standard concepts we now write the biomass at time t as a linear combination of the **A** previous years. Without loss of generality, we can drop the subscripts on the survival terms and assume that average weight at age is invariant with respect to time. Further, set the product **S_o Egg** equal to the coefficient **"**. The biomass at time t can now be written as

$$B_t = R_{t-1}S^1W_1 + R_{t-2}S^2W_2 + R_{t-3}S^3W_3 + .. + R_{t-(A-1)}S^{A-1}W_{A-1} + R_{t-A}S^AW_A \quad (4)$$

Substituting Eq. (2) into Eq. (4) leads to

$$B_t = \alpha B_{t-1}S^1W_1 + \alpha B_{t-2}S^2W_2 + \alpha B_{t-3}S^3W_3 + .. + \alpha B_{t-(A-1)}S^{A-1}W_{A-1} + \alpha B_{t-A}S^AW_A \quad (5)$$

Dividing the left hand side of Eq. (5) by the right hand side specifies the identity

$$1 = \frac{B_t}{\alpha B_{t-1}S^1W_1 + \alpha B_{t-2}S^2W_2 + \alpha B_{t-3}S^3W_3 + .. + \alpha B_{t-(A-1)}S^{A-1}W_{A-1} + \alpha B_{t-A}S^AW_A} \quad (5a)$$

In a steady state, non-growing population, $B_t = B_{t-1} = ... = B_{t-n}$ for all values of n. Therefore all of the biomass terms drop out of Eq. (5a) leading to:

$$1 = \alpha S^1 W_1 + \alpha S^2 W_2 + \alpha S^3 W_3 + .. + \alpha S^{A-1} W_{A-1} + \alpha S^A W_A \quad (5b)$$

If we write N_j = " $S^j W_j$ then Eq. (5b) implies that

$$1 = \sum_{j=1}^{A} \phi_j \qquad (5c)$$

Moreover, since all of the component terms of N_j i.e., " $S^j W_j$ are all positive non-zero values, Eq. (5c) also implies that <u>all</u> N_j terms are less than or equal to one. Finally, Eq. 5 to 5c imply that the biomass at time t <u>must</u> be a moving average of the previous biomasses whose offspring comprise the population at time t. Equations 5-5c further imply that coefficients can be written in terms of basic life history and fishery parameters. In particular, if one writes $F_{a,t}$ as the product of age specific partial recruitment and a fishing mortality rate, say F_{max}, then the N_j terms serve as a explicit empirical test of the assumption that the population trajectory is shaped by an optimal fishing mortality rate. Writing N_j = " $S^j W_j$ = S_o Egg $S^j W_j$ and substituting these terms into Eq. (5c) leads to:

$$S_o = \frac{1}{\sum_{j=1}^{A} Egg\ S^j\ W_j} \qquad (5d)$$

Eq. 5d is similar to the expression derived by Vaughan and Saila (1976) for the solution of the first year survival terms in a Leslie matrix model. The parameter S_o represents the survival rate from the egg to the age at recruitment. It also serves as the primary scaling factor for the Leslie matrix model in which the dominant eigenvalue is defined as one.

Populations are probably never at equilibrium but the relevant question is whether the departures from equilibrium are important. The structural smoothing equation proposed above constitutes an explicit hypothesis of the age-specific weighting factors that would shape a population at equilibrium.

We can now explicitly test the hypothesis that the population is at equilibrium by substituting observed indices of abundance into the equilibrium model (Eq. 5a). If the index of abundance I_t is proportional to abundance B_t we can write $\mathbf{I_t = q\ B_t}$ where **q** is the catchability coefficient. Substituting this relationship into Eq. 5a results in expression that we have called the replacement ratio $\mathbf{Q_t}$

$$\Psi_t = \frac{\frac{I_t}{q}}{\alpha \frac{I_{t-1}}{q} S^1 W_1 + \alpha \frac{I_{t-2}}{q} S^2 W_2 + \alpha \frac{I_{t-3}}{q} S^3 W_3 + .. + \alpha \frac{I_{t-(A-1)}}{q} S^{A-1} W_{A-1} + \alpha \frac{I_{t-A}}{q} S^A W_A} \quad (6)$$

By noting that the q's cancel out, and letting N_j = " S^jW_j , Eq. 6 simplifies to

$$\Psi_t = \frac{q\, I_t}{\sum_{j=1}^{A} \phi_j\, q\, I_{t-j}} \qquad (7)$$

Under the null hypothesis that the population is at equilibrium and not growing, Eq. (6) can be used as a measure of population trend. If the coefficients of the moving average are explicitly defined as from externally derived parameters (i.e., S_o, Egg, F_{TARGET}, M, PR_j, W_j) then replacement ratio Q_t can be used as an explicit test of the equilibrium assumption. Deviations from Q_t =1 imply either violations of the assumptions embedded in the estimated N_j weighting terms, measurement variability in the abundance indices I_t, or wide variations in recruitment. Over time, deviations attributable to either measurement error or recruitment are less important than those attributable of variations in the component terms of N_j. The most important of these terms is fishing mortality.

Considerations on the Applicability of the Replacement Ratio

1) Under the assumption that recruitment is proportional to abundance $\mathbf{R_t = S_o\ Egg\ B_t}$, and that $\mathbf{S_o}$ and **Egg** are constants, the population will decline when F increases above its nominal value and increase when F is below its nominal level. Thus Q_t will be a decreasing function of F and will equal 1 when $F=F_{TARGET}$.

2) If recruitment is assumed to be constant then R_t = R, and the behavior of the replacement ratio will be fundamentally different. Increases in F will induce an initial reduction in Q_t as the population declines to a new equilibrium level consistent increased value of F. However, as the population approaches this new equilibrium level, the replacement ratio will once again approach unity. Conversely, a reduction in F will induce an increase in population size and a transient increase in Q_t followed by a gradual return to one as the population approaches its new equilibrium level associated with the decreased value of F. For these cases, the relationship between Q_t and relF would consist of multiple stable points. The replacement ratio will be one for multiple levels of relF. Values of Q_t above or below one would be attributable to transient population states as the population moves to its new equilibrium point. It should be noted that the assumption of constant recruitment, irrespective of stock size, invokes the most extreme form of density dependence possible. Constant recruitment implies that the R/SSB ratio approaches infinity at the stock size (SSB) approaches zero. Consistent trends in F, from low to high or vice versa, would tend to maintain the transient behavior in the replacement

ratio for longer periods. Therefore, the relationship between $\mathbf{Q}_t$ and relative F would approximate that observed in paragraph **1)**.

3) The behavior of the replacement ratio in situations where the underlying stock recruitment function invokes varying degrees of compensation (say a Beverton-Holt relation), will be intermediate between behaviors described in paragraphs **1)** and **2)** above. If the stock is near carrying capacity then deviations from an average level of recruitment will be small. For this situation, the behavior of the replacement ratio will be similar to that described in paragraph **2)**. When the population is small relative to the level that produces maximum or near maximum levels of recruitment, the behavior of $\mathbf{Q}_t$ and its relationship to relative F should be similar to that described in paragraph **1)**. The ability to distinguish between the behaviors in $\mathbf{Q}_t$ induced by simultaneous changes in F or constancy in recruitment (as the population increases toward some designated level), will be difficult.

4) Many, if not most, of the stocks in the Northeast are at relatively low levels of abundance and have experienced, until recently, extended periods of increasing fishing mortality. If the populations are controlled by some form of density-dependent stock recruitment function, it is likely that the recruitment is nearly linear in the vicinity of the current stock size. Under these conditions it is expected that the relationship between $\mathbf{Q}_t$ and relF should be similar to that described in paragraph **1)**.

5) For stocks that are approaching carrying capacity or the some value at which recruitment becomes nearly constant (e.g., Georges Bank yellowtail flounder), the utility of the derived value of the relF at replacement is compromised. In this circumstance, a piecewise examination of the data may be instructive.

Appropriate Number of Terms in Moving Average

The survival term $\mathbf{S}^j$ is equivalent to the $\mathbf{l}_x$ term in the Euler-Lotka equation for population growth ($\mathbf{l}_x$ is the probability of surviving to age x). For high levels of fishing mortality the $\mathbf{S}^j$ term is decreasing faster than the average weight $\mathbf{W}_j$ is increasing. Thus the importance of earlier indices rapidly diminishes. All of the $\mathbf{I}_t$ and $\mathbf{N}_j$ terms are positive, and at equilibrium, $\mathbf{I}_t=\mathbf{I}_{t+1}$ and $\mathbf{I}_t = \mathrm{G}\,\mathbf{N}_j\,\mathbf{I}_{t-j}$ both hold. Therefore, $\mathrm{G}\,\mathbf{N}_j = 1$ and all of the $\mathbf{N}_j > 0$. It would be desirable to express each of the $\mathbf{N}_j$ weighting terms as function of the underlying population parameters. As expected, increases in fishing mortality increase the weight to more recent indices, whereas the converse hold for lower fishing mortality rates. As an approximation for this initial analyses, we assumed that all of the $\mathbf{N}_j = \mathbf{N}$ which implies that $\mathbf{N} = 1/\mathbf{A}$.

Given the high rate of fishing mortality observed in Northeast stocks, we further assumed that A=5 was a valid approximation. Note that even moderate levels of fishing mortality imply low $\mathbf{N}_j$ values beyond the fifth term. (e.g., F=0.5, M=0.2 imply $S^5 = 0.03$. For the fifth to be important the ratio of the weights between the youngest and oldest ages would have to be greater than $1/S^5$ which, for this example, would exceed 33. As a first approximation, we defined $\mathbf{N}_j$ =1/5 for all j. Thus Eq. 7 becomes the ratio of the current index to the average of the 5 previous years.

A limited amount of testing was conducted to evaluate the applicability of the 5 term smoothing model. For several stocks it was possible to examine the relationship between spawning stock biomass and recruits derived from long series of data. These stocks included Georges Bank haddock (1931-2000), redfish (1952-2000), Georges Bank yellowtail flounder (1963-2000), Southern New England yellowtail flounder (1963-2000), and Gulf of Maine cod (1963-2000). Cross correlation analyses of the relationship between SSB and recruits suggested statistically significant correlations at lags of 1 to 5 years for SNE yellowtail flounder and GB yellowtail flounder, and lags of 1 to 8 years for GB haddock (see Fig. 3.1 to 3.4). Interestingly, the cross correlations between SSB and recruits for redfish first become significant at about 7 years lag. Correlations with lags between 6 and 10 yr approach the statistically significant threshold, suggesting that the lags underlying the fit of the model can be "recovered" using standard statistical techniques. This bodes well for additional analyses of the replacement ratio and implementation of more formal methods of model identification.

As a elementary test of this principle, linear regression was used to fit a zero intercept model of the form: SSB(t)=aR(t-1) +b R(t-2) + c R(t-3) + d R(t-4) +e R(t-5) to the Georges Bank haddock stock.

Effect	Lag	Coefficient	Lower < 95%>	Upper
R1	1	0.209809	0.097675	0.321944
R2	2	0.219194	0.101660	0.336728
R3	3	0.376315	0.259659	0.492971
R4	4	0.253541	0.135948	0.371133
R5	5	0.206456	0.094681	0.318231

The unweighted mean of the coefficients is 0.252 and more importantly, there seems to be little variation in the magnitude of the coefficients with this range of lags. Hence the assumption that the $\mathbf{N}_j$ = $\mathbf{N}$ ~ 1/**A** is partially satisfied. Further simulation testing of this property is warranted.

A similar analyses with redfish was also conducted, but the lags of 6 to 10 years were used to account for the pattern observed in the cross correlation plot (i.e., SSB(t)=aR(t-6) +b R(t-7) + c R(t-8) + d R(t-9) +e R(t-10)). Results shown below, suggest that an assumption of equal weighting within the replacement ratio may be a reasonable working hypothesis.

Parameter	Lag	Estimate	A.S.E.	Param/ASE	Lower < 95%>	Upper
R6	6	0.237457	0.069769	3.403497	0.095512	0.379403
R7	7	0.253191	0.071008	3.565651	0.108723	0.397658
R8	8	0.412828	0.100267	4.117281	0.208833	0.616823
R9	9	0.379631	0.099645	3.809814	0.176901	0.582361
R10	10	0.376568	0.098226	3.833696	0.176726	0.576410

RELATION BETWEEN REPLACEMENT RATIO AND RELATIVE F

Application of any smoothing technique reflects a choice between signal and noise (Rago 2001) A greater degree of smoothing eliminates the noise but may fail to detect true changes in the signal. Given the abrupt changes in fishing mortality that have occurred in some Northeast stocks, we chose to utilize the current year in the numerator of the replacement ratio. Use of the current index in the numerator rather than a running average of say k years, increases the sensitivity of the ratio to detect such changes. The penalty for such sensitivity is that the proportions of false positives and false negative responses increase. This penalty was judged acceptable for two reasons. First, it is desirable to detect abrupt changes in resource condition given the magnitude of recent and proposed management regulations. Second, the current formulation of the replacement ratio has a natural relationship to stock-recruitment hypotheses and the ratio can be investigated as a function of variations in underlying parameters, especially survival. Alternative formulations of the replacement ratio, say with a 2-yr average population size in the numerator can be developed, but their basic properties have not been investigated.

When fishing mortality rates exceed the capacity of the stock to replace itself the population is expected to decline over time. The expected behavior of $\mathbf{Q}_t$ under varying fishing mortality and recruitment is complicated, but it will have a stable point = 1 when the fishing mortality rate is in balance with recruitment and growth. Variations in fishing mortality will induce complex patterns, but in general terms, $\mathbf{Q}_t$ will exceed 1 when relative F is too high, and will be below 1 when F is too low. To account for these general properties and to reduce the influence of wide changes in either $\mathbf{Q}_t$ or the relative F, we applied robust regression methods (Goodall 1983) to estimate the relative F corresponding to $\mathbf{Q}_t$ =1. The parameters of the regression model were estimated by

$$\ln(\Psi_t) = a + b \ln(relF_t) \qquad (8)$$

minimizing the median absolute deviations. Median Absolute Deviation estimators are known as MAD estimators in the statistical literature (eg. Mosteller and Tukey 1977). Residuals were down weighted using a bisquare distribution in which the sum of the MAD standardized residuals was set to 6. This roughly corresponds to a rejection point of about plus or minus two standard deviations from the mean. (Goodall 1983).

The relative F at which $\mathbf{Q}_t$ = 1 was estimated from Eq. 8. as

$$relF_{threshold} = e^{-a/b} \qquad (9)$$

where the estimates of **a** and **b** from Eq. 8 were substituted into Eq. 9. This derived quantity may be appropriately labeled as a threshold since values in excess of it are expected to lead to declining populations. Alternatively, populations are expect to increase when $\mathbf{relF_t} < \mathbf{relF_{threshold}}$. Employing the general standard that managers should attempt to rebuild fish stocks within 10 years, we estimated the relative fishing mortality rate at which the expected value of $\mathbf{Q_t}$ = 1.1 as a measure of $\mathbf{relF_{target}}$. Applying a little algebra to the Eq. 8 leads to the following estimator of $\mathbf{relF_{target}}$:

$$relF_{target} = e^{\frac{0.09531 - a}{b}} \qquad (10)$$

The asymptotic standard errors of $\mathbf{relF_{threshold}}$ and $\mathbf{relF_{target}}$ were derived from the Hessian matrix of the regression model.

RANDOMIZATION TESTS

The usual tests of statistical significance do not apply for the model described in Eq. 8. The relation between $\mathbf{Q_t}$ and $\mathbf{relF_t}$ is of the general form of Y/X vs X where X and Y are random variables. The expected correlation between Y/X and X is less than zero and is the basis for the oft stated criticism of spurious correlation. To test for spurious correlation we developed a sampling distribution of the correlation statistic using a randomization test. The randomization test is based on the null hypothesis that the catch and survey time series represent a random ordering of observations with no underlying association. The randomization test was developed as follows:

1. Create a random time series of length **T** of $\mathbf{C_{r,t}}$ from the set {$\mathbf{C_t}$} and $\mathbf{I_{r,t}}$ from the set {$\mathbf{I_t}$} by sampling with replacement.

2. Compute a random time series of relative F ($\mathbf{relF_{r,t}}$) and replacement ratios ($\mathbf{Q_{r,t}}$)
3. Compute the r-th correlation coefficient, say $\mathbf{D_r}$ between ln($\mathbf{relF_{r,t}}$) and ln($\mathbf{Q_{r,t}}$).
4. Repeat steps 1 to 3 1000 times.
5. Compare the observed correlation coefficient $\mathbf{r_{obs}}$ with the sorted set of $\mathbf{D_r}$
6. The approximate significance level of the observed correlation coefficient $\mathbf{r_{obs}}$ is the fraction of values of $\mathbf{D_r}$ less than $\mathbf{r_{obs}}$

It should be emphasized that relF is not necessarily an adequate proxy for Fmsy, since this parameter only estimates the average mortality rate at which the stock was capable of replacing itself. Thus, while relF defined as average replacement fishing mortality is a necessary condition for an F_{msy} proxy, it is not sufficient, since the stock could theoretically be brought to the stable point under an infinite array of biomass states.

Even with an estimate of relF derived from the above procedure, externally-derived estimates of B_{msy} or MSY are necessary in order to develop consistent estimates of all the management reference points: MSY, Bmsy and Fmsy or their proxies. For index-based assessments these terms are related by

$$MSY/I_{Bmsy} = relF$$

where I_{Bmsy} is the survey index associated with Bmsy. Knowledge of any two of these terms allows for estimation of the third. For some index stocks (e.g. Gulf of Maine haddock) an external estimate of MSY was considered, based on average catches over a stable period. For others, the I_{Bmsy} proxy was considered more reliable.

GRAPHICAL ANALYSES

The six panel plot developed for the “index” species attempts to show the interrelationships among survey estimates of abundance, landings, functions of landings and relative abundance, and time. The two functions of landings and relative abundance considered are the replacement ratio (Eq. 6, section 3.0) and relative F (Eq. 9, section 4.0). The concept of using multiple panels to relate multiple variables over time has been advocated for use in fisheries science (e.g. Clark 1976, Hilborn and Walters 1992) and other fields (e.g. Cleveland 1993). The 6-panel plots attempt to show the logical connections among variables and to estimate underlying biological rates. The example for GOM Haddock (Fig. 6.1) will be discussed in detail here.

The first aspect to note about the plots are the shared axes in the top four plots (A. B., C, D) and F. Panels B , D and F show the time series for the replacement ratio, the fall survey index, and the relative F, respectively. The horizontal line in A and B is the replacement ratio =1 line. The relationship between the replacement ratio and relative F in panel A is the key to understanding the influence of fishing mortality on stock size. Panel A is a phase plane that describes the relationship between two variables ordered by time. The degree of association between these variables is characterized by a Gaussian bivariate ellipsoid with a nominal probability level of p=0.6827 equivalent to $\pm$ 1 SD about the mean of the x and y variables. The primary and secondary axes of the ellipse are the first and second principal components, respectively. When the degree of association between relative F and replacement ratio decreases, the ellipse becomes more circle-like. The implication is that either the survey is too imprecise to detect changes induced by historical levels of fishing removals, or that the levels of fishing effort have been too low to effect changes in relative abundance. These alternatives can often be distinguished by consideration of the sampling gear and its interaction with the behavior of the species. Similarly incompleteness of the catch record, particularly for species in which the magnitude of discard mortality has varied widely, is another critical factor in the interpretation of the confidence ellipse.

The assumption that the relative F and replacement ratio have a joint bivariate normal distribution in the log –log scale may not hold for all (or any) species. In particular, the replacement ratio model is designed to be sensitive to contemporary changes, so that by definition it will be highly variable. Large changes that are subsequently validated by future observations imply true changes in population status. When the converse is true, it is proper to conclude that the change was an artifact of sampling variation. The degree to which high residuals influence the pattern is tested using the robust regression method of Tukey (Mosteller and Tukey 1977) that downweights large residuals using a bisquare distribution (see Goodall 1983 for details). Thus the regression line in panel A will not be aligned with the primary axis of the ellipse when high residuals distort the confidence ellipse. The expected value of correlation between the replacement rate and relative F is negative. The empirically derived estimate of the sampling distribution for the correlation coefficient , via the randomization test, provides a way of judging the significance of the robust regression line.

The predicted value of relative F at which the replacement ratio is 1 is defined by Eq. 8 and denoted by the vertical line in Panel A and B. The precision of that point depends largely upon where it lies within the confidence ellipse. If the confidence ellipse is nearly centered about the intersection point, then the precision of the relative F threshold will be high. This also indicates that over time, a wide range of F and replacement ratios greater than one have been observed. In contrast, when the intersection point lies in the upper right portion of ellipse, the precision will be low. This is, of course, is a common property of linear regression in which the prediction interval for Y increases with the square of the distance between the independent variable X and its mean. Thus a high degree of correlation between relative F and the replacement ratio does not necessarily ensure high precision in the threshold if relatively few observations have replacement ratios greater than one. Panel A demonstrates, in a slightly different way, the implications of the "one-way trip" described in Hilborn and Walters (1992)

Panel C depicts the phase plane for relative biomass (i.e., . The index) and the relative F. At equilibrium, the population should move up and down a linear isocline. The degree of departure from linearity reflects both sampling variation as well as true variations induced by recruitment pulses and its transient influence on total biomass. Thus the trace of points can give useful insights into parametric model selection of population dynamics under exploitation .

The simple data of catch and survey are generally not sufficient to estimate simultaneously both the threshold F and biomass targets. This property characterizes the common property of indeterminancy of r and K in standard surplus production models. For the GOM haddock example, the relative biomass target is defined external to the model (Panel C and D).

To facilitate the detection of temporal patterns, Lowess smoothing is applied in panels B, D, and F. A relatively low tension =0.3 (i.e., 30% of the span of data are used for the estimate of each smoothed Y value) is used to allow for more sensitive flexing of the smoothed line. As noted earlier, the heightened sensitivity is desirable for this particular application in fisheries management. In a sense, the Lowess smoothing counterbalances the sensitivity built into the definitions of replacement ratio and relative F, by damping the rates of change and allowing for detection of general trends.

The final point to note is that the 6 panel plot may allow one to develop a reasonable picture of the population dynamics in relation to exploitation. With the exception of a brief period in the late 70's the replacement rate for GOM haddock was below one and continued its downward trend until 1990 (Panel A). This was accompanied by a continuously decreasing population size (Panel D). The reduction in landings from nearly 8000 mt in 1984 to less than 500 mt by 1989 (Panel E) greatly reduced the relative F (Panel F) below the threshold level and subsequently led to the replacement ratio exceeding one. The inter-relationships among Panels B, D, and F resemble the kinetics of simple chemical reactions and conceptually one should look for counteracting trends among indices and the influence of the trends in catch and relative survey abundance.

Graphical analyses of all 19 Northeast stocks for the fall and spring surveys may be found in the Final Report on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002).

PROJECTIONS FROM INDEX-BASED METHODS

Simple Forecasts for Index Stocks

The estimates of $\mathbf{relF_{threshold}}$ and $\mathbf{relF_{target}}$ from Eq. 9 and 10 respectively, can be used to project the expected catches during any forecast period. Under the theory, multiplication of the current abundance index I_t by $\mathbf{relF_{threshold}}$ leads to an estimate of Ct. If the estimate of $\mathbf{relF_{threshold}}$ is unbiased then the population is expected to remain constant. This leads to the rather uninteresting forecast of constant catches over any time horizon. Conversely, when the population is fished at $\mathbf{relF_{target}}$, the population is expected to grow by an average of 10% per year and the catches will grow at a similar rate. For short time periods and low initial population sizes, this approximation is likely to hold. Results of this approach, summarized in Table 2, suggest a reasonable degree of coherence with rebuilding schedules and catch projections derived from more complicated age-structured models. Thus, the catch projection estimates for the species without more complicated models may be used for planning and management purposes.

Estimates of relative F at replacement, generated for all stocks and surveys, are summarized in Table 1. In addition the estimates of the relative F necessary for a 10% growth rate of the population are provided in Table 1. The 10% criterion for population growth should not be construed as a fixed value or scientific recommendation. Rather, it provides a rough measure of the population's capacity for growth that is consistent with the available data. The precision of this estimate as well as the relative F at replacement is provided along with the results of the randomization tests to test for spurious correlations. In general, low precision of the estimates of relF at replacement are associated with uninformative times series. These times series also suggest a weak relationship between the replacement ratio and relative F. In most instances the analyses for the NMFS spring trawl survey mirror the results for the longer time series of autumn (fall) indices. Table 1 also provides a comparison between the current 3yr average of relative F and the predicted relative F s at replacement and at 10% growth rate. The ratio of the current relative F to these nominal target levels provides an alternative measure of the relative magnitude of fishing mortality.

The index based method can also be used to generate simple projections of landings over the period 2002-2009. Catch estimates are obtained by multiplying the current population value (in kg/tow) by the target relative F (000 mt/(kg/tow)) in Eq. 10. Thus:

$$\hat{C}_t = relF_{target}\ I_t$$

By definition, application of $\mathbf{relF_{target}}$ to the population results in 10% rate of increase per year. Of course this assumption is appropriate for a limited number of years. A 10% rate of population increase implies a doubling of the population in roughly 8 years. In more formal notation, we can project the population status as:

$$\hat{I}_{t+1} = 1.1 * I_t(F = relF_{target})$$

Recursive application of the above two equations allows for projection of the population status (in units of kg/tow) and catch (in thousands of mt; Table 2). Comparisons of recent average catches with the average during the rebuilding period suggest that landings would have to be reduced for most species. Note however, that these catch projections are not defined in terms of a target index biomass at the end of 2009.

Due to the developmental nature of these analyses, they should not necessarily be considered reliable for the purposes of management. Initial comparisons however, between these projections and those generated by the age-structured models, suggest reasonable coherence.

Complex Forecasts for Index Stocks

Forecasts for index-based stocks rely on the basic concepts that the 1) the survey indices are proportional to stock biomass, 2) fishing mortality is proportional to the ratio of total catch to survey index, 3) population growth rate can be expressed as a linear function of stock size, and 4) the relationship between the replacement ratio (Eq. 7) and relative F can be summarized with a linear regression in the log-log scale. The index-based can provide useful advice on the current magnitude of fishing mortality and the approximate magnitude of reduction in F necessary to initiate rebuilding for depleted stocks.

Extension of the index approaches to estimate catches consistent with rebuilding plan requires consideration of several additional factors. These include the magnitude of the desired increase in population size, the time frame over which the target population size is to be attained, and catches that may have been removed from the population since the estimate of relative density was obtained. (In this specific example, the population in must be advanced to the start of 2002 based on the removals in 2001.) As noted earlier, the index methodology is not sufficient to uniquely specify the target level of relative biomass. Instead this information is obtained from examination of the trajectories of one or more survey indices, and external information about the historical fisheries. These data are often sufficient to allow scientists to define a proper target biomass. In most instances the defined target biomass coincides with a period of moderate to high abundance, stable catches and replacement ratios at or above 1.0. Let $\mathbf{I_{TARGET}(T)}$ represent the desired relative population size at year **T**, the end year of the rebuilding period. The current condition of the resource at the start of the rebuilding period is defined as $\mathbf{I_{CURRENT}(t)}$. In order to grow from $\mathbf{I_{CURRENT}(t)}$ to $\mathbf{I_{TARGET}(T)}$ over the period **t** to **T** the population must grow at a constant average rate of at least $Q_{rebuild}$ which is defined as:

$$\Psi_{rebuild} = \frac{\log_e\left(\frac{I_{TARGET}(T)}{I_{CURRENT}(t)}\right)}{T - t}$$

The next step is to estimate the relative F necessary to induce a population growth rate equal to $Q_{rebuild}$. The robust linear regression model (Eq. 8 Working Group Report) can be used to estimate the relative F sufficient for rebuilding ($relF_{rebuild}$). This can be defined by rearranging Eq. 8 (Working Group Report) to solve for $relF_{rebuild}$ as follows:

$$relF_{rebuild} = \frac{\Psi_{rebuild} - a}{b}$$

The projected catches consistent with the rebuilding strategy can now be estimated by multiplying the relative F by the current index of abundance, i.e.,

$$C_{rebuild}(t) = relF_{rebuild}\, I(t)$$

The last step in the projection process is to project the population to the next year. This is accomplished by multiplying the current population by the $Q_{rebuild.}$

$$\hat{I}(t+1) = \Psi_{rebuild}\, I(t)$$

The preceding two equations are simply applied recursively until year T, the end of the rebuilding period.

A complication that arises for projection of catches in 2002 and 2003 is that neither the catches nor survey values in 2001 were available when the index-based reference points were derived. The values in Tables 1 and 2 represent estimates for year 2000 relative biomasses and relative fishing mortality rates.

Thus it was necessary to advance the population to the start of 2002 before applying Eq. 1 to 4. The following approach was used:

1. Project the population in 2000 to 2001 by computing the predicted replacement ratio (i.e., growth rate) associated with the average relative F in 2000.

$$\Psi(2000) = \exp^{a + b \log_e(relF_{2000})}$$

2. The average predicted population size in 2001 is obtained as:

$$\hat{I}(2001) = \frac{\Psi_{2000}\, I(2000) + I(2000) + I(1999)}{3}$$

3. The relative F for 2001 as the ratio of catch divided by the predicted population size. To retain consistency with the methods used in Table 2, the point estimate of relative F in 2001 is estimated as the ratio of catch over average relative biomass of the three year period as follows:

$$relF(2001) = \frac{C(2001)}{\left(\frac{\hat{I}(2001) + I(2000) + I(1999)}{3}\right)}$$

4. Substitute the result of Eq. 7 into Eq. 5 to obtain the replacement rate associated with the removals in 2001.

$$\Psi(2001) = \exp^{a + b \log_e(relF_{2001})}$$

5. Project the population in 2002 is similar to the step 2 except that the estimates are substituted for the replacement rate in 2001 and relative biomass in 2001.

$$\hat{I}(2002) = \frac{\Psi_{2001}\, \hat{I}(2001) + \hat{I}(2001) + I(2000)}{3}$$

6. Equations can now be applied recursively using **relF$_{rebuild}$** to estimate the catches in 2002 and 2003 consistent with the long term goal of restoring the population to I_{TARGET} in year T =2009.

An additional complication arise if the predicted relative population size in 2002 exceed the target index measure. This arises for GOM haddock because the recent low relative Fs lead to the prediction of high replacement ratios. For this stock, the relative F was capped at the replacement level of F. Therefore the catches and population sizes are predicted to remain constant over the rebuilding period. Results of these forecast methods are summarized for index-based and age-based stocks in Tables 3 and 4, respectively.

<u>Comparisons with Age-Based Projections</u>

Application of the above forecast procedures are compared to age-based assessments for Georges Bank cod, haddock, and yellowtail stocks (Fig. 7.1, 7.2, 7.3, respectively), Gulf of Maine cod (Fig. 7.4), Cape Cod yellowtail flounder (Fig. 7.5), American plaice (Fig. 7.6), witch flounder (Fig. 7.7), and Acadian redfish (Fig. 7.8). Comparisons of index-based catches were also done for the Southern New England stock of winter flounder (Fig. 7.9). Results of comparisons are mixed. Projections for Georges Bank cod and haddock are similar for both methods and the survey methods lie within the 80% confidence interval for the age-based projection. American plaice and redfish also show a high degrees of overlap. Comparisons for the other stocks, however, reveal moderate to severe deviations. The correlations between the catch projections are very high but the scaling issues need additional work.

Stock	Correlation between age and index-based catch projections
GOM cod	0.974
GB cod	0.998
GB haddock	0.973
GB yellowtail flounder	0.628
CC yellowtail flounder	0.178
Amer Plaice	0.061
SNE winter	0.924
Redfish	0.65

Lack of correspondence between the two approaches appears to be greatest for stocks which are either rebuilding rapidly (e.g., GB yellowtail) or stock requiring major rebuilding. I anticipate that a more thorough examination of the prediction error in the regression model for replacement ratio and relative F will allow for more rigorous comparisons. It should also be noted that the validity of replacement ratio concept diminishes for stocks whose fishing mortality rate greatly departs from the replacement F.

APPLICATION OF THE ENVELOPE PLOT

The "Envelope Plot" is a tool introduced at SARC 33 (NEFSC 2001) to develop bounds on the likely magnitude of population estimates. The basic concept is to combine a long series of catch data with a shorter time series of catch and survey data as a way of inferring historical population sizes. As a simple example, division of an observed catch series C_t by a constant value of exploitation rate U gives an estimate of the biomass at time t (B_t). As F approaches a large value, U approaches 1.0 and biomass B approaches the observed C. Conversely, if it is assumed that the observed catches are the result of a very low level of exploitation, then the population size will be very high. Thus

$$\hat{B}_{t,\,low} = \frac{C_t}{U_{high}}$$

$$\hat{B}_{t,\,high} = \frac{C_t}{U_{low}}$$

One can extend this simple notion by considering the observed time series of relative F as measure of the historical exploitation pattern. The inverse of this quantity, i.e, I_t/C_t, can be used as a multiplier of historical catch to obtain an estimate of the possible values of survey estimates. Thus one can impute a historical time series of relative abundance indices based on the an observed set of I_t/C_t value. More precisely consider a catch series C_t where t=1, 2,..., T. Suppose that a survey I_t beginning in year m has been conducted such that we also have a series of indices I_t, t=m, m+1, ...,T. The set of ratios $\{I_t/C_t$, t=m,..., T$\}$ can now be used as a way of estimating possible values of I_t for the period t=1, 2,..., m-1. Define $p_{\alpha}(I_t/C_t)$ as the α%-ile of I_t/C_t. If it is reasonable to assume that the observed range of I_t/C_t is representative of possible values of I_t/C_t during the unobserved period (i.e., t=1, ..., m-1). If we let $p_{\alpha}(I_t/C_t)$ and $p_{\beta}(I_t/C_t)$ represent lower and upper percentiles, respectively, for the observed ratios then the estimates of relative abundance for the period t=1, 2,..., m-1 can be approximated as:

$$\hat{I}_{t,\alpha} = C_t\, p_\alpha\left(\left\{\frac{I_\tau}{C_\tau}\right\}\right) \textit{ for } \forall\tau \in\{m, m+1,\ldots,T\},\ \forall t \in\{1,2,\ldots,m-1\}$$

$$\hat{I}_{t,\beta} = C_t\, p_\beta\left(\left\{\frac{I_\tau}{C_\tau}\right\}\right) \textit{ for } \forall\tau \in\{m, m+1,\ldots,T\},\ \forall t \in\{1,2,\ldots,m-1\}$$

A similar equation can be constructed for the median of I_t/C_t and the imputed time series can be concatenated with the observed series.

At first glance one might wonder about the value of estimating the likely range of relative abundance estimates from surveys that were never conducted. Simple plots of the concatenated time series for Georges Bank haddock (Fig. 8.1), cod (Fig. 8.2), yellowtail flounder (Fig. 8.3), and redfish (Fig.8.4) confirm commonly held notions that the historical population sizes of haddock and redfish were much higher than values observed in the last 40 years. Importantly, plots for both haddock and redfish suggest that conditions similar to long-term median values existed at the start of the fall survey time series (early 1960's). In contrast Fig. 8.2 for cod suggests that average densities between 1963 and 1980 were generally higher that the median imputed estimates for the period 1890 to 1960. If the landings for this early period are representative and complete, then the average relative abundance estimates between 1963-80 are similar to the 90%-ile of the imputed abundance index. This conclusion however is highly speculative and other information about the nature of the fishery and landings during this period must be considered. For example, if the fishery was prosecuted only on inshore stocks and most of the offshore population was unaffected by fishing, then the contemporary estimates of I_t/C_t may be of little use for interpreting historical patterns.

A similar set of arguments could be made for Georges Bank yellowtail flounder (Fig. 8.3). Envelope plot results suggest that the abundance levels in the 1960's were higher than imputed relative indices during the 1940-1960 period. The history of the geographical expansion of this fishery however, needs to be considered. Nonetheless, the envelope plot provides a diagnostic tool for evaluating the historical population and may provide confirmatory information for estimates of target biological reference points that are higher than recently observed values. The following text table compares the age-based and index-based estimates of the ratio of current biomass to biomass levels under Bmsy levels.

Comparison of B(t)/ Bmsy estimates based on age- and index based methods.				
Species	GB haddock	GB cod	GB Yellowtail	Redfish (/1)
Survey Average 1998-2000 (kg/tow)	14.76	2.40	6.05	5.51
Age-based estimated ratio of B(t) to B_msy (/2)	0.26	0.13	0.72	0.5
90%-ile of composite median index (kg/tow)	48.88	12.63	7.41	10.55
Index based ratio 1998-00 average index to 90%ile of median composite index	0.30	0.19	0.82	0.52
Difference between age and index based estimates of B(t)/Bmsy	- 0.04	-0.06	-0.10	-0.02
(/1) The 75%-ile of the median was used for redfish				
(/2) obtained from Fig. 4.2.3 of Panel Report				

APPLICATION OF METHODOLOGY TO SUMMER FLOUNDER AND SCUP

The fourth Term of Reference for the Methods Working Group is to "Investigate the applicability of these methods to summer flounder and scup assessments for SAW 35". These issues are addressed below.

Data

The raw data for summer flounder and scup are summarized in Tables 9.1 and 9.2 respectively. For both species, total catch estimates are available for only part of the available time series. The relative contributions of recreational landings and discards to the total catch have varied considerably over time. The Southern Demersal Working Group on summer flounder did not prepare total catch estimates for years prior to 1982. Therefore, for the purpose of testing the applying the index methodology to summer flounder, commercial landings were used as proxy for total catch. A simple linear regression of total catch versus commercial landings for the period 1982-2001 explained 80% of the variation in total catch ($P<0.001$), suggesting that the relative exploitation rate derived from commercial landings would characterize the fishery. Since 1991 however, the relative contributions of commercial and recreational landings, and discards to the total catch have changed in response to management measures designed to increase spawning stock abundance.

Estimates of total catch for scup are hampered by incomplete information on landings and discard. The scup Working Group used a variety of extrapolation methods to estimate total catch from landings and discard data. Incomplete landings records, removals by distant water fleets, limited discard sampling, and extrapolated recreational landings estimates were all noted as sources of uncertainty by the scup Working Group. Despite these limitations, restricting the index analyses to only one catch component, say commercial landings, was considered inappropriate. Therefore the index-based estimates of relative F and replacement ratios were based on the best estimates of total catch.

Replacement Ratio Estimates

Graphical analyses of summer flounder (Fig. 9.2 , 9.3) reveal similar patterns with respect to the spring and fall trawl surveys. Both surveys show a strong upward trend in abundance since 1990, consistent with the imposition of quota regulations in same period. Relative F estimates exhibit the opposite trend and reached the lowest levels on record in 2001. The replacement ratio has increased above 1.0 in the spring survey (Fig. 9.2) about 1993 and about 1996 in the fall survey (Fig. 9.3). Estimates of the relationship between the replacement ratio and relative F suggest a consistent pattern for both surveys. As shown below, randomization tests of both regressions were statistically significant. Low levels of relative F in recent years are strongly associated with replacement ratios above 1.0. The results provide strong evidence that the reduced fishing mortality rates of the past decade have been instrumental in the recovery

Summer Flounder			
Fall Survey		**Spring Survey**	
Randomization Test Summary		***Randomization Test Summary***	
Observed Correlation	**-0.622**	Observed Correlation	**-0.619**
Sampling Distribution Stats		***Sampling Distribution Stats***	
median	-0.308	median	-0.317
min	-0.664	min	-0.744
max	0.239	max	0.273
95%ile	-0.015	95%ile	-0.020
5%ile	-0.535	5%ile	-0.554
Approximate Significance		***Approximate Significance***	
Level of test statistic		***Level of test statistic***	
P(Corr<Obs Correlation)		***P(Corr<Obs Correlation)***	
0.00704		**0.01829**	

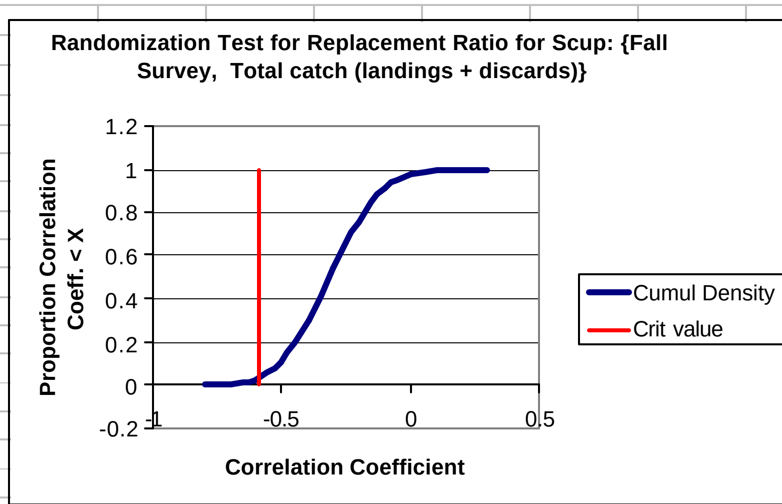
of summer flounder.

Results for scup were less conclusive(Fig. 9.3-4). Analyses of the fall survey (Fig. 9.3) suggest that the recent increase in fallu survey biomass is strongly associated with the decline in relative F. The replacement ratio first increased above 1.0 about 1996 and the regression between replacement ratio and relative F is statistically significant (below).

Randomization Test Summary	
Observed Correlation	-0.590

Sampling Distribution Stats	
median	-0.314
min	-0.723
max	0.296
95%ile	-0.031
5%ile	-0.567

Approximate Significance Level of test statistic P(Corr<Obs Correlation)
0.03599



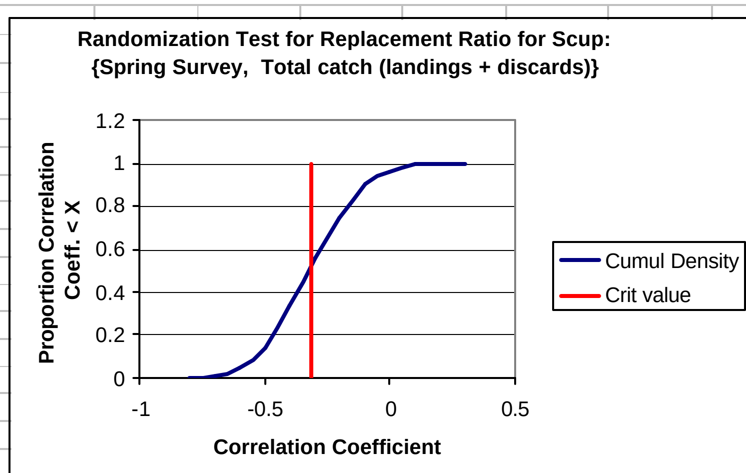
In contrast the randomization test for scup suggests the relative F at replacement is imprecisely estimated and not statistically significant (below). Spring survey abundance has generally declined since the late 1960s and has, only in recent years, shown any sign of reversal.

Relative F has declined in 2000 and 2001 but the contrast with previous years is sharp (Fig. 9.4). The relative information content of the two surveys is further depicted in Fig. 9.5. The imprecision of the spring survey-based estimates of replacement F lead to wide asymptotic parametric confidence intervals but much smaller intervals for the fall surveys. These results suggest that possible re-examination of the reliance on the spring survey rather than the fall survey as a signal of stock abundance trends may be warranted.

Randomization Test Summary	
Observed Correlation	-0.315

Sampling Distribution Stats	
median	-0.324
min	-0.771
max	0.298
95%ile	-0.025
5%ile	-0.587

Approximate Significance Level of test statistic P(Corr<Obs Correlation)
0.512



Projections of relative biomass and landings

As described in Section 7.0 the index methodology can be extended to provide projections of catch (or landings) and relative stock. The validity of these projections is primarily governed by the difference in magnitude of the current relative F and the relative F at replacement. As with any linear regression, projections that rely independent variables that are far from their means are less reliable that estimates close to the mean. For the index methodology, transient effects during stock rebuilding may result in overly optimistic projections of stock recovery and/or landings.

The projection scenarios for summer flounder and scup (Table 7) were based on a continuation of contemporary rates of relative exploitation. Relative F levels for both summer flounder and scup are sufficiently low such that continuing increases are expected in the short term. Projections for summer flounder suggest a near 3-fold increase in relative biomass and landings through 2005. Projected landings for scup are similarly optimistic irrespective of whether the analyses include or exclude discard estimates from the total catch estimates.

The dynamics of both species are likely to be dominated by strong year classes and the projections may not be realistic in the longer term. However, both scenarios suggest that the populations and landings should continue to increase in the short run, predictions that are consistent with more detailed projections derived from analytical models.

SARC COMMENTS - INDEX METHODS

The SARC reviewed a working document on the development of empirical methods for stock assessments based on analysis of total catch and trends in abundance indices. The work discussed is in progress and, while it was developed with feedback from the SAW methods group, it had not been subject to extensive peer review prior to the SARC.

TERMS OF REFERENCE

1. Describe the underlying theoretical basis for the index-based assessment and projection methodologies
2. Identify critical limitations for application of such methodologies.
3. Compare reference point estimates and projections with results from VPA and other modeling approaches.
4. Investigate the applicability of these methods to summer flounder and scup assessments for SAW 35.

Potential of the methods

The SARC concluded that the method has considerable potential as a monitoring tool that to evaluate stock trajectories and provide valuable information in interim years between analytical assessments. Similarly, the technique has utility in presenting an integrated picture of stock dynamics for resources where only catch statistics and survey trends are available. The visual techniques were considered very useful as a summary of stock status trends.

The SARC also discussed the value of the method in terms of its usefulness for providing objective estimates of proxies for management reference points. While the method does not provide, *a priori*, a proxy for Fmsy, it has potential for estimating a relative F for stock replacement, especially in cases where density-dependence is not apparent and other conditions of the method (discussed below) are met. In such cases, the method may be preferable to subjective methods currently used to provide reference points. Under conditions of low stock density, the level of recruitment is likely to be proportional to stock abundance and thus increase the applicability of the method.

The SARC further provided technical comments on aspects of the derivation of the method, and conditions under which it might be inappropriate to apply this method. Most of these limitations also apply to the application of alternative methods.

Theoretical bases for the methods

A number of issues were raised at the SARC regarding the theoretical basis for the index-based assessment and projection methods:

- The use of the moving average in the denominator of the replacement ratio statistic could be generalized to a broader family of smoothing equations, thereby retaining the empirical nature and extending the flexibility of the method; the link to survival and recruitment is an unnecessary constraint and may limit the development of better predictors of stock status based on available indices. On the other hand, development of a theoretical basis for the method could allow interpretation of underlying assumptions leading to stock replacement.

- The ratio of current biomass to the weighted sum of previous biomasses, as specified in the current derivation (equation 6) equals one, irrespective of the trend in the population. However, the SARC concluded that the statistic proposed, defined as the ratio between the last index of abundance and the moving average of the previous five indices, can be used as an empirical measure of biomass trend because of variation in population processes (survival and recruitment).

- The basis for estimating the relative rate of fishing mortality at which the stock would replace itself from the empirical regression between the index of trend and the relative fishing mortality was questioned on the following grounds: if density-dependence was operating, there would be infinite levels of replacement F; results of the regression approach would reflect a composite of alternative stable points and transient effects. It is possible that clustering of data points in various quadrants can be taken as indications of multiple stable equilibria.

Conditions for application of the methods

- The method requires the use of reliable catch statistics so it would not be applicable to stocks for which catch records are inadequate, or substantial portions of the catch are poorly estimated (e.g. discards, recreational catch etc).

- The method assumes that the survey indices adequately represent the fishable biomass. Concern was raised by the SARC that this assumption could be problematic as the surveys often catches younger fish than the fishery. The problem may be more severe when there have been major changes in the exploitation pattern.

- The method will not adequately estimate relF at replacement when stock trends are mainly driven by environmental effects. Strong year classes or, worse, persistent changes in productivity such as connected to regime shifts would lead to spurious results.

- The method would be unsuitable for developing fisheries, or situations when fishing mortality is increasing from a low value. It may be unsuitable for other types of fisheries depending on their exploitation history, but that needs to be investigated.

- Similar to the limitations of using biomass-weighted F as an overfishing definition (SAW 33) relF and $relF_{rep}$ will be sensitive to transition effects due to variations in recruitment, PR, average weights, age structure and other factors.

- The validity of the envelope plots used to reconstruct historical stock trajectories clearly depends on the historical exploitation being in the range of observed relFs. In instances where the catch series represents a developing fishery, then the envelope would be insufficient to estimate stock size.

Comparison of projections with results from VPA and other modeling approaches

- Projections are based on linear rates of increase and as such they should not be used to project population trends beyond a few years.

- Projections are sensitive to transient effects even in the absence of density dependence. For example, initial stock increases obtained in response to reductions in F may be fast initially but the increase would slow down as the age structure broadens.

- The selection of the relative F needed to achieve a given rate of increase in the projections would be sensitive to transient conditions. For example, a stock that is rebuilding fast in response to a recent large reduction in F may transiently show a replacement index higher than required; in this case the procedure would produce an increase in relative F when in fact such an increase would not be guaranteed. When required relative F differs markedly from the current, catch projections will be off scale compared to projections made using conventional age-structured models (e.g. in GB yellowtail).

- Further evaluation of the degree to which the method produces results that are comparable with those produced by VPA are required, noting that the new method has the potential to be applied when data limit the applicability of other methods

Applicability to summer flounder and scup assessments for SAW 35

Due to inadequate catch records, the SARC concluded that the method was not applicable to the scup assessment.

The method could have potential for summer flounder as an interim technique between analytical assessments to evaluate new catch and survey data relative to management targets, especially in combination with medium-term projections from assessments.

RESEARCH RECOMMENDATIONS

- Evaluate the performance of the proposed index methods using age-structured simulations representing different histories of exploitation, fishery selectivity, assumptions of density dependence, stock trajectories, and time lags.

- Compare reference points resulting from the method with traditional BRPs

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Table C1. Summary of replacement ratio analyses for 19 stocks. Estimates of replacement ratios are based on robust regression of the model ln(RR)=a + b ln(relF). Replacement F is estimated as the point where the replacement ratio equals 1.0. Asymptotic standard errors of the estimate are approximate. Significance test is based on randomization test.

								Current Stock Condition		
Stock	Species	Survey	relF where	SE(F_replac	relF where	SE (F grow)	Significance	Average	Ratio of	Ratio of
Georges Bank	Cod	Fall	2.04	0.58	1.64	0.56	0.113	3.91	1.92	2.39
		Spring	1.10	0.30	0.93	0.29	0.112	1.29	1.17	1.38
	Haddock	Fall	0.72	0.08	0.65	0.08	0.001	0.44	0.61	0.68
		Spring	0.58	0.08	0.51	0.08	0.001	0.59	1.03	1.16
	N. Windowpane	Fall	0.37	0.48	0.17	0.32	0.197	0.20	0.54	1.17
	Winter Flounder	Fall	1.18	0.11	1.06	0.11	0.001	0.62	0.52	0.58
	Yellowtail	Fall	2.42	0.36	2.13	0.33	0.001	0.77	0.32	0.36
		Spring	1.96	0.40	1.68	0.36	0.003	0.72	0.37	0.43
Gulf of Maine	American Plaice	Fall	1.40	0.60	0.90	0.62	0.460	1.49	1.06	1.66
		Spring	2.56	0.59	2.06	0.55	0.132	2.43	0.95	1.18
	Cod	Fall	0.67	0.30	0.45	0.27	0.012	1.41	2.10	3.16
		Spring	0.94	0.35	0.70	0.35	0.269	0.99	1.05	1.40
	Haddock	Fall	0.23	0.05	0.20	0.05	0.004	0.15	0.67	0.76
		Spring	0.83	0.35	0.67	0.29	0.010	0.79	0.95	1.18
	Halibut	Fall	0.01	0.01	0.01	0.01	0.284	0.02	1.21	1.45
		Spring	0.02	0.01	0.02	0.01	0.665	0.01	0.29	0.33
	Pollock (all)	Fall	15.48	3.67	12.01	3.36	0.050	12.93	0.84	1.08
	Pollock (USA)	Fall	3.57	0.97	2.70	0.87	0.050	4.33	1.21	1.60
	Pollock (5&6)	Fall	5.88	1.05	4.83	1.00	0.024	5.56	0.94	1.15
	Redfish	Fall	0.83	0.35	0.51	0.23	0.005	0.06	0.08	0.13
		Spring	0.42	0.22	0.31	0.17	0.030	0.06	0.14	0.20
	White Hake	Fall	0.54	0.07	0.42	0.07	0.036	0.80	1.48	1.89
		Spring	0.57	0.15	0.48	0.15	0.040	1.54	2.68	3.19
	Witch flounder	Fall	1.34		0.92		0.346	3.27		
		Spring					0.554	2.26	1.68	2.45
	Yellowtail	Fall	0.44	0.19	0.34	0.18	0.472	0.25	0.57	0.75
		Spring	0.30	0.36	0.23	0.35	0.686	0.35	1.17	1.54
Southern New England	Mid Atl	Fall	0.33	0.16	0.30	0.15	0.108	1.19	3.60	4.02
		Spring	0.09	0.06	0.07	0.05	0.194	0.55	6.22	7.33
	Ocean pout	Spring	0.01	0.03	0.00	0.01	0.118	0.01	0.60	2.00
	Windowpane	Fall	0.98	0.45	0.73	0.42	0.101	0.70	0.72	0.96
	Winter Flounder	Fall	5.14	1.00	4.40	0.91	0.004	2.15	0.42	0.49
		Spring	6.97	0.53	6.51	0.52	0.001	4.44	0.64	0.68
	Yellowtail	Fall	0.47	0.61	0.35	0.52	0.461	1.10	2.33	3.12
		Spring	0.37	0.44	0.28	0.39	0.498	0.48	1.31	1.71

Table C2. Catch projections based on index model. Catches for 2002 represent status quo relative F, rel F at replacement, and rel F at 10% growth rate.

			Current Stock		Predicted Catch for 2002			Predicted Catches (mt) with rel F = F_grow and population growth of 10% per year.								
Stock	Species	Survey	Average	Average	Predicte	Catch at	Catch at	2003	2004	2005	2006	2007	2008	2009	average	Average
Georges Bank	Cod	Fall	2.4	3.91	9.4	4.9	3.9	4.3	4.8	5.2	5.8	6.3	7.0	7.7	5.6	9.30
		Spring	8.2	1.29	10.5	9.0	7.6	8.4	9.2	10.1	11.1	12.3	13.5	14.8	10.9	9.30
	Haddock	Fall	14.8	0.44	6.6	10.7	9.6	10.6	11.6	12.8	14.0	15.4	17.0	18.7	13.7	6.80
		Spring	10.6	0.59	6.3	6.1	5.4	5.9	6.5	7.2	7.9	8.7	9.6	10.5	7.7	6.80
	N. Windowpane	Fall	1.2	0.20	0.2	0.4	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.3	0.19
	Winter Flounder	Fall	2.3	0.62	1.4	2.7	2.4	2.7	2.9	3.2	3.6	3.9	4.3	4.7	3.5	1.41
	Yellowtail	Fall	6.1	0.77	4.7	14.7	12.9	14.2	15.6	17.2	18.9	20.8	22.8	25.1	18.4	4.81
		Spring	6.1	0.72	4.4	12.0	10.2	11.3	12.4	13.6	15.0	16.5	18.1	19.9	14.6	4.81
Gulf of Maine	American Plaice	Fall	2.5	1.49	3.8	3.5	2.3	2.5	2.7	3.0	3.3	3.7	4.0	4.4	3.2	3.69
		Spring	1.5	2.43	3.7	3.9	3.2	3.5	3.8	4.2	4.6	5.1	5.6	6.2	4.5	3.69
	Cod	Fall	3.2	1.41	4.6	2.2	1.4	1.6	1.7	1.9	2.1	2.3	2.6	2.8	2.1	4.34
		Spring	4.2	0.99	4.1	3.9	2.9	3.2	3.6	3.9	4.3	4.7	5.2	5.7	4.2	4.34
	Haddock	Fall	7.3	0.15	1.1	1.7	1.5	1.6	1.8	1.9	2.1	2.4	2.6	2.8	2.1	0.78
		Spring	1.0	0.79	0.8	0.8	0.7	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.0	0.78
	Halibut	Fall	1.5	0.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
		Spring	3.5	0.01	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.02
	Pollock (all)	Fall	1.0	12.93	13.4	16.1	12.5	13.7	15.1	16.6	18.2	20.1	22.1	24.3	17.8	14.13
	Pollock (USA)	Fall	1.0	4.33	4.5	3.7	2.8	3.1	3.4	3.7	4.1	4.5	5.0	5.5	4.0	4.74
	Pollock (5 &6)	Fall	1.0	5.56	5.8	6.1	5.0	5.5	6.1	6.7	7.3	8.1	8.9	9.8	7.2	6.09
	Redfish	Fall	5.5	0.06	0.4	4.6	2.8	3.1	3.4	3.7	4.1	4.5	4.9	5.4	4.0	0.33
		Spring	5.7	0.06	0.3	2.4	1.7	1.9	2.1	2.3	2.5	2.8	3.1	3.4	2.5	0.33
	White Hake	Fall	4.8	0.80	3.8	2.6	2.0	2.2	2.5	2.7	3.0	3.3	3.6	4.0	2.9	3.73
		Spring	3.1	1.54	4.8	1.8	1.5	1.7	1.8	2.0	2.2	2.4	2.7	2.9	2.2	3.73
	Witch flounder	Fall	0.6	3.27												
		Spring	0.8	2.26	1.9	1.1	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.1	2.52
	Yellowtail	Fall	6.3	0.25	1.6	2.8	2.1	2.3	2.6	2.8	3.1	3.4	3.8	4.1	3.0	1.71
		Spring	6.6	0.35	2.3	2.0	1.5	1.6	1.8	2.0	2.2	2.4	2.6	2.9	2.1	1.71
Southern New England	Mid Atl	Fall	0.2	1.19	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.30
		Spring	0.5	0.55	0.3	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.30
	Ocean pout	Spring	2.1	0.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02
	Windowpane	Fall	0.2	0.70	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.12
	Winter Flounder	Fall	2.0	2.15	4.2	10.2	8.7	9.6	10.5	11.6	12.7	14.0	15.4	16.9	12.4	4.23
		Spring	0.9	4.44	4.2	6.6	6.2	6.8	7.5	8.2	9.0	9.9	10.9	12.0	8.8	4.23
	Yellowtail	Fall	0.7	1.10	0.7	0.3	0.2	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.3	0.68
		Spring	1.4	0.48	0.7	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.7	0.5	0.68

Table C3. Catch projection estimates for index based stocks. Target index values are externally supplied and are based on analysis of the historical fishery and trends in research survey indices. Part A illustrates the initial projection from 2000 to 2002 based on the observed landings in 2001 and methodology described in the text. Part B summarizes the catch projections given the annual growth rates necessary to reach the biomass targets in 2009.

Part A

			Parameters ln(RR) =a+b ln(relF)		*Survey Estimates (kg/tow)*			*Projection of Stock from 2000 to 2002*				
Stock	*Species*	*Survey*	*a*	*b*	*1998*	*1999*	*2000*	*Average Relative F (last 3-yr)*	*Projected Relative Biomass in 2001 (kg/tow)*	*Observed Landings in 2001 (k mt)*	*relF estimate in 2001*	*Projected Relative Biomass in 2002 (kg/tow)*
Georges	Winter Flounder	Fall	0.150	-0.892	1.57	2.64	2.66	0.616	3.13	2.67	0.95	3.20
Bank	N. Windowpane	Fall	-0.121	-0.123	1.66	0.73	1.22	0.202	1.082	0.04	0.04	1.24
Gulf of	Haddock	Fall	-1.083	-0.733	2.92	4.91	14.03	0.153	*9.57*	0.95	0.10	13.73
Maine	Pollock (Area 5 & 6)	Fall	0.857	-0.483	0.76	1.52	0.83	5.556	1.14	4.90	4.21	1.11
	White Hake	Fall	-0.243	-0.393	4.27	3.44	6.72	0.798	*4.76*	**3.56**	0.72	5.24
		Spring	-0.301	-0.543	1.09	2.97	3.33	1.536	*2.71*	**3.56**	1.19	2.63
Southern	S.Windowpane	Fall	-0.008	-0.331	0.18	0.12	0.28	0.702	0.20	0.11	0.56	0.24
New	SNE Yellowtail Fl	Fall	-0.243	-0.324	0.90	0.10	0.99	1.099	0.53	1.03	1.91	0.62
England		Spring	-0.358	-0.358	0.97	1.76	1.44	0.481	1.48	1.03	0.66	1.38
	Ocean Pout	Spring	-0.337	-0.079	1.73	2.56	2.02	0.008	2.26	0.02	0.01	2.21
	MidAtl Yellowtail Fl	Fall	-0.959	-0.864	0.09	0.50	0.11	1.188	0.23	0.21	0.74	0.15

Part B

			Biological Targets			*Predicted Catch (k mt)*							
Stock	*Species*	*Survey*	*Target Relative Biomass (kg/tow)*	*Annual Growth rate necessary to rebuild by 2009*	*Relative F for Rebuild*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Georges	Winter Flounder	Fall	2.74	0.978	1.183	3.79	3.79	3.79	3.79	3.79	3.79	3.79	3.79
Bank	N. Windowpane	Fall	0.94	0.962	0.373	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Gulf of	Haddock	Fall	22.17	1.071	0.208	2.86	3.06	3.28	3.51	3.76	4.02	4.31	4.61
Maine	Pollock (Area 5 & 6)	Fall	3.00	1.153	4.381	4.84	5.58	6.44	7.43	8.57	9.88	11.39	13.14
	White Hake	Fall	12.00	1.126	0.399	2.09	2.35	2.65	2.98	3.36	3.78	4.25	4.79
		Spring	12.00	1.242	0.385	1.01	1.26	1.56	1.94	2.41	2.99	3.72	4.62
Southern	S.Windowpane	Fall	0.92	1.210	0.550	0.13	0.16	0.20	0.24	0.29	0.35	0.42	0.51
New	SNE Yellowtail Fl	Fall	15.00	1.577	0.116	0.07	0.11	0.18	0.28	0.44	0.70	1.10	1.74
England		Spring	12.00	1.363	0.155	0.21	0.29	0.40	0.54	0.73	1.00	1.36	1.86
	Ocean Pout	Spring	4.90	1.120	0.003	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02
	MidAtl Yellowtail Fl	Fall	12.91	1.887	0.158	0.02	0.05	0.09	0.16	0.30	0.57	1.08	2.04

Table C4. Catch projection estimates for stocks assessed with age structured models. Target index values are derived by multiplying the ratio of total biomass estimates B(2009):B(2002) defined in the AGEPRO projections by the projected index balue in 2002. Part A illustrates the initial projection from 2000 to 2002 based on the observed landings in 2001 and methodology described in the text. The last column represents the projected increase in between 2002 and 2009. Part B summarizes the catch projections given the annual growth rates necessary to reach the biomass targets in 2009.

Part A

			Parameters ln(RR) =a+b ln(relF)		*Survey Estimates (kg/tow)*			*Projection of Stock from 2000 to 2002*					Target Increase ratio in mean SSB between 2002 and 2010
Stock	*Species*	*Survey*	*a*	*b*	*1998*	*1999*	*2000*	*Average Relative F (last 3-yr)*	*Projected Relative Biomass in 2001 (kg/tow)*	*Observed Landings in 2001 (k mt)*	*relF estimate in 2001*	*Projected Relative Biomass in 2002 (kg/tow)*	
Georges Bank	Cod	Fall	0.310	-0.436	2.80	3.00	1.40	3.911	2.07	12.77	5.92	1.59	3.88
		Spring	0.053	-0.574	11.70	4.70	8.20	1.285	6.79	12.77	1.94	6.63	3.88
	Haddock	Fall	-0.281	-0.873	5.75	23.13	15.41	0.445	20.38	11.55	0.59	20.08	2.70
		Spring	-0.433	-0.785	6.12	7.75	17.88	0.592	11.99	11.55	0.92	12.72	2.70
	Yellowtail Fl.	Fall	0.651	-0.735	4.35	7.97	5.84	0.769	9.29	7.74	1.00	10.96	1.30
		Spring	0.406	-0.601	2.32	9.31	6.70	0.723	9.05	7.74	0.93	9.98	1.30
Gulf of Maine	Cod	Fall	-0.092	-0.233	1.50	3.50	4.70	1.413	3.64	7.99	2.03	3.72	4.05
		Spring	-0.019	-0.325	4.20	5.10	3.20	0.990	4.13	7.99	1.93	3.54	4.05
	Redfish	Fall	-0.036	-0.193	6.49	4.68	5.36	0.064	6.36	0.33	0.06	7.43	1.19
		Spring	-0.252	-0.293	1.60	3.89	11.46	0.060	8.45	0.33	0.04	12.20	1.19
	Witch flounder	Fall	0.075	-0.254	0.47	0.88	1.11	2.259	0.90	3.46	3.59	0.91	0.81
	C.C. Yellowtail Fl.	Fall	-0.280	-0.344	2.53	9.28	7.12	0.253	8.02	2.57	0.32	8.05	6.10
		Spring	-0.410	-0.340	1.81	2.85	15.15	0.350	8.09	2.57	0.30	10.46	6.10
	American Plaice	Fall	0.072	-0.214	2.22	2.57	2.80	1.488	2.62	5.37	2.02	2.62	1.89
		Spring	0.416	-0.444	1.11	1.20	2.30	2.427	1.69	5.37	3.10	1.85	1.89
S. New England	Winter Flounder	Fall	0.998	-0.610	2.23	1.55	2.14	2.148	2.35	4.75	2.36	2.76	1.65
		Spring	2.701	-1.391	0.85	1.25	1.12	4.439	1.38	4.75	3.80	1.91	1.65

Part B

			Biological Targets			*Predicted Catch (k mt)*							
Stock	*Species*	*Survey*	*Target Relative Biomass (kg/tow)*	*Annual Growth rate necessary to rebuild by 2009*	*Relative F for Rebuild*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*
Georges Bank	Cod	Fall	6.17	1.214	1.306	2.08	2.50	3.10	3.70	4.50	5.50	6.60	8.10
		Spring	25.74	1.214	0.782	5.18	6.29	7.64	9.27	11.25	13.66	16.58	20.13
	Haddock	Fall	54.17	1.152	0.616	12.37	14.25	16.43	18.93	21.81	25.13	28.96	33.38
		Spring	34.33	1.152	0.481	6.12	7.06	8.13	9.37	10.80	12.44	14.34	16.52
	Yellowtail Fl.	Fall	14.30	1.039	2.302	25.23	26.21	27.22	28.28	29.37	30.51	31.69	32.91
		Spring	13.02	1.039	1.844	18.41	19.12	19.86	20.63	21.43	22.26	23.12	24.01
Gulf of Maine	Cod	Fall	15.08	1.221	0.285	1.06	1.29	1.58	1.93	2.36	2.88	3.52	4.29
		Spring	14.34	1.221	0.511	1.81	2.21	2.70	3.29	4.02	4.91	6.00	7.33
	Redfish	Fall	8.87	1.026	0.726	5.39	5.53	5.67	5.82	5.97	6.12	6.28	6.44
		Spring	14.58	1.026	0.388	4.73	4.86	4.98	5.11	5.24	5.38	5.51	5.66
	Witch flounder	Fall	0.73	0.970	1.343	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
	C.C. Yellowtail Fl.	Fall	49.13	1.295	0.210	1.69	2.18	2.83	3.66	4.74	6.14	7.95	10.30
		Spring	63.80	1.295	0.140	1.46	1.90	2.46	3.18	4.12	5.33	6.90	8.94
	American Plaice	Fall	4.93	1.095	0.916	2.40	2.62	2.87	3.15	3.44	3.77	4.13	4.52
		Spring	3.48	1.095	2.084	3.85	4.22	4.61	5.05	5.53	6.06	6.63	7.26
S. New England	Winter Flounder	Fall	4.56	1.074	4.574	12.62	13.56	14.57	15.65	16.81	18.06	19.41	20.85
		Spring	3.15	1.074	6.621	12.63	13.56	14.57	15.66	16.82	18.07	19.41	20.85

Table C5. Commercial landings of summer flounder, autumn and spring NMFS research trawl abundance indices, and derived relative F and replacement ratios. Note that 2002 index is preliminary.

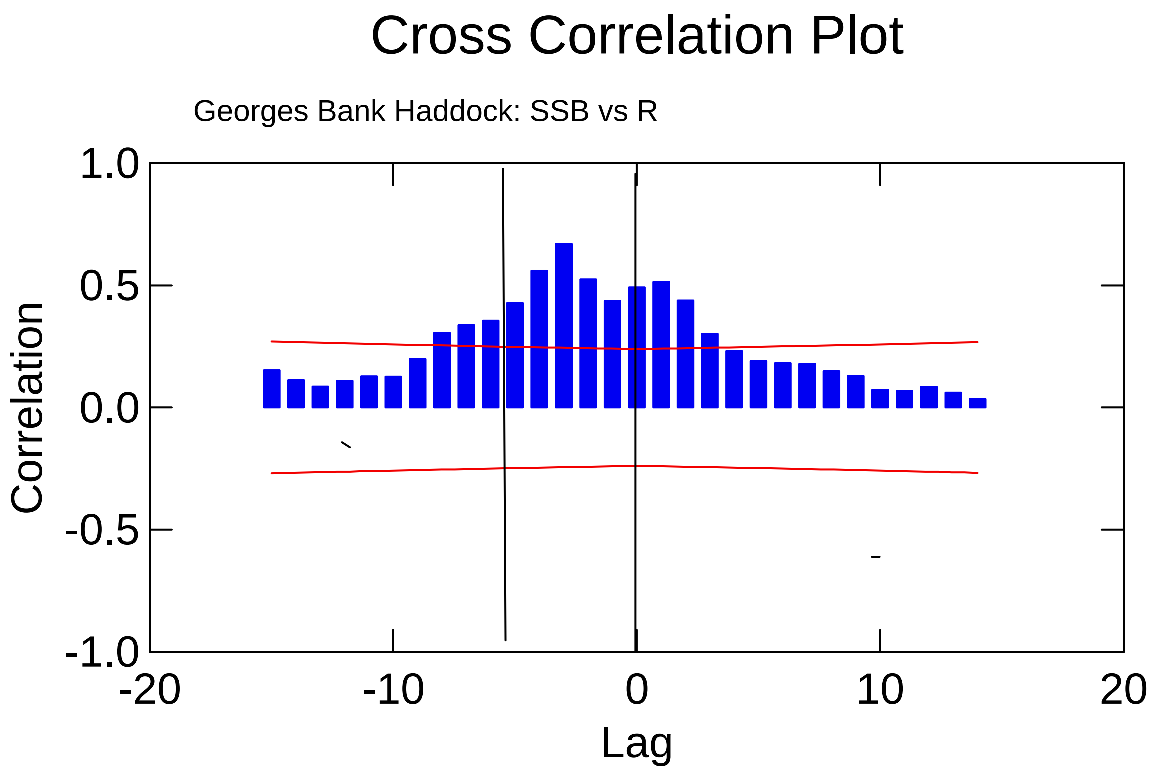
Year	Landings (000 mt)	NEFSC Autumn Survey Weight (kg) Per Tow Index	NEFSC Spring Survey Weight (kg) Per Tow Index	Relative F wrt fall survey (000 mt/(kg/tow))	Replacement index wrt fall survey (5yr)	Relative F wrt spr survey (000 mt/(kg/tow))	Replacement index wrt spr survey (5yr)
1965	4.6						
1966	6.4						
1967	5.9	1.25					
1968	4.1	1.00	0.16	4.31			
1969	3.0	0.61	0.16	5.24		22.22	
1970	4.0	0.13	0.09	11.94		22.75	
1971	4.2	0.27	0.28	18.99		21.94	
1972	4.2	0.27	0.21	10.73	0.41	12.18	
1973	7.3	0.63	0.54	7.97	1.38	10.94	3.00
1974	10.2	1.86	1.26	6.18	4.87	9.01	4.92
1975	11.9	2.48	1.61	6.90	3.92	7.35	3.38
1976	15.1	0.85	2.00	8.94	0.77	8.49	2.56
1977	13.6	1.75	1.74	13.58	1.44	7.88	1.55
1978	13.0	0.40	1.43	12.59	0.26	11.05	1.00
1979	17.9	0.94	0.35	28.19	0.64	21.03	0.22
1980	14.2	0.57	0.78	19.05	0.44	22.01	0.55
1981	9.6	0.72	0.80	13.08	0.80	10.65	0.63
1982	10.4	0.90	1.11	14.93	1.03	12.79	1.09
1983	13.4	0.47	0.53	19.91	0.67	19.91	0.59
1984	17.1	0.65	0.38	25.82	0.90	24.36	0.53
1985	14.7	0.87	1.20	22.35	1.31	18.34	1.67
1986	12.2	0.45	0.82	22.85	0.62	15.23	1.02
1987	12.3	0.28	0.38	43.83	0.42	19.58	0.47
1988	14.7	0.11	0.68	93.74	0.20	33.89	1.03
1989	8.1	0.08	0.24	64.14	0.17	20.48	0.35
1990	4.2	0.19	0.27	28.63	0.53	14.65	0.41
1991	6.2	0.17	0.35	21.97	0.77	17.29	0.73
1992	7.5	0.49	0.46	32.27	2.95	17.51	1.20
1993	5.7	0.04	0.48	19.48	0.19	12.25	1.20
1994	6.6	0.35	0.46	16.20	1.80	14.12	1.28
1995	7.0	0.83	0.46	12.84	3.35	13.16	1.14
1996	5.8	0.45	0.67	7.87	1.20	9.95	1.52
1997	4.0	0.92	0.61	4.06	2.13	5.87	1.21
1998	5.08	1.58	0.76	3.66	3.05	6.40	1.42
1999	4.82	1.66	1.01	2.86	2.01	4.17	1.71
2000	5.085	1.82	1.7	3.00	1.67	3.13	2.42
2001	4.916	1.61	2.16	2.87	1.25	2.40	2.27
2002			2.29				1.83

Table C6. Total catch of Scup with discard and recreational landings, autumn and spring NMFS research trawl abundance indices, and derived relative F and replacement ratios.

Year	Total Catch (k mt)	NEFSC Autumn Survey Weight (kg) Per Tow Index	NEFSC Spring Survey Weight (kg) Per Tow Index	Relative F wrt fall survey (000 mt/(kg/tow))	Replacement index wrt fall survey (5yr)	Relative F wrt spring survey (000 mt/(kg/tow))	Replacement index wrt spring survey (5yr)
1963	37.7852	1.21					
1964	29.6681	2.23		21.92			
1965	29.0885	0.62		26.77			
1966	21.2802	0.41		25.64			
1967	15.9281	1.46		19.83			
1968	13.6924	0.54	0.94	6.34	0.46		
1969	9.3341	4.48	0.39	5.34	4.26	10.65	
1970	8.0462	0.22	1.30	4.88	0.15	7.40	
1971	7.7174	0.25	1.57	8.24	0.18	6.14	
1972	8.7627	2.34	0.90	7.47	1.68	7.38	
1973	10.4546	0.93	1.09	7.33	0.59	7.74	1.07
1974	13.0307	1.01	2.06	7.32	0.61	6.79	1.96
1975	13.5500	3.40	2.61	3.46	3.58	7.82	1.89
1976	12.2494	7.35	0.53	2.95	4.63	4.91	0.32
1977	13.9511	1.71	4.35	4.03	0.57	5.60	3.03
1978	14.6948	1.32	2.59	12.11	0.46	5.30	1.22
1979	14.1065	0.61	1.38	14.85	0.21	8.36	0.57
1980	15.7914	0.92	1.09	10.43	0.32	14.06	0.48
1981	17.4571	3.01	0.90	10.27	1.26	17.40	0.45
1982	15.4484	1.17	1.02	10.25	0.77	23.77	0.49
1983	14.5551	0.34	0.03	15.99	0.24	31.64	0.02
1984	11.0530	1.22	0.33	6.48	1.01	45.42	0.37
1985	13.7290	3.56	0.37	6.40	2.67	20.29	0.55
1986	14.5320	1.66	1.33	8.12	0.89	14.83	2.51
1987	11.6570	0.15	1.24	18.41	0.09	10.60	2.01
1988	9.5670	0.09	0.73	53.15	0.06	14.54	1.11
1989	8.7170	0.30	0.004	21.44	0.22	25.05	0.01
1990	10.3640	0.83	0.31	19.93	0.72	40.70	0.42
1991	14.3620	0.43	0.45	18.10	0.71	44.42	0.62
1992	14.0560	1.12	0.21	26.52	3.11	43.47	0.38
1993	7.6380	0.04	0.31	18.04	0.07	41.66	0.91
1994	6.3940	0.11	0.03	18.10	0.20	41.70	0.12
1995	5.7480	0.91	0.12	13.80	1.80	101.44	0.46
1996	5.5290	0.23	0.02	8.21	0.44	66.35	0.09
1997	4.5350	0.88	0.11	7.56	1.83	75.58	0.80
1998	6.1331	0.69	0.05	5.05	1.59	73.60	0.42
1999	7.1876	2.07	0.09	2.86	3.67	86.25	1.36
2000	6.0561	4.79	0.11	2.25	5.01	24.55	1.41
2001	7.5446	1.2	0.54	2.52	0.69	23.21	7.11

Table C7. Summary of projected landings (k mt) and relative biomass levels (kg/tow) for summer flounder and scup

			Landings (000 mt)			
Basis	**Species**	**Survey**	**2002**	**2003**	**2004**	**2005**
comm Landings	Summer Flounder	Fall	7.47	10.33	14.62	20.62
comm Landings	Summer Flounder	Spring	8.60	12.48	17.59	24.91
Landing + Discard	Scup_ w/Disc	Fall	12.71	19.45	32.44	53.53
Landings Only	Scup_ w/oDisc	Fall	6.61	9.10	13.95	21.03
Total Catch	Summer Flounder	Fall	13.48	17.00	22.27	29.65
Total Catch	Summer Flounder	Spring	14.87	19.63	25.92	34.92
			Projected Index Biomass Levels (kg/tow)			
Basis	**Species**	**Survey**	**2002**	**2003**	**2004**	**2005**
comm Landings	Summer Flounder	Fall	2.57	3.55	5.03	7.09
comm Landings	Summer Flounder	Spring	2.66	3.86	5.44	7.70
Landing + Discard	Scup_ w/Disc	Fall	5.00	7.65	12.76	21.05
Landings Only	Scup_ w/oDisc	Fall	4.57	6.29	9.64	14.54


Cross Correlation Plot
Georges Bank Haddock: SSB vs R
Correlation
Lag
1.0
0.5
0.0
-0.5
-1.0
-20
-10
0
10
20

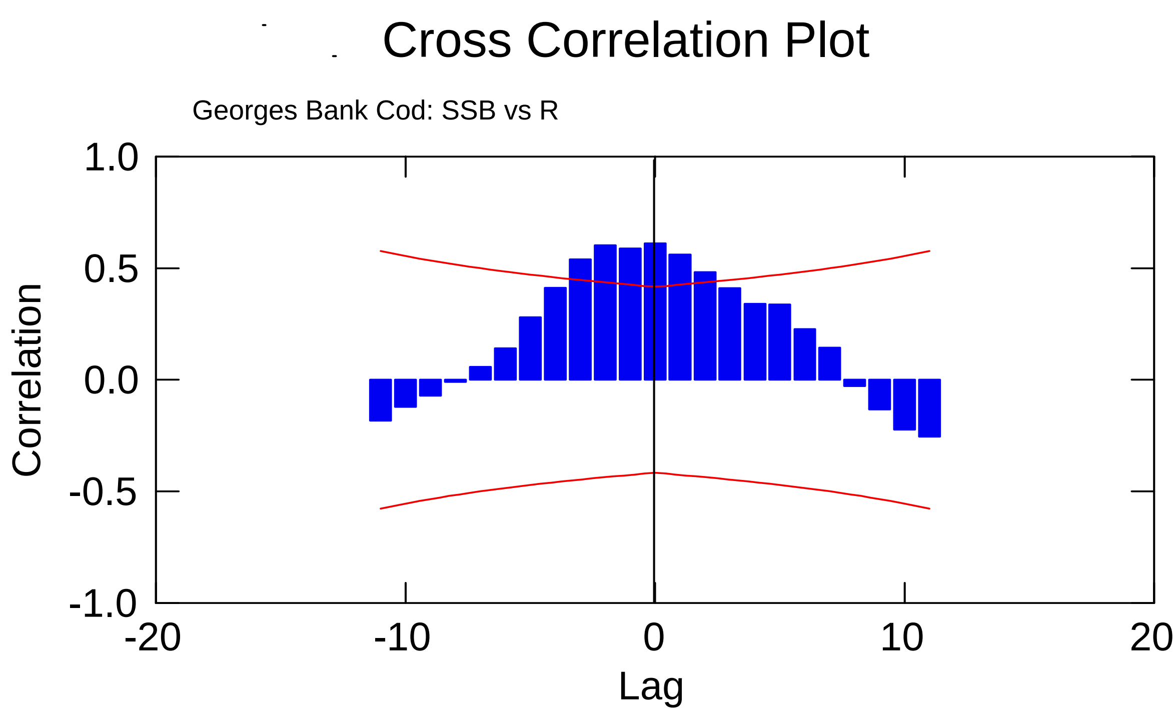
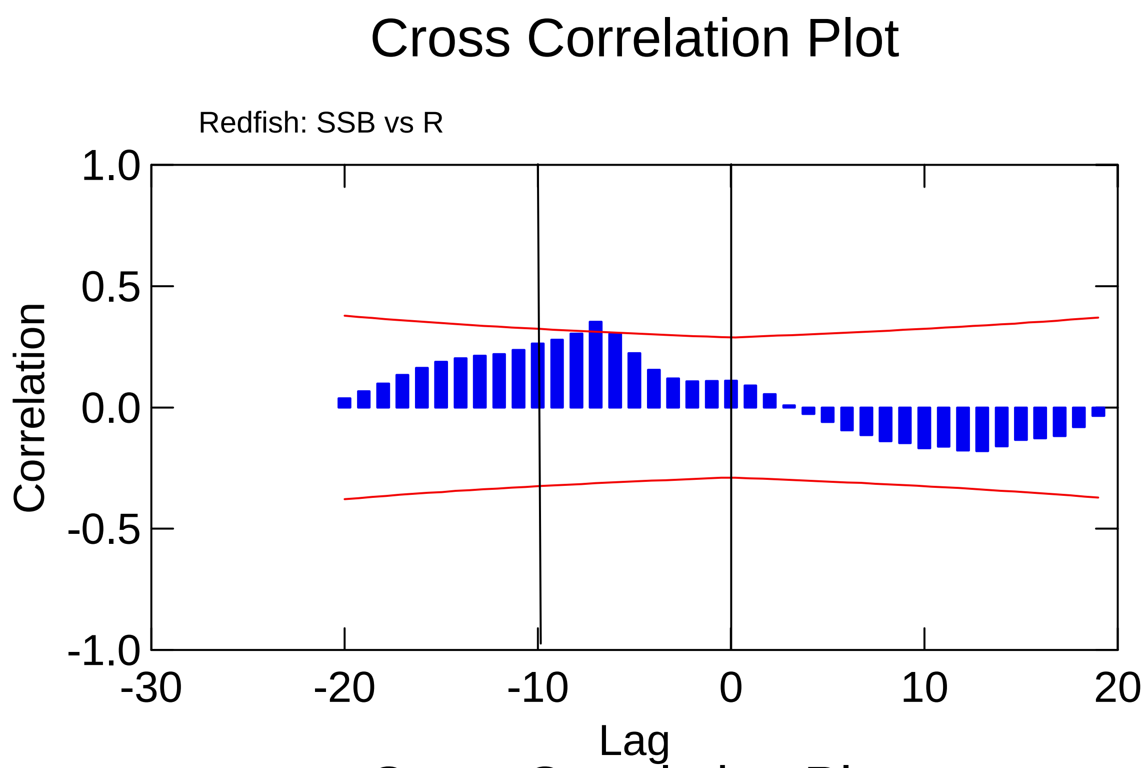

Cross Correlation Plot
Georges Bank Cod: SSB vs R
Correlation
Lag
1.0
0.5
0.0
-0.5
-1.0
-20
-10
0
10
20

Figure C3.1


Cross Correlation Plot
Redfish: SSB vs R
Correlation
1.0
0.5
0.0
-0.5
-1.0
-30
-20
-10
0
10
20
Lag

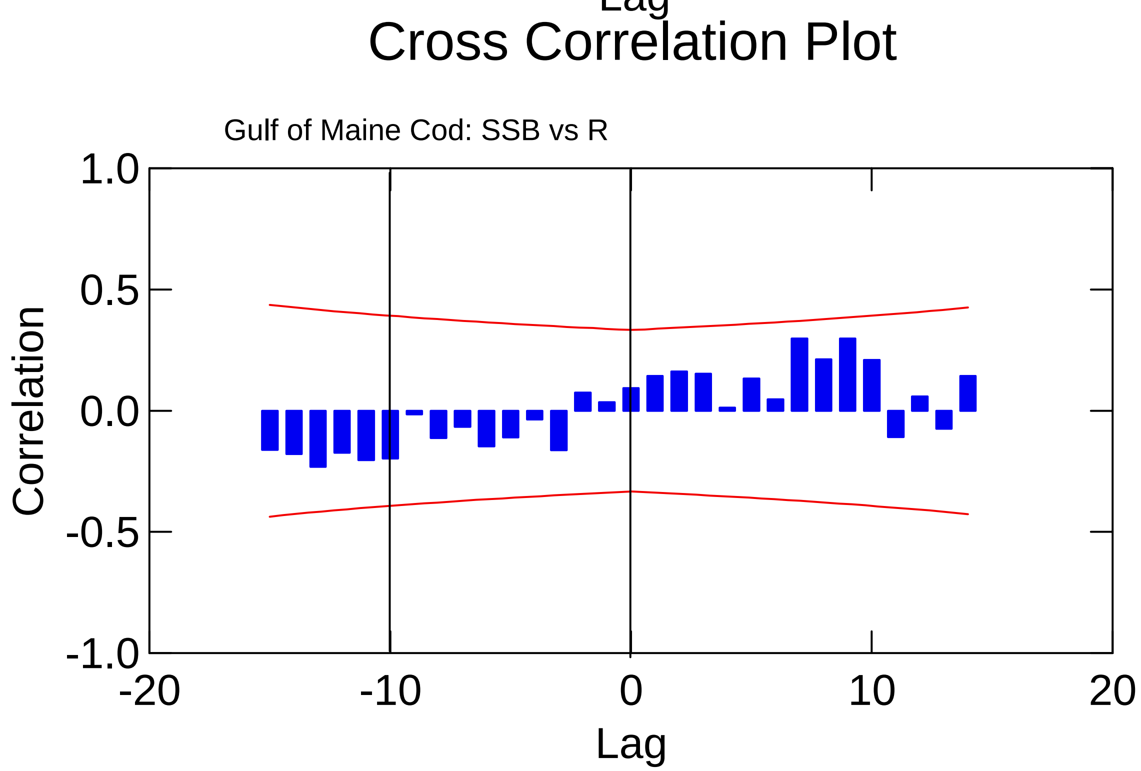
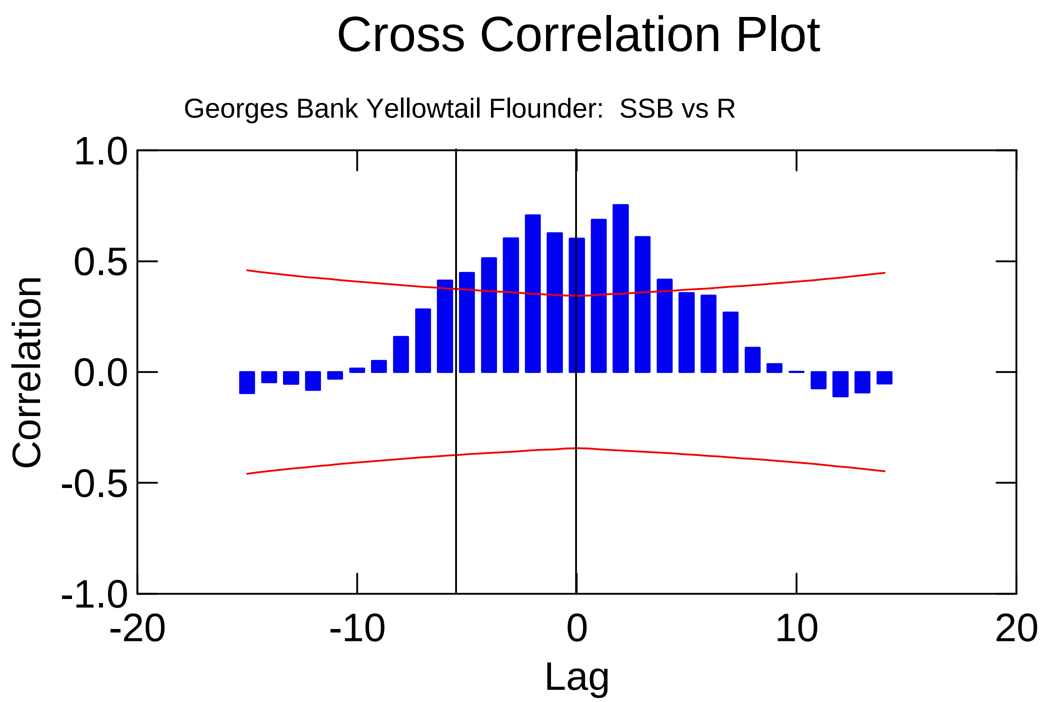

Cross Correlation Plot
Gulf of Maine Cod: SSB vs R
Correlation
1.0
0.5
0.0
-0.5
-1.0
-20
-10
0
10
20
Lag

Figure C3.2


Cross Correlation Plot
Georges Bank Yellowtail Flounder: SSB vs R
1.0
0.5
0.0
-0.5
-1.0
Correlation
-20
-10
0
10
20
Lag

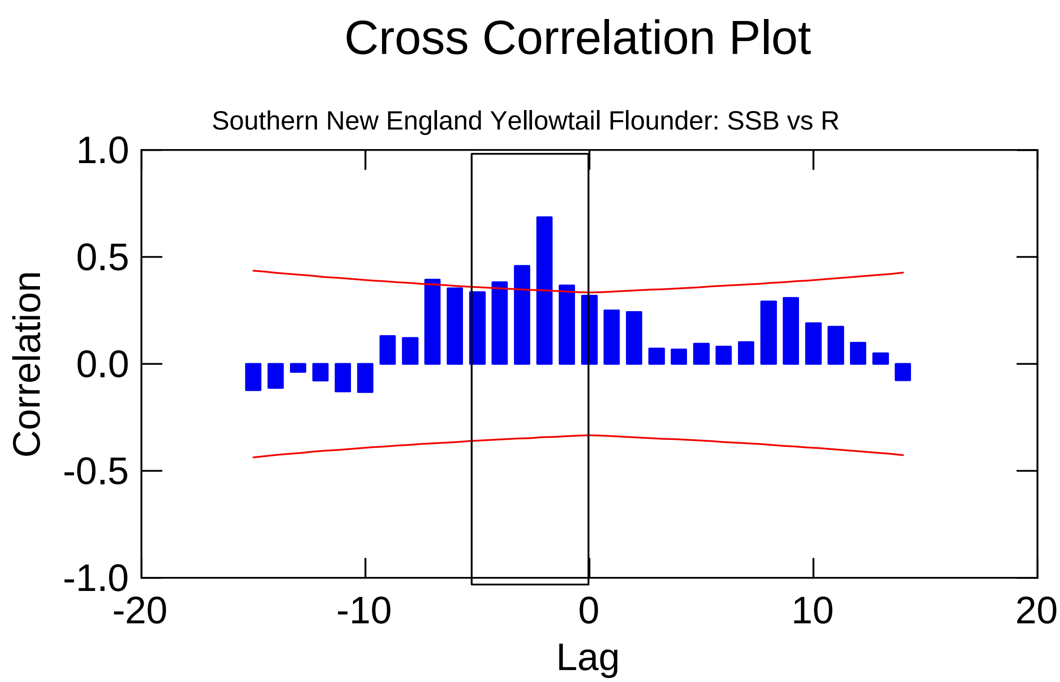

Cross Correlation Plot
Southern New England Yellowtail Flounder: SSB vs R
1.0
0.5
0.0
-0.5
-1.0
Correlation
-20
-10
0
10
20
Lag

Figure C3.3

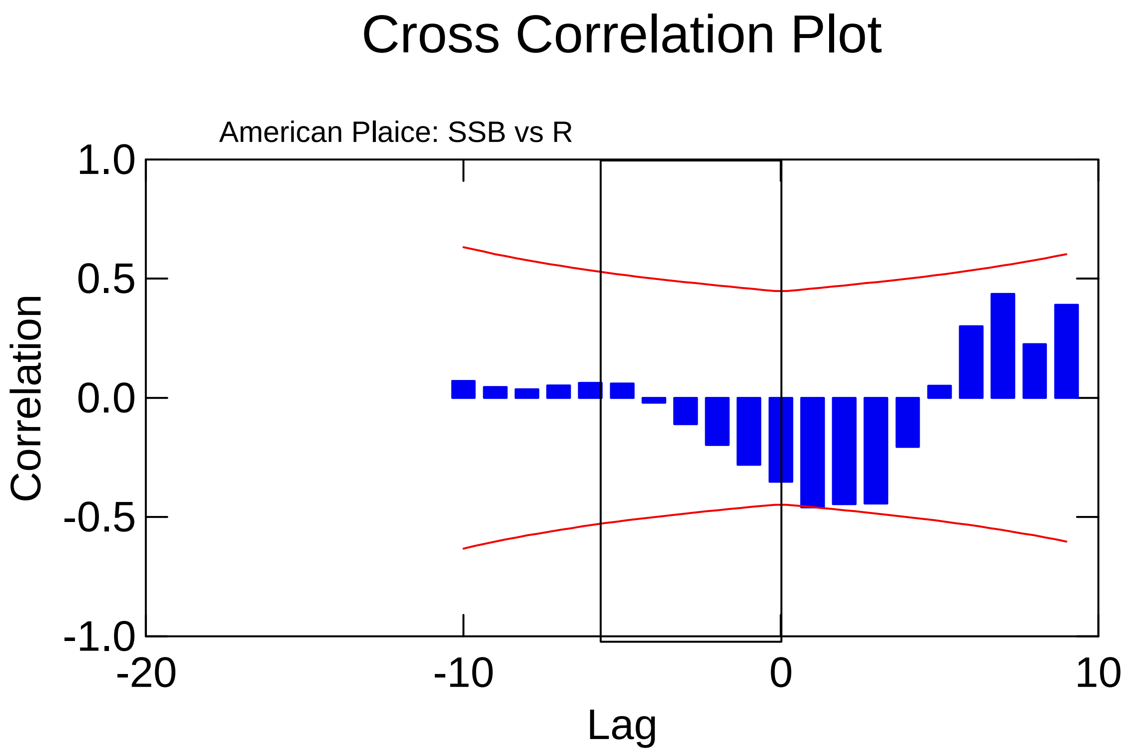
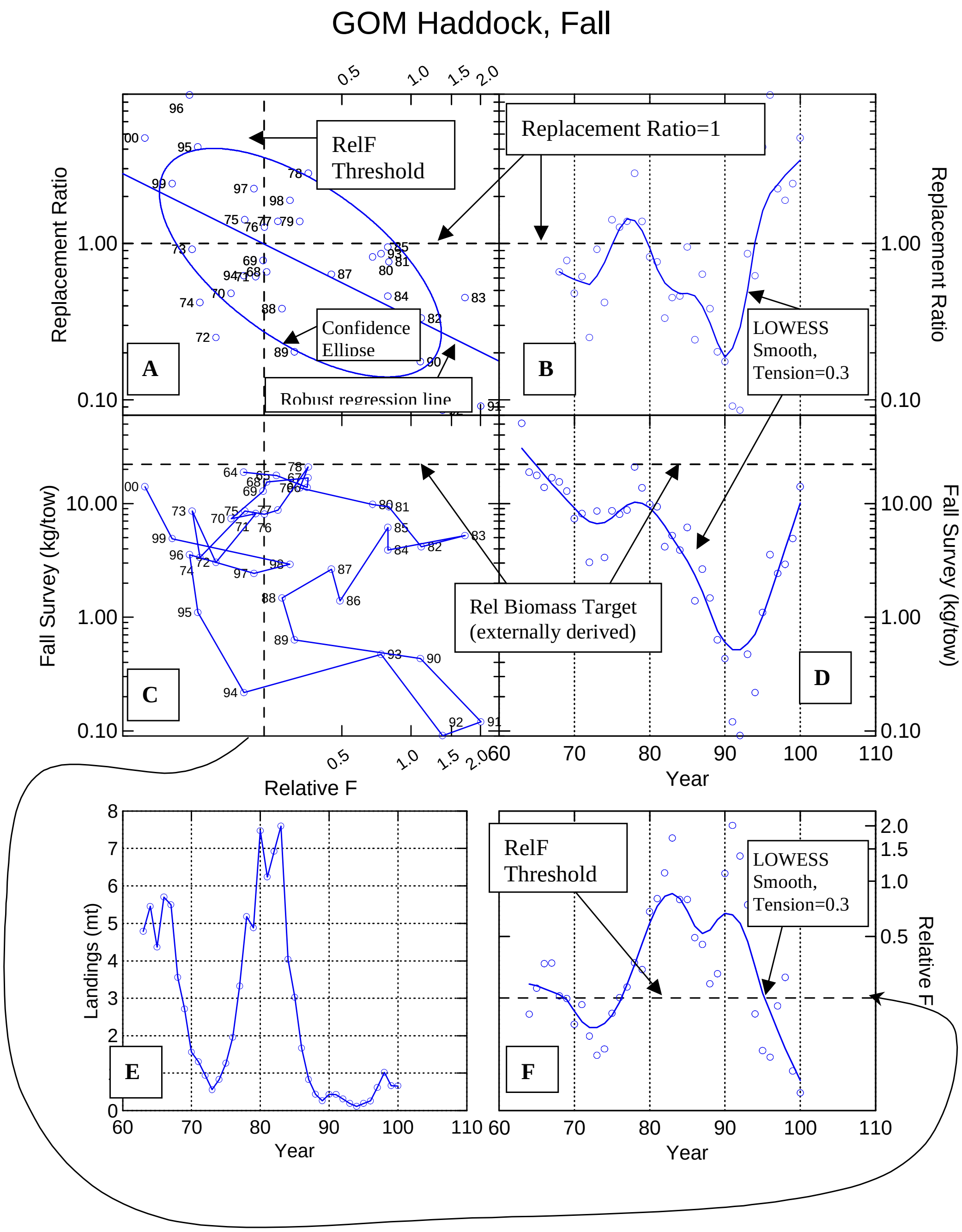

Cross Correlation Plot
American Plaice: SSB vs R
Correlation
1.0
0.5
0.0
-0.5
-1.0
-20
-10
0
10
Lag

Figure C3.4

Figure C6.1 Annotated six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for Gulf of Maine haddock. Horizontal dashed (- - -) lines represent replacement ratios = 1 in (A) an d (B), threshold relF in (F) and target relative biomass in (C) and (D). Vertical dashed lines in (A) and (C) represent the derived relF thresholds. Smooth lines in (B), (D), and (F) are Lowess smooths (tension=0.3). The confidence ellipse in (A) has a nominal probability level of 0.68 The regression line in (A) represents a robust regression using bisquare downweighting of residual. See text for additional details.



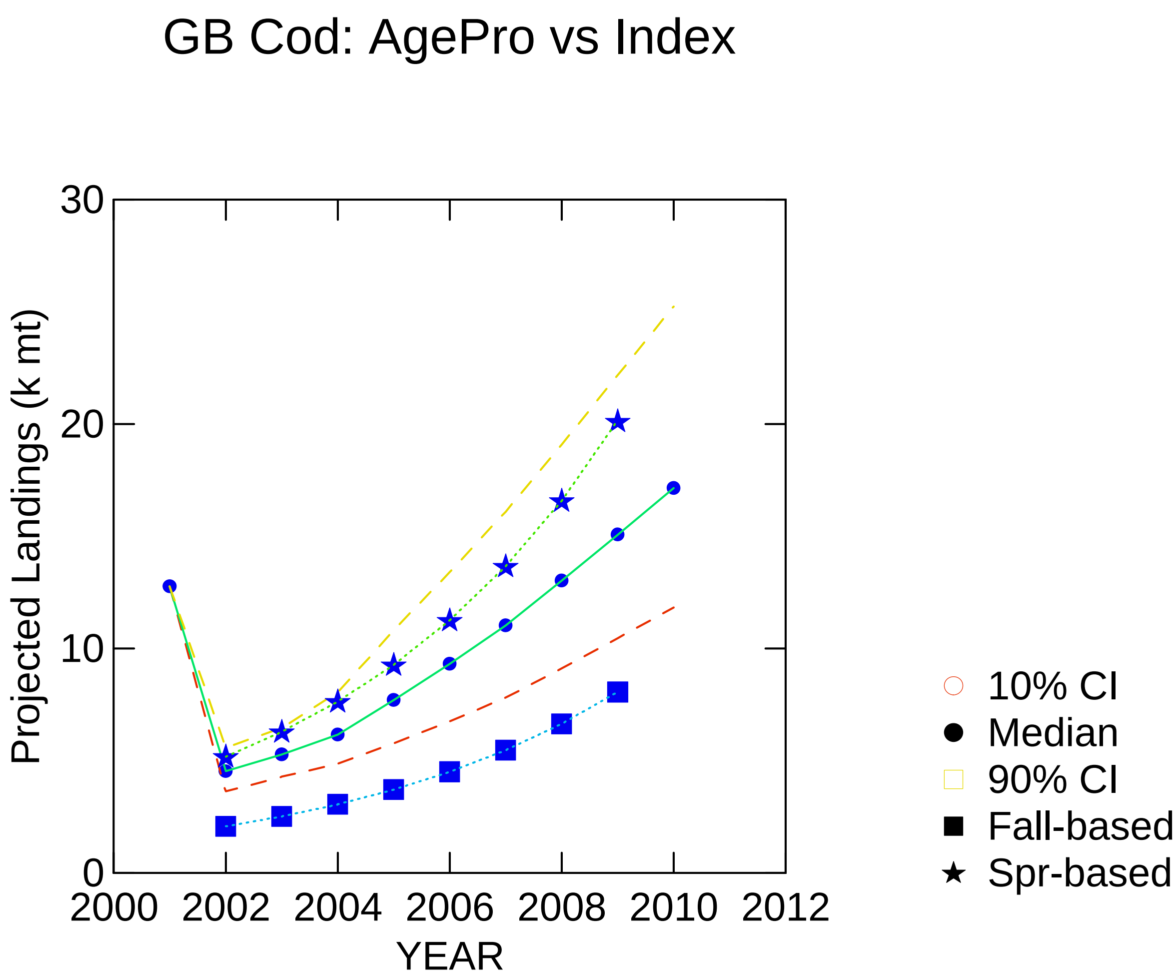


Figure C7.1. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Georges Bank cod with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

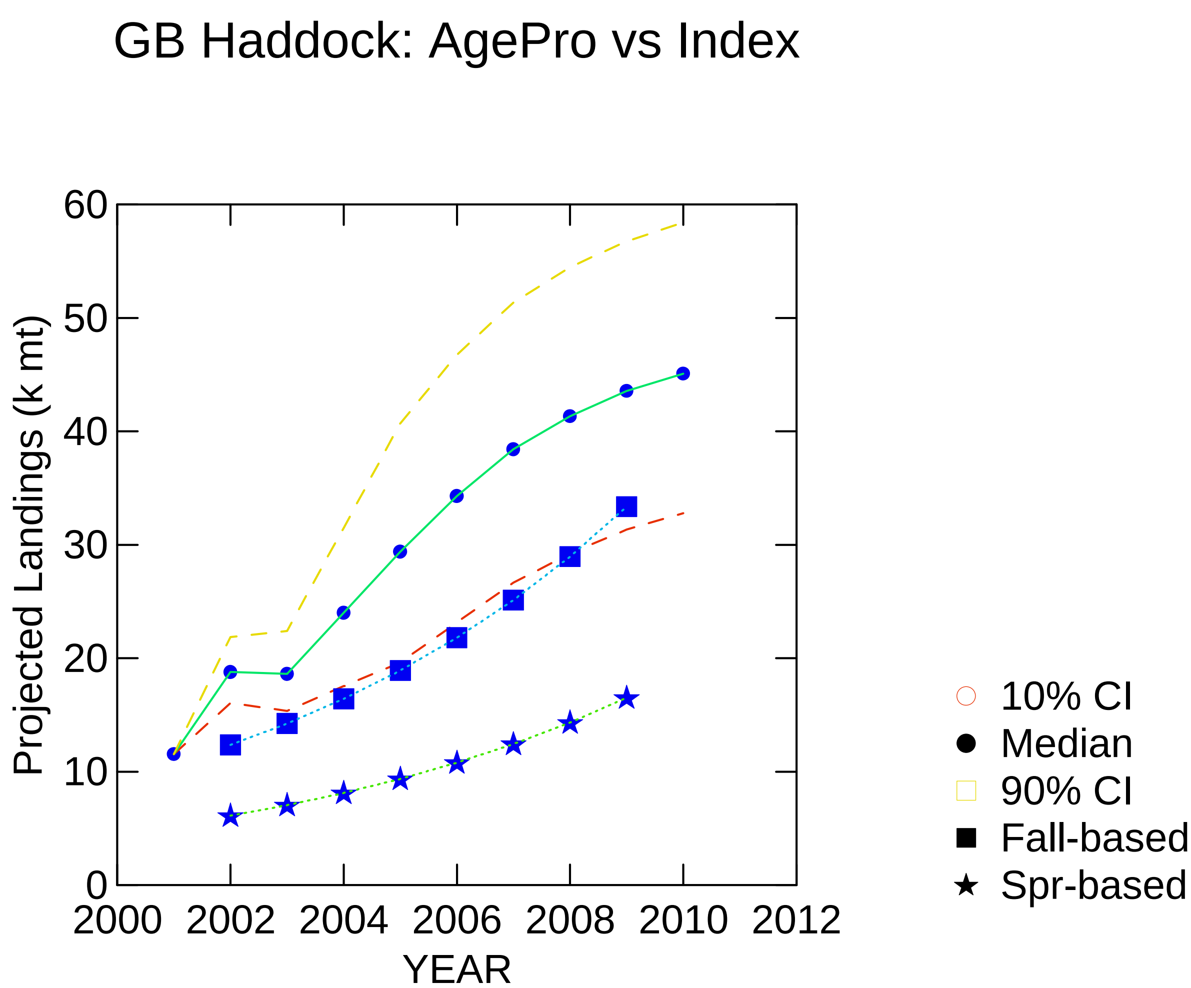


Figure C7.2. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Georges Bank haddock with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

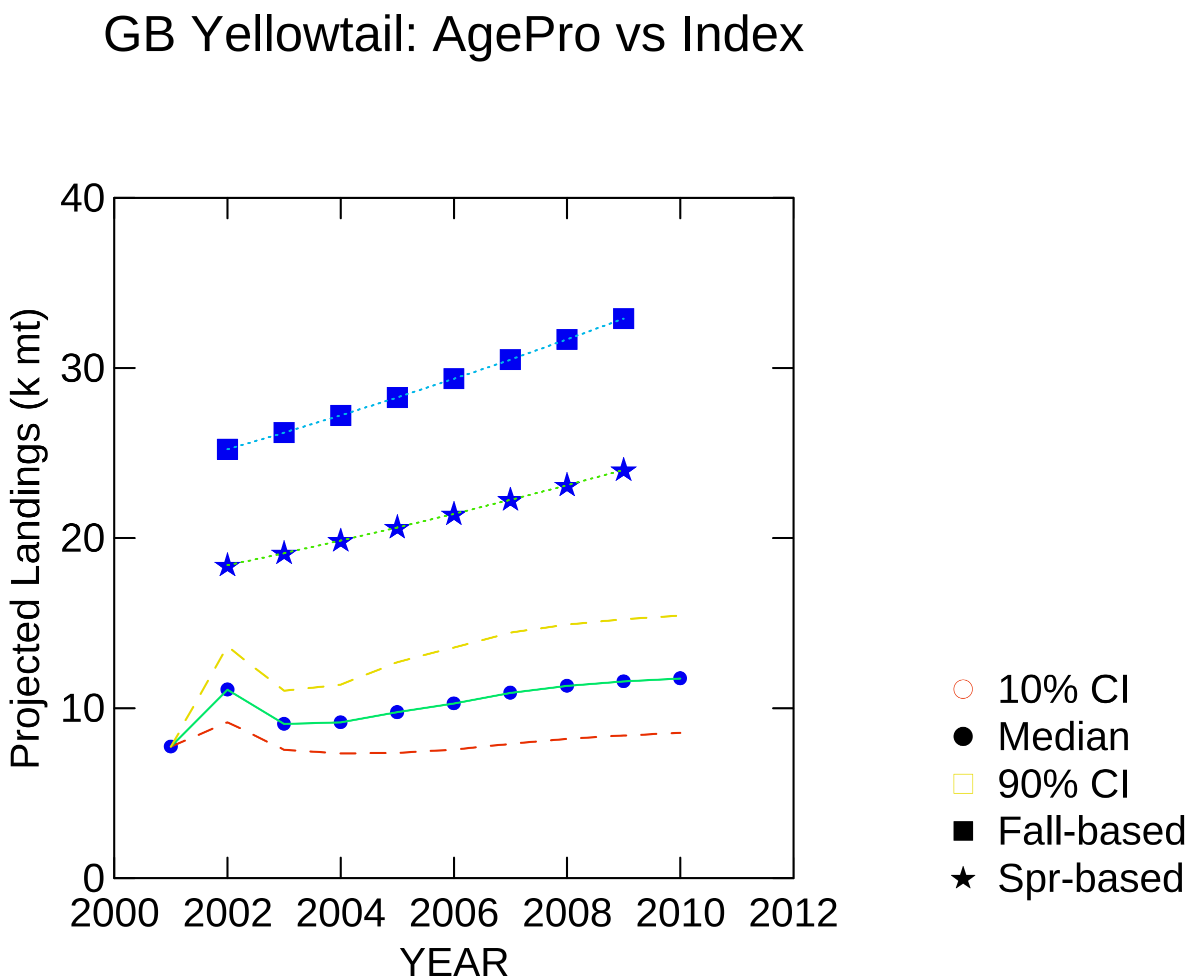


Figure C7.3. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Georges Bank yellowtail flounder with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

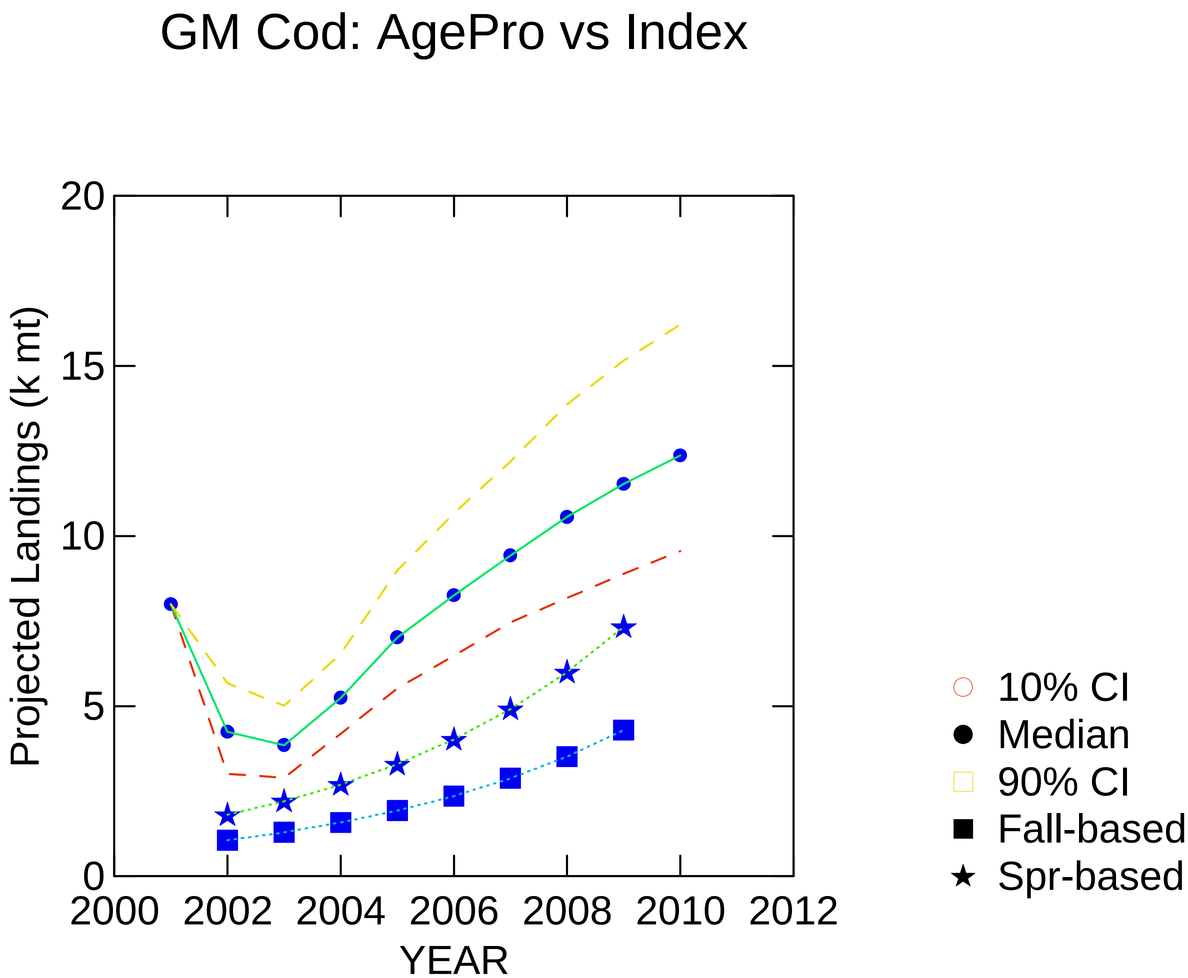


Figure C7.4. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Gulf of Maine cod with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

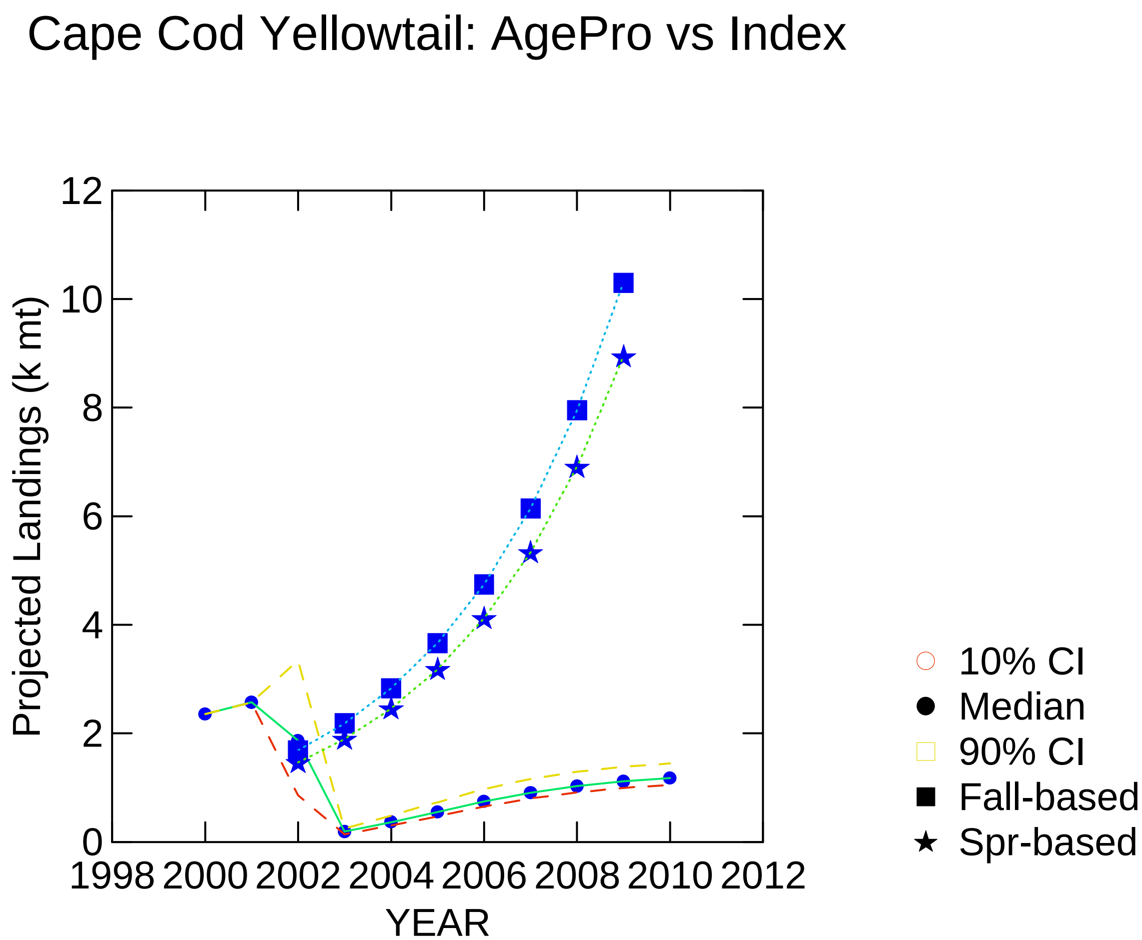


Figure C7.5. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Cape Cod yellowtail flounder with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

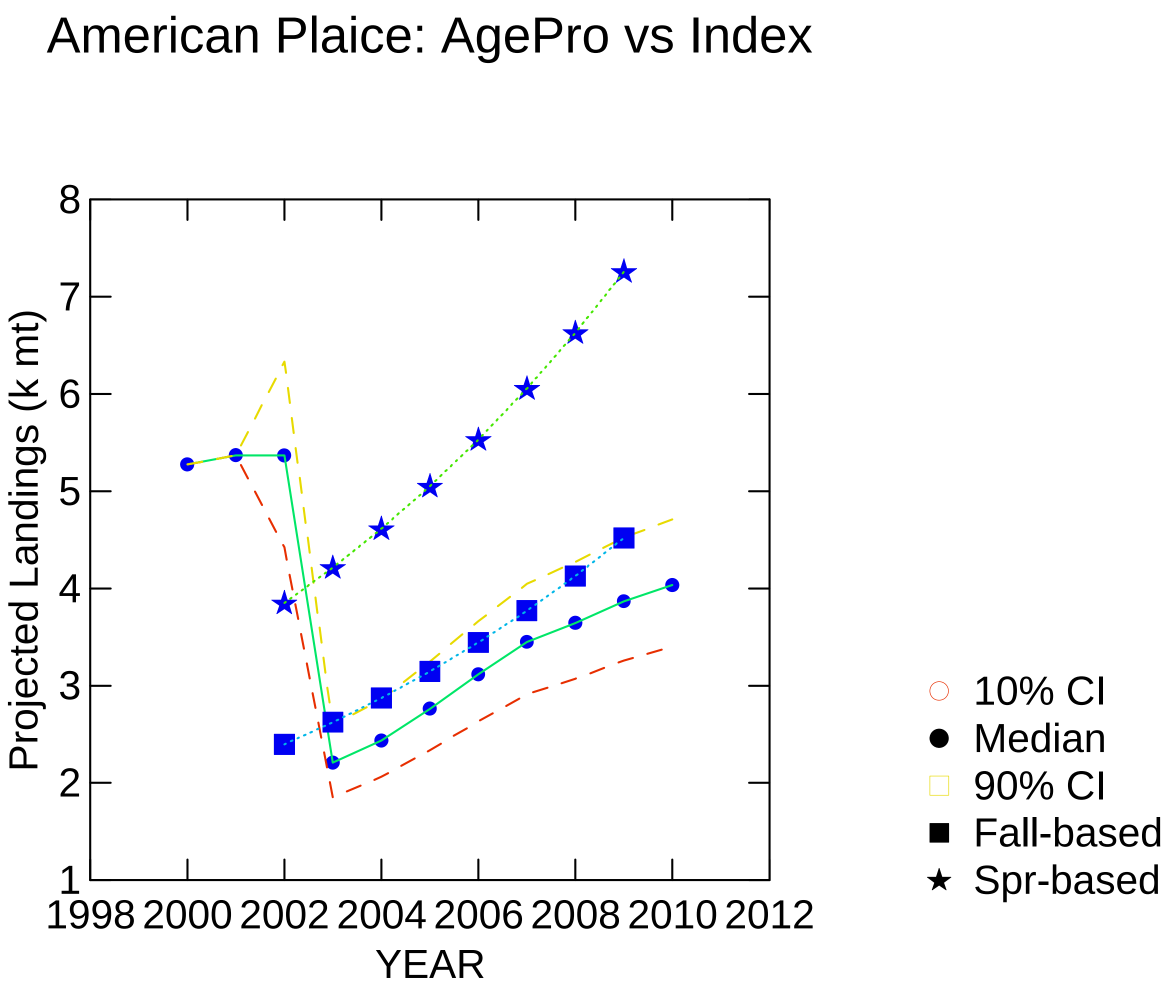


Figure C7.6. Comparison of fall and spring survey index-based forecasts of landings (k mt) for American plaice with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

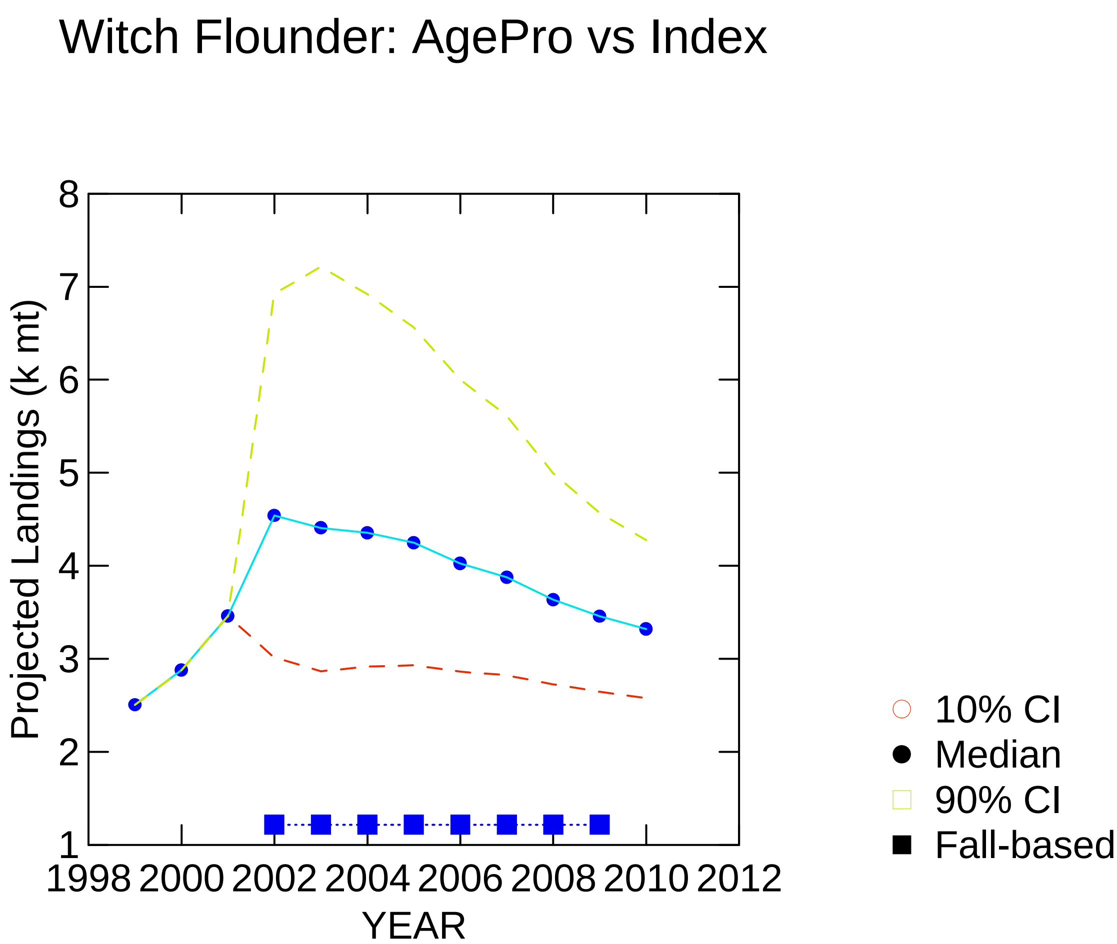


Figure C7.7. Comparison of fall and spring survey index-based forecasts of landings (k mt) for witch flounder with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings

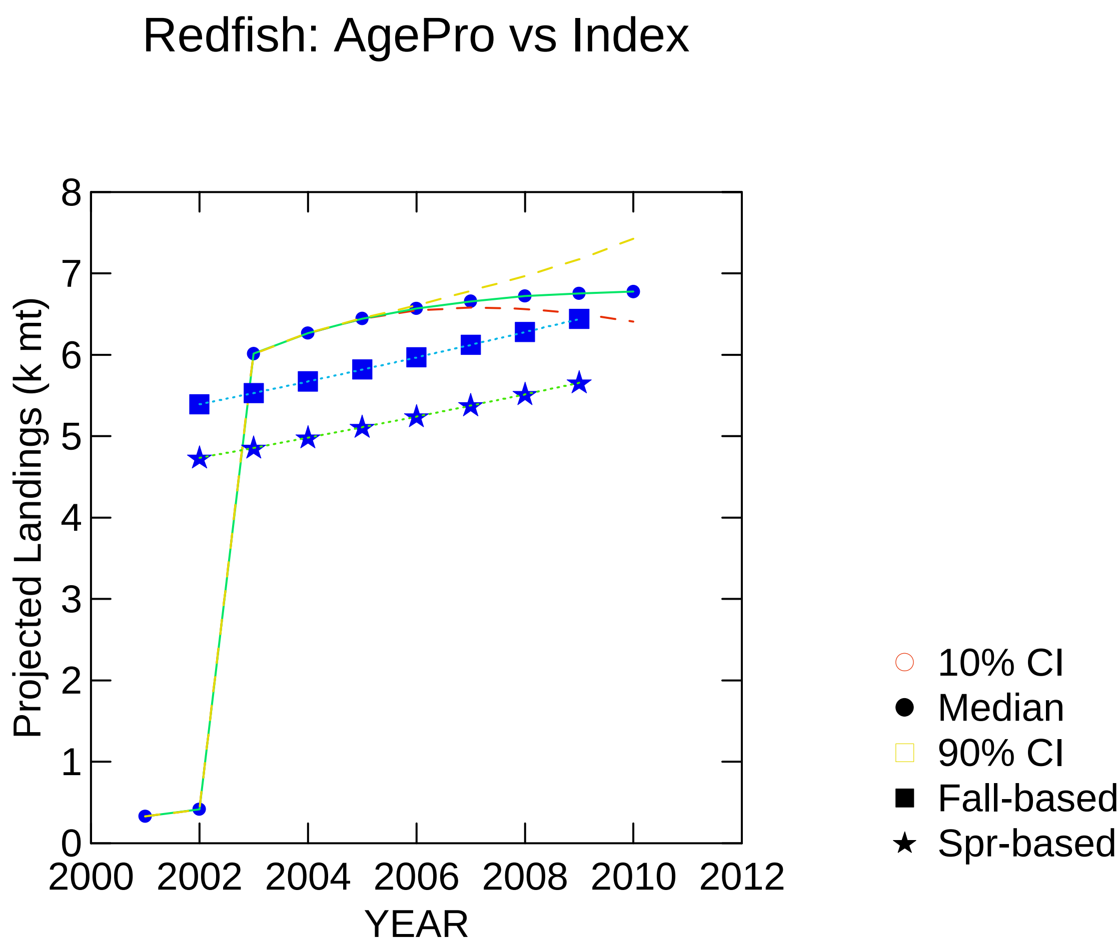


Figure C7.8. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Acadian redfish with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

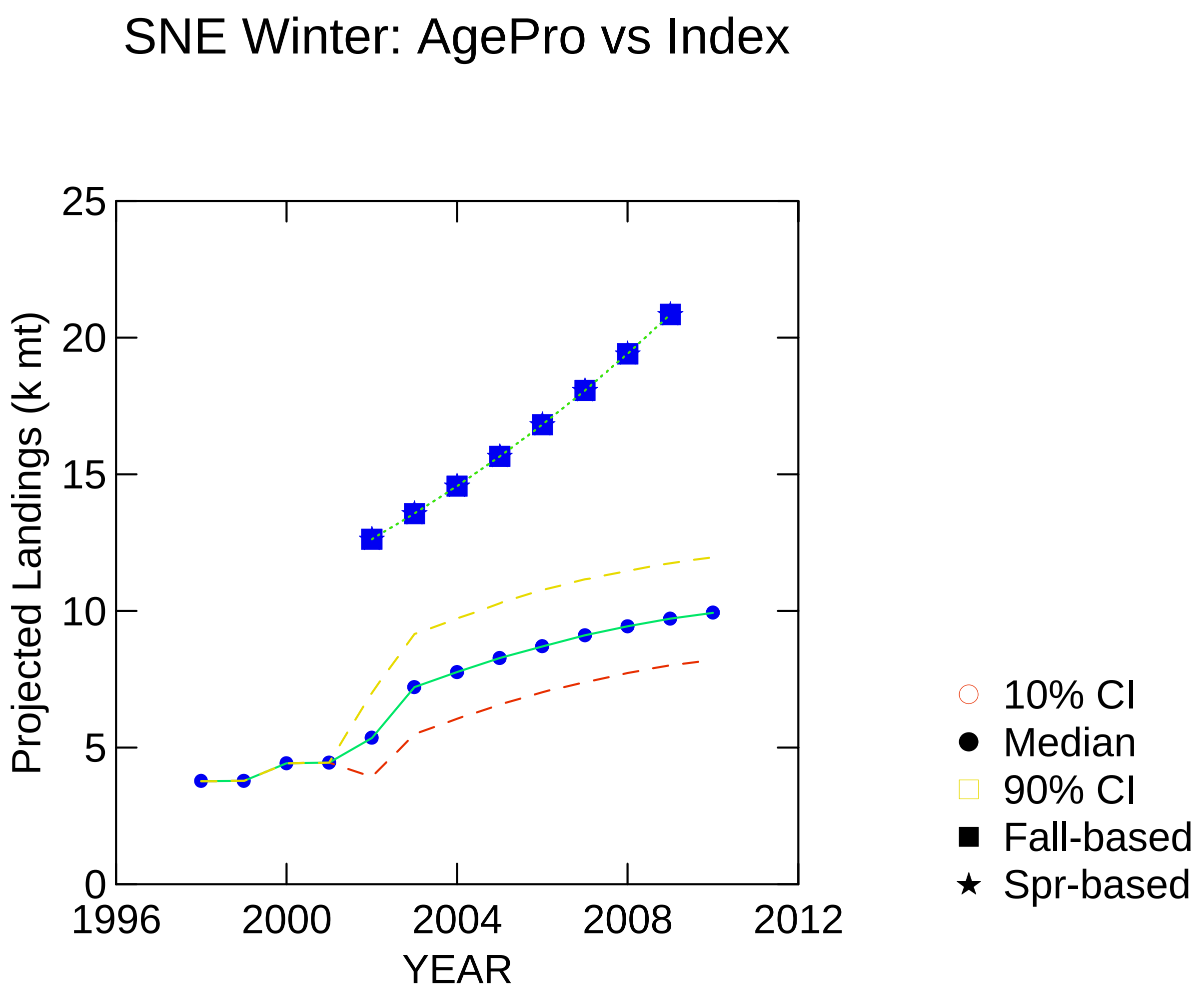


Figure C7.9. Comparison of fall and spring survey index-based forecasts of landings (k mt) for Southern New England yellowtail flounder with forecasts based on stochastic age-based projection model (AGEPRO) for the period 2002-2009. Relative biomass targets for the index-based method were computed by multiplying the projected estimate of relative biomass in 2002 by the ratio of the absolute estimates of total biomass computed via the AGEPRO for 2002 and 2009. No other tuning measures were applied to develop the index-based estimates of landings.

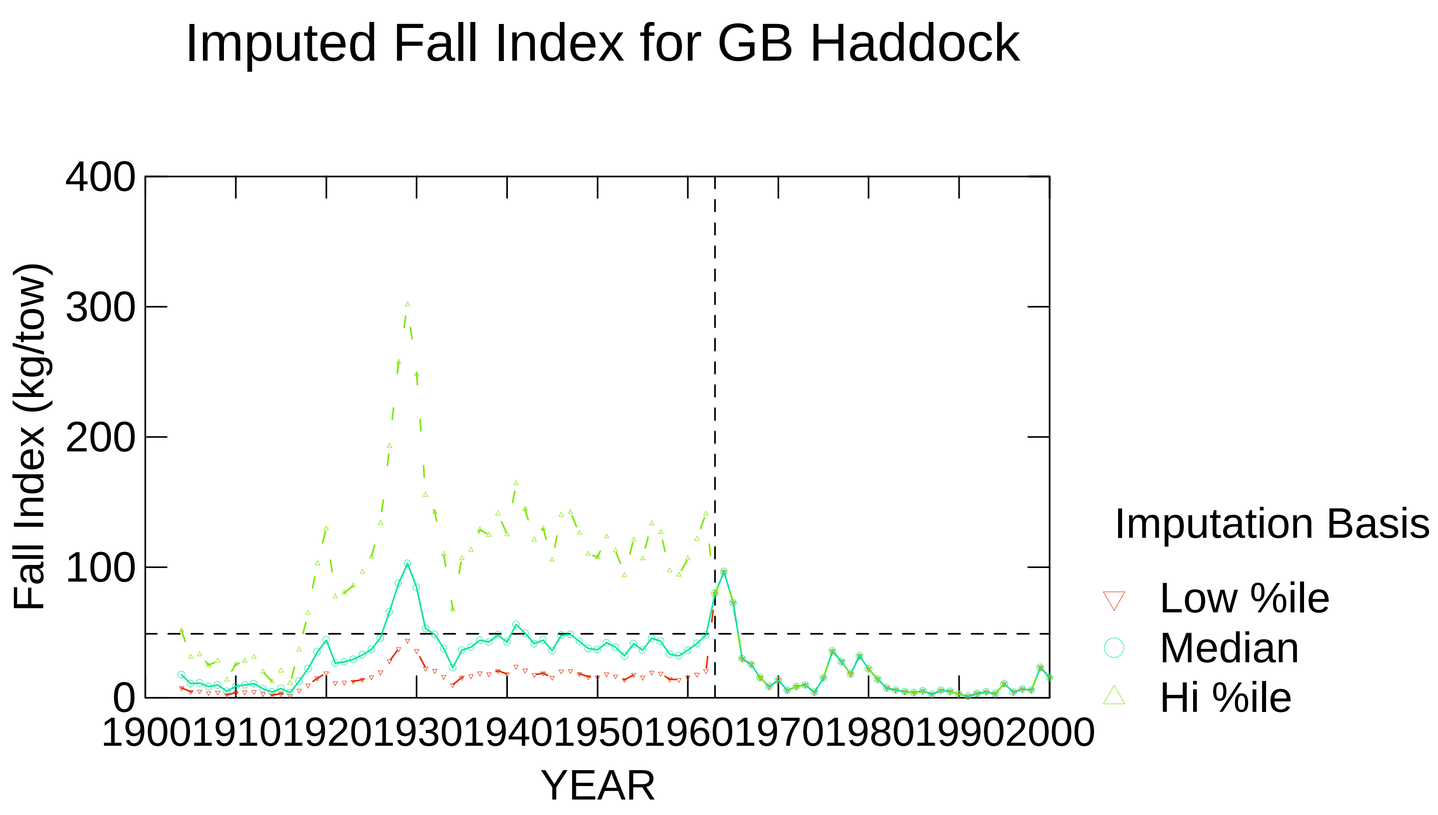


Figure C8.1. Imputed fall index values (kg/tow) for Georges Bank haddock. Low, median, and high survey values prior to 1963 are computed by multiplying the landings by the 10%-ile, 50%-ile, and 90%-ile of the ratio of landings to survey index for the period 1963 to 2000. The horizontal dashed line represents the 90%-ile of the concatenated series of the median imputed indices (1904-1962) and observed series (1963-2000).

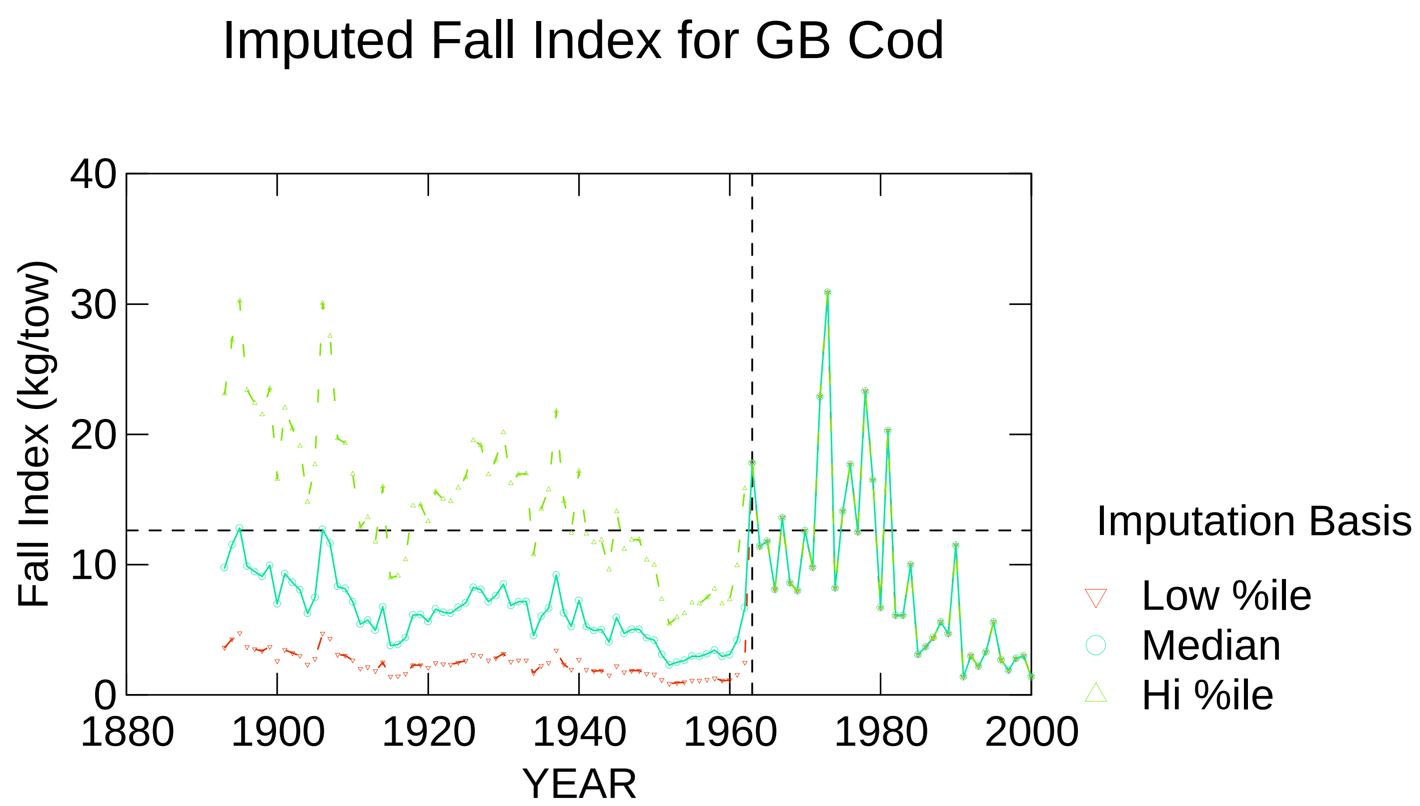


Figure C8.2. Imputed fall index values (kg/tow) for Georges Bank cod. Low, median, and high survey values prior to 1963 are computed by multiplying the landings by the 10%-ile, 50%-ile, and 90%-ile of the ratio of landings to survey index for the period 1963 to 2000. The horizontal dashed line represents the 90%-ile of the concatenated series of the median imputed indices (1904-1962) and observed series (1963-2000).

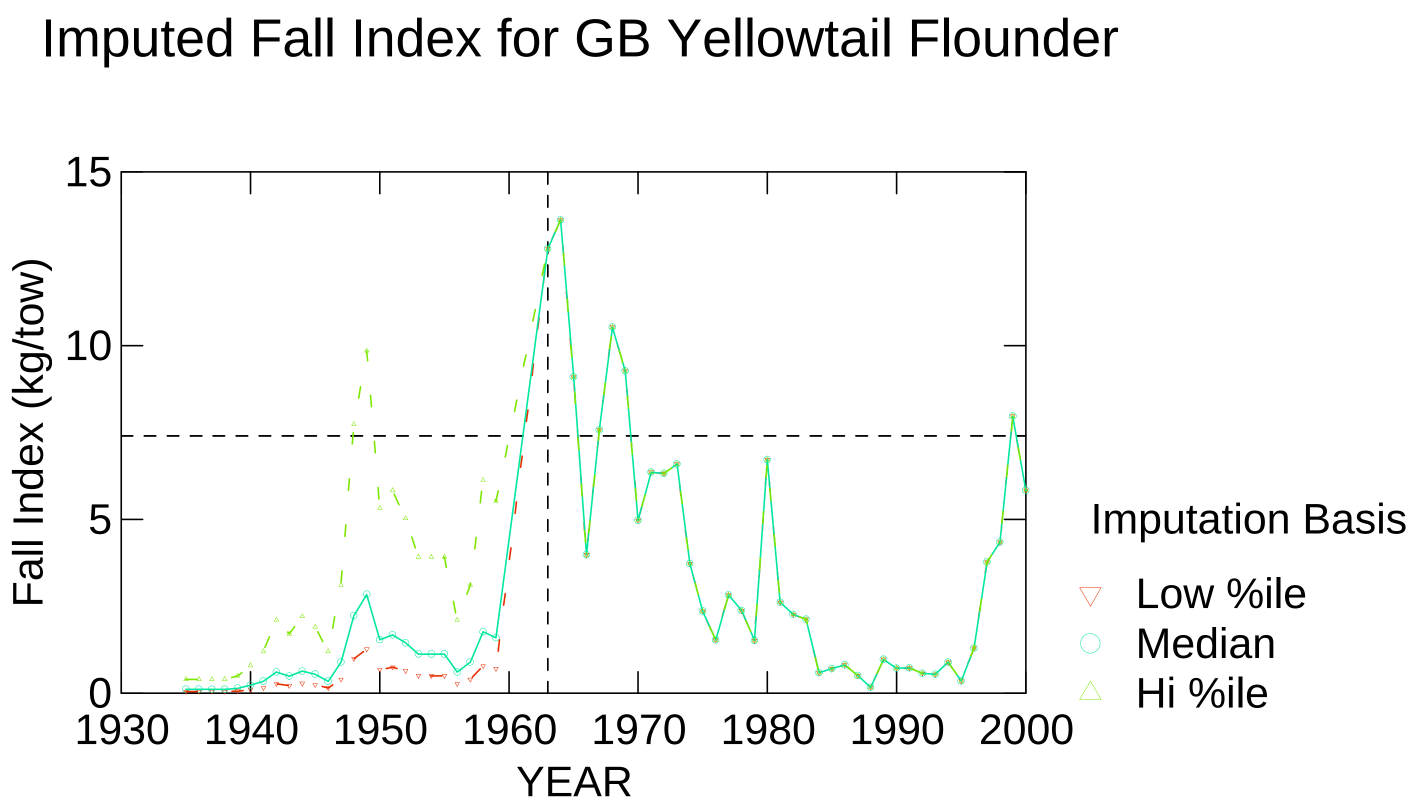


Figure C8.3. Imputed fall index values (kg/tow) for Georges Bank yellowtail flounder. Low, median, and high survey values prior to 1963 are computed by multiplying the landings by the 10%-ile, 50%-ile, and 90%-ile of the ratio of landings to survey index for the period 1963 to 2000. The horizontal dashed line represents the 90%-ile of the concatenated series of the median imputed indices (1904-1962) and observed series (1963-2000).

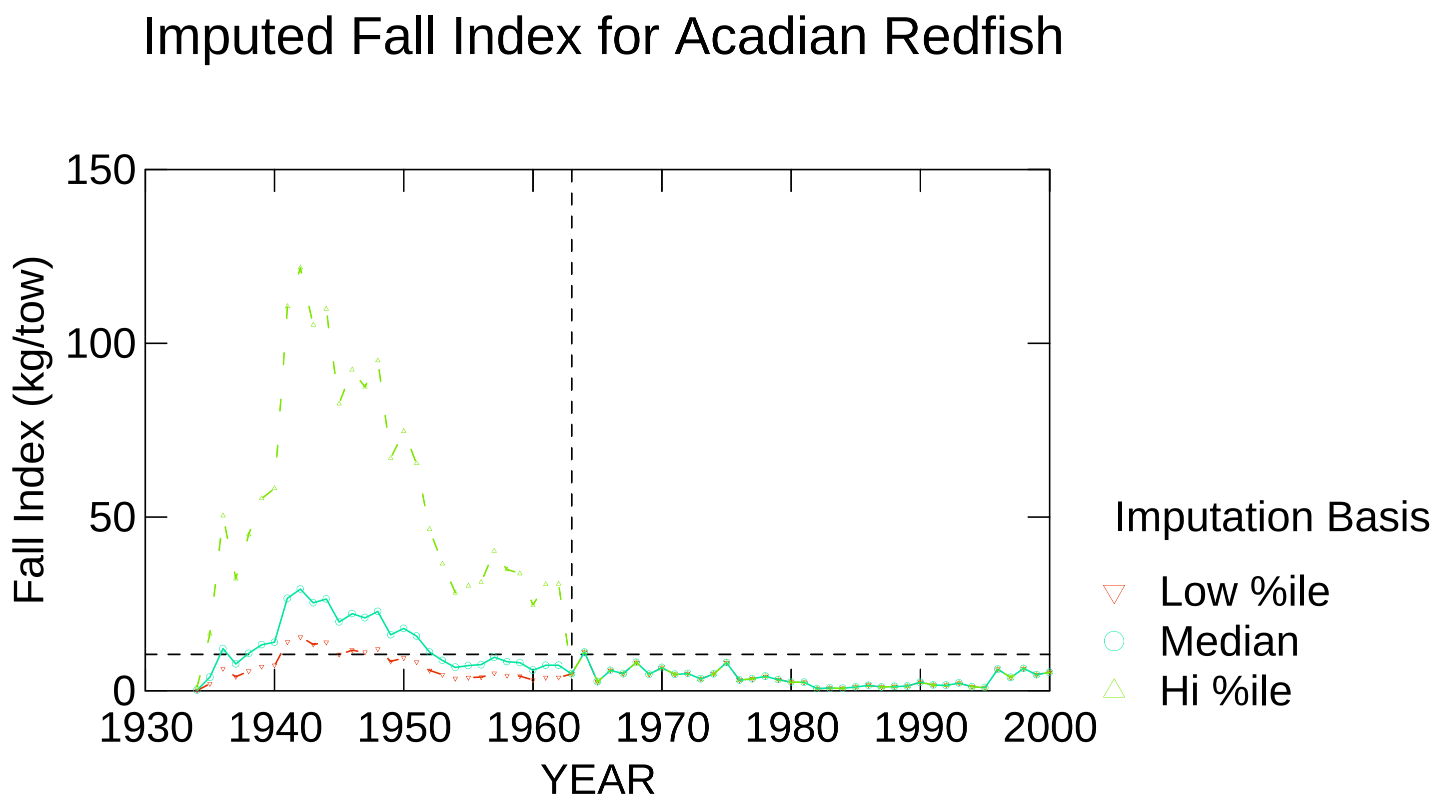


Figure C8.4. Imputed fall index values (kg/tow) for Acadian redfish. Low, median, and high survey values prior to 1963 are computed by multiplying the landings by the 25%-ile, 50%-ile, and 75%-ile of the ratio of landings to survey index for the period 1963 to 2000. The horizontal dashed line represents the 75%-ile of the concatenated series of the median imputed indices (1904-1962) and observed series (1963-2000).

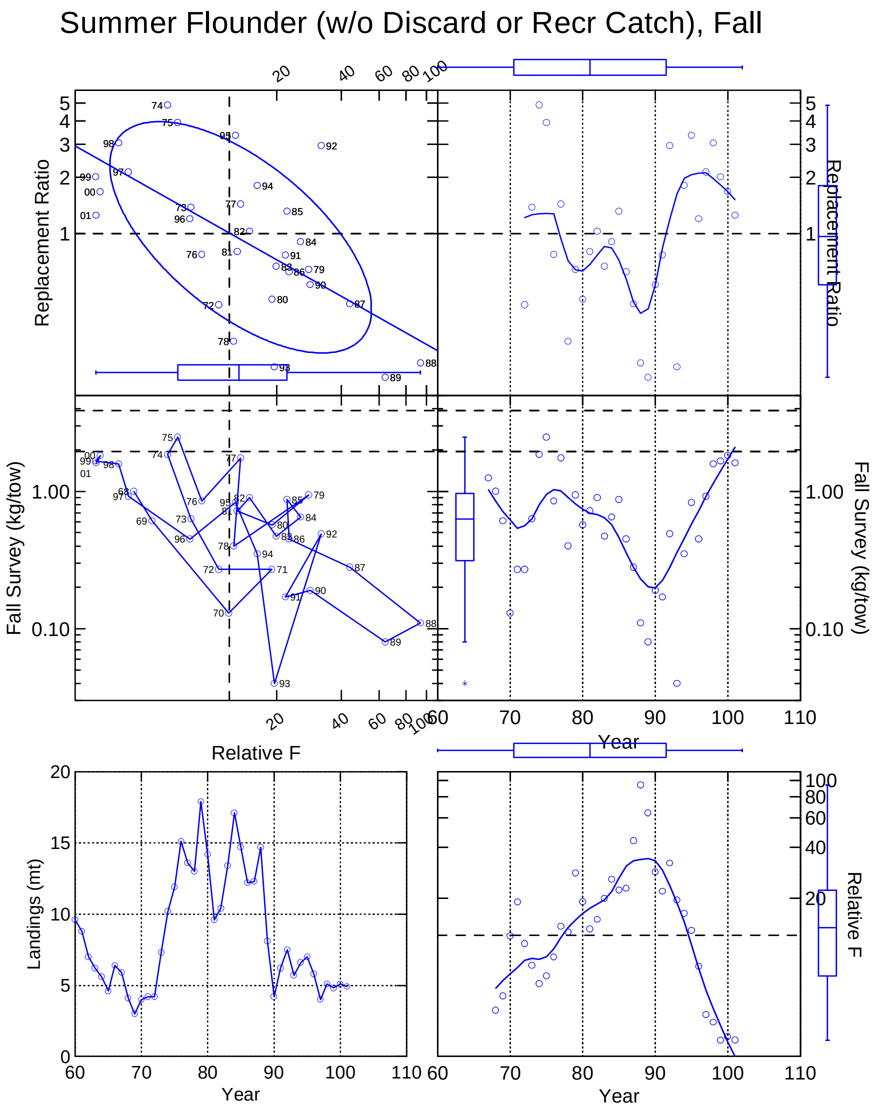


Figure 9.1 Six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for Summer Flounder commercial landings and the NEFSC fall survey. Horizontal dashed (- - -) lines represent replacement ratios = 1 in (A) an d (B), threshold relF in (F). Vertical dashed lines in (A) and (C) represent the derived relF thresholds. Smooth lines in (B), (D), and (F) are Lowess smooths (tension=0.3). The confidence ellipse in (A) has a nominal probability level of 0.68 The regression line in (A) represents a robust regression using bisquare downweighting of residual. Box plots depict marginal distributions of variables. See text for additional details.

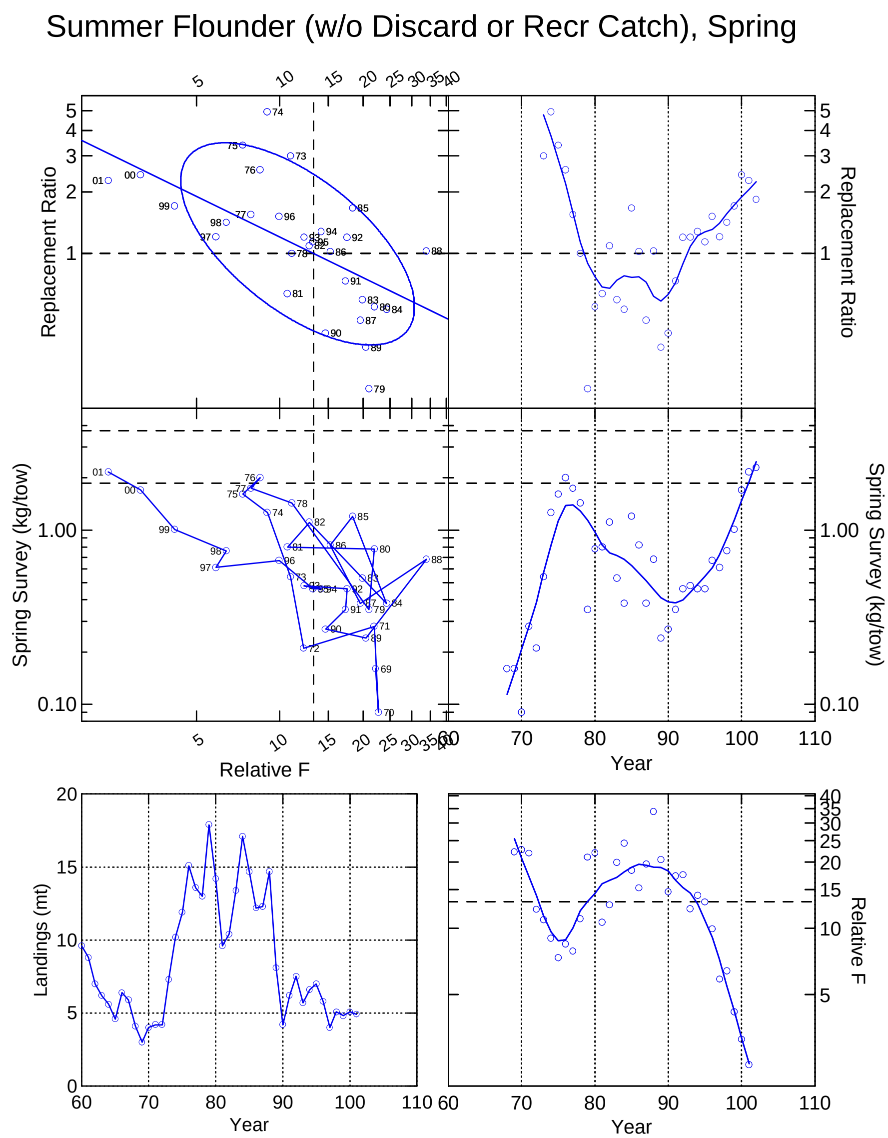


Figure 9.2 Six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for Summer Flounder commercial landings and the NEFSC spring survey. Horizontal dashed (- - -) lines represent replacement ratios = 1 in (A) an d (B), threshold relF in (F). Vertical dashed lines in (A) and (C) represent the derived relF thresholds. Smooth lines in (B), (D), and (F) are Lowess smooths (tension=0.3). The confidence ellipse in (A) has a nominal probability level of 0.68 The regression line in (A) represents a robust regression using bisquare downweighting of residual. Box plots depict marginal distributions of variables. See text for additional details.

Scup (with Recr + Discard), Fall

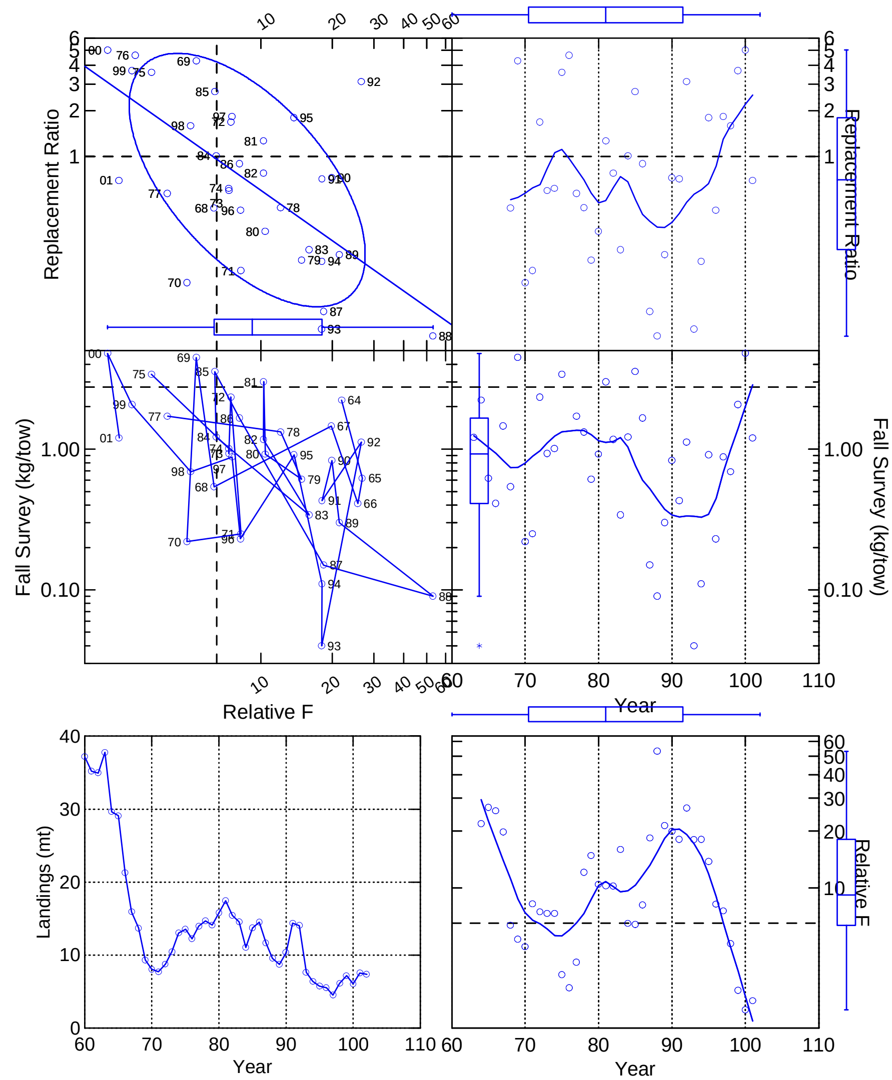


Figure 9.3 Six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for scup catch (commercial + recreational landings plus discards, and the NEFSC fall survey. Horizontal dashed (**- - -**) lines represent replacement ratios = 1 in (A) an d (B), threshold relF in (F). Vertical dashed lines in (A) and (C) represent the derived relF thresholds. Smooth lines in (B), (D), and (F) are Lowess smooths (tension=0.3). The confidence ellipse in (A) has a nominal probability level of 0.68 The regression line in (A) represents a robust regression using bisquare downweighting of residual. Box plots depict marginal distributions of variables. See text for additional details.

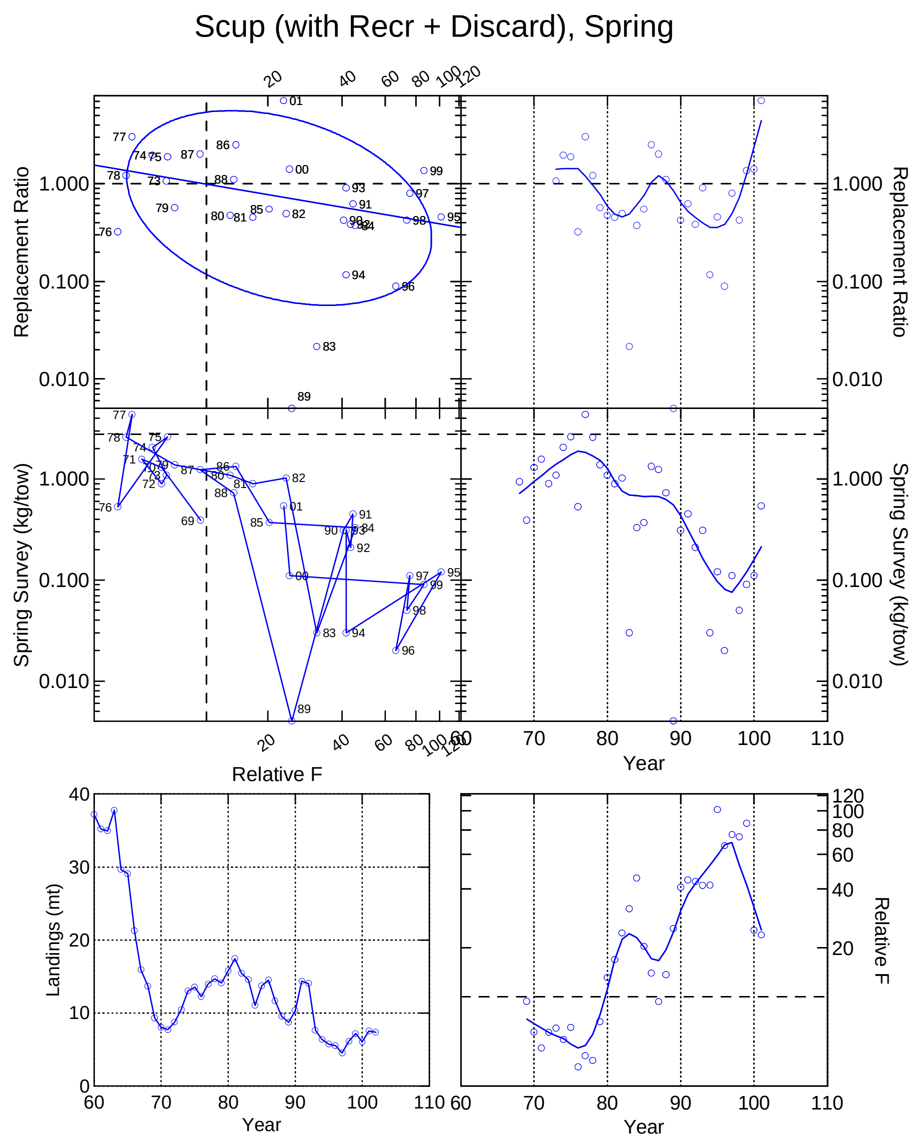


Figure 9.4 Six-panel plot depicting trends in relative biomass, landings, relative fishing mortality rate (landings/index) and replacement ratios for scup catch (commercial + recreational landings plus discards, and the NEFSC spring survey. Horizontal dashed (- - -) lines represent replacement ratios = 1 in (A) an d (B), threshold relF in (F). Vertical dashed lines in (A) and (C) represent the derived relF thresholds. Smooth lines in (B), (D), and (F) are Lowess smooths (tension=0.3). The confidence ellipse in (A) has a nominal probability level of 0.68 The regression line in (A) represents a robust regression using bisquare downweighting of residual. Box plots depict marginal distributions of variables. See text for additional details.

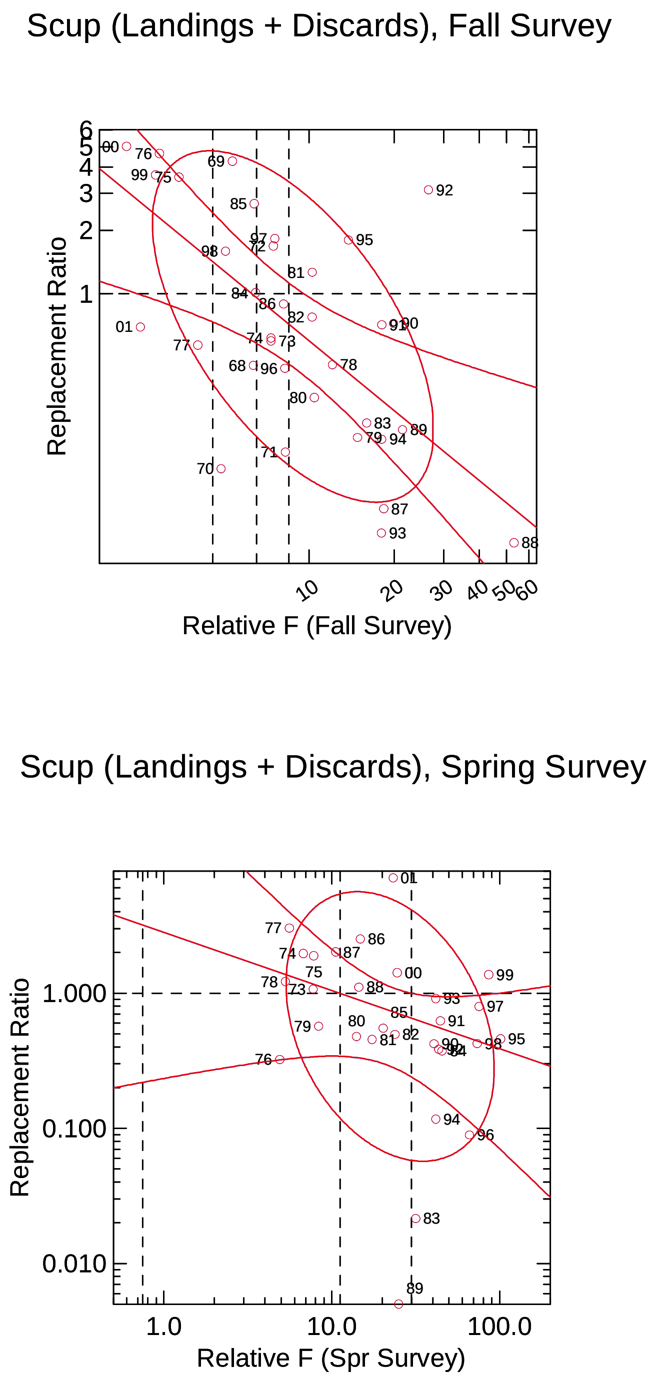


Fig 9.5 Comparison of relationship between replacement ratio and relative F for scup based on the fall (top) and spring (bottom) surveys. The vertical dashed lines depict the asymptotic parametric confidence intervals for point estimate of the relative F at replacement.

D. SILVER HAKE STOCK IDENTIFICATION

SARC COMMENTS

Objectives

The SARC provided technical review of Phoel et al. (2002, SARC WPD1) and provided advice on the implications of the results for the management of the silver hake stock.

Part I. Silver Hake Abundance and Mid-Atlantic Bight Bottom Water Temperatures

Based on descriptive analysis of survey information, WPD1 concludes that:

1. Both commercial landings and survey catches confirm the decrease in silver hake abundance in the Mid-Atlantic Bight (MAB).
2. There is a trend toward warmer bottom water during the spring, albeit only about 1°C increase in the 33 years studied.
3. In both spring and fall, temperatures lie well within the preferred temperature range published for this species.

Despite the lack of hypothesis testing and limitations with temperature data, the conclusions are supported by temporal patterns in observed survey temperature and biomass indices. However, the SARC questioned whether the increase in temperature was significant.

Part II. Stock identification of silver hake following Mendelian inheritance and Hardy-Weinberg equilibrium of a microsatellite DNA locus heterogeneity with P^2 test for goodness of fit.

Major technical problems with genetic analyses, selection of characters and statistical analyses invalidate the conclusions stated in WPD1: "each sample appears to represent a separate silver hake population." Silver hake were sampled from the Mid-Atlantic Bight, southern Georges Bank, northern Georges Bank, the Gulf of Maine and the Scotian Shelf. Sample sizes were 14-15 fish from each area. Genotype frequencies at a single locus were compared to Hardy-Weinberg (H-W) expectations of pooled (combined-area) samples to test for genetic differences among areas using P^2 tests (i.e., differences from pooled H-W expectations were used to test that heterogeneous samples were pooled).

Interpretations of allelic frequencies at "locus 4" from PCR images are not appropriate. Primarily, the use of a null allele should be avoided, unless the presence of a such an allele can be confirmed through testing. Analyses should be based on several (4-10) loci with clearly defined bands and several to many alleles from many more spawning fish (40-100) for each spawning ground. Secondarily, the statistical tests used in WPD1 are inappropriate and associated interpretations are incorrect. Using H-W comparisons to detect group differences is unconventional and inefficient, because there are many sources of deviation from H-W equilibrium. More conventional analyses that test for differences among areas should be applied. Other more appropriate analyses may include genetic distance matrices, molecular variance and phylogenetic trees, such as the analyses presented to the SARC by P. Straub.

The samples from each putative stock should be collected over an adequate geographic and temporal range to represent each spawning group in order to more closely conform to the assumption of randomness in the statistical analysis. Existing samples may be available in NMFS archives with associated location, date and maturity condition.

SARC CONCLUSIONS

Given the deficiencies that were identified in the study, such as the use of a single locus with a null allele and unrepresentative samples, the SARC concluded that the data were inadequate to form reliable interpretations. Accordingly, the preliminary finding of significant genetic differences among samples should be disregarded. Management units of silver hake should be based on interdisciplinary analysis of published stock identification information (e.g., Almeida 1987, Helser et al. 1995, Bolles and Begg 2000). Further research should address the technical deficiencies of the genetic analyses, sampling design and statistical methods.

SOURCES OF INFORMATION

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