Northeast Fisheries Science Center Reference Document 00-15

31st Northeast Regional Stock Assessment Workshop (31st SAW)

Stock Assessment Review Committee (SARC) Consensus Summary of Assessments

October 2000

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00-10 **Assessment of the Georges Bank Yellowtail Flounder Stock for 2000.** By S.X. Cadrin, J.D. Neilson, S. Gavaris, and P. Perley. [A report of the 3rd Transboundary Resources Assessment Committee Meeting]. August 2000.

00-11 **CTD Data Collection on Northeast Fisheries Science Center Cruises: Standard Operating Procedures.** By M.H. Taylor and C. Bascuñán. August 2000.

00-12 **Stock Assessment of Georges Bank Haddock, 1931-1999.** By R.W. Brown and N.J. Munroe. [A report of the 3rd Transboundary Resources Assessment Committee Meeting.] September 2000.

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A Report of the 31st Northeast Regional Stock Assessment Workshop

31st Northeast Regional Stock Assessment Workshop (31st 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

October 2000

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MEETING OVERVIEW

The Stock Assessment Review Committee (SARC) meeting of the 31st Northeast Regional Stock Assessment Workshop (31st SAW) was held in the Aquarium Conference Room of the Northeast Fisheries Science Center's Woods Hole Laboratory, Woods Hole, MA during June 26-30, 2000.

The SARC Chairman was Dr. Robert Mohn, Bedford Institute of Oceanography, Department of Fisheries and Oceans, Halifax, Nova Scotia. Members of the SARC included scientists from the Northeast Fisheries Science Center (NEFSC, NOAA, NMFS); the Northeast Regional Office (NERO), the Southeast Fisheries Science Center (SEFSC); the New England and Mid-Atlantic Fishery Management Council (NEFMC); Atlantic States Marine Fisheries Commission (ASMFC), the States of Connecticut and Maryland; the Department of Fishery and Oceans, Canada, the Marine Research Institute of Iceland; Lowestoft Laboratory, Great Britain; and the commercial fishing industry (Table 1). In addition, 42 other persons attended some or all of the meeting (Table 2). The meeting agenda is presented in Table 3.

OPENING

Dr. Michael P. Sissenwine, Science and Research Director (NERO/NEFSC) welcomed the meeting participants. Dr. Terrence Smith, Stock Assessment Workshop (SAW) Chairman, briefly reviewed the overall SAW process. Dr. Mohn reviewed the agenda and discussed the conduct of the meeting.

Table 1. SAW-31 SARC Composition.

Robert Mohn, Chairman
DFO, Halifax
(representing the CIE/University of Miami),

Northeast Fisheries Science Center:
ChrisChambers
Wendy Gabriel
Joseph Idoine
Gary Shepherd

NMFS Northeast Regional Office:
John Witzig, NMFS/NERO

Regional Fishery Management Councils:
Andrew Applegate, NEFMC
Chris Moore, MAFMC

Atlantic States Marine Fisheries Commission/States:
Penny Howell, CT
Paul Piavis, MD
Geoff White, ASMFC

Other experts:
Marinelle Basson, Lowestoft, U.K.
(representing the CIE/University of Miami)
Diane Beanlands, DFO, Halifax
Chris Legault, SEFSC
Gudrun Thorarinsdóttir, MSI- Iceland

Industry Advisors
Kathy Downey
Peter Morse

Table 2. List of Participants.

NMFS, Northeast Fisheries Science Center

Jon Brodziak	Paul Rago
Steve Clark	Terry Smith
Larry Jacobson	Pie Smith
Ralph Mayo	Katherine Sosebee
Steven Murawski	Mark Terceiro
Paul Nitschke	James Weinberg
Victor Nordahl	Stuart Whipple
Loretta O'Brien	

NMFS, Northeast Regional Office

George Darcy

ASMFC/States

Sherri Archer, NY	Steve Correia, MA
James Armstrong, NC	Najih Lazar, RI
Bob Beal, ASMFC	Matthew Mitro, ASMFC
Mark Gibson, RI	April Valliere, RI

Interested Parties

Tom Alspach, Industry	Joel Havanesian, ECFF
Eleanor Bochanek, Rutgers	Peter A. LaMowich
John Boland	Rick Marks, Consultant
Andrew Cooper, Ntl. Audubon	J.J. Maguire, Consultant
Thomas Dahlgren, WHOI	Geir Monsen, Industry
David Dowdell, ECFF	James D. O'Malley, ECFF
Bud Fernandes, NEFMC	Eric Powell, Rutgers
James Fletcher, UNFA	George Richardson, Indus.
Ken Halanych, WHOI	David Wallace, Industry

AGENDA and REPORTS

The SAW-31 SARC agenda (Table 3) included presentations on assessments for scup, goosefish (monkfish or anglerfish), ocean quahog, and summer flounder (fluke), The panel discussed and refined each assessment and developed assessment summaries for managers, research recommendations and assessment conclusions.

These summaries and discussions have been compiled into two reports - the "Draft Advisory Report on Stock Status, The 31st Northeast Regional Stock Assessment Workshop" and this volume, "Draft Stock Assessment Review Committee (SARC) Consensus Summary of Assessments, 31st Northeast Regional Stock Assessment Workshop (31st SAW)."

The Consensus Summary includes chapters on each stock assessment review with details on how the assessment was conducted as well as a record of the panel discussion. The Advisory Report is a much briefer summary document for managers that includes information on the status of the stock and management advice.

Both draft reports will be available at the SAW-31 Public Review Workshops that will be held during regularly scheduled NEFMC, MAFMC and ASMFC meetings (26 July, NEFMC; 15-17 August, MAFMC; 21-24 August, ASMFC).

Following the Public Review Workshops, the draft documents will be finalized and published in the NEFSC Reference Document series as the *31st SARC Consensus Summary of Assessments* and the 31st *SAW Public Review Workshop* Report (the latter document includes the final version of the Advisory Report).

THE PROCESS

The SAW Steering Committee, which guides the SAW process, is composed of the executives of the five partner organizations (NMFS/NEFSC, NMFS/NER, NEFMC, MAFMC, ASMFC). Working groups assemble the data for assessments, decide on methodology, and prepare documents for SARC review. The SARC members have a dual role; panelists are both reviewers of assessments and drafters of management advice. More specifically, although the SARC's primary role is peer review of the assessments tabled at the meeting, the Committee also prepares a report with advice for fishery managers known as the *Advisory Report on Stock Status*.

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

Table 3. Agenda of the 31sth Northeast Regional Stock Assessment Workshop (SAW-31) Stock Assessment Review Committee (SARC) meeting.

Aquarium Conference Room
NEFSC Woods Hole Laboratory
Woods Hole, Massachusetts
June 26-30, 2000

AGENDA

TOPIC	WORKING GROUP & PRESENTER(S)	SARC LEADER	RAPPORTEUR
MONDAY, 26 June (1:00 PM - 6:00 PM)........			
Opening			
Welcome	**Michael Sissenwine, S&RD, NEFSC** **Terry Smith, SAW Chairman**		
Introduction	**Bob Mohn, SARC Chairman**		**P. Smith**
Agenda			
Conduct of meeting			
Scup (A)	**Matt Mitro**	**Marinelle Basson**	**Mike Armstrong**
Informal reception (7:00 PM)			
TUESDAY, 27 June (8:30 AM - 6:00 PM)........			
Goosefish (B)	**Anne Richards**	**Diane Beanlands**	**Katherine Sosebee**
WEDNESDAY, 28 June (8:30 AM - 5:00 PM)........			
Ocean Quahog (C)	**Larry Jacobson/ Jim Weinberg**	**Gudrun Thorarinsdóttir**	**Chad Keith**
THURSDAY, 29 June (8:30 AM - 6:00 PM)........			
Summer Flounder (D)	**Mark Terceiro**	**Chris Moore**	**Paul Nitschke**
Review Advisory Reports and Sections for the SARC Report			
FRIDAY, 30 June (8:30 AM - 5:00 PM)........			
SARC comments, research recommendations, and 2nd drafts of Advisory Reports			
Other business			

Table 4. SAW-31 Working Group meetings and participants

Working Group and Participants		Meeting Date	Stock/Species
ASMFC Scup Stock Assessment Subcommittee			**Scup**
S. Archer, NYDEC	M. Mitro, MAFMC		
M. Armstrong, MADMF	E. Powell, Rutgers		
R. Beal, ASMFC	D. Simpson, CTDEP		
S. Correia, MADMF	M. Terceiro, NEFSC		
M. Gibson, RIDFW	V. Whalon, MAFMC		
Southern Demersal Working Group		16-17, May, 2000	**Goosefish**
A. Applegate, NEFMC	J. Brodziak, NEFSC	S. Cadrin, NEFSCy	P. Haring, NEFMC
H. Lai, NEFSC	J. Maguire, Halieutikos	R. Mayo, NEFSC	S. Murawski, NEFSC
P. Nitschke, NEFSC	P. Rago, NEFSC	A. Richards, NEFSC	K. Sosebee, NEFSC
N. Stolpe, Monkfish Defense Fund		M. Terceiro, NEFSC	S. Wigley, NEFSC
SAW Invertebrate Subcommittee		24-26 May, 2000 (Woods Hole) 2 June, 2000 (Woods Hole)	**Ocean Quahog**
T. Alspach, Sea Watch		A. Applegate, NEFMC	E. Bochenek, Rutgers
J. Brodziak, NEFSC		D. Cohen,	S. Correia, MA
D. Doolittle, NEFSC		B. DuPaul, VIMS	C. Glass, Manomet
D. Haksever, NEFMC		R. Hanlon, MBL	L. Hendrickson, NEFSC
T. Hoff, MAFMC		A. Howe, MA	L. Jacobson, NEFSC
R. Johnston, MA		C. Keith, NEFSC	J. Kirkley, VIMS
H. Lai, NEFSC		A. Lange	D. McKiernan, MA
R. Mann, VIMS		H. Milliken, NEFSC	E. Powell, Rutgers
J. Reichle,		B. Rothschild, UMass	D. Schick, ME
R. Seagraves, MAFMC		E. Steady, NEFSC	D. Simpson, CT
D. Wallace, MAFMC Advisor		J. Weinberg, NEFSC	D. Whittaker, MA
SAW Southern Demersal Working Group		30-31 May, 2000	**Summer Flounder**

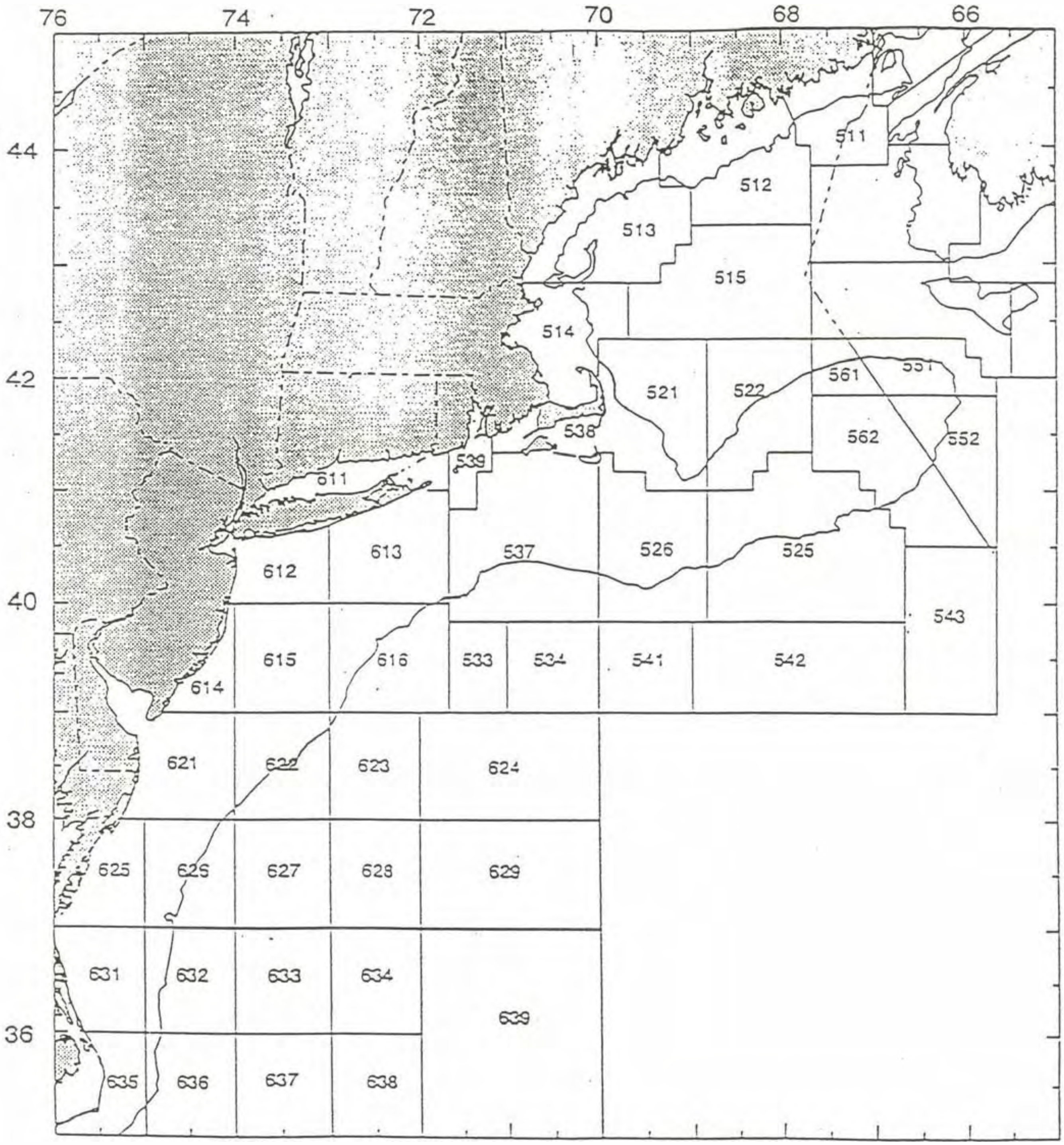


Figure 1. Statistical areas used for catch monitoring in offshore fisheries in the Northeast United States.

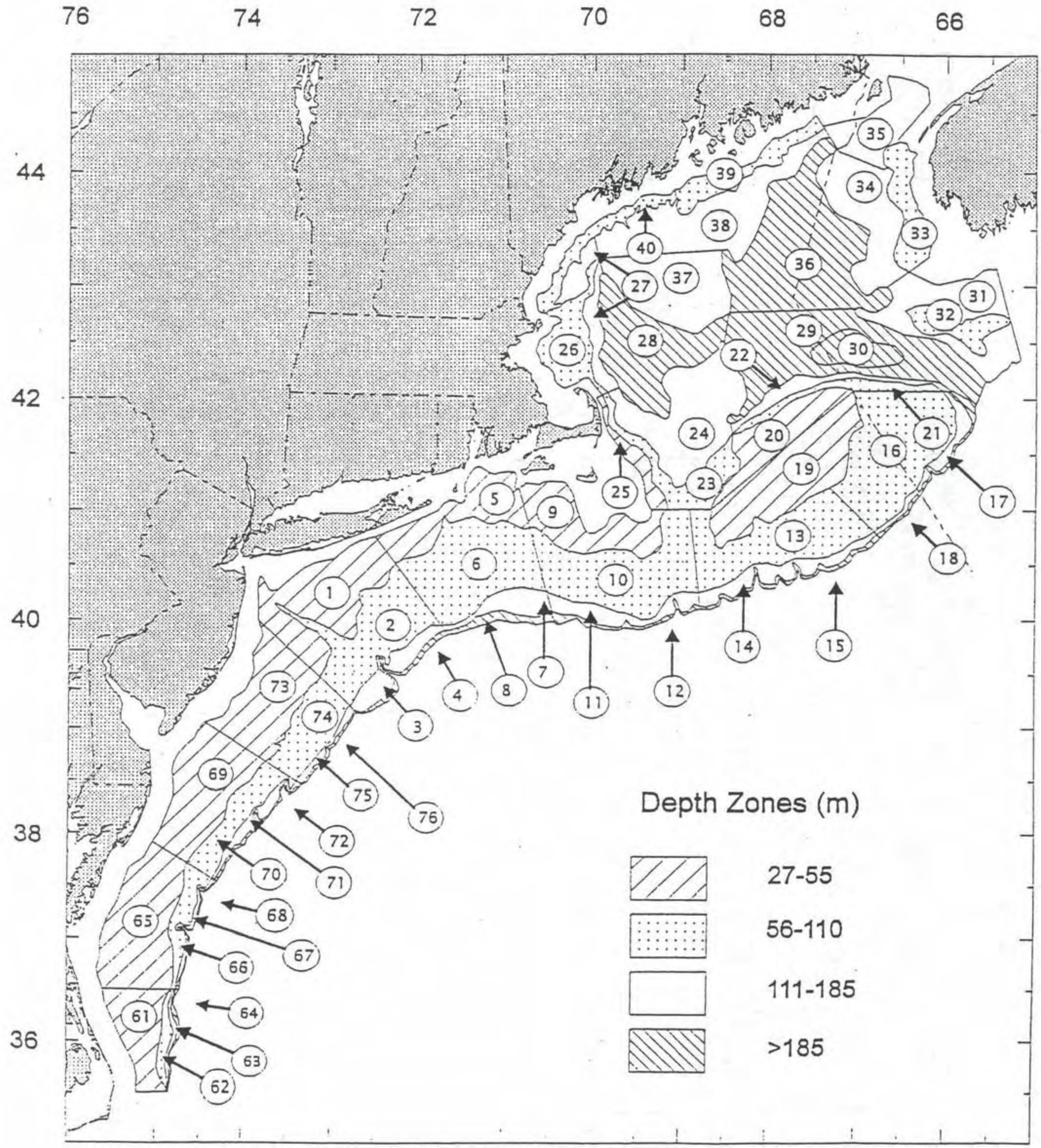


Figure 2. Offshore sampling strata used in NEFSC bottom trawl surveys.

A. SCUP

TERMS OF REFERENCE

a. Update research vessel survey indices of abundance, total mortality rate and size/age composition.

b. Update commercial and recreational landings data, and provide a summary of biological characteristics of the catch, as data permit.

c. Summarize available sea sampling data relative to the quantity and biological characteristics of scup discards.

d. Evaluate stock status with respect to established target and threshold overfishing levels.

e. Develop a methodology to develop and evaluate possible rebuilding schedules.

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 has as a management unit all scup from Cape Hatteras northward to the US-Canadian border. The FMP implemented in 1996 minimum size requirements of 9 in total length (23 cm) for commercial scup landings and 7 in total length (18 cm) for recreational scup landings and a minimum mesh size of 4.0 in for commercial vessels retaining more than 4,000 lbs of scup. Exploitation rates were to be reduced to 47% (F=0.72) in 1997-1999, to 33% (F=0.45) in 2000-2001, and to 19% (F=0.24) in 2002 through coast-wide commercial quotas and season and possession limits in the recreational fishery. The minimum mesh size was increased in 1997 to 4.5 in and the level of catch triggering the mesh requirement changed to seasonal thresholds of 4,000 lbs from November through April and 1,000 lbs from May through October.

The Total Allowable Catch (TAC) established for 1997 of 9.11 million lbs (4,132 mt) 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 of 7.28 million lbs (3,300 mt) in 1998 included a commercial fishery quota of 4.57 million lbs (2,074 mt), a recreational fishery harvest limit of 1.55 million lbs (704 mt), and projected total discards of 1.15 million lbs (522 mt). The TAC was reduced in 1999 to 5.92 million lbs (2,686 mt), including a commercial fishery quota of 2.53 million lbs (1,149 mt), a recreational harvest limit of 1.24 million lbs (562 mt), and projected total discards of 2.15 million lbs (975 mt). The minimum mesh and fish sizes remained the same in 1999 as in 1998, but the levels of catch triggering the commercial fishery mesh requirement were reduced to 200 lbs from November through April and 100 lbs from May through October.

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 ASMFC Summer Flounder, Scup, and Black Sea Bass Management Board approved on 5 April 2000 an Emergency Rule for the summer 2000 scup fishery that established a summer 2000 quota of 1,319,270 lbs (600 mt) and reallocated the available summer period quota through a state-by-state quota system using a 1983-1992 base period with updated landings data from MA.

THE FISHERY

Commercial Landings

US commercial landings averaged less than 10,000 mt annually from 1930 to 1947 (Figure 1), over 19,000 mt per year from 1953 to1964 (peaking at over 22,000 mt in 1960), and declined to about 4,000 mt per year in the early 1970s. Landings fluctuated between 7,000 and 10,000 mt from 1974 to 1986 and have since declined to less than 3,000 mt. Under TAC and other restrictions, landings in 1999 were 1,469 mt (3.2 million lbs), the lowest observed in the time series beginning in 1930 (Table 1). During the 1995-1999 period, landings have become more evenly distributed among the three fishery periods: Winter I (January-April), Summer (May-October), and Winter II (November-December) (Figure 2).

Commercial landings in 1994-1999 were reported by dealers 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 proration 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.

Distant water fleet landings (principally from the Southern New England area) were reported from 1963 to 1981. Landings were greatest in 1963 at about 5,900 mt, averaged about 1,100 mt per year from 1964 to 1975, and decreased to about 1 mt in 1981 (Figure 1).

About two-thirds of the commercial landings of scup for the period 1979-1999 were in Rhode Island (37%) and New Jersey (28%) (Table 2). Landings in New York composed an average of 15% of the total. Scup landings reported for Massachusetts have been revised in this assessment for 1986-1996, increasing an average of 92% or 218 mt per year (range, 182 to 268 mt and 40 to 216%). 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. The landings records have been inspected by NEFSC fishery statistics staff and have now been 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 1979-1999 (Table 3). 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%. About 30% of the commercial landings in 1979-1999 were in state waters and about 70% were in the EEZ.

The intensity of NER commercial fishery biological sampling in 1979-1999 is summarized in Table 4. 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 16 of the last 21 years. However, this alone does not indicate adequate sampling because scup are landed in 7 commercial market categories from over 20 statistical areas, and many of these strata have substantial landings but lack samples. Commercial landings at age were not estimated for 1998 and 1999 because the analytical assessment (i.e., the VPA) for scup 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 1998 and 1999 commercial landings were age-3 fish of the 1995 and 1996 year classes (Figure 3).

Commercial Discards

The NEFSC sea sampling program has collected information on landings and discards in the commercial fishery for 1989-2000 (first quarter). NER discard estimates were raised to account for North Carolina landings. A discard mortality rate of 100% was assumed because there were no published estimates of scup discard mortality rates. The number of trips in which scup were landed and/or discarded is tabulated in Table 5. 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. The number of sampled trips for all gear types increased to 58 in 1997 but decreased to 40 by 1999 (Table 5).

The SARC believed that the NEFSC sea sampling data were inadequate to develop reliable estimates of scup discard at age in the commercial fishery for use in analytical models, as had been previously concluded by the SARC of SAW 27 for sea sampling data available at that time (NEFSC 1998). 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 weighout database to provide estimates of discards for use as guidance in setting TAC levels for management. Only trips with both non-zero landings and discards could be used. Geometric mean rates 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.

The number of trawl gear trips used to calculate geometric mean discard-to-landings ratios (GM D/L) by half year for 1997-1999 ranged from 6 to 17 for trips < 300 kg and from 1 to 4 for trips ≥ 300 kg (Table 6). No trawl gear trips were available for half year two in 1997 and 1999 for trips < 300 kg and for half year two in 1997-1999 for trips ≥ 300 kg. The GM D/L 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 GM D/L ranged from 0.56 to 1.33, with the exception of 1998 half year two where the GM D/L was 4.81 for trips ≥ 300 kg. This 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 weight was estimated by the captain from the vessel. 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 GM D/L. The GM D/L for the first quarter of 2000 was 6.71 for trips < 300 kg (5 trips) and 0.60 for trips ≥ 300 kg (2 trips) (Table 6). The SARC believes that estimates of commercial fisheries discards from the GM D/L are not reliable because of the limited sample size and uncertainty as to the representative nature of the sea sampling data.

The intensity of length frequency sampling of discarded scup from the sea sampling declined in 1992-1995 relative to 1989-1991 (Table 5). 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. Therefore, the length frequencies from sea sampling data may not be representative of discards. 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 1994 to 1996 (Figure 4); 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 4). 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 5). The usual discarding of age 2 fish was also high in 1998 (the 1996 year class) (Figure 5). 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 5).

We compared estimates of GM D/L from sea sampling to estimates from vessel trip reports (VTR) for 1994-1999. VTR data were subset 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 1994-1999 sea sample data were 2 to 43 times greater than GM D/L for VTR data, with a single exception in 1996 for trips landing => 300 kg (Table 7).

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 1979-1999. 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 1979-1999 averaged about 2,100 mt per year (Table 1). The MRFSS data indicated that recreational landings have composed about 25% of the commercial and recreational total since 1979. The 1998 estimate of 395 mt is the lowest of the 1979-1999 time series, and about 56% of the available 1998 harvest limit. Recreational landings increased to 861 mt in 1999, the largest year for recreational landings since 1996.

Recreational catch per unit effort (CPUE) data obtained from MRFSS for 1981-1999 showed an increase in catch per trip in 1999, possibly in response to the strong 1997 year class. However, the time series of catch per trip showed little trend prior to 1999 (Figure 8). The recreational CPUE series tracked the NEFSC autumn survey of scup relatively well (Figure 8).

The estimated recreational discards in weight for 1984-1999 ranged from a low of 21 mt in 1998 to a high of 87 mt in 1986. The average recreational discard weight was about 44 mt per year, based on the assumption that 15% of the discards (type B2) die. No length frequency distribution data on scup discard were collected under the MRFSS program; therefore, recreational discards were assumed to be fish aged 0 and 1, in the same relative proportions as in the landed catch, consistent with regulated minimum fish sizes and informal inspection of samples collected from the New York recreational fishery. 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% (Williams, personal communication). 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. The SAW assumed a recreational fishery discard mortality rate of 15% in previous assessments (NEFSC 1997).

Sampling intensity for lengths varied from 443 to 48 mt/100 lengths in the recreational fishery (Table 4). Sampling in all years except one from 1979 to 1987 failed to satisfy the informal criterion of 200 mt/100 lengths. This criterion was met from 1988 to 1998 when sampling intensity varied from 193 to 48 mt/100 lengths. Sampling intensity decreased to 325 mt/100 lengths in 1999. 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 and 1999 recreational length frequencies were not converted to age because no age-structured analyses were included in this assessment 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 (Figure 6).

STOCK ABUNDANCE AND BIOMASS INDICES

Indices of scup abundance and biomass were calculated from catch-per-tow data from research vessel surveys conducted by the NEFSC, Massachusetts Division of Marine Fisheries, Rhode Island Division of Fish and Wildlife, Connecticut Department of Environmental Protection, New York Department of Environmental Conservation, New Jersey Bureau of Marine Fisheries, and the Virginia Institute of Marine Science.

<u>NEFSC surveys</u>

Abundance indices for scup were obtained from autumn (1963-1999), spring (1968-1999), and winter (1992-1999) NEFSC bottom trawl surveys. Mean numbers and weight per tow indices for the spring and autumn survey time series are presented in Table 8, which included only offshore strata over the early part of the time series for consistency. Although the spring and autumn indices exhibited considerable year-to-year variability, both surveys indicated that recent levels of biomass were much lower than biomass levels in years prior to 1980. The spring indices showed a relatively high biomass level from the late 1960's through the late 1970's, thereafter declining to the current relatively low biomass level (Figure 7). The autumn index, although much more variable than the spring index, indicated a possible increase in biomass from the early 1960s to the mid-1970s, thereafter declining to the lowest observed levels in the time series during 1993-1998 (Figure 8). The winter index showed a variable downward trend in abundance (Table 9 and Figure 9).

Mean number per tow at length and age indices from the spring and autumn surveys were based on tows in offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61 (Tables 10 and 11 and Figures 10 and 11). The indices from the relatively short winter survey series were based on tows in only the above-indicated offshore strata. (Table 12 and Figure 12).

Recent NEFSC trawl surveys indicated that a potentially strong 1997 year class was recruiting to the stock. This year class was tracked beginning with the 1997 autumn survey index at age 0 (mode at 11 cm), in which the 1997 year class appeared to be about the same magnitude as the 1994 year class. The 1997 year class progressed through the 1998 winter and spring surveys at age 1 (mode at about 10 cm), the 1998 autumn survey at age 1 (mode at 15 cm), and the 1999 spring survey at age 2 (mode at 18-20 cm; Figures 10-12). The 1997 year class contributed to overall increases in weight-per-tow indices for 1997 autumn and 1998 winter and spring surveys (Tables 8 and 9).

The 1998 and 1999 year classes also appeared potentially strong in the autumn survey index, but these year classes did not progress through the winter and spring survey indices as did the 1997 year class (Tables 10-12). The 1999 year class appeared greater than the 1998 year class in the autumn, winter, and spring survey indices.

Indices of scup spawning stock biomass per tow (SSB kg/tow) were developed from the NEFSC spring and autumn 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. The 1998-2000 average SSB index was at 0.10 kg/tow, which was about 4% of the maximum observed SSB of 2.77 in 1977-1979.

Massachusetts

The Massachusetts Division of Marine Fisheries (MADMF) has conducted a semi-annual bottom trawl survey of Massachusetts territorial waters in May and September since 1978. Survey coverage extended from the New Hampshire to Rhode Island boundaries and seaward to three nautical miles including Cape Cod Bay and Nantucket Sound. The study area was stratified into geographic zones based on depth and area. Pre-determined trawl sites were allocated in proportion to stratum area and chosen randomly within each sampling stratum. A 20 minute tow at 2.5 knots was made at each station with a 3/4-size North Atlantic two-seam otter trawl (11.9 m headrope, 15.5 m footrope) rigged with a 19.2-m chain sweep with 7.6 cm rubber discs. The net contained a 6.4 mm mesh cod-end liner to retain small fish. About 95 stations were sampled during each survey. Standard bottom trawl survey techniques were used to process the catch of each species. Generally, the total weight (nearest 0.1 kg) and length frequency (nearest cm) were recorded for each species on standard trawl logs. Collections of age and growth structures, maturity observations, and pathology observations were taken. The MADMF changed their methodology since SAW 27 in calculating survey indices. This change was reflected in total numbers per tow and total kg per tow in the spring survey, but has not yet been applied to spring indices at age (Table 13). Therefore, indices at age did not necessarily sum to the total numbers per tow.

The MADMF spring indices dropped sharply from a high in 1980 to relatively low levels through the remainder of the time series, with the exception of a spike in 1990 (Table 13 and Figure 14). The MADMF autumn indices were more variable than the spring indices, but also showed a decreasing trend in numbers and kg per tow over time (Table 14 and Figure15). The MADMF autumn index at age 0 did not indicate a strong 1997 year class, but did indicate a relatively stronger 1999 year class (Table 14).

Rhode Island

The Rhode Island Division of Fish and Wildlife (RIDFW) has conducted an autumn survey since 1979 based on a stratified random sampling design. Three major fishing grounds were considered in the spatial stratification, including Narragansett Bay (NB), Rhode Island Sound (RIS), and Block Island Sound (BIS). Stations were either fixed or randomly selected for each stratum. In order to maintain continuity in the number of stations sampled per stratum each season, an alternate list was generated for substitution in the event of an unexpected hang-up or questionable bottom type. At each station, a 3/4-scale High Rise bottom trawl was towed for 20 minutes at an average speed of 2.5 knots using the R/V *Thomas J. Wright*, a 42 ft Bruno and Stillman western-rigged dragger. The net average vertical opening was estimated at 10 feet. The otter trawl doors were 2 ft by 4 ft in dimension, set 7.5 fathoms ahead of the wings of the net. Survey results were expressed as unweighted arithmetic mean weight and number per tow for the three major areas (NB, RIS and BIS).

The RIDFW autumn survey index showed an increase in number per tow the early 1990's and a general decline thereafter (Table 15 and Figure 16). The 1996 and 1998 age-0 indices were the second and third lowest in the time series. The 1997 and 1999 age-0 indices indicated the strongest year classes since 1993.

Connecticut

The Connecticut Department of Environmental Protection (CTDEP) trawl survey program was initiated in May 1984 and encompassed both New York and Connecticut waters of Long Island Sound. The stratified random design survey is currently conducted in the spring (April-June) and autumn (September-October). Each survey consisted of three cruises, with 40 stations sampled during each cruise, providing a sampling density of one station per 20 square nautical miles per cruise. Prior to 1990, the survey was conducted monthly from April to November.

Scup occurred in all months sampled, but were most common in the autumn when 4,000-40,000 fish between 4 and 38 cm are taken. Large autumn catches were attributed to age-0 fish (<12 cm), which composed 80-90% of the catches. About 2,000-4,000 age 1+ (9-37 cm) scup were typically collected during the 120 tows. Scup occurred in 40-50% of the spring tows and in more than 95% of the autumn tows. Proportional standard errors (PSE) of spring log(mean number/tow) indices ranged from 12 to 14%, whereas autumn PSE ranged from 2 to 7%.

The CTDEP number-per-tow indices indicated that scup abundance was relatively stable during the survey period, except for relatively large numbers per tow in 1991 and 1999 (Table 16 and Figure 17). potential increases from 1984-1991, but abundance has been stable or declining thereafter. There was no indication of a strong 1997 year class, similar to the MADMF index and in contrast to the RIDFW index.

New York

The New York Department of Environmental Conservation (NYDEC) initiated a small mesh trawl survey in 1985 to collect fisheries-independent data on the age and size composition of scup in local waters. This survey was conducted in the Peconic Bays, which are the estuarine waters that lie between the north and south forks of eastern Long Island. The R/V *David H. Wallace*, a 35 ft Bruno and Stillman, was used to sample sixteen stations each week from May through October. Tows were 20 min in duration. The net used had a 16 ft headrope and a 19 ft footrope and was constructed of polypropylene netting with 1.5 in stretch mesh in the body and 1.25 in stretch mesh in the cod-end.

The NYDEC young-of-the-year index was based on slicing at length. Scup were categorized as young-of-the-year if less than or equal to 75 mm in the July survey, 100 mm in August, and 125 mm in September. The time series included 1985 and 1987-1999. The young-of-the-year index peaked in 1991-1992 and declined thereafter through 1996 (Table 17 and Figure 18). The index increased to series-high levels in 1997-1999, peaking in 1998.

New Jersey

The New Jersey Bureau of Marine Fisheries (NJBMF) has conducted a stratified random bottom trawl survey of New Jersey coastal waters from Ambrose Channel south to Cape Henlopen Channel, and offshore from about the 18-ft isobath to the 15-ft isobath. Latitudinal strata boundaries corresponded to those in the NMFS groundfish survey; longitudinal boundaries corresponded to the 30, 60, and 90-ft isobaths. Each survey included two tows per stratum plus one additional tow in each of nine larger strata for a total of 39 tows. A three-in-one trawl with a 100 ft footrope, an 82 ft headrope, 3- 4.7 in mesh throughout most of the body and a 0.25 in mesh cod-end liner was used. Two vessels have been used during the survey: the F/V *Amy Diane* from 1988-1991 and the F/V *ARGO Marine* from 1991 to the present. The survey was conducted in June, August, and October, and an average of the mean number per tow from each month was reported as an overall annual index. Catch per tow at length was reported by survey, pooled, and aged using NEFSC survey age-length keys (augmented with commercial age-length keys when available and necessary). The catch in 1998 and 1999 surveys was aged using the NEFSC 1998 fall age-length key.

The NJBMF survey index showed an increase in the mean number per tow from 1989 to 1993 and a subsequent decline to the lowest levels observed in the time series in 1995-1997 (Table 18 and Figure 19). The mean number per tow increased to about the 1994 level in 1998 and 1999. As with the MADMF, CTDEP, and VIMS recruitment indices, there was no indication of a strong 1997 year class in the NJBMF survey indes.

Virginia Institute of Marine Science

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile scup survey in lower Chesapeake Bay during June-September since 1988. The geometric mean catch per tow of age-0 scup generally declined from relatively high levels peaking in 1990 and 1993 to relatively low levels from 1994 to the present (Table 19 and Figure 20). Numbers per tow in 1997 and 1999 were the two lowest levels in the time series.

Coherence Among Surveys

The surveys conducted by the NEFSC and several states have each produced indices of scup abundance and biomass. Each of these surveys may provide indices for different components of the overall stock because the surveys sample distinct geographic regions. Seasonal movements may also influence the availability of scup and the effectiveness of the various surveys in providing indices that accurately reflect total stock abundance or biomass. Different indices likely measure different spatial and temporal components of the stock.

Stock sizes as indexed by mean weight per tow appeared to have declined during the late 1970's (NEFSC spring survey) and early 1980's (MADMF spring survey). Biomass has continued to trend downward since that time to lowest observed levels in 1993-1999 (NEFSC and MADMF spring surveys). Intermittent increases in biomass were not sustained for more than three years in either index. The fluctuating NEFSC autumn survey index has included several of the lowest observations in the 34 year time series in recent years. Other indices of abundance based on number per tow were much shorter, beginning in 1984. While several of these indices showed increasing trends from 1985 to 1993, indices in 1996 were at or near the lowest values in the survey series and small increases thereafter were attributable to the contributions of the 1997 and 1999 year classes. Recruitment indices (age 0 scup) from 1984-1999 autumn surveys generally showed highest levels in the 1988-1992 time period and lower values thereafter. Among the state recruitment indices at age 0, only the RIDFW survey index indicated a strong 1997 year class (Table 15 and Figure 16). Recent NEFSC surveys also suggested that the 1997 year class may have been strong (Tables 8 and 10).

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).

Estimates of Fishing Mortality from Survey Indices

State and NEFSC survey indices at age for scup were highly variable. The patterns in proportions at age in survey indices and survey catchability coefficients at age estimated in the VPA suggested that all ages of scup may not have been equally available or susceptible to capture by survey trawl gear (NEFSC 1998). As a result, mortality estimates derived from survey catch at age indices were highly variable (Tables 10-13), may have been positively biased, and were probably not reliable for assessing current stock status (NEFSC 1998). However, examination of NEFSC survey length-frequency distributions suggested that the current mortality rate must be much higher than during the 1977-1979 peak because of the lack of larger fish in recent survey length distributions (Figures 10-12).

Catch Curve Analyses

The mean number of scup per tow by year class from the NEFSC autumn and spring surveys were plotted on a $\log_e$ scale and fit with a linear regression line to estimate total mortality for the year class. Total mortality Z equaled the negative of the slope of the regression lines. Plots for 1984-1997 year classes included scup from age 0 to age 3, and the plot for the 1998 year class included scup from age 0 to age 2 (Figure 21). Plots included catch at age 0 in autumn, age 1 in spring and autumn, age 2 in spring and autumn, and age 3 in spring and autumn. Few scup ages 4 and older were caught in the spring and autumn surveys (Tables 10 and 11) and were therefore not included in the catch curve analyses.

Estimates of total mortality Z by year class averaged 2.31 and ranged from 1.82 for the 1985 year class to 3.05 for the 1991 year class (Table 20 and Figure 22). There was not trend in Z across year classes (Figure 22).

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.

The relative exploitation index indicated that the exploitation of scup was relatively low in the 1980's and high in the 1990's (Table 24 and Figure 23). 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 from 1981 to 1997. However, exploitation rates decreased by about 50% in 1998 and 1999 relative to 1997. Relative exploitation index values were less than the time series mean (0.58; range, 18.2-134.9; SD=32.9) in 1981-1983, 1985-1990, 1992, and 1998-1999. Relative exploitation index values were greater than the time series mean in 1984, 1991, and 1993-1997.

BIOLOGICAL REFERENCE POINTS

Yield and Spawning Stock Biomass per Recruit

In FMP Amendment 8, the Mid-Atlantic Fishery Management Council (MAFMC) and the Atlantic States Marine Fisheries Commission (ASMFC) jointly adopted an F_{max} overfishing definition. Analysis from the SAW 19 assessment (NEFSC 1995) indicated that $F_{0.1}$ = 0.141 and F_{max} = 0.236, with yield including both landings and discard. At F_{max}, about 24% of the maximum spawning potential (MSP) is obtained. The SAW 27 assessment (NEFSC 1998) yield per recruit analysis provided estimates of $F_{0.1}$ = 0.147 (15% exploitation rate; 39% MSP) and F_{max} = 0.261 (21% exploitation rate; 23% MSP). SAW 27 noted that reference points from the yield and spawning stock biomass per recruit analysis were subject to uncertainty attributable to the effects of discarding on the fishery exploitation pattern estimated by the exploratory VPA (NEFSC 1998).

FMP Amendment 12 Overfishing Definition for Scup

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} under current fishery conditions was estimated to be 0.26 by 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).

STOCK REBUILDING SCHEDULES

The NEFSC spring survey catch per tow at age (Table 10) was projected under different intrinsic rates of fishing mortality and M=0.20, and converted to an index of spawning stock biomass (SSB; kg/tow) to project possible rebuilding schedules for the scup stock. 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. The following intrinsic rates of fishing mortality were used: F=0, F=0.24 (target for 2002), F=0.72 (target for 1997-1999), F=1.0, F=2.0, and the F necessary for the SSB index to achieve in 10 years the biomass threshold of 2.77 kg/tow. The survey catch per tow at ages 1 to 4 were projected into the next respective age in each time step (up to age 15+), with equilibrium recruitment at age 1. The SSB index was calculated 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 25 years or until the SSB index equaled or exceeded the biomass threshold.

The stock projection results were sensitive to the starting biomass values and recruitment estimates. Starting with year 2000 values of catch per tow at age in the NEFSC spring survey (5.92, 0.72, 0.05, and 0.02 kg/tow at ages 1-4; Table 10), the biomass threshold was achieved in 4 years at F=0, in 6 years at F=0.24, and in 10 years at F=0.34 (Figure 24). The biomass threshold could not be achieved in 25 years at F=0.72, 1.0, and 2.0. Starting with 1993-2000 geometric mean values of catch per tow at age in the NEFSC spring survey (1.40, 0.27, 0.04, and 0.03 kg/tow at ages 1-4; Table 10), the biomass threshold was achieved in 9 years at F=0 and in 10 years at F=0.02 (Figure 25). The biomass threshold could not be achieved in 25 years at F=0.24, 0.72, 1.0, and 2.0. Note that the equilibrium recruitment value was less in the projection using the 1993-2000 geometric mean catch per tow at age (1.40 kg/tow) versus the recruitment value in the projection using the year 2000 catch per tow at age (5.92 kg/tow). Therefore, the time to reach the biomass threshold at a given F is dependent on recruitment.

CONCLUSIONS

The stock is overfished and overfishing is occurring. The current index of spawning stock biomass is low, at less than 5% of the biomass threshold (2.77 SSB kg/tow). Although an estimate of fully-recruited F is not available, catch curve analyses of survey indices indicate that F for ages 0-3 exceeds 1.0 and is considerably above the fishing mortality rate threshold (Fmax = 0.26) for the 1984–1998 year classes. Indices of recruitment have trended downward in recent years, except for moderate 1994, moderate to strong 1999 year-classes and a strong 1997 year class. The stock has a highly truncated age structure, which likely reflects prolonged high fishing mortality.

Fishing mortality should be reduced substantially and immediately. Reduction in fishing mortality from discards will have the most impact on the stock, particularly considering the importance of the 1999 and all future good recruitment to rebuilding the stock. New or enhanced data reporting or sampling for scup is required now and will become more important as fishing mortality approaches the threshold.

SARC COMMENTS

An analytical assessment based on a VPA was not considered by the working group because there was considerable uncertainty associated with the catch data. The SARC agreed with the working group and concluded that a VPA analysis would be inappropriate at this time. An analysis using ASPIC was rejected by the SARC as a basis for management decisions also due to catch data uncertainties.

The SARC evaluated a number of analyses using catch curves. The SARC concluded that, while the estimate of Z's were variable and likely imprecise, they could be used to provide general quantitative advice. These analyses indicate that F is at least 1.0 and possibly greater and has been at this level for the 1984-2000 time series. The SARC noted the truncated age and size structure seen in landings and surveys and near record low indices of biomass and abundance from research surveys also indicate a high F. The SARC noted that further analyses of F are complicated by the lack of older ages in the population, i.e., it is not possible to estimate F on the older age classes because they are not well represented in the surveys. The SARC was not able to provide advice on specific TACs owing to the imprecision of F estimates, but noted that current F is likely significantly higher than the reference point (F_{max}=0.26).

The SARC discussed at length the inadequacies of the discard data. Although there is high uncertainty regarding annual estimates, the SARC concluded that the limited available data from sea sampling indicate discarding of scup has been high throughout the time series (1989-1999), approaching or exceeding landings. Continued unreliability in discard estimates will prevent the use of VPA and production models for assessing this stock.

The SARC discussed the ability of the NEFSC spring survey to catch older scup. Evidence from earlier surveys (1978) suggests that the survey can catch older fish if they are present. However, relative catchability by age to the survey gear is unknown.

Recruitment based on survey indices was evaluated by the SARC. The surveys indicate a strong 1997 year class and moderate to strong year classes in 1994 and 1999. The strength of the 1997 year class is evident in the recreational and commercial catches.

The SARC reviewed data on recreational CPUE. The series showed an increase in 1999 possibly in response to the strong 1997 year class, but overall, showed little trend over the series (1981-1999). The recreational CPUE series tracked the NEFSC autumn survey relatively well.

RESEARCH RECOMMENDATIONS

- Explore alternate methodologies for analyzing the available sea sampling data.
- Explore sensitivity of YPR reference points to changes in input parameters.
- Investigate factors affecting size-specific availability to research surveys.
- Increased and more representative sea and port sampling data of the various commercial fisheries in which scup are landed and discarded is critical to adequately characterize the length composition of both landings and discards. The current level of sampling, particularly of commercial fishery discards, seriously impedes the development of analytic assessments and forecasts of catch and biomass for this stock. A study to develop optimum sampling levels to estimate discards should be implemented. This would quantify the advantages to obtaining sea samples from freezer trawlers and other small mesh fleets from which few samples have been collected, and would provide an opportunity for joint industry research programs.

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

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.

- Expanded age sampling of scup from commercial and recreational catches is required with special emphasis on the acquisition of large specimens.

- Explore other assessment approaches including Bayesian and bootstrap techniques that incorporate uncertainty in catch estimates. Explore models that incorporate within-year survey data.

- A comprehensive database should be maintained that includes all available data from the scup commercial and recreational fishery, research surveys, and sea and port sampling programs, with timely updates from participating agencies.

REFERENCES

ASMFC. 2000. Emergency rule for the summer 2000 scup fishery. Fishery Management Report #26a.

Cogswell, S.J. 1960. Summary of tagging operations, July 1, 1959 through June 30, 1960, U.S.Bur. Comm. Fish., Woods Hole Laboratory, Lab. Ref. No. 60-1.

Cogswell, S.J. 1961. Summary of tagging operations, July 1, 1960 through June 30, 1961, U.S. Bur. Comm. Fish., Woods Hole Laboratory, Lab. Ref. No. 61-12.

Crecco, V., G. Maltezos, and P. Howell-Heller. 1981. Population dynamics and stock assessment of the scup, *Stenotomus chrysops*, from New England waters. Conn. Dept. Environ. Protect., Mar. Fish., Completion Rep. No. 3-328-R-2 CT, 62 p.

Dery, L. and C. Rearden. 1979. Report of the state-federal scup (*Stenotomus chrysops*) age and growth workshop. National Marine Fisheries Service, Northeast Fisheries Center, Woods Hole Laboratory Lab. Ref. Doc. 79-57.

Hamer, P.E. 1970. Studies of the scup, *Stenotomus chrysops*, in the Middle Atlantic Bight. New Jersey Div. Fish, Game and Shellfish, Misc. Rep. No. 5M, 14 p.

Hamer, P.E. 1979. Studies of the scup, *Stenotomus chrysops*, in the Middle Atlantic Bight. New Jersey Div. Fish, Game and Shellfish, Misc. Rep. No. 18M, 67 p.

Howell, P.T. and D.G. Simpson. 1985. A study of marine recreational fisheries in Connecticut. March 1, 1981 - February 28, 1984. CTDEP, Fed. Aid to Sport Fish Restoration F54R, Final Rep., 60 p.

Mayo, R.K. 1982. An assessment of the scup, *Stenotomus chrysops* (L.), population in the Southern New England and

Middle Atlantic regions. NMFS, NEFC, Woods Hole Lab. Ref. Doc. No. 82-46, 60 p.

Morse, W.W. 1978. Biological and fisheries data on scup, *Stenotomus chrysops* (Linnaeus). NMFS, NEFC, Sandy Hook Lab. Tech. Ser. Rep. No. 12, 41 p.

NEFSC. 1993. Status of Fishery Resources off the Northeastern United States. NOAA Tech. Mem. NMFS-F/NEC-101. 140 p.

NEFSC. 1995. Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 95-08: 221 p.

NEFSC. 1997. Report of the 25th Northeast Regional Stock Assessment Workshop (25th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 97-14: 143 p.

NEFSC. 1998. Report of the 27th Northeast Regional Stock Assessment Workshop (27th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 98-15: xxx p.

Neville, W.C. and G.B. Talbot. 1964. The fishery for scup with special reference to fluctuations in yield and their courses. U.S. Fish Wild. Serv. Spec. Sci. Rept. - Fish. No. 459, 61 p.

Pennington, M. 1985. Estimating the relative abundance of fish from a series of trawl surveys. Biometrics 41:197-202.

Simpson, D.G., P.T. Howell and M.W. Johnson. 1990. Section 2 Job 6 Marine finfish survey Assessment Workshop (27th SAW): Stock Assessment Review Committee (SARC) consensus summary of assessments. Northeast Fish. Sci. Cent. Ref. Doc. 98-15: xxx p.

Simpson, D.G.; P.T. Howell and M.W. Johnson. 1990. Section 2 Job 6: Marine finfish survey in State of Connecticut D.E.P., A study of marine recreational fisheries in Connecticut, 1984-1988. CTDEP, Fed. Aid to Sport Fish Restoration, F54R Final Rep., 265 p.

Sisson, R.T. 1974. The growth and movement of scup (Stenotomus chrysops) in Narragansett Bay, RI and along the Atlantic Coast. RI Division of Fish and Wildlife Completion Report, 3-138-R-3. 21 p.

Wigley, S., M. Terceiro, A. DeLong, and K. Sosebee. 1997. Proration of 1994-196 commercial landings of cod, haddock and yellowtail flounder. SAW 24 SARC Working Paper Gen 4. 32 p.

Williams, E. Pers. Comm. University of Rhode Island, Department of Fisheries and Aquaculture, Kingston, RI. November 1, 1994. NEFSC. 1993.

Table A1.–Scup landings (mt) from Maine to North Carolina from 1979 to 1999, including revised landings for Massachusetts for 1986-1997.

Year	Commercial Landings	Recreational Landings	Total Landings
1979	8,584	1,198	9,782
1980	8,424	3,109	11,533
1981	9,856	2,636	12,492
1982	8,703	2,361	11,064
1983	7,794	2,836	10,630
1984	7,769	1,096	8,865
1985	6,726	2,764	9,490
1986	7,176	5,264	12,440
1987	6,280	2,806	9,086
1988	5,941	1,936	7,877
1989	3,979	2,521	6,500
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	3,076	596	3,672
1996	2,948	1,016	3,964
1997	2,194	543	2,737
1998	1,893	395	2,288
1999	1,469	861	2,330

Table A2.–Commercial landings (mt) of scup by state from 1979 to 1999, including revised landings for Massachusetts for 1986-1997. One mt was landed in DE in 1995 and was included in the 1995 MD total.

Year	ME	MA	RI	CT	NY	NJ	MD	VA	NC	Total
1979		782	3,123	91	1,422	2,159	21	397	589	8,584
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	3,202	25	1,473	1,746	2	1,042	668	8,703
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	1,492	17	74	271	6,726
1986		875	2,987	67	894	1,895	14	272	172	7,176
1987	5	739	2,162	301	911	1,817		232	113	6,280
1988	9	536	2,832	359	687	1,334	1	125	58	5,941
1989	32	579	1,398	89	603	1,217	1	45	15	3,979
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	1,048	90	511	1,084	2	20	11	3,076
1996		436	776	99	377	1,141	20	72	27	2,948
1997		677	491	50	376	596	1	2	1	2,194
1998		435	361	44	279	758	5	4	7	1,893
1999		300	581	6	208	361		13		1,469

Table A3.–Commercial landings (mt) of scup by major gear types from 1979 to 1999, including revised landings for Massachusetts for 1986-1997. All North Carolina landings for 1990-1999 were assumed to be obtained by otter trawls. Mid-water paired trawl landings were combined with other gears for 1994-1999.

Year	Otter trawl	Paired trawl	Floating trap	Pound net	Pots and traps	Hand lines	Other gear	Total
1979	6,387	146	1,305	429	26	215	76	8,584
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	43	8,703
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	15	6,726
1986	5,163	540	629	332	9	493	10	7,176
1987	4,607	237	590	193	213	423	17	6,280
1988	4,142	166	1,052	53	44	396	88	5,941
1989	3,174	89	193	74	104	334	11	3,979
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	2,208		331	41	146	215	135	3,076
1996	2,201		229	8	129	374	7	2,948
1997	1,497		86	12	104	489	6	2,194
1998	1,376		11	4	98	391	13	1,893
1999	992		140	30	63	174	70	1,469

'able A4.–Sampling intensity for scup commercial and coastal recreational fisheries in the Northeast Region (NER) from Maine to Virginia.

	Commercial fishery				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	7,995	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	8,035	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	6,455	211	741	3,282	443
1986	54	5,467	6,746	123	2,580	5,908	229
1987	61	6,491	5,956	92	777	2,980	384
1988	85	8,691	5,670	65	2,156	2,414	112
1989	46	4,806	3,701	77	4,111	3,248	79
1990	46	4,736	4,237	89	2,698	2,007	74
1991	31	3,150	6,798	216	4,230	3,634	86
1992	33	3,260	5,875	180	4,419	2,110	48
1993	23	2,287	4,410	193	2,206	1,341	61
1994	22	2,163	4,012	185	1,374	1,188	86
1995	22	2,487	2,883	116	822	595	72
1996	61	6,544	2,661	41	526	1,015	193
1997	37	3,732	2,193	59	399	479	120
1998	41	4,022	1,886	47	286	394	138
1999	57	5,941	1,469	25	265	861	325

Table A5.–Summary of scup sampling in the Northeast Region sea sampling (SS) program from 1989 to 1999. OT= number of trips sampled in which otter trawl gear was used. H1 = first half year and H2 = second half year. SS discard is an estimate of discards based on applying the ratio of discards to landings by trip to reported weighout landings (stratified landings level < 300 kg per trip and ≥300 kg per trip). 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.)

	Trips		Lengths			SS Discard (mt)	Intensity (mt/100 lengths)
Year	All	OT	H1	H2	Total		
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	1,843	245
1998	41	33	618	64	682	7,304	1,071
1999	40	35	586	89	675	1,622	240

Table A6.–Scup discard estimates from the NEFSC Domestic Sea Sampling program for 1997-1999. Geometric mean discards-to-landings ratios (GM D/L) were stratified by half-year period (H1 and H2) and trip landings level (< 300 kg and ≥ 300 kg). N is the number of sea sampling trips with both scup landings and discards, which were used to calculate discard ratios. Corresponding dealer landings are from the NEFSC database.

	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)
				1997				
H1	0.8957	17	258	231	0.8221	4	1,244	1,023
H2	0.8957	0	279	250	0.8221	0	413	340
Total			537	481			1,657	1,363
				1998				
H1	0.8758	7	196	172	4.8106	1	920	4,426
H2	1.1396	10	281	320	4.8106	0	496	2,386
Total			477	492			1,416	6,812
				1999				
H1	0.5552	6	245	136	1.3259	2	785	1,041
H2	0.5552	0	178	99	1.3259	0	261	346
Total			423	235			1,046	1,387
				2000				
QTR1	6.7146	5	158	1,061	0.5984	2	472	282

Table A7.–Geometric mean discard ratios for scup captured by trawl, estimated by Sea Sampling (SS) and from Vessel Trip Reports (VTR). Estimates are the r transformed means of the $\log_e$ of discard-to-landed ratios for trips in which sc were caught. VTR data were subset to include only trawl trips that reported s discard of any species. Values in bold were substituted when data were inade for discard calculation (i.e., missing or unrepresentative SS trips; see text).

		Trip landings < 300 kg		Trip landings ≥ 300 k	
Year	Reporting system	Half-year 1	Half-year 2	Half-year 1	Half-yea
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	**4.81**
	VTR	0.28	0.64	0.11	0.05
1999	SS	0.55	**0.55**	1.33	**1.33**
	VTR	0.25	0.43	0.04	0.05

Table A8.–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 other tables. **Note that the 2000 indices are preliminary and based on unaudited data.**

	Spring		Spring (SSB)		Autumn	
Year	No./tow	Kg/tow	Kg/tow	3-yr ave.	No./tow	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	7.73	0.25
1972	49.80	2.30	0.90	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	48.23	4.56	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	0.09	25.35	0.69
1999	1.70	0.12	0.11	0.10	85.23	2.07
2000	6.71	0.33	0.15			

Table A9.–NEFSC winter trawl survey indices for scup. Strata set includes only offshore strata 1-12 and 61-76. Note that the 2000 indices are preliminary and based on unaudited data.

Year	Winter No./tow	Winter Kg/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	21.78	1.21

Table A10.–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 the 2000 indices are preliminary and based on unaudited data; year 2000 ages were calculated using a pooled 1997-1999 age-length key.

Spring

	Age													Age		
Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	2+	3+	F
1984		4.95	1.55	0.18	0.10	0.02							6.88	1.85	0.30	2.13
1985		9.84	1.65	0.17	0.01								11.98	1.83	0.18	2.07
1986		0.84	8.06	0.19									9.47	8.25	0.19	1.13
1987		3.76	2.96	1.49	0.61	0.03	0.02	0.02	0.01				8.90	5.15	2.19	2.91
1988		13.66	6.90	0.14	0.02		0.02	0.05					20.98	7.13	0.23	4.17
1989		0.66	0.42	0.08	0.01								1.36	0.51	0.09	-0.4
1990		0.14	0.24	0.25	0.15	0.08	0.11	0.03					1.01	0.86	0.62	-0.4
1991		8.26	0.42	0.89	0.16								10.17	1.47	1.05	1.57
1992		4.60	0.71	0.06	0.04	0.05	0.10						5.46	0.96	0.25	1.15
1993		0.50	1.62	0.14	0.09	0.02							2.37	1.87	0.25	3.93
1994		1.07	0.08	0.03									1.24	0.11	0.03	-0.2
1995		1.84	0.36	0.08	0.04								2.35	0.48	0.12	2.57
1996		0.35	0.04	0.02	0.01								0.42	0.07	0.03	-0.3
1997		0.27	0.52	0.08									0.87	0.60	0.08	3.89
1998		32.15	0.08	0.01									32.24	0.09	0.01	2.00
1999		0.82	0.54	0.01									1.37	0.55	0.01	1.89
2000		5.92	0.72	0.05	0.02								6.71	0.78	0.07	

Table A11.–NEFSC autumn trawl survey stratified mean number of scup per tow at age. Strata set includes offshore strata 1-2, 23, 25, 61-76 and inshore strata 1-61.

Autumn

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	Total	Age 2+	3+	F
1984	47.64	9.2	0.34	0.03	0.01		0.01						59.96	0.39	0.05	-0.15
1985	61.22	11.53	1.1	0.26	0.06	0.05							74.71	1.47	0.37	4.79
1986	70.19	6.58	0.57		0.01								77.36	0.58	0.01	3.86
1987	49.93	29.85	0.46	0.01									80.45	0.47	0.01	1.35
1988	47.44	15.95	0.67	0.1									64.22	0.77	0.10	3.05
1989	176.37	25.92	0.66	0.03									202.99	0.69	0.03	2.65
1990	77.45	9.21	0.75	0.04									87.46	0.79	0.04	3.48
1991	151.62	12.51	0.07	0.02									164.24	0.09	0.02	0.21
1992	25.92	14.51	1.66	0.04	0.02								42.15	1.72	0.06	n/a
1993	46.78	9.76	0.32										56.86	0.32	0.00	3.27
1994	39.54	3.92	0.04	0.01									43.52	0.05	0.01	1.41
1995	33.04	2.61	0.08	0.01									35.74	0.09	0.01	2.00
1996	24.42	2.86	0.43	0.01									27.73	0.44	0.01	3.58
1997	46.91	0.61	0.02		0.01								47.66	0.03	0.01	-0.49
1998	57.73	9.64	0.09	0.03	0.01								67.50	0.13	0.04	0.36
	94.19	9.02	1.34	0.07	0.01								104.63	1.41	0.07	

Table A12.–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 the 2000 indices are preliminary and based on unaudited data; year 2000 ages were calculated using a pooled 1997-1999 age-length key.

Winter

	Age													Age		
Year	0	1	2	3	4	5	6	7	8	9	10	11	Total	2+	3+	F
1992		57.61	4.75	0.19	0.09	0.10	0.45						63.18	5.57	0.82	1.38
1993		2.51	22.05	0.56	0.57	0.02							25.71	23.19	1.15	5.76
1994		16.31	0.73	0.02	0.02	0.01							17.09	0.79	0.06	1.17
1995		64.94	1.87	0.15	0.01	0.01	0.02	0.01					67.01	2.07	0.20	3.75
1996		12.95	5.31	0.03	0.01								18.29	5.34	0.04	3.68
1997		13.27	0.52	0.11									13.90	0.64	0.11	-0.01
1998		45.62	0.75	0.22	0.21	0.08	0.03	0.01					46.92	1.30	0.55	1.97
1999		12.48	2.41	0.12	0.02	0.01							15.04	2.56	0.15	1.11
2000		17.21	3.87	0.58	0.09	0.01	0.01						21.78	4.56	0.69	

Table A13.–MADMF spring trawl survey mean number of scup per tow at age, total mean number per tow, and total mean kg per tow from 1978 to 1999 (survey regions 1-3). Fishing mortality (F) was calculated from mean number per tow at age from age 2+3 to age 3+4.

	Age					Total	Total	Age		
Year	0	1	2	3	4	No./tow	Kg/tow	2+3	3+4	F
1978						88.20	31.11			
1979						74.48	17.64			
1980						191.91	42.05			
1981						292.37	17.40			
1982						10.37	0.97			
1983						24.42	3.40			
1984		0.07	4.18	1.95	2.14	17.80	6.50	6.13	4.09	1.58
1985		55.75	8.08	0.83	0.20	65.85	3.33	8.19	1.03	0.80
1986		0.15	38.48	3.07	0.20	43.76	7.28	41.55	3.27	2.41
1987		0.33	2.20	2.61	0.45	6.01	1.36	4.81	3.06	0.40
1988		0.00	10.75	2.33	0.30	13.98	2.08	13.08	2.63	-0.45
1989		0.08	125.62	16.40	0.43	13.05	1.97	142.02	16.83	1.48
1990		3.71	107.96	24.33	2.26	141.74	21.21	132.29	26.59	1.72
1991		0.58	7.80	17.65	1.82	28.62	6.04	25.45	19.47	2.82
1992		0.05	12.50	0.84	0.40	14.26	2.47	13.34	1.24	0.35
1993		0.05	10.01	6.77	0.92	18.41	4.08	16.78	7.69	1.66
1994		0.24	2.52	2.61	0.00	9.60	2.82	5.13	2.61	1.39
1995		42.60	4.58	0.72	0.33	48.30	2.72	5.30	1.05	3.30
1996		0.38	4.50	0.12	0.04	5.04	0.66	4.62	0.16	0.70
1997		0.48	0.85	1.88	0.00	3.21	0.71	2.73	1.88	
1998						1.26	0.19			
1999						11.26	1.87			

Table A14.–MADMF autumn trawl survey mean number of scup per tow at age, total mean number per tow, and total mean kg per tow from 1984 to 1999 (all survey regions).

	Age			Total	Total
Year	0	1	2+	No./tow	Kg/tow
1978	1,748.9	13.2	3.7	1,765.9	14.01
1979	1,071.8	10.5	6.3	1,088.6	11.38
1980	1,090.3	19.0	2.9	1,112.2	11.77
1981	871.4	29.8	10.0	911.2	13.51
1982	1,997.8	13.0	1.8	2,012.7	8.61
1983	1,520.8	13.7	2.1	1,536.6	12.22
1984	881.2	24.4	1.5	907.2	11.54
1985	551.7	33.9	20.1	605.7	11.41
1986	692.5	28.0	7.1	727.6	8.57
1987	520.2	7.9	2.3	530.4	7.29
1988	1,311.8	13.3	0.7	1,325.9	13.37
1989	513.5	39.7	1.8	555.0	7.34
1990	1,041.4	9.6	3.4	1,054.4	6.76
1991	1,077.5	10.8	0.7	1,088.9	9.67
1992	2,293.9	12.5	1.4	2,307.8	10.90
1993	954.8	1.5	1.1	957.4	9.94
1994	778.3	1.3	1.4	781.1	9.35
1995	475.3	5.9	0.5	481.7	3.88
1996	956.0	7.5	1.4	965.0	8.65
1997	867.4	6.0	0.7	874.1	6.88
1998	639.8	30.8	0.3	670.9	6.55
1999	1,121.9	21.1	9.2	1,152.2	17.11

Table A15.–RIDFW autumn trawl survey mean number of scup per tow at age, total mean number per tow, and total mean kg per tow.

Year	Age 0	1	2	3	4	5	6	Total No./tow	Total Kg/tow
1984	539.56	45.58	3.23	0.92	0.32	0.05	0.00	589.67	
1985	71.42	2.62	0.17	0.04	0.00	0.02		74.27	
1986	262.97	54.40	9.25	18.63	1.22			346.47	
1987	289.99	23.52	1.39					314.90	
1988	759.01	44.68	0.00	0.31				804.00	
1989	263.55	61.77	1.53					326.85	
1990	512.39	14.01	0.91					527.31	
1991	557.85	97.81						655.66	
1992	976.65	12.05	0.55	2.88				992.13	
1993	1234.70	11.03	0.63					1246.35	
1994	227.63	8.47	0.02	0.00				236.12	
1995	400.77	22.09	0.16					423.02	
1996	170.10	13.95	0.65	0.01				184.71	
1997	592.11	5.76	0.03					597.90	
1998	197.72	4.38	0.13	0.01				202.24	2.03
1999	603.36	7.54	0.37	0.09	0.02			611.38	10.01

Table A16.–CTDEP autumn trawl survey mean number of scup per tow at age and total mean number per tow.

Year	Age 0	1	2	3	4	5	6	Total No./tow
1984	7.47	0.97	0.73	0.49	0.26	0.08	0.02	10.02
1985	23.96	4.65	0.39	0.53	0.19	0.04	0.03	29.80
1986	12.88	9.89	2.68	0.26	0.01	0.01	0.01	25.74
1987	12.57	3.97	1.27	0.61	0.08	0.01	0.02	18.52
1988	31.70	5.88	1.81	0.24	0.05			39.68
1989	38.71	24.67	1.53	0.11	0.03	0.00		65.05
1990	54.19	6.83	7.57	0.84	0.03	0.00	0.02	69.47
1991	291.25	17.32	1.67	1.21	0.11	0.02		311.57
1992	47.04	29.45	6.39	0.52	0.29	0.04		83.72
1993	73.91	1.74	1.09	0.16	0.01	0.01		76.92
1994	90.64	1.08	0.52	0.22	0.01			92.47
1995	32.39	26.60	0.15	0.01				59.14
1996	51.50	8.39	1.53	0.03		0.01		61.46
1997	31.78	8.60	0.65	0.25	0.01			41.29
1998	90.40	12.24	0.54	0.07	0.02			103.27
1999	498.18	30.93	8.35	0.20	0.02	0.01		537.68

Table A17.–NYDEC index of young-of-the-year scup (geometric mean catch per stati
August-September).

Year	Stations	Number	Geometric mean number/station
1985	181	209	0.50
1987	201	83	0.22
1988	223	338	0.50
1989	206	150	0.40
1990	206	1,512	1.97
1991	192	3,323	4.39
1992	205	3,940	3.76
1993	208	79	0.19
1994	220	1,728	1.77
1995	184	157	0.38
1996	203	129	0.26
1997	187	4,386	4.65
1998	192	18,524	10.42
1999	195	9,147	5.81

Table A18.–New Jersey Bureau of Marine Fisheries trawl survey mean number of scup per tow at age and total number per tow for 1989-1999.

Year	Age 0	1	2	3	4	Total
1989	198.97	146.30	6.82	0.05	0.00	352.14
1990	190.53	153.24	20.82	0.87	0.00	365.45
1991	681.32	273.69	0.25	0.06	0.01	955.33
1992	643.83	413.83	11.74	0.04	0.02	1069.46
1993	987.49	211.95	8.31	0.01	0.00	1207.75
1994	305.69	101.34	0.15	0.00	0.00	407.17
1995	40.77	86.97	0.58	0.02	0.00	128.34
1996	15.06	127.95	2.22	0.10	0.00	145.33
1997	35.69	34.18	1.01	0.12	12.08	87.09
1998	319.50	23.64	0.70	0.15	0.00	343.99
1999	238.05	87.57	2.50	0.49	0.00	328.60

Table A19.–VIMS age-0 scup index of abundance for Chesapeake Bay (geometric mea
catch per tow, June-September).

Year	No./tow	Lower CL	Upper CL	n
1988	2.07	1.24	3.21	92
1989	3.06	2.05	4.41	112
1990	4.86	3.08	7.42	112
1991	1.90	1.11	2.99	103
1992	0.65	0.41	0.93	104
1993	3.36	2.16	5.00	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

Table A20.–Estimates of total mortality (Z) for 1984-1998 year classes calculated from $\log_e$-scaled plots of NEFSC autumn and spring survey indices of age 0-3 scup.

Year class	B_0	B_1	r^2	Z
1984	5.44	-2.30	0.78	2.30
1985	3.91	-1.82	0.75	1.82
1986	5.61	-2.48	0.85	2.48
1987	5.14	-2.33	0.92	2.33
1988	3.89	-1.88	0.57	1.88
1989	3.95	-2.27	0.61	2.27
1990	5.12	-2.24	0.87	2.24
1991	6.17	-3.05	0.94	3.05
1992	3.53	-2.34	0.75	2.34
1993	4.35	-2.66	0.92	2.66
1994	3.73	-2.26	0.70	2.26
1995	3.42	-2.36	0.76	2.36
1996	2.18	-1.86	0.68	1.86
1997	5.71	-2.66	0.89	2.66
1998	4.12	-2.15	0.44	2.15

Table A21.–Relative exploitation index for scup for 1981-1999. Landings are 1,000's lbs. and SSB index values are kg/tow.

Year	Landings	Spring SSB (3-year average)	Relative Exploitati Index
1981	27,543	1.00	27.5
1982	24,394	0.65	37.5
1983	23,436	0.46	50.9
1984	19,545	0.24	81.1
1985	20,922	0.68	30.8
1986	27,421	0.98	28.0
1987	20,051	1.10	18.2
1988	17,372	0.66	26.3
1989	14,326	0.35	40.9
1990	14,224	0.26	20.1
1991	23,697	0.32	74.0
1992	18,210	0.32	56.9
1993	13,613	0.18	75.6
1994	12,310	0.15	82.1
1995	8,097	0.06	134.9
1996	8,740	0.08	109.3
1997	6,034	0.06	100.6
1998	5,042	0.09	56.0
1999	5,137	0.10	51.4

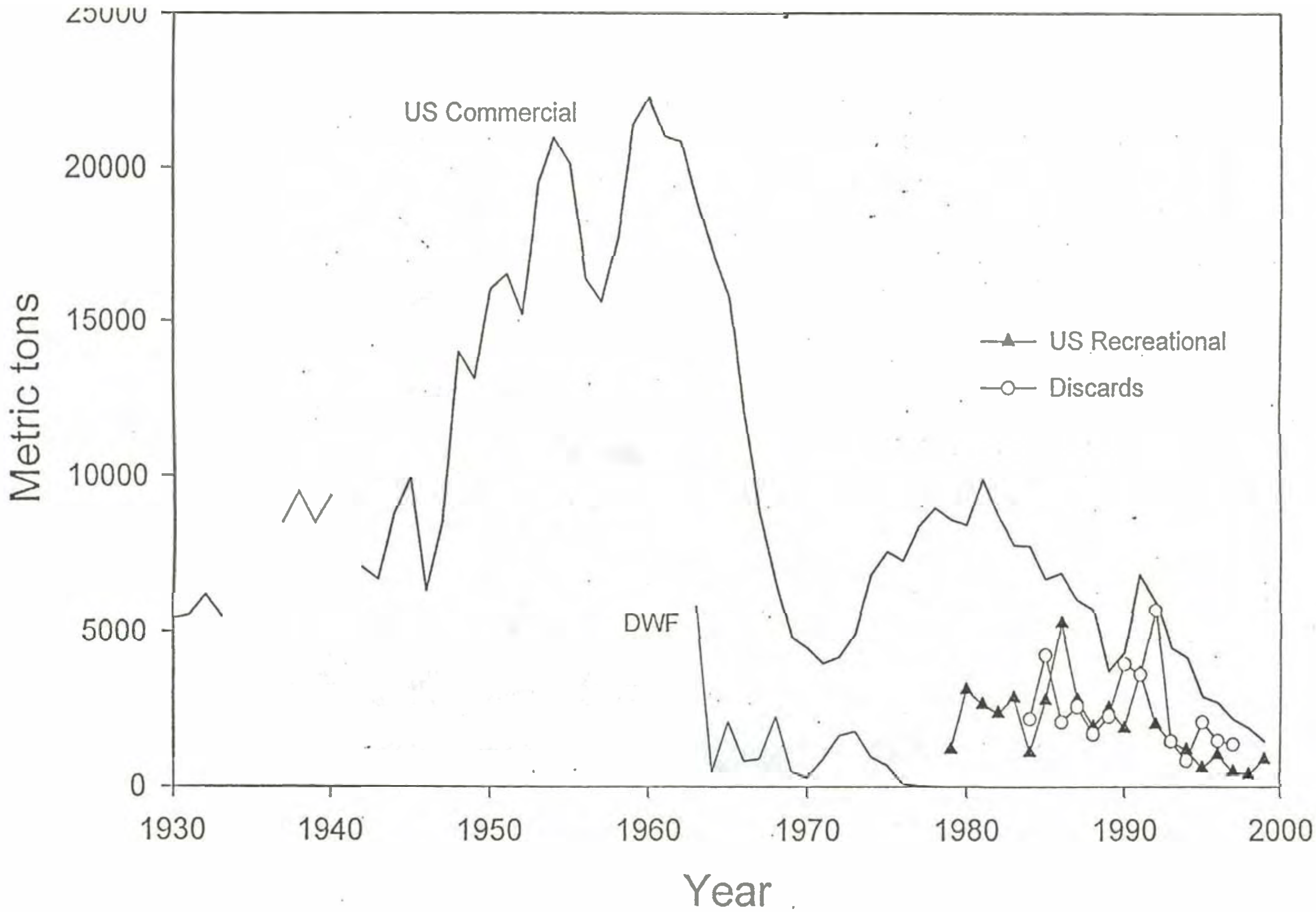


Figure A1. Catch of scup from Maine through North Carolina, including US commercial landings (does not include North Carolina prior to 1979), distant water fleet (DWF) landings, recreational landings, and commercial and recreational discards combined.

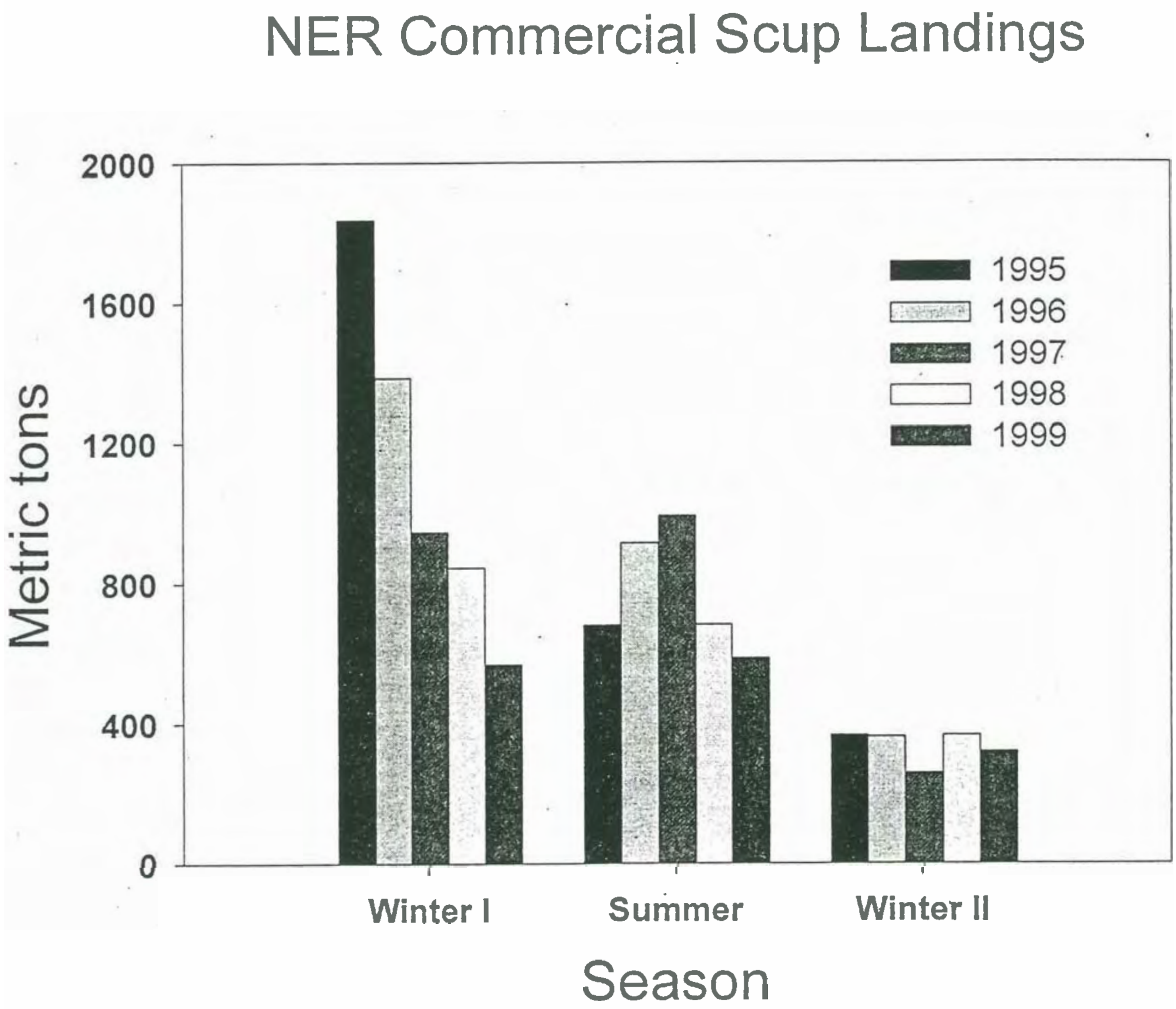


Figure A2. Seasonal distribution of commercial scup landings for 1995-1999.

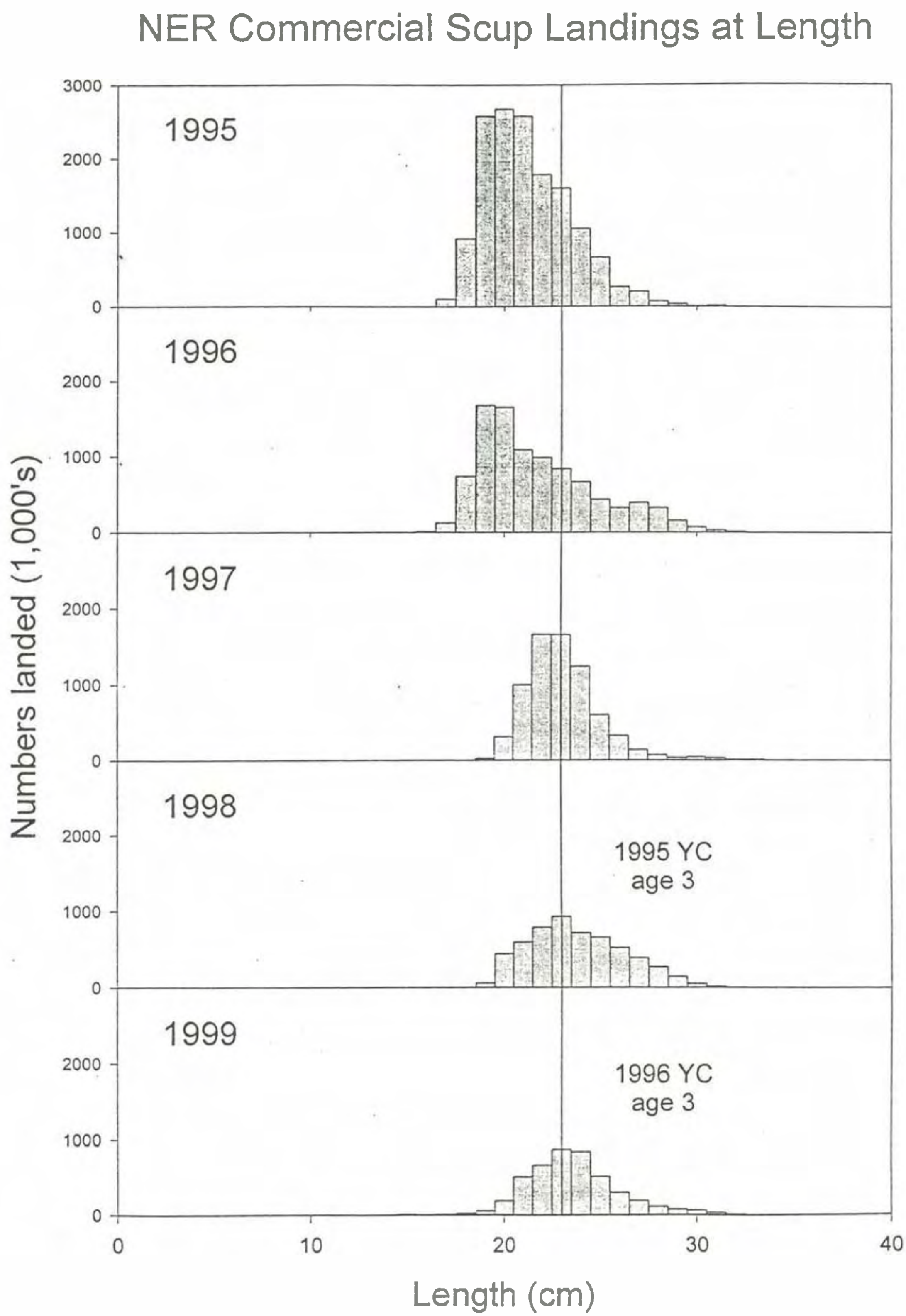


Figure A3. Northeast Region (NER; ME to VA) commercial fishery estimates of scup landings at length (fork length, cm). Vertical line is at the current minimum size of 23 cm total length (9 in).

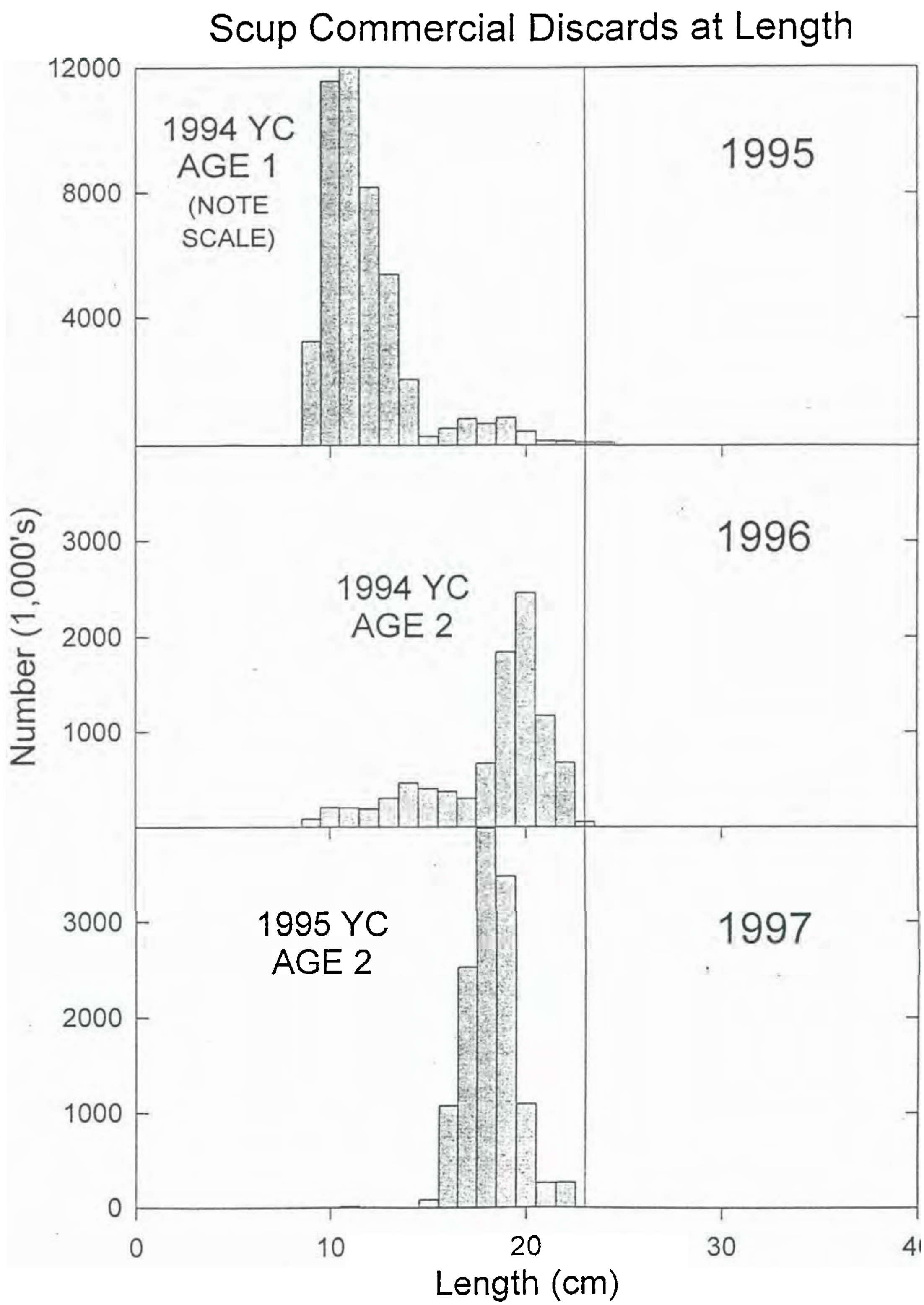


Figure A4. Northeast Region (NER; ME to VA) commercial fishery estimates of scup discards at length (fork length, cm) for 1995-1997. Vertical line is at the current minimum size of 23 cm total length (9 in).

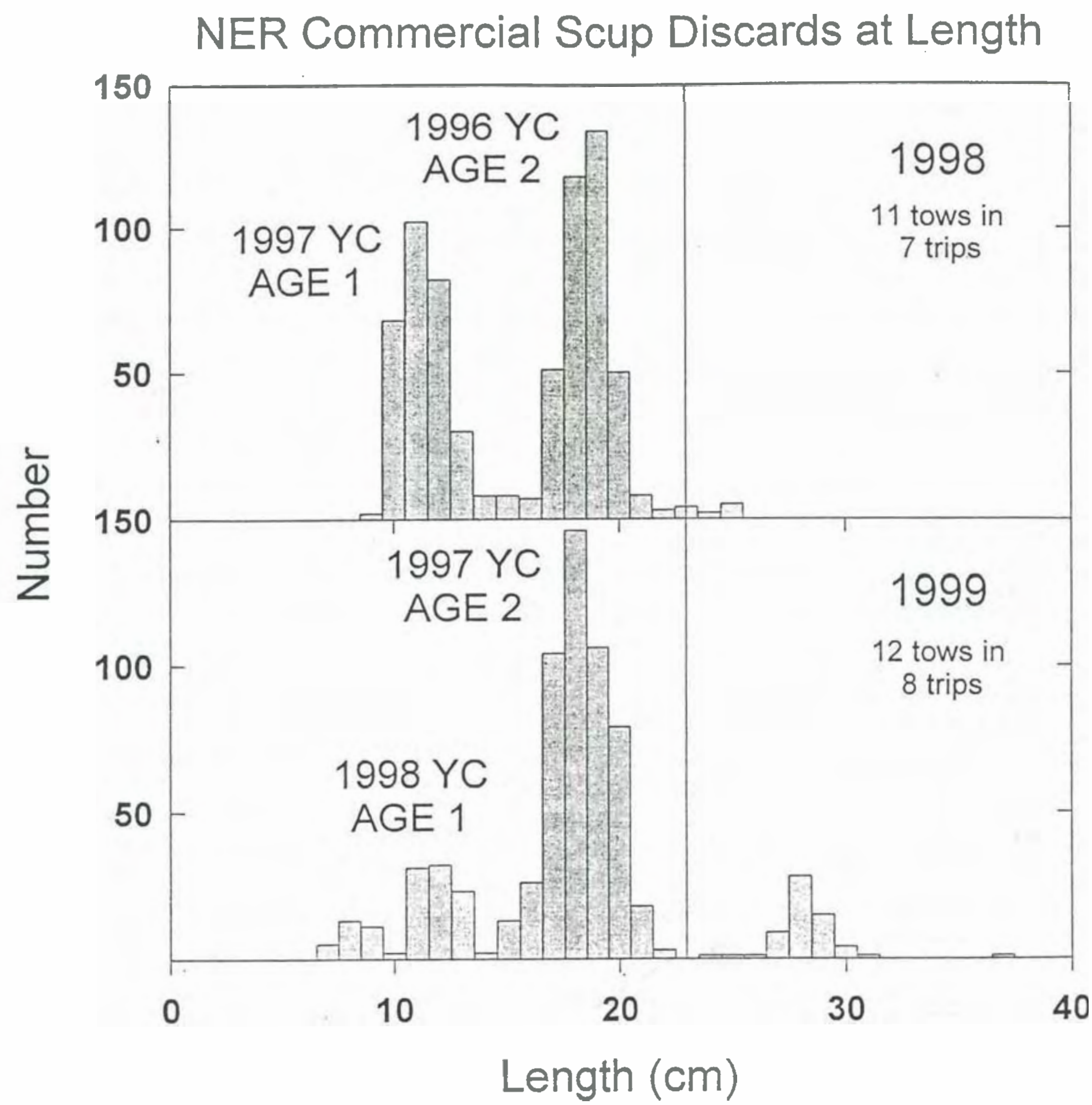


Figure A5. Northeast Region (NER; ME to VA) commercial fishery estimates of scup discards at length (fork length, cm) for 1998-1999. Vertical line is at the current minimum size of 23 cm total length.

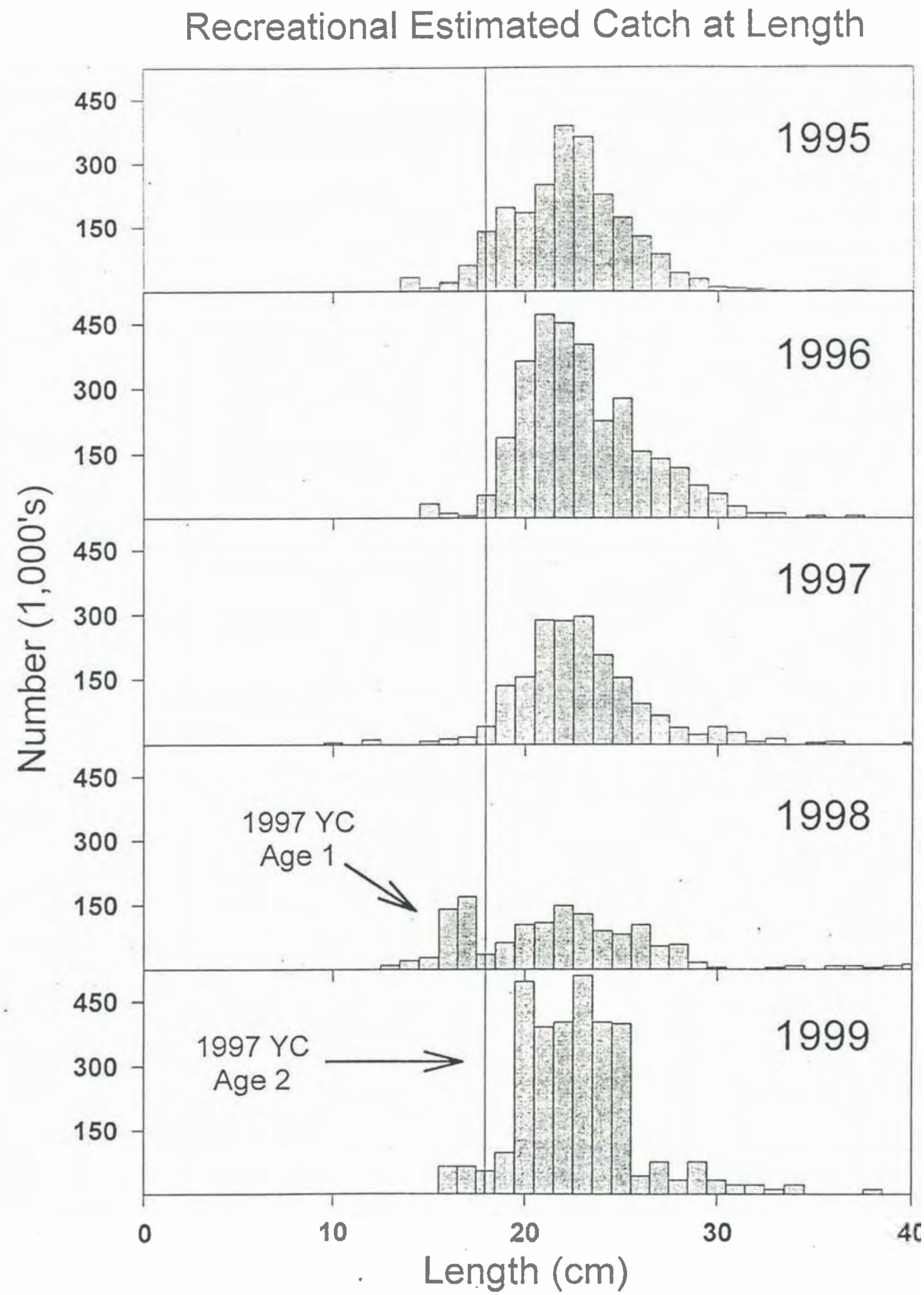
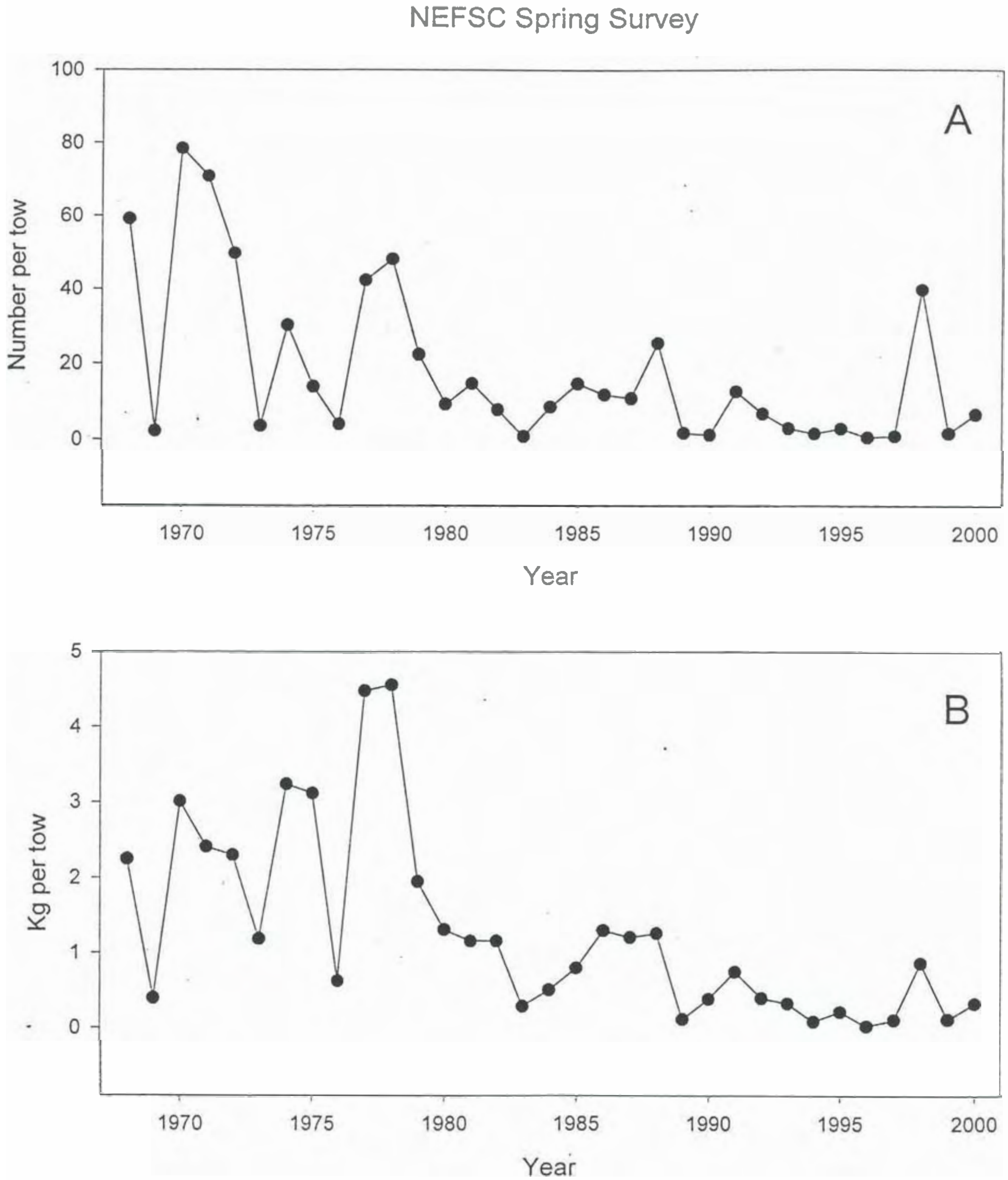


Figure A6. Coastal recreational fishery estimates of scup catch at length (fork length, cm; NC). Vertical line is at the current minimum size of 18 cm total length (7 in).



ıre A7. Scup abundance indices from NEFSC spring research vessel surveys (1968-2000) offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61; mean number per tow (A) and mean kg per tow (B).

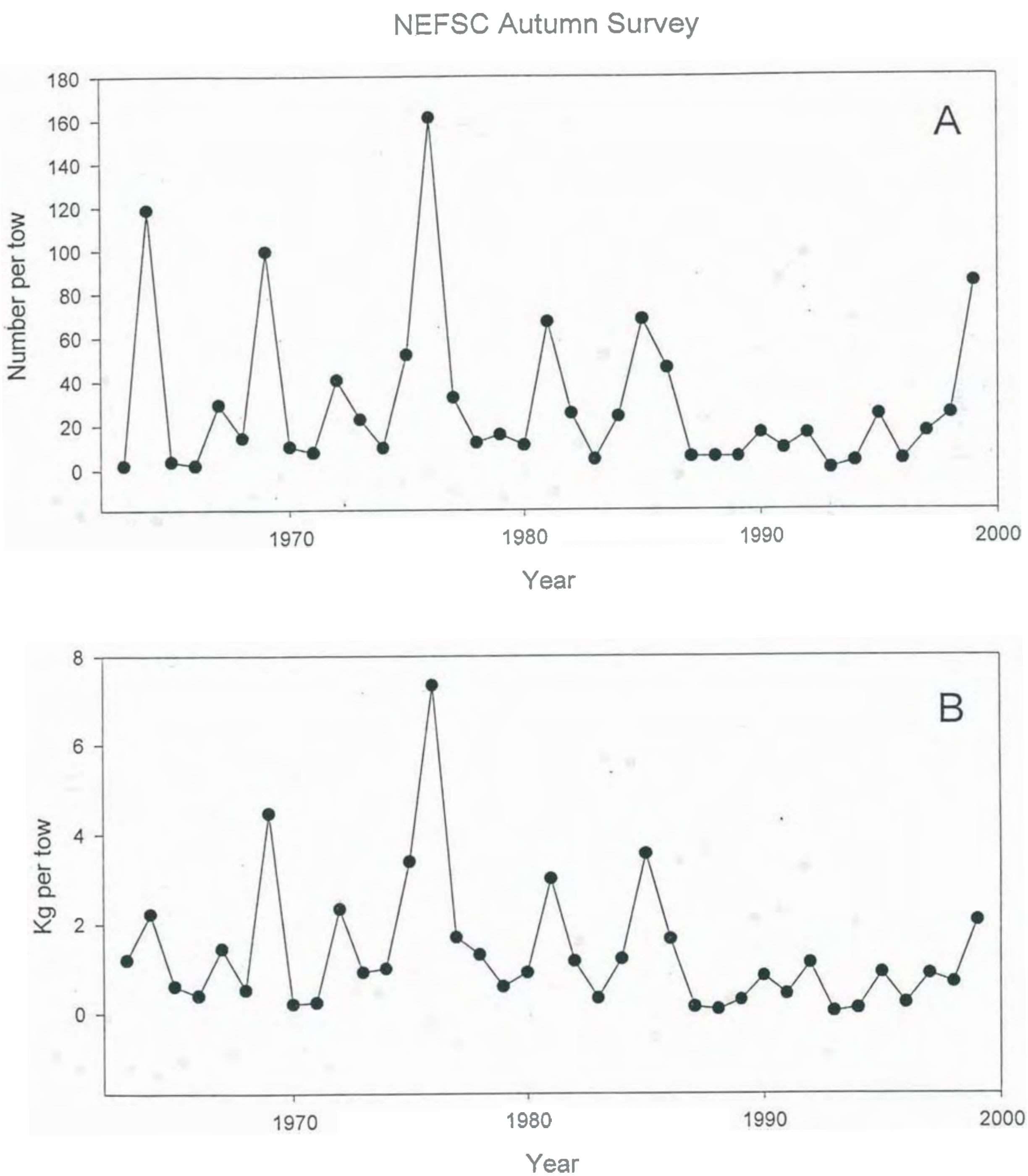


Figure A8. Scup abundance indices from NEFSC autumn research vessel surveys (1963-1999) offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61; mean number per tow (A) and mean kg per tow (B).

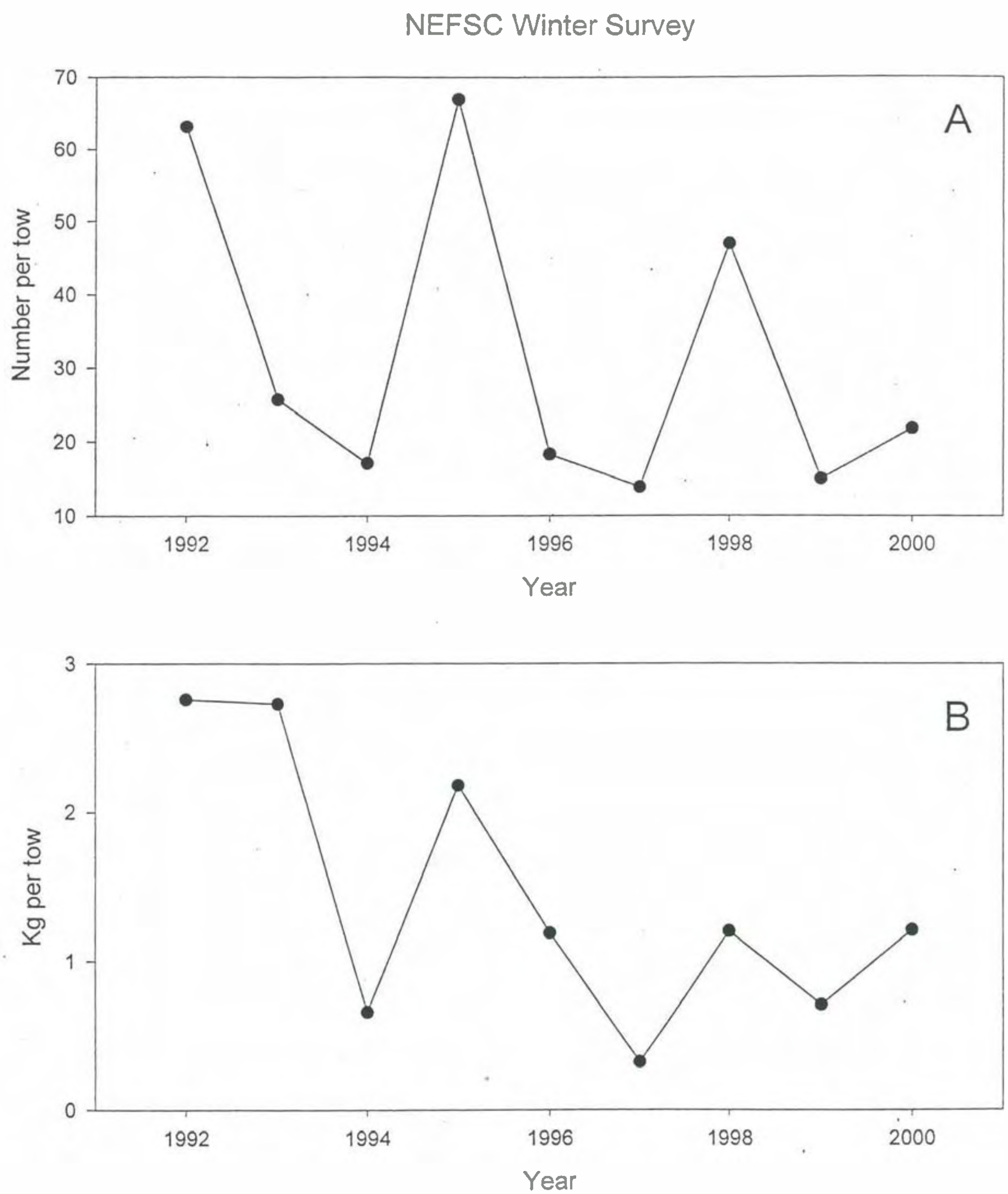


Figure A9. Scup abundance indices from NEFSC winter research vessel surveys (1992-2000) offshore strata 1-12, 23, 25, and 61-76: mean number per tow (A) and mean kg per tow (B).

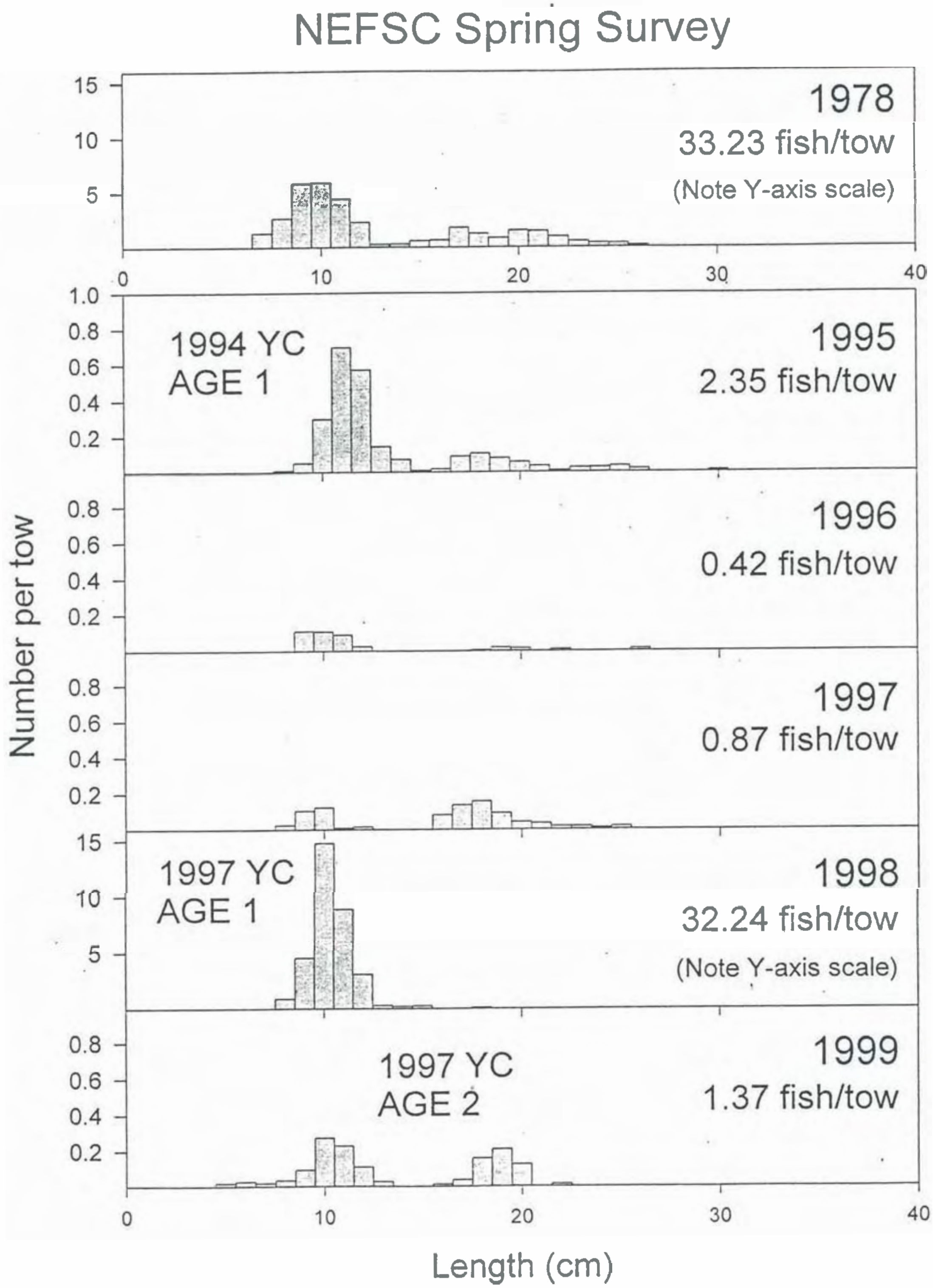


Figure A10. Scup abundance indices from NEFSC spring research vessel surveys for offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61: stratified mean number per tow at length. Note: y-axis scale difference for 1978 and 1998.

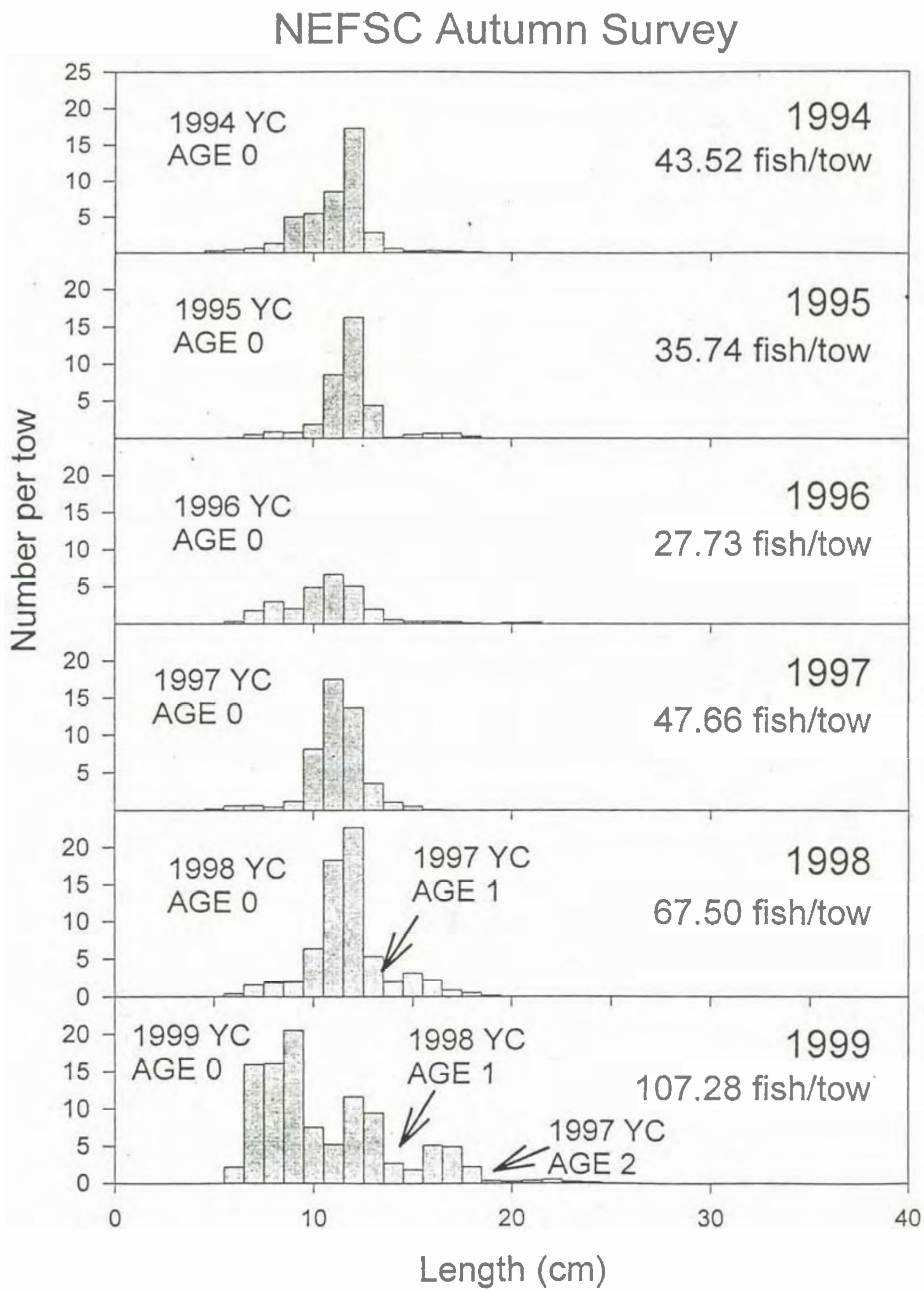


Figure A11. Scup abundance indices from NEFSC autumn research vessel surveys for offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61: stratified mean number per tow at length.

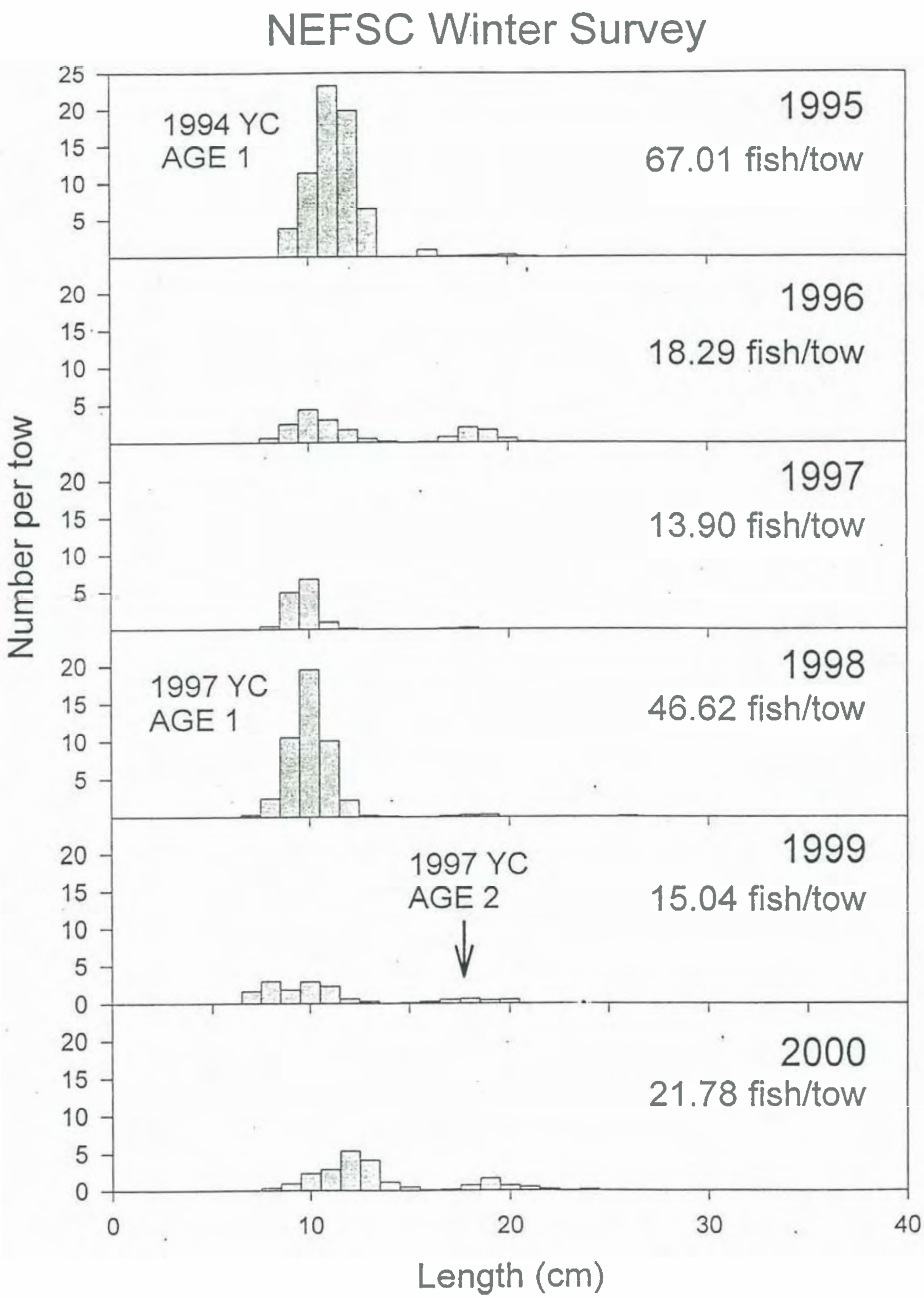


Figure A12. Scup abundance indices from NEFSC winter research vessel surveys for offshore strata 1-12, 23, 25, and 61-76 and inshore strata 1-61: stratified mean number per tow at length.

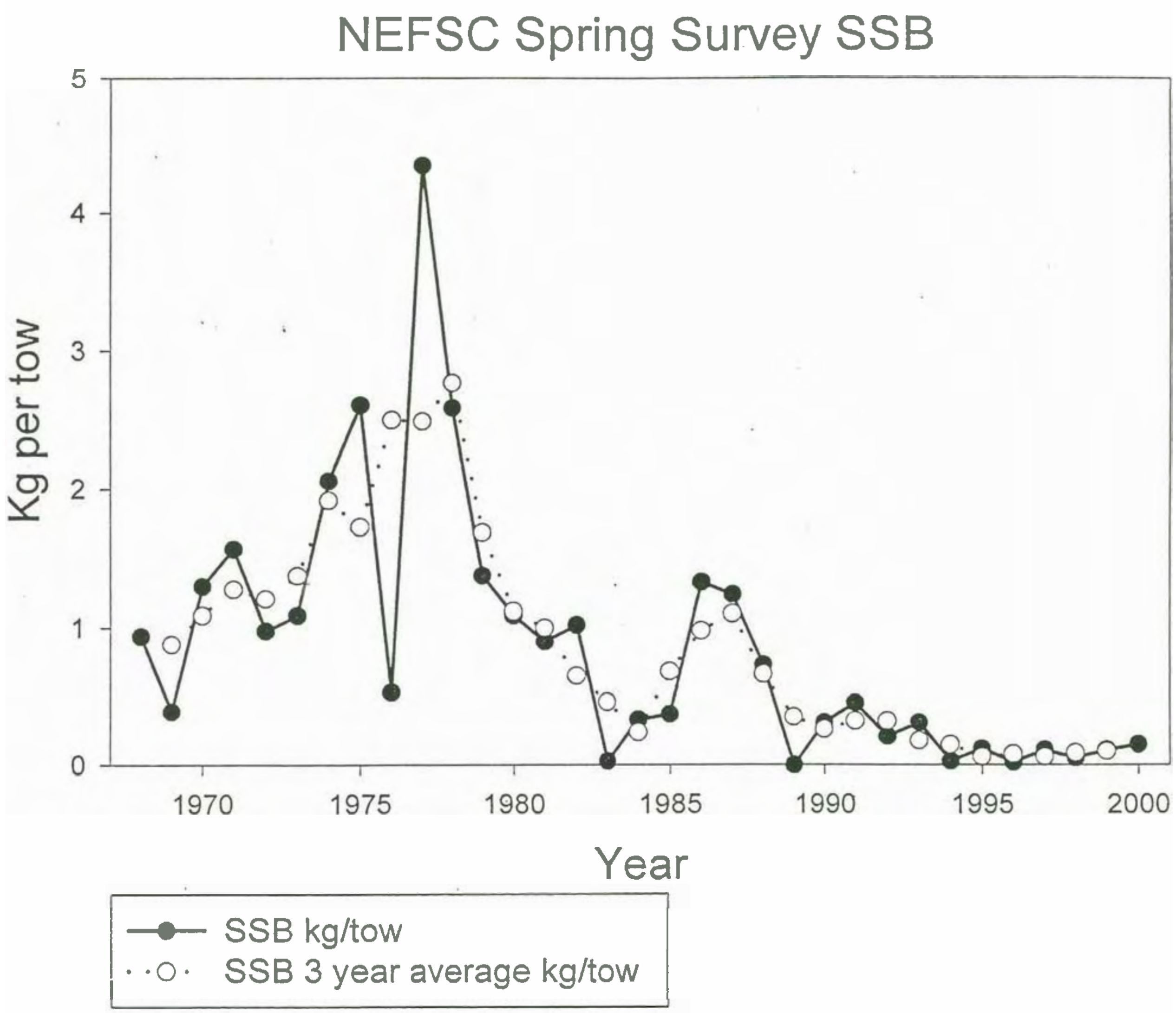


Figure A13. Scup spawning stock biomass indices from NEFSC spring research vessel surveys, offshore strata 1-12, 23, 25, and 61-76. Indices are SSB kg/tow by year (black circles) and 3-year moving averages (e.g., 1978 point is average of 1977, 1978, and 1979 annual indices; white circles).

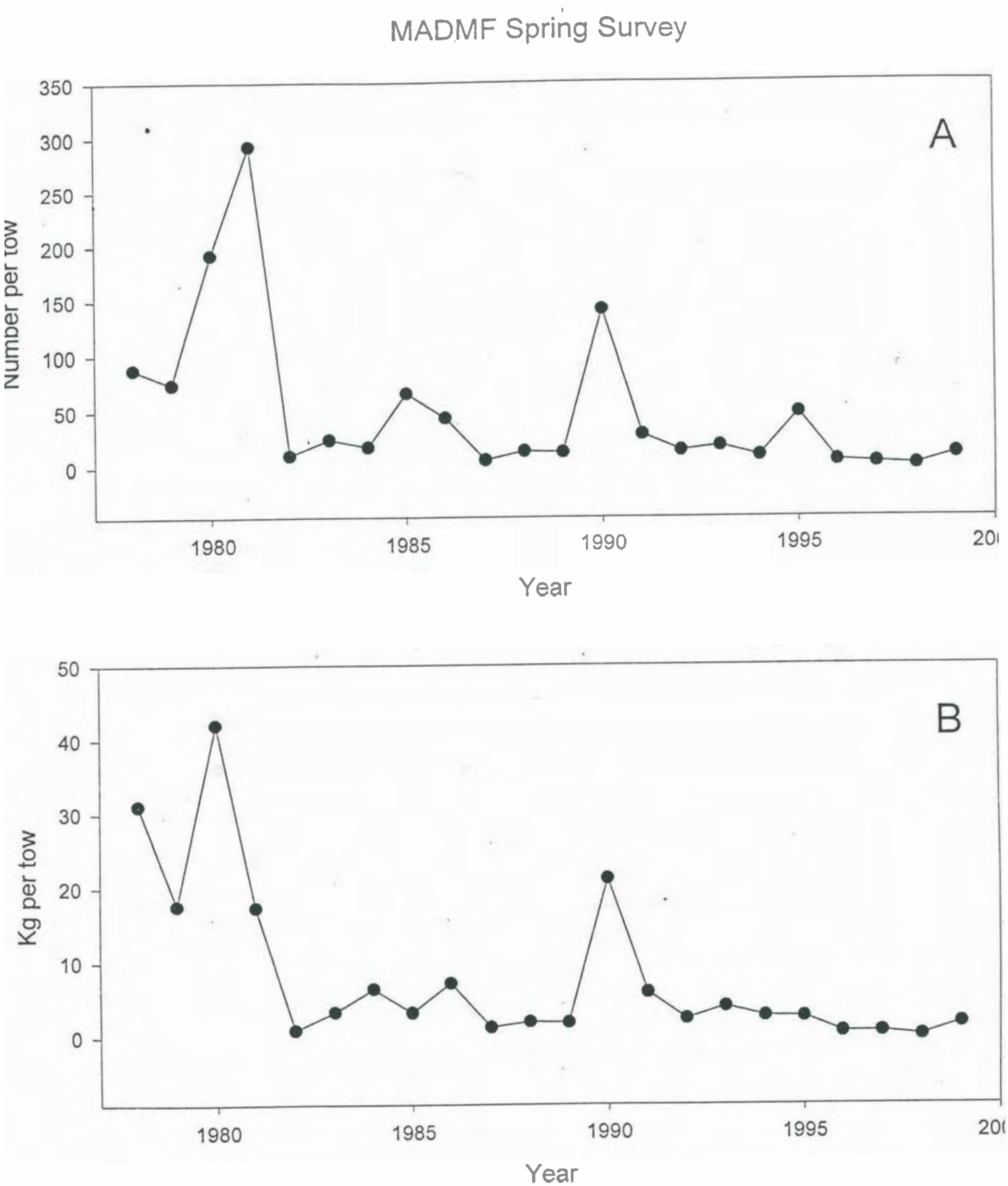


Figure A14. MADMF spring research vessel surveys for scup from 1978 to 1999: (A) mean number per tow and (B)mean kg per tow.

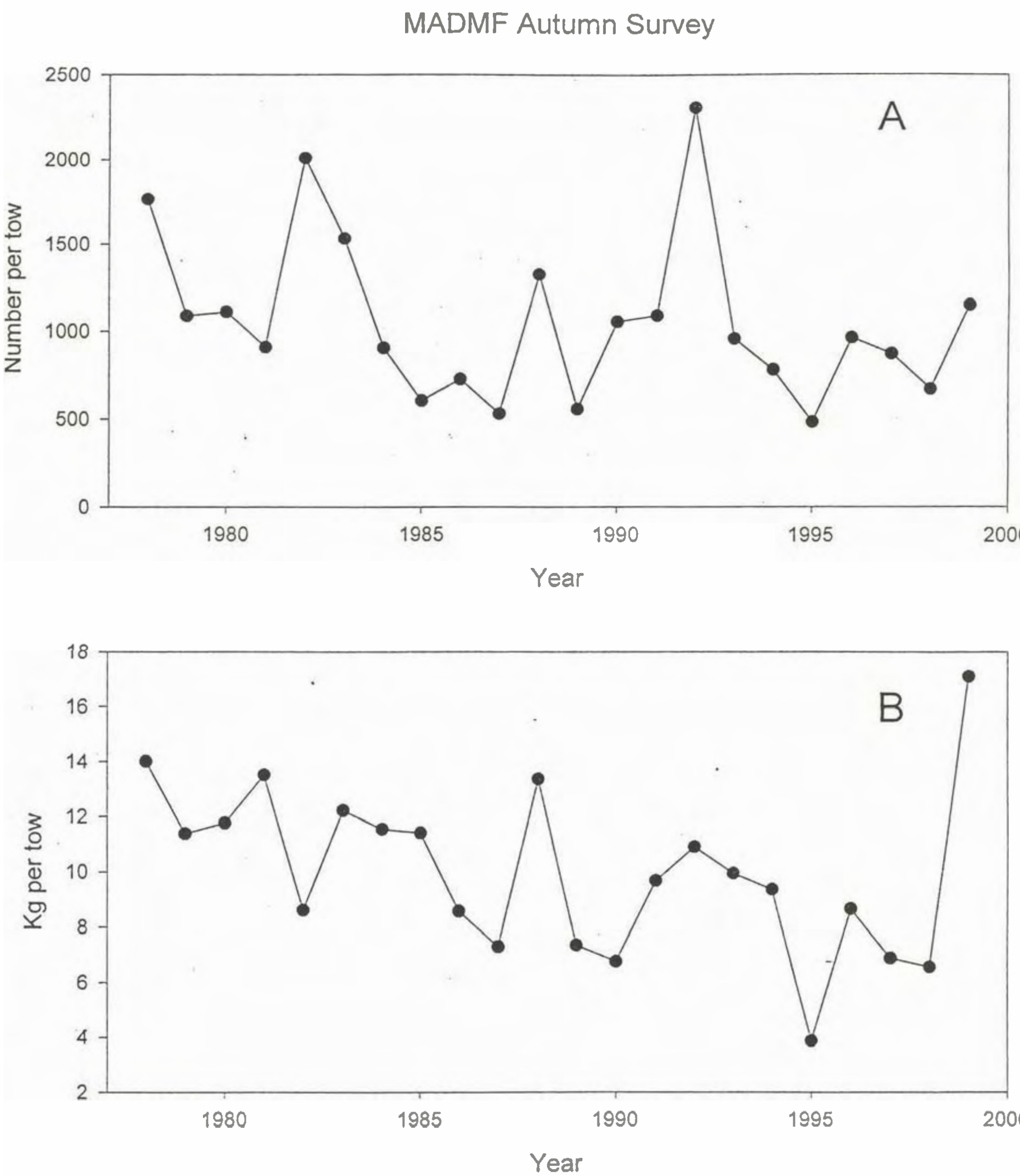


Figure A15. MADMF autumn research vessel surveys for scup from 1978 to 1999: (A) mean number per tow and (B)mean kg per tow.

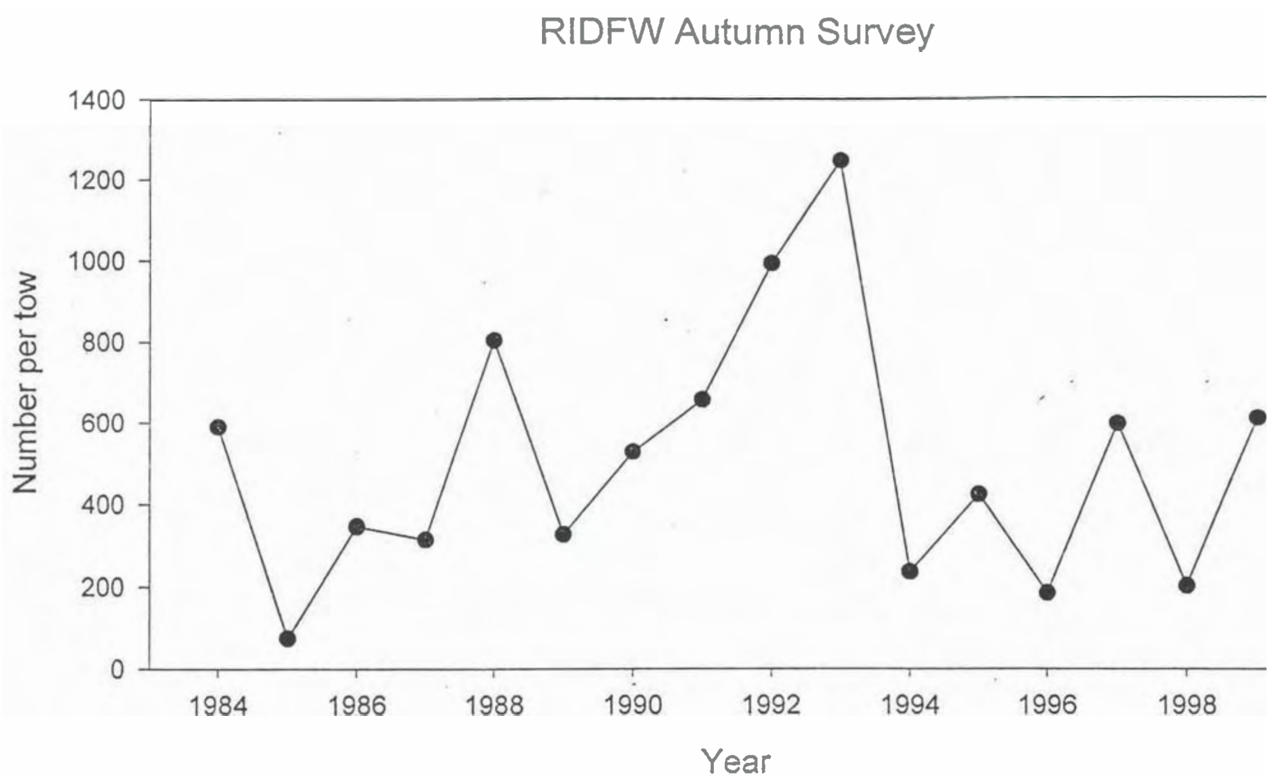


Figure A16. RIDFW autumn research vessel surveys for scup (mean number per Tow; 1984-1999).

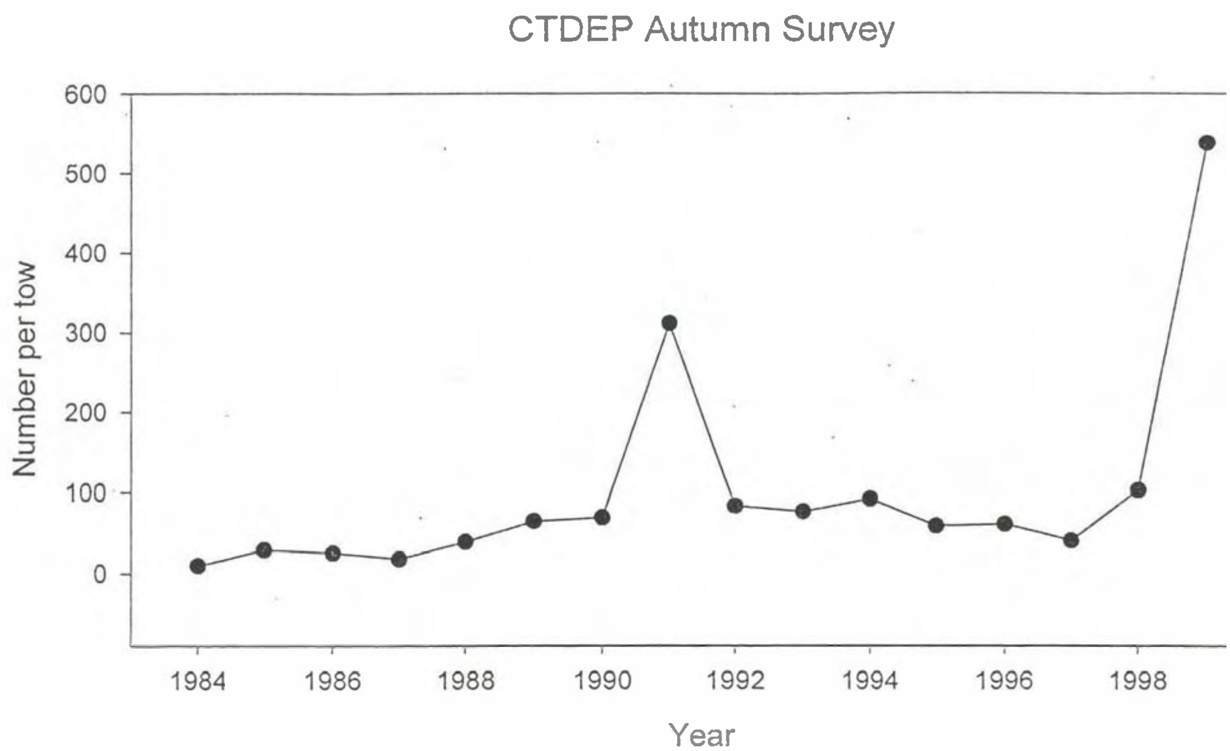


Figure A17. CTDEP autumn research vessel surveys for scup (mean number per Tow; 1984-1999).

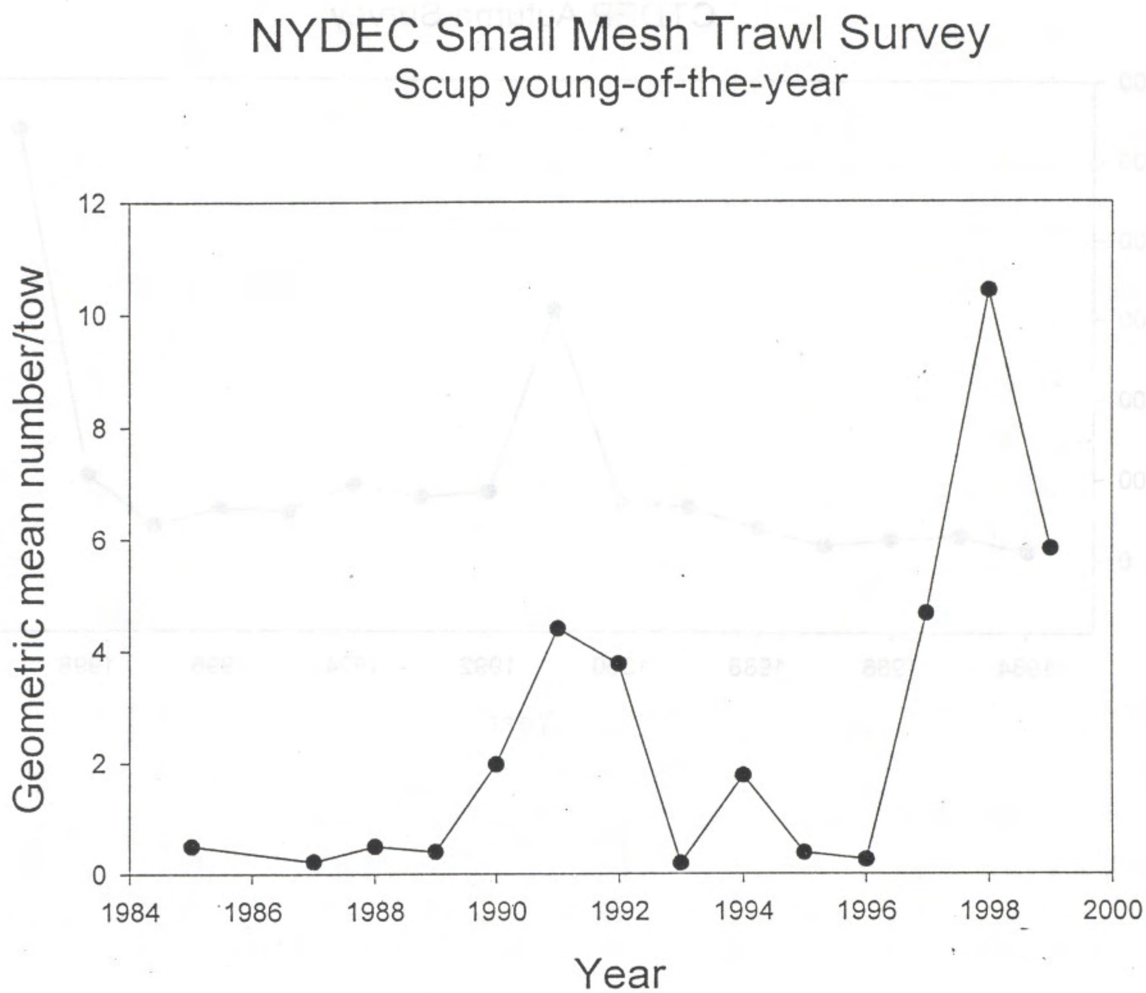


Figure A18. NYDEC small mesh trawl survey for scup young-of-the year (geometric mean number per tow; 1985, 1987-1999).

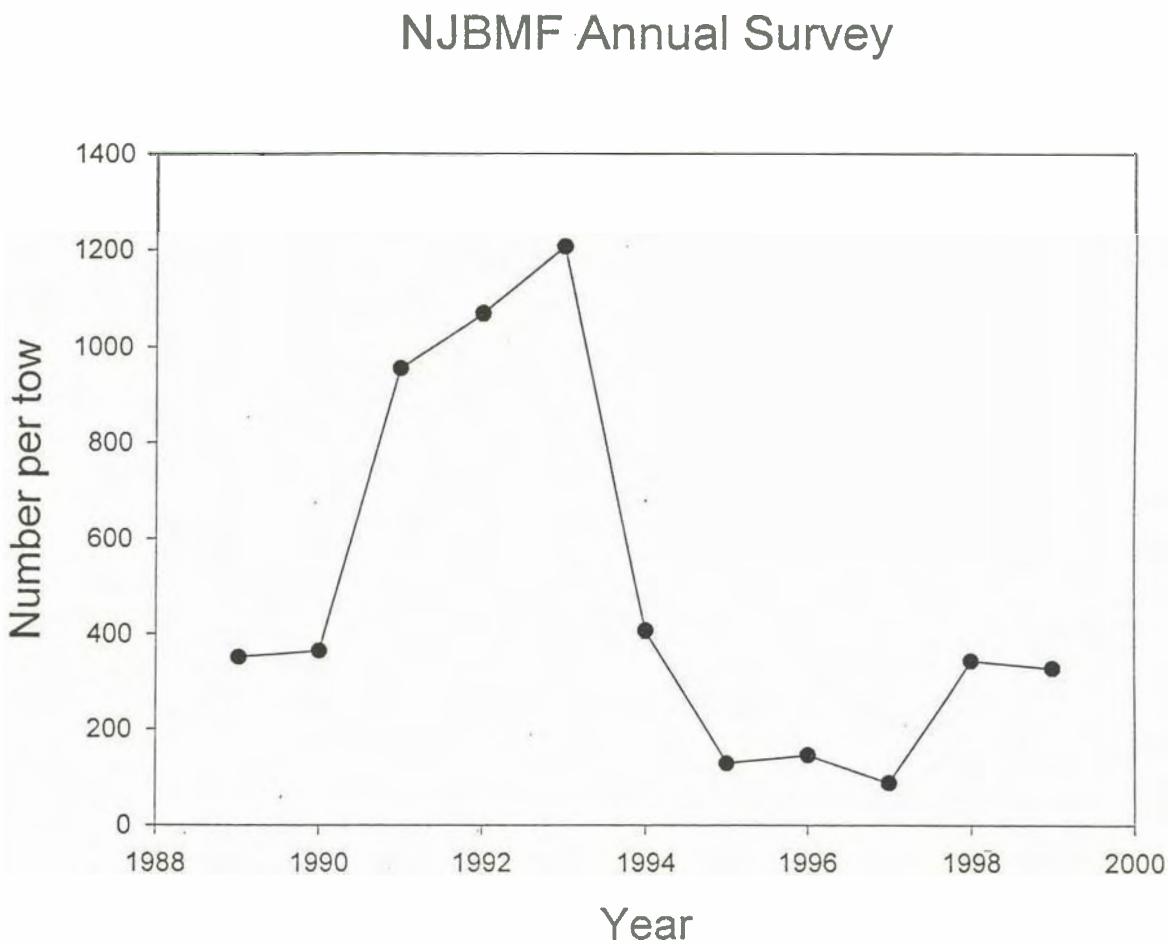


Figure A19. NJBMF annual survey index for scup (mean number per tow; 1989-1999).

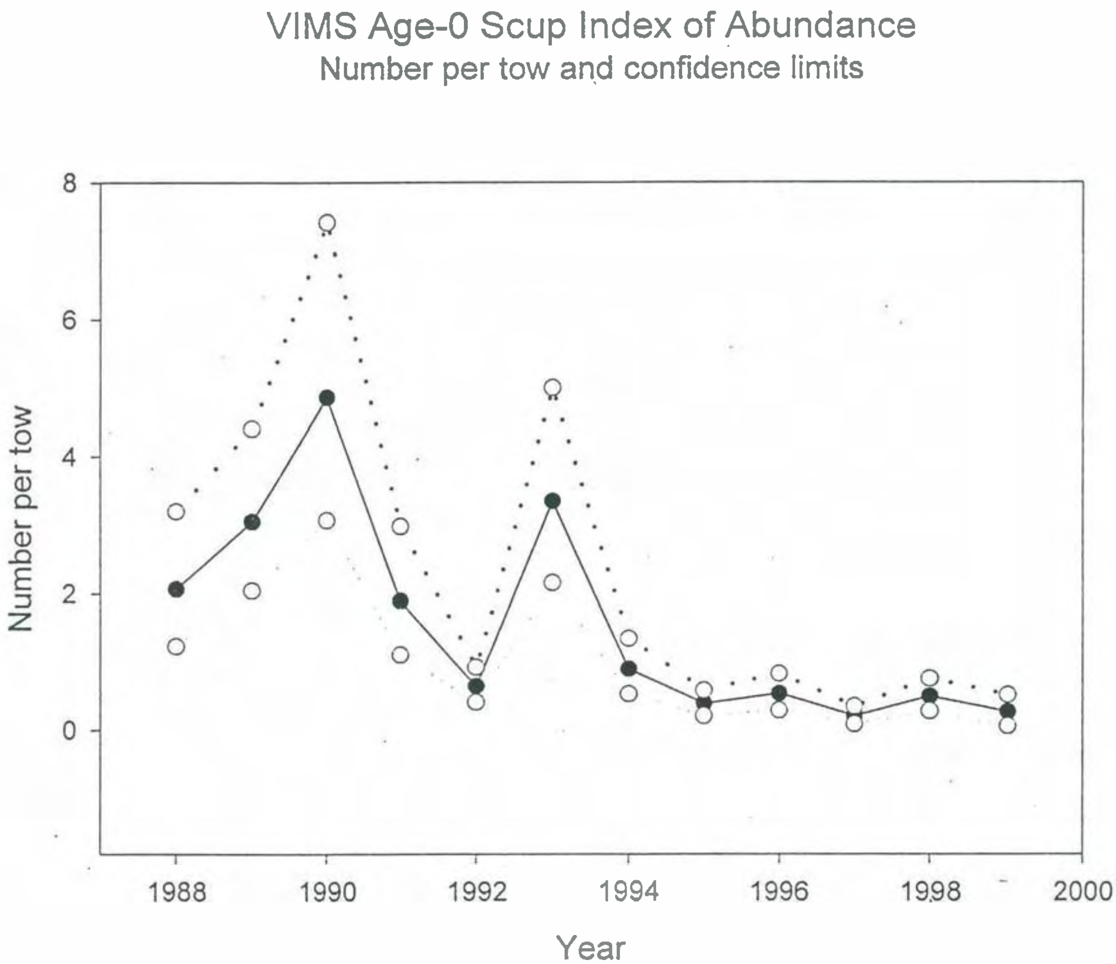


Figure A20. VIMS index of abundance for age-0 scup (mean number per tow and confidence limits; 1989-1999).

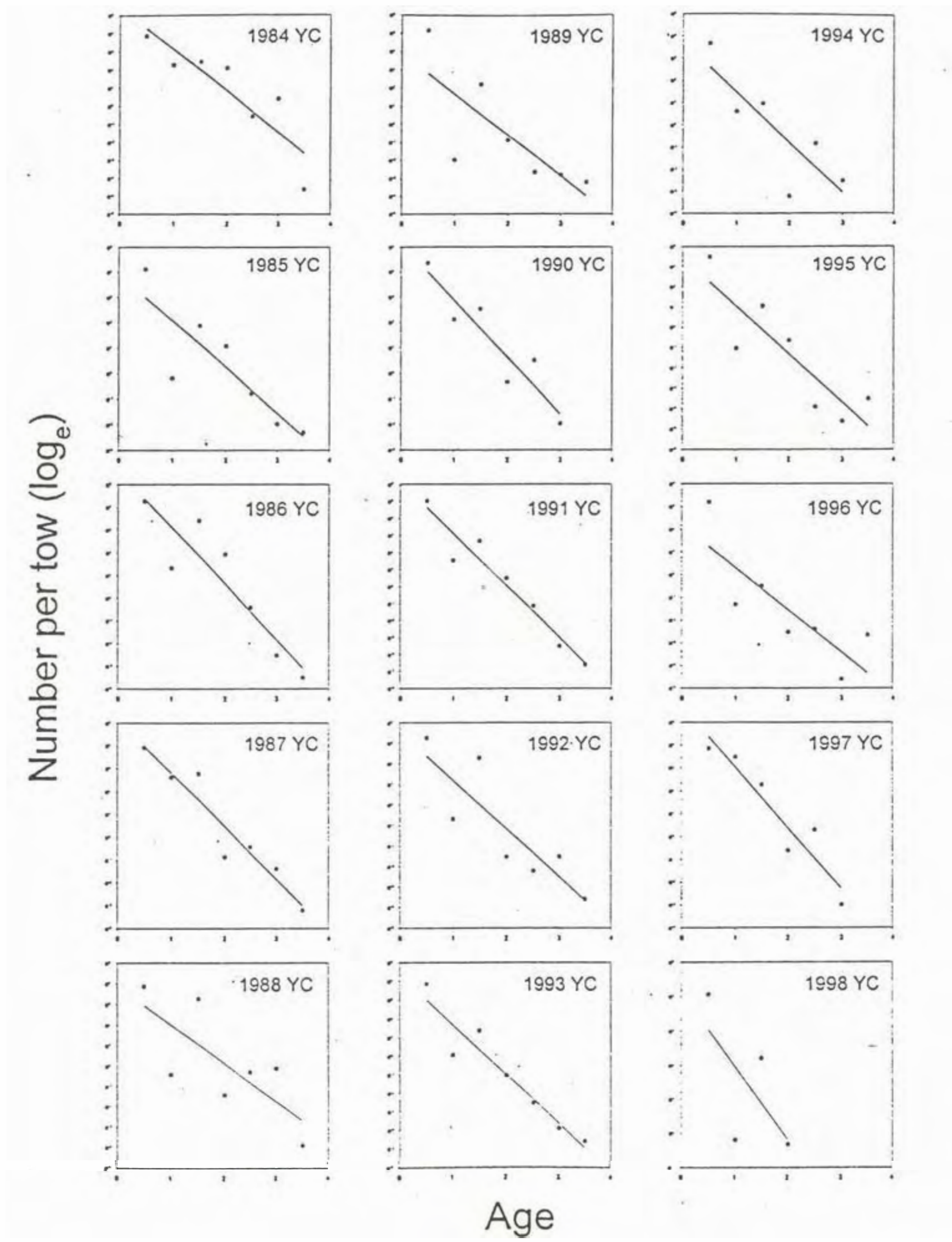


Figure A21. Log_e-scale plots of mean number of scup per tow by year class, from NEFSC autumn and spring surveys, and linear regression lines. Age 0.5=age 0 autumn, age 1=age 1 spring, age 1.5=age1 autumn, age 2=age 2 spring, age 2.5=age 2 autumn, age 3=age 3 spring, and age 3.5=age 3 autumn.

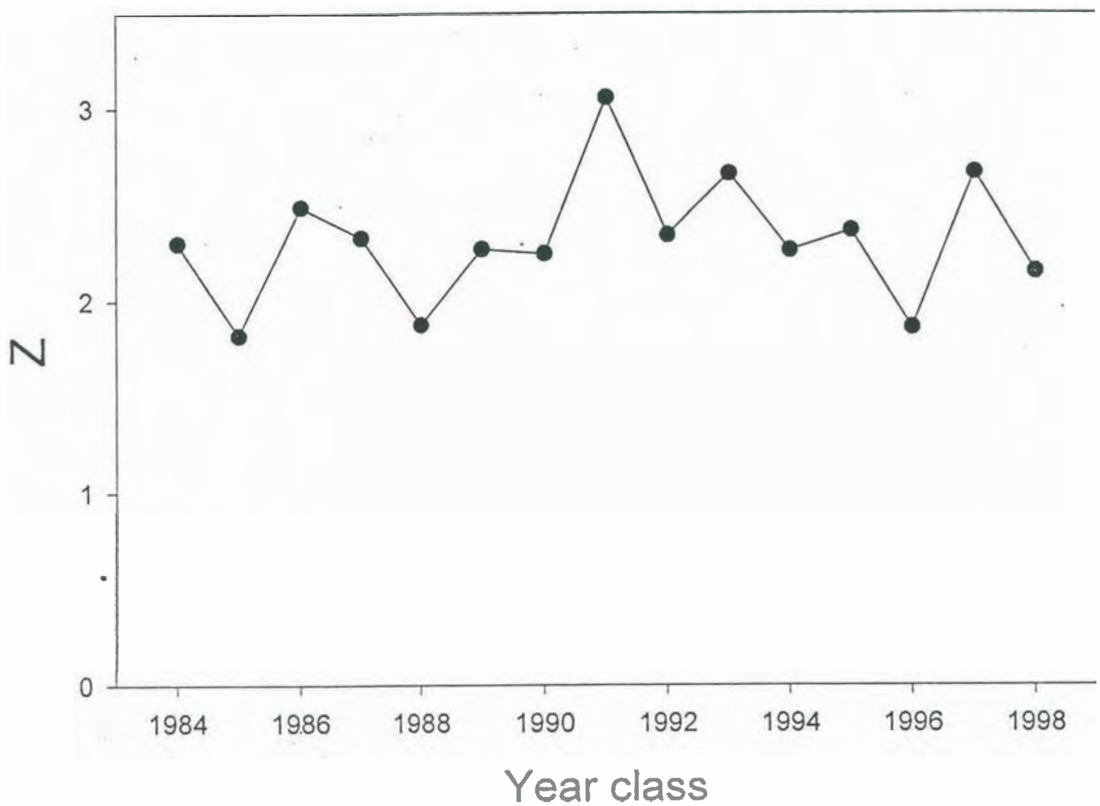


Figure A22. Estimates of total mortality (Z) for year classes 1984-1998 obtained from linear regressions of Log_e-scaled NEFSC autumn and spring survey indices of scup ages 0 to 3.

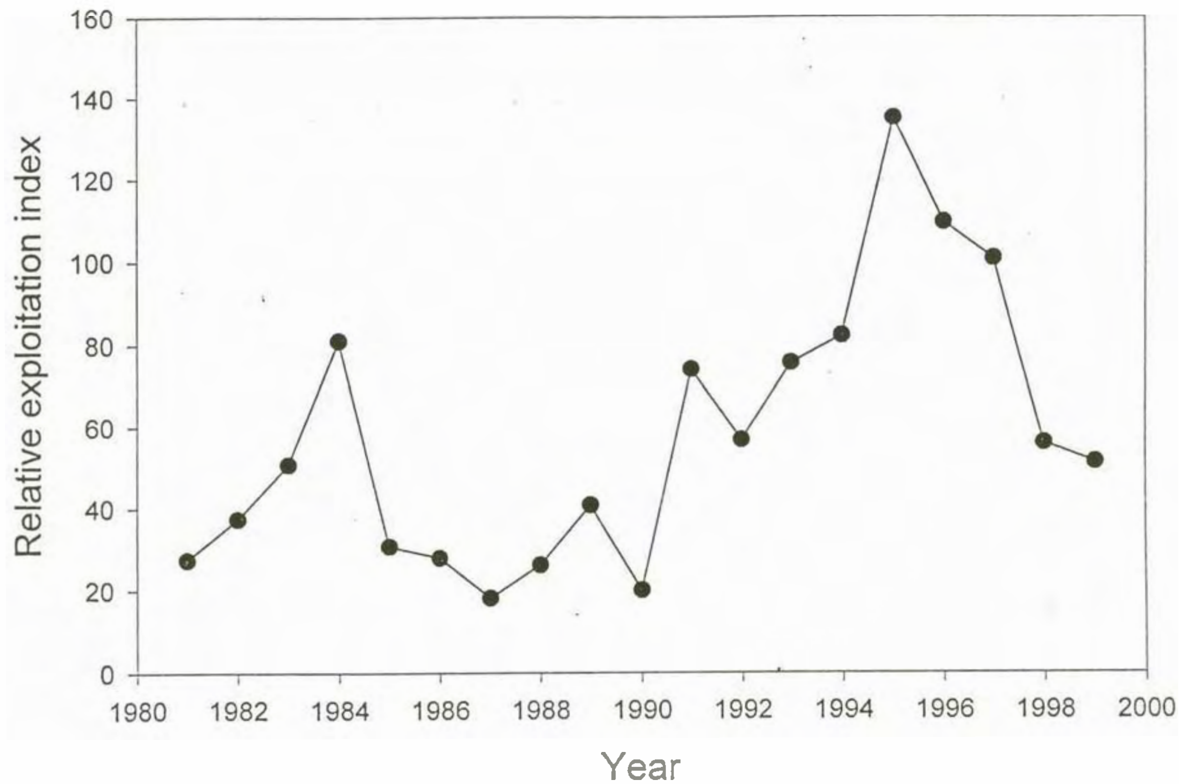


Figure A23. Relative exploitation index for scup for 1981-1999.

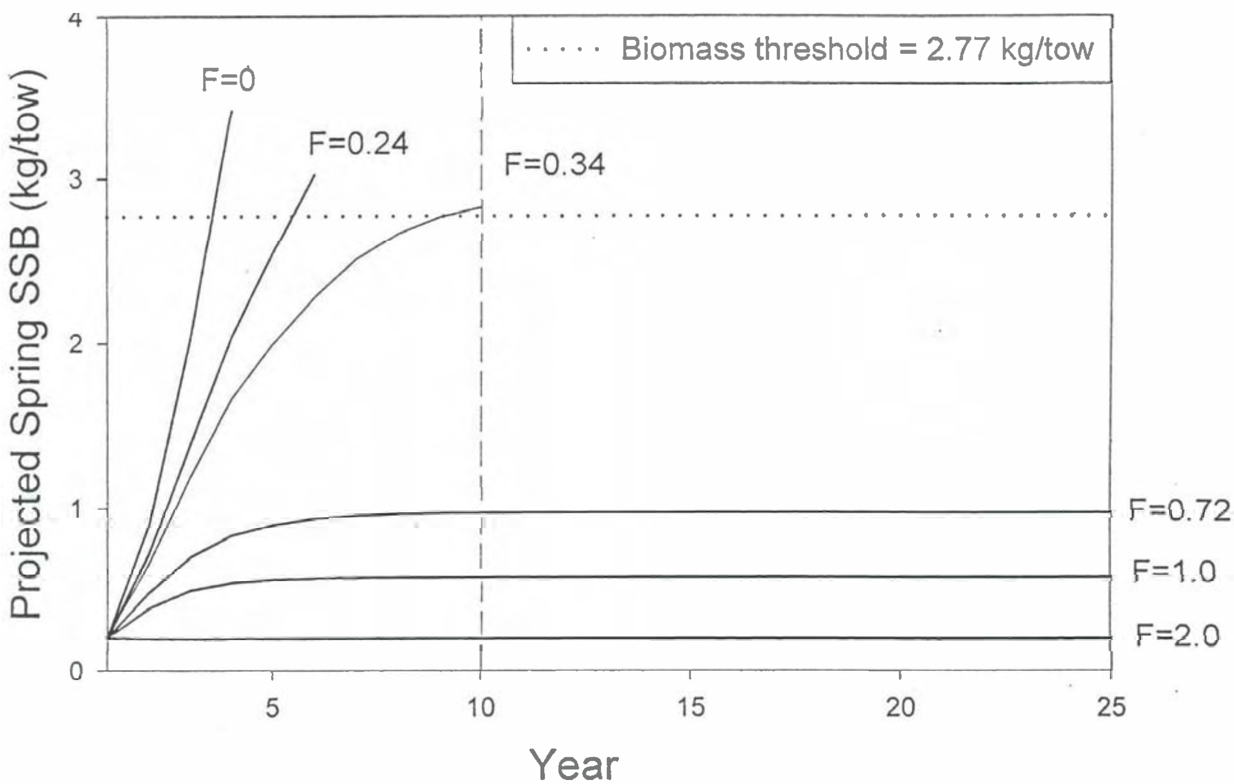


Figure A24. Projections of the NEFSC spring survey of scup SSB (kg/tow) starting with year 2000 NEFSC spring survey catch per tow at age. Yearly recruitment is assumed at equilibrium at the year 2000 catch per tow at age 1. Projections are for 25 years or until the SSB index exceeds the biomass threshold of 2.77 kg/tow (dotted line). Projections are for F values of 0, 0.24, 0.72, 1.0, and 2.0, and for the F value at which the biomass threshold is achieved in ten years (dashed line; F=0.34).

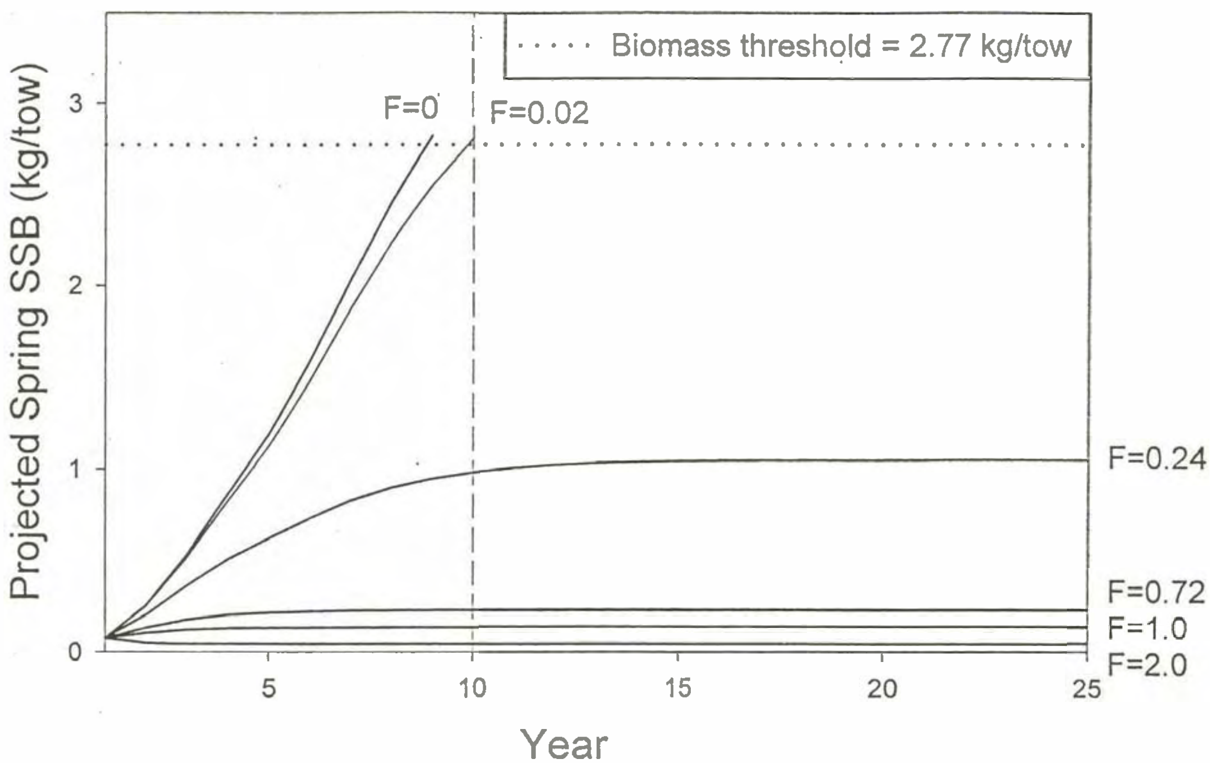


Figure A25. Projections of the NEFSC spring survey of scup SSB (kg/tow) starting with NEFSC spring survey 1993-200 geometric catch per tow at age. Yearly recruitment is assumed at equilibrium at the catch per tow at age 1. Projections are for 25 years or until the SSB index exceeds the biomass threshold of 2.77 kg/tow (dotted line). Projections are for F values of 0, 0.24, 0.72, 1.0, and 2.0, and for the F value at which the biomass threshold is achieved in ten years (dashed line; F=0.02).

B. GOOSEFISH

TERMS OF REFERENCE

The following terms of reference were addressed for goosefish (also known as monkfish).

(a) Update research vessel survey indices of abundance, estimates of total mortality rate and size/age composition; incorporate or comment on data collected in any supplementary surveys or experimental fisheries occurring in water deeper than the standard survey strata.

(b) Update commercial and recreational landings data, including biological characteristics of the catch (length and age composition).

(c) Summarize the available sea sample data for monkfish, from the NEFSC observer program or other sources.

(d) Explore alternative analytical methods for estimating mortality rates and trends in abundance.

(e) Evaluate stock status with respect to established target and threshold overfishing levels and determine if current overfishing targets and thresholds are still appropriate.

(f) Re-estimate proxies for F_{MSY} and B_{MSY} if new information would significantly change their values.

(g) Update historical time series of landings by area, market category and data source, including landings by stock area for 1994-1999, and including any updated estimates of foreign and historically unreported removals.

(h) Integrate Canadian landings data, biological sampling and research surveys to estimate removals from the northern region landed in Canada.

(i) Include, if suitable, state research survey indices in assessment of inshore components of the population.

(j) Report on the status of stock identification work, including egg and larval survey data analysis, genetic, morphometric, parasite and/or elemental analyses, and implications for current or future stock assessments.

INTRODUCTION

Goosefish (also known as monkfish) fisheries are managed in the Exclusive Economic Zone (EEZ) through a joint New England Fishery Management Council - Mid-Atlantic Fishery Management Council Monkfish Fishery Management Plan (FMP). The overfishing definition for goosefish is:

Monkfish in the northern and southern management areas are defined as being overfished when the three-year moving average autumn survey weight per tow falls below the 33rd percentile of the time series, 1963-1994, or when fishing mortality exceeds $F_{threshold}$. Monkfish are in danger of becoming overfished when the three-year moving average autumn survey weight per tow falls below the median of the three-year moving average during 1965-1981 and when fishing mortality is between F_{target} and $F_{threshold}$.

For the northern and southern areas, $F_{threshold}$ is based on conditions of stock stability at high abundance, calculated at the fishing mortality rate that prevailed during 1970-1979. F_{target} for the southern area is $F_{0.1}$. For the northern area, F_{target} is currently undefined.

Goosefish fisheries are managed on the assumption of two distinct stock components. Data to definitively distinguish goosefish stock units is not presently available; however, SAW 23 (NEFSC 1997) reviewed the available population dynamics evidence and concluded that the assumption of two stock components was reasonable given historical patterns of distribution and recruitment. Samples are currently being collected for a genetic study of goosefish stock composition (Alan Kuzirian, Marine Biological Laboratory, personal communication); however, results are not yet available. This assessment continues the stock definitions based on groups of survey and statistical areas that were defined in the SAW 23 assessment (Table B1).

The southern deepwater extent of the range of goosefish (*Lophius americanus*) overlaps with the northern extent of the range of blackfin goosefish (*Lophius gastrophysus*) (Caruso, 1983). The importance of this taxonomic problem in identification of survey catches and landings from the southern extent of the range of goosefish is believed to be small. The NEFSC has closely examined winter and spring 2000 survey catches for the presence of blackfin goosefish and found none, indicating that these survey indices were not affected by catches of blackfin goosefish. Some fishery landings come from deeper southern waters where blackfin goosefish are distributed; however there is no information to assess whether blackfin goosefish make up a significant proportion of the landings.
The spatial distribution of goosefish catches in spring and autumn bottom trawl surveys is shown (summarized in 5-year blocks) in Figure B1.

Larval distributions have been inferred from collections by the NEFSC Marine Resources Monitoring, Assessment and Prediction (MARMAP) ichthyoplankton survey (Steimle et al. 1999) (Figure B2). Larvae were collected during March-April over deeper (< 300 m) offshore waters of the Mid-Atlantic Bight. Later in the year, they were most abundant across the continental shelf at 30 to 90 m. Larvae were most abundant at integrated water column temperatures between 10-16° C, and peak catches were at 11-15° C regardless of month or area. Relatively few larvae were caught in the northern stock area (Figure B 2).

FISHERY DATA

U.S. Landings

Landings statistics for goosefish are sensitive to conversion from landed weight to live weight, because most landings have occurred as tails only (or other parts). The conversion of landed weight of tails to live weight of goosefish in the NEFSC weighout database is made by multiplying landed tail weight by a factor of 3.32. Initial inspection of the database indicated that in 1980, reported live weight equaled reported landed weight of tails, so we assumed that values for 1980 had not been converted to live weight in that year. Table B2 reflects this adjustment.

Prior to July 1994, the National Marine Fisheries Service Statistics Division reported total landings of goosefish as the sum of landings reported through the NEFSC weighout system, landings data collected by port agents for ports not included in the weighout system and landings reported by states not included in the weighout system. Within NEFSC, the latter two components of landings have historically been known as general canvas" data. The NMFS Statistics Division summary is reported as Oracle table GENCAN. These total summary statistics are reported in Table B2 with the heading "Adjusted General Canvas Database." For these data, landings are usually assumed to be reported in the data base as live weight. For goosefish, however, landings as reported in the GENCAN data base were lower than those reported in the weighout data base from 1964-1985. It appears that a conversion from landed to live weight was not made for those years. An adjustment is made in Table B2. For 1986-1989, a conversion factor of 2.57 had been used to generate estimates in the GENCAN data base of live weight from landings, but for consistency, a conversion factor of 3.32 was implemented over the time series in Table B2. All landings of goosefish are reported in the GENCAN data as "unclassified tails." Consequently, some landed weight attributable to livers may be inappropriately converted to live weight. Because statistical areas are not associated with all landings reported through this system, landings were assigned to northern or southern region, depending on state of landing. Because Massachusetts borders on both northern and southern regions, Massachusetts landings were split between regions based on areas associated with weighout landings in that year.

Beginning in July 1994, the commercial landings collection system of the NEFSC was redesigned to consist of vessel trip reports (VTR data) and sampling of dealers. Landings for 1994-1999 in Table B2 were derived by combining dealer weighout data and information from the VTR data. The VTRs include area fished for each trip which is used to apportion dealer reported landings to statistical areas. Each VTR trip should have a direct match in the dealer data base; however, this is not always true. For data with no matches, we dropped the record if there was a VTR with no dealer landings and retained the record if there were dealer landings but no VTR. For dealer landings with no matching VTR, we apportioned the landings to area using proportions calculated from successfully matched trips pooled over gear, state and quarter.

Total landings (live weight) remained at low levels until the middle 1970s, increasing from hundreds of metric tons to around 6000 mt in 1978 (Table B2, Figure B3). Landings remained stable at between 8,000-10,000 mt until the late 1980s. Landings increased steadily from the late 1980s through 1992, and have fluctuated around 26,000 mt since 1993. Peak landings occurred in 1997 (28,327 mt) and have declined slightly since then. By region, landings began to increase in the north in the mid-1970s, and began to increase in the south in the late 1970s. Most of the increase in landings in recent years has been from the southern region.

Trawls, scallop dredges and gill nets are the primary gear types that land goosefish (Figure B4). During 1997-1999, trawls accounted for 53% of the total landings, scallop dredges about 20%, and gill nets 26%. Trawl landings (mt) are about equal in the northern and southern areas; however, in recent years scallop dredges and gill nets have landed more from the south than from the north.

Until the late 1990s, total landings were dominated by landings of goosefish tails. From 1964 to 1972, the only recorded parts were tails (unclassified). Much of the fish caught went to shack until the mid-1970's. From 1964 to 1975 landings of tails rose from 19 mt to 634 mt (landed weight, Table B3). Those landings then increased to 2302 mt in 1980 and 7192 mt in 1998. In 1999, landings of tails equaled 5254 mt while landings of round or gutted whole fish were 6793 mt. On a regional basis, most tails were landed from the northern component in the 1960's (75 to 90%) through to the late 1970's (74% in 1978) (Tables B4, B5). From 1979 to 1989, landings of tails were about equal from both regions. In the 1990's, landings from the south began predominate, currently providing 60% or more of tails.

Beginning in 1982, several market categories were added to the system (Table B3). Tails were broken down into large (> 2.0 lbs), small (0.5 to 2.0 lbs), and unclassified categories. At the same time, livers began being sold. In 1989, unclassified round fish were added; and in 1991, peewee tails (<0.5 lbs) and cheeks appeared. Finally, in 1992 bellyflaps were also recorded, and whole gutted fish were first recorded in 1993.

The increase in landings of livers is especially notable. Landings of this product increased steadily from 1982, when 10 mt were landed, to an average of over 600 mt during 1997 - 1999. During 1982-1994, ex-vessel prices for livers rose from an average of $0.97/lb to over $5.00/lb, with seasonal variations as high as $19.00/lb. Landings of unclassified round (whole) or gutted round fish jumped in 1994 to 2045 mt and 1454 mt, respectively; landings of gutted round fish have continued to increase through 1999. The tonnage of peewee tails landed increased through 1995 to 364 mt and then declined to 96 mt in 1998 and 154 mt in 1999.

Figure B5 shows the distribution of goosefish catches as reported in unaudited vessel trip reports. The vessel trip report database (VTR) was summarized by gear, area fished and depth to determine if a change in the depth distribution of goosefish trips and landings has occurred over time during 1994-1999. The northern stock component did not show a change in either number of trips or landings of goosefish for any of the gears (Figures B6 and B7). The southern area, however, shows a small increase in the number of trips taking place in waters greater than 200 fathoms and a large increase in the total landings coming from those trips (Figures B8 and B9). The depth distribution of tows in NEFSC bottom trawl surveys (Figure B10) is very similar to the depth distribution of otter trawl trips.

Canadian Landings

Landings (live wt) from Canadian waters (5Zc) are shown in Table B2 and Figure B3. Data are only available from 1986 on, but show a rapid rise from about 340 mt in 1986 to a peak of over 1550 mt in 1990. In more recent years, Canadian landings from 5Zc declined to around 200 mt.

Size Composition of U.S. Landings and Catch

Table B6 shows the number of commercial samples and length measurements taken through the port sampling program by year, market category, and stock area. Length frequencies expanded to landings are shown in Figures B11 (by stock area) and B12 (for north and south combined). In 1996 "unclassified round" landings from the south were expanded using the "unclassified round" samples (n=2) from the north. In 1997 there were no samples for "tail only", so landings in this market category were distributed according to the proportion of peewee, small and large tail landings within each stock area. Sampling intensity and coverage was low in 1998. Length frequency of landings for unsampled market categories was estimated according to the proportion of peewee, small, and large tail landings in the north and large and small tails in the south. In 1999 "tail small" was used to expand "tail peewee" landings within each stock component. "Head on gutted" was used for unclassified round, and "tail only" landings were redistributed according to the proportion of small and large tail landings. The length-weight equation used in the expansion was taken from Almeida et. al. (1995).

Length composition data sampled by the NEFSC fishery observer program (sea sample data) were summarized for 1996-1999. Sea sample data for goosefish were collected aboard trawls, scallop dredges and gill nets (drift and sink). Figures B13 and B14 show length frequency distributions from sea sampling data by major gear type, stock region and year. Discards were generally between 20-40 cm, while kept fish were greater than 40 cm. The "kept" length frequency data for 1996 trawlers in the north appear to be in error, and are probably really discarded lengths.

Discard Estimates

Catch data from the fishery observer program were used to investigate discarding frequencies and rates. The frequency of tows with goosefish discards varied widely among stocks and gear types (Table B7). Trawlers in the northern area generally had the highest frequency of discarding while gill nets in the northern area had the lowest frequency. The most frequent reasons for discarding in the trawl and scallop fisheries were that the fish were too small, either for the market or for regulations. In the gill net fisheries, poor quality was the primary reason for discarding.

We estimated annual weight of goosefish discarded by calculating discard ratios (kg discarded / kg kept) on a stock, gear type and half-year basis. We applied the discard ratios to reported landings (live weight, by stock, gear type and half-year cells) to derive metric tons discarded and total catch (Tables B8 and B9). For gears for which no sampling was available, we applied the overall mean discard ratio for all gears and years. The overall discard ratio (Table B9) ranged from 0.06 - 0.16 mt discarded per mt kept. The percentage of the catch discarded has ranged from 6-13%, with the highest rates occurring in 1996.

Selectivity of Trawls and Scallop Dredges

An exploratory analysis of selectivity patterns of trawls and scallop dredges was performed. The analysis was based on the following assumptions:

1) The index of abundance in a given length category is proportional to the population. That is, $n_i = c N_i$, where c is a constant of proportionality over all length categories and years, and n_i and N_i, respectively, are the abundance index and population size of the ith length category.

(2) The proportion of the population vulnerable to the fishing gear (vulnerability) is an S-shaped function of length, which can be described by a half-gaussian curve:

$$v_i = \exp[-0.5(l_i - L_{full})^2/s], \quad \text{if } l_i < L_{full}$$
$$= 1, \quad \text{if } l_i \geq L_{full}$$

where l_i is the length of the ith category and L_{full} is the length of fully vulnerable individuals.

(3) The exploitation rate (u) operates equally on all vulnerable individuals in the population, and thus, the catch in number of the ith length category is

$$C_i = u\, v_i\, N_i.$$

The length-frequency distributions in proportion (p_i) are then expressed by the equations in assumptions (1) and (3):

$$p_i = C_i / \Sigma\, C_i = v_i\, n_i / \Sigma\, v_i\, n_i.$$

If P_i is the observed proportion of catch in the ith length category, which is a measurement of population's p_i with an error of e_i, it implies that $P_i = p_i + e_i$.

The method of least squares was used to estimate the location parameter L_{full} and the shape parameter s of the vulnerability, or selection, curve. In order to apply the method, the number of samples for the abundance index should be sufficient, i.e. the values of n_i's of all length categories should be large enough to make a smoothed length-frequency distribution without too many null categories. Gillnets were not included in the analysis because the upper range of survey length-frequency distributions does not extend to that sampled from the gillnets.

For the northern stock, the vulnerability of kept goosefish sampled from vessels using scallop dredges was consistent during 1996-1998, with less than 10% vulnerable at 40 cm and almost 100% vulnerable near 45 cm. Vulnerability curves of kept goosefish from trawlers were similar in 1997 and 1998 but different from that in 1996 (Table B10). Some discards in 1996 may have been mis-coded as kept, resulting in a less steep curve.

For the southern stock, the vulnerability of kept goosefish to trawls and scallop dredges was similar in 1996 and 1997, when compared with data from scallop and winter surveys (Table B10). Differences occurred after 1998 although some were similar. It should be noted that relatively small samples were collected in 1998-1999 compared to 1996-1997. The small samples probably biased the length-frequency distributions of the kept portion of the catch.

RESEARCH SURVEY ABUNDANCE AND BIOMASS INDICES

NEFSC Survey Indices

NEFSC spring and autumn bottom trawl survey indices were standardized to adjust for statistically significant effects of trawl type and vessel on catch rates as noted below. The trawl conversion coefficients apply only to the spring survey during 1973-1981.

Effect	Coefficient	Source
Trawl	Weight: 0.2985	Sissenwine and Bowman, 1977 Number: 0.4082
Vessel	Weight: Not significant	Anon. 1991 Number: 0.83

Figure B15 shows the distribution of goosefish catches in fall bottom trawl surveys (1963-1999), spring bottom trawl surveys (1968-1999), winter flatfish surveys (1992-1999) and scallop dredge surveys (1984-1999).

Northern Region

Indices from NEFSC autumn research trawl surveys indicate that biomass fluctuated without trend between 1963-1975, appears to have increased briefly in the late 1970's, but declined thereafter to near historic lows during the 1990's. The three year moving average of the index (1997-1999) is currently at 33% of the 1965-1981 biomass target (Table B11, Figure B16). The point estimate of biomass in 1999 (0.825 kg/tow) is the second lowest in the time series. Abundance in numbers (Table B11, Figure B17) declined during the early 1960s, and then fluctuated without trend until the late 1980s. Abundance increased steadily from the late 1980s to a peak in 1994, declined to 1997, then increased again in 1998 and 1999. The 1999 point estimate for numbers is the second highest in the series.

Indices from the NEFSC spring research trawl surveys reflect similar trends of relatively high biomass levels in the mid 1970s (but with possible declines in the late 1970s), and a declining trend from the early 1980s to the lowest values in the time series in 1998 (Table B12, Figure B18). As in the autumn survey series, abundance in numbers fluctuated until the early 1980s (Figure B19). Since 1987, numbers have trended upwards to some of the highest levels observed in the time series. The 1999 abundance index (numbers) is the second highest on record. Figure B20 shows the fall and spring survey indices plotted together for comparison of trends.

Other indices are available from survey series covering shorter periods of time and/or more restricted areas. Abundance indices from the NEFSC sea scallop survey are based on a few strata on the northern edge of Georges Bank rather than over then entire Gulf of Maine region. The trends in this index are consistent with the general pattern seen in the trawl surveys of increased abundance through 1998 (Table B13, Figure B21). No index is available for 1999 because only 1 tow was completed. (No time series of biomass indices is available from this survey.) The ASMFC shrimp survey likewise covers only a small portion of the area. It shows a generally increasing trend in biomass which contrasts with the other series; however, abundance indices show the same spike in 1999 as the other surveys do (Table B14, Figures B22 and B23).

Length distributions have become increasingly truncated over time (Figure B24). By 1990, fish greater than 80 cm long were uncommon in length frequency distributions, and by 1996, fish greater than 60 cm had become relatively uncommon as well. The minimum, mean and maximum lengths in the trawl surveys have declined steadily over time (Figures B25 and B26). Although recent length frequency distributions indicate a fairly high abundance of small fish, few of those modes can be followed more than two years.

Several modes potentially representing strong year classes have appeared consistently in survey distributions in recent years. Abundance indices for goosefish 10-20 cm TL (corresponding approximately to age 1 goosefish) were estimated to help identify potential recruitment patterns (Figure B27, Table B15). To the extent that these indices reflect recruitment, recruitment in the northern area has increased in the past decade. Relatively strong year-classes were produced in 1992, 1993 and 1998. Length frequencies and survey abundance at age data corroborate the suggestion of a relatively strong 1998 year-class (Figure B24, Table B16) in the northern area.

Survey age data are available from the autumn trawl survey for 1994-1999. The mean length at age (Table B17, Figures B28 and B29) corresponds closely to the *ad hoc* 'ageing' convention adopted for SAW 23 and with predictions from vonBertalanffy equations. Within the range of ages observed in the surveys, growth is essentially linear and there are no obvious differences with gender or stock (Figure B28).

Some differences in patterns of abundance between surveys may arise due to different gear efficiencies and areal coverage. It is clear, however, that recent increases in numbers of fish at small sizes in this region have not lead to accumulated biomass in following years, especially when length compositions are compared to length compositions from surveys in earlier years (Figure B24).

Southern Region

Biomass indices from the NEFSC autumn research survey declined rapidly in the second half of the 1960s, and then fluctuated until the early 1980s (Table B18, Figure B30). In the mid-1980s, biomass declined and has remained low since 1987. The three year moving average of the index (1997-1999) is currently at 25% of the 1965-1981 biomass target. Abundance in numbers has shown similar declines after the mid-1960s, with a spike in 1972, slight increases in the late 1970s-early 1980s and a decline thereafter (Figure B31). In recent years, abundance in numbers has fluctuated without trend at low levels.

The Overfishing Definition biomass target and thresholds for the southern component are based on NEFSC autumn survey indices beginning in 1963. NEFSC survey strata south of Hudson Canyon were not sampled during 1963-1966, and so indices for those years are not directly comparable to indices for 1967 and later years. The SARC recommended the adoption of southern component biomass target and thresholds based on indices for 1967-1994 and 1967-1981, respectively.. This revision changes the biomass target from 1.848 kg per tow to 1.846 kg per tow, and the biomass threshold from 0.750 kg per tow to 0.704 kg per tow. Figure B32 compares autumn survey indices for Hudson Canyon and north to the time series for the entire area sampled since 1967. The two series show similar trends.

The NEFSC spring research survey data reflects similar trends as the autumn series: stock levels remained fairly high during the mid 1970s - early 1980s, but declined to record low levels in the early 1980s and have fluctuated at low levels in recent years (Table B19, Figures B33 and B34). The spring 1998 and 1999 biomass and abundance indices were both up slightly.

Biomass indices based on the NEFSC winter flatfish survey have fluctuated without trend, consistent with lack of trend in other surveys (Table B20, Figures B35, B36, B38) while abundance indices appear to be trending downward. However, the 1999 point estimate for abundance was higher than 1998, which is consistent with the spring trawl survey. Abundance indices based on the NEFSC sea scallop survey do not show a strong trend over time (Table B21, Figure B37); however, the 1999 index was up as in two other surveys.

Length distributions from the southern region show increasing truncation over time (Figure B39), which is reflected in declines in minimum, mean and maximum length over time (Figures B40 and B41. Maximum lengths declined by approximately 20 cm or more over the time series.

Abundance indices for goosefish 10-20 cm TL (corresponding approximately to age 1 goosefish) were estimated to help identify potential recruitment patterns (Figure B27, Table B15)). To the extent that these indices reflect recruitment, there appear to have been stronger year-classes produced in the southern area in 1971, 1982, 1986, 1990, 1993, 1994 and possibly 1998. Survey abundance at age data (Table B16) agree with these inferences from size-based indices. The 1993 and possibly 1994 year-classes were relatively strong, followed by weak year-classes during 1995-1997. The 1998 year-class appears to be somewhat stronger.

As in the northern region, recent year class events are rarely observable in survey length frequency distributions at lengths greater than 40 cm, Currently, fish greater than 60 cm are rare, especially when compared to the 1960s. Any recent strong recruitment events do not appear to survive long enough to contribute substantially to increased stock biomass.

<u>MA DMF Survey Indices</u>

Surveys conducted by the Massachusetts Division of Marine Fisheries show trends in biomass and abundance broadly similar to NEFSC surveys (Figure B42). Biomass indices for the state waters north of Cape Cod show a declining trend in both the spring and the fall. Abundance indices fluctuated at low levels until the 1990s when there was a small peak in 1991 and a large spike in 1995. Abundance of goosefish in inshore waters appears lower during the spring; however, the highest point in the spring series is also 1995. A peak in abundance was observed in 1994 in the NEFSC fall survey.

In Massachusetts waters south of Cape Cod, biomass indices have remained at or near their lowest levels since around 1990 and abundance has been consistently very low.

<u>Egg Production Indices From NEFSC Survey Length Composition Data</u>

NEFSC survey indices were used to develop an index of egg production. Composite length frequencies, based on a five year summation of catch per tow at length, $\bar{I}(L,t)$ were multiplied by predicted eggs at length Egg(L) and the fraction mature (PMAT(L)). The computational formula is:

$$SSB(t) = \sum_{L} SSB(L,t) = \sum PMAT(L) * Eggs(L) * I(L,t)$$

where

$$PMAT(L) = \frac{1}{1 + e^{13.9568 - 0.03862325L}}$$

Parameters for PMAT(L) were derived by fitting the logistic function to derived

L = length (mm)

Eggs~(L) = 0.0683~L^{3.74}

percentiles of fraction mature described in Hartley (1995). The fecundity-length relationship was obtained from Armstrong (1987).

Results for the indices of egg production (Figure B43) mirror the progressive decline in mean length and have continued to decline since the last assessment (SAW 23). Relative to the 1970-1979 period, contemporary spawning stock biomass is at about 32% of maximum levels in the northern area and 22% in the south (Table B22).

Currently, about 12% of SSB is produced by fish less than L_{50}. In the north, about 11-13% of the egg production is by the partially mature component of the length distribution (Figure B43); in the south, 17-30% of the spawning stock biomass is from the partially mature component of the length distribution.

ESTIMATION OF MORTALITY AND STOCK SIZE

Natural Mortality Rate

The instantaneous natural mortality rate for monkfish was assumed to be 0.2 in all analyses, as in the SAW 23 assessment (NEFSC 1997), based on an expected maximum age of 15-20 years given previous studies of age and growth (Armstrong 1987, Armstrong et al. 1992, Hartley 1995) and observed maximum length in NEFSC surveys of 121 cm.

Mortality estimates from NEFSC Surveys

Instantaneous total mortality rates (Z) for goosefish were estimated using a length-based method by Beverton and Holt (1956):

$$z = \frac{K(L_{\infty} - L)}{(\bar{L} - L')}$$

where K and L_{∞} are from von Bertalanffy growth models and LBar is the mean length of individuals in the region (as stratified delta mean catch per tow at length, adjusted for trawl and vessel effects, when significant). L′ is the smallest fully recruited length, and was estimated from inspection of LOWESS smoothed length frequency data (Cleveland, 1979) . The values of L' established in the SAW 23 assessment were 59 cm for the northern region and 19 cm for the southern region.

Parameter	North	South
L_{∞}	126.0 cm.	129.2 cm.
K	0.1080	0.1198
L′	59 cm.	19 cm.

Estimates of Z by area and year, and minimum 95% confidence intervals are presented in Tables B23 and B24. The standard deviation of the mean length (above L′) was used to develop a standardized normal distribution with mean 0 and standard deviation 1. The truncated distribution was rescaled so that unit area was obtained between the values of the standardized normal distribution corresponding to L = L′ and L = L_{∞}. The median of the resulting distribution and boundaries of 95% of the distribution were estimated conditional on given values of L_{∞}, K and L′. The corresponding range in Z thus does not reflect variance contributed by error in estimation of L_{∞}, K or L′, nor any covariance among terms. These estimates should be considered minimum estimates of the potential range in Z.

In the north, for L' = 59 cm, estimates of instantaneous total mortality (Z) have increased from an average of 0.25 from 1970-1979 to 0.35 in 1991-1995 and 0.56 during 1995-1999. If instantaneous natural mortality (M) is assumed to equal 0.2, instantaneous fishing mortality (F) would equal 0.05 in 1970-1979, 0.15 in 1991-1995 and 0.36 in 1995-1999 (Table B23). In the south, for L' = 19 cm, estimates of instantaneous total mortality have increased from an average of 0.34 from 1970-1979 to 0.71 in 1991-1995, then decreased to 0.56 in 1995-1999. If M = 0.2, then F = 0.14 from 1970-1979, 0.49 in 1991-1995 and 0.36 in 1995-1999.

Based on data available since the SAW 23 assessment (commercial length frequencies from port sampling and from sea sampling, survey length frequencies), the SARC examined L' values of 30 cm (the assumed length of full selection of the fishing gear that has sampled the length frequency under analysis) for each region in addition to the 59 cm (northern region) and 19 cm (southern region) cutoffs used in SAW 23. The L' = 30 cm was proposed because 1) recent length frequency distributions for the northern component indicate that a value of L' smaller than 59 cm may be appropriate, 2) the autumn survey catch at age suggests that goosefish are fully recruited to the survey trawl gear between ages 2 (1994-1999 mean length = 24.2 cm) and age 3 (1994-1999 mean length = 34.0 cm), and 3) work to estimate the selection patten of the commercial fishery indicates a length of full selection to the fishery of 40-45 cm for the landed portion of the catch, with a mode in the samples of the catch discarded by trawl and scallop gear at about 30 cm. The SARC agreed that L'=30 is more reasonable than either L'=59 (north) or L'=19 (south). The SARC also recognized that if the assumption of M=0.2 is correct, the Beverton-Holt length-based method using L'=30 gives unreasonable estimates of $F_{threshold}$. However, the analysis showed an underlying trend in total mortality consistent with increasing landings and decreases in average and maximum size in survey time series, and the SARC considered the Beverton-Holt estimates as a useful index of trends in total mortality. The time series of total mortality estimates calculated using L' = 30 cm are presented in Tables B25 and B26 and Figures B44 and B45.

Mortality rates were also estimated from autumn bottom trawl survey abundance at age data (Table B27). Despite inter-annual variation, the trend in age-based Z's is consistent with the trend length-based estimates (Figures B46 and B47).

Surplus Production Model

To explore an alternative approach to assessing the resource, a Shaefer surplus production model was fit for the northern and southern components of the monkfish population using maximum likelihood methods. This modeling approach was applied because it requires fewer data and assumptions than size- or age-structured assessment models. Catch data consisted of reported landings during 1967-1999 for the north and 1964-1999 for the south. NEFSC autumn weight per tow indices were used to measures relative abundance of both stocks. The autumn index was chosen because it was considered to be the most reliable long-term abundance index for this species in previous reviews. For the southern component, only survey data from 1967 to the present were used because spatial coverage differed from the 1963-1966 period. An observation error model was used to estimate Schaefer model parameters of intrinsic growth rate (r), carrying capacity (K), and initial population biomass (B_0). A likelihood formulation with observation error was used to fit a proportional predictor to the observed abundance index where the multiplicative error distribution was a zero-mean, constant variance lognormal distribution similar to that described in Hilborn and Mangel (1997).

Unconstrained maximum likelihood estimates (MLEs) of r, K, and B_0 were computed for each stock. The results indicated that the input data, e.g. catch or survey index, were inconsistent with model assumptions. For the northern component, the estimated r was roughly 0, while the estimated B_0 was much greater than K. For the southern component, there was no convergence to an MLE but negative values of r and K had a higher likelihood than feasible values. A second attempt was made to fit the southern component using a constrained maximum likelihood approach where a penalty function was applied to ensure that parameter estimates were nonnegative. This led to an estimated r of 0 and an estimated B_0 that was much greater than K. Overall, it was concluded that the Schaefer model could not be reliably fit to these data using maximum likelihood methods.

The lack of model fit provided information on the adequacy of model assumptions and the quality of the available data. In particular, early declines in the monkfish survey indices were not concordant with expected changes in population biomass, given the low reported catches and likely values of intrinsic growth rate ($r<1$) and carrying capacity (K on the order of hundreds of kilotons). In particular, these declines implied that surplus production must have been negative in some years for both stock components. To produce the implied amount of biomass loss, model estimates of initial biomass had to greatly exceed carrying capacity with an intrinsic growth rate of nearly zero (using the constrained fit to the southern component). Thus, the model implied that the population was not productive and was at an extraordinary abundance in the 1960s-1970s. This scenario could be possible if environmental forcing was very strong during this period. In this case, the use of constant carrying capacity or intrinsic growth rate parameters would be inappropriate for this population. Alternatively, the negative surplus production implied by the early survey index decline could reflect under-reported catches when foreign distant water fleets were intensively harvesting New England groundfish. The two alternatives of changing environmental conditions and misreported catches were not mutually-exclusive, however.

A Bayesian formulation of the likelihood-based Schaefer surplus production model was developed to account for the lack of fit of the unconstrained MLEs. The joint prior distribution of the parameters (r, K, and B_0) was the product of three independent uniform priors. Because knowledge of the population dynamics of monkfish was limited, uninformative priors were chosen: r ~Uniform[0.01,1.00], K ~Uniform[10, 500], B_0 ~Uniform[10, 500], where K and B_0 have units of kilotons. Computations of the posterior distribution of parameters and derived quantities were conducted using the Metropolis algorithm. Preliminary results presented at the Southern Demersal Subcommittee meeting suggested that the Bayesian approach was a promising alternative model formulation because uncertainty could be explicitly accounted for in the model structure, e.g. likely parameter values and reported catches and because parameter values could be constrained in a logically-consistent manner.

The SARC reviewed a revised version of the Bayesian surplus production model that was developed after the May Subcommittee meeting. In the revised model, biomass trajectories of northern and southern components of the monkfish population were fit using a state-space formulation of the Schaefer surplus production model. Discards of monkfish were derived from estimates of the relative magnitude of standardized fishing effort coupled with assumptions about discard rates during the late 1980s. Catches of monkfish (landings plus discards and unreported catches) were assumed to be measured with higher precision since 1993 when the catch monitoring system improved. Vague prior distributions were used for catch errors, survey catchability, intrinsic growth rate, and carrying capacity. The model likelihood was based on lognormal observation errors calculated from observed minus predicted autumn survey indices. The Markov chain Monte Carlo (MCMC) method was used to sample directly from the posterior distribution of parameters. Diagnostics indicated that the MCMC samples converged to the stationary posterior distribution after a suitable burn-in period. Model outputs showed that current biomasses of both northern and southern monkfish were currently below the biomass that would produce maximum surplus production. Further, the exploitation rate in 1999 was over two times the rate that would produce maximum surplus production for both stocks.

EVALUATION OF STOCK STATUS WITH RESPECT TO REFERENCE POINTS

Northern Region

In the SAW 23 assessment fishing mortality was estimated from autumn survey length frequencies using L' of 59 cm for the north. Analyses conducted during SARC 31 indicated that L' = 30 cm was appropriate based on selectivity patterns. Using this approach resulted in an unfeasible estimate of $F_{threshold}$ for the northern component. The analysis shows an underlying trend in total mortality consistent with increasing catches and decreases in average and maximum size but F cannot be estimated reliably. Therefore, the SARC concluded that although current proxies are considered unreliable, the estimates of Z (taken as a total mortality index) indicate that overfishing is occurring.

The current three-year moving average catch per tow (kg/tow from NEFSC offshore autumn research vessel survey) of 0.823 kg/tow is below the 33rd percentile of the 1963-1994 series, 1.460 kg/tow (Table B33, Figure 48), the biomass threshold below which the stock component is defined to be overfished. The moving average has been below the 33rd percentile since 1989, and is well below the biomass target of 2.496 kg/tow (median of three-year moving average during 1965-1981).

Southern Region

In the SAW 23 assessment fishing mortality was estimated from autumn survey length frequencies using L'= 19 cm for the southern region. Analyses conducted during SARC 31 indicated that L' = 30 cm was appropriate based on selectivity patterns. Using this approach resulted in an estimate of $F_{threshold}$ of F = 0.12 for the southern component; however, the SARC concluded that F could not be estimated reliably. The analysis of total mortality (Z) for the southern region shows an underlying trend consistent with increasing catches and decreases in average and maximum size. Therefore, the SARC concluded that although current proxies are considered unreliable, the estimates of Z (taken as a total mortality index) indicate that overfishing is occurring (Tables B26, 1996-1999 average).

The current three-year moving average catch per tow (kg/tow from NEFSC offshore autumn research vessel survey) of 0.465 is below the 33rd percentile of the 1963-1994 series of 0.750 kg/tow (Table B28, Figure 49), the biomass threshold below which the stock component is defined to be overfished. The moving average has been below the 33rd percentile since 1987, and is well below the biomass target of 1.848 kg/tow (median of three-year moving average during 1965-1981). The current three-year moving average biomass indices are also well below the proposed revised biomass target for the southern region of 1.846 kg per tow, and the proposed revised biomass threshold of 0.704 kg per tow (Table B28).

TRENDS IN STOCK BIOMASS, RECRUITMENT, AND MORTALITY

For the northern component, NEFSC autumn and spring research survey indices indicate a steady decline in biomass since the mid-1980s (Tables B11-B12, Figures B16-B20). Recent increases in both spring and autumn survey abundance indices (numbers per tow, Figures B17 and B19) indicate improved recruitment during the 1990s, reflecting contributions from the 1992, 1993, and 1998 year classes. However, decreases in the abundance of large fish in the spring and autumn surveys and decreases in the maximum and mean lengths of the survey catches (Figures B24-B26) suggest increasing fishing mortality rates over the time series. The NEFSC summer scallop and summer Gulf of Maine shrimp surveys show abundance trends similar to the autumn and spring surveys (Tables B13-B14, Figures B21, B23). The scallop and shrimp surveys sample only a small portion of the goosefish distribution in the northern region.

For the southern component, the NEFSC spring and autumn surveys indicate that stock biomass and abundance have fluctuated around the time series low since the mid-1980s (Tables B18-B19, Figures B30, B31, B33, B34) . As for the northern component, decreases in the abundance of large fish in the spring and autumn surveys and decreases in the maximum and mean lengths of the survey catches suggest increasing fishing mortality rates over the time series (Figures B39-B41). There has been no strong recruitment to the southern component since 1971 (Figures B27, B39); however survey length frequency distributions suggest the appearance of some slightly stronger year classes during the early 1990s and in 1998. The NEFSC summer scallop and winter flatfish surveys indicate stable biomass during the 1990s (Tables B20-B21, Figures B35, B37). However, the summer scallop survey does not sample the Gulf of Maine or the deepest strata sampled by the bottom trawl surveys, and the winter trawl survey samples areas from Georges Bank and south.

For both stock components, indices of egg production (Figure 43) mirror the progressive decline in abundance of larger fish and the decline in mean length of the survey catch.

SARC COMMENTS

The SARC expressed concern about the small number of commercial samples. A consensus was reached that the samples were insufficient to adequately characterize the commercial length frequency.

The seaward extent of the stock, the fishery, and the survey was discussed. The SARC examined a series of distribution maps from logbook data. These show an increase in the otter trawl fishery in depths greater than 100 fathoms. A frequency distribution of both trips and landings of goosefish showed an increase in depths greater than 200 fathoms. These data are unaudited and show obvious outliers. The frequency of depth distribution of tows from the survey was also examined and was very similar to that of the commercial otter trawl fleet. The consensus was that there may be some of the stock that is not covered by the survey, but, in general, the survey does cover most of the areas in which the fishery operates. A recommendation was made to initiate cooperative surveys with industry to determine the full extent of the stock.

The SARC examined trends in CPUE and decided that they were probably not reflective of trends in stock size. Many regulations (i.e. closed areas, multispecies and scallop regulations, size limits) as well as changes in the value and increases in the number of directed trips of the fishery have likely affected the CPUE. The discontinuity of the sink gill net fishery CPUE data was discussed. The low sample size of interview trips and the estimate of days fished for gill nets were given as possible reasons for this. A recommendation was made to develop a study fleet of vessels to collect high quality CPUE data and biological sampling .

Concern arose as to the definition of stock structure. Differences in trends in abundance, recruitment, and fishing patterns were given as the main reasons for splitting goosefish into two stock components. Until other information is obtained (e.g. genetic studies) it was decided to continue examining the components separately. A recommendation was made to also examine the whole area as one stock and to explore the northern extent (Canadian side) of the stock unit.

The SARC concluded that the Bayesian surplus production model was a useful approach but that it needed further study. In particular, the SARC expressed concern that the prior distributions for total catch of both stocks were based on the same fishing effort time series. The SARC noted that the prior distribution for the carrying capacity of the northern stock may have been too narrow to be informative. The SARC recommended inclusion of additional survey indices to provide more information on biomass trends. The SARC also suggested that other surplus production models be explored to account for the possibility of cannibalism. Overall, the SARC encouraged further research to refine this approach

A discussion occurred over the selection of the autumn survey for the estimates of biomass and fishing mortality. The reasons for selecting it were 1) longest time series, 2) greatest spatial coverage of the surveys, 3) no large conversion factors applied (spring survey has gear conversion factors for the change to Yankee 41 gear from 1973-1981 of 0.4 and 0.3 for numbers and weight, respectively), 4) distribution of goosefish not as close to the shelf edge so more of the stock probably within the survey area. The major concern of the SARC was the low number of fish caught in the survey. Because there are so few fish, the length frequency may not be representative. The SARC examined the trends in abundance, biomass, and Z estimates from all surveys and found they were generally consistent. The SARC decided that fishing mortality probably has increased over the time period but were uncertain as to the amount of the increase. Current estimates of Z are probably between 0.4 and 0.6.

The SARC discussed the reference points for both biomass and fishing mortality. There was some concern about the biomass reference point being based on a time period when there were many large fish in the population. This is a concern because cannibalism may play a large role in this species. A recommendation was made to examine predator-prey data for more information. Also, increases in abundance have occurred since the decline in biomass and there may be more medium-sized fish in the stock. In regards to fishing mortality reference points, the SARC was concerned about the estimate of 0.05 in the north. This is probably unrealistically low. The SARC decided that the reference points need to be reevaluated.

RESEARCH RECOMMENDATIONS

1) Continue research to improve the reliability of estimates of life history parameters (growth, maturity, fecundity, sex ratio) by area, over the range of the species distribution.

2) A substantial increase is needed in the number of length and age samples (three to four times the current sampling intensity) and more complete temporal, spatial, and market category coverage to develop reliable estimates of catch at length and age, given the diverse regional fisheries that harvest goosefish. Cooperative research programs between NEFSC and industry should be developed.

3) Work should be continued on the Bayesian biomass dynamics model, including use of multiple indices of abundance, development of diagnostics and projections and exploration of models which could accommodate cannibalism.

4) The current separation of the stock into northern and southern components is based mainly on consideration of patterns in geographic distribution and in recruitment as indicated by NEFSC survey data. Recently developed NEFSC survey age data suggest that growth rates may be similar for the two components, however, and so the SARC encourages further research to more clearly define the stock structure for goosefish. This work could include continued sampling for genetic studies, morphometric studies, parasite studies, elemental analyses, and studies of the distribution of egg veils and larvae in time and space.

5) Develop indices of abundance from industry "study fleets," including coverage from outside the depth and spatial range of the NEFSC research surveys.

6) Investigate further stratification of the available sea sample data into directed and bycatch fisheries for goosefish, based on the reported species targeted. Determine whether discard estimates for the directed and by-catch components of the fishery can be developed.

7) Encourage cooperative research to determine the range and distribution of blackfin goosefish, it's vulnerability to the fisheries, and the proportion of the goosefish landings comprised of blackfin goosefish.

8) Develop a study to estimate the discard mortality rate of goosefish by fishery.

9) Evaluate whether application of the survey gear and vessel conversion factors for goosefish is appropriate.

10) Extend current research surveys or initiate cooperative surveys with industry to evaluate the distribution and characteristics of goosefish occurring in water deeper than

standard survey strata.

11) Integrate information from Canadian landings data, biological sampling and research survey programs (to characterize removals from the northern region landed in Canada).

12) Evaluate suitability of research surveys by states for inclusion in assessment analyses (to characterize distribution and characteristics of inshore components of population).

13) Continue and expand trophic studies (to estimate potential effects of cannibalism (and predation) on natural mortality rates by size and age).

14) The current approach to estimating F for goosefish results in an infeasible estimate for $F_{threshold}$ for the northern region. The consistency of biomass and fishing mortality targets needs to be re-evaluated.

LITERATURE CITED

Almeida, F. P., D.-L. Hartley, and J. Burnett. 1995. Length-weight relationships and sexual maturity of goosefish off the northeast coast of the United States. N. Am. J. Fish. Manage. 15:14-25.

Anon. 1991. Report of the twelfth northeast regional stock assessment workshop (12th SAW). NEFSC Ref. Doc. 91-03.

Anon. 1992. Report of the fourteenth northeast regional stock assessment workshop. NEFSC Ref. Doc. 92-07.

Armstrong, M. P. 1987 Life history of the goosefish, *Lophius americanus*. M. Sc. Thesis, College of William and Mary in Virginia. 80 pp.

Armstrong, M. P., J. A. Musick, and J. A. Colvocoresses. 1992. Age, growth and reproduction of the goosefish, *Lophius americanus* (Pisces: Lophiiformes) U. S. Fishery Bulletin. 90:217-230.

Beverton, R. J. H. and S. J. Holt. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapprts et Proces-Verbaux des Reunions 140: 67-83.

Caruso, J. H. 1983. The systematics and distribution of the lophiid angler fisher: II. Revision of the genera *Lophiomus* and *Lophius*. Copeia 1:11-30.

Cleveland, W. S. 1979. Robust locally weighted regression and smoothing scatterplots. J. Am. Stat. Assoc. 74(368): 829-836.

Hartley, D. 1995 MS. The population biology of the goosefish, *Lophius americanus*, in the Gulf of Maine. M. Sc. Thesis, University of Massachusetts, Amherst. 142 p.

Hilborn, R., and M. Mangel . 1997. The ecological detective. Princeton Univ. Press, 315 p.

Limeburner, R. and R. C. Beardsley. 1982. The seasonal hydrography and circulation over Nantucket Shoals. Journal of Marine Research 40 (Suppl).: 371-406.

Martinez, C.M. 1999. The reproductive biology of the goosefish, *Lophius americanus*. M.S. Thesis, University of Rhode Island.

Mountain, D. G. 1991. The volume of Shelf Water in the Middle Atlantic Bight: seasonal and interannual variability, 1977-1987. Continental Shelf Research 11 (3): 251-267.

NEFSC. 1997. Report of 23rd Northeast Regional Stock Assessment Workshop (23rd SAW). NEFSC Reference Document 97-05.

Sissenwine, M. P. and E. W. Bowman. 1977. Fishing power of two bottom trawls towed by research vessels off the northeast coast of the USA during day and night. ICES C.M. 1977:B30.

Wetherell, J. A, J. J. Polovina and S. Ralston. 1987. Estimating growth and mortality in steady-state fish stocks from length-frequency data. pp. 53-74 *in* D. Pauly and G. K. Morgan, eds. Length-Based Methods in Fisheries Research. ICLARM Conference Proceedings 13, 468 p. International Center for Living Aquatic Resources Management, Manila, Philippines, and Kuwait Institute for Scientific Research, Safat, Kuwait.

Table B2. USA landings (calculated live weight, mt) of goosefish as reported in NEFSC weighout data base 91964-1993) and vessel trip reports 91994-1999) (North = SA 511-523, 561; South = SA 524-639 excluding 551-561; Other = SA 500, 520 or 000 (1994); North Carolina DMF; Canada (NAFO) Area 5Zc); Adjusted General Canvas database (See text. North = ME, NH, northern weighout proportion of MA; South = Southern weighout proportion of MA, RI-VA); 1964-1994. NC and Canadian data use different conversion factors, e.g., NC landings include expanded liver weights.

	Weighout Database						Adjusted General Canvas Database		
Year	North	South	Other	Total	North Carolina	Canada	North	South	Total
1964	5	19	0	64	N/A	N/A	45	61	106
1965	37	17	0	54	N/A	N/A	37	79	115
1966	299	13	0	312	N/A	N/A	299	69	368
1967	539	8	0	547	N/A	N/A	540	59	598
1968	451	2	0	453	N/A	N/A	449	36	485
1969	258	4	0	262	N/A	N/A	240	43	283
1970	199	12	0	211	N/A	N/A	199	53	251
1971	213	10	0	223	N/A	N/A	213	53	266
1972	437	24	0	461	N/A	N/A	437	65	502
1973	710	139	0	848	N/A	N/A	708	240	948
1974	1,197	101	0	1,297	N/A	N/A	1,200	183	1,383
1975	1,853	282	0	2,134	N/A	N/A	1,877	417	2,294
1976	2,236	428	0	2,663	N/A	N/A	2,256	608	2,865
1977	3,137	829	0	3,965	1	N/A	3,167	1,314	4,481
1978	3,889	1,338	0	5,227	46	N/A	3,976	2,073	6,049
1979	4,014	3,372	0	7,386	162	N/A	4,068	4,697	8,765
1880	1,113	1,188	0	2,302	283	N/A			
1980[1]	3,695	3,949	0	7,675		N/A	3,623	6,035	9.658
1981	3,217	2,274	0	5,492	106	N/A	3,171	4,142	7,313
1982	3,860	3,658	0	7,524	64	N/A	3,757	4,492	8,249
1983	3,849	4,086	0	7,935	29	N/A	3,918	4,707	8,624
1984	4,202	3,610	0	7,812	89	N/A	4,220	4,171	8,391
1985	4,616	4,107	0	8,722	155	N/A	4,452	4,806	9,258
1986	4,327	3,954	0	8,280	83	339	4,322	4,264	8,586
1987	4,960	3,706	0	8,666	56	748	4,995	3,933	8,926
1988	5,066	4,483	0	9,549	112	909	5,033	4,775	9,809
1989	6,391	8,296	0	14,687	57	1,176	6,263	8,678	14,910
1990	5,802	7,142	0	12,944	62	1,554			
1991	5,693	9,800	0	15,494	65	1,015			
1992	6,923	13,925	0	20,848	17	469			
1993	10,645	15.061	0	25,706	37	352			
1994	10,950	12,037	0	22,988	89	0			
1995	11,995	14,419	0	26,414	243	418			
1996	10,770	15,780	0	26,550	243	184			
1997	9,280	18,507	0	28,327	319	189			
1998	7,413	19,262	0	26,675	307	190			

Table B2. USA landings (calculated live weight, mt) of goosefish as reported in NEFSC weighout data base 91964-1993) and vessel trip reports 91994-1999) (North = SA 511-523, 561; South = SA 524-639 excluding 551-561; Other = SA 500, 520 or 000 (1994); North Carolina DMF; Canada (NAFO) Area 5Zc); Adjusted General Canvas database (See text. North = ME, NH, northern weighout proportion of MA; South = Southern weighout proportion of MA, RI-VA); 1964-1994. NC and Canadian data use different conversion factors, e.g., NC landings include expanded liver weights.

	Weighout Database						Adjusted General Canvas Database		
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1978	3,889	1,338	0	5,227	46	N/A	3,976	2,073	6,049
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1982	3,860	3,658	0	7,524	64	N/A	3,757	4,492	8,249
1983	3,849	4,086	0	7,935	29	N/A	3,918	4,707	8,624
1984	4,202	3,610	0	7,812	89	N/A	4,220	4,171	8,391
1985	4,616	4,107	0	8,722	155	N/A	4,452	4,806	9,258
1986	4,327	3,954	0	8,280	83	339	4,322	4,264	8,586
1987	4,960	3,706	0	8,666	56	748	4,995	3,933	8,926
1988	5,066	4,483	0	9,549	112	909	5,033	4,775	9,809
1989	6,391	8,296	0	14,687	57	1,176	6,263	8,678	14,910
1990	5,802	7,142	0	12,944	62	1,554			
1991	5,693	9,800	0	15,494	65	1,015			
1992	6,923	13,925	0	20,848	17	469			
1993	10,645	15.061	0	25,706	37	352			
1994	10,950	12,037	0	22,988	89	0			
1995	11,995	14,419	0	26,414	243	418			
1996	10,770	15,780	0	26,550	243	184			
1997	9,280	18,507	0	28,327	319	189			
1998	7,413	19,262	0	26,675	307	190			
1999	9,353	15,671	0	25,024					

[1] **1980 landed weight as reported in WOLANDS 80 database equaled 1980 live weight. If expansion factor were applied to landed weight, revised (higher) weights may be obtained.**

Table B3. Landed weight (mt) of goosefish by market category for 1964-1999 for combined assessment areas (SA 511-636), NEFSC weightout database and vessel trip reports (1994-1999).

Year	Belly Flaps	Cheeks	Livers	Gutted	Round	Tails Unc.	Tails Large	Tails Small	Tails Peewee	All Tails
1964	0.0	0.0	0.0	0.0	0.0	19.3	0.0	0.0	0.0	19.3
1965	0.0	0.0	0.0	0.0	0.0	16.1	0.0	0.0	0.0	16.1
1966	0.0	0.0	0.0	0.0	0.0	93.9	0.0	0.0	0.0	93.0
1967	0.0	0.0	0.0	0.0	0.0	164.8	0.0	0.0	0.0	164.8
1968	0.0	0.0	0.0	0.0	0.0	136.6	0.0	0.0	0.0	136.6
1969	0.0	0.0	0.0	0.0	0.0	79.1	0.0	0.0	0.0	79.1
1970	0.0	0.0	0.0	0.0	0.0	63.5	0.0	0.0	0.0	63.5
1971	0.0	0.0	0.0	0.0	0.0	67.1	0.0	0.0	0.0	67.1
1972	0.0	0.0	0.0	0.0	0.0	139.0	0.0	0.0	0.0	139.0
1973	0.0	0.0	0.0	0.0	0.0	255.5	0.0	0.0	0.0	255.5
1974	0.0	0.0	0.0	0.0	0.0	390.7	0.0	0.0	0.0	390.7
1975	0.0	0.0	0.0	0.0	0.0	642.8	0.0	0.0	0.0	642.8
1976	0.0	0.0	0.0	0.0	0.0	802.2	0.0	0.0	0.0	802.2
1977	0.0	0.0	0.0	0.0	0.0	1,194.4	0.0	0.0	0.0	1,194.4
1978	0.0	0.0	0.0	0.0	0.0	1,574.5	0.0	0.0	0.0	1,574.5
1979	0.0	0.0	0.0	0.0	0.0	2,224.7	0.0	0.0	0.0	2,224.7
1980	0.0	0.0	0.0	0.0	0.0	2,302.4	0.0	0.0	0.0	2,302.4
1981	0.0	0.0	0.0	0.0	0.0	1,654.2	0.0	0.0	0.0	1,654.2
1982	0.0	0.0	10.2	0.0	0.0	2,059.8	153.1	53.3	0.0	2,266.2
1983	0.0	0.0	11.6	0.0	0.0	2,009.9	241.4	138.6	0.0	2,390.0
1984	0.0	0.0	25.0	0.0	0.0	2,121.6	186.8	44.5	0.0	2,352.9
1985	0.0	0.0	28.0	0.0	0.0	2,467.0	86.7	73.4	0.0	2,627.1
1986	0.0	0.0	36.3	0.0	0.0	2,365.4	76.4	52.2	0.0	2,494.0
1987	0.0	0.0	54.2	0.0	0.0	2,463.7	139.9	6.7	0.0	2,610.3
1988	0.0	0.0	112.8	0.0	0.0	2,646.3	195.1	34.8	0.0	2,876.2
1989	0.0	0.0	146.3	0.0	15.6	3,501.8	557.4	360.0	0.0	4,419.2
1990	0.0	0.0	179.7	0.0	217.7	2,601.8	854.1	377.4	0.0	3,833.3
1991	0.0	8.6	270.3	0.0	415.4	2,229.1	1,661.9	614.1	36.6	4,541.6
1992	0.2	3.7	321.5	0.0	386.0	2,778.7	1,908.1	1,293.0	183.3	6,163.1
1993	0.0	1.7	459.9	98.2	528.7	3,503.2	1,933.0	1,851.1	262.4	7,549.8
1994	0.0	5.3	458.1	1,453.6	2,044.8	1,256.9	2,230.7	2,063.3	258.0	5,808.9
1995	2.3	1.0	500.1	2,763.2	2,652.6	895.6	2,524.6	2,424.4	363.5	6,208.1
1996	0.4	0.6	571.6	3,475.9	1,064.3	1,086.9	2,094.1	3,032.1	269.8	6,482.9
1997	0.1	0.1	630.7	3,210.0	795.2	675.5	3,067.7	3,295.7	151.6	7,191.5
1998	0.0	0.5	607.4	3,592.1	581.8	861.9	3,013.6	2,654.8	95.5	6,625.8
1999	0.1	0.2	588.7	5,660.6	1,131.6	416.3	2,436.2	2,246.5	153.9	5,252.9

Table B4. Landed weight (mt) of goosefish by market category for 1964-1999 for northern assessment area (SA 511-523 and 561), NEFSC weighout database and vessel trip reports (1994-1999).

Year	Belly Flaps	Cheeks	Livers	Gutted	Round	Tails Unc.	Tails Large	Tails Small	Tails Peewee	All Tails
1964	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0	0.0	13.5
1965	0.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	0.0	11.0
1966	0.0	0.0	0.0	0.0	0.0	90.1	0.0	0.0	0.0	90.1
1967	0.0	0.0	0.0	0.0	0.0	162.5	0.0	0.0	0.0	162.5
1968	0.0	0.0	0.0	0.0	0.0	135.9	0.0	0.0	0.0	135.9
1969	0.0	0.0	0.0	0.0	0.0	77.8	0.0	0.0	0.0	77.8
1970	0.0	0.0	0.0	0.0	0.0	59.8	0.0	0.0	0.0	59.8
1971	0.0	0.0	0.0	0.0	0.0	64.1	0.0	0.0	0.0	64.1
1972	0.0	0.0	0.0	0.0	0.0	131.6	0.0	0.0	0.0	131.6
1973	0.0	0.0	0.0	0.0	0.0	213.8	0.0	0.0	0.0	213.8
1974	0.0	0.0	0.0	0.0	0.0	360.4	0.0	0.0	0.0	360.4
1975	0.0	0.0	0.0	0.0	0.0	558.0	0.0	0.0	0.0	558.0
1976	0.0	0.0	0.0	0.0	0.0	673.4	0.0	0.0	0.0	673.4
1977	0.0	0.0	0.0	0.0	0.0	944.7	0.0	0.0	0.0	944.7
1978	0.0	0.0	0.0	0.0	0.0	1,171.4	0.0	0.0	0.0	1,171.4
1979	0.0	0.0	0.0	0.0	0.0	1,209.1	0.0	0.0	0.0	1,209.1
1980	0.0	0.0	0.0	0.0	0.0	1,113.1	0.0	0.0	0.0	1,113.1
1981	0.0	0.0	0.0	0.0	0.0	969.0	0.0	0.0	0.0	969.0
1982	0.0	0.0	10.0	0.0	0.0	1,145.6	15.0	2.0	0.0	1,162.6
1983	0.0	0.0	9.3	0.0	0.0	1,152.3	4.8	2.4	0.0	1,159.4
1984	0.0	0.0	14.7	0.0	0.0	1,261.9	3.7	0.0	0.0	1,265.6
1985	0.0	0.0	11.4	0.0	0.0	1,385.9	1.6	2.6	0.0	1,390.2
1986	0.0	0.0	13.7	0.0	0.0	1,302.7	0.3	0.2	0.0	1,303.2
1987	0.0	0.0	24.0	0.0	0.0	1,491.5	1.7	0.7	0.0	1,493.9
1988	0.0	0.0	47.4	0.0	0.0	1,516.9	5.6	3.3	0.0	1,525.8
1989	0.0	0.0	58.7	0.0	11.2	1,464.5	327.0	130.2	0.0	1,921.6
1990	0.0	0.0	77.9	0.0	30.3	1,173.7	410.7	154.0	0.0	1,738.4
1991	0.0	3.3	70.0	0.0	0.3	1,013.9	538.6	153.2	9.1	1,714.8
1992	0.0	0.7	83.0	0.0	0.1	910.5	589.9	505.4	79.4	2,085.3
1993	0.0	0.6	208.3	98.2	350.6	1,034.3	867.9	1,061.8	102.9	3,067.0
1994	0.0	1.4	207.6	532.7	981.3	403.0	1,205.7	1,074.8	136.2	2,819.7
1995	0.0	0.7	45.7	1,223.4	1,115.5	366.6	1,173.9	1,010.7	305.6	2,856.8
1996	0.0	0.2	65.1	1,126.0	751.7	92.3	932.8	1,381.9	224.0	2,631.0
1997	0.0	0.1	50.9	629.4	243.3	31.2	1,153.8	1,364.2	119.2	2,668.4
1998	0.0	0.0	24.0	577.9	142.1	21.8	1,068.7	821.7	79.2	1,991.4
1999	0.0	0.1	172.6	1,641.9	499.0	47.6	1,034.9	881.3	139.4	2,103.2

Table B5. Landed weight (mt) of goosefish by market category for 1964-1999 for southern assessment area (SA 524-636 excluding 561), NEFSC weighout database and vessel trip reports (1994-1999).

Year	Belly Flaps	Cheeks	Livers	Gutted	Round	Tails Unc.	Tails Large	Tails Small	Tails Peewee	All Tails
1964	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	5.7
1965	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	5.0
1966	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	3.8
1967	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	2.3
1968	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6
1969	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	1.2
1970	0.0	0.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	3.7
1971	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	3.0
1972	0.0	0.0	0.0	0.0	0.0	7.4	0.0	0.0	0.0	7.4
1973	0.0	0.0	0.0	0.0	0.0	41.7	0.0	0.0	0.0	41.7
1974	0.0	0.0	0.0	0.0	0.0	30.3	0.0	0.0	0.0	30.3
1975	0.0	0.0	0.0	0.0	0.0	84.8	0.0	0.0	0.0	84.8
1976	0.0	0.0	0.0	0.0	0.0	128.8	0.0	0.0	0.0	128.8
1977	0.0	0.0	0.0	0.0	0.0	249.6	0.0	0.0	0.0	249.6
1978	0.0	0.0	0.0	0.0	0.0	403.1	0.0	0.0	0.0	403.1
1979	0.0	0.0	0.0	0.0	0.0	1,015.6	0.0	0.0	0.0	1,015.6
1980	0.0	0.0	0.0	0.0	0.0	1,189.3	0.0	0.0	0.0	1,189.3
1981	0.0	0.0	0.0	0.0	0.0	685.0	0.0	0.0	0.0	685.0
1982	0.0	0.0	0.2	0.0	0.0	912.4	138.1	51.3	0.0	1,101.8
1983	0.0	0.0	2.3	0.0	0.0	857.7	236.6	136.2	0.0	1,230.5
1984	0.0	0.0	10.3	0.0	0.0	859.7	183.1	44.5	0.0	1,087.3
1985	0.0	0.0	16.7	0.0	0.0	1,081.1	85.1	70.8	0.0	1,236.9
1986	0.0	0.0	22.6	0.0	0.0	1,062.6	76.1	52.0	0.0	1,190.8
1987	0.0	0.0	330.2	0.0	0.0	972.2	138.2	6.0	0.0	1,116.4
1988	0.0	0.0	65.4	0.0	0.0	1,129.3	189.5	31.5	0.0	1,350.4
1989	0.0	0.0	87.6	0.0	4.5	2,037.4	230.4	229.8	0.0	2,497.5
1990	0.0	0.0	101.8	0.0	187.3	1,428.1	443.4	223.4	0.0	2,094.9
1991	0.0	5.2	200.2	0.0	415.1	1,215.2	1,123.3	460.9	27.5	2,826.8
1992	0.2	3.0	238.5	0.0	385.9	1,868.2	1,318.3	787.6	103.9	4,077.9
1993	0.0	1.1	251.5	0.0	178.1	2,468.9	1,065.1	789.3	159.4	4,482.8
1994	0.0	3.8	250.5	921.0	1,063.5	853.9	1,025.0	988.5	121.8	2,989.2
1995	2.3	0.3	454.4	1,539.7	1,537.1	529.1	1,350.8	1,413.7	57.9	3,351.5
1996	0.4	0.5	506.5	2,349.8	312.6	994.6	1,161.4	1,650.2	45.8	3,852.0
1997	0.1	0.0	579.8	2,580.6	551.9	644.3	1,913.9	1,931.5	32.4	4,522.1
1998	0.0	0.5	583.4	3,014.2	439.8	840.1	1,944.8	1,833.1	16.3	4,634.3
1999	0.1	0.1	416.1	4,018.7	632.7	368.7	1,401.3	1,365.2	14.5	3,149.7

Table B6. Number of commercial samples and length measurements taken by year, market category, and stock area. Live metric tons are also shown.

Year	Market Category	NORTH Samples	Lengths	Live mt	mt/sample	SOUTH Samples	Lengths	Live mt	mt/sample	TOTAL Samples	Lengths	mt
1996	tails only	1	109	306	306	1	123	3,302	3,302	2	232	3,608
	tails large	13	1,383	3,097	238	6	618	3,856	643	19	2,001	6,953
	tails small	10	1,438	4,588	459	6	609	5,479	913	16	2,047	10,067
	tails peewee	9	1,258	744	83	4	415	152	38	13	1,673	896
	unclass round	2	252	752	376	-	-	313	-	2	252	1,065
	head on, gutted	3	478	1,284	428	7	1,287	2,679	383	10	1,765	3,963
1997	tails only	-	-	104	-	-	-	2,139	-	-	-	2,243
	tails large	12	1,324	3,831	319	12	1,220	6,354	530	24	2,544	10,185
	tails small	12	1,262	4,529	377	14	1,451	6,413	458	26	2,713	10,942
	tails peewee	9	863	396	44	3	300	108	36	12	1,163	504
	unclass round	10	936	243	24	1	98	552	552	11	1,034	795
	head on, gutted	1	53	718	718	4	551	2,942	736	5	604	3,660
1998	tails only	-	-	72		-	-	2,789	-	-	-	2,861
	tails large	6	713	3,548	591	5	487	6,457	1,291	11	1,200	10,005
	tails small	8	877	2,728	341	4	444	6,086	1,522	12	1,321	8,814
	tails peewee	1	136	263	263	-	-	54	-	1	136	317
	unclass round	-	-	142		-	-	440	-	-	-	582
	head on, gutted	-	-	659		-	-	3,436	-	-	-	4,095
1999	tails only	-	-	158	-	-	-	1,224	-	-	-	1,382
	tails large	6	634	3,436	573	5	480	4,652	930	11	1,114	8,088
	tails small	19	1,997	2,926	154	8	814	4,533	567	27	2,811	7,459
	tails peewee	-	-	463	-	-	-	48	-	-	-	511
	unclass round	-	-	499	-	-	-	633	-	-	-	1,132
	head on, gutted	1	115	1,872	1,872	4	254	4,581	1,145	5	369	6,453

Table B7. Frequency of tows with discard by stock area and gear based on fishery observer data.

TRAWLS		No. of trips	No. tows with goosefish	No. tows with goosefish discard	% with discard	o. tows wit goose kep	% with kept	All tows kept mt	discard m
North									
	1996	76	543	445	82.0	409	75.3	41.8	8.0
	1997	23	379	292	77.0	360	95.0	35	3.3
	1998	10	111	94	84.7	105	94.6	6.8	0.8
	1999	24	251	171	68.1	237	94.4	16.7	1.2
	mean(96-99)				78.0		89.8		
South									
	1996	71	430	178	41.4	385	89.5	14.7	1.9
	1997	62	531	279	52.5	499	94.0	79.9	3.5
	1998	43	286	109	38.1	253	88.5	7.1	0.6
	1999	40	325	163	50.2	278	85.5	18.6	1.7
	mean(96-99)				45.6		89.4		
SCALLOP DREDGES									
North									
	1996	13	458	287	62.7	315	68.8	4.5	1.4
	1997	8	574	268	46.7	402	70.0	9.6	1.5
	1998	7	246	142	57.7	230	93.5	6.4	0.4
	1999	2	105	53	50.5	91	86.7	0.6	0.1
	mean(96-99)				54.4		79.7		
South									
	1996	33	2532	1857	73.3	2080	82.1	36.3	8.4
	1997	23	1950	1625	83.3	1754	89.9	32.6	8.4
	1998	22	1208	537	44.5	1174	97.2	26.2	1.4
	1999	20	846	539	63.7	707	83.6	10.2	2.7
	mean(96-99)				66.2		88.2		
GILL NETS									
North	1996	50	167	92	55.1	146	87.4	4	0.5
	1997	45	130	37	28.5	123	94.6	3.2	0.3
	1998	91	239	48	20.1	221	92.5	5.4	0.2
	1999	69	215	34	15.8	199	92.6	7.1	0.2
	mean(96-99)				29.9		91.8		
South									
	1996	136	440	133	30.2	430	97.7	45.9	3.1
	1997	183	648	295	45.5	628	96.9	110.6	6.4
	1998	135	426	194	45.5	415	97.4	82.3	6.6
	1999	29	118	61	51.7	115	97.5	14.7	0.8
	mean(96-99)				43.2		97.4		

Table B8. Discard ratios (kg discarded / kg landed live weight) and estimated catch (kg) for trawls, scallop dredges, and gill nets.

	Discard ratio		Landings live wt (mt)		Estimated discard (mt)		Estimated catch (mt)		
North	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Jun	Jul-Dec	Jan-Dec
Trawls									
1996	0.195	0.107	4383.1	4009.1	854.7	429.0	5237.8	4438.1	9675.9
1997	0.103	0.070	4067.2	3380.6	418.9	236.6	4486.1	3617.3	8103.4
1998	0.092	0.085	3200.1	2239.4	294.4	190.3	3494.5	2429.7	5924.3
1999	0.097	0.056	4003.2	2989.0	388.3	167.4	4391.5	3156.4	7547.9
Scallop Dredges									
1996	0.166	0.222	40.7	910.1	6.7	202.1	47.4	1112.2	1159.6
1997	0.011	0.055	218.6	1131.0	2.4	62.2	221.0	1193.2	1414.2
1998	0.081	0.049	245.4	786.2	19.9	38.5	265.3	824.7	1090.0
1999	0.107	0.000	282.8	501.6	30.3	0.0	313.0	501.6	814.6
Gill nets									
1996	0.128	0.123	381.1	1002.4	48.8	123.6	429.9	1126.0	1555.9
1997	0.034	0.191	303.2	700.6	10.2	134.0	313.4	834.6	1148.0
1998	0.018	0.040	274.5	645.6	5.0	26.1	279.5	671.7	951.2
1999	0.061	0.003	408.2	1133.9	24.7	3.7	432.9	1137.7	1570.6
Other[a]									
1996	0.199	0.199	33.8	9.9	6.7	2.0	40.6	11.9	52.4
1997	0.107	0.107	10.2	8.9	1.1	1.0	11.3	9.9	21.2
1998	0.074	0.074	10.0	11.4	0.7	0.8	10.7	12.2	23.0
1999	0.057	0.057	4.8	29.8	0.3	1.7	5.1	31.5	36.6
South									
Trawls									
1996	0.164	0.083	3117.0	4100.5	511.2	340.3	3628.2	4440.9	8069.0
1997	0.024	0.086	3971.5	4214.6	95.3	362.5	4066.8	4577.1	8643.9
1998	0.057	0.025	3950.8	3884.0	225.2	97.1	4175.9	3981.1	8157.1
1999	0.026	0.069	3989.0	2261.3	103.7	156.0	4092.7	2417.3	6510.1
Scallop Dredges									
1996	0.189	0.165	1789.1	2511.6	338.1	414.4	2127.3	2926.0	5053.3
1997	0.193	0.303	2219.2	2670.3	428.3	809.1	2647.5	3479.4	6126.9
1998	0.042	0.059	2510.5	2596.4	105.4	153.2	2615.9	2749.5	5365.5
1999	0.324	0.105	1695.1	1371.4	549.2	144.0	2244.3	1515.4	3759.7
Gill nets									
1996	0.071	0.052	2770.3	1457.7	198.0	76.3	2968.3	1534.0	4502.3
1997	0.070	0.015	3712.6	1489.4	258.2	22.3	3970.8	1511.7	5482.5
1998	0.079	0.062	4121.1	2059.9	327.0	128.7	4448.1	2188.6	6636.8
1999	0.049	0.051	4284.8	1641.5	209.7	84.5	4494.5	1726.0	6220.5
Other[a]									
1996	0.139	0.139	25.2	8.8	3.5	1.2	28.6	10.0	38.6
1997	0.082	0.082	170.8	58.7	14.0	4.8	184.8	63.5	248.3
1998	0.074	0.074	78.7	60.6	5.8	4.5	84.5	65.1	149.6
1999	0.120	0.120	173.1	254.7	20.8	30.6	193.9	285.3	479.2

[a] Discard ratios set equal to overall mean discard ratio for corresponding stock and year

Table B9. Reported landings (live weight, mt), overall estimated discard ratio (mt discarded/mt landec and estimated catch (mt) of goosefish.

	Reported landings (live wt, mt)	Estimated Discard (mt)	Overall discard ratio	Percent of catch discarded	Estimated catch (mt)
North					
1996	10770	1673.6	0.155	13.4	12443.8
1997	9820	866.5	0.088	8.1	10686.8
1998	7413	575.8	0.078	7.2	7988.4
1999	9353	616.4	0.066	6.2	9969.6
South					
1996	15780	1883.1	0.119	10.7	17663.2
1997	18507	1994.5	0.108	9.7	20501.6
1998	19262	1046.9	0.054	5.2	20308.9
1999	15671	1298.4	0.083	7.7	16969.4
Total					
1996	26550	3556.8	0.134	11.8	30107.0
1997	28327	2861.0	0.101	9.2	31188.4
1998	26675	1622.7	0.061	5.7	28297.3
1999	25024	1914.8	0.077	7.1	26939.1

Table B10. Estimated parameters (L_{full} and shape parameter s) of the vulnerability function and length (cm) at 90%, 75%, 50%, 25%, and 10% vulnerability for the kept goosefish caught by commercial vessels using trawls and scallop dredges and compared with length frequency distributions obtained from scallop survey and winter and autumn trawl surveys in 1996-1999.

Northern Stock	Trawl catch VS Scallop survey				Dredge catch vs Scallop Survey			
	1996	1997	1998	1999	1996	1997	1998	1999
SS	0.0233	0.0158	0.0272	Incomplete	0.0498	0.0099	0.0231	Incomplete
Lfull (cm)	58.08	40.80	38.72	Survey	49.74	55.54	47.04	Survey
s	291.06	0.83	1.13		6.68	58.57	3.02	
Length (cm) at:								
90% Vulnerability	50.24	40.38	38.23		48.55	52.03	46.25	
75% Vulnerability	45.13	40.11	37.91		47.78	49.73	45.73	
50% Vulnerability	37.99	39.72	37.46		46.70	46.53	45.00	
25% Vulnerability	29.67	39.28	36.95		45.44	42.80	44.15	
10% Vulnerability	21.46	38.84	36.43		44.19	39.12	43.31	

Southern Stock	Trawl catch VS Scallop survey				Dredge catch vs Scallop Survey				Trawl catch vs Winter survey				Dredge catch vs Winter Survey			
	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999	1996	1997	1998	1999
SS	0.0091	0.0126	0.0059	0.0390	0.0087	0.0088	0.0113	0.0219	0.0068	0.0027	0.0071	0.0104	0.0112	0.0051	0.0067	0.0076
Lfull (cm)	43.40	43.13	37.59	53.06	47.89	43.16	67.94	53.97	43.04	40.04	48.67	60.22	44.92	40.01	48.90	80.63
s	14.82	5.15	4.96	44.82	35.60	5.14	375.99	76.23	3.09	3.15	31.50	56.72	6.37	2.71	16.53	244.44
Length (cm) at:																
90% Vulnerability	41.63	42.08	36.57	49.99	45.15	42.12	59.04	49.96	42.23	39.22	46.10	56.76	43.76	39.26	47.03	73.45
75% Vulnerability	40.48	41.40	35.90	47.98	43.36	41.44	53.24	47.34	41.71	38.69	44.42	54.50	43.00	38.76	45.81	68.77
50% Vulnerability	38.87	40.45	34.97	45.18	40.86	40.49	45.11	43.69	40.97	37.95	42.07	51.35	41.94	38.07	44.11	62.22
25% Vulnerability	36.99	39.35	33.88	41.91	37.95	39.39	35.66	39.43	40.11	37.08	39.33	47.68	40.71	37.27	42.13	54.60
10% Vulnerability	35.14	38.25	32.81	38.70	35.08	38.30	26.33	35.23	39.27	36.23	36.63	44.06	39.50	36.48	40.17	47.08

Table B11. Stratified mean weight (kg), number, individual fish weight, and length (cm) per tow for goosefish from NEFSC offshore autumn research vessel bottom trawl surveys in the Gulf of Maine to Northern Georges Bank region (20-30, 34-40); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and total number of tows completed in each year.

	Biomass						Abundance													Number	Number of	
	Raw Index			Smoothed			Raw Index			Smoothed				Length						of	Nonzero	Number
	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	Tows	of Tows
1963	3.757	2.161	5.353	2.843			0.801	0.508	1.094	0.568			4.661	11	14	59	58.3	103	111	86	39	90
1964	1.712	0.896	2.528	2.357			0.392	0.219	0.564	0.451			4.354	21	21	58	59.4	92	102	32	23	87
1965	2.509	1.350	3.667	2.422			0.347	0.230	0.463	0.394			7.137	28	36	70	71.6	96	110	40	30	88
1966	3.266	2.102	4.431	2.432	1.654	3.575	0.492	0.331	0.653	0.375	0.265	0.529	6.532	37	48	73	73.1	90	96	55	33	86
1967	1.283	0.441	2.125	2.002	1.362	2.943	0.189	0.090	0.288	0.297	0.210	0.419	6.799	48	48	69	70.3	91	92	18	14	86
1968	2.036	0.521	3.552	2.223	1.512	3.268	0.286	0.115	0.457	0.319	0.226	0.450	7.121	11	26	72	71.4	105	106	32	16	86
1969	3.705	1.781	5.628	2.618	1.781	3.849	0.418	0.277	0.559	0.368	0.261	0.520	8.718	13	41	78	78.8	101	110	39	30	88
1970	2.237	0.947	3.527	2.442	1.661	3.590	0.395	0.222	0.569	0.391	0.277	0.552	5.754	22	36	67	67.2	90	98	41	21	92
1971	2.914	1.436	4.391	2.415	1.643	3.551	0.491	0.312	0.670	0.411	0.291	0.581	5.864	15	22	69	67.0	97	101	44	27	94
1972	1.404	0.651	2.157	2.106	1.432	3.096	0.318	0.195	0.442	0.384	0.272	0.542	4.354	21	21	61	56.9	97	99	29	22	94
1973	3.114	1.782	4.446	2.412	1.641	3.546	0.514	0.320	0.709	0.406	0.288	0.574	5.992	16	16	58	65.2	109	112	63	29	92
1974	2.063	1.114	3.011	2.327	1.583	3.421	0.313	0.189	0.436	0.367	0.260	0.519	6.362	13	13	69	64.9	109	111	37	23	97
1975	1.711	1.003	2.418	2.434	1.655	3.578	0.298	0.178	0.418	0.369	0.262	0.522	5.721	11	11	60	62.9	97	102	40	27	106
1976	3.387	1.555	5.219	3.227	2.195	4.744	0.422	0.244	0.601	0.429	0.304	0.606	7.620	29	30	71	72.1	106	121	32	24	87
1977	5.568	3.489	7.646	4.140	2.816	6.087	0.626	0.458	0.794	0.504	0.357	0.712	8.635	21	35	73	71.1	107	119	112	56	126
1978	5.101	3.487	6.714	4.353	2.961	6.400	0.579	0.429	0.729	0.511	0.362	0.722	8.106	10	24	70	67.6	104	116	146	78	201
1979	5.133	3.566	6.700	4.114	2.798	6.049	0.474	0.364	0.584	0.477	0.338	0.674	10.233	15	19	77	73.5	103	115	125	78	211
1980	4.458	2.234	6.682	3.351	2.279	4.926	0.535	0.366	0.703	0.448	0.317	0.632	7.549	6	16	66	63.9	101	111	65	39	97
1981	1.984	1.183	2.786	2.252	1.532	3.311	0.406	0.288	0.523	0.373	0.264	0.526	4.892	9	13	55	57.5	93	101	46	30	93
1982	0.936	0.379	1.492	1.648	1.121	2.423	0.142	0.070	0.213	0.293	0.207	0.414	6.606	29	29	71	68.9	97	100	17	14	95
1983	1.617	0.927	2.308	1.765	1.200	2.594	0.470	0.284	0.656	0.375	0.266	0.530	3.415	13	17	54	53.0	88	96	38	27	82
1984	3.010	1.413	4.607	2.003	1.362	2.945	0.483	0.353	0.613	0.412	0.292	0.583	5.803	11	26	63	62.7	102	106	36	29	88
1985	1.441	0.419	2.463	1.729	1.176	2.542	0.369	0.190	0.548	0.408	0.289	0.576	3.985	12	15	55	53.1	101	102	32	23	88
1986	2.353	1.099	3.608	1.688	1.148	2.481	0.604	0.379	0.829	0.431	0.305	0.609	3.703	19	23	52	53.8	82	100	46	26	90
1987	0.873	0.256	1.491	1.317	0.896	1.936	0.264	0.116	0.411	0.363	0.257	0.513	3.324	15	15	53	52.2	92	96	22	15	87
1988	1.525	0.484	2.565	1.355	0.921	1.992	0.313	0.130	0.496	0.379	0.268	0.535	4.870	11	11	53	57.1	92	93	26	17	89
1989	1.384	0.478	2.290	1.287	0.875	1.892	0.428	0.266	0.590	0.449	0.318	0.635	3.096	9	9	39	40.8	93	96	39	25	87
1990	1.001	0.439	1.562	1.164	0.792	1.712	0.593	0.383	0.804	0.551	0.390	0.778	1.705	9	10	25	32.3	72	89	55	35	89
1991	1.235	0.568	1.903	1.166	0.793	1.715	0.576	0.383	0.768	0.642	0.455	0.907	2.067	9	10	31	38.3	83	95	62	33	88
1992	1.104	0.557	1.651	1.124	0.764	1.652	0.938	0.602	1.274	0.806	0.571	1.138	1.183	9	9	26	33.0	79	86	78	37	86
1993	1.044	0.343	1.746	1.096	0.745	1.611	0.989	0.691	1.287	0.913	0.646	1.290	1.077	6	9	20	27.1	71	94	103	45	86
1994	0.973	0.378	1.569	1.103	0.750	1.622	1.351	0.969	1.732	0.980	0.694	1.385	0.668	9	9	19	24.9	55	98	110	51	87
1995	1.711	0.663	2.759	1.208	0.821	1.777	0.922	0.688	1.155	0.849	0.600	1.200	1.724	10	12	34	39.6	84	91	87	40	93
1996	1.071	0.498	1.645	1.047	0.709	1.544	0.630	0.407	0.853	0.695	0.491	0.985	1.688	8	11	38	40.3	63	95	51	30	88
1997	0.669	0.321	1.017	0.893	0.597	1.335	0.498	0.304	0.693	0.608	0.424	0.872	1.335	8	9	35	35.4	70	86	39	27	90
1998	0.974	0.522	1.425	0.925	0.581	1.471	0.609	0.397	0.820	0.609	0.401	0.922	1.531	10	10	30	35.5	68	77	56	38	104
1999	0.825	0.303	1.348				1.084	0.737	1.431				0.716	8		22			58	111		

Table B12. Stratified mean weight (kg), number, individual fish weight, and length (cm) per tow for goosefish from NEFSC offshore spring research vessel bottom trawl surveys in the Gulf of Maine to Northern Georges Bank region (20-30, 34-40); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and total number of tows completed in each year.

	Biomass						Abundance													Number	Number of	
	Raw Index			Smoothed			Raw Index			Smoothed				Length						of	Nonzero	Number
	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%CI	U95%CI	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	Tows	of Tows
1968	0.973	0.260	1.686	1.187			0.178	0.074	0.283	0.202			5.427	50	51	68	70.4	89	90	13	11	86
1969	1.309	0.141	2.476	1.357			0.186	0.046	0.325	0.219			7.044	33	33	71	71.5	99	100	15	10	87
1970	1.967	0.712	3.221	1.590			0.344	0.216	0.472	0.265			5.709	30	30	62	65.4	98	99	32	22	90
1971	1.021	0.414	1.629	1.615	1.052	2.478	0.158	0.072	0.245	0.269	0.179	0.406	6.366	45	53	69	72.6	99	100	20	15	96
1972	4.644	3.021	6.266	2.230	1.453	3.423	0.643	0.453	0.832	0.391	0.259	0.590	7.064	13	39	74	72.7	100	105	59	38	96
1973	1.908	0.956	2.860	1.882	1.226	2.888	0.435	0.184	0.686	0.407	0.270	0.614	4.313	17	26	68	65.7	99	106	91	36	87
1974	1.476	0.863	2.090	1.574	1.025	2.415	0.438	0.315	0.561	0.406	0.269	0.612	3.391	20	23	58	58.3	97	111	86	41	83
1975	0.934	0.593	1.275	1.373	0.895	2.107	0.339	0.228	0.450	0.384	0.254	0.579	2.760	16	19	53	54.0	87	109	73	36	87
1976	2.826	1.691	3.962	1.552	1.012	2.383	0.673	0.469	0.877	0.395	0.262	0.595	3.759	14	20	60	61.5	95	106	158	52	99
1977	1.012	0.563	1.462	1.173	0.765	1.801	0.259	0.159	0.360	0.283	0.188	0.427	3.594	10	31	66	63.4	93	106	61	37	107
1978	0.626	0.340	0.913	0.979	0.638	1.503	0.141	0.095	0.186	0.216	0.143	0.325	4.014	15	19	73	65.5	89	92	37	30	113
1979	0.893	0.274	1.513	1.104	0.719	1.694	0.144	0.102	0.185	0.219	0.145	0.330	4.652	12	14	67	62.5	100	118	48	40	139
1980	1.622	0.787	2.458	1.434	0.935	2.201	0.379	0.270	0.488	0.294	0.195	0.443	3.748	17	22	43	53.3	98	107	84	38	85
1981	1.744	0.913	2.576	1.716	1.118	2.633	0.376	0.282	0.470	0.333	0.221	0.502	4.444	11	21	52	57.7	95	120	95	42	87
1982	3.015	1.273	4.758	2.030	1.322	3.115	0.346	0.155	0.536	0.348	0.230	0.524	8.594	25	36	61	68.8	105	108	33	22	92
1983	1.587	0.530	2.643	1.840	1.199	2.824	0.418	0.191	0.645	0.364	0.242	0.550	3.663	12	13	49	49.9	96	112	34	22	90
1984	1.696	0.596	2.796	1.842	1.201	2.827	0.328	0.181	0.474	0.348	0.231	0.525	4.732	17	19	62	60.8	93	100	26	19	86
1985	2.113	1.094	3.133	1.951	1.271	2.993	0.346	0.199	0.492	0.347	0.230	0.524	6.122	13	13	68	66.9	104	108	25	21	81
1986	2.165	0.951	3.378	1.957	1.275	3.003	0.340	0.200	0.481	0.347	0.230	0.524	6.244	11	14	63	65.4	109	121	30	22	90
1987	1.728	0.726	2.730	1.834	1.195	2.815	0.245	0.138	0.352	0.352	0.233	0.530	7.052	16	16	66	64.2	99	100	21	16	83
1988	2.111	0.906	3.315	1.790	1.166	2.747	0.610	0.398	0.822	0.454	0.301	0.685	3.343	10	20	49	49.8	89	110	43	26	90
1989	1.631	0.611	2.650	1.563	1.018	2.399	0.625	0.321	0.929	0.481	0.319	0.725	2.590	10	11	40	43.2	80	94	48	24	85
1990	1.005	0.366	1.643	1.327	0.864	2.036	0.282	0.157	0.406	0.427	0.283	0.644	3.587	15	18	47	49.1	106	107	25	17	90
1991	1.827	0.478	3.175	1.357	0.884	2.083	0.592	0.374	0.811	0.502	0.333	0.757	2.723	12	15	35	42.3	78	100	48	28	86
1992	0.890	-0.217	1.997	1.137	0.741	1.746	0.492	0.158	0.825	0.528	0.350	0.796	1.793	16	17	35	40.6	82	101	36	20	83
1993	1.162	0.693	1.630	1.124	0.732	1.725	0.684	0.475	0.893	0.581	0.385	0.877	1.695	10	11	44	41.0	71	90	59	27	87
1994	0.948	0.376	1.520	1.086	0.708	1.667	0.452	0.275	0.629	0.574	0.380	0.865	2.159	10	13	40	41.0	83	89	45	24	88
1995	1.713	0.789	2.638	1.151	0.750	1.767	0.984	0.662	1.305	0.665	0.441	1.003	1.817	15	16	33	39.9	73	97	83	39	88
1996	1.006	0.449	1.563	0.933	0.608	1.434	0.668	0.344	0.992	0.593	0.393	0.895	1.466	15	17	41	43.0	60	70	49	20	82
1997	0.532	0.146	0.918	0.720	0.467	1.109	0.339	0.158	0.520	0.488	0.322	0.738	1.595	9	9	36	39.4	75	89	34	19	89
1998	0.444	0.187	0.701	0.680	0.435	1.063	0.414	0.288	0.540	0.512	0.333	0.786	1.065	11	11	19	31.3	67	78	46	33	115
1999	1.202	0.625	1.780	0.855	0.510	1.432	0.824	0.547	1.102	0.620	0.378	1.017	1.389	9	14	31	35.5	71	97	62	33	87

Table B13. Stratified mean number and length (cm) per tow for goosefish from NEFSC summer scallop surveys in the Northern Georges Bank region (shellfish strata 49-54,65-68,71-72); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and the total number of tows completed in each year.

	Abundance						Length						Number of Fish	Number of Nonzero Tows	Number of Tows
	Raw Index			Smoothed											
	Mean	L95%	U95%	Mean	L95%	U95%	Min	5%	50%	Mean	95%	Max			
1984	0.542	0.353	0.731	0.623			34	37	56	62.9	90	115	53	34	86
1985	0.843	0.531	1.155	0.684			25	39	50	54.1	82	98	86	36	85
1986	0.721	0.427	1.016	0.652			18	22	53	57.0	88	97	89	41	98
1987	0.383	0.225	0.541	0.580	0.403	0.836	14	14	51	51.2	84	101	43	29	96
1988	0.536	0.361	0.712	0.683	0.475	0.984	23	24	51	56.1	88	96	59	38	98
1989	1.566	0.641	2.491	0.947	0.658	1.363	15	27	46	47.4	65	96	83	28	60
1990	0.765	0.431	1.099	0.936	0.650	1.347	12	16	51	47.1	67	81	64	38	84
1991	1.033	0.675	1.391	1.059	0.735	1.524	8	11	27	33.9	70	90	111	48	99
1992	1.340	1.025	1.654	1.218	0.846	1.753	8	16	37	37.9	59	91	135	51	96
1993	1.278	0.829	1.726	1.313	0.912	1.891	9	9	18	25.9	56	79	154	47	87
1994	1.475	1.029	1.921	1.442	1.002	2.077	13	14	27	34.3	64	93	191	53	99
1995	2.190	1.473	2.906	1.561	1.083	2.249	11	19	37	38.2	59	86	241	64	98
1996	1.449	0.935	1.963	1.345	0.931	1.943	12	18	42	41.6	66	80	155	53	94
1997	0.900	0.611	1.188	1.102	0.753	1.613	19	30	49	50.9	73	100	114	54	110
1998	0.942	0.678	1.207	1.035	0.667	1.605	13	18	44	45.1	75	89	103	47	96
1999	0.000	0.000	0.000				-			-		-		0	1

Table B14. Stratified mean weight (kg), number, and length (cm) per tow for goosefish from ASMFC summer shrimp surveys in the Gulf of Maine region (shrimp strata 1-12); confidence limits for indices; minimum and maximum lengths; number of fish caught, number of positive tows, and number of tows completed. Note: From 1986-1990, goosefish were not always identified to species.

	Biomass Raw Index			Abundance Raw Index				Length						Number of Fish	Number of Nonzero Tows	Number of Tows
	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max			
1986	2.111	1.157	3.064	0.800	0.313	1.287	2.619	14	14	50	46.6	83	85	29	11	54
1987	7.252	2.529	11.975	2.082	1.266	2.897	2.547	10	10	31	39.8	81	110	117	43	57
1988																43
1989	0.739	0.293	1.185	0.880	0.200	1.561	0.847	13	13	28	30.0	62	72	37	16	49
1990	1.788	0.650	2.927	0.841	0.396	1.285	2.233	9	11	43	41.4	83	97	40	29	47
1991	1.714	1.005	2.422	2.730	1.981	3.479	0.615	9	10	22	26.4	56	96	157	47	55
1992	3.261	1.877	4.645	3.300	2.540	4.061	0.937	5	12	28	30.7	56	97	180	49	55
1993	3.131	1.422	4.840	4.103	1.854	6.352	0.730	7	10	18	26.6	56	102	195	48	53
1994	1.677	0.886	2.468	3.314	2.338	4.291	0.517	5	11	19	24.5	53	95	168	39	47
1995	1.637	0.729	2.544	2.087	1.216	2.958	0.747	11	19	26	31.2	67	76	83	24	35
1996	3.633	1.583	5.684	3.392	2.236	4.457	1.044	13	14	34	33.9	52	90	126	32	34
1997	2.081	1.040	3.122	1.583	1.073	2.093	1.321	11	16	32	37.7	62	73	72	31	40
1998	2.104	0.738	3.469	2.083	1.426	2.741	0.996	12	15	23	30.6	61	77	92	33	39
1999	5.675	4.362	6.989	6.553	5.040	8.067	0.883	8	9	28	30.5	64	82	315	42	45

Table B15. Indices of abundance (number per tow) of goosefish 10-20 cm TL from NEFSC research surveys.

	Northern Area				Southern Area			
Year	Spring	Autumn	Scallop	Shrimp	Spring	Autumn	Scallop	Winter
63		0.12				0.11		
64		0.00				0.07		
65		0.00				0.09		
66		0.00				0.19		
67		0.00				0.05		
68	0.00	0.01			0.00	0.02		
69	0.00	0.01			0.00	0.05		
70	0.00	0.00			0.00	0.04		
71	0.00	0.02			0.02	0.06		
72	0.03	0.00			0.01	0.96		
73	0.01	0.03			0.05	0.20		
74	0.01	0.03			0.02	0.02		
75	0.02	0.02			0.01	0.05		
76	0.03	0.00			0.01	0.02		
77	0.01	0.00			0.01	0.04		
78	0.01	0.02			0.05	0.03		
79	0.01	0.02			0.05	0.12		
80	0.01	0.03			0.01	0.03		
81	0.02	0.02			0.03	0.09		
82	0.00	0.00	0.00		0.09	0.09	0.11	
83	0.05	0.03	0.02		0.00	0.12	0.89	
84	0.03	0.02	0.00		0.00	0.05	0.34	
85	0.02	0.03	0.00		0.00	0.08	0.28	
86	0.02	0.02	0.03		0.01	0.05	0.65	
87	0.01	0.03	0.03		0.01	0.22	1.97	
88	0.03	0.02	0.00		0.03	0.00	0.10	
89	0.11	0.09	0.01		0.01	0.05	0.28	
90	0.03	0.22	0.09		0.01	0.09	0.75	
91	0.10	0.07	0.23	0.92	0.02	0.21	1.38	
92	0.06	0.11	0.10	0.68	0.02	0.08	0.63	0.15
93	0.14	0.42	0.63	2.02	0.02	0.11	1.75	0.19
94	0.08	0.68	0.31	1.60	0.02	0.21	1.88	0.25
95	0.16	0.06	0.17	0.24	0.01	0.19	0.50	0.06
96	0.04	0.05	0.13	0.85	0.01	0.02	0.80	0.08
97	0.02	0.11	0.00	0.21	0.01	0.03	0.10	0.16
98	0.21	0.13	0.12	0.65	0.06	0.09	0.43	0.07
99	0.18	0.47		1.80	0.02	0.12	1.33	0.20

Table B16. Stratified delta mean number per tow at age for goosefish from NEFSC offshore autumn bottom trawl surveys.

	Age										
Year	0	1	2	3	4	5	6	7	8	9	Total
North: NEFSC offshore strata 20-30, 34-40											
1994	0.065	0.560	0.287	0.208	0.086	0.089	0.019	0.024	0.011	0.000	1.351
1995	0.000	0.059	0.163	0.285	0.234	0.092	0.021	0.014	0.054	0.000	0.922
1996	0.012	0.048	0.062	0.152	0.206	0.093	0.034	0.011	0.012	0.000	0.630
1997	0.039	0.094	0.016	0.122	0.136	0.052	0.031	0.000	0.007	0.000	0.498
1998	0.000	0.116	0.150	0.090	0.048	0.052	0.135	0.018	0.000	0.000	0.609
1999	0.192	0.310	0.292	0.179	0.015	0.033	0.020	0.040	0.003	0.000	1.084
South: NEFSC offshore strata 1-19, 61-76											
1994	0.015	0.095	0.295	0.056	0.066	0.036	0.021	0.007	0.008	0.000	0.598
1995	0.000	0.102	0.151	0.120	0.053	0.049	0.017	0.000	0.000	0.000	0.493
1996	0.000	0.007	0.030	0.054	0.059	0.060	0.026	0.000	0.000	0.000	0.235
1997	0.017	0.008	0.041	0.055	0.035	0.105	0.031	0.016	0.000	0.000	0.308
1998	0.000	0.070	0.072	0.037	0.059	0.044	0.034	0.008	0.008	0.000	0.332
1999	0.005	0.101	0.172	0.118	0.040	0.014	0.000	0.000	0.000	0.000	0.450

Table B17. Mean lengths (cm) at age for goosefish from NEFSC offshore autumn bottom trawl surveys.

North: NEFSC offshore strata 20-30, 34-40

Year	0	1	2	3	4	5	6	7	8
1994	9.5	14.2	21.8	30.9	42.8	53.4	64.0	68.9	98.0
1995		10.0	25.4	32.2	41.2	50.7	65.4	78.2	87.0
1996	8.0	12.9	23.9	35.2	42.2	54.2	60.4	82.0	95.0
1997	9.0	12.4	28.0	34.7	43.3	54.4	67.4		86.0
1998		13.0	25.6	33.2	43.4	51.4	63.4	76.6	
1999	10.4	15.1	26.9	36.0	40.6	56.5	60.1	73.3	79.0
Mean		12.9	25.3	33.7	42.2	53.4	63.4	75.8	89.0

South: NEFSC offshore strata 1-19, 61-76

Year	0	1	2	3	4	5	6		8
1994	8.2	14.9	23.3	34.5	44.5	52.0	60.3		83.0
1995		14.5	21.1	34.0	40.8	52.2	65.0		
1996		18.0	22.6	33.1	44.5	51.8	64.7		
1997	9.5	11.0	24.8	35.4	47.8	54.4	64.4	71.0	
1998		14.0	21.9	32.3	45.1	54.0	62.7	72.0	87.0
1999		17.1	25.1	36.1	46.6	55.0			
Mean		14.9	23.1	34.2	44.9	53.2	63.4	71.5	85.0

Table 18. Stratified mean weight (kg), number, individual fish weight, and length (cm) per tow for goosefish from NEFSC offshore autumn research vessel bottom trawl surveys in the Southern Georges Bank to Mid-Atlantic region (1-19, 61-76); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and total number of tows completed in each year.

	Biomass						Abundance													Number	Number of	
	Raw Index			Smoothed			Raw Index			Smoothed				Length						of	Nonzero	Number
	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max	Fish	Tows	of Tows
1963	3.724	1.786	5.663	4.168			1.257	0.745	1.769	1.304			2.926	7	17	53	50.4	91	97	102	36	73
1964	5.486	3.391	7.581	4.496			1.636	0.907	2.366	1.337			3.467	14	21	53	52.0	86	101	132	34	83
1965	5.163	2.731	7.594	4.242			1.148	0.778	1.519	1.197			4.199	10	15	59	56.3	91	104	83	39	85
1966	6.986	4.936	9.037	3.507	2.040	6.029	1.926	1.364	2.488	1.102	0.625	1.942	3.563	7	7	51	49.6	87	98	101	56	87
1967	1.122	0.588	1.655	1.825	1.061	3.137	0.519	0.324	0.715	0.697	0.395	1.228	2.173	14	19	31	40.6	83	100	98	42	163
1968	0.850	0.413	1.287	1.316	0.766	2.263	0.399	0.206	0.591	0.537	0.305	0.947	2.131	12	17	45	46.3	75	86	77	39	164
1969	1.138	0.483	1.793	1.275	0.741	2.191	0.497	0.281	0.714	0.505	0.287	0.891	2.273	10	14	41	45.4	88	96	101	43	163
1970	1.357	0.512	2.203	1.332	0.775	2.289	0.350	0.235	0.466	0.481	0.273	0.848	3.566	4	13	55	53.3	84	104	58	35	161
1971	0.786	0.196	1.377	1.374	0.799	2.362	0.282	0.150	0.414	0.567	0.322	0.999	2.813	5	8	39	42.3	95	98	55	28	168
1972	4.918	3.295	6.541	2.062	1.200	3.545	4.113	1.281	6.944	1.067	0.606	1.882	1.298	12	16	23	31.8	74	99	604	85	161
1973	1.986	0.994	2.978	1.726	1.004	2.966	1.176	0.857	1.494	0.812	0.461	1.431	1.568	13	14	32	37.7	77	93	280	70	154
1974	0.710	0.322	1.098	1.314	0.764	2.258	0.218	0.116	0.320	0.482	0.273	0.849	3.277	14	16	54	52.9	81	101	56	26	153
1975	2.043	1.326	2.759	1.512	0.880	2.600	0.653	0.434	0.871	0.486	0.276	0.857	3.030	8	17	45	46.3	87	105	127	51	158
1976	1.084	0.539	1.630	1.422	0.827	2.445	0.314	0.189	0.438	0.403	0.229	0.710	3.166	11	11	51	50.7	77	95	60	34	165
1977	1.873	1.192	2.554	1.605	0.934	2.760	0.372	0.265	0.479	0.395	0.224	0.696	5.024	5	16	55	53.1	95	106	94	50	172
1978	1.395	0.883	1.906	1.633	0.950	2.807	0.259	0.178	0.340	0.403	0.228	0.710	5.384	13	17	61	56.5	87	101	68	39	219
1979	2.275	1.278	3.272	1.847	1.074	3.175	0.694	0.483	0.905	0.553	0.314	0.974	2.779	7	16	34	40.5	84	109	182	70	205
1980	1.868	1.166	2.570	1.816	1.056	3.122	0.726	0.427	1.025	0.651	0.369	1.148	2.664	3	16	34	41.6	85	104	113	42	159
1981	2.858	0.883	4.834	1.752	1.019	3.012	0.965	0.578	1.352	0.714	0.405	1.258	2.363	6	17	38	40.7	71	99	176	59	146
1982	0.646	0.350	0.941	1.217	0.708	2.092	0.610	0.373	0.847	0.638	0.362	1.125	1.060	13	15	26	32.5	66	73	98	42	143
1983	2.150	0.693	3.608	1.294	0.753	2.224	0.776	0.470	1.080	0.589	0.334	1.037	2.304	7	16	45	44.4	72	100	109	49	146
1984	0.740	0.148	1.332	0.977	0.569	1.680	0.311	0.114	0.508	0.451	0.256	0.794	2.445	5	13	47	45.7	68	93	42	25	146
1985	1.318	0.752	1.884	0.890	0.518	1.530	0.524	0.356	0.692	0.443	0.251	0.781	2.444	17	17	40	42.0	72	96	100	46	145
1986	0.552	0.237	0.867	0.622	0.362	1.070	0.325	0.169	0.481	0.389	0.221	0.686	1.681	7	14	34	37.6	68	78	60	33	146
1987	0.274	0.117	0.432	0.472	0.275	0.811	0.482	0.307	0.657	0.386	0.219	0.680	0.575	12	13	20	25.0	56	61	67	27	132
1988	0.554	0.210	0.899	0.515	0.300	0.885	0.230	0.097	0.364	0.329	0.186	0.579	2.391	19	27	36	45.1	87	91	27	19	129
1989	0.625	0.278	0.972	0.535	0.311	0.919	0.382	0.181	0.583	0.356	0.202	0.627	1.646	7	7	42	38.0	57	77	57	23	129
1990	0.426	0.017	0.834	0.500	0.291	0.859	0.294	0.113	0.474	0.367	0.208	0.647	1.265	9	13	24	33.1	61	81	47	22	136
1991	0.783	0.206	1.360	0.521	0.303	0.895	0.690	0.245	1.136	0.440	0.250	0.775	1.085	14	15	23	30.8	57	81	106	27	131
1992	0.312	0.170	0.454	0.412	0.240	0.708	0.342	0.220	0.463	0.389	0.221	0.686	0.919	8	11	30	32.2	54	74	46	21	129
1993	0.294	0.055	0.532	0.393	0.228	0.675	0.290	0.135	0.445	0.376	0.213	0.663	0.944	10	13	32	30.4	52	68	46	24	130
1994	0.611	0.175	1.047	0.455	0.265	0.782	0.598	0.344	0.852	0.433	0.245	0.763	0.906	8	12	25	29.2	59	83	85	31	135
1995	0.386	0.160	0.612	0.432	0.251	0.744	0.493	0.258	0.728	0.400	0.227	0.706	0.777	11	13	25	29.4	54	66	72	29	129
1996	0.387	0.214	0.560	0.443	0.257	0.766	0.235	0.131	0.338	0.322	0.181	0.570	1.638	18	19	42	42.3	62	68	31	21	131
1997	0.592	0.325	0.858	0.498	0.283	0.878	0.308	0.186	0.430	0.319	0.177	0.577	1.914	9	9	49	44.6	70	71	43	24	131
1998	0.500	0.226	0.774	0.499	0.260	0.958	0.332	0.146	0.519	0.324	0.164	0.642	1.525	11	11	36	37.0	68	87	45	20	131
1999	0.304	0.167	0.441				0.450	0.289	0.612				0.672	14		27			52	109	44	106

Table B19. Stratified mean weight (kg), number, individual fish weight, and length (cm) per tow for goosefish from NEFSC offshore spring research vessel bottom trawl surveys in the Southern Georges Bank to Mid-Atlantic region (1-19, 61-76); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and total number of tows completed in each year.

	Biomass						Abundance							Length							Number of Fish	Number of Nonzero Tows	Number of Tows
	Raw Index			Smoothed			Raw Index			Smoothed													
	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max				
1968	1.142	0.552	1.731	1.067			0.211	0.126	0.297	0.216			5.344	21	23	63	62.5	94	95	65	31	150
1969	0.938	0.427	1.448	1.020			0.221	0.138	0.305	0.220			4.064	7	25	47	54.3	91	111	41	31	155
1970	1.005	0.460	1.549	1.031			0.175	0.103	0.247	0.223			5.699	22	22	65	63.9	102	108	40	31	166
1971	0.762	0.313	1.211	1.061	0.673	1.673	0.204	0.104	0.304	0.265	0.170	0.412	3.675	13	16	50	53.3	101	115	42	24	160
1972	1.883	1.161	2.604	1.364	0.865	2.151	0.371	0.272	0.469	0.375	0.241	0.584	5.071	14	22	59	59.1	103	123	79	48	165
1973	1.857	1.494	2.220	1.412	0.895	2.226	1.051	0.854	1.249	0.536	0.344	0.834	1.744	11	19	32	41.1	80	110	589	128	187
1974	1.129	0.728	1.530	1.215	0.770	1.916	0.486	0.368	0.604	0.486	0.313	0.757	2.367	14	21	44	49.1	93	117	201	70	132
1975	0.936	0.562	1.310	1.098	0.696	1.732	0.447	0.326	0.568	0.442	0.284	0.687	2.044	10	22	44	47.6	87	107	169	61	134
1976	1.209	0.833	1.585	1.105	0.701	1.743	0.403	0.307	0.500	0.398	0.256	0.619	2.777	13	22	48	51.5	91	110	259	78	162
1977	1.205	0.754	1.657	1.048	0.664	1.652	0.302	0.232	0.372	0.355	0.228	0.552	3.803	16	21	51	56.8	95	116	173	75	160
1978	0.735	0.512	0.959	0.904	0.573	1.425	0.335	0.265	0.405	0.353	0.227	0.549	2.184	11	17	39	45.9	90	104	196	66	161
1979	0.733	0.441	1.026	0.895	0.568	1.411	0.281	0.164	0.397	0.364	0.234	0.566	2.589	10	14	37	44.4	98	124	125	50	194
1980	0.799	0.494	1.104	1.013	0.643	1.598	0.451	0.354	0.548	0.446	0.287	0.694	1.636	18	21	34	40.8	83	106	346	99	204
1981	1.816	1.145	2.486	1.346	0.854	2.123	0.784	0.540	1.029	0.544	0.349	0.846	2.259	12	22	40	44.6	89	113	345	74	141
1982	2.803	1.584	4.021	1.463	0.928	2.308	0.942	0.657	1.226	0.517	0.333	0.805	2.800	11	14	38	42.4	89	104	251	68	150
1983	0.955	0.421	1.489	1.027	0.652	1.620	0.270	0.176	0.365	0.329	0.212	0.512	3.514	24	24	47	51.8	97	112	55	36	147
1984	0.747	0.223	1.272	0.758	0.481	1.195	0.182	0.090	0.274	0.239	0.154	0.372	4.067	21	21	47	50.9	96	97	35	22	149
1985	0.327	0.089	0.565	0.564	0.358	0.890	0.159	0.072	0.247	0.209	0.134	0.325	2.052	22	22	39	42.3	85	90	31	21	147
1986	0.823	0.342	1.303	0.606	0.384	0.955	0.283	0.125	0.442	0.219	0.141	0.341	2.917	15	24	43	48.7	90	102	65	36	149
1987	0.496	-0.014	1.007	0.529	0.336	0.835	0.108	0.054	0.162	0.194	0.124	0.301	4.612	15	15	59	52.7	102	103	30	21	150
1988	0.427	0.264	0.590	0.483	0.306	0.762	0.440	0.280	0.601	0.253	0.163	0.394	0.971	17	18	30	34.0	61	82	67	33	132
1989	0.365	0.122	0.608	0.479	0.304	0.756	0.202	0.097	0.306	0.229	0.147	0.356	1.807	15	24	41	41.4	69	79	36	18	129
1990	1.005	0.431	1.579	0.571	0.362	0.901	0.205	0.099	0.311	0.224	0.144	0.349	4.861	16	21	53	56.5	86	93	39	23	128
1991	0.582	0.236	0.927	0.466	0.296	0.735	0.319	0.142	0.495	0.234	0.150	0.364	1.819	15	23	33	37.6	69	101	61	31	132
1992	0.210	0.067	0.353	0.328	0.208	0.517	0.177	0.089	0.266	0.198	0.127	0.308	1.235	14	19	28	35.0	69	85	28	17	128
1993	0.264	0.097	0.431	0.311	0.197	0.490	0.195	0.096	0.295	0.180	0.116	0.280	1.319	17	19	38	38.6	56	72	29	18	128
1994	0.321	0.117	0.525	0.329	0.208	0.518	0.114	0.057	0.172	0.156	0.100	0.242	2.866	13	13	41	43.8	91	93	24	18	131
1995	0.526	0.031	1.021	0.354	0.224	0.558	0.196	0.100	0.292	0.166	0.107	0.259	2.637	18	19	38	45.7	80	81	32	20	129
1996	0.284	0.112	0.457	0.291	0.184	0.459	0.135	0.070	0.200	0.159	0.102	0.247	2.083	9	9	44	43.7	80	81	27	20	143
1997	0.132	0.035	0.228	0.243	0.154	0.385	0.124	0.050	0.198	0.168	0.108	0.263	1.064	18	18	37	35.9	58	75	38	14	130
1998	0.282	0.157	0.407	0.307	0.191	0.494	0.254	0.164	0.344	0.220	0.139	0.349	1.110	12	16	35	35.9	64	77	40	30	131
1999	0.629	0.342	0.916	0.409	0.237	0.709	0.335	0.217	0.453	0.260	0.153	0.443	1.899	16	19	41	42.8	74	94	63	32	131

Table B20. Stratified mean weight (kg), number, individual fish weight, and length (cm) per tow for goosefish from NEFSC winter flatfish surveys in the Southern Georges Bank to Mid-Atlantic region (1-19, 61-76); confidence limits for indices; minimum and maximum lengths; number of fish caught, number of positive tows, and total number of tows completed.

	Biomass Raw Index			Abundance Raw Index				Length						Number of Fish	Number of Nonzero Tows	Number of Tows
	Mean	L95%	U95%	Mean	L95%	U95%	Ind wt	Min	5%	50%	Mean	95%	Max			
1992	5.395	3.515	7.275	5.176	3.665	6.687	0.986	11	22	34	36.0	52	95	583	66	110
1993	6.317	4.565	8.070	5.002	3.941	6.062	1.188	9	21	36	37.7	53	98	585	77	109
1994	2.787	1.958	3.617	2.534	1.855	3.212	1.078	8	16	31	35.1	61	78	278	56	82
1995	3.398	2.249	4.457	2.738	1.859	3.617	1.245	19	21	36	37.9	57	101	390	76	123
1996	5.701	4.683	6.720	3.779	3.035	4.523	1.498	10	24	39	41.1	61	100	554	87	123
1997	5.390	3.781	6.998	3.172	2.445	3.900	1.667	10	20	43	42.0	62	91	455	89	119
1998	2.851	2.061	3.641	1.416	1.105	1.726	1.983	10	20	42	44.9	69	103	240	77	134
1999	3.792	2.869	4.715	2.803	2.183	3.423	1.340	10	18	35	38.3	61	87	459	83	138
2000	5.539	4.225	6.854	4.115	3.184	5.047	1.346	11	22	37	38.7	57	96	661	93	124

Table B21. Stratified mean number and length (cm) per tow for goosefish from NEFSC summer scallop surveys in the Southern Georges Bank to Mid-Atlantic region (shellfish strata 1-48,55-64,69-70,73-74); confidence limits for both the raw index and the indices smoothed using an integrated moving average (theta = 0.45); minimum and maximum lengths; number of fish caught, number of positive tows, and the total number of tows completed in each year.

	Abundance						Length						Number of Fish	Number of Nonzero Tows	Number of Tows
	Raw Index			Smoothed											
	Mean	L95%	U95%	Mean	L95%	U95%	Min	5%	50%	Mean	95%	Max			
1984	1.068	0.911	1.225	1.111			6	12	28	30.6	60	82	523	232	389
1985	1.073	0.921	1.226	1.141			7	10	30	32.8	64	113	594	234	404
1986	0.934	0.714	1.155	1.221			8	10	16	22.1	53	95	465	203	371
1987	2.418	1.927	2.909	1.564	1.102	2.219	8	9	13	18.7	51	90	1429	313	433
1988	1.444	1.182	1.705	1.494	1.053	2.120	7	12	29	30.3	49	97	725	234	435
1989	1.241	1.078	1.405	1.461	1.029	2.073	6	10	34	33.7	54	101	373	175	352
1990	1.401	1.222	1.580	1.594	1.123	2.262	6	10	18	25.6	57	94	579	211	342
1991	2.216	1.935	2.496	1.896	1.336	2.691	7	9	14	21.0	45	94	809	242	323
1992	1.877	1.608	2.146	2.032	1.432	2.884	5	9	25	27.3	52	97	644	235	324
1993	2.639	2.387	2.892	2.298	1.619	3.261	8	10	15	22.4	49	79	1012	270	325
1994	3.095	2.738	3.452	2.366	1.667	3.358	8	10	15	22.5	51	87	1151	271	338
1995	2.093	1.826	2.361	2.035	1.434	2.888	7	9	28	30.0	58	92	776	252	338
1996	1.814	1.580	2.048	1.717	1.209	2.438	7	9	24	29.9	59	81	639	227	307
1997	1.046	0.904	1.188	1.395	0.980	1.987	7	13	33	37.2	65	76	398	204	336
1998	0.958	0.827	1.089	1.377	0.955	1.985	6	11	22	31.5	63	79	380	188	339
1999	2.441	2.047	2.835	1.733	1.137	2.642	6	9	17	24.6	60	84	859	250	311

ıble B22. Indices of egg production of goosefish 1967-1999 by region. Egg production index is a function of numbers at length, proportion mature at length, and fecundity at length, pooled over a 5-year interval. Proportion < L_{99} is proportion of egg production generated by fish smaller than the length at 99% maturity.
Maturity rates from NEFSC (1992).

Year	North Spring EPI	North Spring P < L_{99}	North Autumn EPI	North Autumn P < L_{99}	South Spring EPI	South Spring P < L_{99}	South Autumn EPI	South Autumn P < L_{99}
1967			1.46	0.01			2.18	0.03
1968			1.23	0.00			1.86	0.03
1969			1.46	0.00			1.48	0.03
1970			1.41	0.00			1.11	0.03
1971			1.37	0.00			0.53	0.05
1972	1.15	0.01	1.39	0.01	0.63	0.02	0.86	0.04
1973	1.31	0.01	1.54	0.01	0.72	0.03	0.94	0.04
1974	1.40	0.01	1.33	0.01	0.77	0.04	0.89	0.04
1975	1.28	0.01	1.27	0.01	0.76	0.05	0.93	0.05
1976	1.54	0.01	1.32	0.01	0.81	0.05	0.93	0.04
1977	1.13	0.01	1.69	0.01	0.74	0.05	0.66	0.04
1978	0.94	0.02	1.75	0.01	0.64	0.05	0.61	0.03
1979	0.83	0.01	1.97	0.01	0.58	0.04	0.68	0.03
1980	0.88	0.01	2.19	0.01	0.54	0.04	0.64	0.03
1981	0.71	0.02	1.99	0.01	0.58	0.07	0.70	0.05
1982	0.86	0.01	1.58	0.01	0.63	0.08	0.57	0.07
1983	0.93	0.01	1.28	0.01	0.63	0.08	0.61	0.08
1984	1.00	0.02	1.11	0.01	0.62	0.07	0.53	0.09
1985	1.05	0.01	0.87	0.01	0.57	0.08	0.48	0.10
1986	1.12	0.01	0.92	0.02	0.48	0.06	0.38	0.09
1987	1.00	0.01	0.91	0.02	0.33	0.05	0.36	0.08
1988	1.05	0.01	0.90	0.02	0.26	0.07	0.26	0.07
1989	1.01	0.02	0.73	0.03	0.20	0.13	0.23	0.12
1990	0.88	0.02	0.64	0.04	0.26	0.09	0.17	0.15
1991	0.74	0.03	0.51	0.05	0.22	0.10	0.17	0.16
1992	0.67	0.05	0.52	0.07	0.18	0.13	0.17	0.17
1993	0.56	0.08	0.46	0.08	0.17	0.13	0.13	0.23
1994	0.50	0.08	0.41	0.09	0.18	0.09	0.13	0.19
1995	0.55	0.09	0.47	0.10	0.14	0.12	0.13	0.19
1996	0.49	0.12	0.46	0.12	0.12	0.10	0.11	0.18
1997	0.44	0.13	0.41	0.12	0.12	0.12	0.14	0.14
1998	0.38	0.13	0.40	0.12	0.12	0.10	0.17	0.11
1999	0.40	0.12	0.33	0.12	0.15	0.10	0.14	0.10

Table B23 Total instantaneous mortality rate (Z), goosefish, northern region, 1963-1999; approximate upper and lower 95% confidence intervals (minimum variance estimate); mean length, standard deviation and number of fish at length of capture or above.

	Total Mortality (Z)			Length > 58		
Year	Median	L95% CI	U95%	Mean	SD(mean)	n
1963	0.23	0.17	0.37	79.93	2.31	17
1964	0.25	0.17	0.37	79.61	2.86	5
1965	0.20	0.13	0.28	82.99	2.32	7
1966	0.28	0.19	0.48	77.48	1.82	14
1967	0.42	0.26	0.83	72.75	3.72	2
1968	0.26	0.18	0.42	78.66	4.05	4
1969	0.19	0.13	0.28	83.13	2.45	11
1970	0.30	0.21	0.51	76.46	2.59	5
1971	0.28	0.19	0.45	77.58	2.27	10
1972	0.42	0.26	0.76	73.07	3.22	4
1973	0.17	0.12	0.26	84.77	3.45	8
1974	0.21	0.15	0.32	81.96	3.24	5
1975	0.26	0.17	0.42	78.74	2.57	5
1976	0.21	0.15	0.33	81.26	3.20	8
1977	0.25	0.17	0.39	79.12	2.00	27
1978	0.22	0.15	0.35	80.70	1.67	31
1979	0.19	0.13	0.28	83.22	1.66	30
1980	0.17	0.12	0.26	84.76	2.29	11
1981	0.30	0.21	0.51	76.58	2.49	5
1982	0.27	0.18	0.42	78.27	3.91	12
1983	0.51	0.30	1.17	70.69	3.43	15
1984	0.30	0.21	0.51	76.52	3.31	24
1985	0.32	0.21	0.55	75.78	4.61	13
1986	0.33	0.22	0.59	75.13	2.48	22
1987	0.37	0.25	0.69	73.79	5.45	8
1988	0.27	0.19	0.45	77.98	3.34	13
1989	0.18	0.13	0.27	83.86	4.64	8
1990	0.37	0.23	0.69	74.14	3.32	9
1991	0.48	0.30	1.03	71.21	3.75	12
1992	0.35	0.22	0.64	74.68	2.55	12
1993	0.23	0.16	0.35	80.30	4.15	6
1994	0.39	0.26	0.76	73.14	6.16	6
1995	0.29	0.19	0.48	77.39	3.60	10
1996	0.39	0.17	1.56	73.36	6.91	5
1997	0.64	0.30	2.32	68.80	4.82	4
1998	0.93	0.64	1.56	65.97	1.75	12
1999	0.55	0.35	1.17	69.75	2.92	7

Mean	1970-1979	0.25
	1991-1995	0.35
	1995-1999	0.56

Table B24 Total instantaneous mortality rate (Z), goosefish, southern region, 1963-1999; approximate upper and lower 95% confidence intervals (minimum variance estimate); mean length, standard deviation and number of fish at length of capture or above.

	Total Mortality (Z)			Length > 18		
Year	Median	L95% CI	U95%	Mean	SD(mean)	n
1963						
1964						
1965	0.21	0.17	0.27	58.84	3.62	37
1966	0.22	0.18	0.29	57.59	2.84	78
1967	0.46	0.35	0.71	41.25	4.36	14
1968	0.33	0.25	0.44	48.51	3.70	9
1969	0.33	0.26	0.44	48.42	3.20	19
1970	0.22	0.18	0.29	57.59	2.18	23
1971	0.26	0.21	0.33	53.67	2.91	13
1972	0.77	0.53	1.29	33.93	3.97	83
1973	0.46	0.35	0.71	41.09	2.66	47
1974	0.24	0.19	0.30	55.65	4.17	6
1975	0.33	0.25	0.44	48.50	3.14	26
1976	0.27	0.21	0.35	53.12	3.12	9
1977	0.23	0.18	0.29	56.90	3.19	20
1978	0.22	0.17	0.27	58.60	3.84	9
1979	0.44	0.32	0.61	43.18	3.13	31
1980	0.41	0.32	0.57	43.59	3.08	25
1981	0.46	0.33	0.65	42.11	2.77	36
1982	0.77	0.53	1.29	34.15	1.80	87
1983	0.35	0.27	0.46	47.15	2.50	76
1984	0.27	0.22	0.37	52.26	2.99	31
1985	0.41	0.32	0.61	43.28	2.40	85
1986	0.44	0.33	0.65	42.17	2.98	42
1987	1.14	0.65	2.58	29.79	2.35	40
1988	0.39	0.30	0.53	45.09	4.70	23
1989	0.41	0.32	0.57	43.63	2.18	31
1990	0.53	0.37	0.77	39.86	3.12	32
1991	0.77	0.49	1.29	34.16	2.37	59
1992	0.57	0.41	0.84	38.53	2.59	30
1993	0.65	0.44	1.02	36.57	2.74	22
1994	0.77	0.53	1.29	34.02	2.20	60
1995	0.75	0.49	1.29	34.17	2.14	47
1996	0.44	0.35	0.53	42.98	2.38	30
1997	0.35	0.29	0.41	47.64	2.31	37
1998	0.41	0.32	0.53	44.23	3.03	33
1999	0.92	0.71	1.14	32.04	1.48	48

1970-1979	0.34
1991-1995	0.70
1995-1999	0.57

Table 25. Total instantaneous mortality rate (Z), goosefish, northern region, 1963-1999; approximate upper and lower 95% confidence intervals (minimum variance estimate); mean length, standard deviation and number of fish at length of capture or above.

	Total Mortality (Z)			Length > 29		
Year	Median	L95% CI	U95%	Mean	SD(mean)	n
1963	0.17	0.13	0.21	68.14	2.77	58
1964	0.18	0.13	0.25	65.96	3.99	29
1965	0.13	0.10	0.17	73.44	3.57	29
1966	0.13	0.11	0.15	73.13	2.15	42
1967	0.15	0.12	0.19	70.25	3.05	16
1968	0.11	0.09	0.14	76.71	3.25	22
1969	0.10	0.08	0.12	79.92	2.70	36
1970	0.17	0.13	0.20	67.93	2.62	36
1971	0.15	0.12	0.17	71.26	2.48	42
1972	0.22	0.17	0.30	61.48	3.57	26
1973	0.16	0.12	0.21	68.92	3.43	44
1974	0.13	0.10	0.18	72.52	4.12	26
1975	0.17	0.13	0.22	66.76	3.43	29
1976	0.13	0.10	0.17	73.60	3.57	36
1977	0.14	0.12	0.17	71.85	2.20	78
1978	0.15	0.13	0.17	71.26	1.98	108
1979	0.11	0.09	0.12	78.46	2.01	91
1980	0.16	0.12	0.21	69.07	3.37	47
1981	0.20	0.16	0.25	63.71	2.92	32
1982	0.13	0.10	0.19	72.54	4.34	12
1983	0.27	0.22	0.35	57.14	2.73	34
1984	0.18	0.14	0.22	66.47	3.21	39
1985	0.23	0.17	0.33	60.27	3.90	27
1986	0.22	0.18	0.27	61.48	2.72	43
1987	0.27	0.20	0.39	57.25	3.97	20
1988	0.21	0.16	0.28	62.95	3.80	24
1989	0.28	0.20	0.42	56.47	4.37	23
1990	0.35	0.25	0.55	52.77	3.93	21
1991	0.42	0.30	0.60	50.14	3.21	31
1992	0.42	0.32	0.55	50.00	2.76	35
1993	0.37	0.28	0.55	51.14	3.11	27
1994	0.55	0.39	0.76	46.10	2.75	31
1995	0.59	0.45	0.76	44.99	2.03	66
1996	0.55	0.45	0.69	45.83	1.94	44
1997	0.59	0.45	0.76	45.25	2.17	31
1998	0.42	0.33	0.55	49.84	2.49	34
1999	0.69	0.51	1.03	42.64	2.27	41

Mean	1970-1979	0.15
	1991-1995	0.47
	1995-1999	0.57

Table B26 Total instantaneous mortality rate (Z), goosefish, southern region, 1963-1999; approximate upper and lower 95% confidence intervals (minimum variance estimate); mean length, standard deviation and number of fish at length of capture or above.

Year	Total Mortality (Z)			Length > 29		
	Median	L95% CI	U95%	Mean	SD(mean)	n
1963	0.27	0.24	0.33	59.76	1.97	70
1964	0.33	0.29	0.37	56.62	1.55	117
1965	0.24	0.21	0.29	62.85	2.02	82
1966	0.26	0.23	0.29	61.48	1.54	124
1967	0.37	0.29	0.49	54.05	3.02	48
1968	0.41	0.35	0.49	52.47	1.97	52
1969	0.39	0.32	0.49	52.98	2.38	62
1970	0.26	0.23	0.32	60.87	2.32	46
1971	0.32	0.24	0.44	57.30	3.78	31
1972	0.35	0.30	0.39	55.78	1.30	196
1973	0.57	0.46	0.65	42.72	1.62	112
1974	0.27	0.22	0.37	60.07	3.37	27
1975	0.32	0.27	0.39	56.83	1.95	72
1976	0.35	0.29	0.44	55.39	2.26	45
1977	0.20	0.17	0.25	67.03	2.66	45
1978	0.21	0.18	0.25	66.51	2.33	44
1979	0.35	0.30	0.44	55.25	2.10	80
1980	0.53	0.44	0.71	47.89	1.91	88
1981	0.49	0.44	0.61	48.93	1.52	98
1982	0.71	0.57	0.92	44.23	1.71	41
1983	0.39	0.35	0.46	53.05	1.43	84
1984	0.37	0.30	0.44	54.50	2.18	34
1985	0.44	0.37	0.57	51.22	2.05	53
1986	0.49	0.39	0.65	49.14	2.59	29
1987	0.71	0.49	1.02	44.82	2.89	14
1988	0.57	0.37	0.92	47.66	3.92	26
1989	0.61	0.53	0.71	46.50	1.25	35
1990	0.53	0.39	0.71	48.55	2.82	19
1991	0.57	0.46	0.77	46.92	1.88	35
1992	0.77	0.57	1.02	43.82	2.18	23
1993	0.92	0.71	1.29	41.26	1.91	20
1994	0.65	0.49	0.92	45.18	2.35	29
1995	0.84	0.65	1.14	42.29	1.85	28
1996	0.61	0.46	0.77	46.77	2.09	25
1997	0.46	0.37	0.57	50.78	2.03	33
1998	0.39	0.32	0.53	52.89	2.66	23
1999	1.14	0.84	1.48	39.68	1.51	26

1970-1979	0.32
1991-1995	0.75
1995-1999	0.69

Table B27. Mortality estimates based on NEFSC autumn survey age compositions, 1994-1999.
F estimates assume natural mortality (M)=0.2.

Northern Region

Year	Numbers at Age 2+	3+	4+	Mortality Estimates Z: 2+	Z: 3+	F: 2+	F: 3+
1994	0.725	0.438	0.230	0.03	0.05	-0.17	-0.15
1995	0.863	0.700	0.415	0.53	0.67	0.33	0.47
1996	0.570	0.508	0.357	0.49	0.81	0.29	0.61
1997	0.365	0.348	0.226	0.06	0.32	-0.14	0.12
1998	0.493	0.343	0.253	0.53	1.12	0.33	0.92
1999	0.582	0.290	0.112				
[(1994-95:age t)/(1995-96:age t+1)]				0.27	0.39	0.07	0.19
[(1997-98:age t)/(1998-99:age t+1)]				0.30	0.64	0.10	0.44
[(1994-98:age t)/(1995-99:age t+1)]				0.32	0.54	0.12	0.34

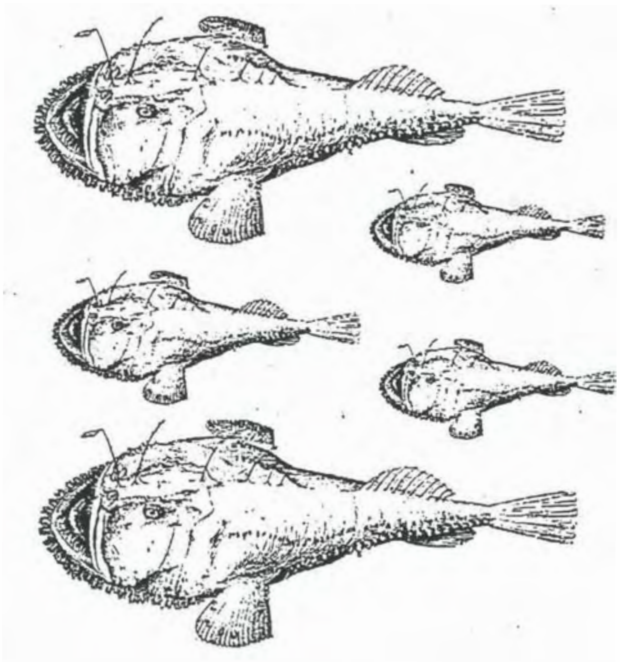
Southern Region

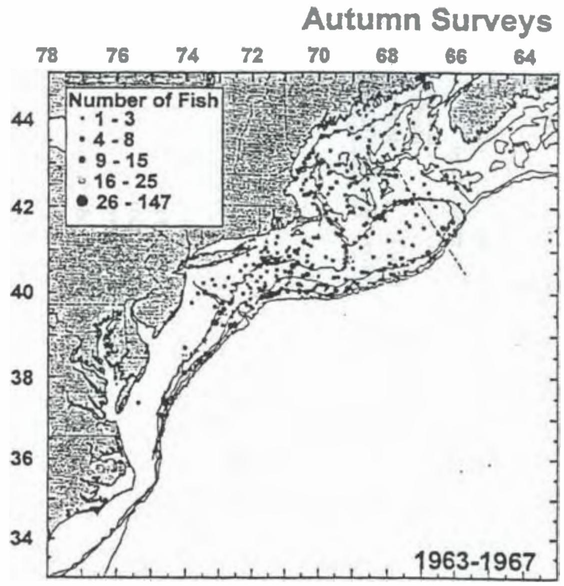
Year	Numbers at Age 2+	3+	4+	Mortality Estimates Z: 2+	Z: 3+	F: 2+	F: 3+
1994	0.489	0.194	0.137	0.71	0.49	0.51	0.29
1995	0.391	0.239	0.119	0.68	0.51	0.48	0.31
1996	0.228	0.198	0.144	-0.06	0.06	-0.26	-0.14
1997	0.283	0.242	0.187	0.39	0.46	0.19	0.26
1998	0.262	0.191	0.153	0.42	1.26	0.22	1.06
1999	0.344	0.172	0.054				
[(1994-95:age t)/(1995-96:age t+1)]				0.70	0.50	0.50	0.30
[(1997-98:age t)/(1998-99:age t+1)]				0.41	0.74	0.21	0.54
[(1994-98:age t)/(1995-99:age t+1)]				0.46	0.48	0.26	0.28

Table B28 Stratified mean catch per tow in weight (kg), 33 rd percentile, three-year moving averages, medians, NEFSC offshore autumn research vessel bottom trawl in northern region (survey strata 20-30, 34-40); and southern region (survey strata 1-19, 61-76); means from delta distribution.

	Northern Management/ Assessment Area				Southern Management/ Assessment Area			
	Mean Weight/To	33rd Percentile 1963-1994 series	Three-year Moving Average	Median, Three-Year Moving Average 1965-1981	Mean Weight/Tow	33rd Percentile 1963-1994 series	Three-Year Moving Average	Median, Three-Yea Moving Average 1965-1981
1963	3.757				3.724			
1964	1.712				5.486			
1965	2.509	1.460	2.659	2.496	5.163	0.750	4.791	1.848
1966	3.266		2.496		6.986		5.878	
1967	1.283		2.353		1.122	1967-1994:	4.423	1967-1981:
1968	2.036		2.195		0.895	0.704	3.001	1.846
1969	3.705		2.341		1.138		1.051	
1970	2.237		2.659		1.357		1.130	
1971	2.914		2.952		0.786		1.094	
1972	1.404		2.185		4.918		2.354	
1973	3.114		2.477		1.986		2.564	
1974	2.063		2.193		0.710		2.538	
1975	1.711		2.296		2.043		1.580	
1976	3.387		2.387		1.084		1.279	
1977	5.568		3.555		1.873		1.667	
1978	5.101		4.685		1.395		1.451	
1979	5.133		5.267		2.275		1.848	
1980	4.458		4.897		1.868		1.846	
1981	1.984		3.859		2.858		2.334	
1982	0.936		2.459		0.646		1.791	
1983	1.617		1.513		2.150		1.885	
1984	3.010		1.855		0.740		1.179	
1985	1.441		2.023		1.318		1.403	
1986	2.353		2.268		0.552		0.870	
1987	0.873		1.556		0.274		0.715	
1988	1.525		1.584		0.554		0.460	
1989	1.384		1.261		0.625		0.485	
1990	1.001		1.303		0.426		0.535	
1991	1.235		1.207		0.783		0.611	
1992	1.102		1.113		0.312		0.507	
1993	1.044		1.127		0.294		0.463	
1994	0.973		1.040		0.611		0.406	
1995	1.711		1.243		0.386		0.430	
1996	1.07		1.252		0.387		0.461	
1997	0.669		1.150		0.592		0.455	
1998	0.974		0.904		0.500		0.493	
1999	0.825		0.823		0.304		0.465	

Goosefish





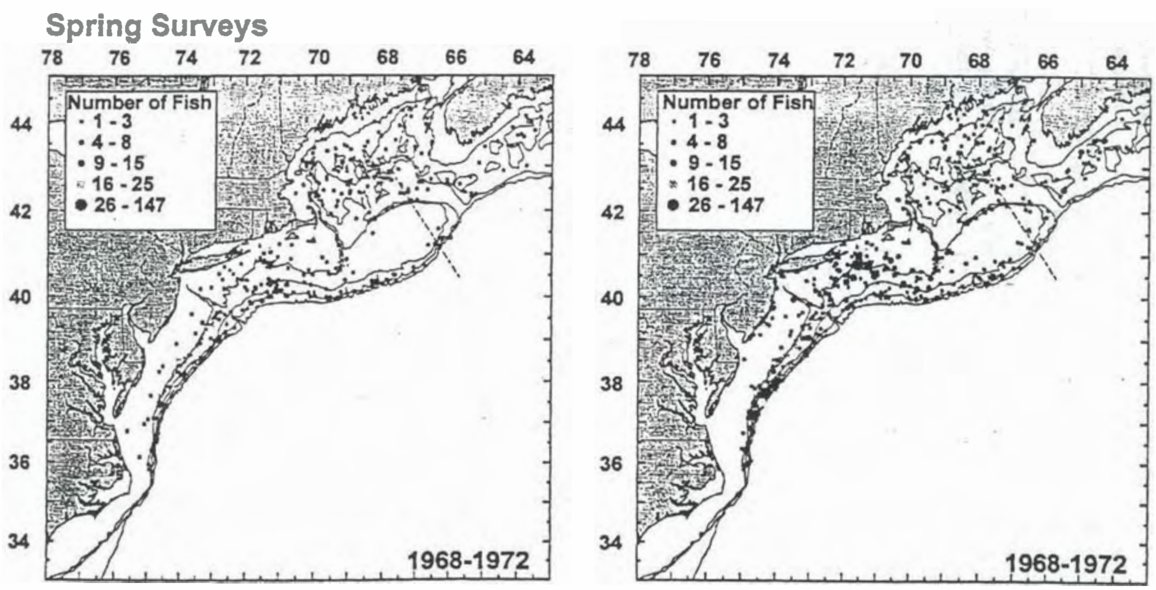


Figure B1. Distribution of goosefish catches in NEFSC autumn and spring bottom trawl surveys, 1963-1972

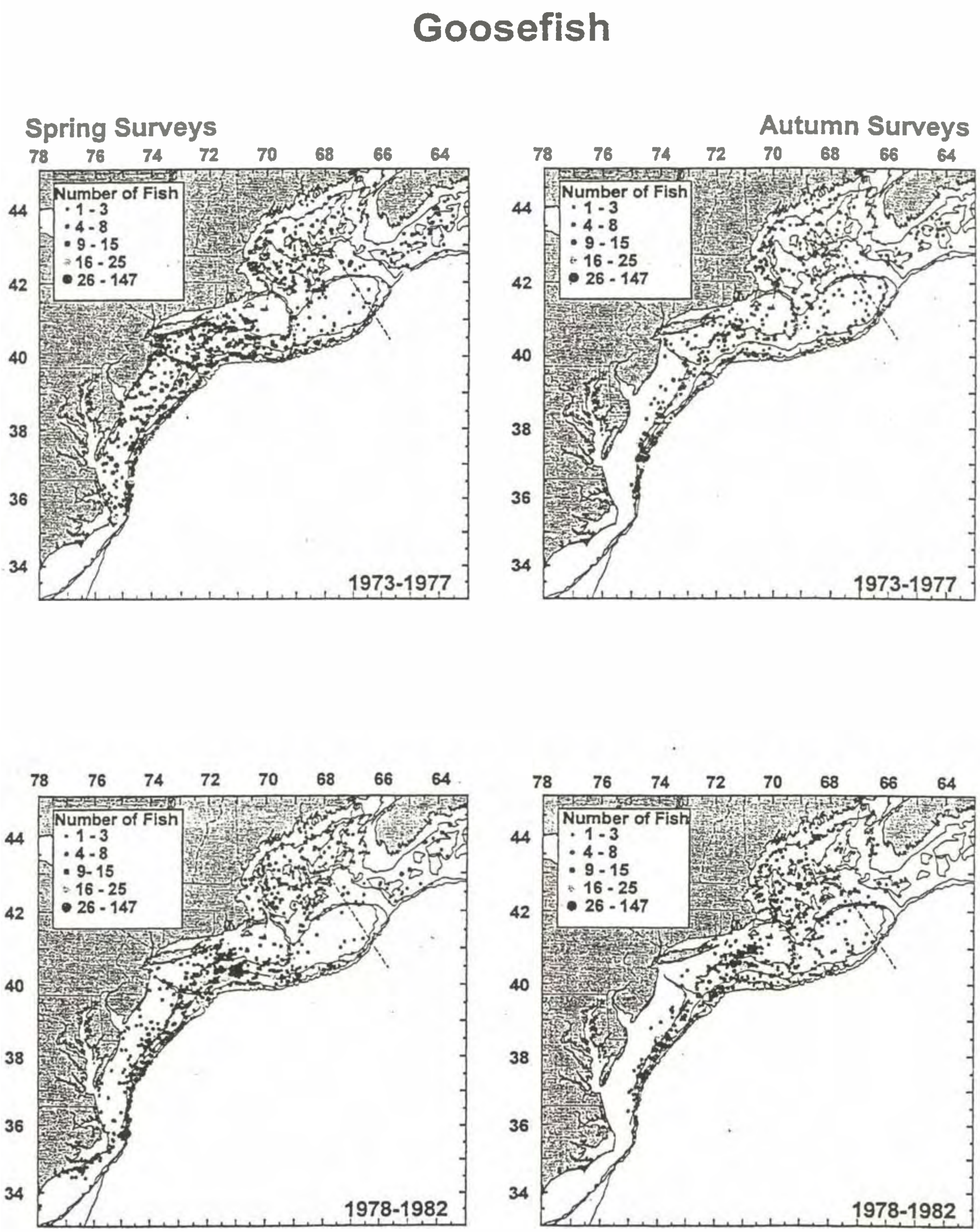


Figure B1 continued. Distribution of goosefish catches in NEFSC autumn and spring bottom trawl surveys, 1973-1982.

Goosefish

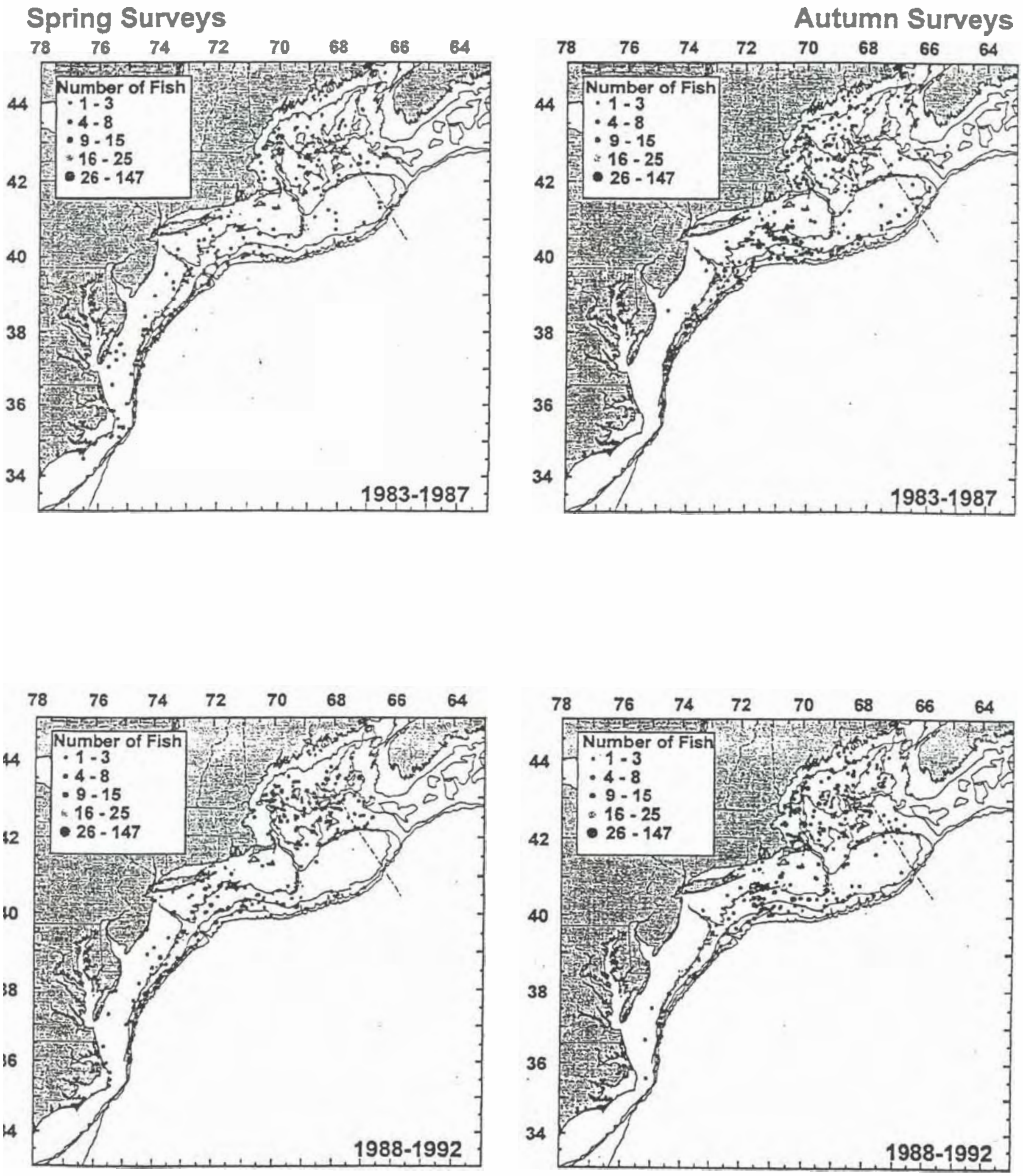


Figure B1 continued. Distribution of goosefish catches in NEFSC autumn and spring bottom trawl surveys, 1983-1992.

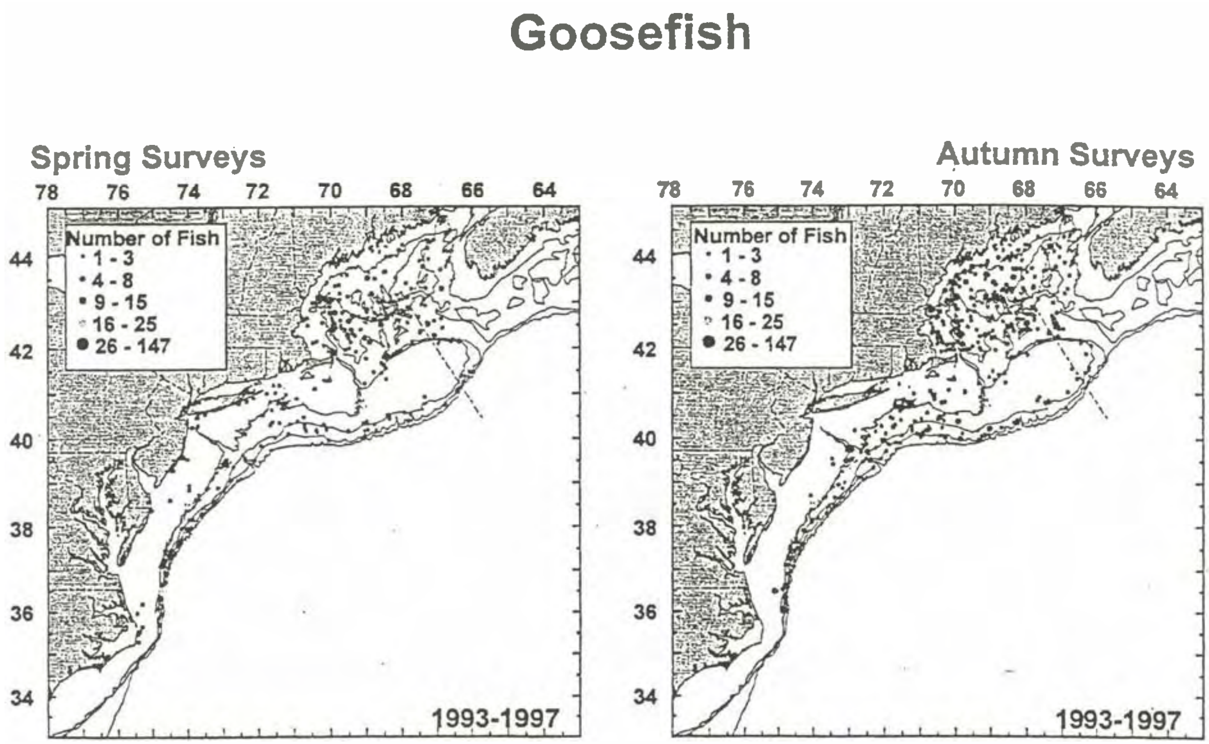


Figure B1 continued. Distribution of goosefish catches in NEFSC autumn and spring bottom trawl surveys, 1993-1997.

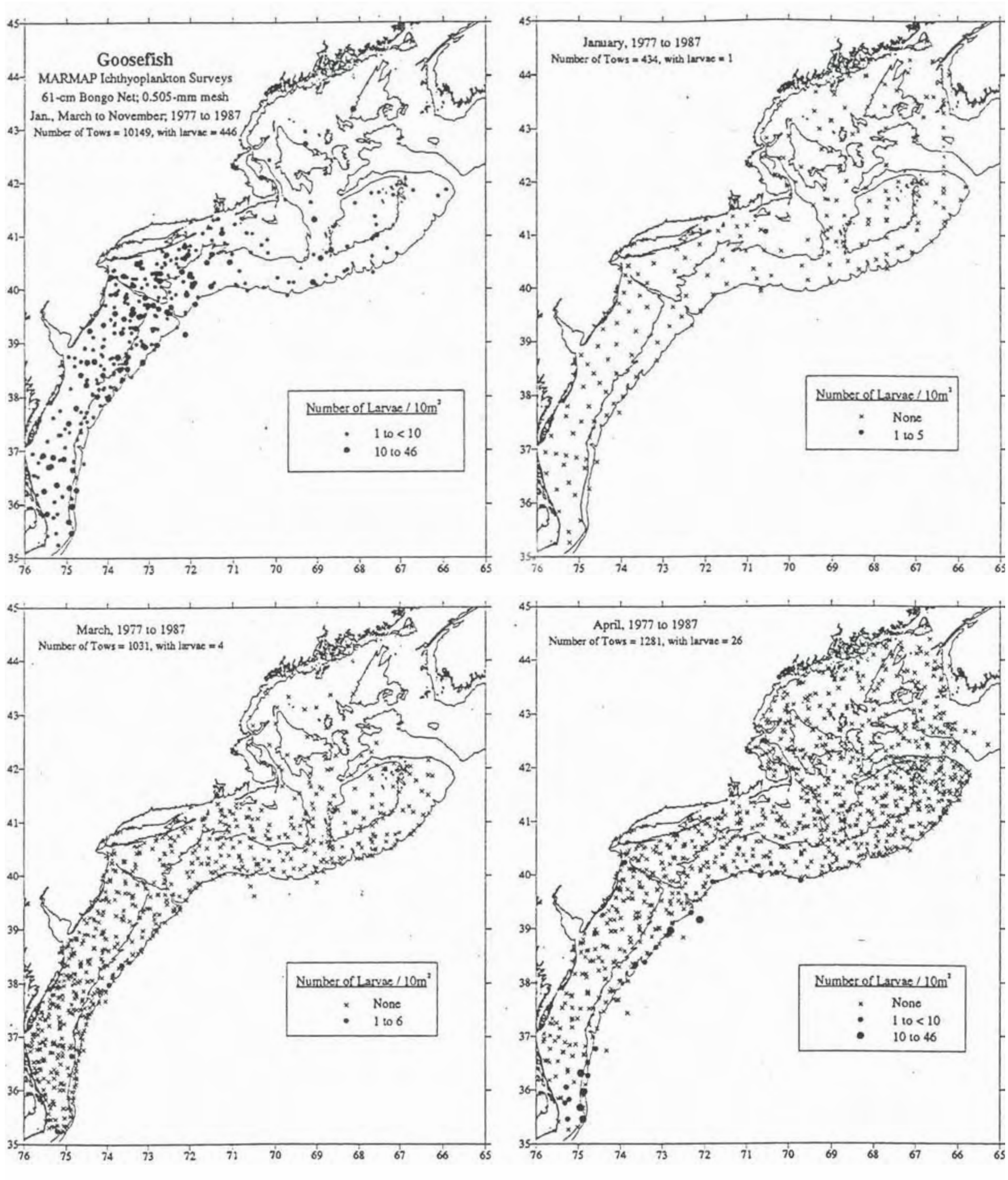


Figure B2. Distribution and abundance of goosefish larvae (overall and monthly) from the NEFSC MARMAP ichthyoplankton surveys, 1977-1987 (from Steimle et al, 1999).

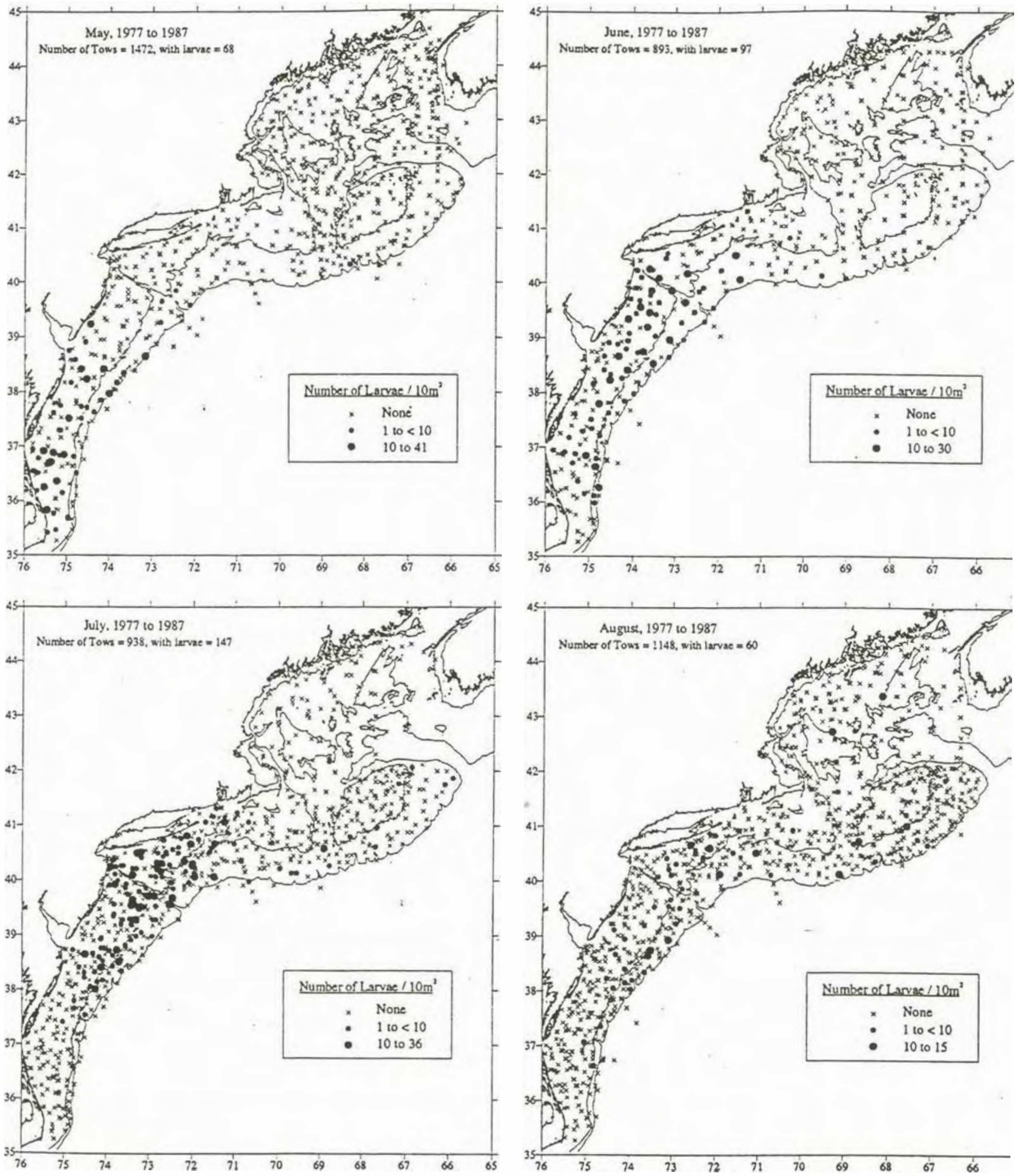


Figure B2 continued. Distribution and abundance of goosefish larvae (overall and monthly) from the NEFSC MARMAP ichthyoplankton surveys, 1977-1987 (from Steimle et al, 1999).

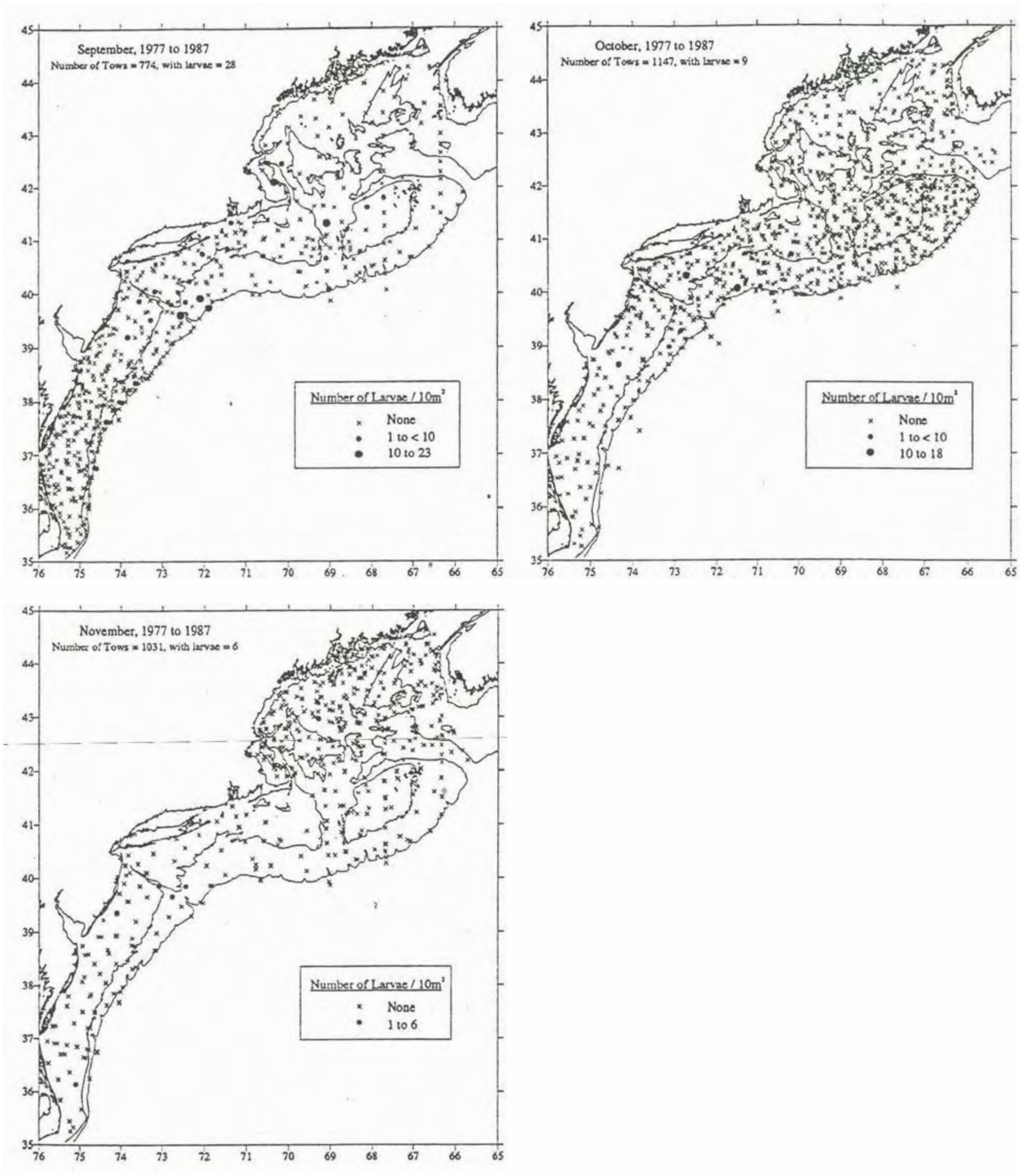


Figure B2 continued. Distribution and abundance of goosefish larvae (overall and monthly) from the NEFSC MARMAP ichthyoplankton surveys, 1977-1987 (from Steimle et al, 1999).

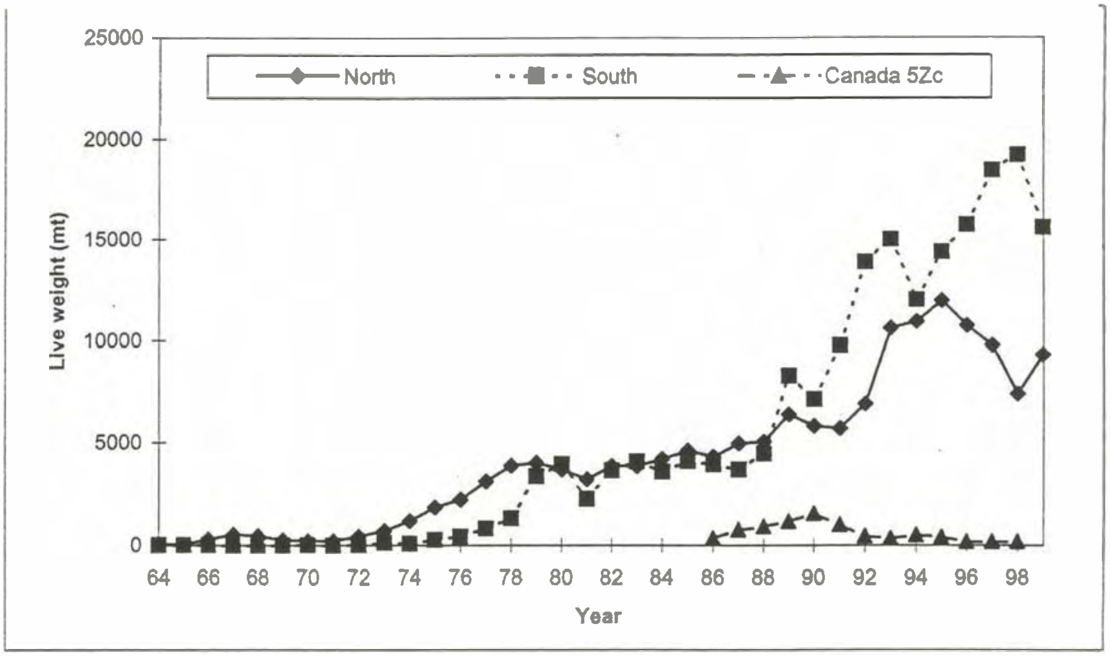


Figure B3. US and Canadian commercial landings (calculated live weight, mt) of goosefish by assessment area (North=Statistical areas 511-523 plus 561; South=Statistical areas 524-639 excluding 561; Canada=Georges Bank, NAFO Subdivision 5Zc).

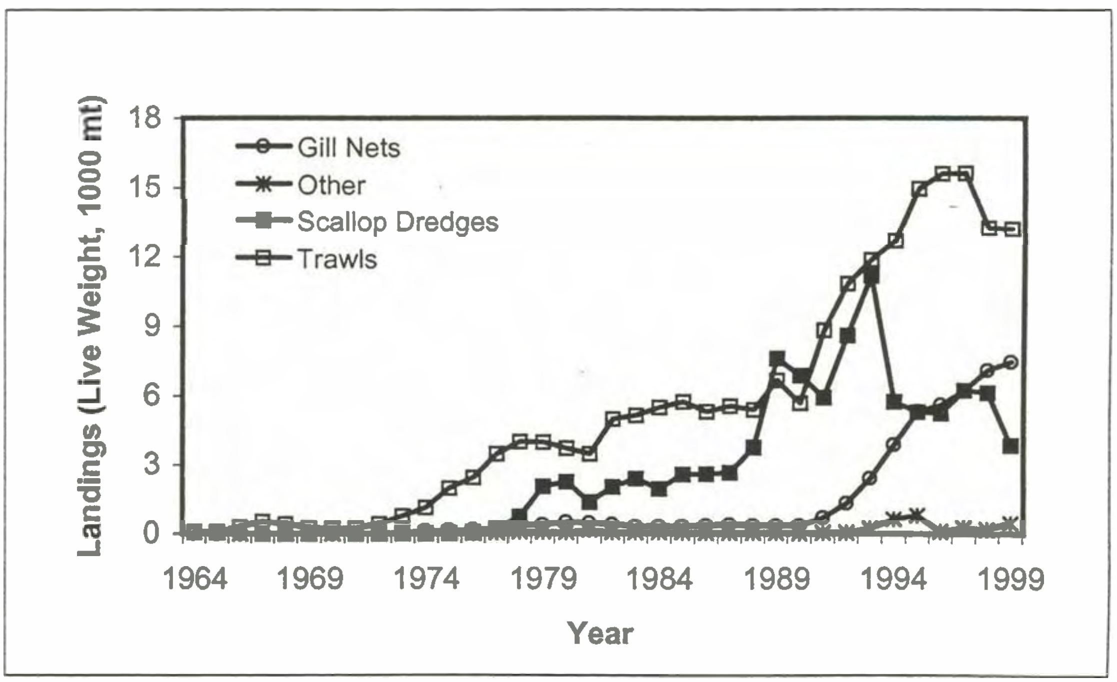


Figure B4. U.S. landings (live weight, 1000 mt) by gear type.

Goosefish Trip Locations 1998 (Unaudited Vessel Trip Reports)

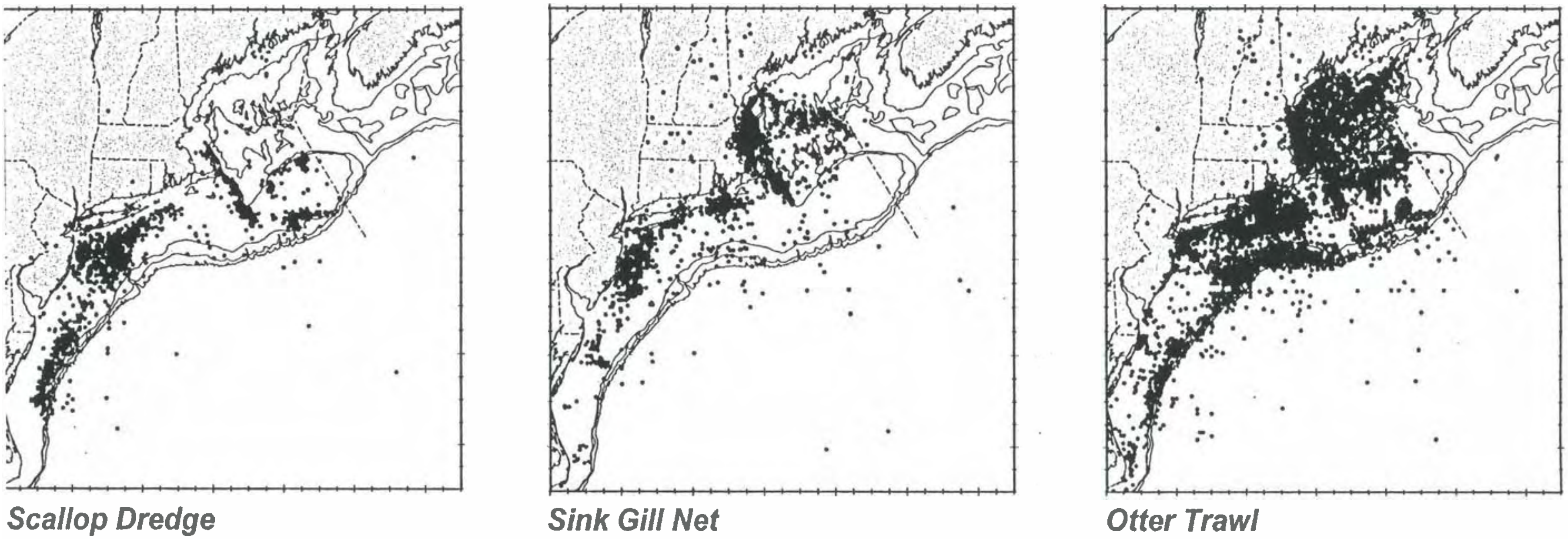


Figure B5. Locations of trips which caught goosefish in 1998 from scallop dredges, sink gill nets, and otter trawls (source: unaudited logbook data).

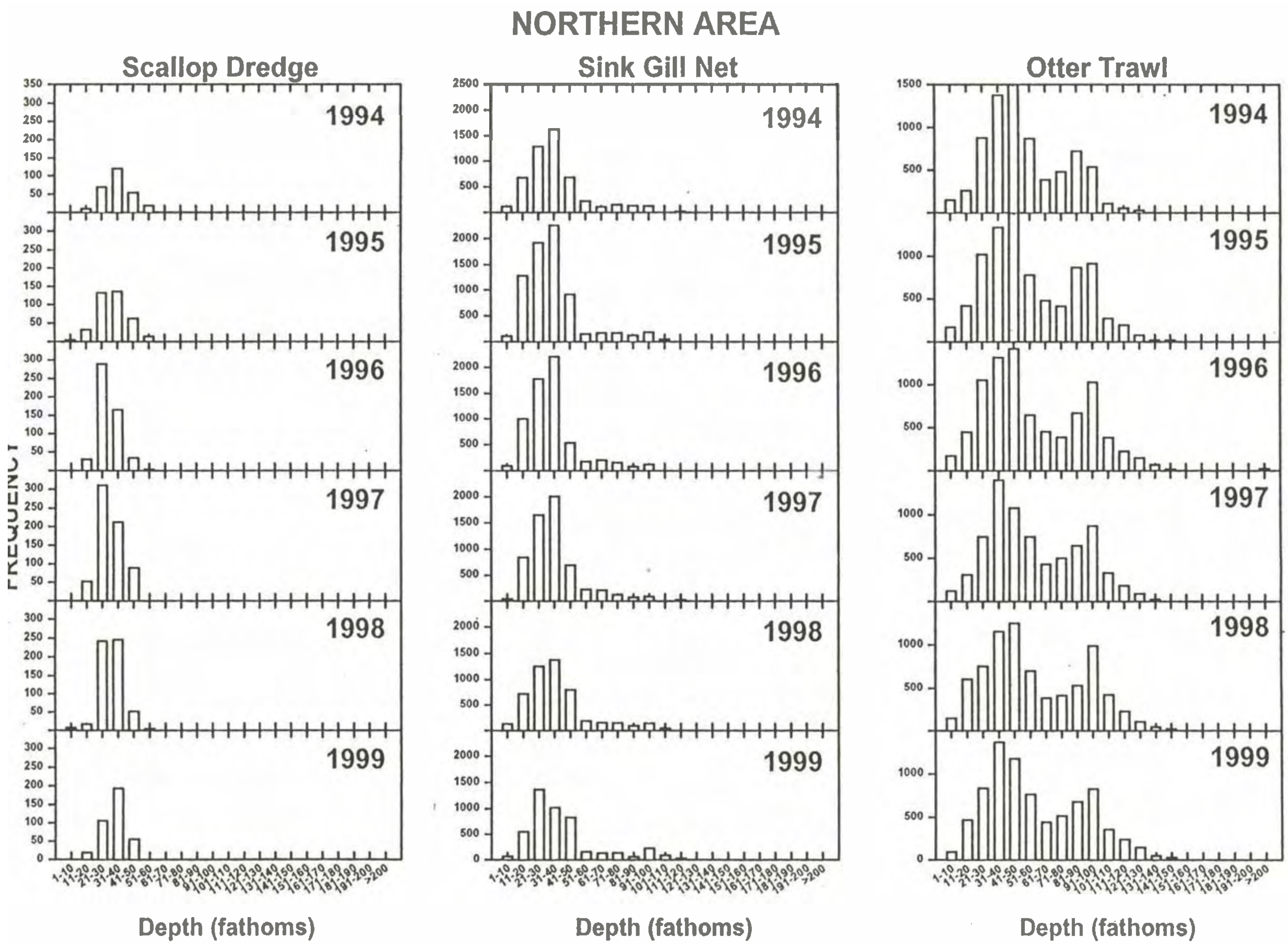


Figure B6. Frequency distribution of depth (in fathoms) for scallop dredge, sink gill net, and otter trawl trips which caught goosefish in the northern area from 1994 to 1999 (source: unaudited logbook data).

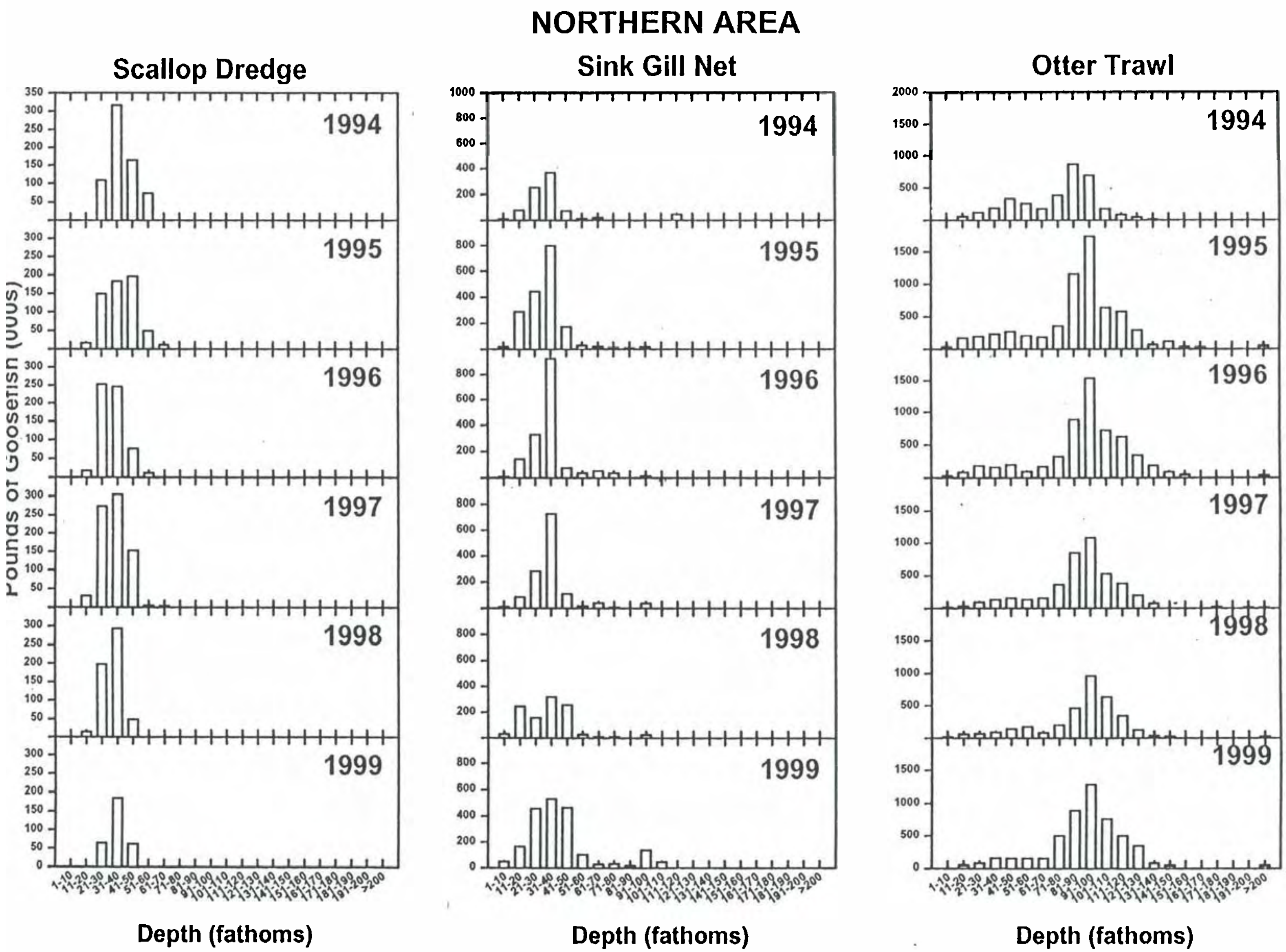


Figure B7. Catches of goosefish by depth (in fathoms) for scallop dredge, sink gill net, and otter trawl trips in the northern area from 1994 to 1999 (source: unaudited logbook data).

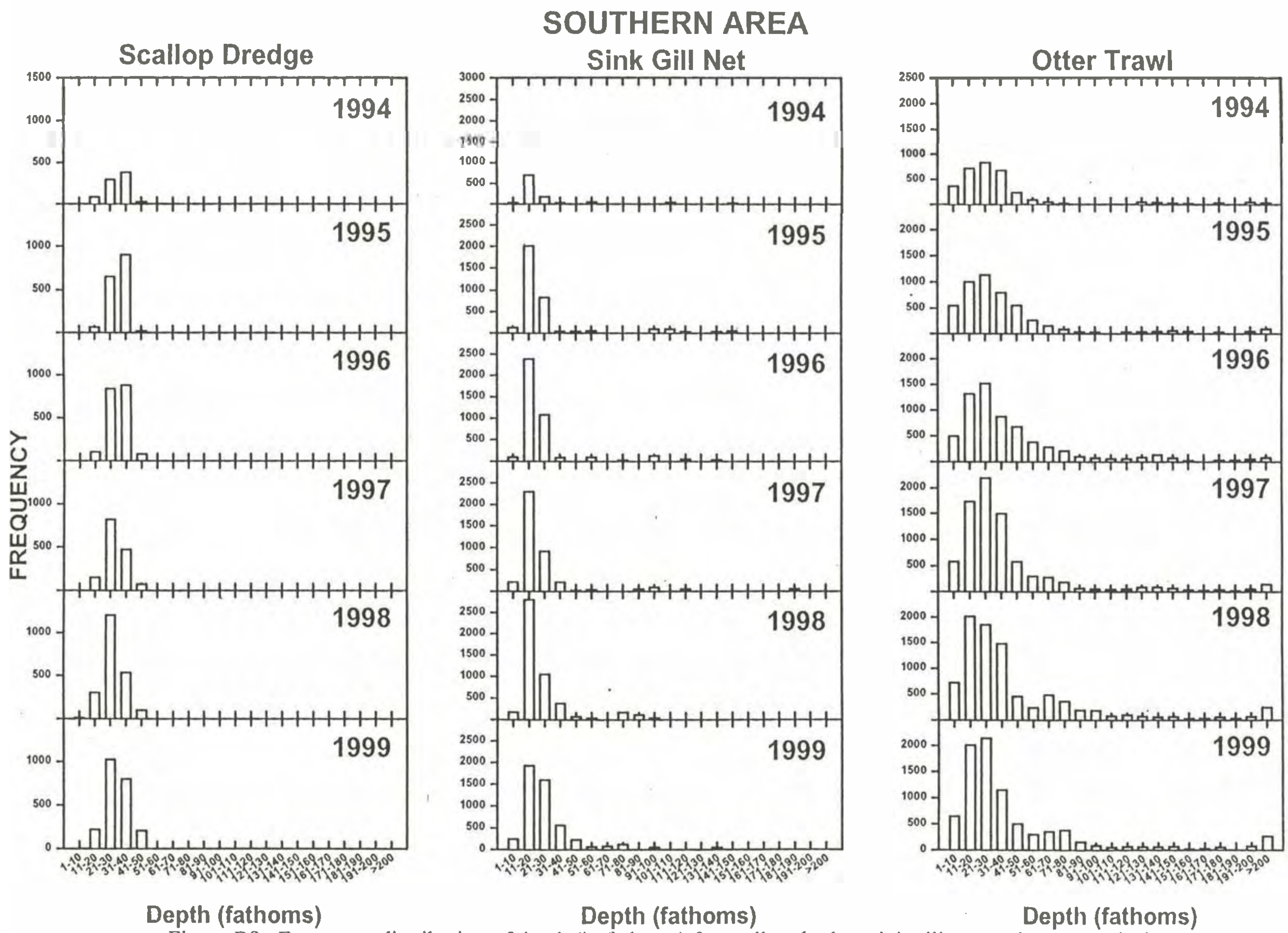


Figure B8. Frequency distribution of depth (in fathoms) for scallop dredge, sink gill net, and otter trawl trips which caught goosefish in the southern area from 1994 to 1999 (source: unaudited logbook data).

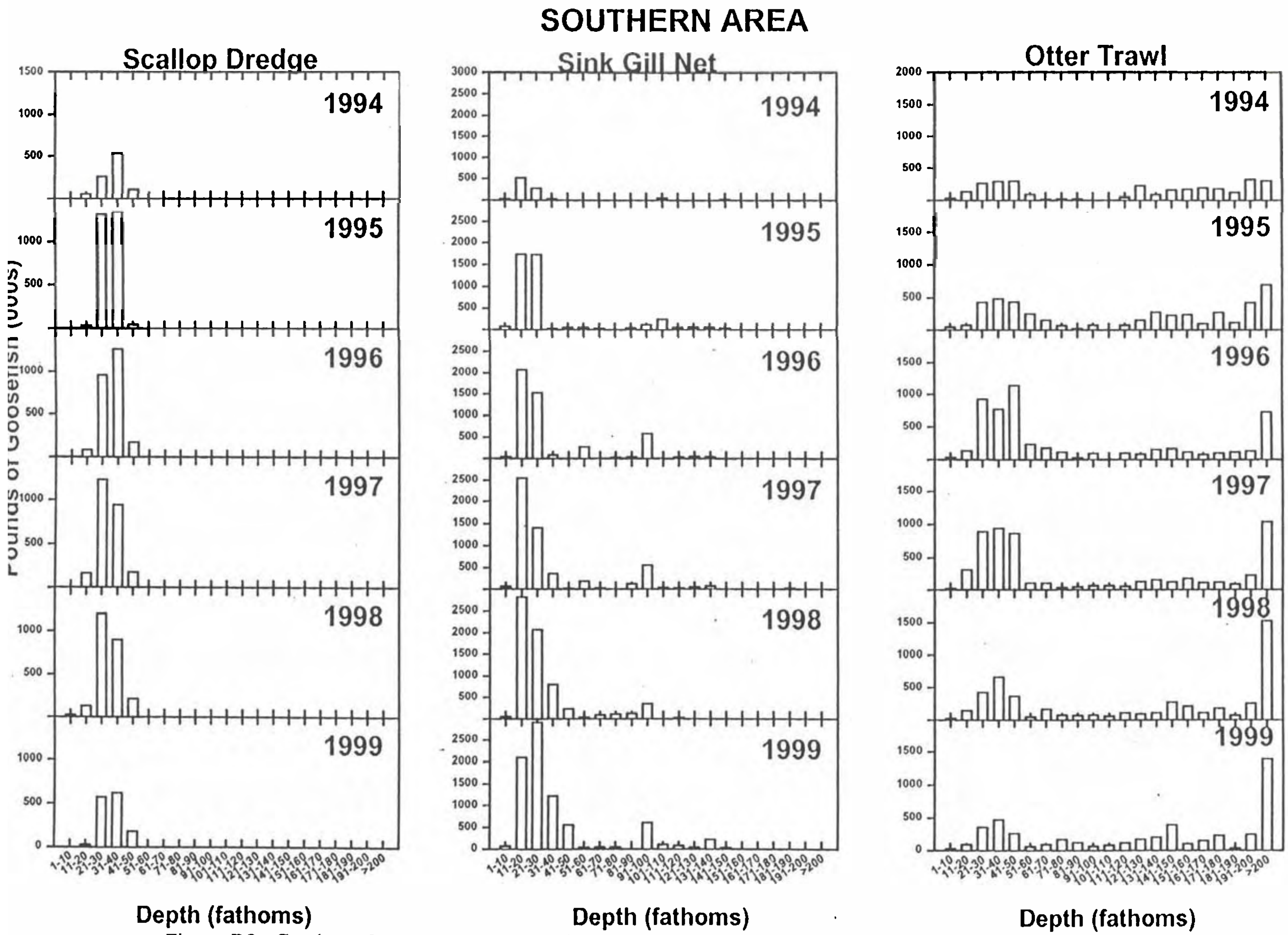


Figure B9. Catches of goosefish by depth (in fathoms) for scallop dredge, sink gill net, and otter trawl trips in the southern area from 1994 to 1999 (source: unaudited logbook data)

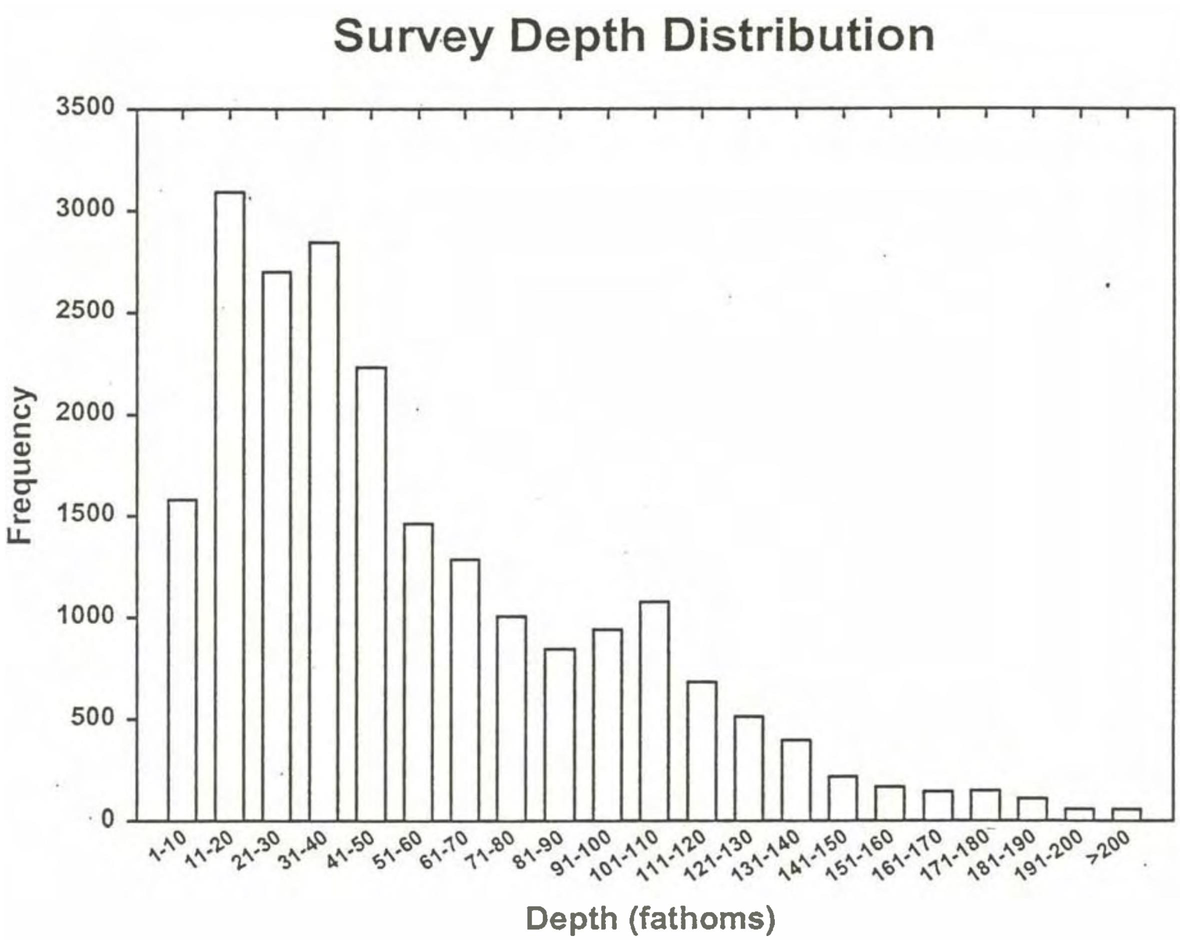


Figure B10. Distribution of NEFSC spring and autumn survey tows by depth.

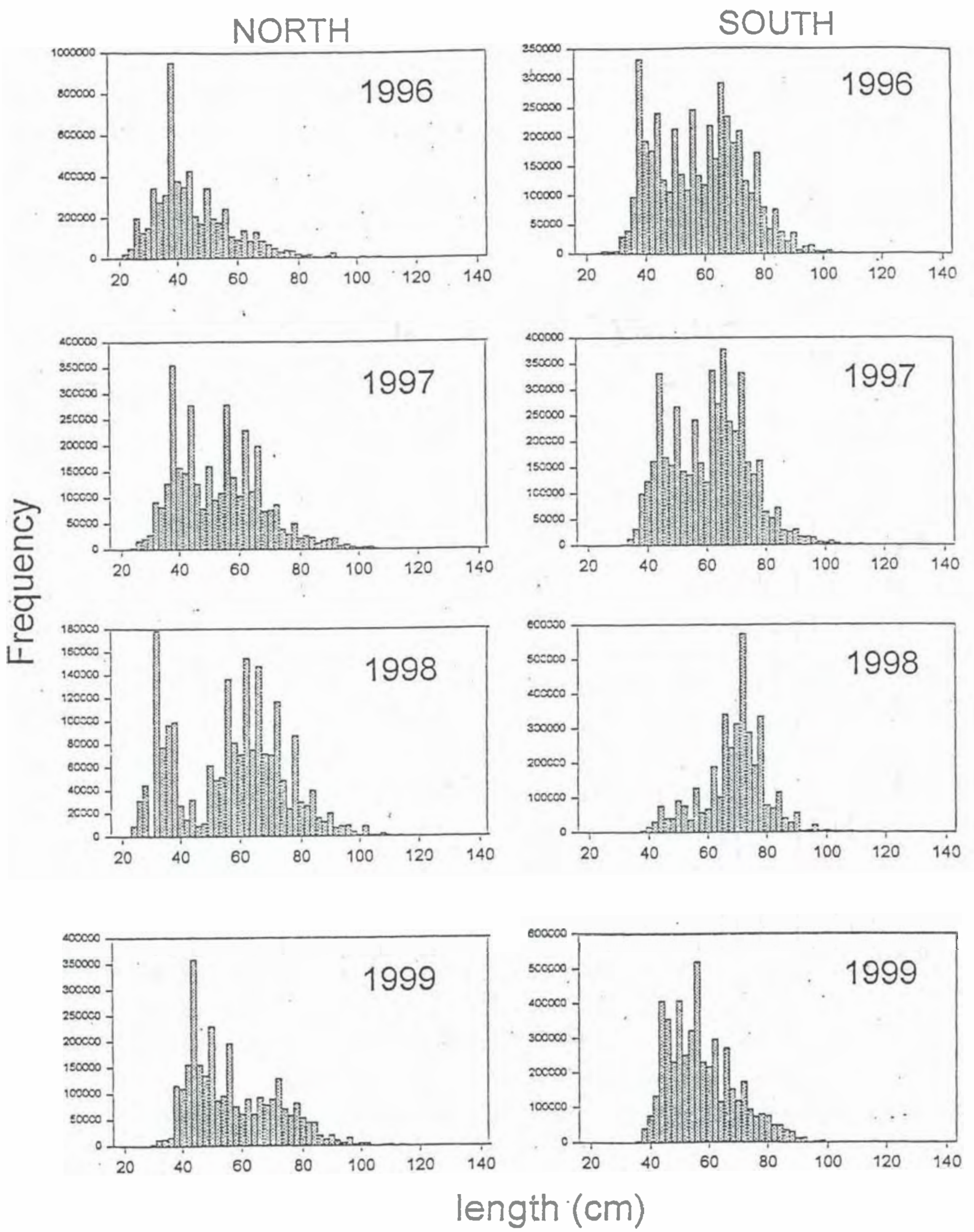


Figure B11. Expanded length frequencies of commercial landings by management region.

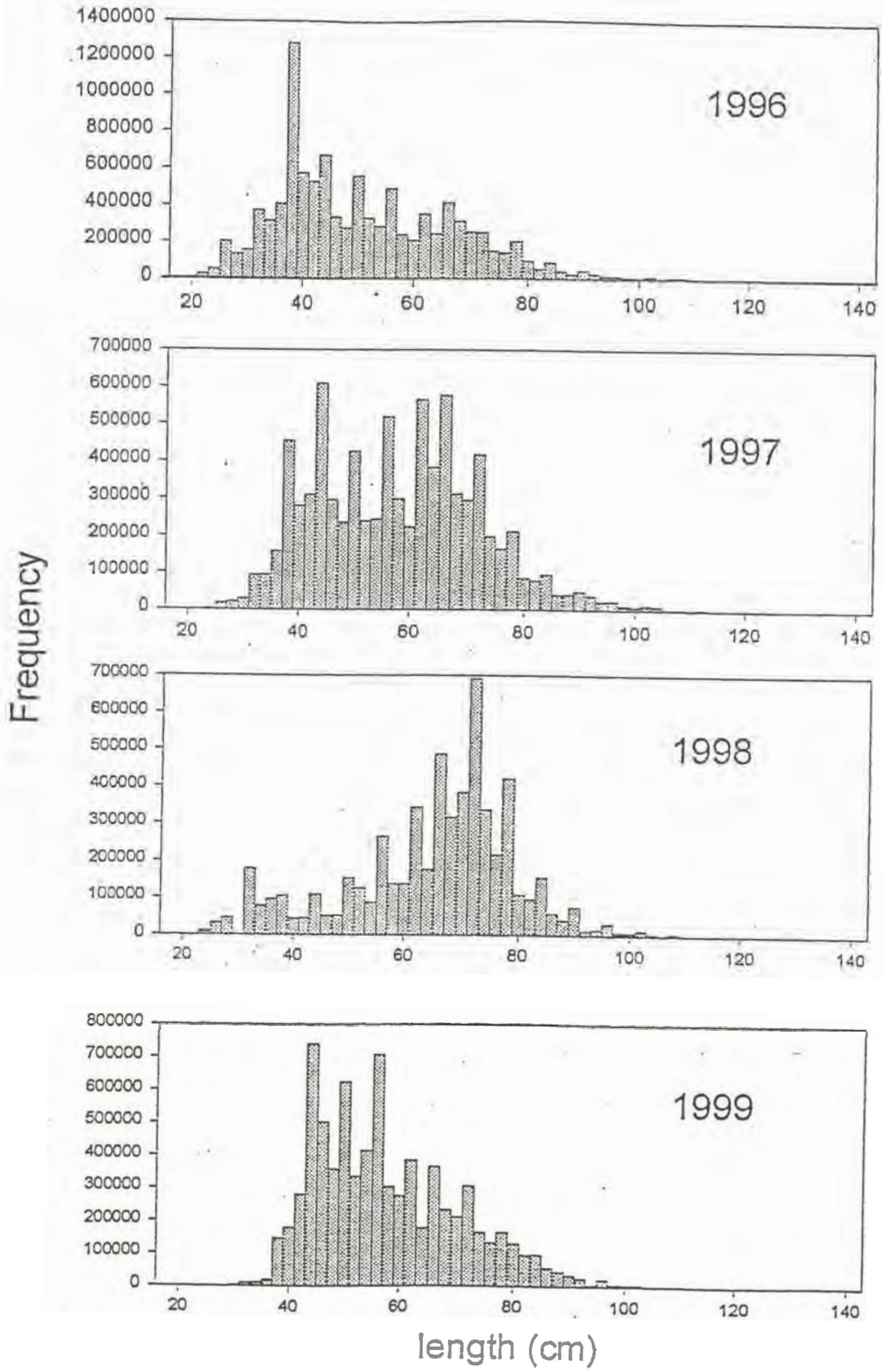


Figure B12. Expanded length frequencies of commercial landings by management region.

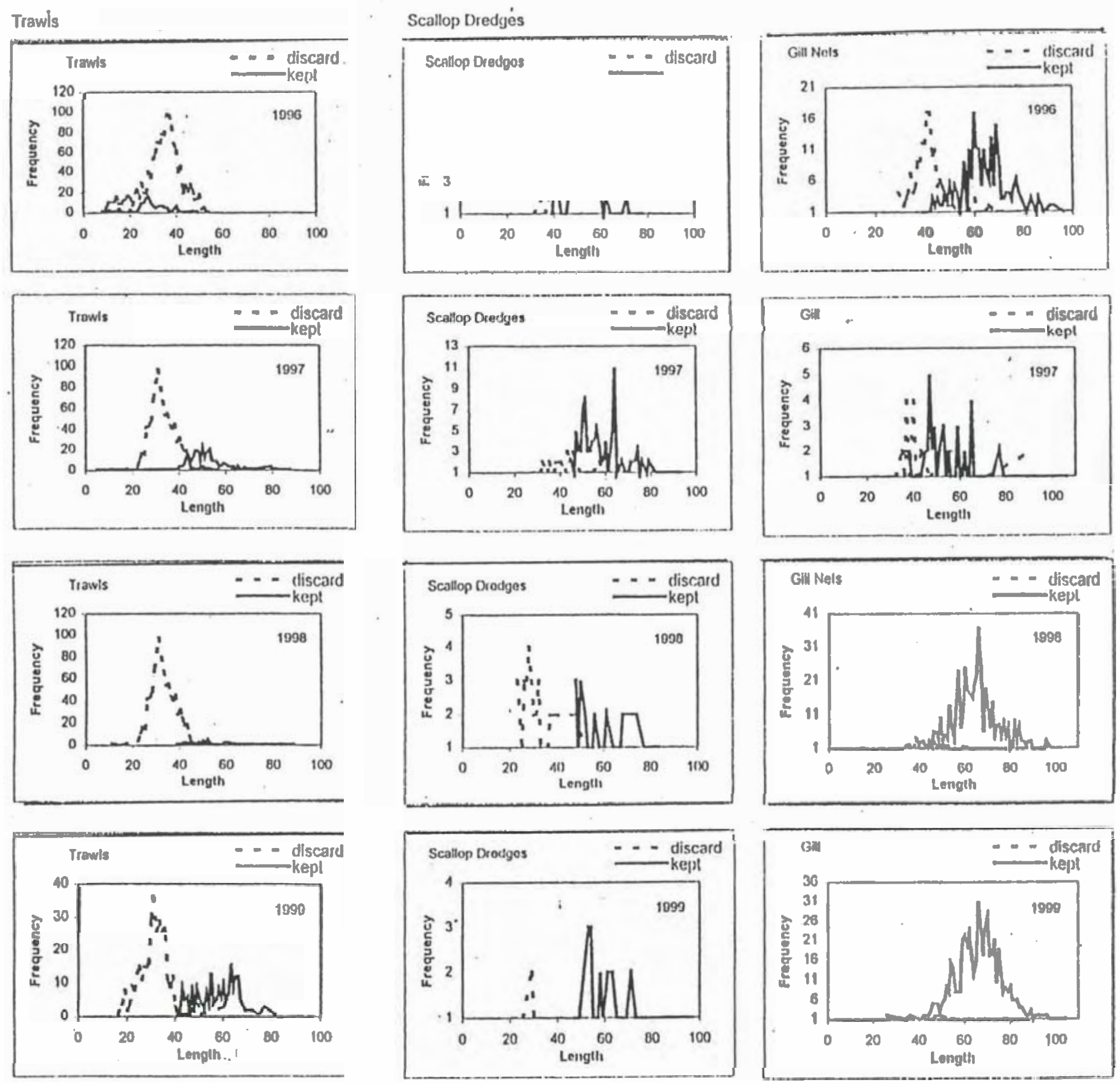


Figure B13. Size composition of discarded and kept goosefish estimated from sea sampling observations, northern regi

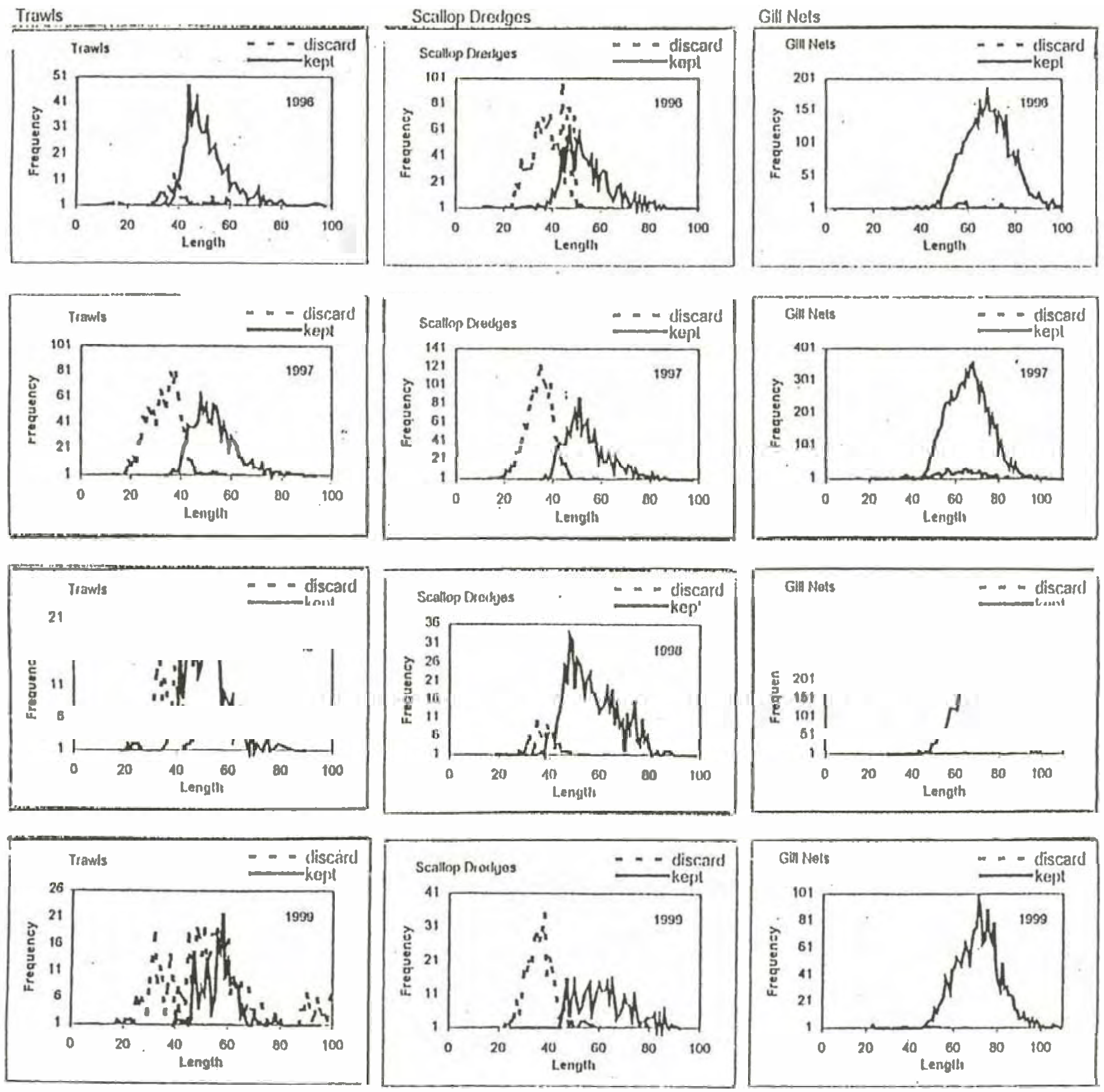


Figure B14. Size composition of discarded and kept goosefish estimated from sea sampling observations, southern region.

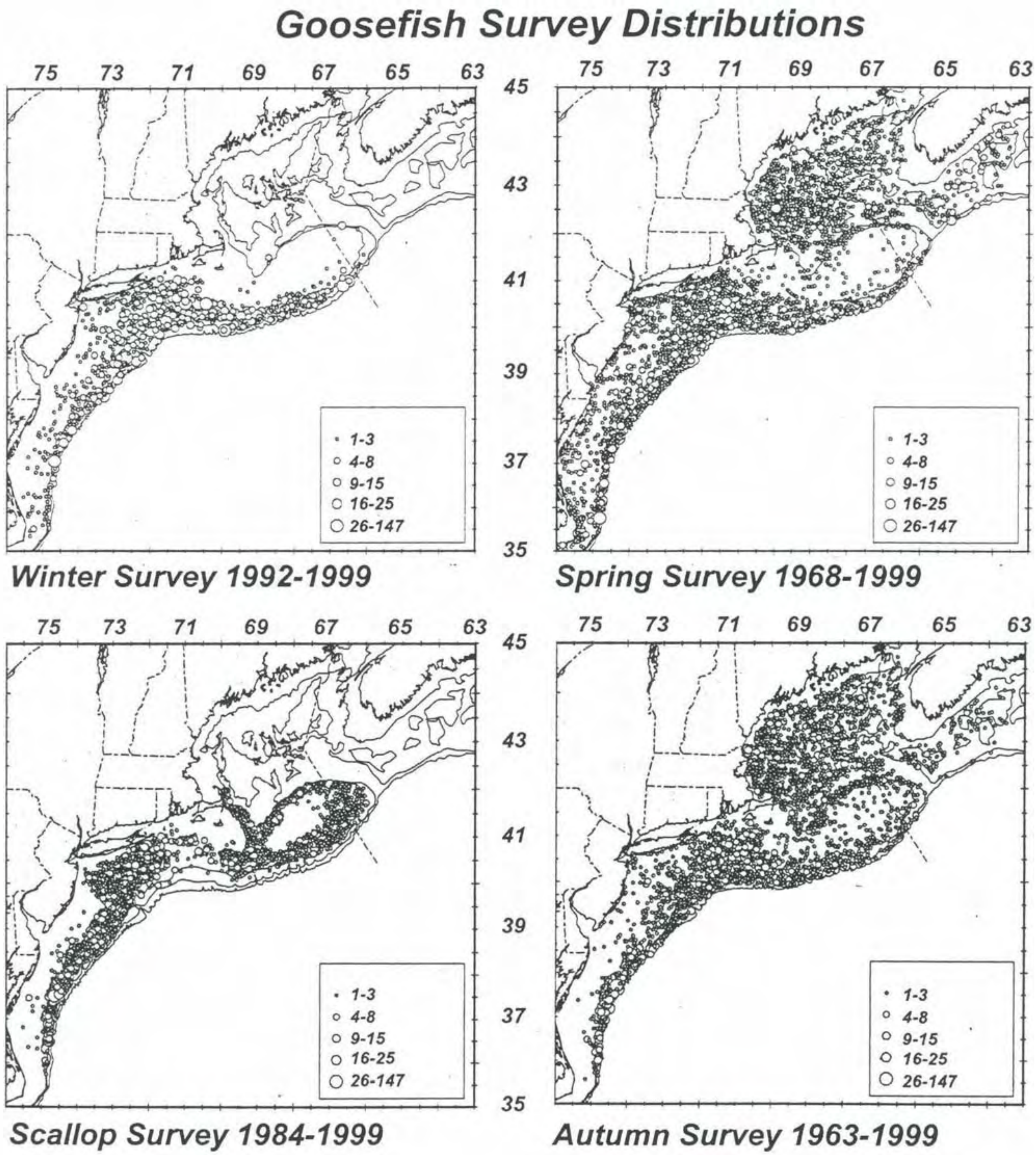


Figure B15. Distribution of goosefish catches in the NEFSC winter surveys (1992-1999), spring surveys (1968-1999), scallop surveys (1984-1999), and autumn surveys (1963-1999).

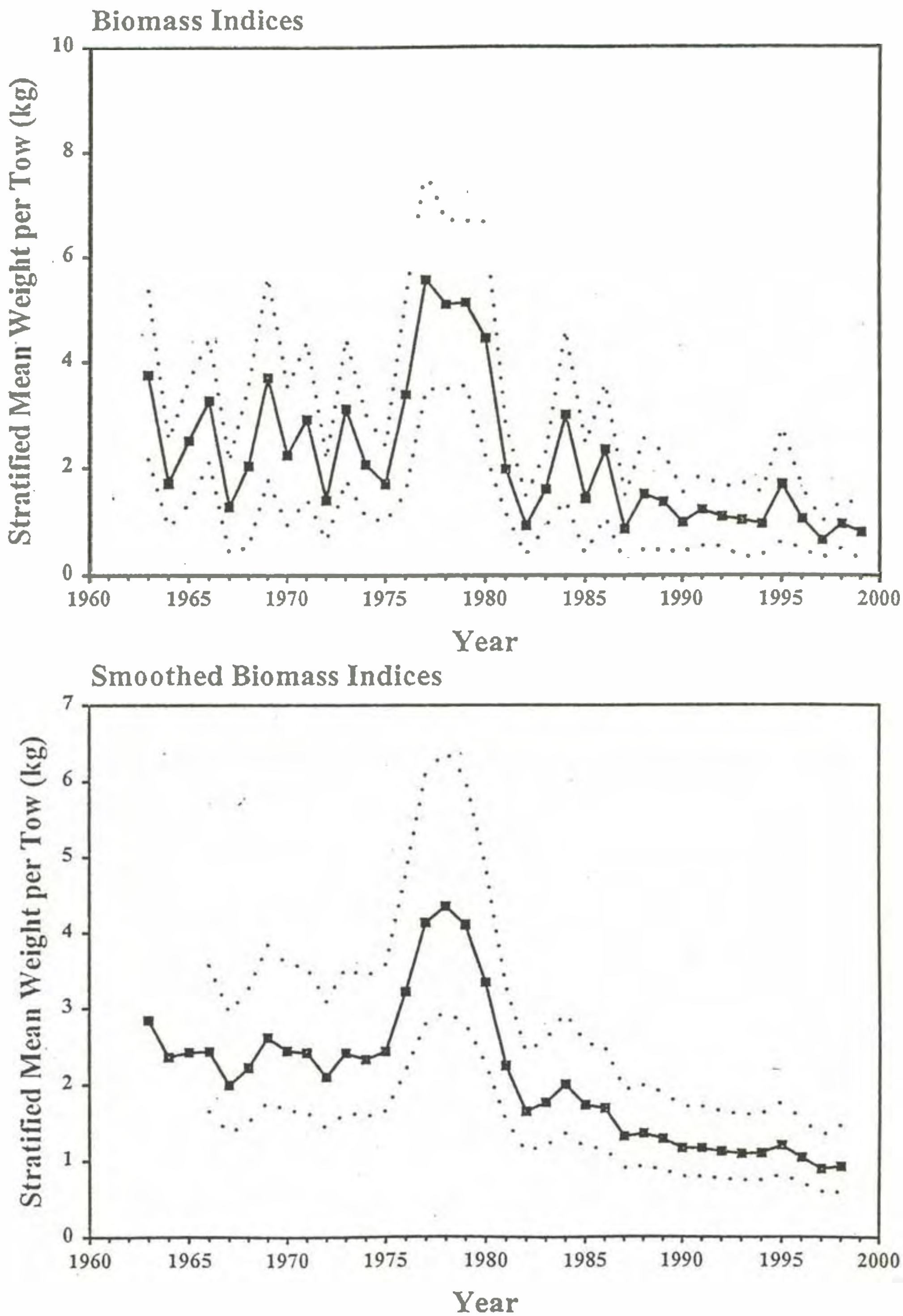


Figure B16. Biomass indices and smoothed indices from the NEFSC autumn bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1963-1999. The 95% confidence limits are shown by the dashed line.

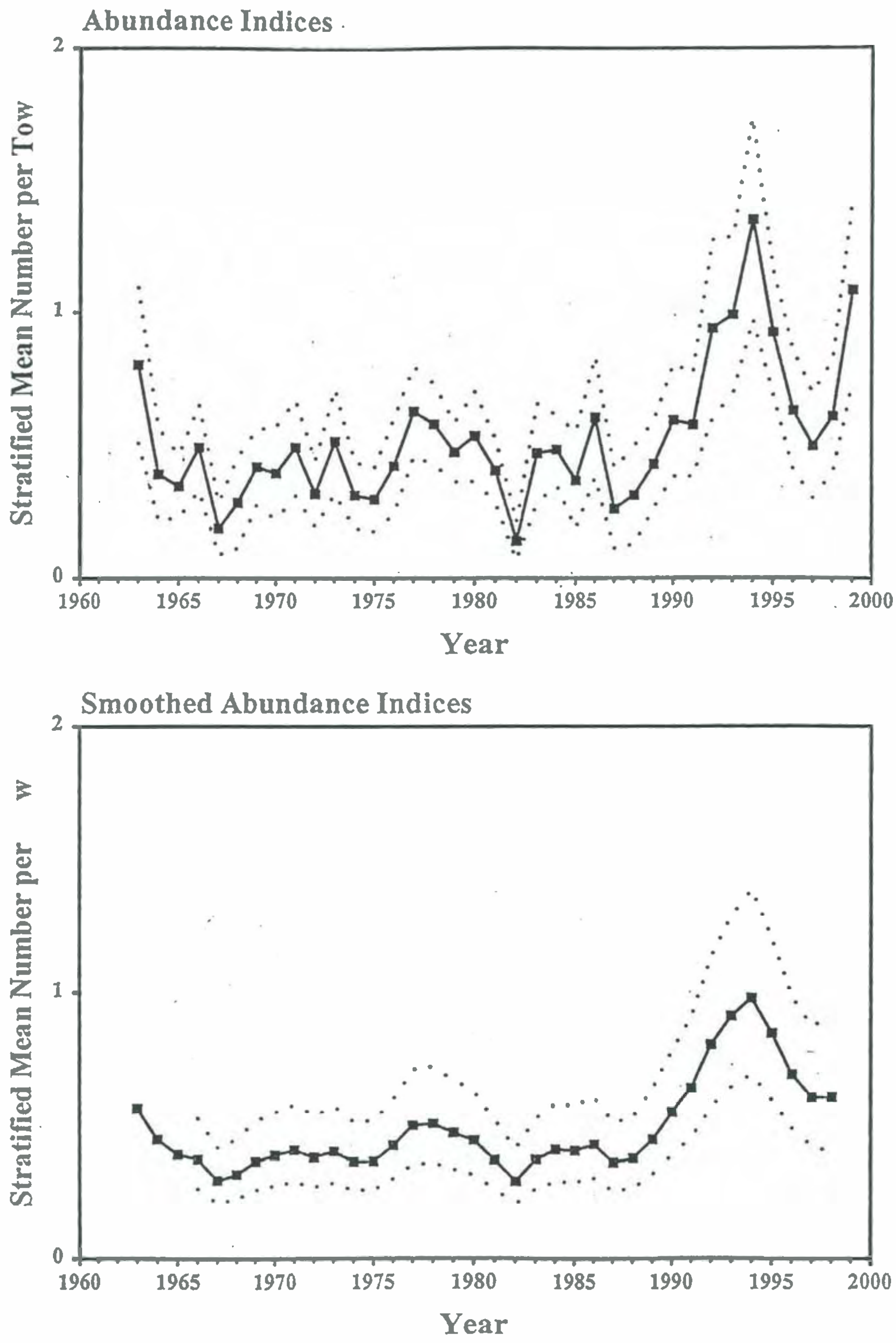
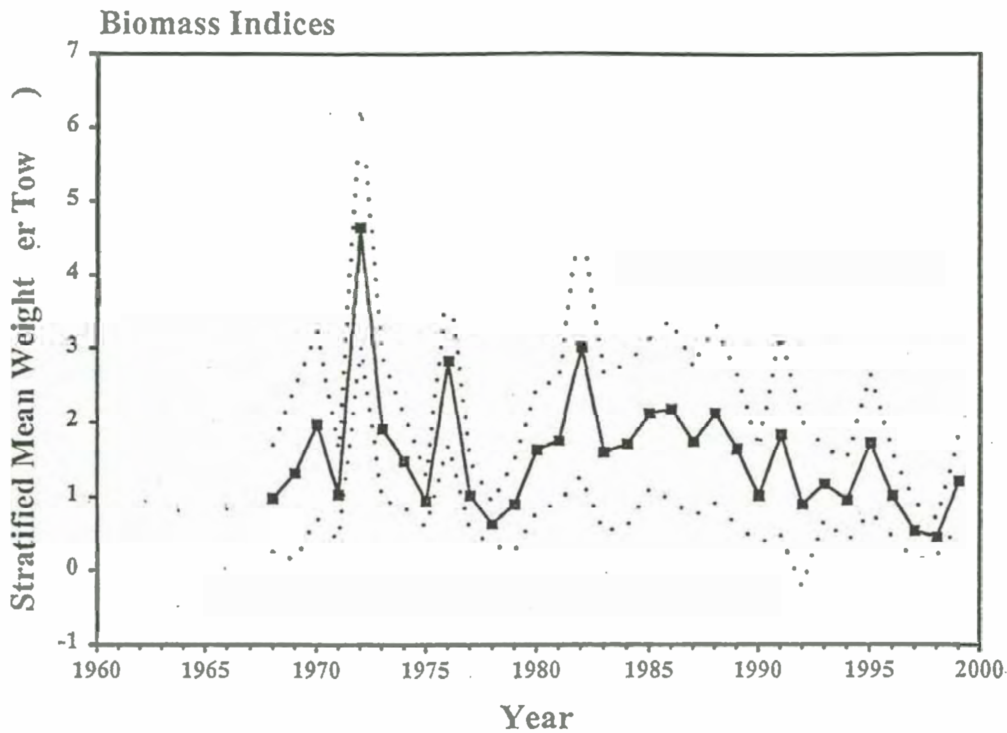
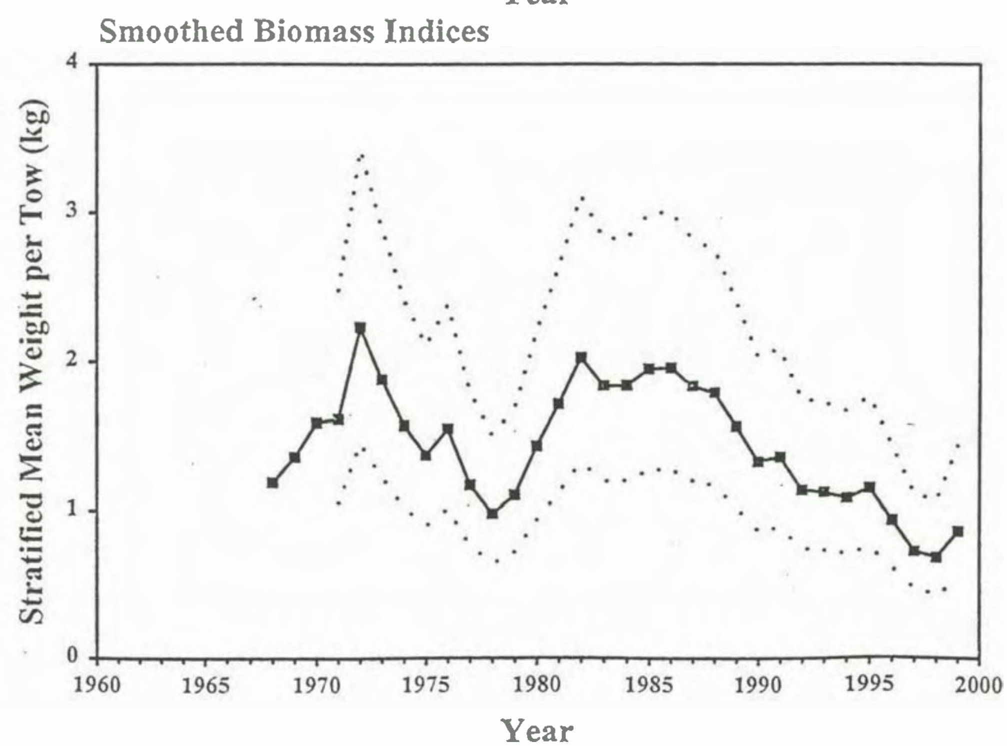


Figure B17. Abundance indices and smoothed indices from the NEFSC autumn bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1963-1999. The 95% confidence limits are shown by the dashed line.





igure B18. Biomass indices and smoothed indices from the NEFSC spring bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1968-1999. The 95% confidence limits are shown by the dashed line.

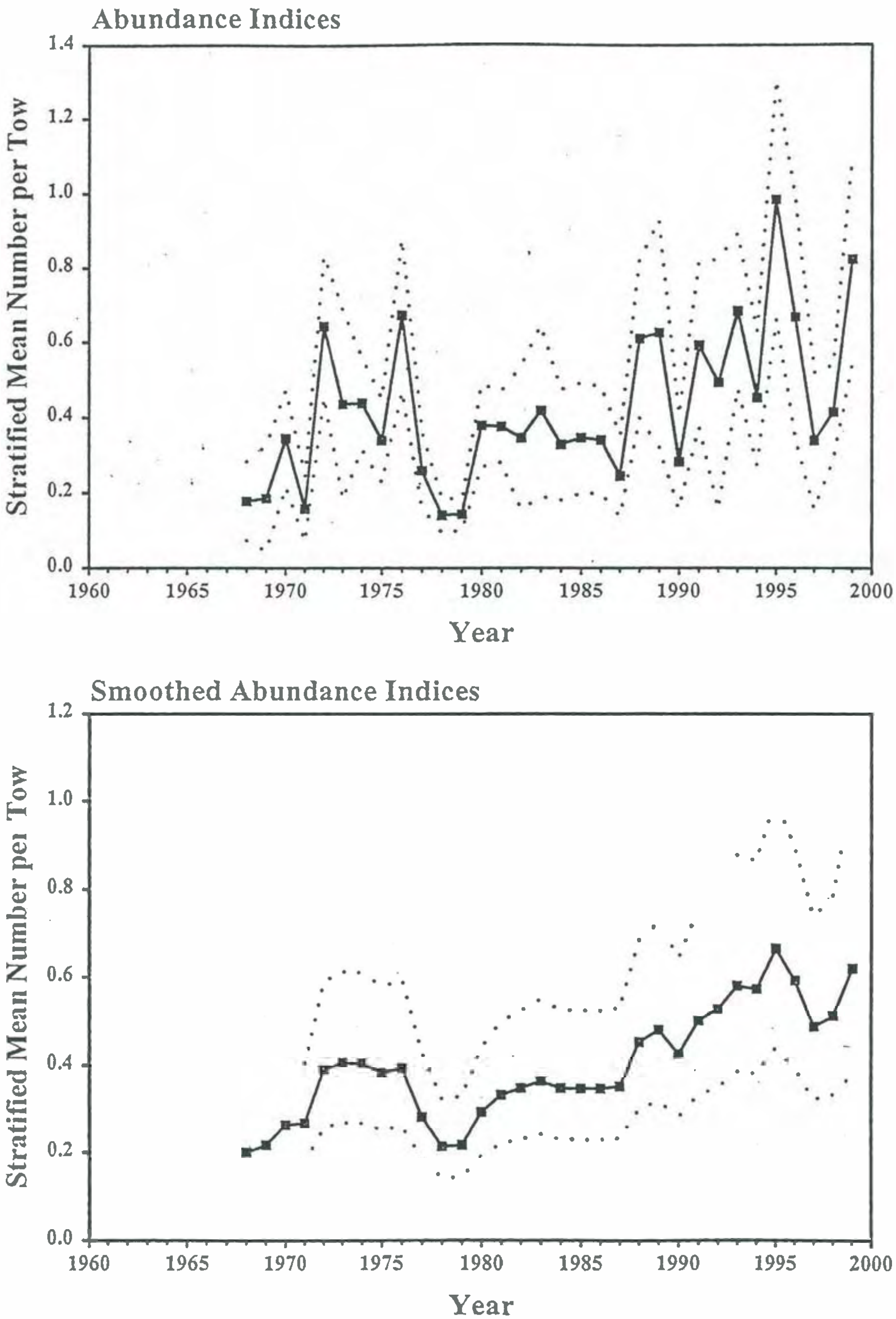
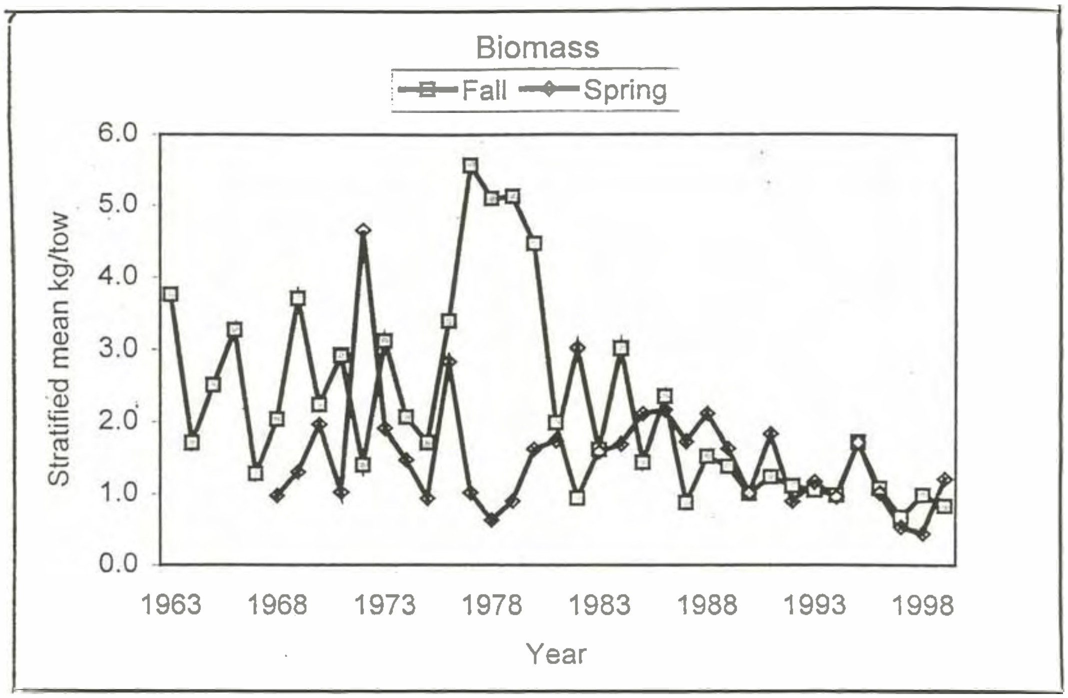
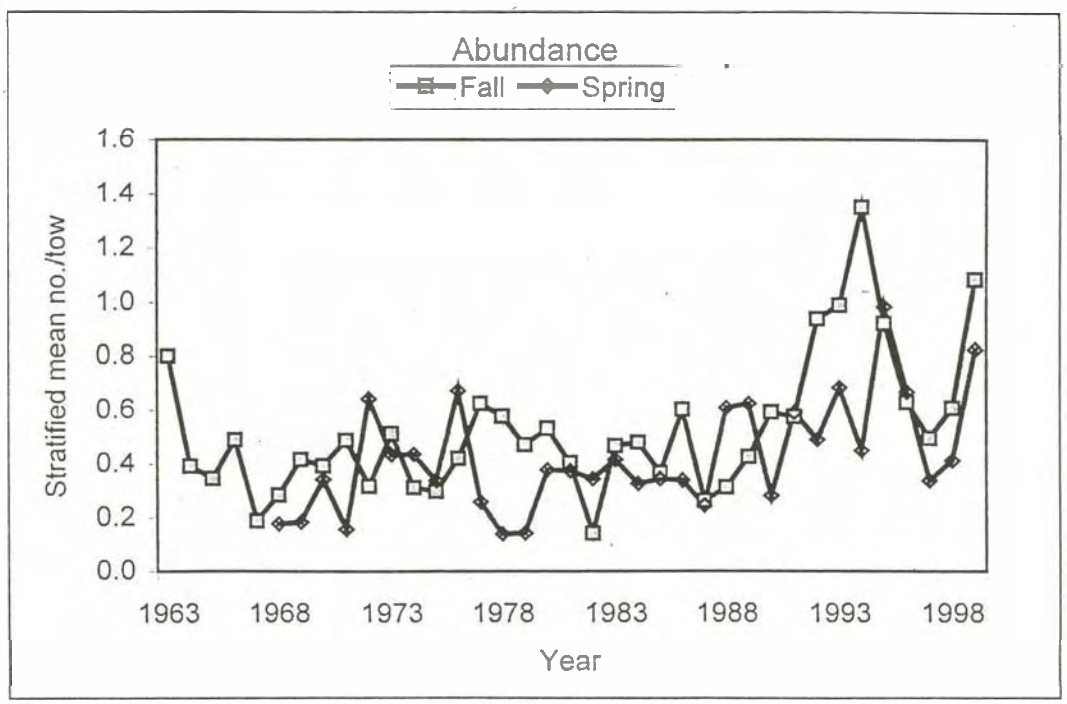
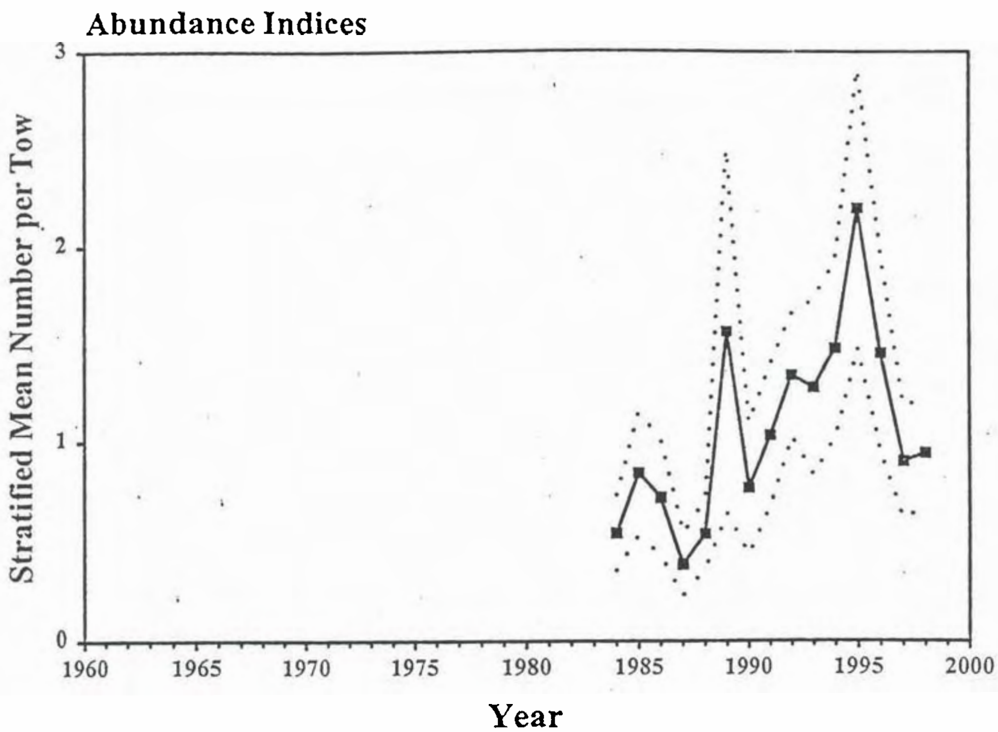


Figure B19. Abundance indices and smoothed indices from the NEFSC spring bottom trawl survey for the Gulf of Maine to Northern Georges Bank region from 1968-1999. The 95% confidence limits are shown by the dashed line.

Figure B20. Biomass and abundance indices from NEFSC spring and autumn trawl surveys, northern management region.







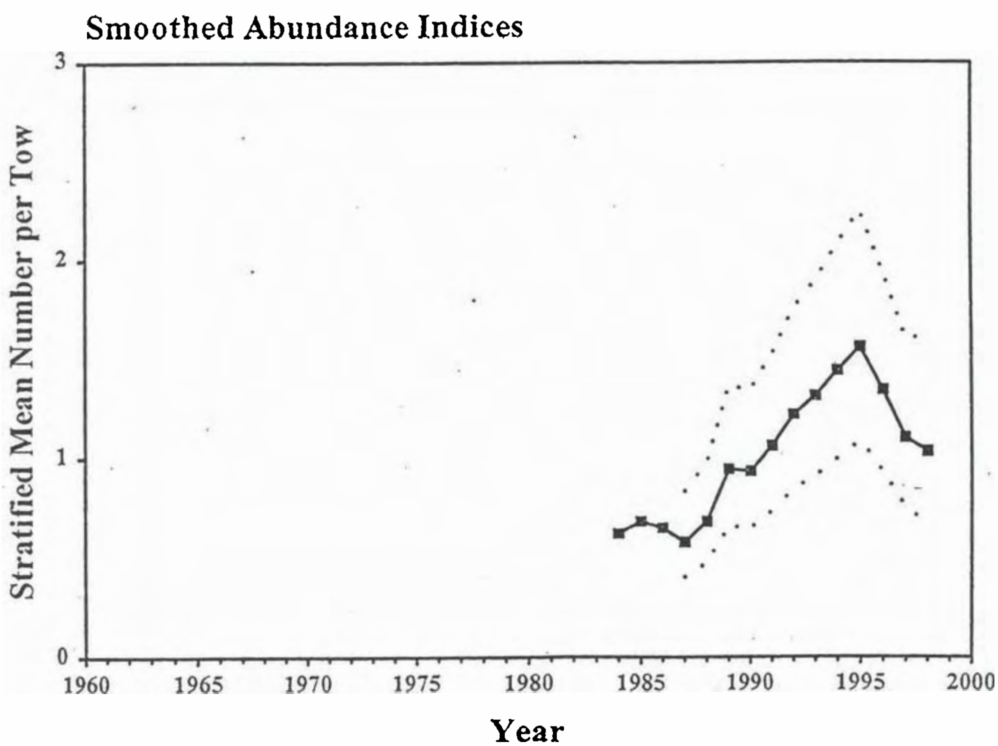


Figure B21. Abundance indices and smoothed indices from the NEFSC scallop dredge survey for the Northern Georges Bank region from 1984-1999. The 95% confidence limits are shown by the dashed line. Only one tow was completed in 1999.

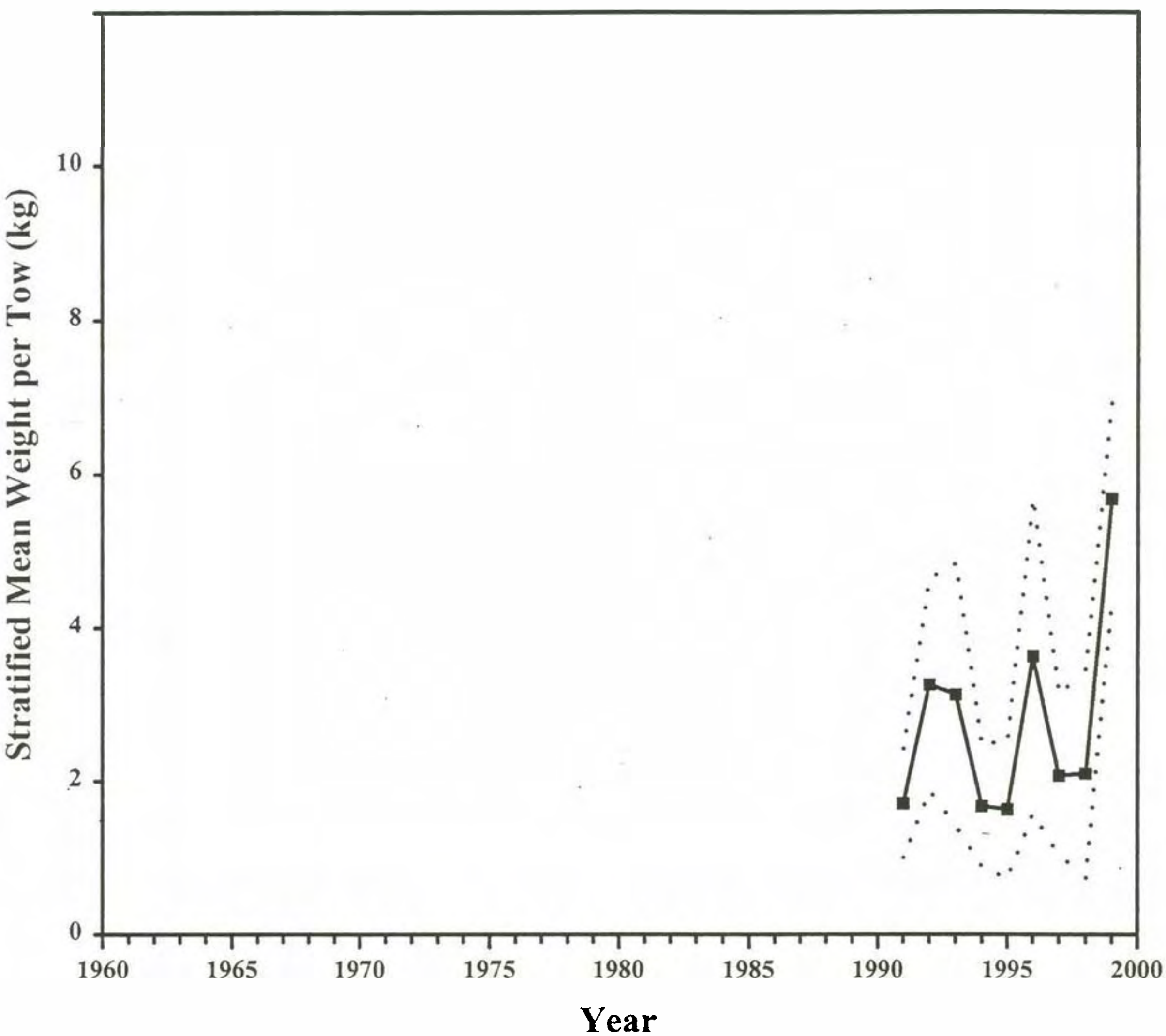


Figure B22. Biomass indices from the ASMFC summer shrimp survey for the Gulf of Maine region from 1986-1999. The 95% confidence limits are shown by the dashed line.

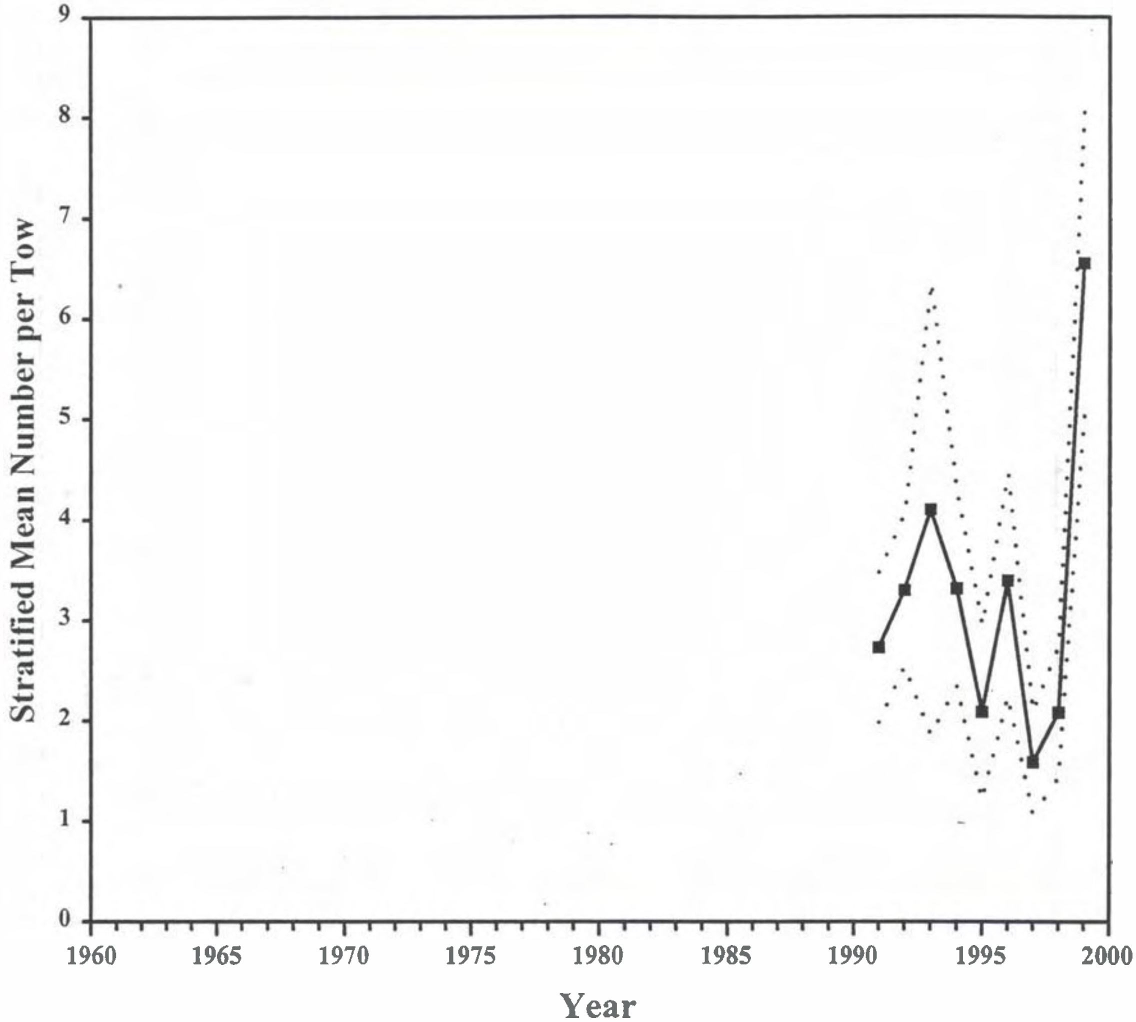


Figure B23. Abundance indices from the ASMFC summer shrimp survey for the Gulf of Maine region from 1991-1999. The 95% confidence limits are shown by the dashed line.

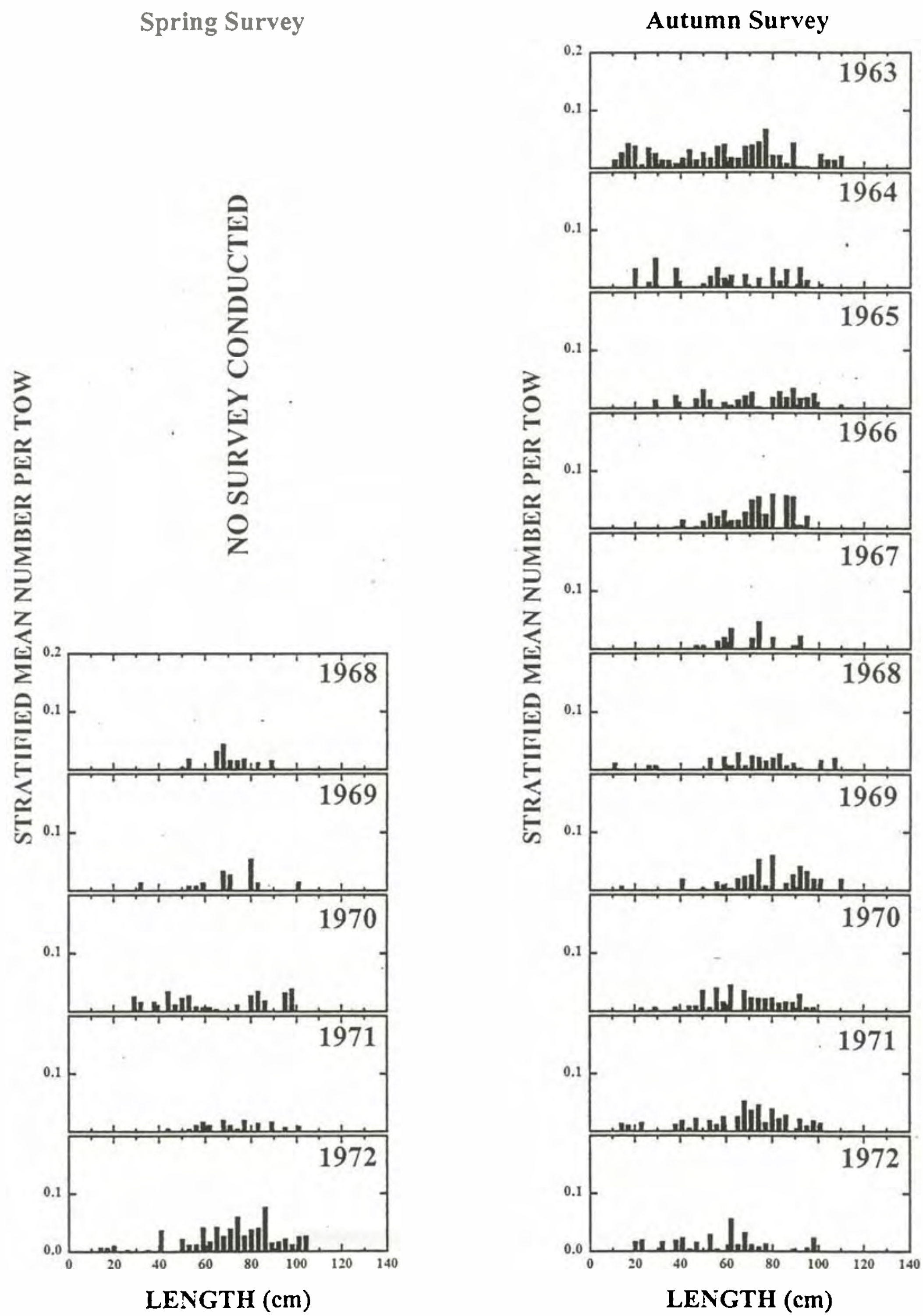


Figure B24. Goosefish length composition from the NEFSC spring bottom trawl (March-April), Gulf of Maine summer inshore bottom trawl (July-August), summer scallop (July-August), and autumn (September-October) bottom trawl surveys and the ASMFC summer shrimp trawl survey (August) in the Gulf of Maine to Northern Georges Bank region, 1963-1999.

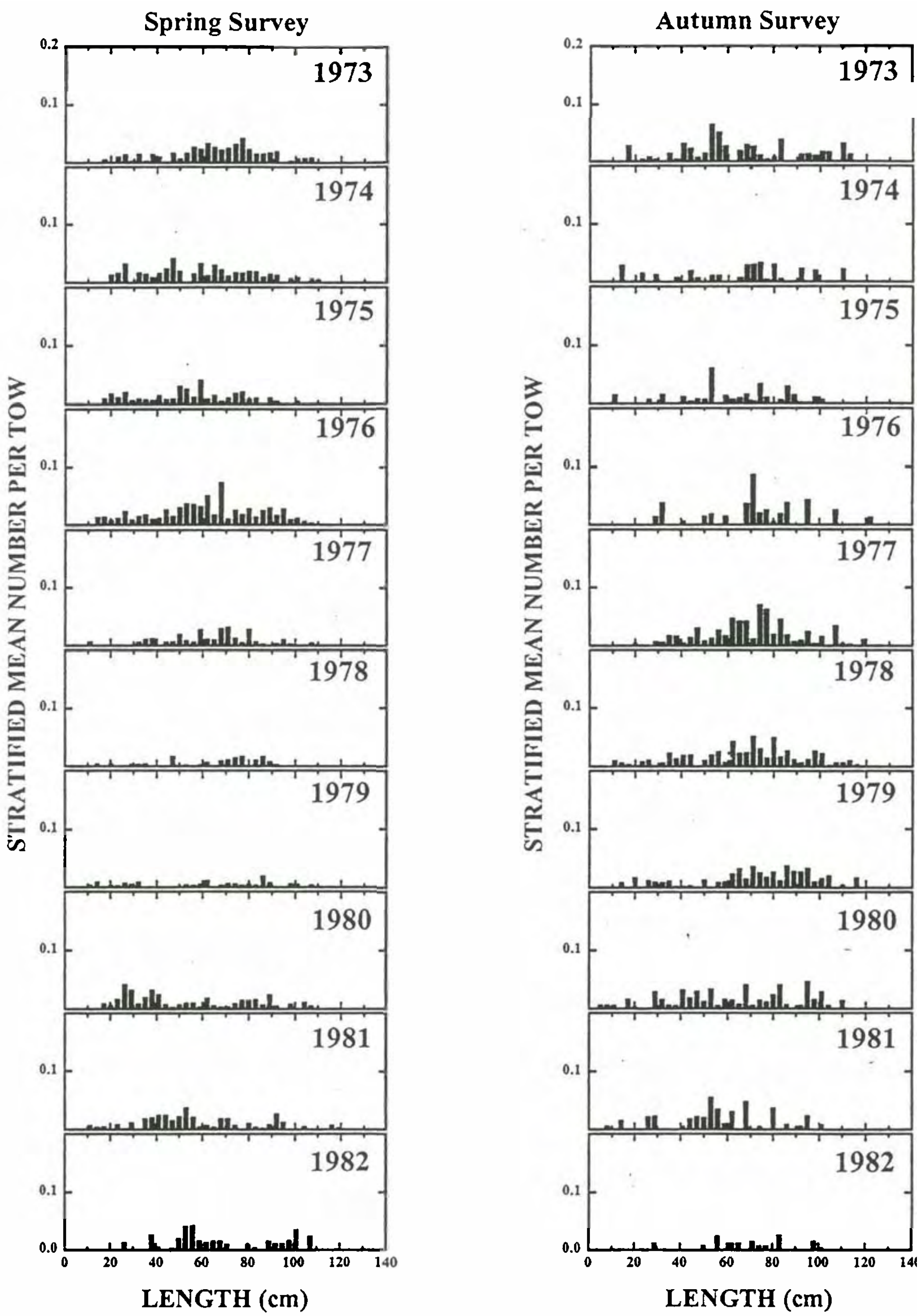


Figure B24. continued.

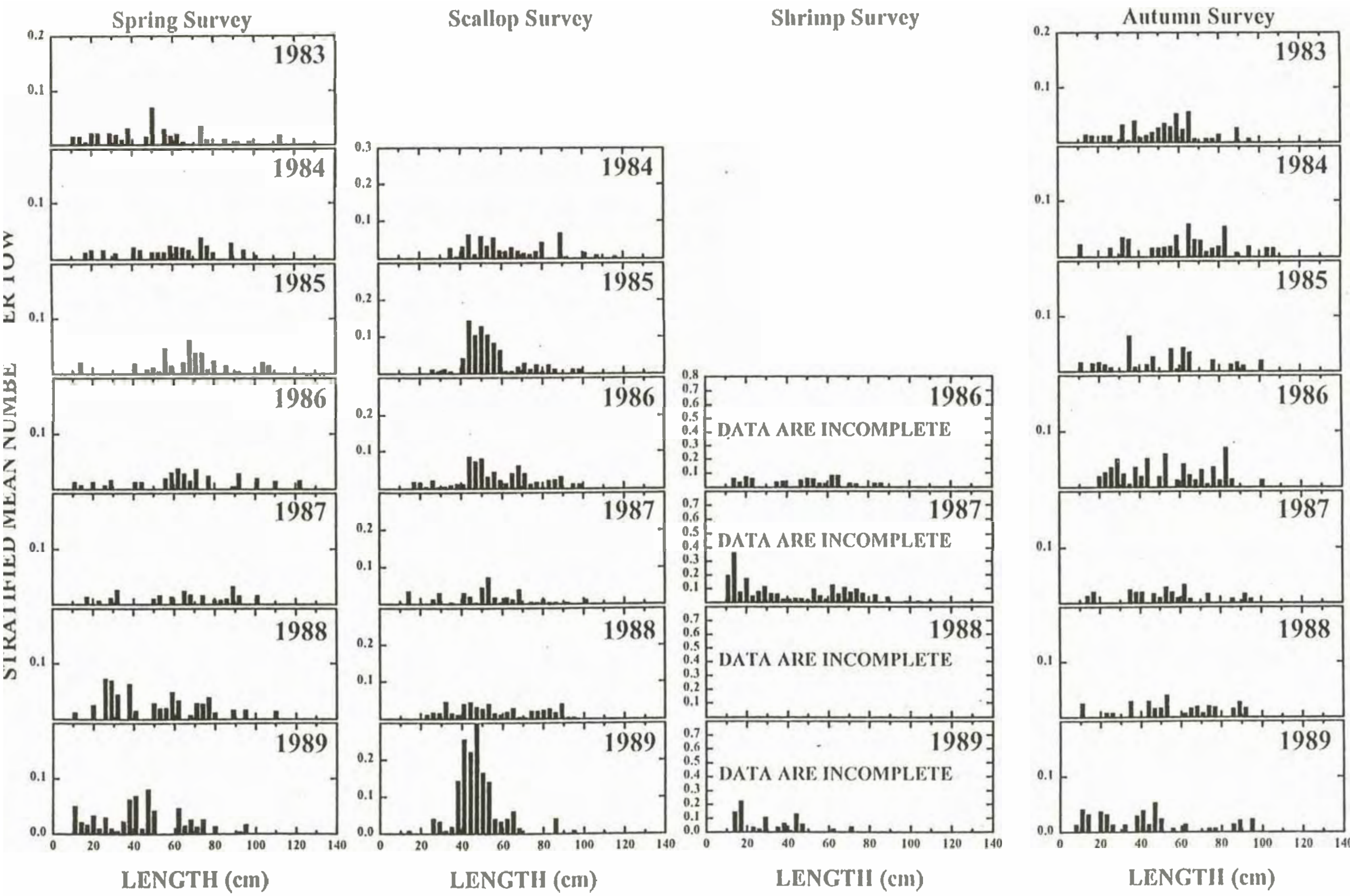


Figure B24, continued.

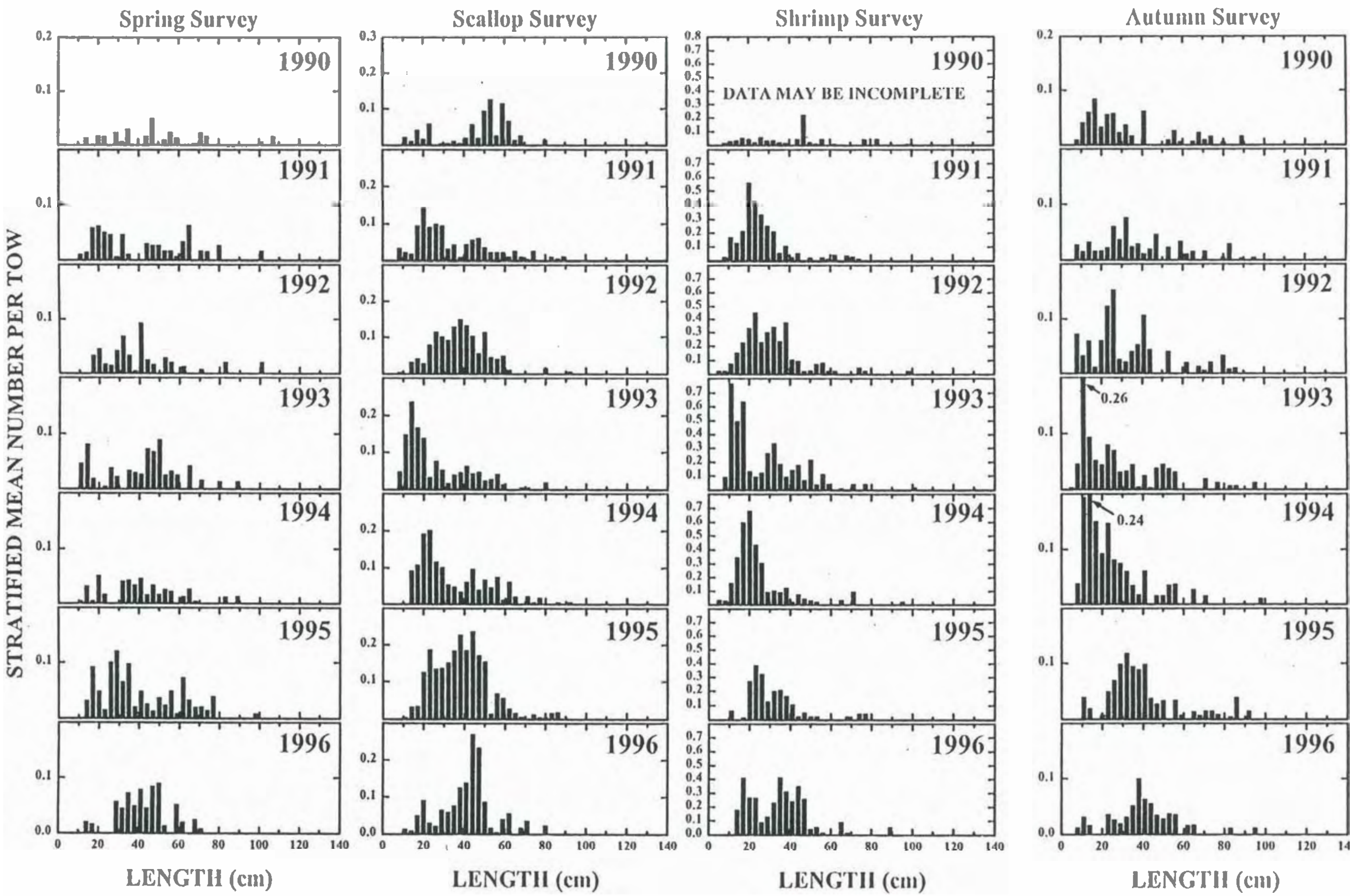


Figure B24. continued

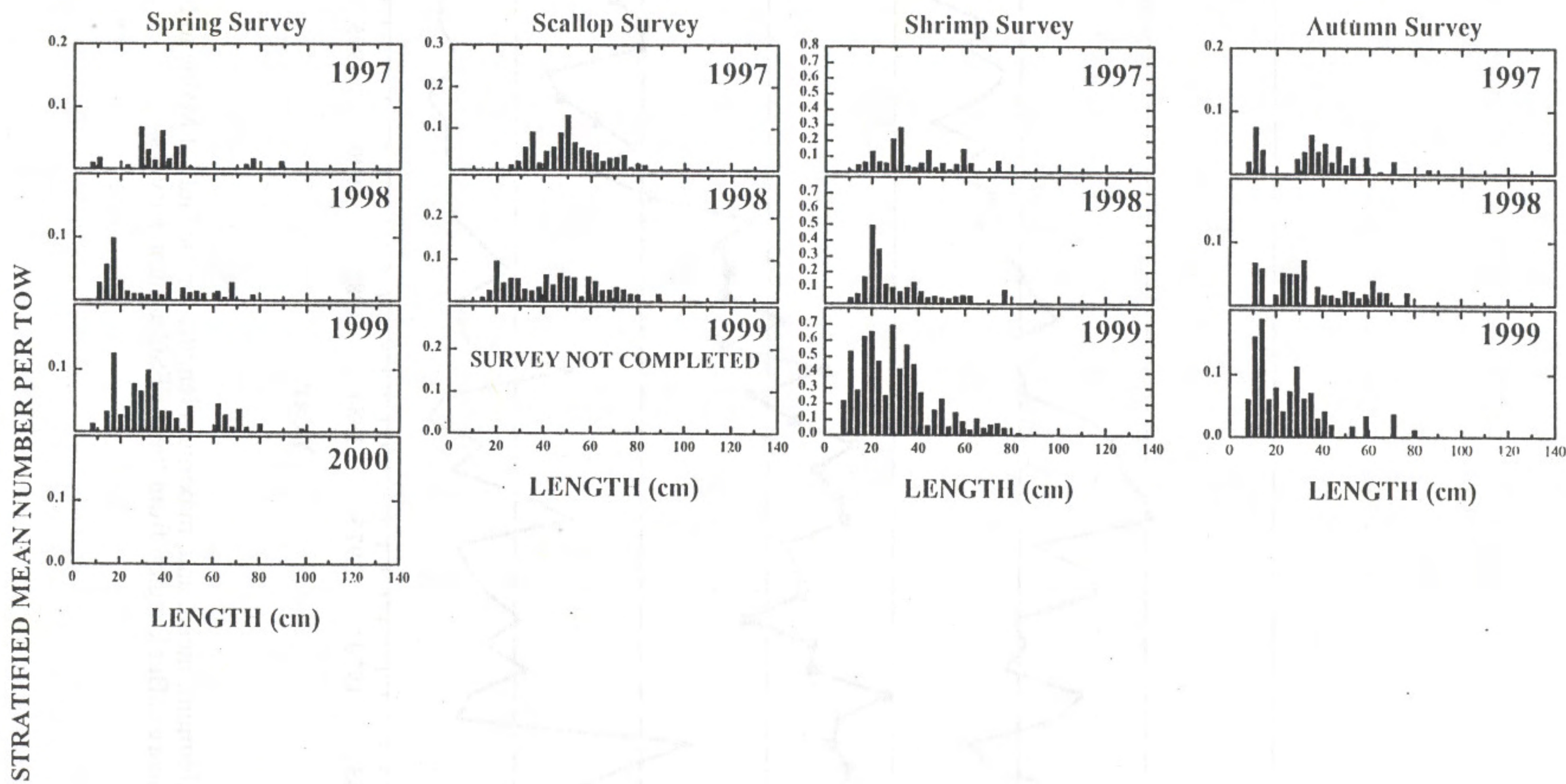


Figure B24, continued.

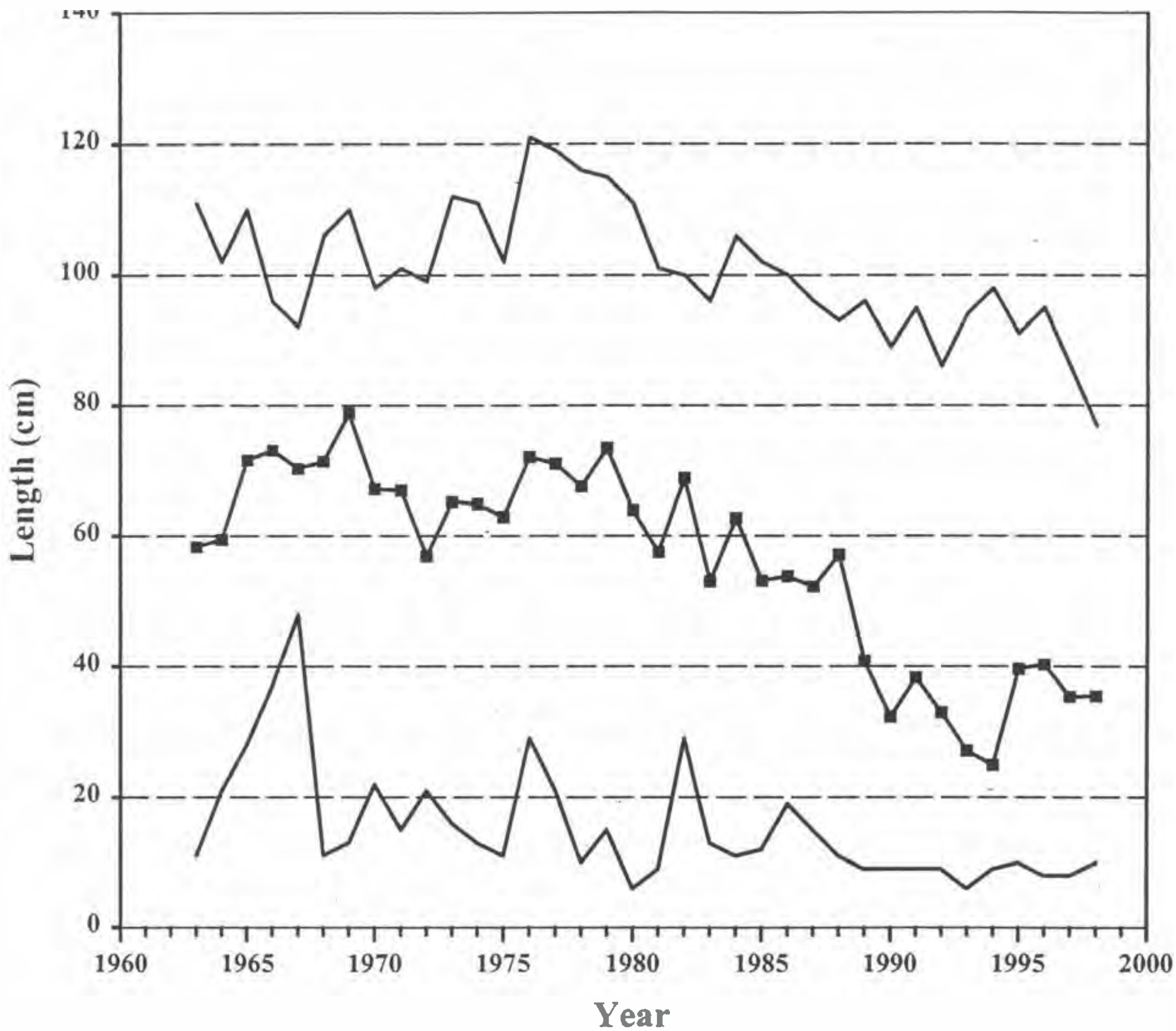


Figure B25. Minimum, mean, and, maximum lengths for the Gulf of Maine to Northern Georges Bank region from the NEFSC autumn surveys.

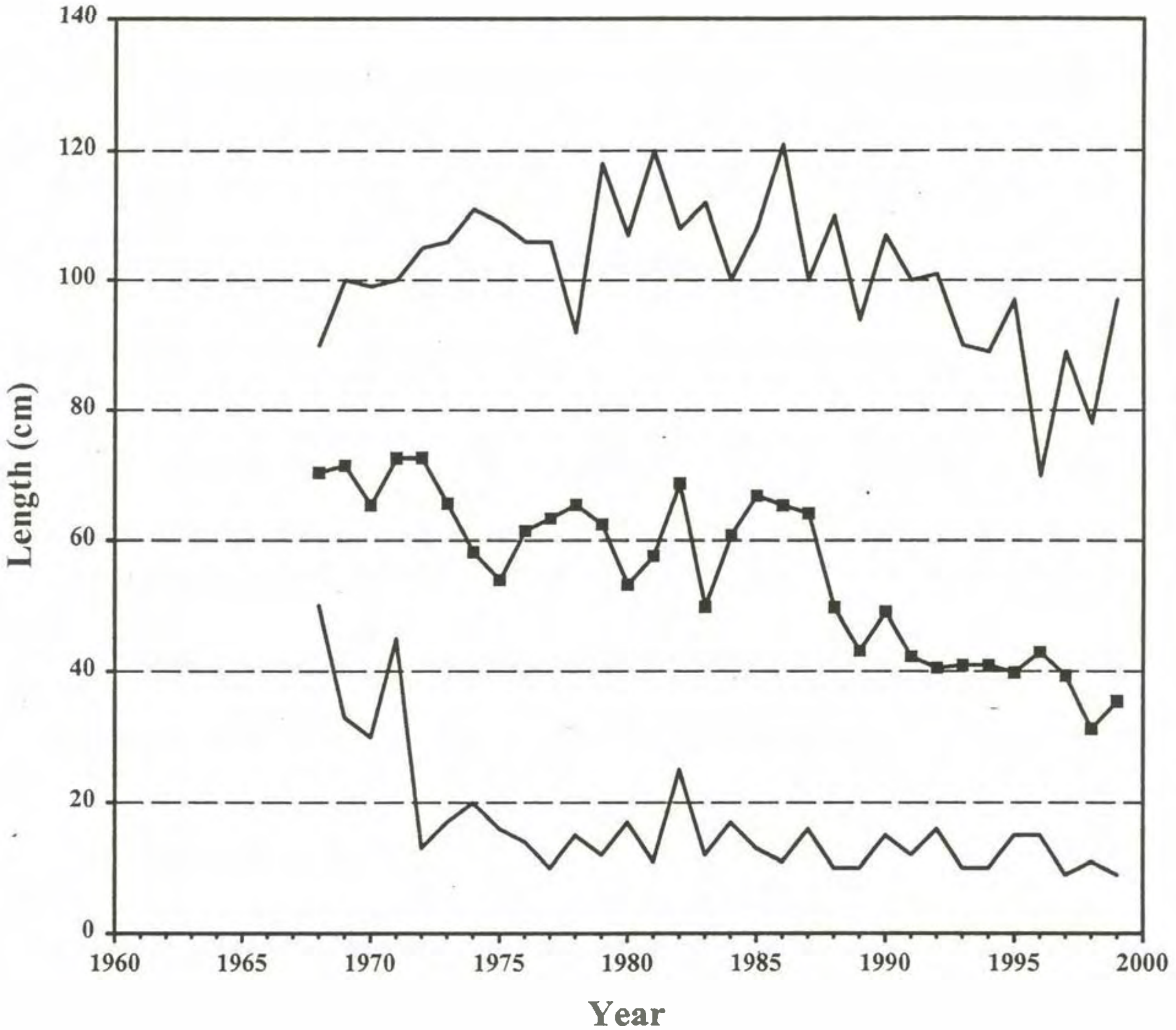
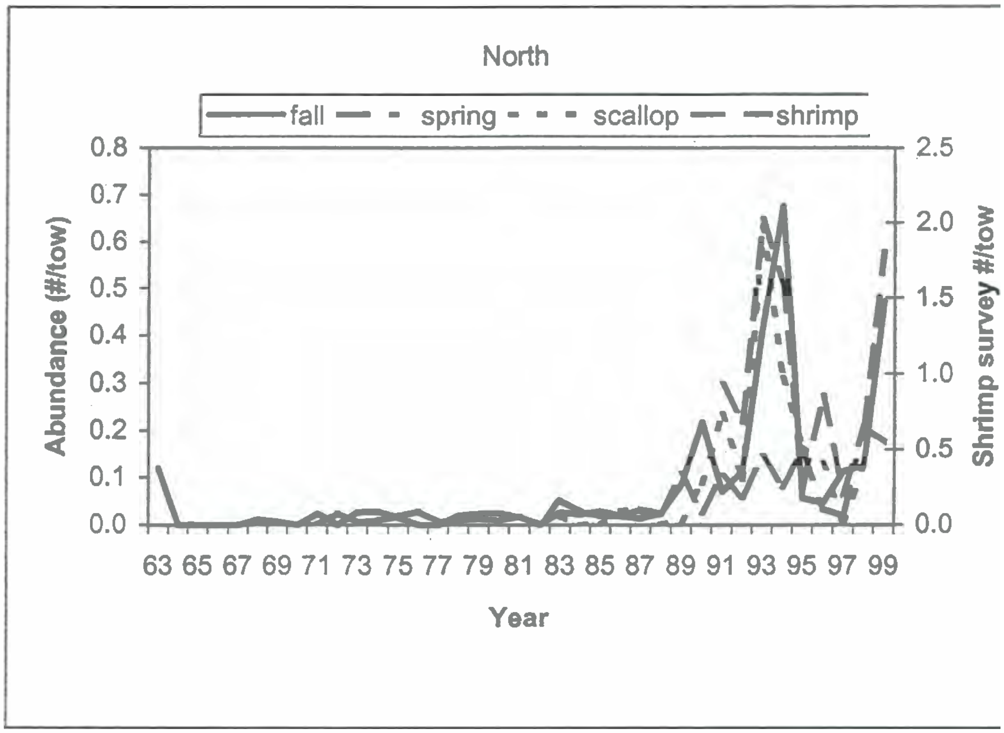
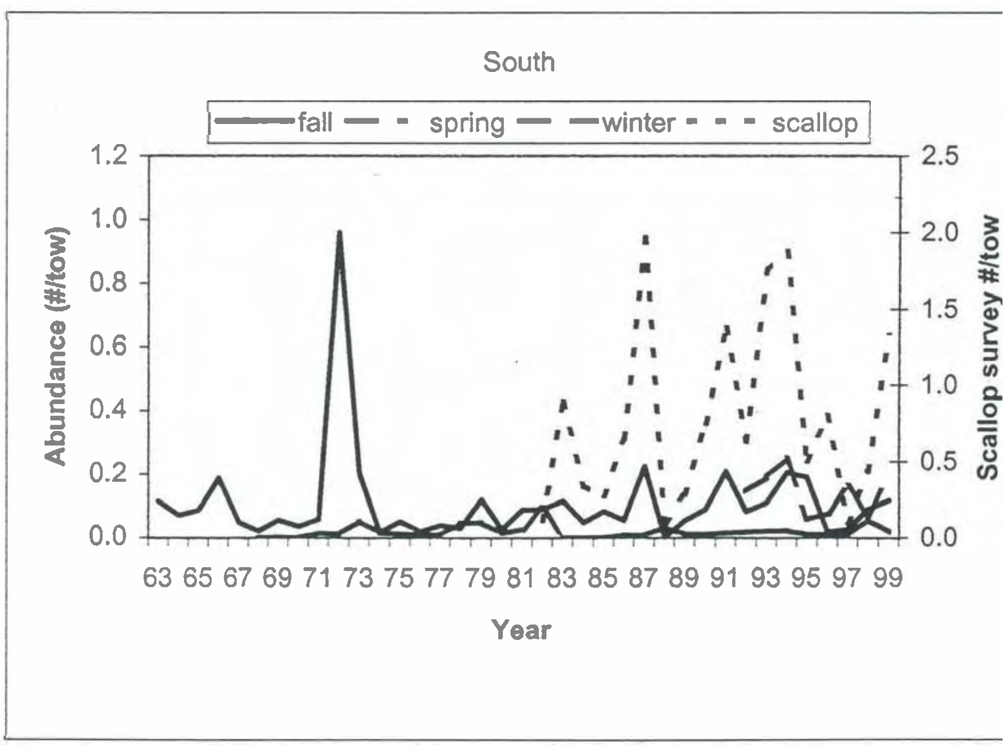


Figure B26. Minimum, mean, and, maximum lengths for the Gulf of Maine to Northern Georges Bank region from the NEFSC spring surveys.

Figure B27. Abundance indices (stratified mean number per tow) for 10-20 cm goosefish from NEFSC research surveys.





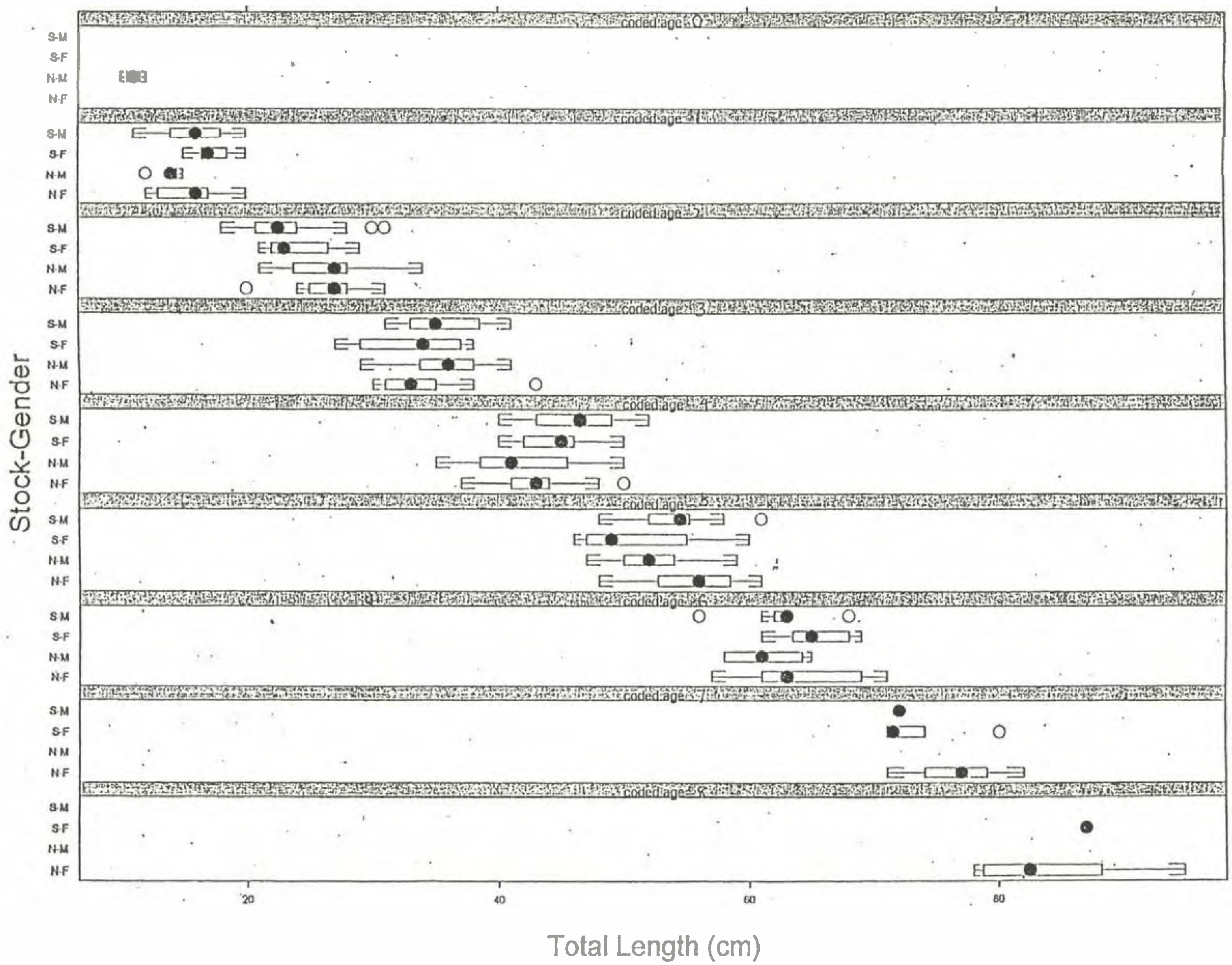
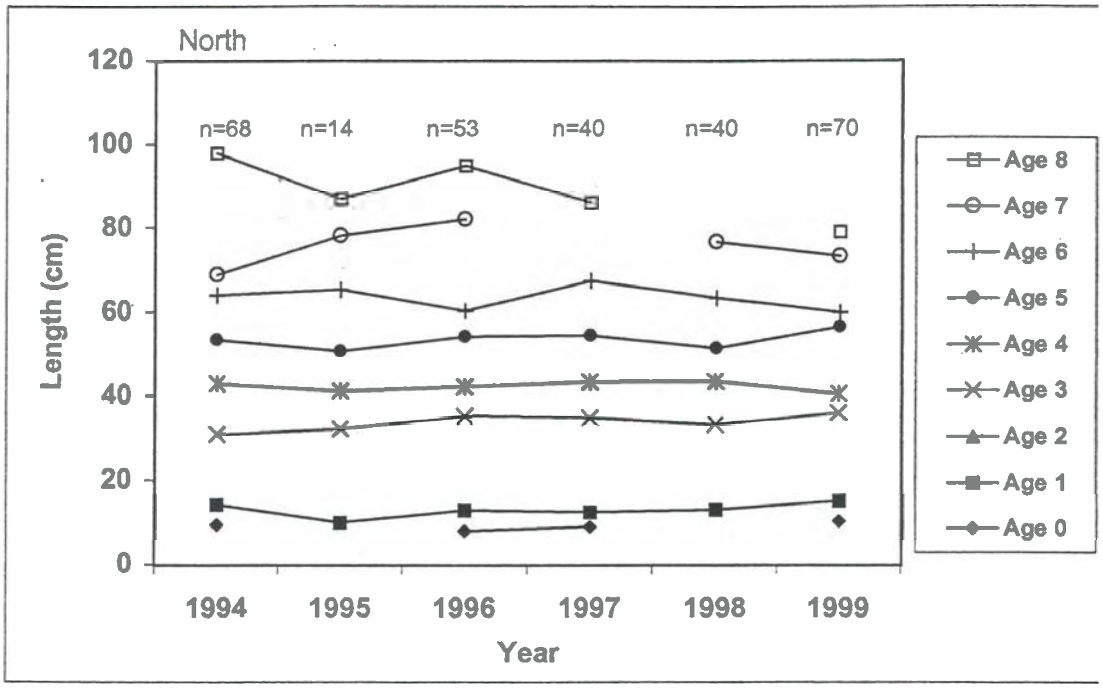


Figure B28. Mean length (cm) at age of goosefish by management region and sex

Figure B29. Mean length at age from NEFSC autumn surveys, northern and southern areas.



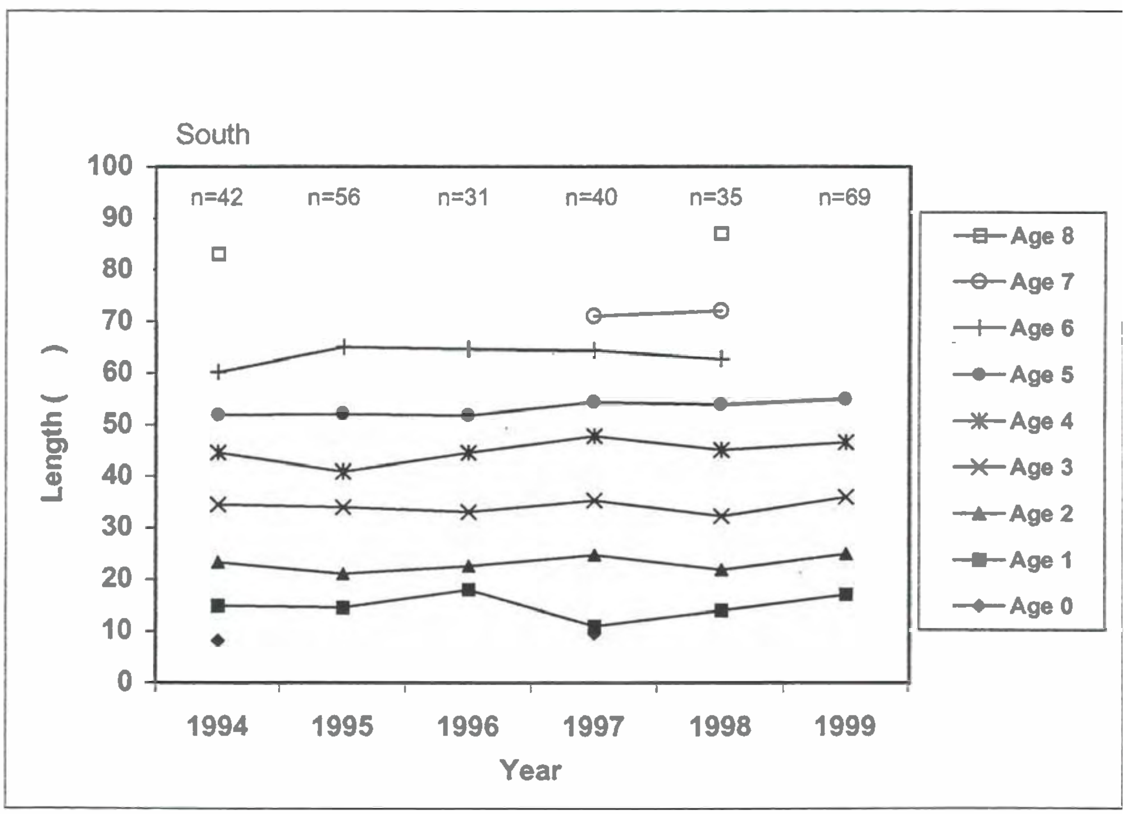
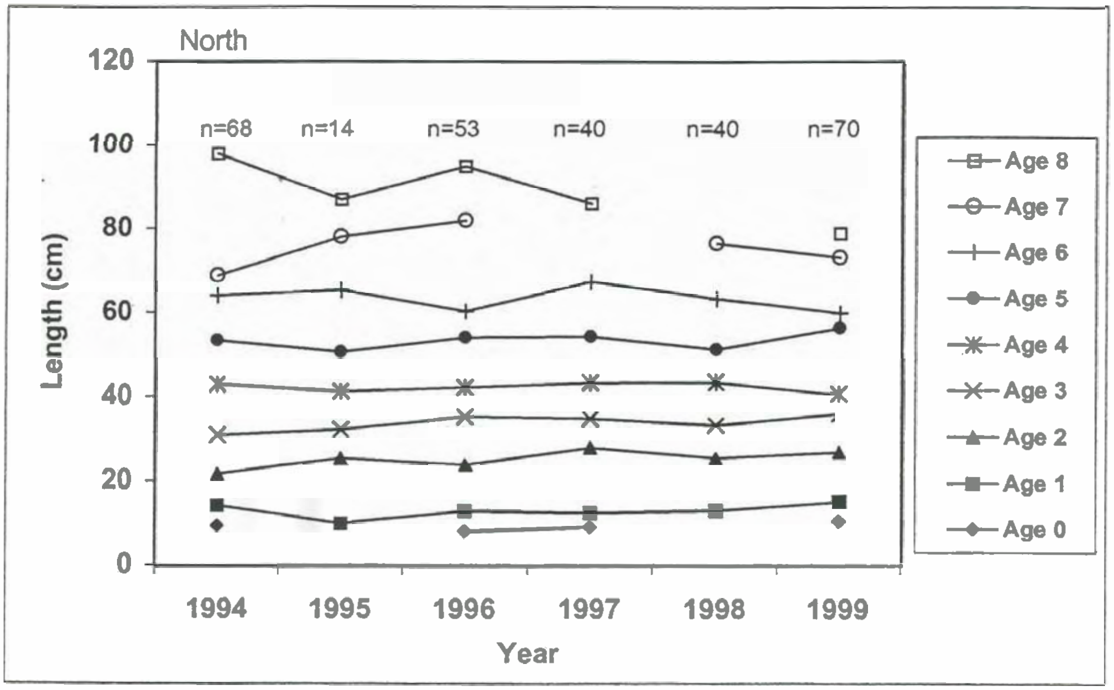
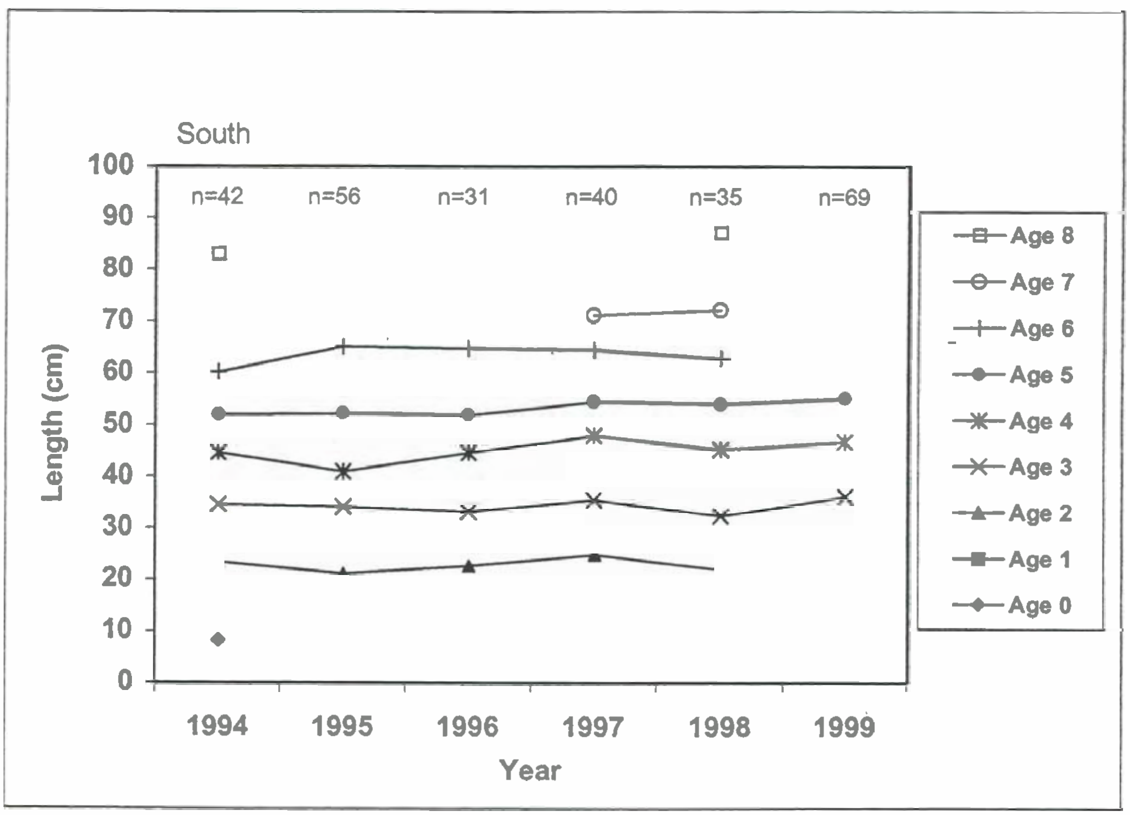
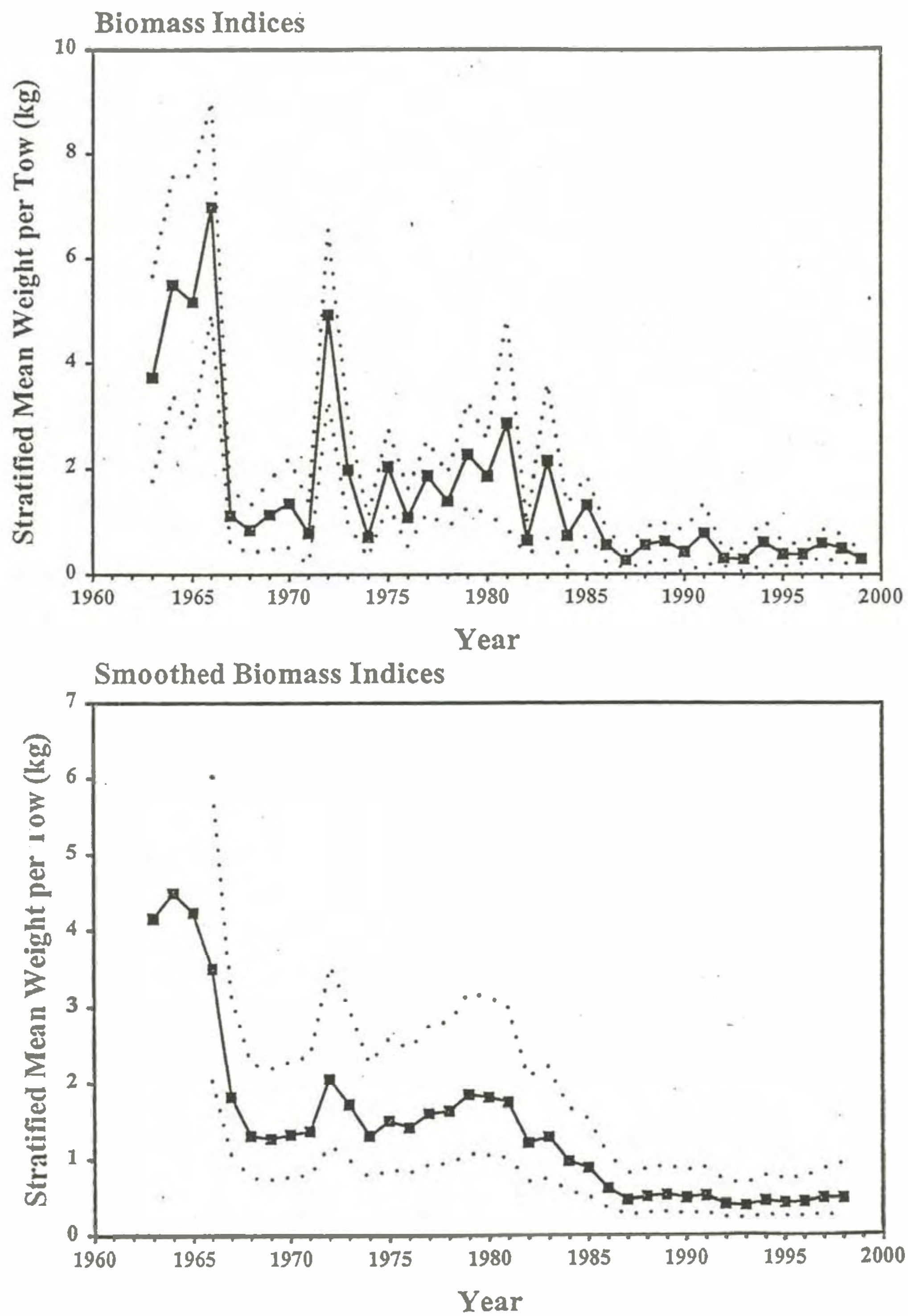


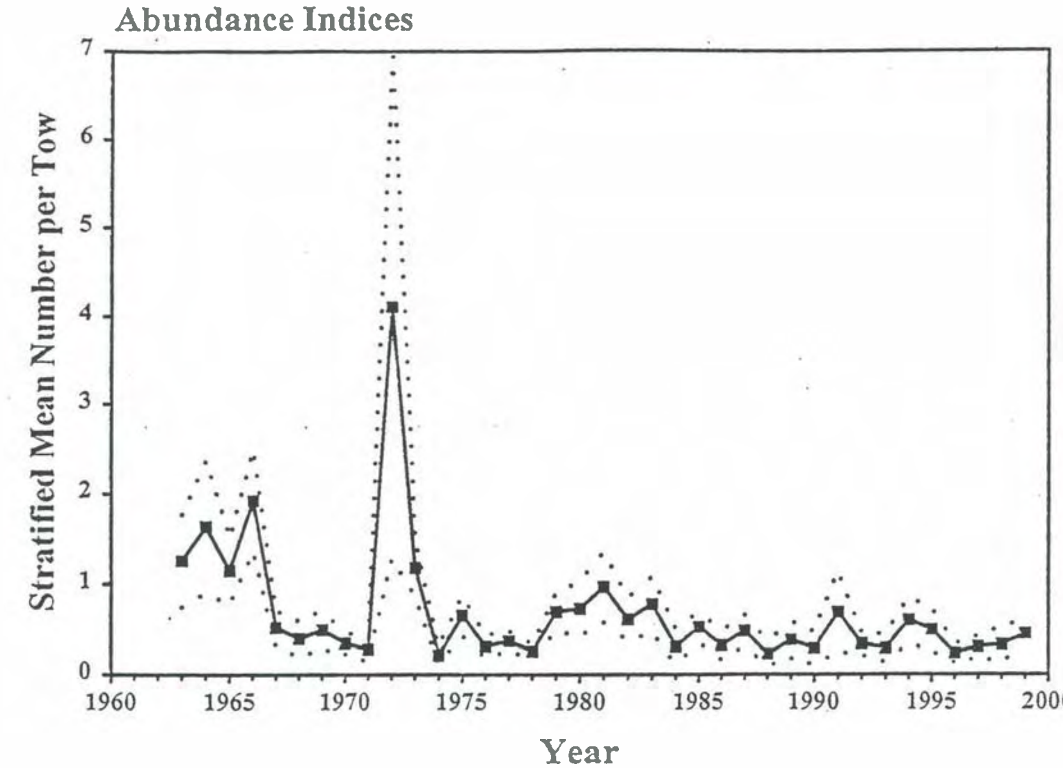
Figure B29. Mean length at age from NEFSC autumn surveys, northern and southern areas.







30. Biomass indices and smoothed indices from the NEFSC autumn ottom trawl survey for the Southern Georges Bank region to Mid-Atlantic gion from 1963-1999. The 95% confidence limits are shown by the dashed line.



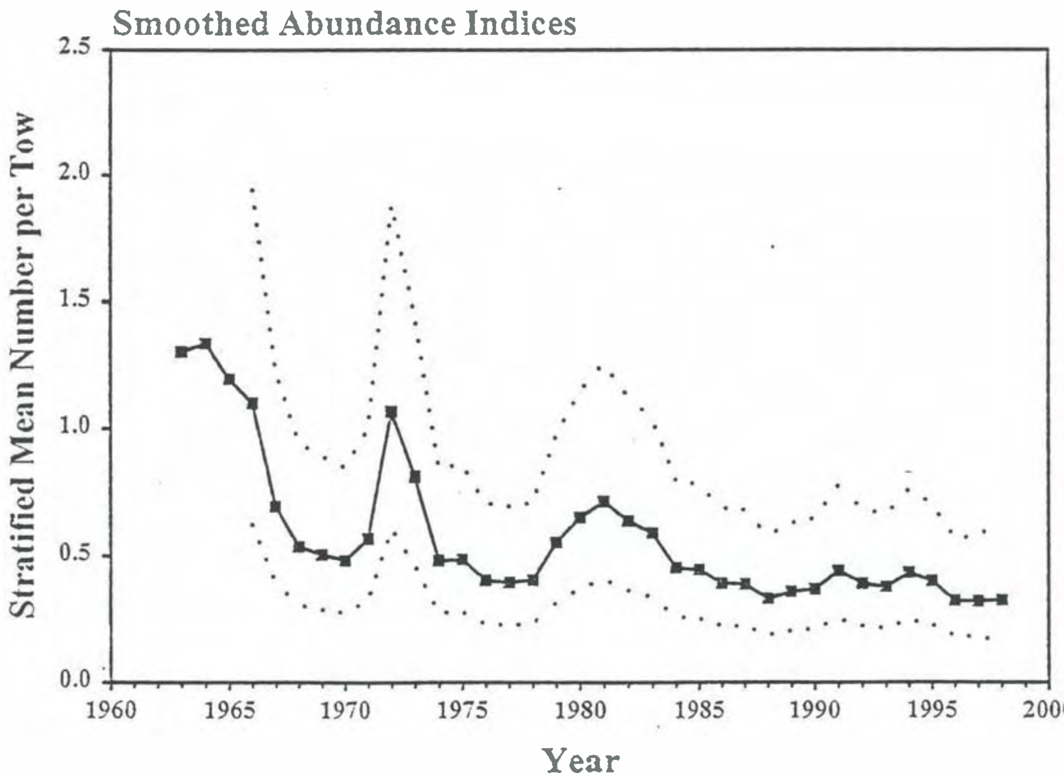
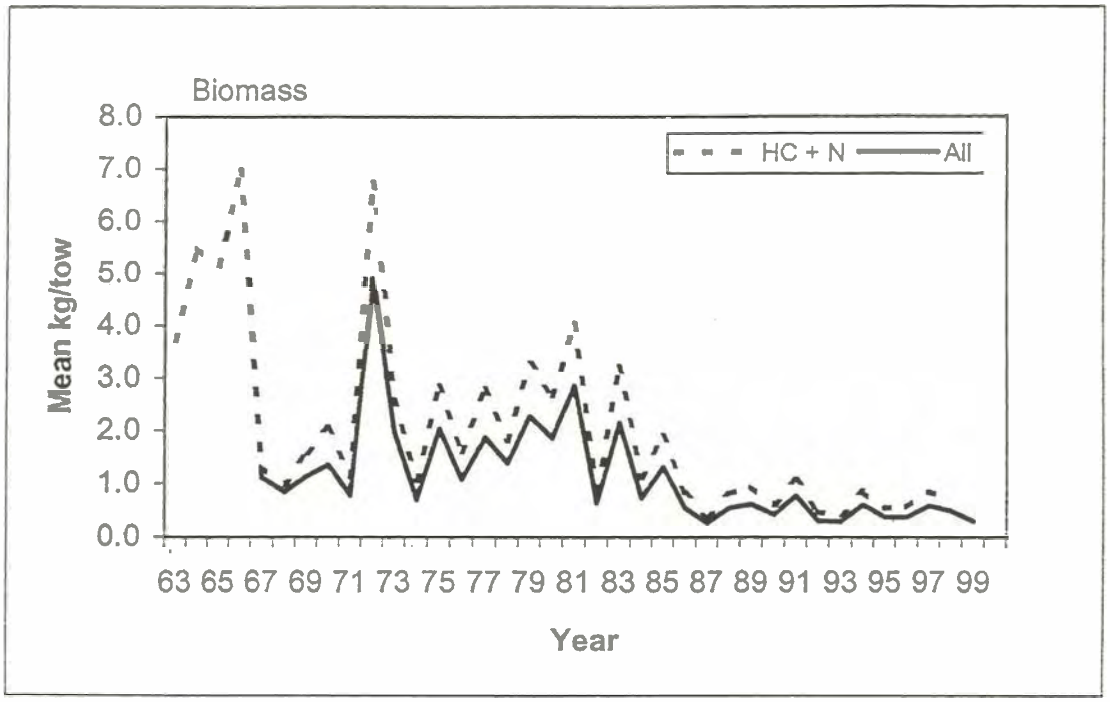
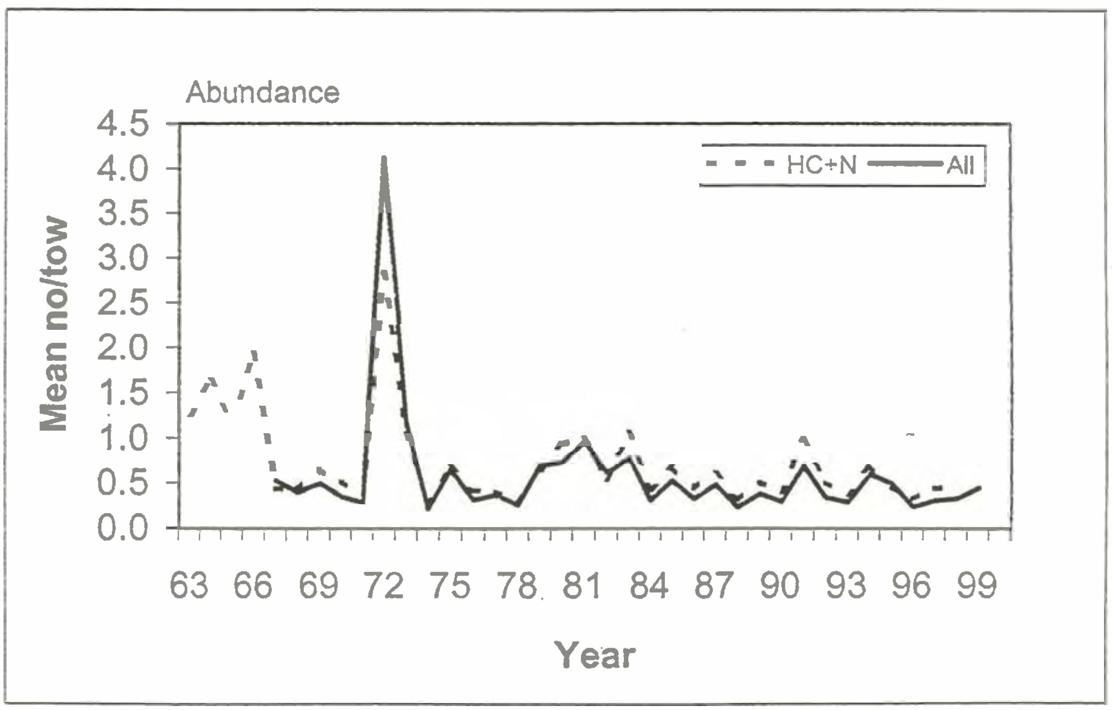


Figure B31. Abundance indices and smoothed indices from the NEFSC autumn bottom trawl survey for the Southern Georges Bank to Mid-Atlantic region from 1963-1998. The 95% confidence limits are shown by the dashed line.





igure G32. Autumn survey indices for southern area for Hudson Canyon and north only (strata 1-19).

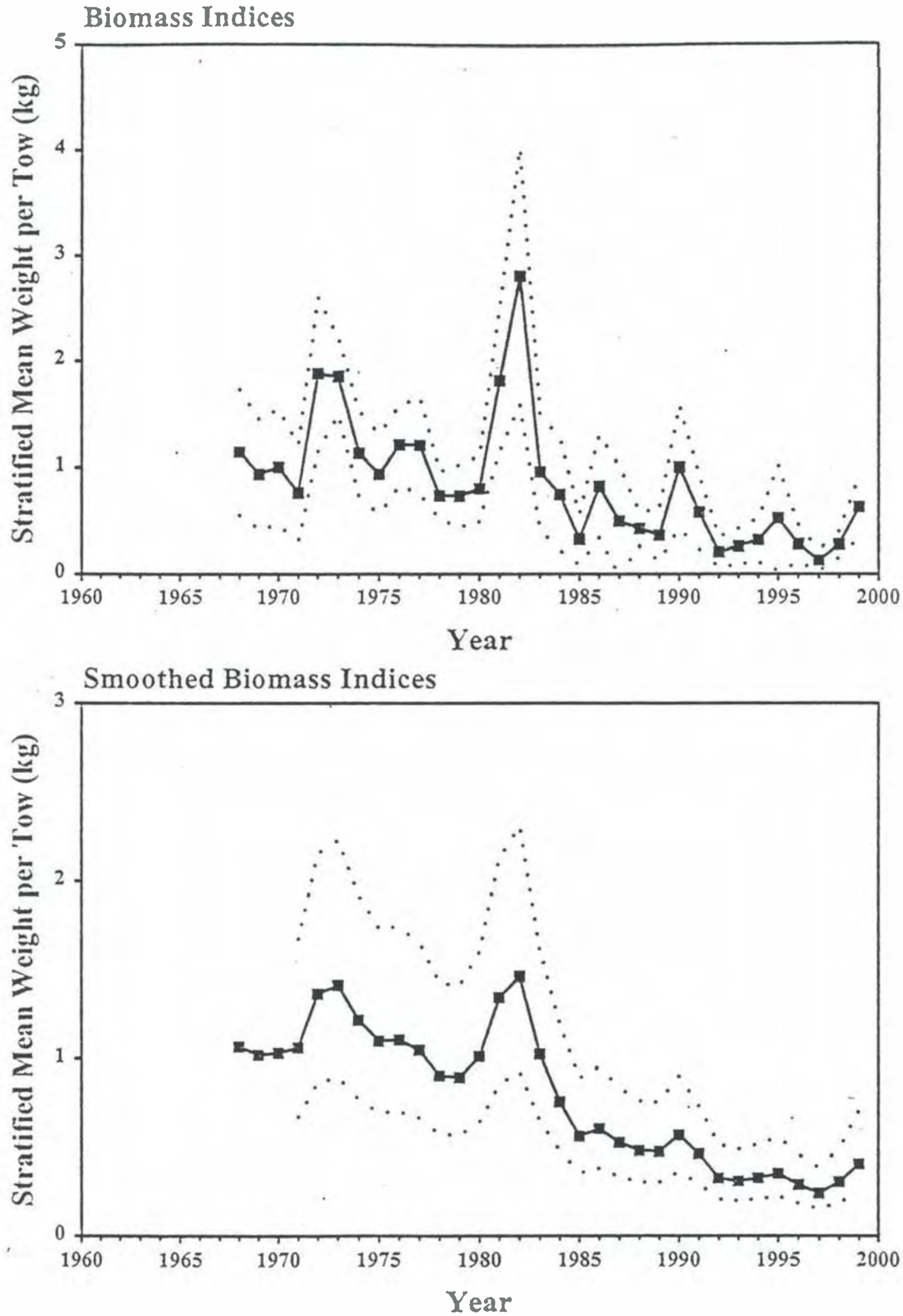
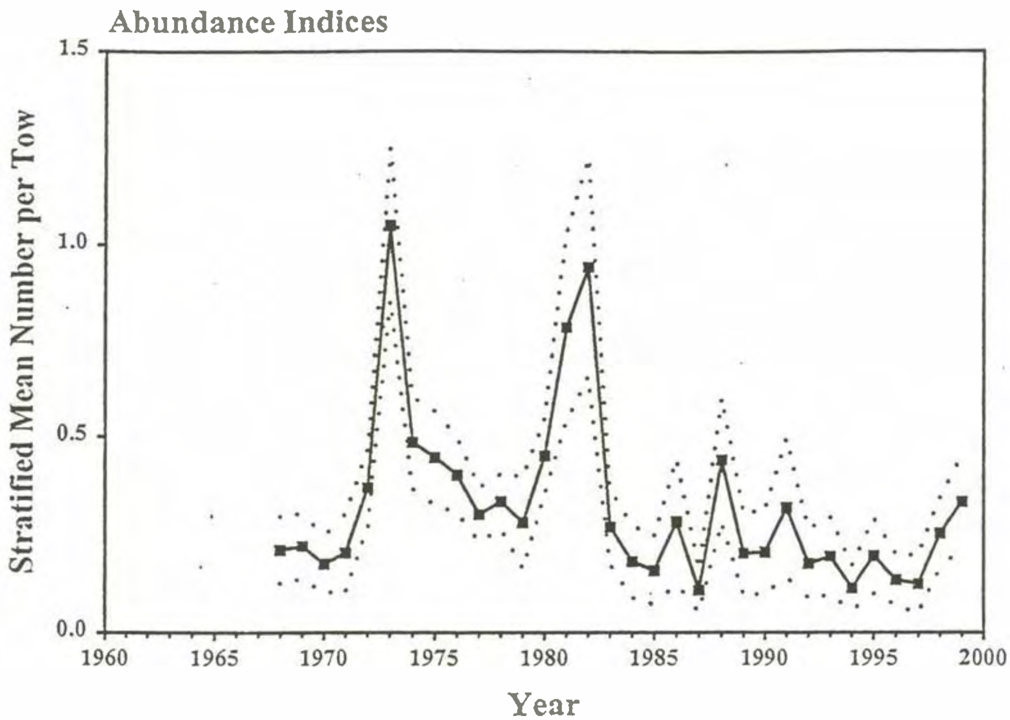


Figure B33. Biomass indices and smoothed indices from the NEFSC spring bottom trawl survey for the Southern Georges Bank to Mid-Atlantic region from 1968-1999. The 95% confidence limits are shown by the dashed line.



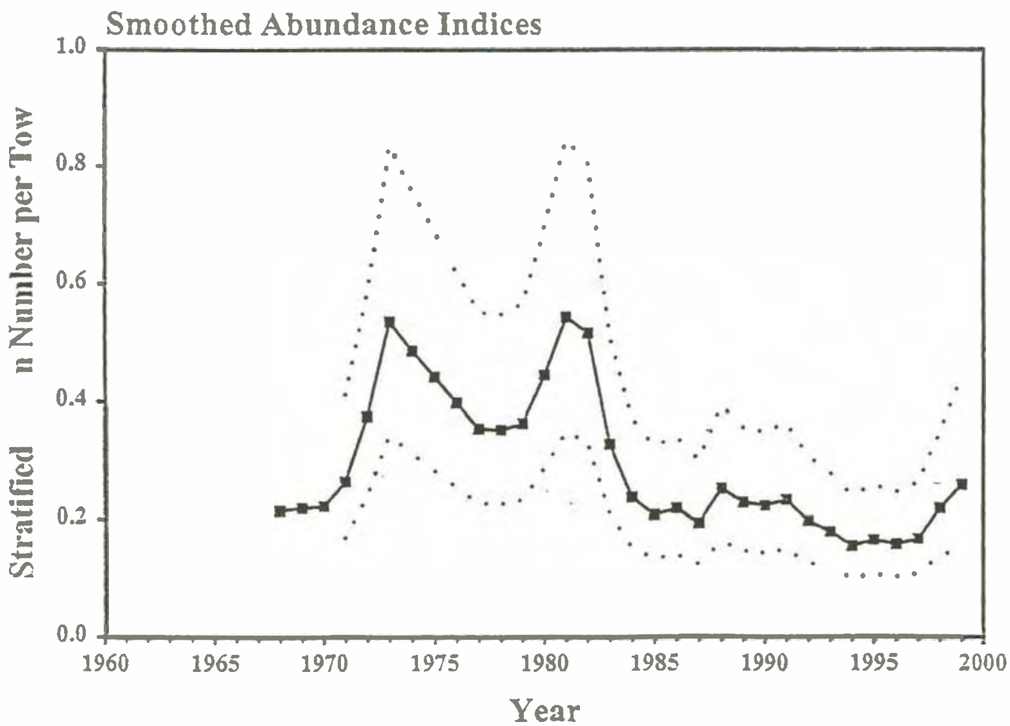


Figure B34. Abundance indices and smoothed indices from the NEFSC spring bottom trawl survey for the Southern Georges Bank to Mid-Atlantic region from 1968-1999. The 95% confidence limits are shown by the dashed line.

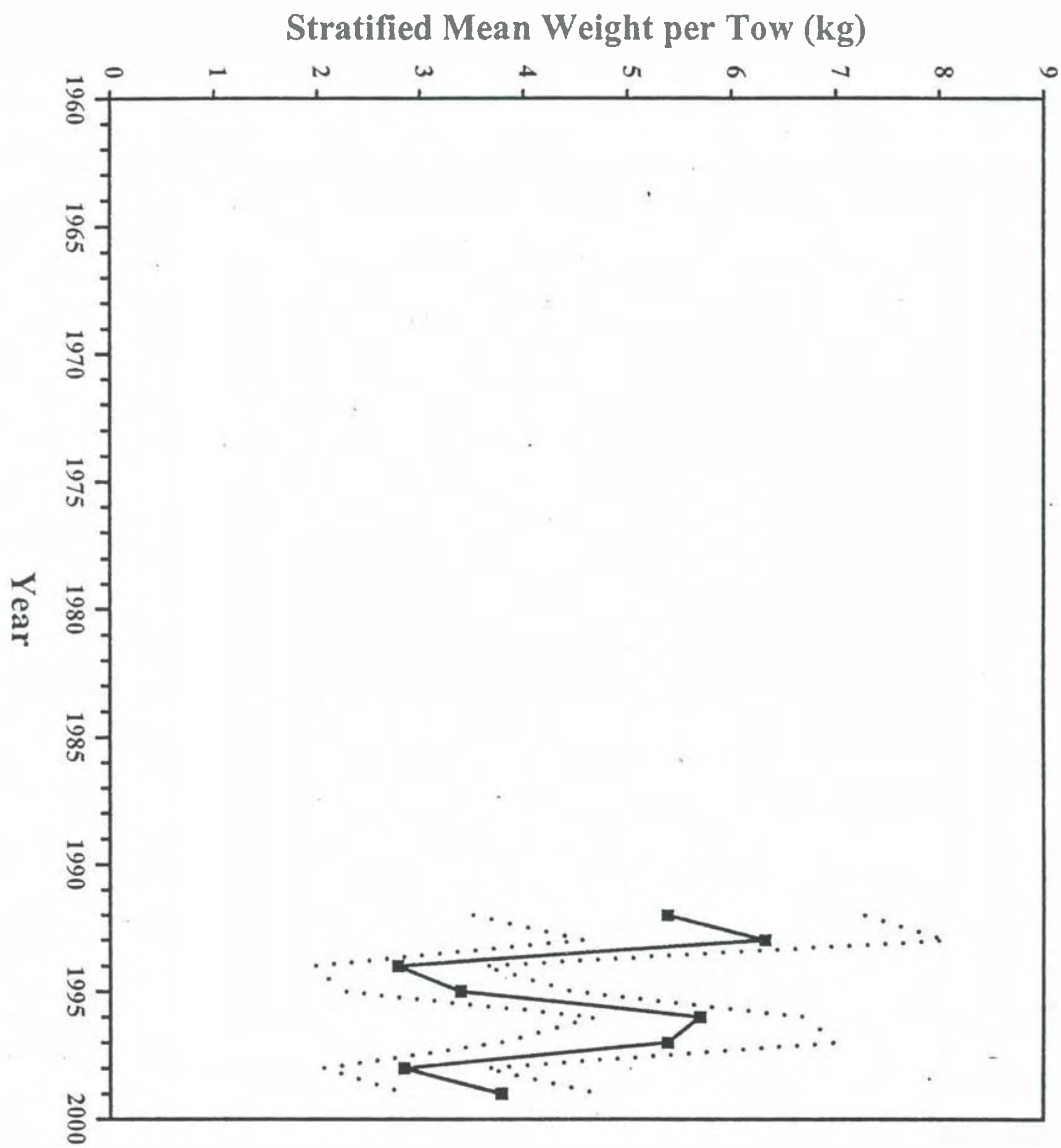


Figure B35. Biomass indices from the NEFSC winter flatfish survey for the Southern George Bank to Mid-Atlantic region from 1992-1999. The 95% confidence limits are shown by the dashed line.

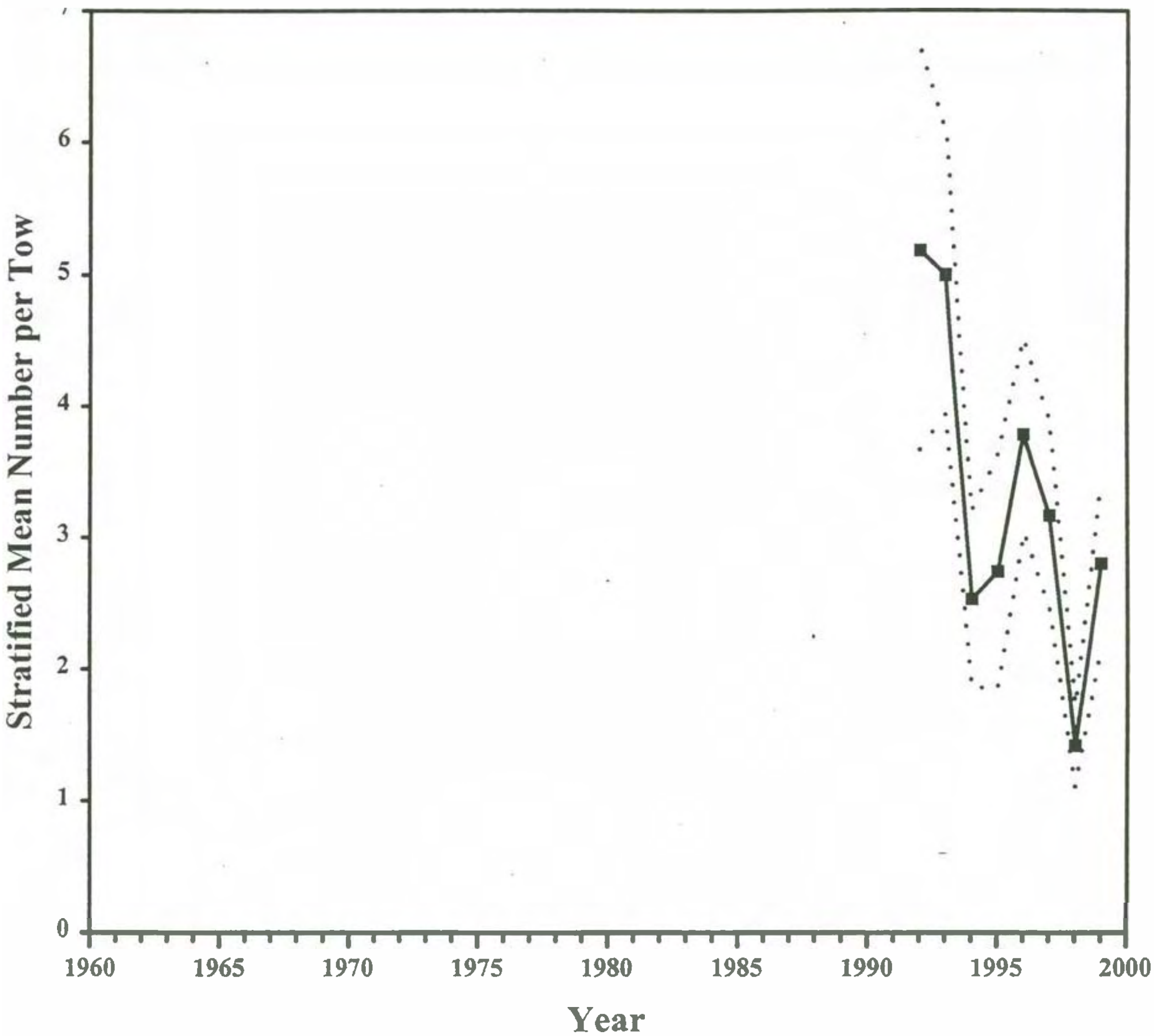


Figure B36. Abundance indices from the NEFSC winter flatfish survey for the Southern Georges Bank to Mid-Atlantic region from 1992-1999. The 95% confidence limits are shown by the dashed line.

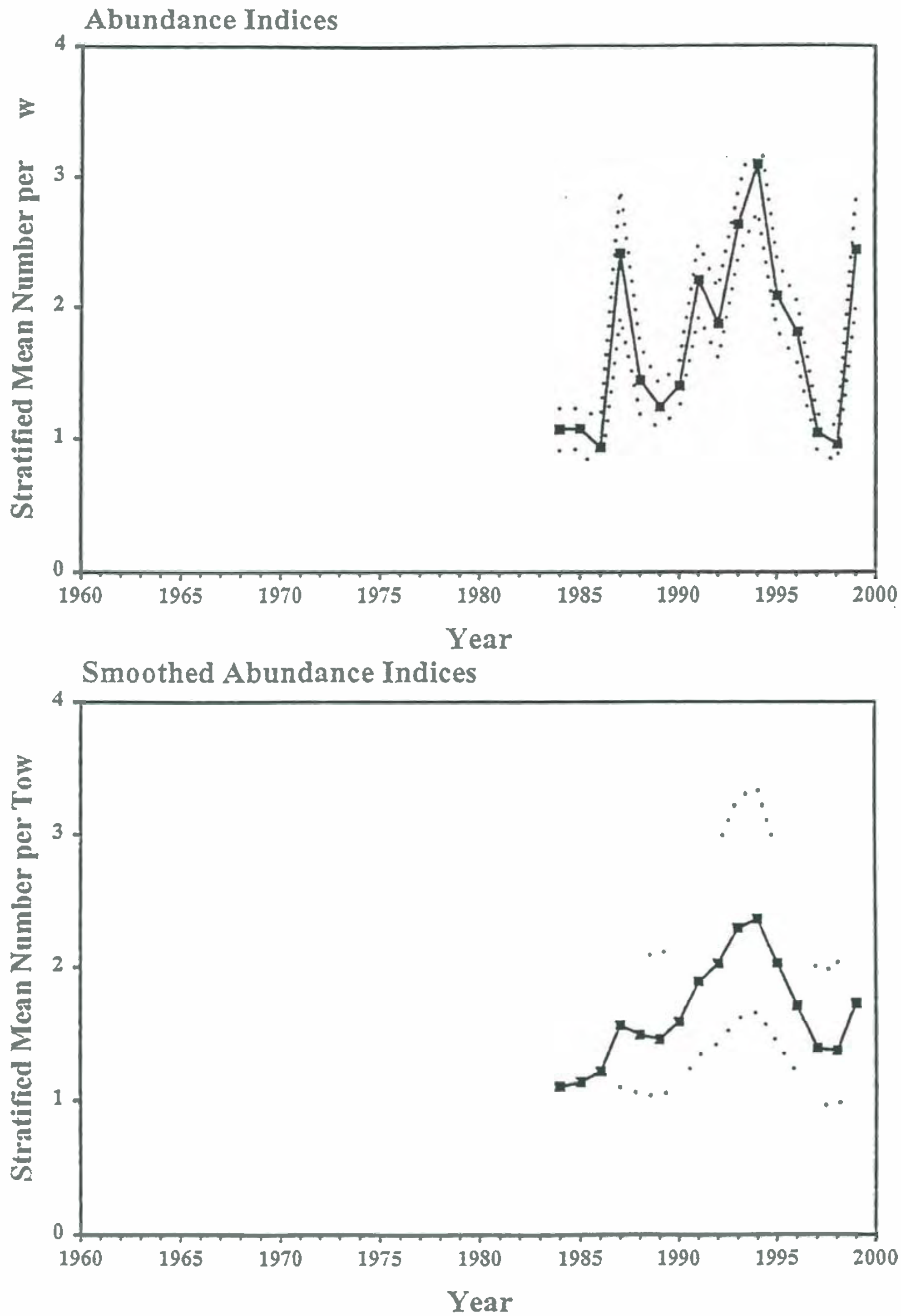
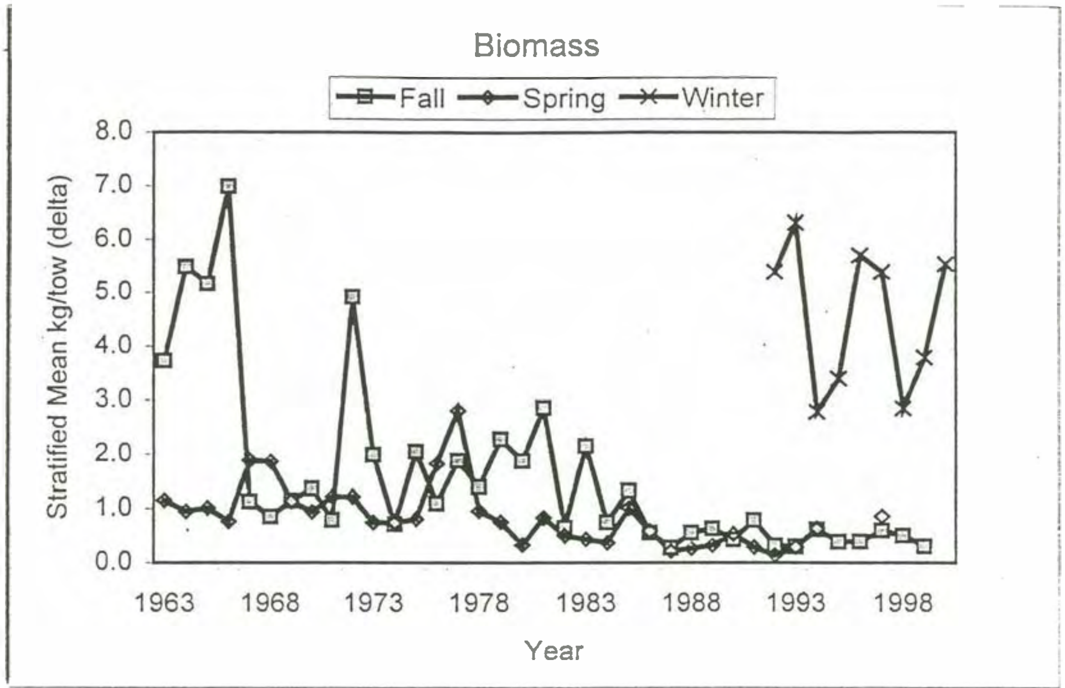


Figure B37. Abundance indices and smoothed indices from the NEFSC scallop d:
survey for the Southern Georges Bank to Mid-Atlantic region from 1984-1
The 95% confidence limits are shown by the dashed line.



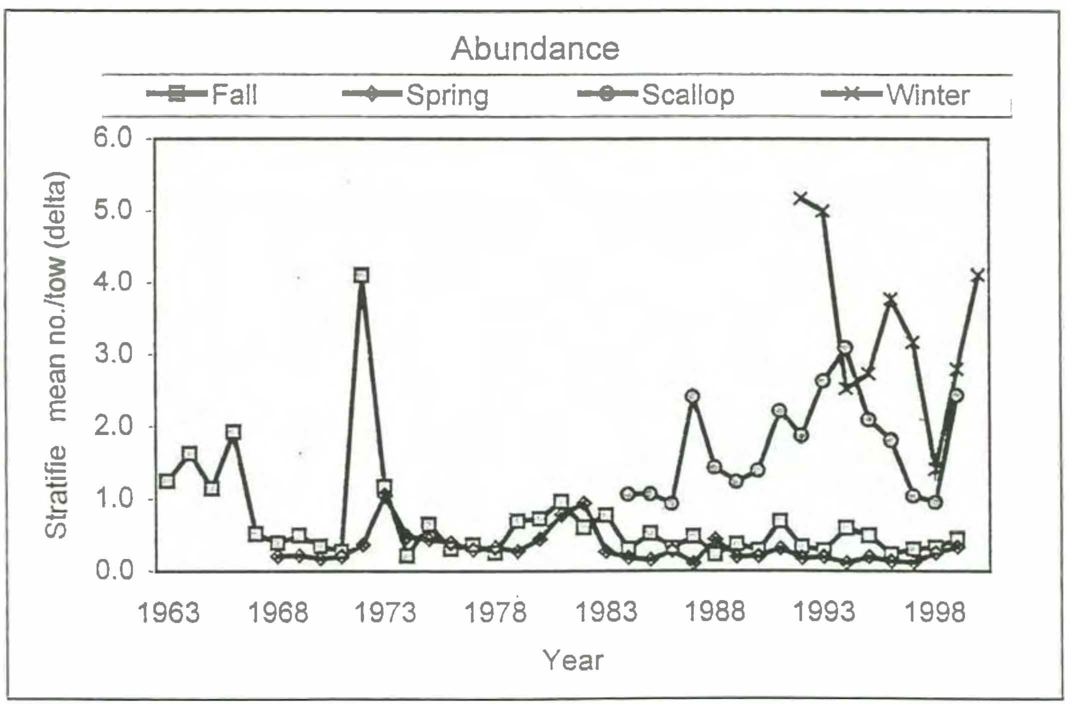
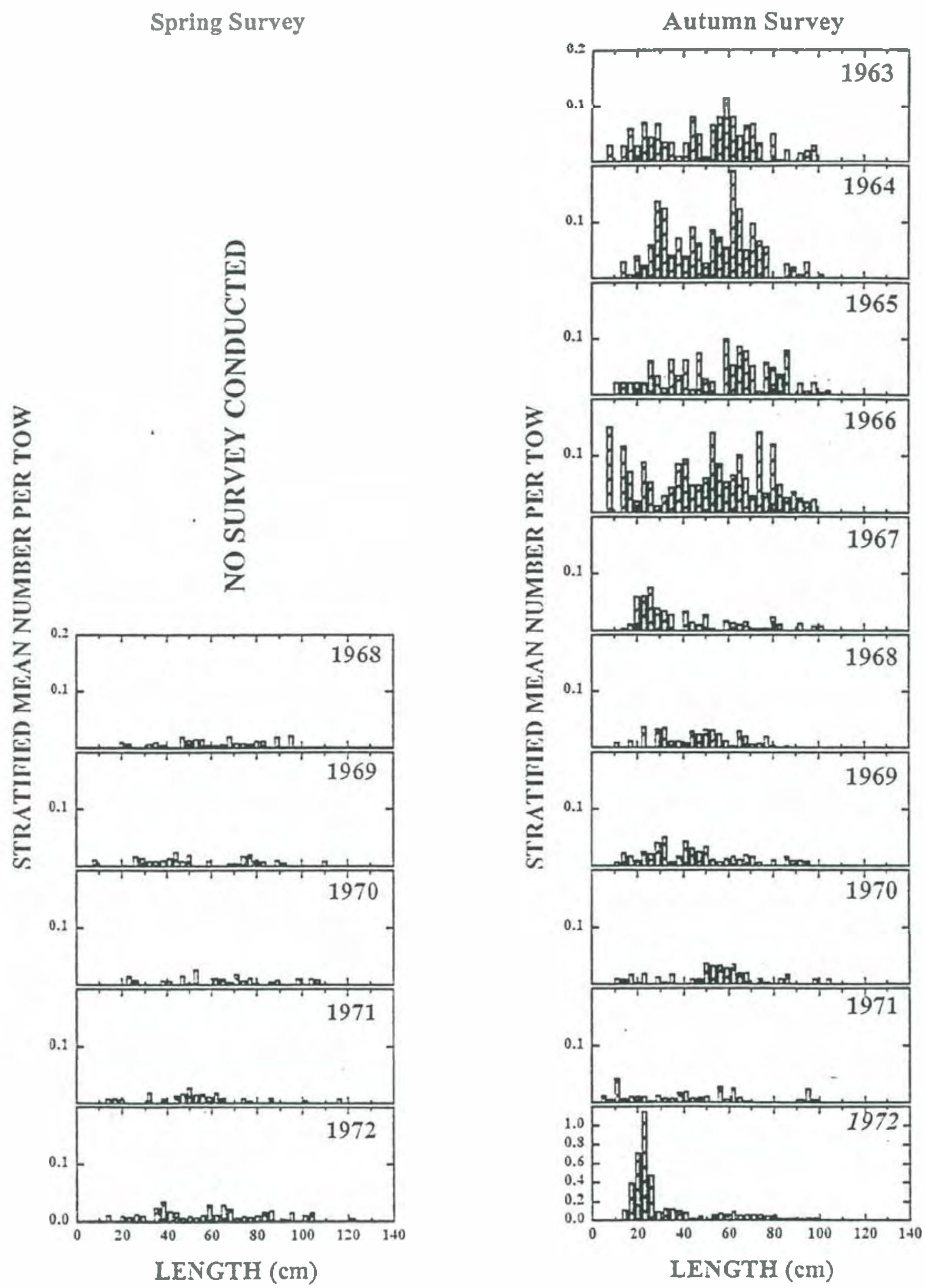


Figure B38. Biomass and abundance indices from the NEFSC spring and autumn trawl surveys, southern management region.



.gure B39. Goosefish length composition from the NEFSC spring bottom trawl (March-April), winter flatfish (February), summer scallop (July-August), and autumn (September-October) bottom trawl surveys in the Southern Georges Bank to Mid-Atlantic region, 1963-1999.

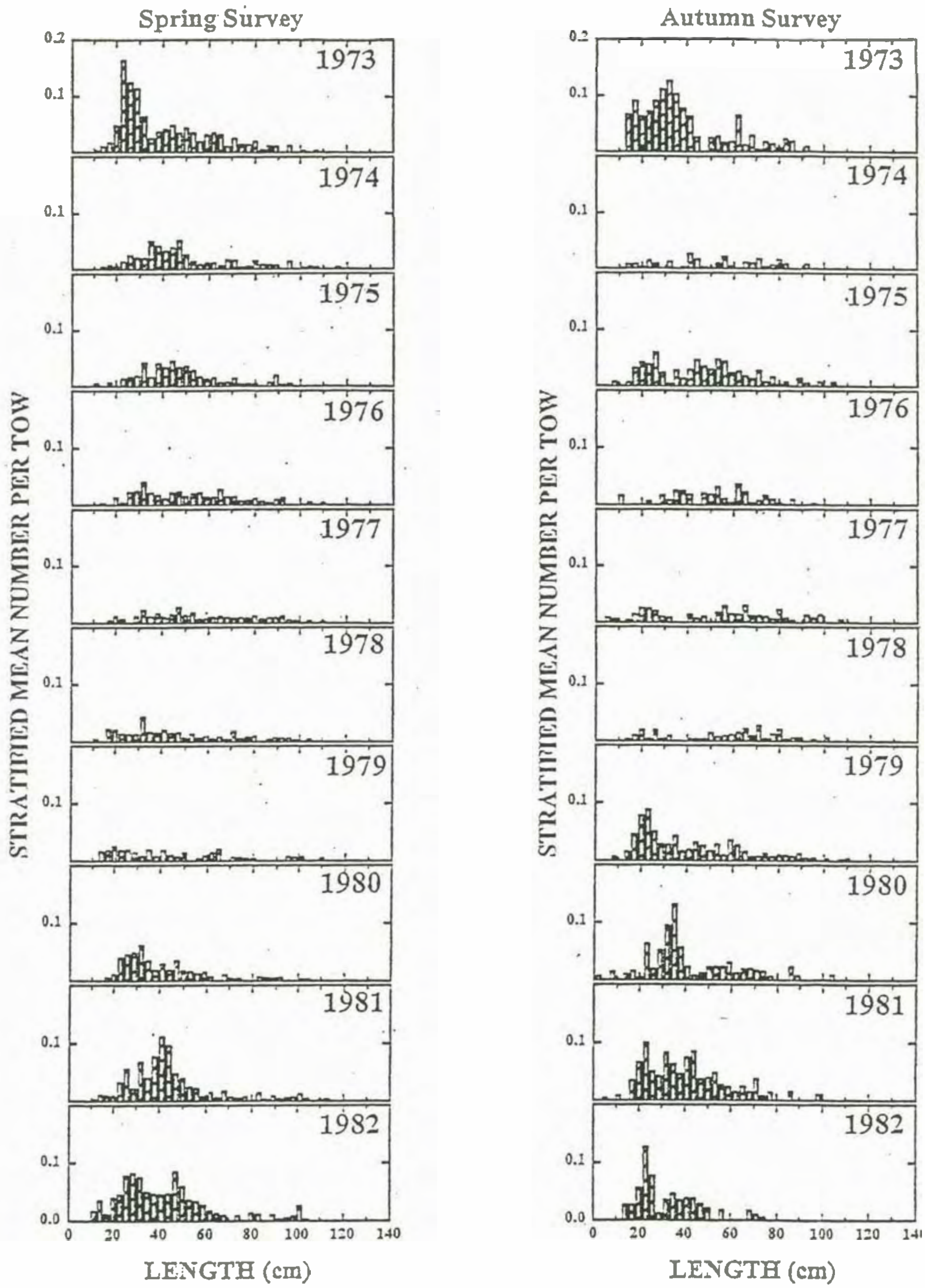


Figure B39. Continued

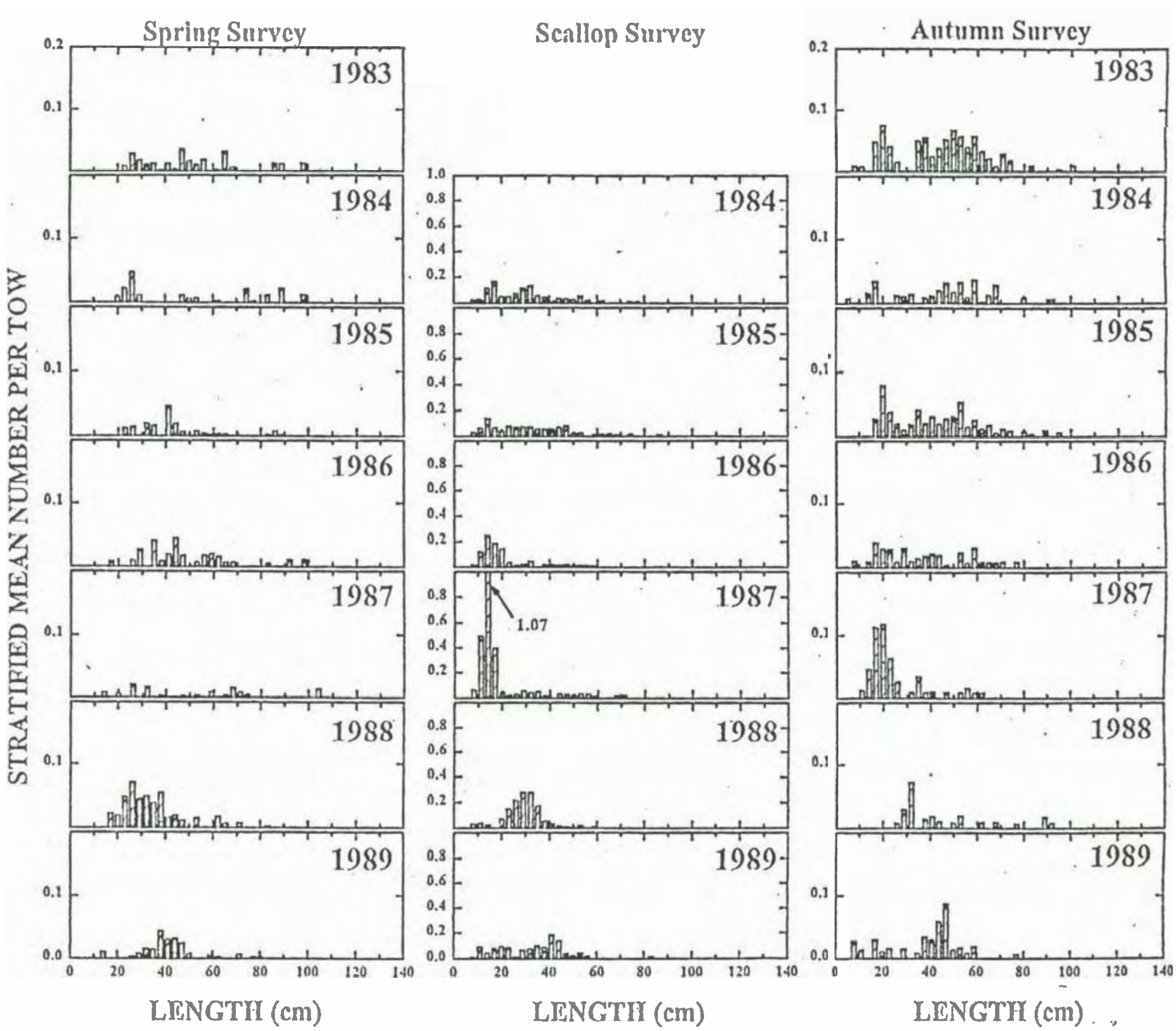


Figure B39. Continued

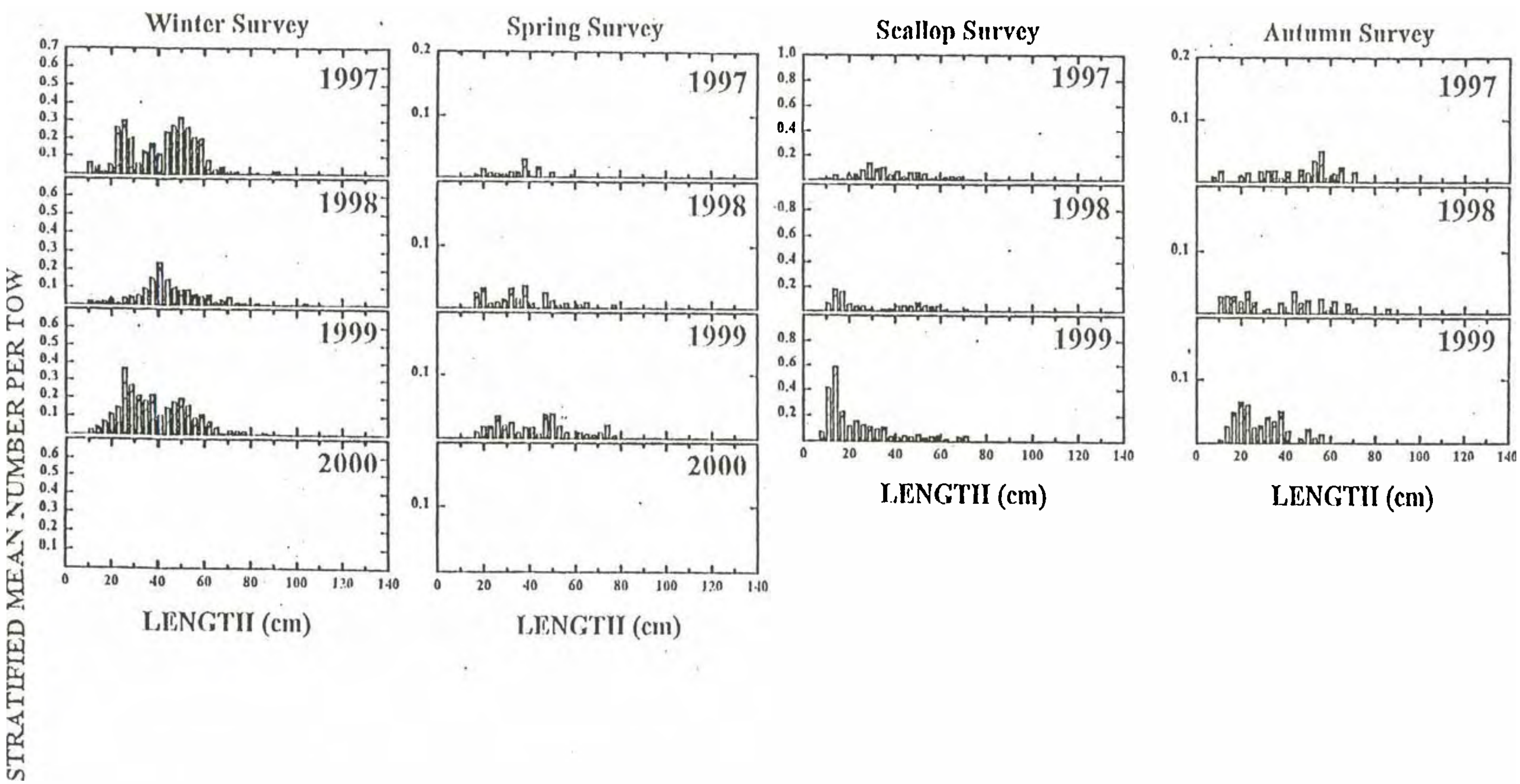


Figure B39. Continued

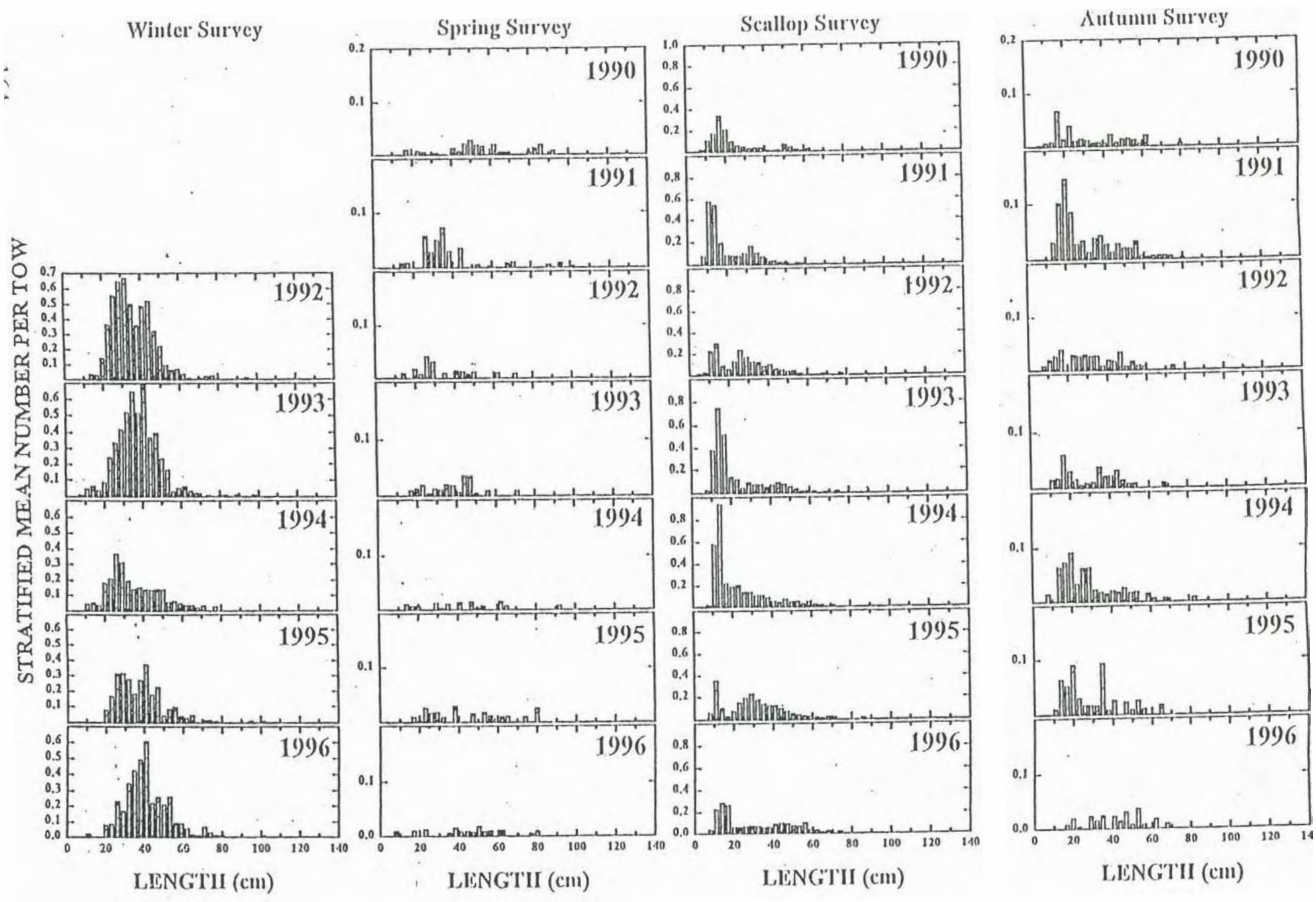


Figure B39. Continued

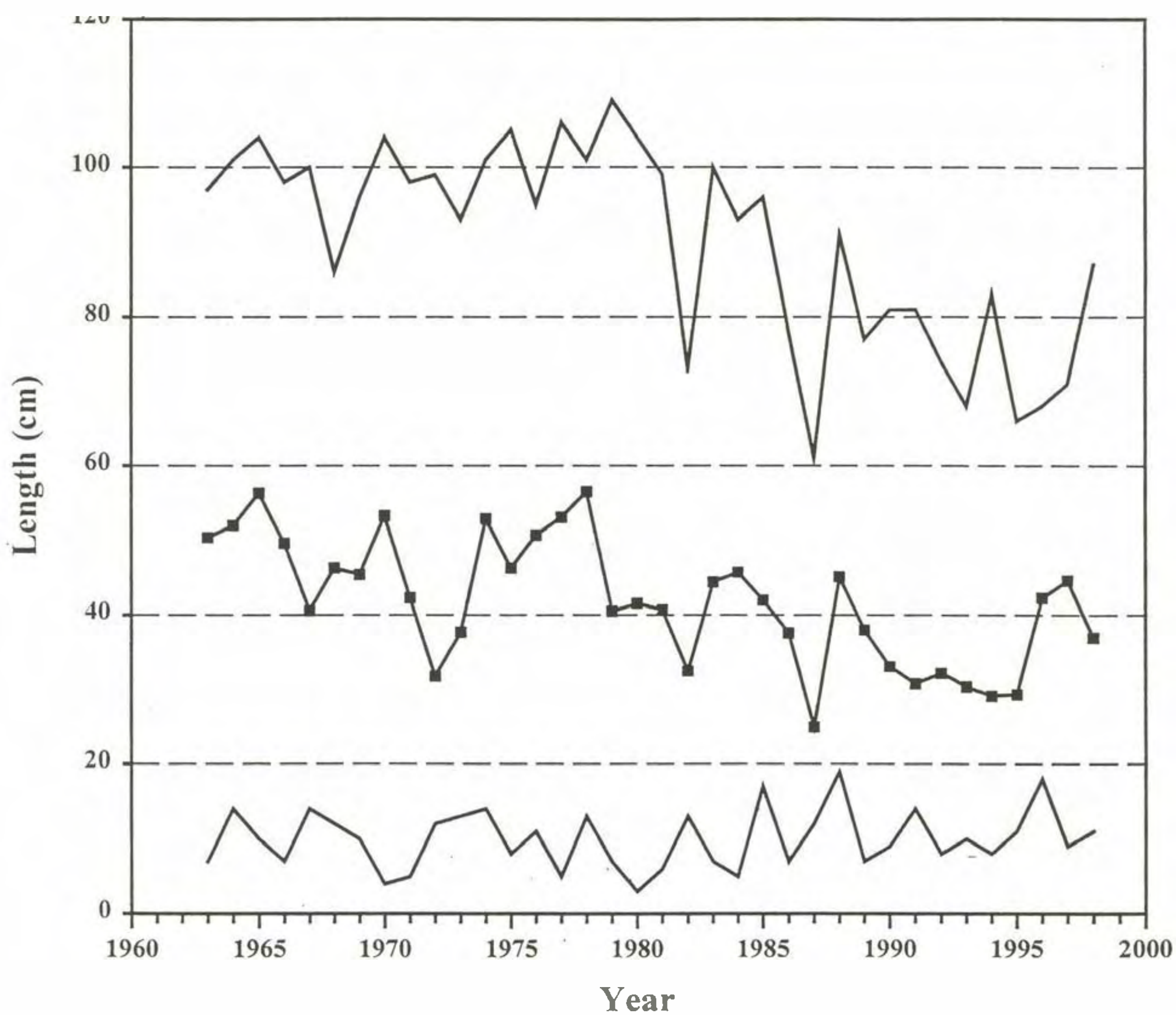


Figure B40. Minimum, mean, and, maximum lengths for the Southern Georges Bank to Mid-Atlantic region from the NEFSC autumn surveys.

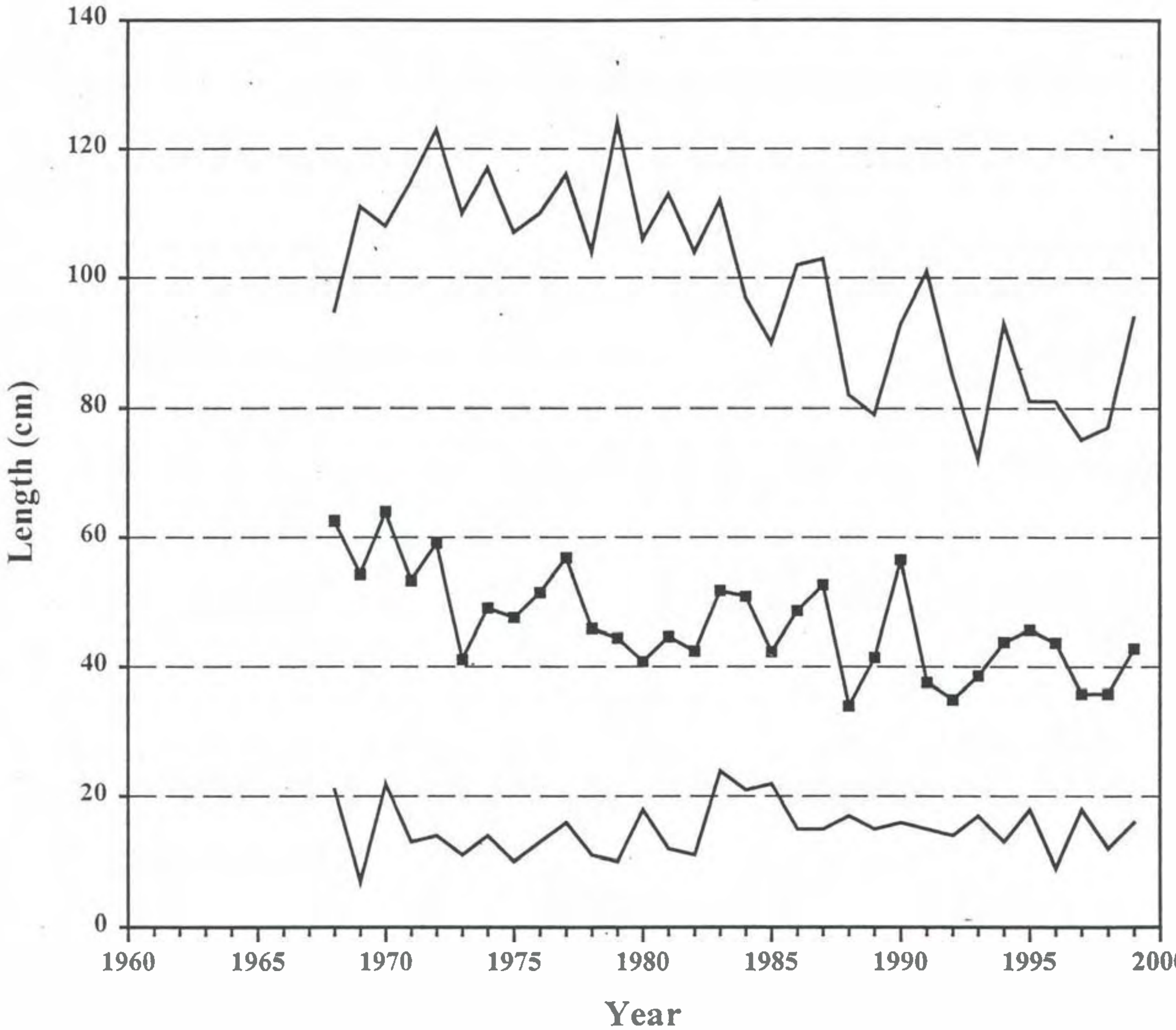


Figure B41. Minimum, mean, and, maximum lengths for the Southern Georges Bank to Mid-Atlantic region from the NEFSC spring surveys.

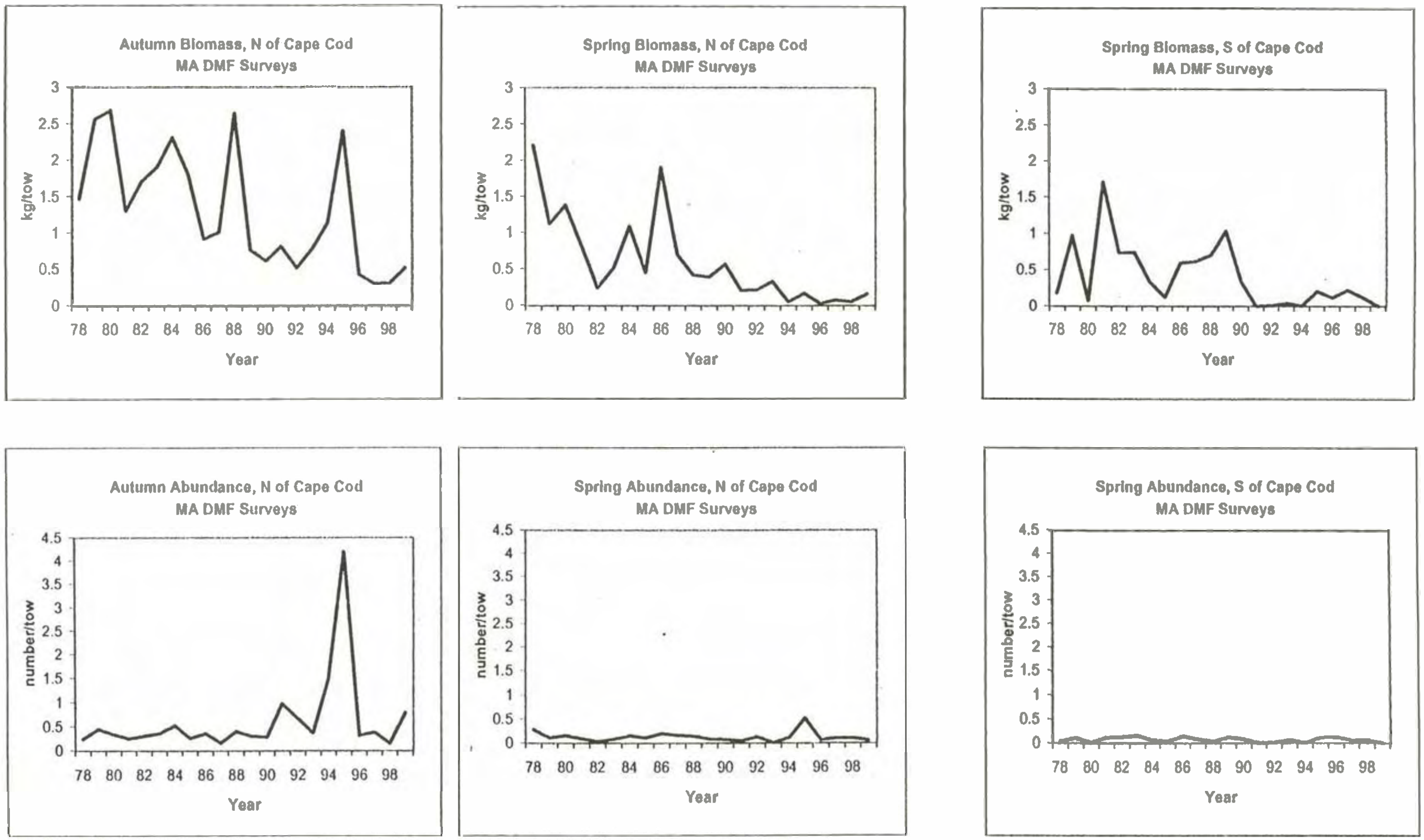
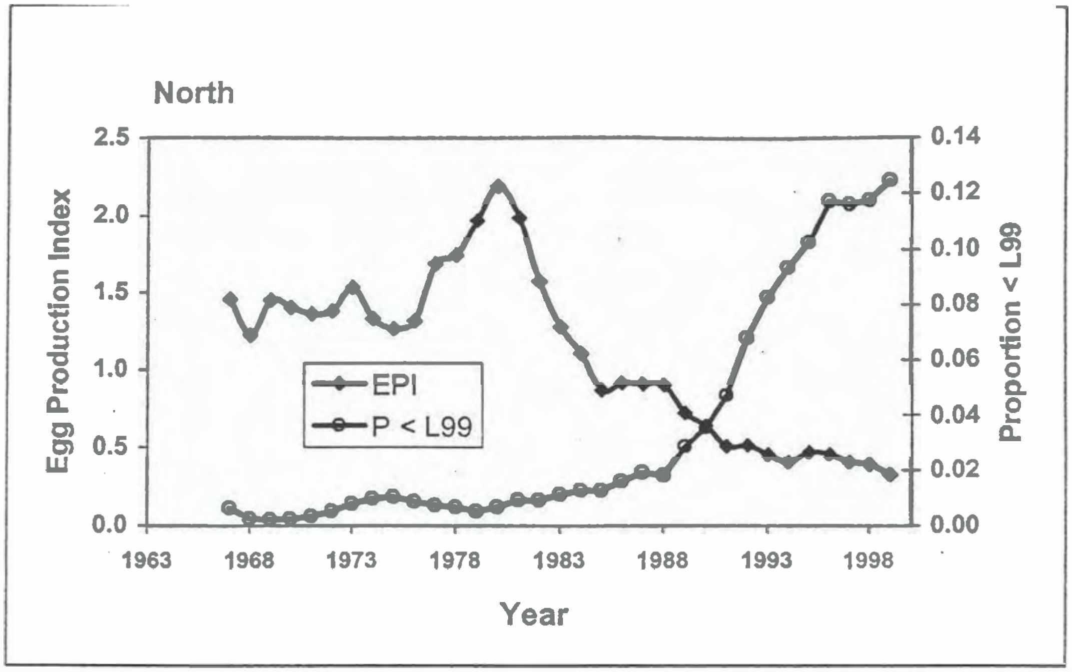


Figure B42. Biomass and abundance indices for goosefish from Massachusetts state bottom trawl surveys.



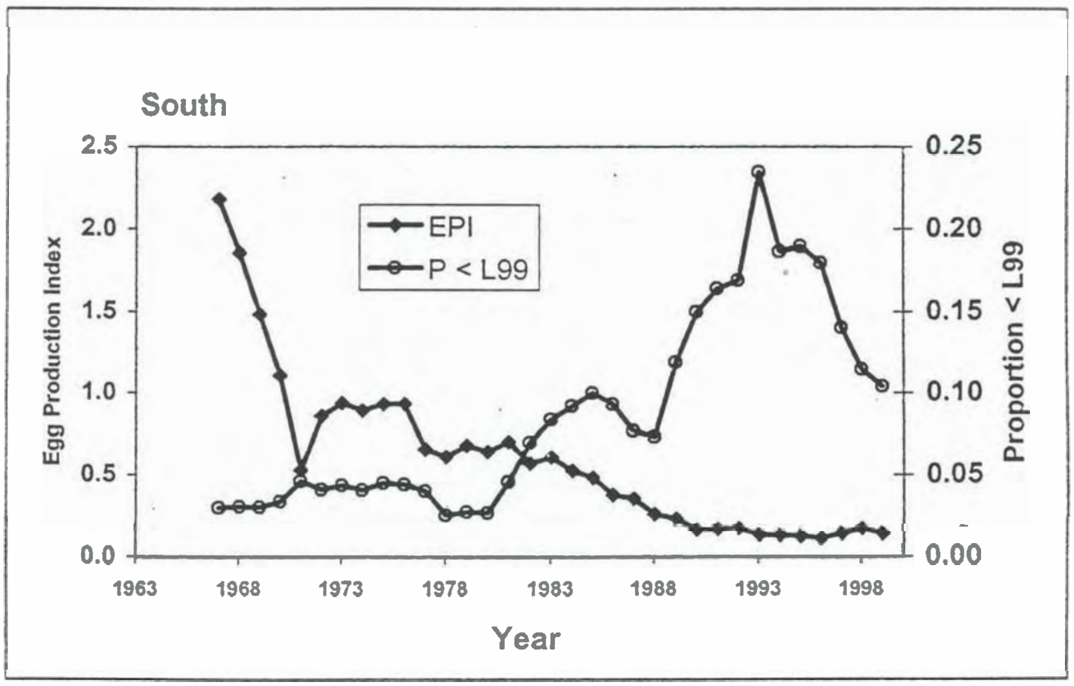


Figure B43. Indices of egg production by goosefish, based on composite length frequency distributions from autumn survey indices (catch per tow at length), proportion mature of length and fecundity at length. Year represents the terminal year of a 5-year pooled length frequency sample. Proportion <L99 is the fraction of egg production from goosefish smaller than the size at 99% maturity.

Figure B44. Total mortality index (Z) and landings (1000 mt, live weight) for the northern region.

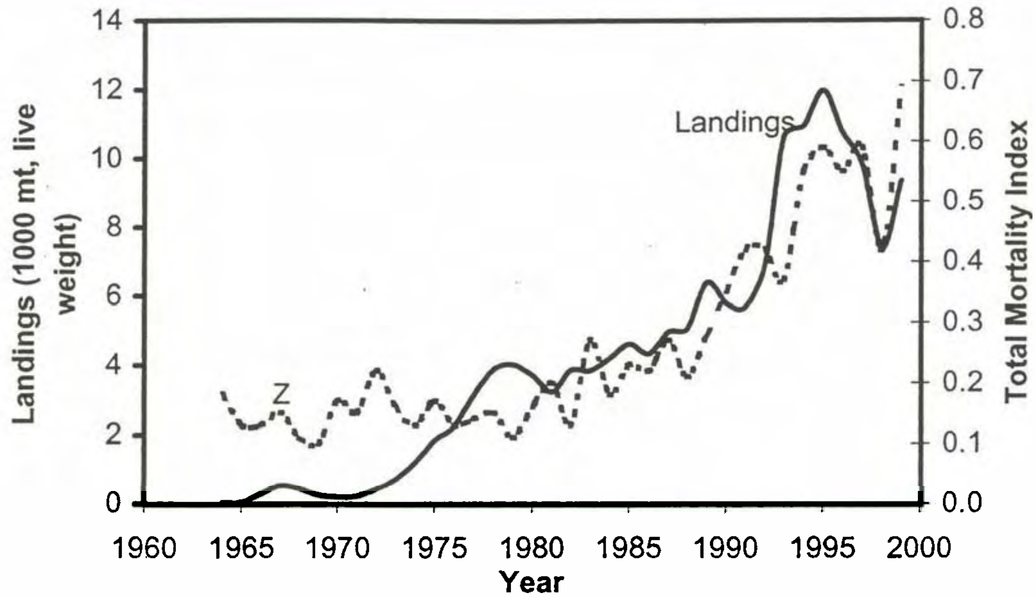


Figure B45. Total mortality index (Z) and landings (1000 mt, live weight) for the southern region.

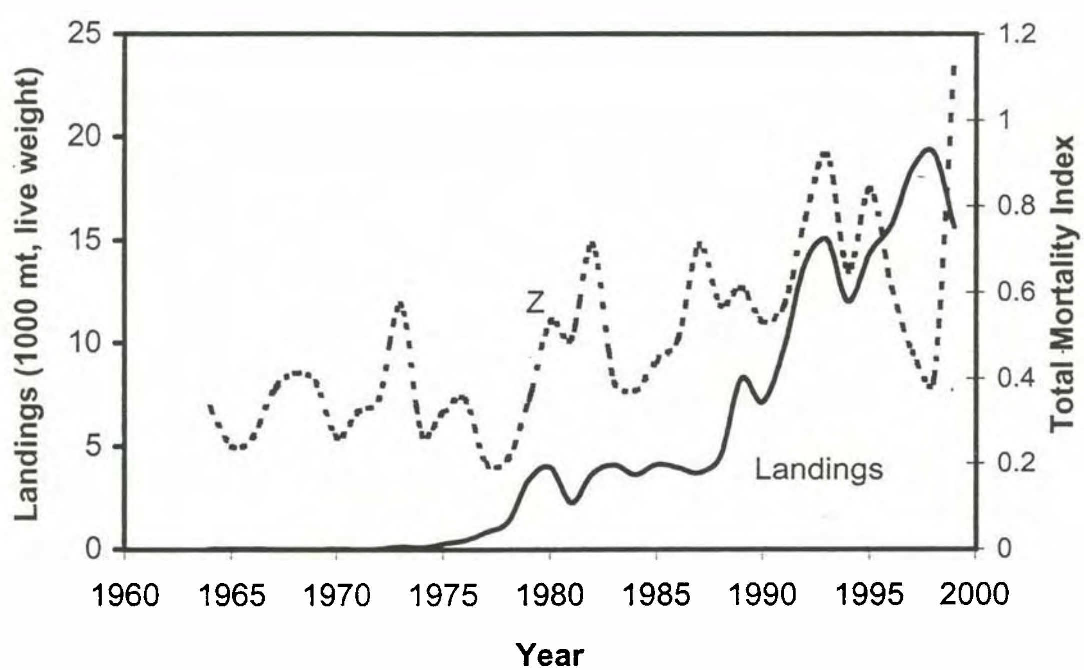


Figure B46. Total mortality indices (Z) from autumn and spring survey catch per tow at length and from autumn survey catch per tow at age, northern region.

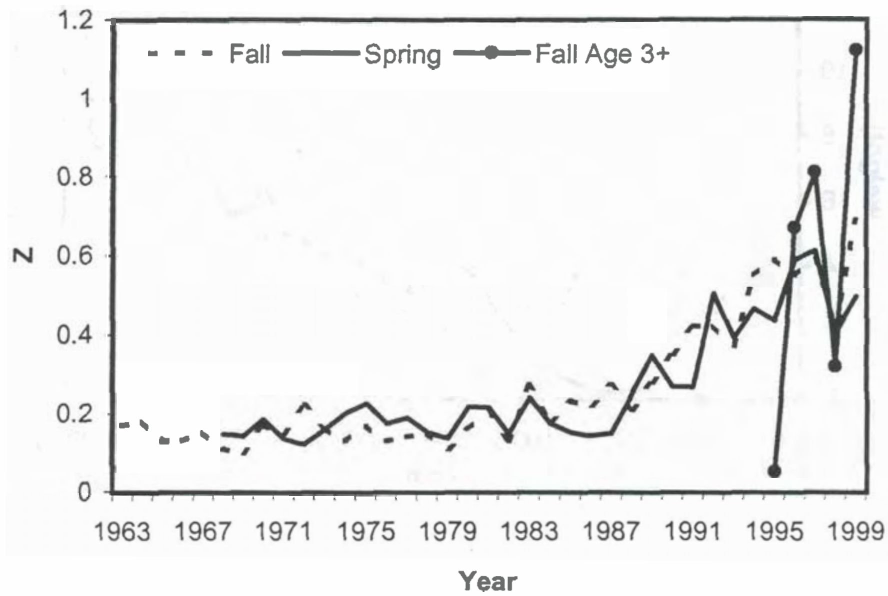


Figure B47. Total mortality indices (Z) from autumn and spring survey catch per tow at length and from autumn survey catch per tow at age, southern region.

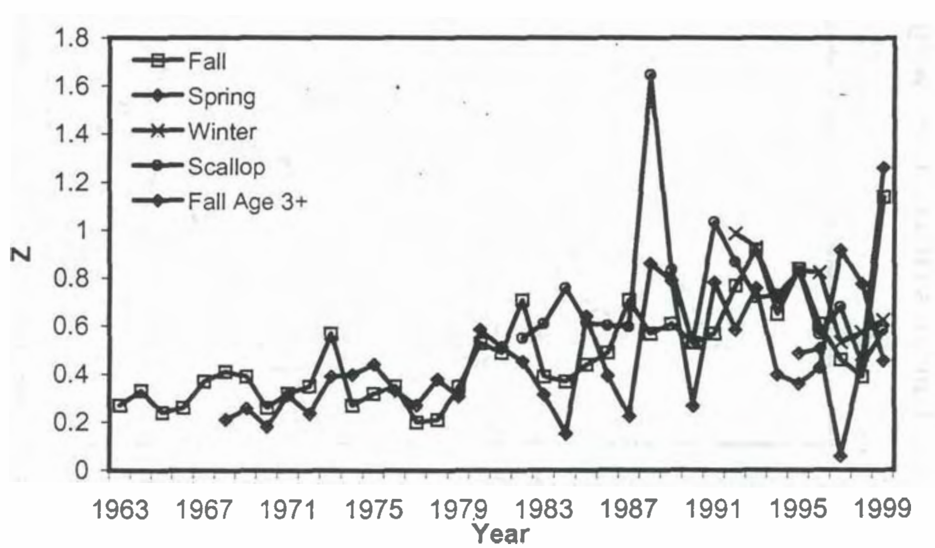


Figure B48. Biomass threshold (B threshold) and 3-year running average kg/tow from NEFSC autumn bottom trawl surveys, northern region.

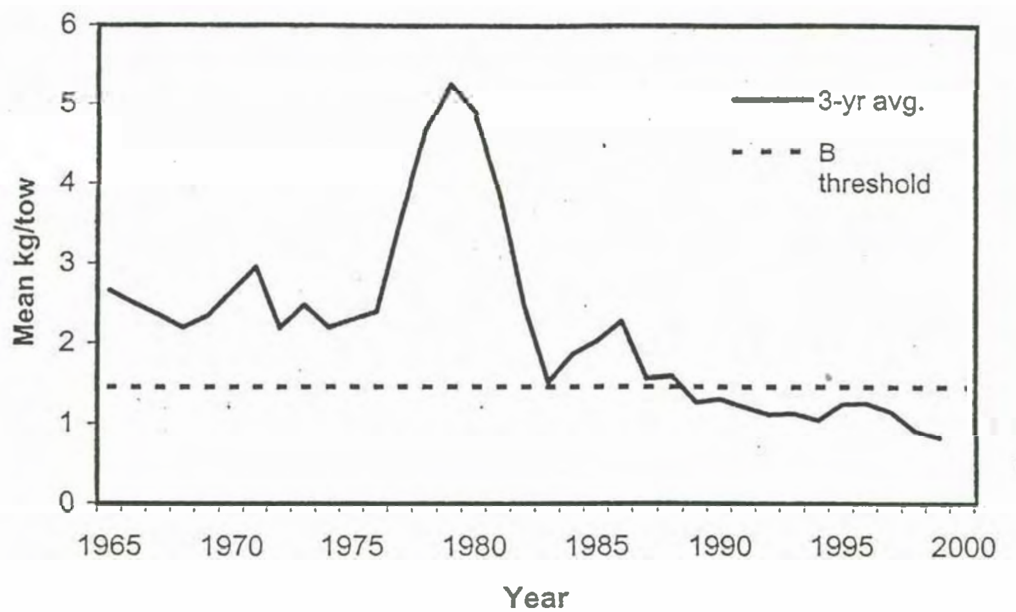
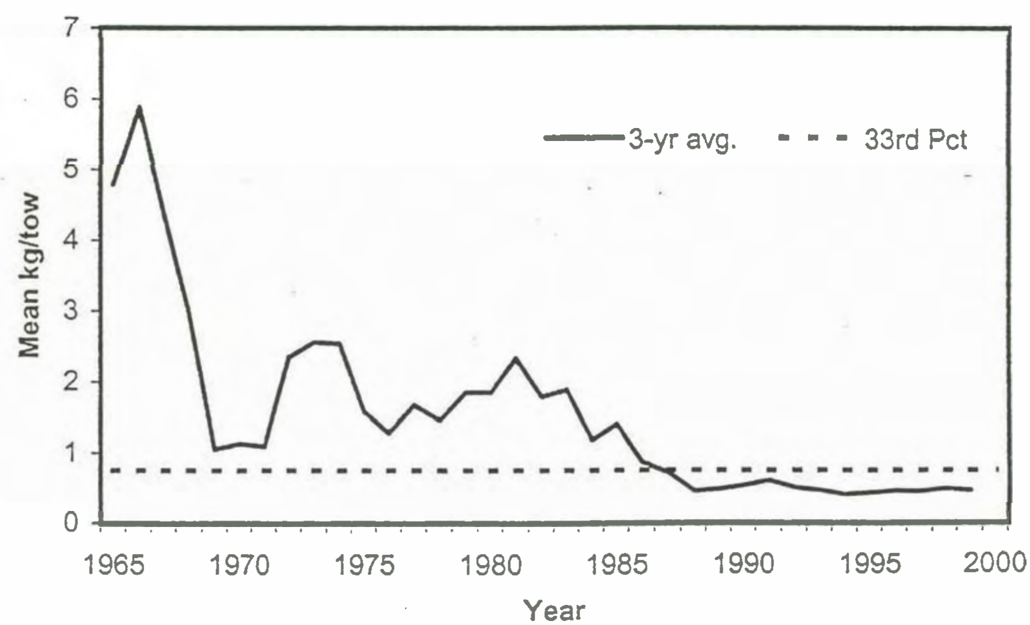


Figure B489 Biomass threshold (B threshold) and 3-year running average kg/tow from NEFSC autumn bottom trawl surveys, southern region.



C: OCEAN QUAHOG

TERMS OF REFERENCE (TOR)

The following Terms of Reference were addressed:

(A) Update status of the resource in aggregate, and by assessment sub-region. Characterize uncertainty in estimates of stock size and fishing mortality. Provide quota options consistent with Council target reference points.

(B) Estimate Fmsy or appropriate proxies for the stock as a whole and by assessment sub-region.

(C) Estimate dredge efficiency for the NMFS survey dredge based on field experiments conducted in 1999, and refine estimates derived from 1997 sampling.

(D) Develop approaches to integrated stock assessment models incorporating all available research survey, commercial catch and ancillary biological information.

(E) Characterize the distribution and biomass of the resource in deeper portions of the survey range, based on results from the 1999 survey.

SUMMARY

(A) Update status of the resource in aggregate, and by assessment sub-region. Characterize uncertainty in estimates of stock size and fishing mortality. Provide quota options consistent with Council target reference points.

- Ocean quahogs are long lived (100+ yr), slow-growing (<1 mm per year as adults) bivalves. The curve for growth in length indicates that recruitment (at 70 mm) occurs at about age 26 throughout the MidAtlantic region.

  Ocean quahogs in federal waters (the EEZ) are managed as a single stock. This assessment was based on a number of smaller, stock assessment regions:

Abbreviation	Stock Assessment Area
SVA	Southern Virginia and North Carolina
DMV	Delmarva
NJ	New Jersey
LI	Long Island
SNE	Southern New England
GBK	Georges Bank

- In most years, over 90% of the total landings were from the EEZ. Recent annual landings from the EEZ ranged from 18,000 to 24,000 mt of meats, and those landings were close to annual EEZ quotas.

  Fishing grounds have changed through time. The fishery moved northward from Delmarva and New Jersey, to the Long Island region in 1992 and to S. New England in 1995. In 1999, EEZ landings by region were: S. Virginia (0%), Delmarva (6%), New Jersey (18%), Long Island (37%), S. New England (39%).

A distinct fishery for ocean quahogs takes place off the coast of Maine. Volume of quahogs captured per trip is much smaller in that region. Landings and LPUE have increased recently.

Nominal LPUE for each assessment region was calculated as total landings divided by total hours fished. In addition, two types of general linear model (GLM) analysis were used to compute standardized LPUE time series. The second type of GLM model worked at a finer spatial scale than in the traditional GLM, stratified the regions based on total commercial fishing effort ("effort areas"), and used estimates of relative abundance among effort areas from survey catches by the NMFS research vessel.

Average survey catch rates show that areas with both high commercial effort and LPUE have much higher quahog abundance than areas with low commercial effort. Thus, fishing effort has been concentrated on fishing grounds where abundance is highest.

Overall, LPUE declined in recent years in DMV, NJ, and LI. In SNE, LPUE has been high recently, but variable over time.

In the regions where LPUE declined recently, the trends were not simple. Rather, the first years of the fishery had intermediate catch rates. In subsequent years the catch rate increased to a maximum as the fishery developed, and then LPUE declined gradually to relatively low values.

- Between 1982 and 1999, average length of clams landed from New Jersey (approximately 90 mm - 95 mm) was greater than that from other areas (typically 80 mm - 90 mm). Mean length of clams landed from the Delmarva region has decreased steadily from 1994 to 1999. Mean length of clams landed from the New Jersey region has remained relatively steady.

- Research vessel survey methods changed significantly before and after 1980, so only the period 1980-1999 is used to measure abundance trends. Even within this period some methods have changed, making it more difficult to detect temporal trends in stock size.

- Few (usually zero) ocean quahogs were captured at random stations in deep water south of Long Island and S. New England. This area consists of green mud. In addition, samples from muddy strata within S. New England (#42 and 43) caught zero ocean quahogs at most of the stations, which suggests that ocean quahogs are not widely distributed in these strata.

In the 1999 survey, samples were not collected from the S. Virginia - N. Carolina region, the Great S. Channel just to the west of Georges Bank, or from the NW corner of Georges Bank (Strata 67, 68). This was done to save time for sampling of deeper strata.

Based on the research survey, modal size in the New Jersey and Delmarva regions (90-100 mm shell length) is greater than that from the more northern regions Georges Bank, S. New England, and Long Island (70-90 mm). The size structure of clams changed little over time in most regions. The population structure off Long Island and on Georges Bank has been more dynamic.

Swept area biomass (mt meats) estimates, corrected for survey dredge efficiency for surveys in 1997 and 1999, were:

Region	1997	1999
SVA	22	22
DMV	69,236	47,261
NJ	291,560	162,375
LI (Traditional)	530,076	343,780
LI (Deep)	110	110
SNE (Traditional)	284,960	381,715
SNE (Deep)	9,770	9,770
GBK (Traditional)	488,745	583,817
GBK (Deep)	87,676	87,676
All Regions	1,762,156	1,616,527
All Regions less GBK	1,185,735	945,033

Ninety-five percent confidence intervals for total, efficiency adjusted, swept-area biomass during 1997 and 1999 overlapped (i.e. 720 - 4,308 thousand mt in 1997 and 608 - 4,297 thousand mt in 1999).

The KLAMZ model was useful for all stock assessment regions but SVA. The model assumes that biomass in 1978 was near virgin level and that recruitment is constant. Recent (average during 1997-1999) regional F's ranged 0.00-0.022 and were highest in SNE and DMV. Ratios of recent to virgin biomass were 100% (GBK), 92% (SNE), 90% (LI), 73% (NJ), 47% (DMV). Estimated virgin biomass was 2.1 million mt for the stock as a whole and 1.5 million mt excluding GBK. Estimated annual recruitment was about 23,000 mt per year for the stock as a whole and 16,000 mt per year excluding Georges Bank. Ratios of annual recruitment biomass to standing stock biomass in

1999 were 1.3% for the stock as a whole and 1.4% excluding GBK.

Estimates and projections from KLAMZ indicate that biomass of the entire EEZ stock was about 1.8 million mt (87% of virgin biomass) during 1999 and is projected to decline to about 1.7 million mt (81% of virgin biomass) by 2009. Excluding GBK (where no fishing occurs due to PSP), biomass was about 1.2 million mt (81% of virgin) during 1999 and projected to decline to about 1.0 million mt (72% of virgin) by 2009. Projections assumed constant recruitment and recent (mean 1997-1999) catch levels.

Status determination was based on estimates and 95% confidence intervals for "recent" F and total biomass (averages during 1997-1999) from the catch-swept area and KLAMZ models. For all regions (including Georges Bank), recent F estimates were 0.01 y^{-1} from both models and upper bounds on 95% confidence intervals were 0.014-0.015 y^{-1} . Thus, it is unlikely that recent fishing mortality rates exceeded the overfishing threshold ($F_{25\%} = 0.042\ y^{-1}$) . Overfishing of the entire stock does not appear to be occurring.

The GBK region contains 34-36% of the resource and this region has been closed to harvesting since 1990 when Paralytic Shellfish Poison (PSP) was detected. If GBK is excluded, point estimates for F on the remaining regions increase to 0.015 - 0.017.

Recent biomass estimates from both models can be compared to the target (one-half virgin biomass) and threshold (one-quarter virgin biomass) levels. According to KLAMZ model results, virgin biomass for the whole stock is 2.0 million mt of meats so the biomass target is 1.0 million mt and the biomass threshold is 0.5 million mt. Recent biomass estimates were 1.7-1.8 million mt and lower bounds on 95% confidence intervals were 1.2-1.4 million mt. Thus, ocean quahog biomass levels are probably at or above target levels. The entire stock does not appear to be overfished.

(B) Estimate Fmsy or appropriate proxies for the stock as a whole and by assessment sub-region.

- According to NEFSC (1998), F_{MAX}=0.065 y^{-1}, $F_{0.1}$=0.022 y^{-1} and $F_{25\%}$=0.042 y^{-1} for ocean quahog. Biological reference points for ocean quahog were not updated in this assessment because no new life history information has been gathered since 1997.

- The KLAMZ model was used to estimate virgin biomass (K) in each stock assessment region and for the stock as a whole.

- $F_{0.1}$ and M are common F_{MSY} proxies. For ocean quahog, $F_{0.1}$=0.022 y^{-1} and M =0.02 y^{-1}.

- Alternative harvest policies for ocean quahog may be more compatible with National Standard Guidelines (DOC

1998). The current threshold for ocean quahog $F_{25\%}$=0.042 y^{-1} exceeds conventional F_{MSY} proxies like $F_{0.1}$=0.022 y^{-1} and M =0.02 y^{-1} and the current fishing mortality target $F_{0.1}$=0.022 y^{-1} equals or exceeds the conventional proxies for F_{MSY}.

Current catch levels are close to MSY for the entire stock. Applying the proxy $F_{MSY}=F_{0.1}$=0.022 y^{-1} to 1/2 virgin biomass, the MSY catch level would be 22 thousand mt y^{-1} for the whole stock and 14 thousand mt y^{-1} for the whole stock less GBK.

Conventional proxies for MSY related parameters may not be suitable for ocean quahog, which have an unusually long lifespan (100+ years) and slow growth rate.

(C) Estimate dredge efficiency for the NMFS survey dredge based on field experiments conducted in 1999, and refine estimates derived from 1997 sampling.

Three approaches (i.e. resampling, comparison of random stations, and depletion) were used to examine dredge efficiency, E, in 1999.

The mean of the estimates from depletion experiments for ocean quahogs, 0.346 (CV = 0.40), was taken as the survey dredge efficiency for ocean quahogs in 1999. The 1999 value was also applied to the 1997 survey.

For catches at "resampled" stations, the ratio estimator $R = N_{(99)} / N_{(97)}$ was 0.911 (CV = 76%). The ratio estimate suggests that the efficiency of the dredge in 1999 relative to 1997 on Georges Bank was approximately 90%.

- For catches from random stations, the stockwide ratio of meat weight per tow in 1999 relative to 1997 was 0.92 (CV = 46%). This was similar to the ratio estimated from catches at resampled stations on GBK. Some data also suggested that a change in dredge efficiency may have occurred during the 1999 survey from south to north.

(D) Develop approaches to integrated stock assessment models incorporating all available research survey, commercial catch and ancillary biological information.

- Two models were used to estimate biomass: 1)a swept-area estimate based on the 1997 and 1999 surveys, using adjustments for dredge efficiency and tow distance, and 2) the KLAMZ biomass dynamic model, which uses the historical survey and commercial catch and effort data to estimate past, present and future biomass.

  The KLAMZ model is a biomass dynamic model based on a delay difference approach that assumes virgin biomass existed in 1978 and annual recruitment has been constant.

- The KLAMZ model utilized survey dredge efficiency estimates from field studies, estimates of age and growth, survey and LPUE trend data, and all other available information with the exception of length composition data for survey and fishery catches.

(E) Characterize the distribution and biomass of the resource in deeper portions of the survey range, based on results from the 1999 survey.

- Results for most surveys suggest that quahog biomass is highest at depths of 40-60 m in all areas but GBK. In GBK, catch rates are highest in deeper water at 60-80 m. The deepest (> 90 m) samples from GBK contained moderate biomass.

- In 1999, tows were taken randomly in the deep (40-60 fathom) strata south of LI, SNE and GBK. The percentage of the total regional biomass that exists in the deep strata is 0% (LI), 2% (SNE), and 13% (GBK).

INTRODUCTION

The ocean quahog has a broad distribution in cold waters of the northern hemisphere. Ocean quahogs are common around Iceland, in the eastern Atlantic as far south as Spain, and in the western Atlantic as far south as Cape Hatteras (Theroux and Wigley 1983; Thorarinsdottir and Einarsson 1996). The depth range is between 10 m and 200-400 m, depending on the reference (Theroux and Wigley 1983; Thompson et al. 1980a). In a study of the mitochondrial cytochrome b gene, Dahlgren et al. (in press) did not find geographical differentiation between populations along the coast of the US from Maine to Virginia. This bivalve has a slow growth rate and extreme longevity; some individuals have been aged at over 200 yrs (Jones 1983; Steingrimsson and Thorarinsdottir, 1995). Early studies of populations off New Jersey and Long Island (Thompson et al. 1980a; Murawski et al. 1982) demonstrated that clams ranging in age from 50-100 years were common. Although they can grow to approximately 100 mm in shell length, the growth rate of fully recruited ocean quahogs (0.51-0.77% in meat weight per year and < 1 mm in shell length per year) is an order of magnitude slower than for Atlantic surfclams (SARC-22, NEFSC 1996).

Females are more common than males among the oldest and largest individuals in the population (Ropes et al. 1984; Fritz 1991; Thorarinsdóttir and Einarsson 1994). Size and age at maturity are variable. Off Long Island, the smallest mature quahog found was a male 36 mm long and 6 years old; the smallest and youngest mature female found was 41 mm long and 6 yr old (Ropes et al. 1984). Some clams in this region are still sexually immature at ages of 8-14 years (Thompson et al. 1980b; Ropes et al. 1984).

The history of surfclam and ocean quahog management along the Atlantic coast of the United States is summarized in Murawski and Serchuk (1989) and Serchuk and Murawski (1997). An individual transferable quota (ITQ) system was established in 1990. With one exception, the entire USA EEZ stock is treated as one management unit with an annual quota. A small but valuable fishery has developed off the coast of Maine, and that area has had its own quota since 1999.

Ocean quahogs were assessed in 1994 and 1997 (NEFSC 1995, 1998a) for

SARC/SAW-19 and 27 respectively. The 1997 assessment reported on a) abundance and mortality rate, b) revised biological reference points, c) status of the EEZ ocean quahog population under management and d) the potential biomass of ocean quahogs in deep, unsurveyed water. The 27th SAW (NEFSC 1998b) concluded that 1) the ocean quahog resource in surveyed EEZ waters from Southern New England to Delmarva was at a medium-high level of biomass and 2) the stock would be considered under exploited at the scale of the single management unit from Georges Bank to North Carolina. Results from the present assessment are similar.

Surveys of the stock are conducted every 2-3 years by NMFS with the R/V *Delaware II* (DE-II). The clam dredge has a submersible hydraulic pump which shoots water into the bottom to loosen the clams from the substrate. In 1997, bottom contact sensors were used on the survey dredge for the first time to get a direct estimate of tow length. In previous surveys, tow length was estimated by doppler readings and assumptions about when the dredge was fishing. The sensor data provided a better estimate of minimum swept-area biomass (NEFSC 1998). The sensors used at sea and the data collected with them are described in previous reports (NEFSC 1998a, 1998c, 2000).

In 1999 and 2000, dredge efficiency experiments were carried out both directly with the NMFS survey vessel and indirectly with commercial vessels working at sites sampled earlier by the DE-II. No direct measure of the DE-II's dredge efficiency for ocean quahogs was available in 1997; so, a dredge efficiency of 0.43 was assumed for 1997, based on the median efficiency of five experimental depletion studies by commercial vessels dredging for ocean quahogs.

The present assessment was based on data from multiple sources including: annual commercial landings and effort (time fishing), port samples of the shell lengths in the commercial catch, experiments to estimate the efficiency of the NMFS dredge, and NMFS survey data. Throughout the MidAtlantic region, this species occurs almost entirely in EEZ waters. In the 1999 survey, tows were made in deep, previously unsurveyed areas off Long Island, Southern New England and Georges Bank to evaluate what fraction of the resource occurred there. Biomass and fishing mortality rates were determined from 1) recent commercial landings, 2) survey catch swept-area data adjusted for dredge efficiency, and 3) a new stock assessment model, known as KLAMZ, that is based on historical survey and commercial data.

Region-specific parameters relating shell length to meat weight from Murawski and Serchuk (1979), were derived from samples obtained in winter. Revised length/weight data were collected from Long Island and Georges Bank during the summer 1997 resource survey aboard the *R/V Delaware II*. The later were used to update Biological Reference points for SARC-27 (NEFSC, 1998a).

COMMERCIAL DATA

Commercial landings and effort data from 1980 to 1999 are from mandatory vessel logbooks. It is assumed throughout this assessment that one bushel of ocean quahogs = 10 lbs = 4.5359 kg of usable meats in all regions but Maine. The conversion for Maine is 11 lbs/bushel. Vessel size class categories are: Class 1 (small, 1-50 GRT), Class 2 (medium, 51-104 GRT), and Class 3 (large, 105+ GRT). Commercial length frequencies were estimated by region from port agent sampling. Regions used in this assessment are shown in Figure C1. Figure C1 also shows the strata used in NMFS stratified random clam surveys.

Landings and Effort

Total landings were partitioned into state (0-3 mi) and EEZ components (Table C1). The EEZ fishery started in 1976, but landings were low until 1979 (Figure C2). In most years, over 90% of the landings were from the EEZ. Total annual EEZ landings have been stable from 1985 to present. Recent annual landings from the EEZ ranged from 18,000 to 24,000 mt of meats, and were close to the annual EEZ quotas.

In the MidAtlantic region, this species occurs offshore (i.e., beyond state waters). Along the coast of Maine, the resource straddles state and EEZ waters; starting in 1999, that region was given its own quota of 100,000 bushels. That is approximately 2% of the total quota for the entire EEZ.

While the total annual EEZ catch has been stable, it has been taken from different regions through time. In the 1980s, almost the entire EEZ fishery took place in the southern regions, Delmarva and New Jersey (Tables C2, C3; Figures C3, C4). The fishery moved northward to the Long Island region in 1992 and to S. New England in 1995. In 1999, the percentage of the EEZ landings by region were: S. Virginia (0%), Delmarva (6%), New Jersey (18%), Long Island (37%), S. New England (39%).

Movement of the fishery to the north is evident in maps of cumulative landings, by ten minute square (TNMS), for the periods 1980-1985 (Figure C5) and 1980-1999 (Figure C6). A new processing plant began operating in New Bedford, MA in the 1990s. In 1997, 1998, and 1999, landings were taken primarily from depths shallower than 50 fathom (90 m) off Long Island and S. New England (Figures C7, C8 and C9). Figures C10 and C11 show the location of landings with respect to the NMFS clam survey strata in the New England region.

A distinct fishery for ocean quahogs also takes place off the coast of Maine. They are harvested at a smaller size for the half-shell market rather than the canned chowder market. The volume of quahogs captured per trip is much smaller than in other regions. The landings span the line between state and EEZ waters, and are difficult to partition (Figure C12). NMFS has not conducted a survey, with stratified random sampling, in this region. However, the NMFS vessel *Delaware II* (DE-II) made tows at non-random stations in 1992 and 1994, using a 1" liner in the dredge. There is strong overlap between the TNMS with the highest commercial landings and the NMFS stations with high catch. The fishery encompasses a much larger area than that sampled by the DE-II (Figure C12).

Landings per Effort (LPUE)

Logbook data for ocean quahog give hours fished and landings (bushels of whole clams) for all fishing activity in federal waters. Landings data for quahogs are reported in logbooks as bushels but can be converted approximately to meat weights using conversion factors described above. Catch rate data are landings, usually in units of kg or bushels per hour fished.

Several factors affect interpretation of LPUE data. First, industry sources suggest that fishers work grounds until abundance is reduced and catch rates fall below the level that makes fishing profitable (80 bushels or 400 kg per hour fishing). Second, fishing grounds are smaller than the spatial scale at which commercial logbooks report catch and fishing effort data (10' x 10' squares). Thus, it is difficult to calculate catch rates that represent every 10' x 10' square. Furthermore, it is likely that commercial catch rates "saturate" (Hilborn and Walters 1992) and decline more slowly than biomass.

Nominal landings per unit fishing effort (Table C4) for each assessment region was calculated as total landings divided by total hours fished. In addition, two types of general linear model (GLM) analysis were used to compute standardized LPUE time series. Trends in LPUE estimated from GLM models were scaled to units for the largest vessel size (tonclass 3) operating in January.

The first type of GLM was a traditional approach for ocean quahog (e.g. NEFSC 1998). For each stock assessment region, the traditional GLM was fit by linear regression analysis with the logarithm of LPUE (bushels per hour) for each trip as the dependent variable and dummy variables for vessel size (ton class), subregion, month and year as independent variables. Back transformed (arithmetic scale) year parameter estimates (with no bias adjustment) from the GLM model measure trends in LPUE (Table C4, Figures C13 - C17).

The traditional GLM approach assumes that trends in LPUE over time are the same in all parts of the stock assessment region. This assumption is not valid because declines in abundance are most pronounced in regions with highest fishing effort (NEFSC 1998). The number of observations (trips) in logbook records is highest for areas with the highest fishing effort, so areas with the highest effort are implicitly given more weight in fitting the GLM. Areas with the highest fishing effort are areas with the highest catch rates (see below), so traditional GLM results measure trends in areas where catch rates and fishing effort are highest. This could be a problem if a large portion of the stock biomass is scattered across relatively large areas but at low densities where catch rates are too low to support fishing.

The second type of GLM model used for quahog LPUE data was an experimental approach that considered spatial variation within stock assessment regions. The goal was to work at a finer spatial scale than subregions used in the traditional GLM and to estimate trends that might be easier to interpret as abundance trends. First, total cumulative fishing effort was calculated for each ten minute square (TNMS) based on all years in the commercial logbook data base. Second, all TNMS in a stock assessment region were assigned to strata called "effort areas" based on quartiles of cumlative fishing effort. For example, TNMS in a region with highest cumulative catch rates (fourth quartile) were assigned to effort area 4 and TNMS with lowest cumulative catch rates (first quartile) were assigned to effort area 1. Third, the logarithm of LPUE for individual trips was fit by linear regression to a model that included dummy variables for vessel size, effort area, month, year and interactions between effort area and years. Finally, an index of trends in LPUE for the whole stock assessment area was computed as a weighted average of the trends in each effort area using an independent

independent proxy for stock biomass as weights. The proxy for stock biomass was the size of the effort area (number of TNMS, proportional to nm^2) times the average catch rate (KG/standard tow, tow distances measured by doppler) in all surveys that sampled all of the TNMS in a stock assessment region.

The interaction between year and effort area in the new GLM approach means that the new model could potentially measure independent trends in LPUE for different effort areas in the same stock assessment region. The stratification scheme based on effort areas assumes that all of the TNMS in an effort region follow the same average trend in LPUE. This assumption was not completely satisfied but the alternative (assuming the same trends everywhere in the assessment region) is certainly less plausible.

Only four effort areas were used in GLM analyses for quahog LPUE data because finer stratification schemes gave too many instances with missing data for some effort area strata in some years. A finer spatial stratification (preferably individual TNMS) would have been better if enough data for each stratum had been available in most years.

Within an effort area, there were probably more observations from TNMS with the highest catch rates. The importance of this problem may have been reduced, however, because all of the TNMS in one effort area had fairly similar amounts of cumulative fishing effort.

Average survey catch rates show that areas with high LPUE also have high quahog abundance (see below). This shows that fishing effort is concentrated on fishing grounds where abundance is highest.

Region	Survey Mean Number/Tow in Effort Area 1	Survey Mean Number/Tow in Effort Area 2	Survey Mean Number/Tow in Effort Area 3	Survey Mean Number/Tow in Effort Area 4
SNE	68.2	98.7	260.2	275.2
LI	111.6	230.0	475.6	392.8
NJ	15.2	9.4	34.1	190.0
DMV	16.6	6.3	60.0	206.9

Results for all areas but MNE (Figures C18 - C22) show that the proportion of total hours fished in effort areas 2-3 increased after 1990 and decreased in effort area 4. In recent years, however, the trend has reversed with decreasing hours fished in effort areas 2-3 and increased hours fished in effort area 4. Apparently, fishing activity is moving back onto grounds occupied prior to 1990.

Surprisingly, trends in nominal and standardized LPUE from both GLM approaches were similar (Table C4, Figures C13 - C17). The experimental GLM approach gave highest weight to TNMS with the highest quahog biomass. However, biomass and fishing effort were correlated so that the experimental GLM (biomass weighted), traditional GLM (effectively effort weighted) and nominal LPUE (mathematically equivalent to effort weighted averages for individual trips) approaches gave similar estimated trends. Trends in LPUE for different effort areas in the same stock assessment region were generally similar (Table C4, Figures C13 - C17).

Overall, nominal and standardized LPUE declined in recent years in DMV, NJ, and LI (Figures C13 - C15). Fishing effort has been low in DMV from 1992 - 1999 (Table C3), and catch rates during this period have not returned to the high levels estimated for 1981 - 1988 (Table C4). In SNE, LPUE has been high recently, but variable over time. LPUE increased off the coast of Maine, probably because the fishery is developing and becoming more efficient.

In the regions where LPUE decreased recently, the longterm trends were not simple. Rather, the first years of the fishery had intermediate catch rates. In subsequent years the catch rate increased to a maximum as the fishery developed, and then LPUE declined gradually to relatively low values. This pattern was noted in ocean quahog LPUE data during SAW-19 (NEFSC 1995), and interpreted as "an apparent change in catchability" over time, likely due to improvements in efficiency as the fishery developed. To deal with this potential problem, Leslie-Delury depletion models used by NEFSC (1995) to analyze trends in LPUE and to estimate stock size did not include data from the first years of the fishery in each region. Ricker (1975) and Hilborn and Walters (1992) pointed out that 1) nonconstant catchability is one of the greatest potential sources of error in analyzing LPUE, 2) temporal changes in catchability are indicated by residual patterns, and 3) these changes can result from fishermen learning and changing their methods.

Lack of Consensus about LPUE data

The Invertebrate Committee did not reach consensus about the utility and potential value of LPUE data for ocean quahog. Without presenting evidence, some argued that logbook data were unreliable because: 1) Some vessel owners over-reported landings during 1986-1990 while ITQ management plans were under development, in the event that initial ITQ permit shares would be based on catch histories. 2) After the ITQ management program was implemented in 1990, quota shares became concentrated in the hands of relatively few vessel owners. During 1990 to approximately 1996, there were disputes between the vessel owners and processors concerning prices for both of surfclam and ocean quahog. Some vessel owners under reported catches in logbooks to depress LPUE and cause an apparent decline in abundance, with the goal of reducing quotas and increasing prices. 3) Finally, some captains did not report fishing effort accurately.

Other members of the Committee argued that LPUE data for ocean quahog were useful and provide information about trends in quahog biomass. Some industry representatives stated that logbook data for quahog were likely more accurate than the similar information used to assess and manage many other fisheries. MAFMC staff compared landings data for 1978-1994 tabulated from three separate databases (logbooks, processor reports and port agent records) and found that total landings differed by less than 5% per year. Substantial collusion among vessel captains, processors and port agents would be required to consistently over report catches in all three databases. Ocean quahog (unlike surfclam) have never been regulated by trip limits that would tend to distort reported fishing effort, but there was general agreement that some problems likely exist with accurate reporting of fishing effort data.

The Committee decided, by majority, to use LPUE data for ocean quahog. It was agreed that stock assessment modeling with LPUE data (see below) would assume nonlinear (saturating) relationships between quahog biomass and LPUE (which reduces the importance of trends in LPUE), that CV's for LPUE data assumed in fitting models would be increased to levels larger than CV's for survey data to avoid overstating the precision of LPUE as an index of abundance, and that models would use the effort area weighted LPUE indices that exclude years with no logbook coverage in areas of low abundance. In effect, use of effort area weighted LPUE reduces the importance of LPUE in fitting assessment models because the number of observations was reduced. Finally, it was agreed that sensitivity analysis would be carried out with the stock assessment model to determine the relative importance of LPUE data.

Size Composition of Landings by Region

Length frequency distributions for ocean quahogs landed between 1982 and 1999 are presented for the Delmarva, New Jersey, Long Island, and S. New England regions in Figures C23 - C26, respectively. Sampling data are summarized in Table C5. Between 1982 and 1999, average length of clams landed from New Jersey (approximately 90 mm - 95 mm) was greater than that from other areas (typically 80 mm - 90 mm; Table C5). Mean length of clams landed from the Delmarva region has decreased steadily from 92.5 mm in 1994 to 83 mm in 1999. Mean length of clams landed from the New Jersey region has remained relatively steady. Although mean shell size from the S. New England landings declined in 1997 and 1998, this was due to targeting of specific beds with high meat yield, and does not represent a shift in mean shell size of the exploited stock throughout that region.

RESEARCH SURVEYS

Variability in dredge performance confounds the interpretation of survey indices (e.g., 1994), particularly in swept area biomass calculations (NEFSC 1994; 1998). To address this problem, changes to some operational procedures were implemented in 1997.

Sensor data

Better monitoring of dredge performance in 1997 and 1999 was achieved via the *Delaware II's* Shipboard Computing System (SCS), which permits continuous monitoring of variables (e.g., position, speed) that are critical to operations.

In addition to the SCS sensors, sensors were attached to the clam dredge. During most tows, these sensors collected data on ship's speed, ship's position, dredge angle, power to the hydraulic pump, and water pressure from the pump manifold at depth. Depending on the sensor, the sampling interval varied from once per second to once per ten seconds. The smallest time unit for analysis was one second. In cases where data were not collected every second, empty cells were filled with the previous measurement. The data were then smoothed using a 7-second moving average, centered on the time being calculated. This time window was considered appropriate for smoothing the data and preserving patterns in the data. The sensor data were used to compute distance towed, pump pressure and the track of the dredge as indicated by ship position at each station. Details about the sensors and the data collected from them were given in previous reports (NEFSC 1998a,c and 2000).

DREDGE EFFICIENCY

Efficiency of the Clam Dredge on the R/V *Delaware II*

Field studies were carried out from 1997 to 2000 to estimate efficiency of the clam dredge on the R/V *Delaware II* (DE-II). This is an important parameter to estimate because it is used in the calculation of stock biomass, and because efficiency may vary between surveys, affecting abundance trend estimates. To obtain estimates of relative efficiency between the 1999 and 1997 ocean quahog surveys, two types of studies were conducted: 1) comparisons of catches at resampled (nonrandom) stations from the 1999 and 1997 surveys, and 2) comparisons of catches from random stations in the 1999 and 1997 surveys. In addition, depletion experiments were conducted in various locations and years to obtain absolute estimates of dredge efficiency. Depletion experiments carried out solely by the DE-II provided "direct" estimates of DE-II dredge efficiency. Other depletion experiments provided "indirect" estimates of efficiency through comparison of catches made by the DE-II and commercial vessels at the same location.

Catch at Stations Resampled from the Previous Survey (Relative Efficiency)

A total of 12 stations from the 1997 clam survey were resampled in 1999 by the DE-II to examine the efficiency of the NMFS clam dredge in 1999 relative to 1997. The experiment was conducted on ocean quahogs from Strata #59 and #61 in the Georges Bank region (Figure C1). These stations were located in good habitat for ocean quahogs and no commercial fishing has taken place at these sites between 1994 and 1999.

If there was no change in DE-II dredge efficiency between 1997 and 1999, no fishing mortality, and a balance between rates of natural mortality and recruitment, then the catch of clams in 1999 should equal the catch in 1997. The analysis was based on the number of ocean quahogs per tow that were at least 70 mm in shell length. This size was chosen because the dredge has partial selectivity of smaller sized ocean quahogs (NEFSC 1998a), and because this limits the analysis to larger individuals that have low rates of growth and natural mortality. All catches were standardized to a common tow distance, based on the distance estimates from sensors on the dredge in both years.

Table C6 summarizes the resampled data set and its analysis. Following Mendenhall et. al. (1971), the ratio estimator $R = N_{(99)} / N_{(97)}$ was 0.911 (CV = 76%). The ratio estimate suggests that the efficiency of the dredge in 1999 relative to 1997 on Georges Bank was approximately 90%, but this estimate is not known precisely.

Catch at Random Stations (Relative Efficiency)

Another approach to understanding dredge efficiency in 1999 was based on the ratio of catch per tow in consecutive surveys, each with stratified random sampling. If population levels had not changed, then a change in catch per tow would indicate a change in dredge efficiency. We computed the ratio of biomass per tow for ocean quahogs 70 mm and greater, during 1999 and 1997 in each stock assessment region. We then computed an average ratio for the whole stock, which was weighted by the relative biomass of each region. All survey catches were adjusted beforehand to the same tow distance based on sensor data. The stockwide ratio of meat weight per tow in 1999 relative to 1997 was 0.92 (CV = 46%) (Table C7). This was similar to the ratio estimated from catches at repeated stations on GBK (described earlier).

Based on the values from each region, the efficiency appears to increase with latitude. The ratio computed for LI, NJ, and DMV was 0.62 (CV = 229%). The ratio computed for GBK and SNE was 1.24 (CV = 51%). No explanation for this geographical difference was found. For example, mean pump pressure of the clam dredge, which could affect dredge efficiency, did not vary with latitude or between regions during the 1999 survey.

Table C8 lists the estimates of efficiency of the dredge on the DE-II that were given in previous SARC reports. Those values ranged from 0.27 - 0.59. The same table also summarizes the relative efficiency results (described above) based on comparisons of repeated stations and random stations in 1999 and 1997.

<u>Analytical Models for Depletion Experiments (Absolute Efficiency)</u>

Early studies of clam dredge efficiency (Myer et al., 1981; Smolowitz and Nulk , 1982), did not obtain reliable estimates of dredge efficiency for the dredge currently in use or in the habitat where the clam survey is carried out. Thus, it was necessary to carry out new studies from 1997 to 2000. Results from all recent efficiency studies are summarized in this report. Additional details can be found in NEFSC 1998a,c, and 2000.

Depletion studies were used to estimate absolute efficiency of the survey dredge. The total population is estimated from the rate of decline in catch over successive samples and the total quantity caught.

To date, there have been 19 depletion experiments with commercial vessels (Table C9). In most cases, the DE-II also took samples at these sites and the efficiency of the DE-II's survey dredge could be estimated "indirectly" by comparison of density estimates from the two vessels. Of the 19 experiments, 11 involved Atlantic surfclams and 8 involved ocean quahogs. The DE-II also conducted 3 of its own depletion experiments, 2 on surfclams and one on ocean quahogs. Analysis of these data provide "direct" estimates of the efficiency of the dredge on the DE-II. Most experiments were carried out off Long Island and New Jersey (Figures C27 and C28). A more detailed map (Figure C29) shows the location of the experiments carried out in 1999 and 2000 with the *DE-II*, *John N* and *Danielle Maria*. Ship tracks for the experiments are shown in Figures C30 - C32.

The data from these depletion experiments were analyzed using two distinct models: the traditional Leslie and Davis Model (1939) and the recent Patch Model of Dr. P. Rago (NEFSC 1999). In the first model, catch per tow is written as:

$$C_i = p\,(N - T_{i-1})$$

where T_{i-1} represents the cumulative catch through the I-th minus one tow. The parameter N denotes the population size and p represents the catchability coefficient.

The apparent simplicity of the model belies the complexity of fitting observations to real data. If sampling is random within a defined area in which the population is found, then the expected value of C_i is based on a binomial model with parameters p and ($N-T_{i-1}$). As each catch is removed, the value ($N-T_{i-1}$) decreases and thus the quantity p ($N-T_{i-1}$) also decreases. As a result, the statistical error structure (i.e., the pattern of differences between observed and predicted values) is neither independent nor identical. Both of these conditions are required for linear regression models. Instead, the likelihood model for the experiment can be constructed as a product of linked binomial models in which the ($N-T_{i-1}$) term reflects the history of removals up to the I-th observation. This model is known as chain binomial process or more commonly as a multinomial model. Recently, Gould and Pollock (1997) advanced the theory of estimation for the Leslie-Davis model and proposed some model extensions. Their methodology was used to analyze each of the depletion experiments. The multinomial model was coded in Excel and tested using the original rat population data of Leslie and Davis. Approximate confidence intervals for model parameters were estimated using profile likelihood (Venzon and Moolgavkor 1988).

In 1999, Dr. Paul Rago (NEFSC) extended the model he used to estimate dredge efficiency in 1997 to explicitly consider spatial overlap of tows as a depletion experiment progresses. His negative binomial "patch" model, first used to analyze scallop dredge efficiency (NEFSC, 1999) was applied to the ocean quahog and surfclam depletion experiments. The patch model is described below and in NEFSC, 1999 .

The patch model is designed to estimate the density of sessile (or nearly) animals and the efficiency of capture by a mobile gear. Conceptually, the patch model represents an extension of the classic Leslie-Davis and Delury depletion models to experiments in which the assumption of complete mixing of the population following removals is violated. In the standard Leslie Davis model, it is assumed that the <u>entire</u> domain of the depletion zone is effectively mixed. In the patch model the physical domain of the experiment is divided into set of patches. For sessile animals in deep water it is difficult to control the position of the dredge. Therefore, it is necessary to approximate the position of dredge path as a series of contiguous patches. The underlying hypothesis is that the total catch observed on any given tow represents the summation of catches from individual patches. The expected catch from a single patch depends on how many times the patch has been passed over in previous tows. The patch model performs the bookkeeping necessary to construct the history of each patch, and to estimate the predicted composition of the tow with respect to the number of times each patch within a tow has been passed over.

The patch model also requires the assumption of "mixing" of the population following removals with the mixing occurring at the scale of the patch. If the patch is larger than the width of the dredge, effective mixing can occur due to random positioning of the dredge within the patch on subsequent tows. The effective average density that obtains under the hypothesis of random positioning will be proportional to the ratio of average width of the dredge to the average width of a square patch. This ratio is defined as gamma (γ) and its expected value is equal to the area covered by the dredge within a patch divided by the area of the patch.

The introduction of the gamma parameter into the catch equation allows for reduction in the availability of animals to the dredge on subsequent tows. Gamma can exceed its expected value if animals become less available to the dredge with repeated passes over the same patch. This might occur from: 1. clams blown into or digging into sediment and out of the domain of the experiment, 2. breakage of clams, 3. the dredge becoming less efficient with subsequent passage owing to continual softening of the bottom. 4. clams are lost during retrieval (fall out of dredge, break, lost).

In theory, use of gamma allows one to test the hypothesis that efficiency of the dredge decreases with subsequent tows or equivalently, that the effective population size decreases with multiple passes over the same area. Typically however, there is insufficient information within an individual experiment to test this hypothesis. External information, say from direct observation of organism behaviors or performance of the dredge, is required to specify a range of likely values of gamma. For the series of experiments considered herein, a likely bound on gamma was assumed to be a 1.5 fold increase in the effective dredge width. In other words, the effective population size within a patch that is expected to be available to the dredge on subsequent passes is reduced.

Consider an example in which the patch is 20 x 20 ft^2, the dredge is 10 ft wide, the initial density is 1 animal/ ft^2 and the first pass efficiency is 40%. The initial population size is 400 animals (i.e., 20 x 20 ft^2 * 1 animal/ ft^2). The dredge will cover an average 200 ft^2 on the first pass and pick up 80 animals (i.e., 200 ft^2 * 1 animal/ ft^2 * 0.4 efficiency). Therefore there are 320 (i.e., 400-80) animals remaining and the average density becomes 0.8/ft^2. If there are no losses or reductions in availability, the expected catch in a second tow would be 64 = 200 ft^2 * 0.8 animal/ ft^2 * 0.4 efficiency. If gamma equals 0.75 = 1.5 * 10 ft dredge width /20 ft patch width) then the effective density on the second tow is reduced as if 120 animals (i.e., 300 ft^2 * 1 animal/ ft^2 * 0.4 efficiency) had been removed such that effective density equals 0.7/ft^2 (i.e., (400-120)/400). Thus the expected catch on the second tow would be 56 animals (= 200 ft^2 * 0.7 animal/ ft^2 * 0.4 efficiency). Therefore the expected catch decreases by 12.5% from what it would have been in the absence of indirect losses or reductions in efficiency. Thus the gamma parameter accounts for the reductions in efficiency that are likely to occur when an area is sampled repeatedly.

Depletion experiments for other species have revealed similar findings (Otis et al. 1978, Riley and Fausch 1992, Polovina 1985, Miller and Mohn 1993--and references therein). Schnute (1983) proposed a similar model of reduced efficiency on subsequent sampling. Others have also attempted to address changing capture probabilities (Pollock et al. 1984.,Gould and Pollock 1997, Yamakawa et al. 1994, Wang and Loneragan 1996).

The selection of gamma reflects a tradeoff between positional uncertainty and the tenability of the assumption of complete mixing at the level of the patch. The model could be constructed with a patch size equal to or less than the dredge width with no loss of generality. However, such precision is artificial since the true position of the dredge is not known with such accuracy. Increasing the patch or cell size beyond the width of the dredge better reflects the true positional accuracy but reduces the realism of the assumed post-sample mixing within the patch. As the patch size approaches the size of the experiment domain the patch model will converge to the Leslie-Davis model.

Depletion Experiments and Results

Results from all experiments on Atlantic surfclams are summarized in Table C10. The 2 "Direct" experiments were conducted in different regions (New Jersey and Delmarva) and gave very different efficiency estimates. That result suggests that efficiency is likely to vary with bottom type. Estimates of dredge efficiency for the DE-II in 1997 from "indirect" methods ranged from 0.24-0.57. Estimates in 1997 from "direct" methods (0.6 - 0.7) were higher than those from "indirect" methods . Based on "direct" and "indirect" methods the estimate of dredge efficiency for Atlantic surfclams in 1999 was 0.276 (NEFSC 2000, SARC-30).

Patch model results for ocean quahog experiments carried out in 1999 and 2000 are summarized in Table C11. Indirect estimates of DE-II dredge efficiency from the Patch model ranged from 0.29 to 0.57. Each estimate was derived from the ratio between the density estimate from the DE-II setup tows and the estimate from the model based on data from the commercial vessel.

Each of the data sets from commercial depletion experiments was analyzed using the Patch model and the Leslie-Davis model. Criteria used to judge whether the Patch model was working included 1)shape of the likelihood surface around the solution, 2)sensitivity of solutions to the gamma parameter, and 3)whether the model's density estimate was greater than that based on the actual number captured. In some cases the results from the Leslie-Davis model were considered more plausible, or an average value from the two models was used (bold, underlined values in Table C12). From the experiments, the mean efficiency of commercial vessels fishing for ocean quahogs was 0.593 in 1997-1998, and 0.648 in 2000. The grand mean was 0.620.

The direct estimate of efficiency of the survey dredge, capturing ocean quahogs in 1999 off Long Island, was 0.569 (Table C13). Indirect estimates ranged from 0.227 to 0.313, and a comparison of density estimates at site JN1 gave an estimate of 0.384.

Dredge Efficiency Summary

Three approaches (i.e. resampling, comparison of random stations, and depletion) were described above to examine dredge efficiency, E, in 1999. The mean of the estimates from depletion experiments, 0.346 (CV = 0.40), was taken as the survey dredge efficiency for ocean quahogs in 1999 (Table C13). No ocean quahog experiments were conducted with the DE-II in 1997 to estimate dredge efficiency in that year. Therefore, for the present stock assessment, the 1999 value was also applied to the 1997 survey.

Results on relative efficiency between 1999 and 1997, from the resampled stations on GBK were close to 1. This was also true of the relative efficiency estimated across all regions based on catches of ocean quahogs at random stations. Both results suggested that it was reasonable to apply the 1999 efficiency estimate to the 1997 survey data.

Although a major scientific effort (collaborative field studies between NMFS, academia and the industry, data analysis and modeling) was made in 1999 and 2000 to estimate survey dredge efficiency, E, its value remains uncertain for several reasons:

1) dredge efficiency experiments on ocean quahogs were carried out in the Long Island region. Extrapolation to all other assessment regions may not be warranted,

2) ratios of the 1999 to1997 catches from random survey stations changed among regions, suggesting that E might have changed regionally or during the 1999 survey. Because no explanation for the apparent change in ratios was found, a single dredge efficiency is being applied to the entire stock.

3) Although in theory the Patch model represents an improvement over the simpler Leslie-Davis model, the Patch model did not give reasonable results in 2 of the 4 depletion experiments carried out on quahogs in 1999-2000. Possible reasons are:

> i) these experiments were carried out in deep water, where there is less certainty about dredge location as it was towed across the bottom;
>
> ii) indirect effects of the dredge on the population of quahogs available to the dredge on subsequent tows have not been studied in enough detail to model accurately.

SURVEY RESULTS

Description of Surveys and Database

For this assessment, all data from NMFS trawl surveys for ocean quahog and Atlantic surfclam during 1978-1999 were organized into a new relational database.

Two SAS programs (MKSURV.SAS and MKLEN.SAS) were used to access and process clam survey data in the new database. The first (MKSURV.SAS) tabulated the number and weight per standard tow (0.15 km) of clams (quahog or surfclam) according to user specified length groups, cruise and station (i.e. on a tow-by-tow basis). The most important features of output from MKSURV.SAS were incorporation of "zeroes" for length groups and surveys with zero catch (so that variances could be correctly calculated in the next step) and catch weights calculated from region specific length-weight parameters and lengths in 1 mm intervals.

The second program (MKLEN.SAS), calculated abundance and biomass per standard tow (with variances and CV's) for assessment regions and user specified length groups. Calculations were based on standard formulas for area stratified means. MKLEN.SAS was used with different input parameters to estimate densities in each region for 5 mm length groups (used to plot length compositions) and for all individuals 70+ mm in length (used to measure trends in biomass). The database was tested by comparison of results to programs used in previous assessments.

A series of 22 research vessel survey cruises has been conducted between 1965 and 1997 to evaluate the distribution, relative abundance and size composition of surf clam and ocean quahog populations in the Middle Atlantic, S. New England and Georges Bank (Figure C1). Survey methods changed significantly before and after 1980 (NEFSC 1996, 2000), so the period 1980-1999 is examined here. Even within this period some methods have changed, making it more difficult to detect any temporal trends in stock size. The changes are discussed in more detail below and in NEFSC (2000), but involve gear efficiency and the method used to estimate distance sampled per tow.

Assessment regions are composed of strata which remain fixed through time (Figure C1). The surveys are performed using a stratified random sampling design, allocating a pre-determined number of tows to each stratum. Standardized sampling procedures used in these surveys are described in Murawski and Serchuk (1989). One tow is collected per station, and intended tow duration (once the dredge is on the "poly" line) and speed are 5 minutes and 1.5 knots, respectively. Catch in meat weight per tow is computed by applying appropriate length-weight equations to numbers caught in each 1 mm size category. By averaging over all tows within a stratum, representative size frequency distributions per tow are computed by stratum. Representative size frequency distributions and mean number of clams per tow are also computed by region using as a weighting factor the area of each stratum within the region.

In years prior to 1997, only doppler distance during the timed 5-min tow was measured. This did not consider that the dredge could be sampling during set out and haul back, or that during the tow the blade may not always be in contact with the substrate. Starting in 1997, tow distance was measured with bottom contact sensors mounted on the dredge as well as the original way (doppler). Therefore, more precise measures of tow distance based on bottom-contact sensors are available for the 1997 and 1999 surveys.

Survey catches per tow of both surfclam and ocean quahog were much higher in 1994 than in previous surveys. It is felt that gear efficiency increased significantly during that survey, probably because a higher voltage was used to run the pump (NEFSC1996a,b, NEFSC1998a,c, NEFSC 2000).

Locations of random stations in the 1999 clam survey are shown in Figure C33. Station intensity was greater in some areas (e.g. NJ) because the estimation of population abundance via area-swept methods was anticipated. Samples were not collected from the S. Virginia - N. Carolina region, the Great S. Channel just to the west of Georges Bank, or from the NW corner of Georges Bank (Strata 67, 68) to save time for additional sampling of deeper strata in potential ocean quahog habitat.

In 1999, a new policy was adopted regarding randomly chosen stations with rocky bottom. Pilots searched for towable bottom within 0.5 nmi of the station. If the search was unsuccessful, the log sheet for that station was filled out with a special code (SHG = 151), and the vessel moved on to the next random station. In previous surveys, pilots were likely to search for good bottom and then take a tow, even if it was a considerable distance from the original station location. This procedural change in 1999 is important in providing a better estimate of the area of clam habitat on Georges Bank (NEFSC 1998a,c). In the current assessment, individual stratum areas on Georges Bank were reduced in proportion to the fraction of tows from that stratum that had been assigned code 151 (Table C17). The effect was to reduce the biomass estimates for certain strata.

Abundance Indices and Distribution

Locations of random stations in the 1999 clam survey are shown in Figure C33. Ocean quahog abundance per tow data from the 1997 survey were partitioned into two size classes based on shell length: small (1-69 mm) and large (>= 70 mm). Detailed distribution data by size class are plotted in Figures C34 - C37. Clams in the "large" class were most abundant from Georges Bank to Long Island. The largest concentrations of "small" clams were on Georges Bank.

Certain strata of special concern were surveyed using stratified random sampling for the first time. Few (usually zero) ocean quahogs were captured at random stations in deep water south of Long Island and S. New England (Figures C34 - C37). This area consists of green mud with few macrobenthic organisms (See later section "Distribution of Ocean Quahog in Deep Water" for more results and details). In addition, an industry vessel collected 12 samples from random stations in Strata #42 and 43 (Figure C1), and caught zero ocean quahogs at 10 of the stations (Figure C38). Commercial landings have been reported from the northern edge of these strata (Figures C10 and C11); however, data from the random stations suggest that the ocean quahog stock is not very large or widely distributed in strata #42 and #43.

Ocean quahog catches from the DE-II clam surveys of 1978-1999 are summarized in Table C14 and Figure C39, by cruise and assessment region. Number of ocean quahogs and meat weight per tow are the stratified means, weighted by the areas of the strata within regions. For consistency over the time series, catches from each tow were standardized to 0.15nm based on the doppler reading during the timed, 5-min, tow. (There is a major difference between tow distances estimated from the doppler and the more accurate sensors). Sensors have been used since 1997, and could not be used to standardize the entire time series listed in Table C14.

Tables C16 and C17 present ocean quahog survey results from 1997 and 1999 which used sensor data to estimate tow distance and as the basis for standardizing catch per area. Both the doppler-adjusted survey data (Table C14) and the sensor-adjusted swept area survey biomass estimates (Table C17) were used in biomass models (see later section "Stock Size Models").

Size Frequency Distributions

Size frequency distributions from surveys conducted between 1980 and 1999 are plotted by region in Figures C40 - C44. Data in the graphs were standardized to a common doppler distance. A smaller liner was in the dredge before 1980, so smaller sizes were more likely to be captured in 1978-1979.

The modal size in the New Jersey and Delmarva regions (90-100 mm shell length) is greater than that from the more northern regions Georges Bank, S. New England, and Long Island (70-90 mm). The size structure of clams changed little over time in most regions, and this could be due to partial selectivity of small individuals by the clam dredge, particularly those below 70 mm in length.

The length composition of clams off Long Island and on Georges Bank has been more dynamic and suggests that recruitment events occur. Length structure off Long Island was bimodal from 1978 to 1999. Over this 20 year period, individuals in the smaller mode grew and eventually merged with the larger mode in 1999 (Figure C42). The smaller mode grew from approximately 60 to 80 mm in 20 years, which is consistent with previous studies of growth rate and Figure C48. The other notable result is the increase in the catch of small (<60 mm) ocean quahogs on Georges Bank in the 1990s (Figure C44; and Lewis et al., In prep.).

Distribution of Ocean Quahog in Deep Water

The last stock assessment (NEFSC 1998) concluded that the shallow water boundary of ocean quahog is at the 16° C bottom temperature isotherm, while the deep water boundary extends to at least 91 m (50 fm). Until 1999, the NMFS clam survey occupied stations to 73 m (40 fathoms). The commercial fishery operates at depths of at least 91 m (50 fathoms). Thus, the portion of the quahog stock at depths > 91 m was not tracked by commercial catch rates and the portion deeper than 73 m was not surveyed.

Deep quahog are probably not important in interpreting survey and LPUE data as measures of *relative abundance*. However, deep water quahog could be important in interpreting *swept area biomass* estimates from survey data.

Data for all successful tows in the NMFS clam survey database were used in an analysis of depth distribution patterns. The data set includes 46 randomly selected deep stations occupied during the 1999 survey in nine deep water strata at 73-110 m (Table C15). Deep stations in 1999 were offshore of the LI (strata 32 and 36), SNE (strata 40, 44 and 48) and GBK (strata 56, 58, 60 and 62) regions. Seventy mm was used as a lower bound for survey data in calculations because this is approximately the length that becomes fully selected by the survey dredge.

Data used in this analysis also included thirteen "151" stations in the 1999 survey in five GBK strata and one SNE strata. Stations with the 151 code were assigned catches of zero in the survey database because quahog are rare or absent on rocky bottom.

Most of the deep water LI and SNE strata had a "green mud" bottom where quahog are rare. Tows from deep water were used to calculate catch rates, mean weight (weight per tow divided by number per tow), and the fraction of tows with at least one individual.

NEFSC (1998) showed that survey catch rates are affected by changes from survey to survey dredge efficiency. Differences in depth patterns among regions seemed possible. Therefore, catch rates (either KG/tow from individual tows or stratum means, based on doppler tow distances) were plotted separately against depth for unique combinations of regions and survey cruises. If patterns were clear, averages for all tows and all cruises in a stratum were averaged and stratum means for all strata in the same region were plotted against depth.

Mean weight of individual clams was calculated as biomass catch rates (KG per standard tow) divided by numerical catch rates (number per standard tow) based on doppler tow distance measurements. Therefore, changes in mean weight imply changes in length composition, not changes in condition factors or growth parameters.

Mean weights were probably not affected by dredge efficiency, so mean weight data for the same region but different cruises could be plotted together. Similarly, the proportion of positive tows should be relatively unaffected by dredge efficiency, so proportion positive tows in the same region (for all tows in the same stratum) from different surveys were plotted together.

Results for most surveys (Figure C45) suggest that catch rates (a measure of biomass per unit area) for quahog 70-149 mm are highest at depths of 40-60 m in all areas but GBK. In GBK, catch rates are highest in deeper water at 60-80 m. The deepest (> 90 m) samples from GBK contained reasonably high biomass.

Proportion positive tows (Figure C46) for quahogs 70+ mm increases in most areas up to depths of about 60 m. In the SNE and LI stock assessment areas, and perhaps in NJ, proportion positive tows decline at depths greater than 60 m.

All 18 deep tows (100%) during the 1999 survey in the GBK stock assessment area (Table C15) were positive for ocean quahog (70+ mm). Three out of 12 tows (25%) off LI were positive. Six out of 16 deep tows (38%) off SNE were positive.

Mean weights of individual clams 70-139 mm (Figure C47) declined with depth in all stock assessment areas. Overall, quahog were largest in the SVA stock assessment area.

Distances measured by doppler averaged 2.0 times larger than distances measured by more accurate bottom sensors for the 48 tows at depths greater than 84 m during the 1999 survey (Table C15). This indicates that sensor equipment is particularly important when working in deep water.

Deep water strata in the LI, SNE and GBK regions represent 30%, 40% and 33% of the area and 0%, 2% and 13% of the quahog biomass in these regions (Table C16). Biomass at depths of 73-110 m is significant in the GBK region but not in the LI and SNE regions.

STOCK SIZE MODELS

Efficiency Adjusted Swept Area Biomass

Habitat area on Georges Bank was calculated A=fR where R was the total area (nm^2) of survey strata in the Georges Bank assessment region with ocean quahog habitat. The value f=90% was an area weighted average of the percentage of randomly chosen survey stations in each stratum that were fishable with the survey dredge (haul code not equal 151, Table C17). For lack of data, other stock assessment regions were assumed to be 100% suitable as ocean quahog habitat (i.e. f=1 so that A=R).

Swept area biomass (B), adjusted for survey dredge efficiency (e), was computed:

$$B = \frac{DfR}{ae}$$

where D was the average weight of clams (70+ mm) caught per tow (adjusted to a standard 0.15 nm tow length, kg tow^{-1}), a was area swept per standard tow (standard tow length times dredge width, nm^2), and e was dredge efficiency (probability of capture for clams in the path of the survey dredge). For convenience in variance calculations, swept area biomass (B) and all terms in the swept area biomass calculation (A, f, R, D, a and e) were assumed to be lognormally distributed.

Taking logs gives:

$$\ln(B) = \ln(D) + \ln(f) + \ln(R) - \ln(a) - \ln(e)$$

Neglecting covariance terms, the variance of ln(*B*) can be approximated as the sum of the variances. Covariances involving ln(*f*) with other terms and ln(*R*) with other terms were likely zero. Covariances probably exist between ln(*D*), ln(*a*) and ln(*e*) but were ignored in calculations because their direction and magnitude were difficult to predict.

Log scale variances for terms in swept area biomass calculations were calculated from arithmetic scale coefficients of variation (Jacobson et al. 1994):

$$Var[\ln(x)] = \ln[CV(x)^2 + 1]$$

where CV(x) is the coefficient of variation for x. CV's for survey data (*D*) were from standard errors for stratified means (Table C17). CV's for efficiency estimates (*e*) were based on direct and indirect efficiency experiments on ocean quahogs (see Dredge Efficiency Section). The CV for average area towed (*a*) was the CV for mean tow distance during each survey. CV's of 5% were assumed for the total area of survey strata with quahog habitat in each stock assessment region (*R*). The CV for percent suitable habitat (f) in the Georges Bank assessment area was assumed to be 10%.

CV calculations for swept area biomass estimates likely underestimate actual uncertainty because but not all sources of variability were included and because variation in many of the terms was underestimated. For example, it is likely that CV's for standard catch rates in the survey (D) were underestimated because the variances for survey strata with zero catches and strata with a single tow were assumed to be zero. Variance calculations for swept area biomass do not include uncertainty in length-weight conversion parameters used to convert numbers per tow in surveys to weight per tow.

Upper and lower bounds for 95% confidence intervals on log biomass were computed as ln(B)±1.96 SE[ln(B)] where SE(x) was the standard error of x. Crude (no bias correction, Beauchamp and Olson 1973) asymmetric arithmetic scale confidence intervals were calculated by back-transforming the bounds on the interval for ln(B).

Swept area biomass estimates with corrections for survey dredge efficiency (Table C17) had CV's that were 1-3 times larger than CV's for the original survey data (Table C14). Ninety-five percent confidence intervals for total, efficiency adjusted, swept area biomass during 1997 and 1999 overlapped.

<u>KLAMZ Assessment Model for Ocean Quahog</u>

A configuration of the KLAMZ biomass dynamic model was used to estimate ocean quahog biomass and fishing mortality in each of the SVA, DMV, NJ, LI, SNE and GBK regions (see NEFSC 2000 for a complete description of the model). The approach for quahog was based on Stock Reduction Analysis (Kimura and Tagart 1982; Kimura et al. 1984; Kimura 1985; Butler et al. 1998; Butler et al. 1999) and is similar to the "VPA" modeling approach used in NEFSC (1998). It assumes that quahog in the EEZ were near virgin biomass in 1978, landings data are accurate, and that recruitment of can be approximated as constant from year to year. This KLAMZ model has a three-step "spin up, fish down, check goodness of fit" approach.

In each iteration of the KLAMZ model for quahog, the "spin up" step calculates the virgin biomass (assumed to be the same as biomass in 1978) that would result from the model's current estimate of the recruitment parameter. The "fish down" step involves running the model for 1978-1999 (starting from virgin biomass in 1978) with constant recruitment (at the virgin level), M=0.02 y^{-1}, and actual catches to calculate a time series of biomass and fishing mortality estimates. The third "check goodness of fit" step involves comparing estimates from the model with abundance data by maximum likelihood to determine the plausibility of the model run. Between iterations, the model adjusts parameter estimates until "best" maximum likelihood estimates are found and the model converges.

The KLAMZ model for quahog includes only two parameters, estimated by nonlinear optimization: the logarithm of virgin recruitment (Ω), and the logarithm of an exponent (θ) used to interpret LPUE (see below). Survey scaling parameters (Q), normally estimated by nonlinear regression, were calculated in KLAMZ using a closed form maximum likelihood expression that gives the same result (NEFSC 2000). KLAMZ is implemented as both Excel spreadsheet and AD-Model Builder programs (see NEFSC 2000 for details).

The KLAMZ model for quahog tracks the biomass (meat weight) of individuals 70+ mm in annual (calendar year) time steps. Recruitment in the model is defined as biomass at the beginning of the calendar year due to newly individuals reaching 70+ mm shell length.

<u>Data</u>

The KLAMZ model included survey dredge efficiency estimates from field studies during 1997 and 1999, estimates of age and growth, survey and LPUE trend data, and all other available information with the exception of length composition data for survey and fishery catches. Length and age composition data were not fully utilized because KLAMZ tracks at most two length and age groups.

Catch data (mt y^{-1}) in KLAMZ included landings (Table C2), estimated discards (assumed zero for ocean quahog), and non-catch mortality (assumed zero for ocean quahog). Recent work (Bergman and van Santbrink 2000))indicates that non-catch mortality is likely to be >0, however. Catches were assumed measured without error. The assumption is probably reasonable for ocean quahog landings in their original units (bushels) but the conversion from bushels to weight is based on a single conversion ratio of unknown accuracy.

Standardized "effort area weighted" LPUE data for 1980-1999 were used as abundance indices for quahog in KLAMZ (Table C4). "Traditional" standardized LPUE values were similar in trend to effort area weighted LPUE (see Section LPUE) but not used in KLAMZ because preliminary runs showed that effort area weighted LPUE data worked better.

In preliminary runs, it was clear that increasing trends in LPUE when the fishery was developing (see above) interfered with fitting the model to NMFS clam survey and more recent LPUE data. Poor fits were characterized by pathological patterns in residuals for LPUE and low values of Q for the swept area biomass data. These problems were likely due to increases in LPUE as the fishery developed and became more efficient, while biomass levels in the stock assessment area remained stable. Effort area weighted LPUE data exclude years when the fishery did not operate in all effort areas within a stock assessment region and tend, naturally, to eliminate early years when the fishery was incompletely developed. As described in Section 3, LPUE tended to increase in most stock assessment areas during early years because the fishery was developing.

In order to make LPUE data as useful for tracking abundance of quahog as possible, we examined landings (Table C2), fishing effort (Table C3) and LPUE (Figures C13 - C17) trends to objectively determine when fisheries in the DMV, NJ, LI, and SNE areas became "fully established." Trends in landings suggest that the fisheries in DMV, NJ, LI, SNE were fully established in 1987, 1987, 1992 and 1995, respectively. Trends in effort suggest that the fisheries were fully established in 1983, 1983, 1992 and 1995. LPUE trends suggest that the fisheries in DMV and NJ were fully established in 1985 and 1986-1987 (LPUE trends for LI and SNE were not clear). Based on this evidence, we assumed that the fisheries in DMV, NJ, LI and SNE were fully established in 1985, 1986, 1992 and 1995. LPUE data for earlier years were not used to fit the KLAMZ for ocean quahog.

KLAMZ used efficiency corrected swept area biomass estimates and CV's (Table C17) for quahogs 70+ mm during 1997 (all areas) and 1999 (all but SVA). For greatest accuracy, bottom sensors were used to measure tow lengths in computing swept area biomass data for use in KLAMZ. Estimates for 1997 and 1999 included biomass in deep water strata sampled off LI, SNE and GBK during 1999, and adjustments for portion suitable habitat on Georges Bank (Table C17). KLAMZ was tuned to scale (but not trends) in swept area estimates with a likelihood constraint towards Q=1 (see below). Trends in swept area biomass were ignored because a longer time series of trends in biomass (also from survey data) was available and contained the same information.

In contrast to swept area biomass data, survey time series data for 1978-1999 (Table C14 and Figure C39) were assumed to measure *trends* (rather than the *scale*) in stock biomass. It was not practical to separate survey data into components for new and old recruits (because growth is less than 1 mm per year), so a single time series covering the entire recruited 70+ mm stock was used for all recruited quahog in each stock assessment area. Units for survey trend data were stratified average catch weights per tow (KG per 0.15 nm standard tow) with CV's computed in the new clam database using conventional formulae for stratified means. Doppler distance measurements were used to estimate tow lengths (i.e. bottom sensor data from 1997 and 1999 were ignored) to make the time series consistent. Two surveys during 1978 and 1980 (Table C14) were averaged to obtain one survey observation for 1978 and one observation for 1980 to be used in the KLAMZ model.

Survey data used in the KLAMZ model for each stock assessment region are listed below

Years Survey Data Used in the KLAMZ Model	
SVA	1981, 1982, 1983, 1984, 1986, 1989, 1997
DMV	1980, 1981, 1982, 1983, 1984, 1986, 1989, 1992, 1997, 1999
NJ, LI	1980, 1981, 1982, 1983, 1986, 1989, 1992, 1997, 1999
SNE	1982, 1983, 1986, 1989, 1992, 1997, 1999
GBK	1986, 1989, 1992, 1997, 1999

Survey data were adjusted automatically in the new database to correct for changes in dredge width and mesh size but survey data collected prior to the first summer/fall survey in 1980 were probably not comparable to surveys carried out afterwards. We therefore excluded data from surveys prior to 1980.

Survey coverage was incomplete in some stock assessment areas during some years. We omitted survey data for years when less than half of the strata in a stock assessment region were not sampled.

Survey data collected during 1994 for ocean quahog (NEFSC 1998) and surfclam (NEFSC 2000) were outliers due to problems with voltage supplied to a pump on the survey dredge. Following NEFSC (2000) we omitted survey data from 1994.

Population Dynamics

The KLAMZ model is based on Schnute's (1985) delay-difference equation:

$$B_{t+1} = (1+\rho) L_t B_t - \rho L_t L_{t-1} B_{t-1} - \rho L_t J_t R_t + R_{t+1}$$

where B_t is total or "fishable" (see below) biomass at the beginning of year t; ρ is Ford's growth coefficient (see below); $L_t=\exp(-Z_t)=\exp[-(F_t+M_t)]$ is the fraction of the stock that survived in year t; Z_t, F_t, and M_t are instantaneous rates for total, fishing and natural mortality; and R_t is the biomass of recruits at the beginning of year t. Following NEFSC (1990), the natural mortality rate for ocean quahog was assumed to be $M=0.02$ y^{-1}. The growth parameter $J_t = w_{t-1,k-1} / w_{t,k}$ (where w_a is weight at age a) is the ratio of mean weight one year before recruitment (age k-1 in year t-1) and mean weight at recruitment (age k in year t). In KLAMZ, it is not necessary to specify mean individual body weights at recruitment and one year prior to recruitment (parameters v_{t-1} and V_t in Schnute 1985) because the ratio J_t and recruitment biomass contain the same information. The growth parameter J_t can vary over time in KLAMZ (NEFSC 2000) but was assumed constant for ocean quahog (see below).

The delay-difference model gives the same results as more complicated age structured models (i.e. Leslie matrix model) if recruitment to the fishery in the age structured model is complete and "knife-edged" at age k, natural mortality is the same for all age groups, and Ford's (Von Bertalanffy) growth model holds. Knife-edged recruitment means that quahog recruit to the fishery *en-masse* on their k^{th} birthday so that biomass available to the fishery and stock biomass (B_t) are the same and include all individuals age k and older.

The assumption of knife-edge recruitment at age k in KLAMZ can be relaxed by assuming KLAMZ measures fishable biomass (Butler et al. 1998; Butler et al. 1999). Fishable biomass is the portion of total stock biomass fully vulnerable to fishing mortality. The alternative assumption has implications that are potentially useful for ocean quahog. In particular, recruitment to the fishable stock can include quahog of many ages so the biological age of recruits and selectivity at age is less important.

Ford's growth model:

$$w_a = w_{k-1} + (w_k - w_{k-1})(1+\rho^{1+a-k})/(1-\rho)$$

is mathematically the same as von Bertalanffy's more familiar growth model $\{W_a = W_{max} [1 - \exp(-K(a-t_{zero})]$ where W_{max}, K and t_{zero} are parameters$\}$. The two growth models are the same (Schnute 1985) because $W_{max} = (w_k - r\, w_{k-1})/(1-r)$, $K = -\ln(\rho)$ and $t_{zero} = \ln[(w_k - w_{k-1})/(w_k - \rho w_{k-1})] / \ln(\rho)$.

Growth in length is uncertain for ocean quahog and may depend on area, depth and other factors (Lewis et al., In prep.). No growth parameter estimates were available for quahog growth in units of body weight. However, we were able to estimate von Bertalanffy parameters for growth in weight based on area specific length-weight conversion formulas (see below) and von Bertalanffy parameters for growth in length (NEFSC 1990, 1996a; L_∞=97.28 mm, K=0.0311 y and t_0= -14.967). Data used to estimate von Bertalanffy parameters for length were collected off the coast of New York in the Mid-Atlantic Bight during 1970-1980 (Murawski et al. 1982).

Length-weight conversion parameters for ocean quahog $W=aL^b$ (L shell length in mm and W weight in g).

Parameter	SVA & DMV	NJ	LI	SNE	GBK
	-9.042	-9.847	-9.234	-9.124	-8.969
b	2.788	2.950	2.822	2.775	2.767

For each stock assessment region, predicted lengths from the von Bertalanffy relationship for length were converted to predicted weights. Von Bertalanffy parameters for predicted growth in weight were then estimated by nonlinear regression. The resulting von Bertalanffy growth curves for different stock assessment areas were very similar (Figure C48) so we averaged parameter estimates to get a single set of von Bertalanffy growth parameters for the whole stock (see following table).

Von Bertalanffy parameter estimates for ocean quahog growth in weight.

Parameter	SVA & DMV	NJ	LI	SNE	GBK	Average
W_∞ (g)	46.294	44.202	44.947	40.129	45.203	44.155
k	0.018	0.017	0.018	0.018	0.018	0.018
t_0 (y)	-0.174	0.536	-0.018	-0.233	-0.268	-0.031

The original curve for growth in length indicates that recruitment (at 70 mm) occurs at about age 26. On this basis, predicted weights at age k=26 and k-1=25 were used to calculate the growth parameter J=0.97 (average value) used in KLAMZ for ocean quahog for all stock assessment areas (see below).

Calculation of growth parameter J for use in KLAMZ

Parameter	SVA & DMV	NJ	LI	SNE	GBK	Average
W_k (g)	17.220	15.410	16.491	15.004	16.953	16.216
W_{k-1} (g)	16.697	14.919	15.985	14.550	16.441	15.719
$J=W_{k-1}/W_k$	0.970	0.968	0.969	0.970	0.970	0.969

Fishing mortality rates (F_t) for quahog were calculated from landings and biomass by solving Baranov's catch equation numerically using Sim's (1982) algorithm. In the AD-Model Builder version, the algorithm was implemented with a fixed number (10) of Newton iterations. The Excel version used a Visual Basic function in a spreadsheet macro.

As described above, there were no survey swept area biomass or trend data for newly recruited quahogs because growth during one year ($\leq$ 1 mm) is less than measurement errors in the survey data. Current research (Lewis et al., In. prep.) indicates that recruitment levels can vary from year to year but, based on survey and fishery length composition data, recruitment biomass in most years is probably a small fraction of the standing stock. New recruits to the modeled stock (70+ mm) are likely made up of many age groups. Like a weighted average, trends in new recruits as defined in the KLAMZ model are probably smoother than year to year variation in year class strength. Quahog recruitment in KLAMZ was therefore modeled as a constant value in each year:

$$R_t = e^{\Omega}$$

where Ω was a log-scale recruitment parameter constant over all years. As described below, the recruitment parameter was also important in estimating virgin and initial biomass in the KLAMZ model for ocean quahog.

Parameter Estimation and Tuning

Goodness-of-fit for observed and predicted abundance index data was computed assuming log-normal measurement errors:

$$L_A = 0.5 \sum_{j=1}^{N_v} \left[\frac{\ln\left(I_{v,j} \big/ \hat{I}_{v,j} \right)}{\sigma_{v,j}} \right]^2$$

where $I_{v,t}$ was an abundance index datum for survey v, hats "^" denote model estimates, $\sigma_{v,j}$ was an observation-specific log scale standard error (calculated from an arithmetic scale CV, see below), and N_v was the number of observations.

Predicted values for quahog abundance indices were calculated:

$$\hat{I}_{v,t} = Q_v A_t^{\Theta}$$

where the exponent $\Theta=e^{\theta}$, θ was a model parameter (see below), and Q_v was a scaling parameter that converted biomass to units of the abundance index. A_t was available biomass:

$$A_t = \left[s_1 R_t + s_2 (B_t - R_t) \right]$$

and s_1 and s_2 were survey selectivity parameters for new recruits (R_t) and old recruits (B_t-R_t). For survey data, θ=0 and $\Theta=e^{\theta}=1$. However, θ was estimated in the model for LPUE data to account for potential saturation in the relationship between LPUE and quahog biomass (Hilborn and Walter 1992, see below). For ocean quahog, abundance index selectivity parameters were always set to one (i.e. s_1=1 and s_2=1) because the model did not discriminate between new and old recruits.

Efficiency corrected swept area biomass estimates for quahog during 1997 and 1999 were important sources of information in the KLAMZ model. The expectation Q=1 for swept area biomass data was the basis for the constraint:

$$L_Q = 0.5 \left[\frac{\ln(Q/T)}{\sigma} \right]^2 = 0.5 \left[\frac{\ln(Q)}{\sigma} \right]^2$$

where T=1 was the target (prior) for Q, and σ was a standard error calculated from the average CV (40%) for efficiency estimates from field studies during 1997 and 1999 (Table C13). The constraint and calculation for σ assumed that the distribution of Q was lognormal (an appropriate assumption because Q > 0). The constraint Q=1 for swept area biomass data tends to prevent problems with implausible efficiency values for survey data (e.g. Q_{Survey}>1 for surfclam as in NEFSC 1996).

Arithmetic scale CV's for abundance data were converted to a log scale standard errors used in likelihood calculations with:

$$\sigma_{v,j} = \sqrt{\ln\left(1 + CV_{v,j}^2\right)}$$

In some cases, the relationship was inverted to calculate CVs from log scale standard errors (e.g. to get a CV for arithmetic LPUE trend data from log scale standard errors for year effect parameters estimated in GLM models).

<u>Bootstrap Variance Estimates</u>

Variances for estimates from KLAMZ were calculated by a simple bootstrap procedure (five hundred iterations) involving abundance data (Efron 1982). The first step was to obtain a basecase model fit. The next was to generate a large number of simulated data sets based on predicted data values and randomly sampled log scale residuals from the basecase run. Finally, KLAMZ was fit to each of the simulated data sets. Variance of estimates from the simulated data sets were used to estimate variance for estimates in the original base case fit. For simplicity and ease in calculation, and because the variances of residuals in preliminary runs were similar, residuals from the basecase fits to LPUE, survey and swept area biomass data were mixed during the bootstrap process.

<u>Projections</u>

KLAMZ was used to project biomass levels into the future given a virgin recruitment parameter from a model fit and assumptions about future recruitment and catch. Future recruitment and catch (mean 1997-1999) are the most important feature in projections. In bootstrap runs, estimates of recent recruitment and biomass changed so variance calculations for projections include some uncertainty about population dynamics.

<u>KLAMZ Basecase Model Results</u>

KLAMZ model results (Tables C18-C20; Figures C49-C54) appear useful for all stock assessment areas but SVA (Figure C49). Problems with model results for SVA were due to having one low swept area biomass (20 mt in 1997 compared to a peak catch of 160 mt in 1985). Residual plots indicated good fit to the data although residuals for LPUE in NJ were autocorrelated (Figure C51). Estimates of the scaling parameter Q for efficiency corrected swept area biomass were (with the exception of SVA) near or a little smaller than one (Table C18).

Exponents for the relationship between LPUE and quahog biomass were greater than one for SNE, LI and NJ (Table C18). Implausible exponent values were likely due to the modest amount of contrast in estimated biomass levels for SNE, LI and NJ (recent biomass/virgin biomass levels of 73%-92%) and the short LPUE time series for LI and SNE (Table C18). In comparison, recent biomass/virgin biomass was 47% for DMV which had a plausible exponent estimate θ=0.85.

Recent F's (average during 1997-1999, Table C20) ranged 0.00-0.022 and were highest in SNE and DMV (Table C20). Ratios of recent to virgin biomass (Tables C19 and C27) ranged 24% (SVA, probably unreliable due to low swept area biomass for 1997, see above) to 100% (GBK with no fishing).

Estimated virgin biomass was 2.1 million mt for the stock as a whole and 1.5 million mt excluding GBK (Tables C19 and C27). Estimated annual recruitment was about 23 thousand mt per year for the stock as a whole and 16,000 mt per year excluding Georges Bank. Ratios of recruitment biomass to standing stock biomass in 1999 were 1.3% for the stock as a whole and 1.3% excluding GBK. The low ratio of recruitment to biomass illustrates the importance of growth in the long-lived ocean quahog stock.

Estimates for 1978-1999 and projections for 2000-2009 indicate that biomass of the entire EEZ stock was about 1.8 million mt (87% of virgin biomass) during 1999 and is projected to decline to about 1.7 million mt (81% of virgin biomass) by 2009 (Figure C55). Excluding GBK (where no fishing occurs due to PSP), biomass was about 1.2 million mt (81% of virgin) during 1999 and projected to decline to about 1.0 million mt (72% of virgin) by 2009 (Figure C55). As described above, projections assumed constant recruitment and recent (mean 1997-1999) catch levels.

Sensitivity analyses

In addition to the basecase runs, we carried out a variety of sensitivity runs with the KLAMZ model. The first analyses were for DMV, the stock assessment area with the most informative data (Table C21). Runs involved increasing levels of catch, doubling and halving natural mortality rates, and assumptions about linear and non-linear relationships between LPUE and biomass. In addition, runs were carried out runs with each of the three types of abundance data (NMFS survey, LPUE, and the likelihood constraint towards Q=1 for swept area biomass) removed (e.g. "No LPUE" was a run with LPUE data removed) and with all possible pairs of the three types of abundance data removed. For example, the "LPUE Only" run omitted the NMFS survey and the likelihood constraint for swept area biomass.

Results (Table C22 and Figure C56) indicate KLAMZ model estimates for quahog in the DMV stock assessment region were robust to changes in model configuration, particularly when at least two of the three types of abundance data were included. However, the "LPUE Only" run (with LPUE data as a nonlinear measure of stock biomass and using neither survey data nor the swept area biomass constraint) gave implausible biomass estimates that followed the same trend but were about half as large as estimates from other runs.

Biomass estimates from the "LPUE Only" sensitivity analysis run for quahog in DMV were implausible because they were smaller than swept area biomass estimates for the same years (i.e. Q>1). The negative log likelihood for LPUE data in the sensitivity analysis run was 0.008 compared to 0.009 in the Basecase run (Table C22). The small improvement in log likelihood for LPUE data, despite the large change in estimated biomass, indicates that LPUE data contain little information about the scale of quahog biomass in the DMV stock assessment region.

KLAMZ model estimates for ocean quahog in regions other than DMV were less robust, probably because the data sets were less informative and had less consistent trends. For example, sensitivity analysis runs for the NJ assessment area (Table C23) gave estimates of recent mean biomass that ranged from 216 (swept area biomass only) to 341 (no swept area biomass data) thousand mt. Apparently, trends in the survey and LPUE data for NJ suggest higher biomass levels than the swept area biomass information. Differences in goodness of fit (as measured by log likelihood) among runs were trivial and not statistically significant.

Sensitivity analysis runs for the LI assessment area (Table C24) gave estimates of recent mean biomass that ranged from 424 (swept area biomass only) to 534 (basecase and no LPUE) thousand mt. Differences in goodness of fit among runs were trivial and not statistically significant. Apparently, trends in the survey and LPUE data for LI suggest higher biomass levels than the swept area biomass information. Differences in goodness of fit among runs were small and not statistically significant.

As in sensitivity analyses for DMV, "LPUE Only" runs for NJ and LI gave anomalous results (Tables C23-C24).

The SARC requested additional sensitivity analyses, including projections, based on large changes to assumptions about natural mortality and catch. The purpose was to understand tradeoffs between recruitment and biomass estimates, projected biomass, and assumptions about natural mortality and catch levels. Sensitivity analyses results for DMV with M=0.08 y^{-1} (4x the default rate), M=0.005 y^{-1} (default rate/4), catch ±50% were typical (Table C25 and Figure C57).

Estimated and projected biomass trends for the basecase run and runs with ±50% of catch were parallel (Figure C57). However, recent and projected trends in biomass from the M/4 run declined more quickly than in the basecase run. In contrast, recent and projected trends from the run with 4xM increased. Trends in runs with different levels of natural mortality were due to higher estimated recruitment in the 4xM run (6,310 mt per year) and lower estimated recruitment (300 mt per year) in the M/4 run, relative to the basecase run. Recent reductions in catch of quahog from DMV (Figure C3) with higher recruitment in the 4xM run were sufficient to cause biomass increases. This results shows that relationships between model estimates and assumptions about natural mortality can depend on the exploitation history of the stock.

The total negative log likelihood for runs with ±50% catch were similar to the basecase run (Table C25). However, the run with 4xM had a log likelihood (6.38) that was significantly higher than the basecase run (4.57) while the run with M/4 had a lower negative log likelihood (4.32) than the basecase run. This result indicates that survey trend data for quahog in DMV are not (under the assumptions in the KLAMZ model) compatible with natural mortality rates as high as 0.08 y^{-1} (four times the default value).

The SARC also requested a likelihood profile for the swept area biomass scaling parameter

Q in the KLAMZ model. Likelihood profiles are computed by fixing a model parameter of interest (i.e. Q for swept area biomass) at each of a range of values while estimating all other parameters (Mittertreiner and Schnute 1985). Likelihood profiles are useful for understanding how different types of data effect results from complicated models and can be used to compute confidence intervals (e.g. for Q or swept area biomass).

According to theory, bounds for an approximate confidence interval are found on a one parameter likelihood profile where the total negative log likelihood is $\Lambda+\chi^2_{1,,p} / 2$ where Λ is the log likelihood for the basecase model and $\chi^2_{1,p}$ is the p-value (a.k.a. critical value) from the chi-square distribution with one degree of freedom . For example, the negative log likelihood for the basecase DMV run was 4.60 and $\chi^2_{1,0.1} / 2 = 2.7/2=1.35$ so bounds for a 90% confidence interval around Q (and recent biomass) are where the profile negative log likelihood is 4.60+1.35=5.95 (Table C26). This approximation is a restatement of the statistical result that likelihood ratio tests are distributed asymptotically as χ^2_1 (p. 119 in McCullagh and Nelder 1989; Section 23.3 in Stuart and Ord 1991).

Likelihood profile results for DMV (Table C26 and Figure C58) show that the NMFS dredge survey dominates LPUE data and the swept area biomass constraint in the log likelihood. For DMV, the 90% confidence intervals were roughly 0.35-1.6 for Q and 40-180 thousand for recent biomass. In contrast, the non parametric 90% bootstrap confidence intervals (500 iterations) for recent biomass were 46-83 thousand mt.

BIOLOGICAL REFERENCE POINTS (BRP's) and STOCK STATUS

Biological Reference Points

According to NEFSC (1998), $F_{MAX}=0.065\ y^{-1}$, $F_{0.1}=0.022\ y^{-1}$ and $F_{25\%}=0.042\ y^{-1}$ for ocean quahog. Biological reference points for ocean quahog were not updated in this assessment because no new life history information has been gathered since 1997. $F_{0.1}$ and M are common proxies for F_{MSY} (e.g. for Atlantic surfclam in NEFSC 1999). For ocean quahogs, $F_{0.1}=0.022\ y^{-1}$ and M $=0.02\ y^{-1}$.

The KLAMZ model was used to estimate virgin biomass (K) in each stock assessment region and for the stock as a whole (Table C27).

Overfishing Status Determination

According to the Atlantic Surfclam and Ocean Quahog Fishery Management Plan (FMP), Amendment 12 (MAFMC 1998), the "overfishing definition 'target' is one-half the virgin biomass *[for the whole stock]* and the $F_{0.1}$ level of fishing mortality for the exploited region" (*italics added*)". According to the same source, the "overfishing 'threshold' would be one-half B_{MSY} or one-quarter of the virgin biomass . . . with an $F_{25\%}$ MSP level of fishing mortality that should never be exceeded." As described above, $F_{0.1}=0.022\ y^{-1}$ and $F_{25\%}=0.042\ y^{-1}$ for ocean quahog.

Status determination was based on estimates and 95% confidence intervals for "recent" F and total biomass (averages during 1997-1999) from the catch-swept area (Table C17) and KLAMZ models (Table C18). For all regions (including Georges Bank), recent F estimates were 0.01 y^{-1} from both models and upper bounds on 95% confidence intervals were 0.014-0.015 y^{-1} (Table C27). Thus, it is unlikely that recent fishing mortality rates exceeded the overfishing threshold. Overfishing of the entire stock does not appear to be occurring in the ocean quahog fishery.

Recent biomass estimates were 1.8-1.9 million mt of meats and lower bounds on 95% confidence intervals were 1.2-1.4 million mt of meats. Recent biomass estimates from both models can be compared to the target (one-half virgin biomass) and threshold (one-quarter virgin biomass) levels. According to KLAMZ model results (Table C27), virgin biomass for the whole quahog stock is 2.0 million mt of meats so the biomass target is 1.0 million mt of meats and the biomass threshold is 0.5 million mt of meats. Thus, ocean quahog biomass levels are probably at or above target levels for the whole stock. Thus, the stock does not appear to be overfished.

The GBK region contains 37-40% of the resource (Table C27), and this region has been closed to harvesting since 1990 when PSP was discovered in the clams. If this region is excluded from the stock, point estimates for F on the remaining regions increase to 0.015 - 0.017 and upper bounds on 95% confidence intervals for F were 0.022-0.026 y^{-1} (Table C27). Furthermore, without GBK, point estimates of B decrease to 1.1 - 1.2 million mt meats and lower bounds on 95% confidence intervals for B were 0.7-1.0 million mt of meats

Consistency with SFA Requirements

It may be possible to find harvest policies for ocean quahog that are more compatible with National Standard Guidelines (DOC 1998). According to recommendations, the threshold (i.e. maximum) fishing mortality rate for a stock at relatively high biomass levels should be F_{MSY} or a proxy for $F_{MSY,}$ and target fishing mortality rates should be set less than F_{MSY} or the proxy. However, the current threshold for ocean quahog $F_{25\%}$=0.042 y^{-1} exceeds conventional F_{MSY} proxies like $F_{0.1}$=0.022 y^{-1} and M =0.02 y^{-1} and the current fishing mortality target $F_{0.1}$=0.022 y^{-1} equals or exceeds the conventional proxies for F_{MSY}.

Results from this assessment suggest that current catch levels are about the same as MSY for the exploited region of the stock. KLAMZ model estimates suggest that virgin biomass is 2 million mt of meats for the whole stock and 1.3 million mt for the stock less Georges Bank. Based on these estimates, the biomass target (a proxy for B_{MSY}) would be one-half the virgin level or 1 million mt for the whole stock and 0.65 million mt for the whole stock less GBK. Assuming $F_{MSY}=F_{0.1}$=0.022 y^{-1}, the MSY catch level would be 22 thousand mt y^{-1} for the whole stock and 14 thousand mt y^{-1} for the whole stock less GBK. These MSY estimates are near catch levels during the last five years (17-21 thousand mt y^{-1}, Table C1).

SARC COMMENTS

- Ocean quahog resources in deep-water strata on GBK should be sampled in future NEFSC clam surveys. It is not necessary to resample mud patch areas in the future.

- The "Patch Model" was an improvement from the Leslie-Davis model. However, both models are limited because of a lack of understanding of dredge position and ocean quahog distribution in the sediment.

- The SARC questioned the costs vs. benefits of more depletion experiments for improving swept area biomass estimates. It was decided that more experiments are warranted to understand differences in efficiency from year to year. Dredge efficiency estimates for 1997 and 1999 are the greatest cause of uncertainty in estimates of ocean quahog stock size.

- The KLAMZ model presented to the SARC was accepted after discussions about incorporating landings prior to 1978 and sensitivity runs. The SARC questioned if non-catch mortality is really zero, if estimates of recruitment are a consequence of assumptions of M, and if recruitment is constant.

- Results from the KLAMZ model suggest there has been little or no surplus production by ocean quahogs since 1980, consistent with a stock near carrying capacity.

- Alternative proxies for F_{MSY} and B_{MSY} should be considered given the low productivity, longevity and growth rate of this species.

- Regional estimates of biomass are useful to managers even though the quota is set for the entire stock.

- Analyses should investigate the time it will take for areas that have been heavily fished to return to high biomass levels and what catch rates are not profitable under current economic conditions.

- The recent assessment, industry observations and survey data provide new information about recruitment in ocean quahog. It appears that average annual recruitment (roughly 2% of virgin biomass since 1978) and growth can sustain a fishery. This is a major change in the scientific view of the resource which, originally, was viewed as a non-renewable "mining" operation.

RESEARCH RECOMMENDATIONS

- Determine distribution and movement of ocean quahogs in sediments. Experiments could be conducted at sea and in the lab.

- Depletion experiments to estimate the NMFS clam dredge efficiency should be carried out beyond the Long Island region and in different habitats. These experiments might be improved by more accurate estimates of dredge location while dredge is being

- Sustainable yield of ocean quahogs will depend on their response in recruitment and growth to exploitation. Field studies should be undertaken to determine if recruitment and growth rates have increased in areas that have been most heavily fished.

- To determine the extent of the ocean quahog resource in the south, NEFSC should survey deep-water strata off of NJ.

- Non-catch mortality should be evaluated through literature searches and experiments.

- The NMFS logbook database (called "SfyyVR") provides a consistent source of information about the commercial clam fishery. The other source of clam fishery data (CFDETT and CFDETS tables) needs to be corrected, especially for 1994 to present.

- The KLAMZ model might also incorporate length frequency results from survey data.

- There is little information regarding F_{MSY} and B_{MSY} or suitable proxies for long lived species like ocean quahog. Traditional proxies (e.g., $F_{MSY} = M$, $F_{MSY} = F_{0.1}$, and B_{MSY} at one-half virgin biomass) may be inappropriate for long lived organisms. The question of F_{MSY} and B_{MSY} proxies should be considered.

REFERENCES

Beauchamp, J., and J. Olson. 1973. Corrections for bias in regression estimates after logarithmic transformation. Ecology 54: 1403-1407.

Dahlgren, T, J. Weinberg, and K. Halanych. Phylogeography of the ocean quahog (*Arctica islandica*). Mar. Bio. (In press).

Bergman M. and J. van Santbrink. 2000. Fishing mortality of populations of megafauna in sandy sediments. Chapter 4. In: The Effects of Fishing on Non-target Species and Habitats. Biological, Conservation and Socio-economic Issues. Eds: Kaiser, M. and S. de Groot. Blackwell Science, Ltd., London.

Butler, J. L., L. D. Jacobson and J.T. Barnes. 1998. Stock assessment of blackgill rockfish. In: Pacific Fishery Management Council. 1998. Appendix: Status of the Pacific Coast Groundfish Fishery through 1998 and recommended biological catches for 1999: Stock assessment and fishery evaluation. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon, 97201.

Butler, J. L., L. D. Jacobson, J.T. Barnes, H.G. Moser, and R. Collins. 1999. Stock assessment of cowcod. In: Pacific Fishery Management Council. 1998. Appendix: Status of the Pacific Coast Groundfish Fishery through 1999 and recommended biological catches for 2000: Stock assessment and fishery evaluation. Pacific Fishery Management Council, 2130 SW Fifth Avenue, Suite 224, Portland, Oregon, 97201.

DOC (Department of Commerce). 1997. Magnuson-Stevens Act provisions; National Standard guidelines; final rule. Part II. Fed. Reg. 24211-24237.

Efron, B. 1982. The jackknife, the bootstrap and other resampling plans. Soc. Indust. Appl. Math., Philadelphia, PA. 92p.

Fritz, L. 1991. Seasonal change, morphometrics, growth and sex ratio of the ocean quahog, *Arctica islandica* (Linneaus, 1767) off New Jersey, U.S.A. J. Shellf. Res. 10(1): 79-88.

Gould, W. R. and K. H. Pollock. 1997. Catch-effort maximum likelihood estimation of important population parameters. Can. J. Fish. Aquat. Sci. 54: 890-897.

Hilborn R. and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall. NY.

Jacobson, L.D., N.C.H. Lo and J.T. Barnes. 1994. A biomass based assessment model for northern anchovy, *Engraulis mordax*. Fish. Bull., U.S. 92:711-724.

Jones, D. S. 1983. Sclerochronolgy: Reading the record of the molluscan shell. Amer. Scient. 71: 384-391.

Kimura, D. K. 1985. Changes to stock reduction analysis indicated by Schnute's general theory. Can. J. Fish. Aquat. Sci. 42: 2059-2060.

Kimura, D. K, J. W. Balsiger, and D. H. Ito. 1984. Generalized stock reduction analyses. Can. J. Fish. Aquat. Sci. 41: 1325-1333.

Kimura, D. K., and J. V. Tagart. 1982. Stock reduction analysis, another solution to the catch equations. Can. J. Fish. Aquat. Sci. 39: 1467-1472.

Leslie, P. H. and D. H. S. Davis. 1939. An attempt to determine the absolute number of rats on a given area. Journal of Animal Ecology. 8:94-113.

Lewis, C. 1997. Biological-physical interactions on Georges Bank: plankton transport and population dynamics of the ocean quahogs, *Arctica islandica.* Ph.D. dissertation. MIT/WHOI 97-19, 207 pp.

Lewis, C. , J. Weinberg, and C. Davis. In prep. Population structure and recruitment of *Arctica islandica* (Bivalvia) on Georges Bank from 1980-1999.

MacCullagh, P., and J.A. Nelder. 1983. Generalized linear models. Chapman and Hall, New York, 511p.

MAFMC (Mid-Atlantic Fishery Management Council). 1998. Amendment 12 to the Atlantic surfclam and ocean quahog fishery management plan. Mid-Atlantic Fishery Management Council. Dover, DE. 254 p.

Mendenhall, W., L. Ott, and R.L. Scheaffer. 1971. Elementary Survey Sampling. Duxbury Press. 247 pp.

Merrill, A. S. and J. W. Ropes 1969. The general distribution of the surf clam and the ocean quahog. Proc. Nat, Shellfish. Assoc. 59: 40-45.

Mittertreiner, A., and J. Schnute. 1985. Simplex: a manual and software package for easy nonlinear parameter estimation and interpretation in fishery research. Can. Tech. Rep. Fish. Aquat. Sci. 1384: 90p.

Murawski SA, Serchuk FM (1989) Mechanized shellfish harvesting and its management: the offshore clam fishery of the eastern United States. In: Caddy JF (ed.) Marine Invertebrate Fisheries: Their Assessment and Management. Wiley, New York, pp 479-506.

Murawski, S.A. and F.M. Serchuk. 1979. Shell length - meat weight relationships of ocean quahogs, *Arctica islandica*, from the middle Atlantic shelf. Nat. Shellf. Assoc. 69: 40-46.

Murawski, S.A. J.W. Ropes, and F.M. Serchuk. 1982. Growth of the ocean quahog, *Arctica islandica*, in the middle Atlantic Bight. Fish. Bull. 80: 21-34.

Myer T.L., R. A. Cooper, and K. J. Pecci (1981) The performance and environmental effects of a hydraulic clam dredge. Marine Fisheries Rev. 43(9): 14-22.

NEFSC (Northeast Fisheries Science Center). (1995) Report of the 19th Northeast Regional Stock Assessment Workshop (19th SAW). D. Ocean quahog assessment. pp 177-199. NEFSC Ref. Doc. 95-08.

NEFSC (Northeast Fisheries Science Center). (1996a) 22nd Northeast Regional Stock Assessment Workshop (22th SAW). D. Surfclam and Ocean quahog. pp 173-242. NEFSC Ref. Doc. 96-13.

NEFSC (Northeast Fisheries Science Center). (1996b) 22nd Northeast Regional Stock Assessment Workshop (22th SAW), Public Review Workshop. D. Surfclam and Ocean Quahog Advisory Report. pp 33-37. NEFSC Ref. Doc. 96-16.

NEFSC (Northeast Fisheries Science Center). (1998a) 27th Northeast Regional Stock Assessment Workshop (27th SAW). Concensus summary of assessments. E. Ocean Quahogs. pp 171-244. NEFSC Ref. Doc. 98-15.

NEFSC (Northeast Fisheries Science Center). (1998b) 27th Northeast Regional Stock Assessment Workshop (27th SAW). Advisory Report on Stock Status. E. Ocean Quahogs. pp 26-36. NEFSC Ref. Doc. 98-14.

NEFSC (Northeast Fisheries Science Center). (1998c) 26th Northeast Regional Stock Assessment Workshop (26th SAW). B. Surfclam assessment. pp 51-169. NEFSC Ref. Doc. 98-03.

NEFSC (Northeast Fisheries Science Center). 2000. 30th Northeast Regional Stock Assessment Workshop (30th SAW). E. Surfclams. pp 311-477. NEFSC Ref. Doc. 00-03.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Fisheries Res. Brd. Canada. Bull. No. 191.

Ropes JW, Shepherd GR (1988) Age determination methods for northwest Atlantic species. USDOC. NOAA Tech. Rept. NMFS 72

Ropes, J.W., S.A. Murawski, and F.M. Serchuk. 1984. Size, age, sexual maturity, and sex ratio in ocean quahogs, *Arctica islandica* Linne, off Long Island, New York. Fish. Bull 82: 253-267.

Schnute, J. 1985. A general theory for analysis of catch and effort data. Can. J. Fish. Aquat. Sci. 42: 414-429.

Seber, G. A. F. 1973. The estimation of animal abundance and related parameters. Hafner Press, NY. 506 PP.

Serchuk, F.M. and S. Murawski. 1980. Assessment and status of surf clam *Spisula solidissima* (Dillwyn) populations in offshore middle Atlantic waters of the United States. US DOC/NMFS. Lab. Ref. Doc. 80-33.

Serchuk F. and S. Murawski 1997. The offshore molluscan resources of the Northeastern Coast of the United States: surfclams, ocean quahogs, and sea scallops, p. 45-62. IN: C.L. MacKenzie, Jr., V.G. Burrell, Jr., A. Rosenfield and W.L. Hobart (Eds). The History, Present Condition, and Future of the Molluscan Fisheries of North and Central America and Europe, Volume 1, Atlantic and Gulf Coasts. U.S. Dep. Commer., NOAA Tech. Rep. 127, 234 p.

Sims, S.E. 1982. Algorithms for solving the catch equation forward and backward in time. Can. J. Fish. Aquat. Sci. 39: 197-202.

Smolowitz, R. J. and V. E. Nulk. 1982. The design of an electrohydraulic dredge for clam surveys. Marine Fisheries Rev. 44(4):1-18.

Steingrimsson S.A. and G.Thorarinsdóttir. 1995. Age structure, growth and size at sexual maturity in ocean quahog *Arctica islandica* (Mollusca: Bivalvia), off NW - Iceland. ICES CM 1995/K:54.

Stuart, A., and J.K. Ord. 1991. Kendall's advanced theory of statistics, vol. 2. Oxford Univ. Press, New York, NY. 1323 p.

Theroux R. B. and R. L. Wigley 1983. Distribution and abundance of east coast bivalve mollusks based on specimens in the National Marine fisheries Service Woods Hole collection. U.S. NOAA Tech. Rep. NMFS SSRF768: 172p.

Thompson, I., D.S. Jones, and D. Dreibelbis. 1980a. Annual internal growth banding and life history of the ocean quahog *Arctica islandica* (Mollusca: Bivalvia). Mar. Biol. 57: 25-34.

Thompson, I., D.S. Jones, and J.W. Ropes. 1980b. Advanced age for sexual maturity in the ocean quahog *Arctica islandica* (Mollusca: Bivalvia). Mar. Biol. 57: 35-39.

Thorarinsdóttir, G.G. and S. Tr. Einarsson 1996. Distribution, abundance, population structure and meat yield of the ocean quahog, *Arctica islandica* in Icelandic waters. J. mar. biol Assoc. U. K. 76: 1107-1114.

Venzon, D. J. and S. H. Moolgavkor. 1988 A method of computing profile likelihood-based confidence intervals Appl. Stat. 37:87-94.

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APPENDIX A.

Cruise Results, Ocean Quahog Depletion Studies
March 8 and May 11, 2000, Long Island Coast

Depletion Experiment John N #1
(set up tows: Q99- DE-II)

Exp. 1.
Location: Long Island
F/V John N

Date, Time: 3/8/00 0900-1700 hrs.
Seas 2-3 feet, wind direction: ____ approx. _____ kn, skies: sun

Captain: Steve Novack
Owner: Warren Alexander

Science Personnel:

E. Powell	Rutgers
Sarah Banta	Rutgers
B. McCay	Rutgers
R. Mann	VIMS

Location of Experiment:
LAT: 40° 36.13'
LONG: 71° 59.25'

Water Depth: 58 m,
Knife Blade Width = 150 inches

Operations: 22 dredge tows completed. A total of 5 length frequency samples were obtained.

Depletion Experiment John N #2
(set up tows: Q99- 2)

Exp. 2.
Location: Long Island
F/V John N

Date, Time: 3/8/00 2000-2400 hrs.
Seas 2-3 feet,
wind direction: ____ approx. _____ kn, skies: clear

Captain: Steve Novack
Owner: Warren Alexander

Science Personnel:

E. Powell	Rutgers
Sarah Banta	Rutgers
B. McCay	Rutgers
R. Mann	VIMS

Location of Experiment:
LAT: 40° 23.67'
LONG: 72° 32.58'

Water Depth: 48 m,
Knife Blade Width = 150 inches

Operations:17 dredge tows completed. A total of 3 length frequency samples were obtained.

Depletion Experiment Danielle Maria #1
(set up tows: Q99- 1)

Exp. 3.
Location: Long Island
F/V Danielle Maria

Date, Time: 5/11/00 1900-2400 hrs.
Seas 2-4 feet, wind direction: NW, approx:.
_____ kn, skies: cloudy

Captain: Joel Stevenson
Owner: Cape May Foods, LaMonica

Science Personnel:

E. Powell	Rutgers
Sarah Banta	Rutgers
B. McCay	Rutgers
R. Mann	VIMS

Location of Experiment:
LAT: 40° 34.98'
LONG: 72° 47.81'

Water Depth: 40 m,
Knife Blade Width = 120 inches

Operations: 27 dredge tows completed.
A total of 6 length frequency samples were obtained.

Table C1. Annual landings of ocean quahog (metric tons, meats) from state waters and the Exclusive Economic Zone, and annual quotas.

Year	State Water	EEZ	Total	Percent EEZ	EEZ Quota
1967[1]	20	-	20	0	
1968	102		102	0	
1969	290		290	0	
1970	792		792	0	
1971	921		921	0	
1972	634		634	0	
1973	661		661	0	
1974	365		365	0	
1975	569	-	569	0	
1976	656	1,854	2,510	74	
1977	1,118	7,293	8,411	87	-
1978	1,218	9,197	10,415	88	13,608
1979	1,404	14,344	15,748	91	13,608
1980[2]	-	13,407	11,623	-	15,876
1981	-	13,101	11,202	-	18,144
1982	2,244	14,234	16,478	86	18,144
1983	1,614	14,586	16,200	90	18,144
1984	-	17,974	17,939	100	18,144
1985	1,309	20,726	22,035	94	19,958
1986	1,683	18,902	20,585	92	27,215
1987	1,204	21,514	22,718	95	27,215
1988	734	20,273	21,006	96	27,215
1989	787	22,359	23,146	97	23,587
1990	268	20,966	21,234	99	24,040
1991	-	22,119	22,118	100	24,040
1992	357	22,514	22,871	98	24,040
1993	2,933	21,909	24,843	88	24,494
1994	140	21,017	21,158	99	24,494
1995	2,087	21,166	23,252	91	22,226
1996	990	20,132	21,122	95	20,185
1997	190	19,739	19,929	99	19,581
1998	90	18,007	18,097	100	18,140
1999	-	17,388	-	-	20,411

[1] Values from 1967-1979 are from NEFSC 90-07.

[2] For 1980-1999, "totals" are from the CFDETS database, EEZ landings are from logbooks (SFyyVR), and state landings are by taking the difference. Values assume 1 bushel=4.5359 kg of meats. An additional quota of 100,000 Maine bushels began in 1999.

'able C2. Ocean quahog landings in weight (calculated from number of bushels reported in logbooks) for the US EEZ, by stock assessment region. GBK not shown becau: landings and fishing effort were zero.

YEAR	SVA	DMV	NJ	LI	SNE	Row Totals
1980	0	4,230	7,750	6	0	11,986
1981	56	3,637	8,402	3	0	12,097
1982	6	4,598	8,538	0	0	13,142
1983	0	5,396	8,249	21	629	14,294
1984	6	7,164	8,858	0	822	16,849
1985	160	7,200	10,679	40	693	18,773
1986	0	8,231	9,061	396	562	18,249
1987	0	10,540	9,070	1,180	696	21,487
1988	42	11,715	7,014	640	841	20,253
1989	0	6,439	14,100	605	1,196	22,339
1990	14	3,691	15,583	739	934	20,962
1991	0	4,839	14,575	1,674	865	21,953
1992	0	2,378	6,942	11,939	1,143	22,401
1993	0	1,975	10,172	8,652	1,020	21,819
1994	0	992	6,970	11,983	954	20,899
1995	0	699	5,356	9,464	5,443	20,962
1996	0	736	4,864	5,905	8,319	19,825
1997	0	1,072	4,249	5,130	8,958	19,409
1998	0	1,365	2,664	6,570	6,433	17,032
1999	0	1,072	3,048	6,335	6,609	17,064

Table C3. Nominal fishing effort (hours fished) for ocean quahog in the US EEZ, by stock assessment region.from logbooks. GBK not shown because landings and fishing effort were zero.

YEAR	SVA	DMV	NJ	LI	SNE	Total
1980	0	6,942	16,039	32	0	23,014
1981	73	5,864	15,949	6	0	21,892
1982	7	7,241	14,737	0	0	21,985
1983	3,495	23,095	33,735	497	2,502	63,324
1984	2,351	19,434	34,499	24	3,657	59,965
1985	556	14,196	27,143	87	3,559	45,541
1986	223	13,984	24,785	397	3,587	42,975
1987	262	16,589	26,731	812	5,110	49,503
1988	386	19,861	24,898	615	6,990	52,750
1989	228	13,738	36,099	797	7,159	58,021
1990	1,175	10,258	42,018	1,283	4,870	59,603
1991	0	12,065	30,476	1,899	1,433	45,874
1992	0	5,513	16,150	13,501	1,976	37,141
1993	0	4,731	25,737	13,043	1,783	45,295
1994	0	2,260	20,674	19,282	2,088	44,303
1995	0	1,621	13,598	16,011	8,601	39,830
1996	0	2,450	9,382	10,206	11,843	33,882
1997	0	2,742	9,426	8,295	13,550	34,014
1998	0	3,225	6,960	10,171	10,289	30,646
1999	0	2,543	7,583	9,160	12,266	31,552

Table C4. Commercial catch rates (LPUE, bushels per hour fished) for ocean quahog from logbook data. "Nominal" LPUE values were computed for each stock assessment region as total landings divided by total hours fished during a single year. DMV-"Experimental GLM" values were computed as weighted means of estimates for four effort areas in each stock assessment region during each year, estimated based on GLM results. LPUE values from GLM models were scaled to units of LPUE for the largest vessel size (tonclass 3) operating in January. Results for a traditional GLM analysis were similar to nominal and experimental LPUE values. No GLM models were fit to data for the SVA stock assessment area because data were sparse. Nominal LPUE values for MNE were rescaled (multiplied by 24) to facilitate comparison with GLM values.

Year	SVA-Nominal	DMV-Nominal	DMV-Experimental GLM	CV	LI-Nominal	LI-Experimental GLM	CV	MNE-Nominal	MNE-Experimental GLM	CV	NJ-Nominal	NJ-Experimental GLM	CV	SNE-Nominal	SNE-Experimental GLM	CV
1980		119	115	0.23	37						95	93	0.08			
1981	125	123	116	0.23	111						104	95	0.09			
1982	163	126	121	0.29							115	99	0.08			
1983		146			83						117			79		
1984	81	126	119	0.25	0						112	99	0.10	65		
1985	158	139	135	0.27	93						117	109	0.14	67		
1986		131	131	0.23	220						123	111	0.20	99		
1987		131	126	0.19	291						118	111	0.15	103		
1988	131	120	116	0.22	189						118	119	0.47	101	95	0.29
1989	6	104	102	0.17	152						114			98		
1990	108	89			115						105	102	0.10	100		
1991		80			173	122	0.43	48	54	1.56	95	90	0.09	119		
1992		85			174	146	0.15	44	54	1.48	84	80	0.09	114		
1993		83	85	0.17	133	132	0.16	90	133	5.33	79	76	0.06	114		
1994		88	81	0.20	123	114	0.10	119	108	2.76	67	67	0.09	91		
1995		86	87	0.31	118	113	0.08	235			79	76	0.08	126	108	0.16
1996		97			116	112	0.10	158			104	100	0.14	140	140	0.14
1997		78			123	115	0.10	165			90	87	0.09	132	127	0.1
1998		85	89	0.36	129	122	0.10	152			76	83	0.09	125	116	0.14
1999		84			138	124	0.08	219			80	88	0.09	108	92	

Table C5 . Summary statistics on ocean quahog commercial length frequency data by year/area. Data were collected by port agents taking random samples from catches.

Area/Year	Mean Length (mm)[1]	Min L	Max L	Number of Measured Clams[2]
Delmarva				
1982[3]	85.0	65	115	2611
1983	87.0	65	115	1716
1984	85.2	65	125	3116
1985	-	-	-	-
1986	-	-	-	-
1987	90.2	65	115	900
1988	90.1	55	115	780
1989	89.3	75	115	899
1990	92.4	75	125	900
1991	91.4	35	117	3331
1992	92.9	66	118	1668
1993	91.6	64	115	850
1994	92.5	65	115	120
1995	84.8	65	105	420
1996	84.0	65	115	635
1997	84.6	55	105	570
1998	86.9	65	125	480
1999	83.0	65	115	810
New Jersey				
1982	92.6	65	125	779
1983	93.9	75	115	1980
1984	-	-	-	-
1985	94.5	65	125	900
1986	94.5	75	125	870
1987	94.2	65	115	900
1988	92.6	65	115	933
1989	94.3	65	115	900
1990	95.5	55	115	870
1991	95.5	65	117	658
1992	90.4	77	108	90
1993	94.8	78	112	300
1994	96.9	85	115	90
1995	-	-	-	-
1996	92.0	75	105	60
1997	93.9	65	115	540
1998	88.4	45	115	240
1999	95.4	75	125	270
Long Island				
1992	87.3	70	98	30
1993	-	-	-	-
1994	89.7	75	105	30
1995	-	-	-	0
1996	83.1	65	105	79
1997	89.0	55	135	840
1998	89.9	55	125	660
1999	93.1	65	125	900
S. New England				
1988	89.1	65	105	150
1989	87.3	75	115	240
1990	91.8	75	105	120
1991	90.5	70	109	121
1992	86.4	70	105	150
1993	85.3	72	99	30
1994	-	-	-	-
1995	-	-	-	-
1996	86.7	65	115	356
1997	78.7	55	105	310
1998	78.7	55	125	630
1999	86.5	55	115	244

[1] Mean Length is the expected value from the length frequency distribution, using size classes of 1 cm. Length frequency distributions were derived by weighting trips by their respective catches.
[2] Typically, 30 clams are measured per trip. The minimum and maximum lengths of measured clams are reported.
[3] Values for 1982-1983 are from NEFSC LDR 83-25. Values from 1985-1990 and 1994 are from subsamples of the data. Subsamples contain data from 30 randomly selected trips, when available.

Table C6. Ratio of Ocean Quahog catch from repeated survey stations in 2 years: 199
and 1997. Variance was computed following Mendenhall et al. (1971).
Individuals >=70 mm were included in the analysis. All stations from GBK.

	x	y
Station	**NUMLEN99**	**NUMLEN97**
1	1130.14	615.5
2	238.24	239.8
3	72.99	51.5
4	716.31	482.49
5	911.91	1174.54
6	81.1	205.5
7	221.4	188.5
8	15.37	51.48
9	10.53	245.18
10	3.56	3.61
11	88.91	433.62
12	443.45	624.23
	327.8258333	359.6625
ratio	0.911	
var(ratio)	0.479	
sd	0.692	
CV	0.760	

Table C7. Ratio of Ocean quahog catch, weighted by area, from random survey stations in 2 years; 1999, 1997. Variance was computed following Mendenhall et al. (1971).

All Regions					
	x	y			
Region	B/tow 1999	B/tow 1997	Area (nmi^2)	Wtd 1999	Wtd 1997
GBK	3.785	3.169	7304	27,646	23,146
SNE	3.312	2.473	4922	16,302	12,172
LI	3.29	5.073	4463	14,683	22,641
NJ	1.065	1.913	6510	6,933	12,454
DMV	0.496	0.726	4071	2,019	2,956
mean				13,517	14,674
		ratio	0.921		
		var(ratio)	0.184		
		sd(ratio)	0.429		
		CV	0.466		
LI, NJ,DMV only					
	x	y			
Region	B/tow 1999	B/tow 1997	Area (nmi^2)	Wtd 1999	Wtd 1997
LI	3.29	5.073	4463	14,683	22,641
NJ	1.065	1.913	6510	6,933	12,454
DMV	0.496	0.726	4071	2,019	2,956
mean				7,879	12,683
		ratio	0.621		
		var(ratio)	2.030		
		sd(ratio)	1.425		
		CV	2.294		
GBK, SNE only					
	x	y			
Region	B/tow 1999	B/tow 1997	Area (nmi^2)	Wtd 1999	Wtd 1997
GBK	3.785	3.169	7304	27,646	23,146
SNE	3.312	2.473	4922	16,302	12,172
mean				21,974	17,659
		ratio	1.244		
		var(ratio)	0.399		
		sd(ratio)	0.631		
		CV	0.507		

varratio.xls Oqsurvey stations 9799

Table C8. Sources of information, other than Depletion Experiments, about dredge efficiency (E) for the Delaware-II (DE-II) in 1999. "Ratio" = comparison of survey biomass per tow in 2 different years. Formula for the Variance and CV of the ratio was from Mendenhall et al. 91971). "Patch" = Rago Patch model. "LD" = Leslie Davis model, Linear Regression.

Year	Source			Region	E of DE-II	B Ratio ('99/'97)	CV of B Ratio	Notes
	Previous Studies							
1997	Upper bound for DE-II from Commer Dredges for Ocean quahogs		SARC-27	LI, NJ, SNE	0.43			No DE-II O Q exps.
1997	Upper bound for DE-II Efficiency for Surfclams		SARC-26	All	0.59	-		LD model; Surfclam data
1999	DE-II Efficiency for Surfclams		SARC-30	All	0.276	--		Patch model; Surfclam data
	Repeated Stations							
1999: 1997	DE-II			GBK		0.911	0.76	Repeated stations (give D99/D97=0.911 in OQ numbers)
	Random Stations - Ratios							
1999: 1997	DE-II (North; Random)	Survey Biomass 1999/Survey 1997		GBK+SNE		1.244	0.507	OQ result; B weighted by regional area
1999: 1997	DE-II (North; average Random and Repeated ests.)			GBK+SNE	--	1.078		Aver. of .911, 1.244
1999: 1997	DE-II (South Rand. Sta.)	Survey 99/Survey 97 (South biomass)		LI+NJ+DMV	--	0.621	2.294	OQ result; B weighted by regional area
1999: 1997	DE-II (North & South Rand. Sta.)	Survey 99/Survey 97 (All biomass)		All		0.921	0.466	OQ result; B weighted by regional area
1999: 1997	DE-II (South Rand. Sta.)		SARC-30	DMV+SNJ+NNJ+LI	--	0.598	--	Surfclams (SARC-30)

Table C9. Depletion experiments by commercial clamming vessels.

Count	Species	Year	Month	Location	Lat	Lon	Depth (m)	Exp.(Setup Name)	F/V	Blade Width (in)	Total Tows (#)
1	SC	1997	June	NJ	40 3.19	73 50.35	26	PP	Sherri Ann	100	40
2	SC	1997	June	NJ	39 23.59	73 54.62	30	AC2-1	Jersey Girl	130	13
3	SC	1997	June	NJ	39 23.59	73 54.62	30	AC2-2	Jersey Girl	130	18
4	SC	1997	June	NJ	39 21.9	73 53.9	30	AC1-1	Judy Marie	100	17
5	SC	1997	June	NJ	39 21.9	73 53.9	30	AC1-2	Judy Marie	100	19
1	SC	1999	Sept.	DMV	36 54.12	74 58.55	35	CH-1 (S99-DE II)	Christy	130	28
2	SC	1999	Sept.	NJ	39 40.88	73 44.80	24	JG-1 (S99-5)	Jersey Girl	130	4
3	SC	1999	Sept.	NJ	39 40.88	73 44.80	24	JG-2 (S99-5)	Jersey Girl	130	5
4	SC	1999	Sept.	NJ	39 31.28	73 46.72	26	JG-3 (S99-6)	Jersey Girl	130	6
5	SC	1999	Sept.	NJ	39 33.8	73 54.7	26	MJ-1 (S99-3)	Melissa J	130	4
6	SC	1999	Sept.	NJ	39 46.08	73 54.98	24	MJ-2 (S99-4)	Melissa J	130	10
1	OQ	1997	July	LI	40 16.17	72 17.91	59	SH-1	Laura Ann	93	32
2	OQ	1998	March	LI	40 43.32	72 0.45	44	SH-2	Cape Fear	120	23
3	OQ	1998	March	LI	40 45.99	72 10.77	40	SH-3	Cape Fear	120	14
4	OQ	1997	Aug	NJ	38 30.57	74 6.69	48	WW-1	Agitator	120	32
5	OQ	1998	April	Nantucket	40 28.02	69 28.98	62	NS-1	Cape Fear	120	24
1	OQ	2000	March	LI	40 36.13	71 59.25	58	JN-1 (Q99-DE II)	John N	150	22
2	OQ	2000	March	LI	40 23.67	72 32.58	48	JN-2 (Q99-2)	John N	150	17
3	OQ	2000	May	LI	40 34.98	72 47.81	40	DM-1 (Q99-1)	Danielle Maria	120	27

~/sarc/sarc31/work/2000eff_comparisons.xls (sheet: Summary1)

Table C10. Efficiency estimates for the Delaware II (DE-II) survey dredge catching Atlantic surfclams. D = density from depletion model, E = Efficiency. Surfclam experiments were carried out in 1997 and 1999. Methods: "Depletion" = depletion experiment. "Patch" = Rago Patch model with gamma = 0.75 and cell size = 2 dredge width. "LD = Leslie Davis model, Linear Regression. "Setup Tows" = DE-II made baseline tows before an F/V depleted the area. "F/V" = commercial fishing vessel.

		Surfclam Fieldwork:		1997			1999		
		Data reanalyzed May 2000 for SARC-31				Original Values from SARC-30 (12/99)			
Label	Method	Region	E of DE-II	E of F/V	D (ft^2)	Region	E of DE-II	E of F/V	Notes
Depletion Exp. - Direct methods									
DE-II	Depletion (Patch)	NNJ	0.727	--		DMV	*0.148*		(SARC-30, Patch Model)
	Depletion (LD)	NNJ	0.607	--	0.077	DMV	--		
Depletion Exp. - Indirect methods									
PP1a	Set up tows (Patch)	NJ	0.277	0.393	0.163				
	Set up tows (LD)			0.435	0.149				
AC21	Set up tows (Patch)	NJ	0.336	0.950	0.050				
	Set up tows (LD)			1.161	0.056				
AC22	Set up tows (Patch)	NJ	0.244	0.800	0.069				
	Set up tows (LD)			0.986	0.073				
Average AC2		NJ	0.290						
AC11a	Set up tows (Patch)	NJ	0.573	0.659	0.044				
	Set up tows (LD)			0.981	0.037				
AC12a	Set up tows (Patch)	NJ	0.514	0.606	0.049				
	Set up tows (LD)			0.701	0.070				
Average AC1		NJ	0.544		--				
SARC-30	Indirect (set-up tows)								
F/V Christy						DMV	0.0844	0.431	from SARC-30
Jersey Girl 1&2						NJ	0.3492	0.9	from SARC-30
Jersey Girl 3						NJ	0.3696	0.9	from SARC-30
Melissa 1						NJ	0.2456	0.874	from SARC-30
Melissa 2						NJ	0.0916	0.733	from SARC-30
						NJ, DMV	0.246		SARC-30 (median, 5 exps above).
SARC-30 Christie cross-check						DMV	0.243		SARC-30
Repeated Stations									
SARC-30 Repeat station						DMV	0.389		SARC-30
Random Stations - '99/'97 Ratios									
SARC-30 Ratio surveys						Various	0.353		SARC-30
SARC-30 Grand mean						Various	0.276		SARC-30 (Grand mean)

efficienct1jw.xls Surfclam (rev6-1-00)

Table C11. Patch model results for ocean quahog experiments in 1999 and 2000. Summary of indirect estimates of dredge efficiency for R/V Delaware II through comparisons with commercial fishing vessels from depletion experiments. The first 6 tows of the DE II Ocean quahog Depletion Exp. were treated as setup tows for comparison with the F/V John N at its Exp. 1.

Gamma = 0.75 — Relative Catch Rates by DE II at depletion Exp Site

	Direct Experiment Results			Var(rel Density)			Setup Tow Number							Indirect Efficiency Est for DE II in 1999
Experiment	Tows	Density (#/ft^2)	Efficiency	Rel Density	SD(rel Density)	Response Var	1	2	3	4	5	6	mean	
DE II--Ocean Quahog	60	0.306	0.471											
F/V John N #1	22	0.413	0.950	0.168868	0.000964	catch (raw no.):	880	838	1290	1213	957	729	984.5	0.409
(where DE-II depleted, Q99-DE II)					0.031043	area swept (ft^2):	5040	5874	6152	6045	5998	5871	5830	
F/V John N #2	16	0.095	0.922	0.053822	0.000423	catch (raw no.):	652	344	256				417.3	0.567
(Q99-2)					0.020569	area swept (ft^2):	7993	7792	7477				7754	
F/V Danielle M.	16	0.180	0.735	0.053228	0.000680	catch (raw no.):	502	247	296	277	120	140	263.7	0.296
(Q99-1)					0.026071	area swept (ft^2):	5274	5047	4484	4372	5064	5480	4954	

Table C12. Efficiency estimates for Commercial clam dredges catching Ocean Quahogs (OQ). D= OQ density (ft^2), E=Efficiency. Methods: "Depletion" = depletion experiment "Patch" = Rago Patch model with gamma = 0.75 and cell size = 2 dredge widths. "LD" = Leslie Davis model, Linear Regression. "Minimum Density" = observed catch/area sampled at least once.

Year	Label	Method	Region	E of F/V	D (ft^2) from F/V	D (ft^2) from DE-II
	Depletion Exps. - Direct methods					
1997	SH1a	Depletion (Patch)	LI	0.488	0.44	--
		Depletion (LD)		0.807	0.31	
		Minimum Density			0.228	--
		Average		**0.648**		--
1998	SH2a	Depletion (Patch)	LI	0.401	0.242	
		Depletion (LD)		0.562	0.213	
		Minimum Density			0.15	--
		Average		**0.482**		--
1998	SH3a	Depletion (Patch)	LI	0.950	0.105	
		Depletion (LD)		1.167	0.129	
		Minimum Density			0.112	--
		Average		**1.059**		--
1997	WW1a	Depletion (Patch)	NJ	0.256	0.06	--
		Depletion (LD)		0.235	0.058	--
		Minimum Density			0.021	--
		Average		**0.246**		--
1998	NS1	Depletion (Patch)	SNE	0.950	0.57	--
		Depletion (LD)		0.531	1.095	--
		Minimum Density			0.558	--
		Average		**0.741**		
		Mean of 1997-98 =		**0.593**		
2000	JN1	Depletion (Patch)	LI	0.950	0.413	
		Depletion (LD)		0.563	0.743	0.169
		Minimum Density			0.414	
		Average		0.757	0.578	
2000	JN2	Depletion (Patch)	LI	0.922	0.095	
		Depletion (LD)		0.729	0.172	0.054
		Minimum Density			0.105	
		Average		0.826	0.134	
2000	DM1	Depletion (Patch)	LI	0.734	0.180	
		Depletion (LD)		0.571	0.265	
		Minimum Density			0.138	
		Average		**0.653**	**0.223**	0.053
		Mean of 2000 =		**0.648**		
		Grand Mean =		**0.620**		

efficienct1jw.xls Quahog DEII(rev6-1-00)

Table C13. Efficiency estimates for the Delaware II (DE-II) survey dredge catching Ocean Quahogs (OQ). D= OQ density (ft^2), E=Efficiency. Methods: "Depletion" = depletion experiment. "Patch" = Rago Patch model with gamma = 0.75 and cell size = 2 dredge widths. "LD" = Leslie Davis model, Linear Regression. "Setup Tows" = DE-II made baseline tows before an F/V depleted the area. "Density Ratio" = both the DE-II and an F/V did depletions in close proximity.

Year	Label	Method	Region	E of DE-II	CV of E	D	Notes
	Depletion Exp. - Direct methods						
1999	DE-II	Depletion (Patch)	LI	0.470	--	0.306	
		Depletion (LD)	LI	0.668	--	0.264	
	Average		LI	**0.569**	--	0.285	
	Depletion Exp. - Indirect methods						
2000	JN1	Setup Tows (LD)	LI	**0.227**	--	--	
2000	JN2	Setup Tows (LD)	LI	**0.313**	--	--	
2000	DM1	Setup Tows (Patch & LD)	LI	**0.239**	--	-	
1999, 2000	DE-II and JN1	Density Ratio (DE-II/JN1)	LI	**0.384**	--	--	Ratio of best densities from DE-II and JN1 in nearby areas
	Estimate for 1999	**Mean**	LI	**0.346**	**0.403**	--	**mean and CV of 5 bold underl. estimates above.**
	Estimate for 1997	assume 1999 value		0.346	--	--	

Table C14. NMFS clam survey data for ocean quahog by stock assessment region and cruise. Catches (in numbers and biomass) were standardized to a 0.15 nm tow using doppler distances. Densities were calculated as stratified means based on GIS estimates of the area (nm^2) of NMFS survey strata sampled in the survey. Not all strata were sampled in all surveys. KG per tow was estimated using updated length-weight conversion parameters applied to numbers of clams in 1 mm size groups. For consistency, deep water strata and tows in water > 84 m during the 19993 survey were omitted.

Cruise	Stock Assessment Region	N / Tow	CV	KG / Tow	CV	Number Tows	Number Strata Surveyed	Area (nm^2) Survey	Area (nm^2) Stock Assessment Region
7801	DMV	47.31	61%	1.46	46%	55	6	4,071	4,071
7807	DMV	35.66	23%	1.23	19%	39	6	4,071	4,071
7901	DMV	35.61	49%	1.25	47%	30	4	3,479	4,071
8001	DMV	93.94	41%	3.32	40%	52	4	3,438	4,071
8006	DMV	56.57	61%	1.97	57%	41	5	3,825	4,071
8105	DMV	134.37	31%	4.01	33%	43	6	4,071	4,071
8204	DMV	78.42	32%	2.95	34%	59	6	4,071	4,071
8305	DMV	84.49	49%	2.53	42%	54	6	4,071	4,071
8403	DMV	41.95	48%	1.37	42%	66	4	3,438	4,071
8604	DMV	75.14	23%	2.53	22%	61	6	4,071	4,071
8903	DMV	64.19	56%	1.81	45%	69	6	4,071	4,071
9203	DMV	71.21	36%	2.27	31%	69	6	4,071	4,071
9404	DMV	39.18	24%	1.34	23%	105	6	4,071	4,071
9704	DMV	46.27	21%	1.65	21%	73	6	4,071	4,071
9903	DMV	27.43	30%	0.94	27%	69	6	4,071	4,071
8006	GBK	574.59	35%	13.93	35%	11	5	2,808	7,304
8204	GBK	251.54	12%	7.39	11%	22	9	4,753	7,304
8305	GBK	631.61	22%	16.39	23%	13	5	3,072	7,304
8403	GBK	73.13	88%	1.97	84%	32	6	1,954	7,304
8604	GBK	236.06	16%	5.68	17%	48	16	7,304	7,304
8903	GBK	45.88	26%	1.13	25%	40	10	4,519	7,304
9203	GBK	339.31	25%	9.33	24%	66	14	5,772	7,304
9404	GBK	336.25	23%	9.58	23%	79	16	7,304	7,304
9704	GBK	234.45	20%	6.58	20%	76	16	7,304	7,304
9903	GBK	272.96	20%	8.27	21%	48	12	6,249	7,304
7801	LI	138.17	14%	4.10	14%	64	9	4,463	4,463
7807	LI	438.45	41%	12.88	41%	27	8	3,531	4,463
7901	LI	257.16	21%	7.82	20%	33	8	3,849	4,463
8001	LI	277.09	14%	8.26	13%	28	8	3,849	4,463
8006	LI	200.14	20%	6.14	20%	34	7	3,642	4,463
8105	LI	202.96	24%	5.92	25%	44	9	4,463	4,463
8204	LI	213.98	15%	6.15	16%	48	9	4,463	4,463

Table C14. Cont.

8305	LI	173.09	19%	5.10	20%	87	9	4,463	4,463
8403	LI	6.85	67%	0.23	68%	9	3	604	4,463
8604	LI	281.80	23%	8.23	21%	36	9	4,463	4,463
8903	LI	191.19	27%	4.74	24%	56	9	4,463	4,463
9203	LI	265.62	17%	7.24	16%	52	9	4,463	4,463
9404	LI	498.53	15%	13.60	15%	56	9	4,463	4,463
9704	LI	380.16	16%	10.87	16%	42	9	4,463	4,463
9903	LI	210.21	16%	6.04	14%	45	9	4,463	4,463
7801	NJ	57.58	15%	1.90	14%	126	13	6,510	6,510
7807	NJ	99.15	49%	3.05	44%	68	13	6,510	6,510
7901	NJ	24.05	22%	0.96	22%	46	9	4,838	6,510
8001	NJ	97.79	24%	3.28	23%	80	10	5,078	6,510
8006	NJ	110.56	20%	3.46	18%	85	13	6,510	6,510
8105	NJ	175.43	26%	5.64	26%	87	13	6,510	6,510
8204	NJ	112.56	20%	3.61	19%	100	13	6,510	6,510
8305	NJ	83.89	21%	2.81	21%	98	13	6,510	6,510
8403	NJ	124.10	37%	3.95	36%	112	7	4,343	6,510
8604	NJ	140.74	23%	4.83	23%	103	13	6,510	6,510
8903	NJ	72.38	22%	2.21	21%	110	13	6,510	6,510
9203	NJ	87.17	18%	3.01	17%	110	13	6,510	6,510
9404	NJ	229.54	21%	7.55	20%	162	13	6,510	6,510
9704	NJ	121.02	15%	4.26	15%	124	13	6,510	6,510
9903	NJ	56.86	15%	2.01	14%	129	13	6,510	6,510
7801	SNE	184.36	25%	4.54	26%	30	6	2,947	4,922
7901	SNE	399.12	19%	8.97	18%	8	3	1,794	4,922
8001	SNE	467.76	12%	12.07	12%	13	4	2,072	4,922
8006	SNE	379.66	13%	9.68	13%	11	3	1,731	4,922
8105	SNE	279.07	21%	6.74	19%	25	5	2,732	4,922
8204	SNE	298.84	27%	7.66	25%	36	9	4,432	4,922
8305	SNE	154.35	29%	3.99	30%	58	10	4,922	4,922
8403	SNE	117.64	53%	3.20	56%	36	5	2,343	4,922
8604	SNE	265.39	28%	6.70	29%	27	9	4,707	4,922
8903	SNE	228.05	20%	5.61	19%	27	8	4,047	4,922
9203	SNE	327.17	19%	8.57	20%	36	10	4,922	4,922
9404	SNE	498.33	21%	13.06	20%	43	10	4,922	4,922
9704	SNE	234.89	48%	5.41	41%	39	10	4,922	4,922
9903	SNE	267.49	57%	6.54	52%	31	8	4,217	4,922
7801	SVA	0.00	0%	0.00	0%	11	1	690	712
8001	SVA	0.00	0%	0.00	0%	7	1	690	712
8105	SVA	0.93	0%	0.04	0%	5	2	712	712
8204	SVA	0.04	0%	0.00	0%	5	2	712	712

Table C14. Cont.

8305	SVA	1.89	58%	0.10	58%	10	2	712	71
8403	SVA	0.19	85%	0.01	87%	14	2	712	71
8604	SVA	0.29	0%	0.01	0%	9	2	712	71
8903	SVA	0.39	0%	0.02	0%	9	2	712	71
9203	SVA	0.00	0%	0.00	0%	9	2	712	71
9404	SVA	4.03	76%	0.20	79%	9	2	712	71
9704	SVA	0.12	0%	0.00	0%	9	2	712	71

Table C15. Data for additional tows at deep water stations occupied during the 1999 NMFS clam survey. All tows were in strata not usually used in tabulation of survey data for quahog. "Region Assigned" was assigned based on proximity to standard stock assessment regions and KG/Tow was calculated based on length-weight parameters for the region assigned.

Stratum	Tow	Station	Region Assigned	Doppler Tow Dist. (NM)	Sensor Tow Dist. (NM)	Sensor / Doppler Dist.	Lat. (DD.MM)	Long. (DD.MM)	Depth (m)	Station Type	Haul Type	Gear Cond.	N/Tow	KG/Tow
32	1	597	LI	0.12	0.25	2.06	40.04	72.01	78	1	1	1	0.000	0.000
32	2	600	LI	0.12	0.25	2.08	39.46	72.22	86	1	3	5	0.000	0.000
32	3	599	LI	0.11	0.27	2.46	39.49	72.15	85	1	3	5	0.000	0.000
32	4	598	LI	0.16	0.33	2.08	39.53	72.07	88	1	3	5	0.000	0.000
32	5	601	LI	0.10	0.24	2.36	39.46	72.25	86	1	3	6	0.000	0.000
32	6	602	LI	0.16	0.31	1.93	39.60	72.20	76	1	1	1	0.970	0.016
36	1	594	LI	0.12	0.29	2.40	40.09	71.41	84	1	3	5	1.042	0.017
36	2	591	LI	0.13	0.32	2.46	40.13	71.32	86	1	3	6	0.000	0.000
36	3	593	LI	0.11	0.23	2.10	40.04	71.43	90	1	3	6	0.000	0.000
36	4	596	LI	0.14	0.29	2.06	40.11	71.51	78	1	2	3	0.521	0.009
36	5	595	LI	0.14	0.29	2.04	40.06	71.48	79	1	2	3	0.000	0.000
36	6	592	LI	0.14	0.29	2.09	40.05	71.33	89	1	3	6	0.000	0.000
40	1	589	SNE	0.13	0.32	2.43	40.26	71.08	82	1	3	6	0.000	0.000
40	2	586	SNE	0.13	0.28	2.12	40.23	70.44	90	1	3	6	0.000	0.000
40	3	587	SNE	0.18	0.35	1.93	40.24	70.55	87	1	3	6	0.000	0.000
40	4	590	SNE	0.13	0.31	2.41	40.28	71.16	75	1	3	6	0.000	0.000
40	5	588	SNE	0.19	0.38	2.00	40.30	71.03	78	1	3	6	0.000	0.000
44	1	585	SNE	0.12	0.24	1.98	40.20	70.29	92	1	3	6	0.000	0.000
44	2	582	SNE	0.13	0.25	1.89	40.19	70.02	86	1	3	6	0.000	0.000
44	3	583	SNE	0.11	0.23	2.09	40.19	70.11	87	1	3	6	0.000	0.000
44	4	584	SNE	0.13	0.24	1.83	40.21	70.23	88	1	3	6	0.000	0.000
48	1	578	SNE	0.13	0.25	1.89	40.08	69.32	90	1	1	1	0.000	0.000
48	2	577	SNE	0.15	0.25	1.67	40.11	69.22	90	1	1	1	14.972	0.224
48	3	579	SNE	0.16	0.28	1.75	40.16	69.46	82	1	2	3	13.953	0.209
48	4	576	SNE	0.14	0.25	1.82	40.19	69.25	78	1	3	6	67.212	1.004
48	5	575	SNE	0.13	0.22	1.73	40.16	69.17	87	1	1	1	60.037	0.897
48	6	580	SNE	0.12	0.27	2.29	40.21	69.47	76	1	1	1	26.749	0.399
48	7	581	SNE	0.14	0.30	2.17	40.21	69.56	41	1	2	3	0.985	0.015
56	1	572	GBK	0.14	0.22	1.60	40.26	68.37	87	1	1	1	11.417	0.192
56	2	574	GBK	0.12	0.19	1.60	40.21	68.49	92	1	1	1	5.474	0.091
56	3	571	GBK	0.11	0.22	1.96	40.29	68.39	80	1	1	1	238.040	4.021
56	4	573	GBK	0.11	0.18	1.66	40.24	68.39	89	1	1	1	2.461	0.042
58	1	567	GBK	0.13	0.21	1.65	40.37	68.14	88	1	1	1	321.193	5.425
58	2	562	GBK	0.12	0.23	1.91	40.38	68.03	88	1	1	1	74.780	1.262
58	3	563	GBK	0.15	0.22	1.46	40.41	68.01	84	1	1	1	70.406	1.189
58	4	568	GBK	0.14	0.20	1.45	40.32	68.26	91	1	1	1	20.726	0.350
58	5	566	GBK	0.10	0.22	2.15	40.39	68.09	87	1	1	1	475.116	8.018
60	1	557	GBK	0.12	0.24	1.98	40.56	67.09	82	1	1	1	196.589	3.317
60	2	559	GBK	0.11	0.22	2.00	40.42	67.27	92	1	1	1	34.139	0.577
60	3	558	GBK	0.14	0.20	1.41	40.51	67.21	87	1	1	1	272.465	4.596
60	4	560	GBK	0.11	0.22	2.04	40.39	67.35	87	1	1	1	43.436	0.733
60	5	561	GBK	0.12	0.23	1.94	40.37	67.43	78	1	2	3	39.392	0.665
62	1	523	GBK	0.11	0.24	2.20	41.11	66.43	73	1	2	2	6.817	0.115
62	2	556	GBK	0.11	0.20	1.79	40.54	66.55	90	1	3	5	122.019	2.058
62	3	555	GBK	0.11	0.24	2.19	40.59	66.43	85	1	3	5	97.007	1.639
62	4	554	GBK	0.15	0.28	1.85	41.05	66.39	80	1	2	3	30.258	0.511
													48.8	0.817

Table C16. Swept area biomass calculations for quahog in deep water (73-110 m) strata during the 1999 NMFS dredge survey. Catch rates were standardized using bottom sensor tow distance measurements. Swept area biomass calculations include corrections for survey dredge efficiency and unsuitable habitat. Ratios of biomass and habitat area in deep and traditional quahog strata are shown for comparison.

Stratum	Assigned Area	N tows	KG / Tow	CV	Habitat Area (nm^2)	Swept Area Biomass (MT, Assuming Efficiency=0.346)
32	LI	6	0.003	2.45	631	39
36	LI	6	0.004	1.67	704	70
	Biomass in deep strata		*0.004*	*1.39*	*1,335*	*110*
	Ratio deep /traditional strata				*30%*	*0%*
40	SNE	5	0.000	0.00	516	0
44	SNE	4	0.000	0.00	400	0
48	SNE	7	0.393	1.03	1,063	9,770
	Biomass in deep strata		*0.211*	*1.03*	*1,979*	*9,770*
	Ratio deep / traditional strata				*29%*	*2%*
56	GBK	4	0.187	1.80	214	5,445
58	GBK	5	3.249	1.02	303	23,048
60	GBK	5	1.978	0.94	801	37,089
62	GBK	4	1.081	0.85	873	22,095
	Biomass in deep strata		*1.709*	*0.76*	*2,191*	*87,676*
	Ratio deep / traditional strata				*25%*	*13%*

Table C17. Efficiency adjusted swept-area biomass and variance calculations for ocean quahog (70+ mm) during 1997 and 1999, by stock assessment area. Survey densities are biomass of quahog 70+ mm per standard 0.15 nm tow (tow distance measured by bottom sensors). Results for the SVA stock assessment region are based on 1997 survey data because there was no survey in the SVA stock assessment region during 1999. The CV for SVA in 1997 was assumed to be 30% because only one tow in a single stratum contained ocean quahog. Areas (nm2) measured by GIS. Calculations include adjustments for untrawlable stations (too rocky, coded "151") used to measure the proportion suitable quahog habitat in the GBK assessment area. Data for untrawlable stations were recorded in 1999, but also applied to 1997. Estimates of quahog biomass in deep strata off the LI, SNE and GBK assessment areas are from the 1999 survey, but also used to estimate total biomass during 1997. "Traditional" areas include survey strata < 75 m (41 fathoms) traditionally used to estimate ocean quahog abundance. "Deep" means deep water strata 75-110 m (41-60 fathoms) surveyed in 1999. "Total" biomass excludes the Gulf of Maine . Calculations assume lognormal error distributions and covariances are ignored. CV's are for arithmetic scale estimates, standard errors are for log transformed estimates.

	Estimate for 1997	*Arithmetic CV (for stratified means)*	*Log Scale Standard Error*	*Estimate for 1999*	*Arithmetic CV (for stratified means)*	*Log Scale Standard Error*
Survey Density (D, kg / 0.15 nm standard tow)						
SVA	0.001	30%	0.29	0.001	30%	0.29
DMV	0.726	22%	0.22	0.496	27%	0.27
NJ	1.913	15%	0.15	1.065	14%	0.14
LI Traditional Survey Strata	5.073	17%	0.17	3.290	14%	0.13
LI Deep Strata in 1999 Survey	0.000	0%	0.00	0.000	0%	0.00
LI Traditional + Deep Strata	3.905	17%	0.17	2.532	14%	0.13
SNE Traditional Survey Strata	2.473	36%	0.35	3.312	51%	0.48
SNE Deep Strata in 1999 Survey	0.211	103%	0.85	0.211	103%	0.85
SNE Traditional + Deep Strata	1.824	35%	0.34	2.423	49%	0.47
GBK Traditonal Survey Strata	3.169	17%	0.17	3.785	20%	0.20
GBK Deep Strata in 1999 Survey	1.709	76%	0.68	1.709	76%	0.68
GBK Traditional + Deep Strata	2.832	18%	0.18	3.306	20%	0.20
All regions	2.315	24%	0.23	2.143	32%	0.31
All regions less GBK	2.111	26%	0.26	1.682	36%	0.35

Table C17. Swept Area -Continued (p2 of 6)

	Estimate for 1997 & 1999	Assumed Arithmetic CV	Log Scale Standard Error
Area of standard tow (a, nm²)	0.000123434	5%	0.05
Area of assessment region (R, nm²) - no correction for stations with unsuitable clam habitat			
SVA	712	5%	0.05
DMV	4,071	5%	0.05
NJ	6,510	5%	0.05
LI Traditional Survey Strata	4,463	5%	0.05
LI Deep Strata in 1999 Survey	1,335	5%	0.05
LI Traditional + Deep Strata	5,798	5%	0.05
SNE Traditional Survey Strata	4,922	5%	0.05
SNE Deep Strata in 1999 Survey	1,979	5%	0.05
SNE Traditional + Deep Strata	6,901	5%	0.05
GBK Tradional Survey Strata	7,304	5%	0.05
GBK Deep Strata in 1999 Survey	2,191	5%	0.05
GBK Traditional + Deep Strata	9,495	5%	0.05
All regions	33,487	2%	0.02
All regions less GBK	23,992	2%	0.02

Table C17. Swept Area -Continued (p3 of 6)

	Estimate for 1997 & 1999	Calculated Arithmetic CV	Log Scale Standard Error
Fraction of region suitable as ocean quahog habitat (f)			
GBK Tradional Survey Strata	0.90	10%	0.10
All other areas	1.00	0%	0.00
Habitat area in assessment region ($A=R*f$, nm^2)			
SVA	712	5%	0.05
DMV	4,071	5%	0.05
NJ	6,510	5%	0.05
LI Traditional Survey Strata	4,463	5%	0.05
LI Deep Strata in 1999 Survey	1,335	5%	0.05
LI Traditional + Deep Strata	5,798	5%	0.05
SNE Traditional Survey Strata	4,922	5%	0.05
SNE Deep Strata in 1999 Survey	1,979	5%	0.05
SNE Traditional + Deep Strata	6,901	5%	0.05
GBK Tradional Survey Strata	6,588	11%	0.11
GBK Deep Strata in 1999 Survey	2,191	5%	0.05
GBK Traditional + Deep Strata	8,779	5%	0.05
All regions	32,771	2%	0.02
All regions less GBK	23,992	2%	0.02

Table C17. Swept Area -Continued (p4 of 6)

Habitat area / tow area (A/a)

SVA	*5,768,260*	*7%*	*0.07*

	Estimate for 1997 & 1999	*Calculated Arithmetic CV*	*Log Scale Standard Error*
DMV	*32,981,162*	*7%*	*0.07*
NJ	*52,740,693*	*7%*	*0.07*
LI Traditional Survey Strata	*36,156,945*	*7%*	*0.07*
LI Deep Strata in 1999 Survey	*10,815,488*	*7%*	*0.07*
LI Traditional + Deep Strata	*46,972,433*	*7%*	*0.07*
SNE Traditional Survey Strata	*39,875,529*	*7%*	*0.07*
SNE Deep Strata in 1999 Survey	*16,032,847*	*7%*	*0.07*
SNE Traditional + Deep Strata	*55,908,375*	*7%*	*0.07*
GBK Tradional Survey Strata	*53,369,737*	*12%*	*0.12*
GBK Deep Strata in 1999 Survey	*17,750,362*	*7%*	*0.07*
GBK Traditional + Deep Strata	*71,120,099*	*7%*	*0.07*
All regions	*265,491,022*	*5%*	*0.05*
All regions less GBK	*194,370,923*	*6%*	*0.06*

Table C17. Swept Area -Continued (p5 of 6)

	Estimate for 1997	Arithmetic CV	Log Scale Standard Error	Estimate for 1999	Arithmetic CV	Log Scale Standard Error
Survey dredge efficiency [e]						
All regions	0.346	40%	0.39	0.346	40%	0.39
Swept area biomass (B, mt)						
SVA	22	52%	0.49	22	52%	0.49
DMV	69,236	47%	0.45	47,261	50%	0.47
NJ	291,560	44%	0.42	162,375	43%	0.41
LI Traditional Survey Strata	530,076	45%	0.43	343,780	43%	0.41
LI Deep Strata in 1999 Survey	110	155%	1.11	110	155%	1.11
LI Traditional + Deep Strata	530,076	45%	0.43	343,780	43%	0.41
SNE Traditional Survey Strata	284,960	57%	0.53	381,715	68%	0.61
SNE Deep Strata in 1999 Survey	9,770	119%	0.94	9,770	119%	0.94
SNE Traditional + Deep Strata	294,731	55%	0.51	391,486	66%	0.60
GBK Tradional Survey Strata	488,745	46%	0.44	583,817	46%	0.44
GBK Deep Strata in 1999 Survey	87,676	92%	0.78	87,676	92%	0.78
GBK Traditional + Deep Strata	576,422	42%	0.40	671493	42%	0.40
All regions	1,762,156	23%	0.46	1,616,527	26%	0.50
All regions less GBK	1,185,735	27%	0.26	945,033	32%	0.32

Table C17. Swept Area -Continued (p4 of 6)

Habitat area / tow area (A/a)	Estimate for 1997 & 1999	Calculated Arithmetic CV	Log Scale Standard Error
SVA	5,768,260	7%	0.07
DMV	32,981,162	7%	0.07
NJ	52,740,693	7%	0.07
LI Traditional Survey Strata	36,156,945	7%	0.07
LI Deep Strata in 1999 Survey	10,815,488	7%	0.07
LI Traditional + Deep Strata	46,972,433	7%	0.07
SNE Traditional Survey Strata	39,875,529	7%	0.07
SNE Deep Strata in 1999 Survey	16,032,847	7%	0.07
SNE Traditional + Deep Strata	55,908,375	7%	0.07
GBK Tradional Survey Strata	53,369,737	12%	0.12
GBK Deep Strata in 1999 Survey	17,750,362	7%	0.07
GBK Traditional + Deep Strata	71,120,099	7%	0.07
All regions	265,491,022	5%	0.05
All regions less GBK	194,370,923	6%	0.06

Table C18. Summary of basecase KLAMZ model runs for ocean quahog. All biomass values in thousand mt. Q values are scaling parameters used to scale estimated biomass to units of an abundance index. The KLAMZ model for ocean quahog included an exponent parameter for LPUE data to account for possible nonlinear relationships with biomass. "RMS Residual" means the root mean square of standardized log scale residuals for an abundance index. The RMS residual is analogous to the standard deviation of log scale residuals and approximately equal to the CV or arithmetic scale residuals.

	GBK	SNE	LI	NJ	DMV	SVA
NMFS Dredge Survey 70+ mm						
N Active Observations	5	7	9	9	10	7
RMS Residuals	0.77	0.24	0.26	0.30	0.31	1.24
LPUE						
N Active Observations	0	5	8	13	9	0
RMS Residuals	NA	0.12	0.07	0.11	0.03	NA
Exponent	NA	2.55	1.51	1.39	0.85	NA
Efficiency Corrected Swept Area Biomass 70+						
N Active Observations	2	2	2	2	2	1
Q	1.00	0.99	0.79	0.84	0.93	0.30
RMS Residuals	0.08	0.16	0.21	0.29	0.19	0.00
Status						
Recent Mean F	0.000	0.022	0.011	0.013	0.019	0.000
Recent Mean B (1000 MT)	622	340	534	257	62	0.076
Recent Mean C (1000 MT)	0.000	7.334	6.012	3.320	1.169	0.000
Virgin (1978) Biomass (1000 mt)	622	370	590	355	134	0
Recent Biomass / Virgin Biomass	100%	92%	90%	73%	47%	24%
Recruitment Biomass (1000 mt)	6.85	4.07	6.50	3.91	1.47	0.0035
Recruitment / Recent Biomass	0.01	0.01	0.01	0.02	0.02	0.05

Table C19. Basecase run biomass estimates (1,000 MT meat weights) for ocean quahog from the KLAMZ stock assessment model, by stock assessment region and for the EEZ stock as a whole. CV's were calculated by bootstrapping (500 iterations).

Year	GBK	CV	SNE	CV	LI	CV	NJ	CV	DMV	CV	SVA	CV	EEZ	CV
1978	622	37%	370	12%	590	15%	355	17%	134	8%	0.320	2%	2,072	12%
1979	622	37%	370	12%	590	15%	355	17%	134	8%	0.320	2%	2,071	12%
1980	622	37%	370	12%	590	15%	354	17%	130	8%	0.320	2%	2,067	12%
1981	622	37%	370	12%	590	15%	352	17%	126	9%	0.320	2%	2,061	12%
1982	622	37%	370	12%	590	15%	348	17%	124	9%	0.264	3%	2,055	12%
1983	622	37%	370	12%	590	15%	344	17%	120	9%	0.259	3%	2,047	12%
1984	622	37%	370	12%	590	15%	340	18%	116	9%	0.260	3%	2,038	13%
1985	622	37%	369	12%	590	15%	336	18%	110	10%	0.255	3%	2,027	13%
1986	622	37%	368	12%	590	15%	329	18%	103	11%	0.096	8%	2,013	13%
1987	622	37%	368	12%	590	15%	323	19%	96	11%	0.098	8%	1,999	13%
1988	622	37%	367	12%	589	15%	318	19%	86	13%	0.101	8%	1,982	13%
1989	622	37%	366	12%	588	15%	314	19%	76	14%	0.061	12%	1,966	13%
1990	622	37%	365	12%	587	15%	303	20%	70	16%	0.064	12%	1,948	13%
1991	622	37%	364	12%	587	15%	291	21%	68	16%	0.054	14%	1,932	13%
1992	622	37%	364	12%	585	16%	279	22%	64	17%	0.057	13%	1,914	13%
1993	622	37%	363	12%	573	16%	275	22%	63	18%	0.060	13%	1,896	14%
1994	622	37%	362	12%	565	16%	268	23%	62	18%	0.063	12%	1,878	14%
1995	622	37%	361	12%	553	16%	263	23%	62	18%	0.066	12%	1,861	14%
1996	622	37%	355	12%	544	17%	261	23%	62	18%	0.070	11%	1,845	14%
1997	622	37%	347	12%	539	17%	259	24%	63	18%	0.073	11%	1,830	14%
1998	622	37%	339	13%	534	17%	257	24%	63	18%	0.076	10%	1,815	14%
1999	622	37%	333	13%	528	17%	257	24%	62	18%	0.079	10%	1,803	14%

Table C20. Basecase run fishing mortality (y^{-1}) estimates for ocean quahog from the KLAMZ stock assessment model, by stock assessment region and for the EEZ stock as a whole. CV's were calculated by bootstrapping (500 iterations).

Year	GBK	CV	SNE	CV	LI	CV	NJ	CV	DMV	CV	SVA	CV	EEZ	CV
1978	0.000	0%	0.000	12%	0.000	0%	0.018	17%	0.010	8%	0.000	0%	0.004	14%
1979	0.000	0%	0.000	0%	0.000	0%	0.017	17%	0.042	8%	0.000	0%	0.006	10%
1980	0.000	0%	0.000	0%	0.000	16%	0.022	17%	0.034	8%	0.000	0%	0.006	12%
1981	0.000	0%	0.000	0%	0.000	16%	0.024	18%	0.029	9%	0.193	2%	0.006	12%
1982	0.000	0%	0.000	0%	0.000	0%	0.025	18%	0.038	9%	0.022	3%	0.007	12%
1983	0.000	0%	0.002	12%	0.000	16%	0.024	18%	0.046	9%	0.000	0%	0.007	11%
1984	0.000	0%	0.002	12%	0.000	0%	0.027	18%	0.065	9%	0.024	3%	0.009	10%
1985	0.000	0%	0.002	12%	0.000	16%	0.033	19%	0.069	10%	1.007	4%	0.010	11%
1986	0.000	0%	0.002	12%	0.001	16%	0.028	19%	0.084	11%	0.000	0%	0.009	11%
1987	0.000	0%	0.002	12%	0.002	16%	0.029	20%	0.118	11%	0.000	0%	0.011	10%
1988	0.000	0%	0.002	12%	0.001	16%	0.023	20%	0.147	13%	0.545	7%	0.011	10%
1989	0.000	0%	0.003	12%	0.001	16%	0.046	21%	0.090	14%	0.000	0%	0.012	14%
1990	0.000	0%	0.003	12%	0.001	16%	0.053	22%	0.055	16%	0.239	9%	0.011	16%
1991	0.000	0%	0.002	12%	0.003	16%	0.052	23%	0.075	16%	0.000	0%	0.012	16%
1992	0.000	0%	0.003	12%	0.021	16%	0.025	24%	0.038	17%	0.000	0%	0.012	12%
1993	0.000	0%	0.003	12%	0.015	17%	0.038	24%	0.032	18%	0.000	0%	0.012	13%
1994	0.000	0%	0.003	12%	0.022	17%	0.027	25%	0.016	18%	0.000	0%	0.011	13%
1995	0.000	0%	0.015	13%	0.017	18%	0.021	26%	0.011	18%	0.000	0%	0.011	11%
1996	0.000	0%	0.024	13%	0.011	18%	0.019	26%	0.012	18%	0.000	0%	0.011	10%
1997	0.000	0%	0.026	13%	0.010	18%	0.017	26%	0.017	18%	0.000	0%	0.011	10%
1998	0.000	0%	0.019	13%	0.012	18%	0.011	27%	0.022	18%	0.000	0%	0.010	10%
1999	0.000	0%	0.020	14%	0.012	19%	0.012	27%	0.018	18%	0.000	0%	0.010	10%

ID	Name	Description
0	Basecase	Final run used for status determination
1	Hi Catch	Increase catch in all years by 20%
2	No Survey	NMFS survey time series removed
3	No LPUE	LPUE data removed
4	No Swept Area Biomass	Constraint on Q=1 for swept area biomass removed
5	Swept Area Biomass Only	Constraint towards Q=1 for swept area biomass active, survey and LPUE removed
6	Survey Only	Survey data only; LPUE and swept area biomass constraint removed
7	LPUE Only	LPUE data only; survey and swept area biomass constraint removed
8	Basecase w/Linear LPUE	Same as basecase but LPUE fit with exponent=1
9	Linear LPUE Only	LPUE data with exponent=1 only; survey and swept area biomass constraint removed
10	Half M	Natural mortality rate M=0.01 (one-half default value)
11	Twice M	Natural mortality rate M=0.04 (twice default value)

Table C21. Initial sensitivity analysis runs for the KLAMZ Model and ocean quahog.

Table C22. Sensitivity analysis results for the KLAMZ model fit to data for ocean quahog in the DMV assessment area.

	Like Basecase	Hi Catch	No Survey	No LPUE	No Swept Area Biomass	Swept Area Biomass Only	Survey Only	LPUE Only	Basecase w/LPUE Linear	Linear LPUE Only	Half M	Double M
Control Parameters												
M	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.04
Inflate Landings and Discard By %	0%	20%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
NMFS Survey												
N Active Observations	10	10	10	10	10	10	10	10	10	10	10	10
RMS Residuals	0.31	0.32	0.32	0.31	0.31	0.32	0.31	0.39	0.31	0.31	0.31	0.32
Likelihood Weight	1.00	1.00	0.00	1.00	1.00	1.00	1.00	0.00	1.00	0.00	1.00	1.00
Neg. Log Likelihood	4.571	4.646	4.630	4.571	4.549	4.630	4.549	6.977	4.565	4.565	4.390	5.067
LPUE												
N Active Observations	9	9	9	9	9	9	9	9	9	9	9	9
RMS Residuals	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.02	0.04	0.04	0.03	0.03
Exponent	0.85	0.79	0.79	NA	0.91	NA	NA	0.50	1.00	1.00	0.82	0.92
Likelihood Weight	1.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00
Neg. Log Likelihood	0.009	0.009	0.009	0.011	0.010	0.020	0.010	0.008	0.025	0.025	0.012	0.014
Target Q Swept Area Biomass												
Q	0.93	0.85	1.00	0.93	0.85	1.00	0.85	1.85	0.91	0.91	0.92	0.94
Target Q Swept Area Biomass	1.00	1.00	1.00	1.00	NA	1.00	NA	NA	1.00	NA	1.00	1.00
CV for Target Q	0.40	0.40	0.40	0.40	NA	0.40	NA	NA	0.40	NA	0.40	0.40
Weight	1.00	1.00	1.00	1.00	0.00	1.00	0.00	0.00	1.00	0.00	1.00	1.00
Neg. Log Likelihood	0.020	0.095	0.000	0.020	0.090	<0.001	0.090	1.273	0.028	0.028	0.025	0.013
Status												
Recent Mean F	0.019	0.021	0.021	0.019	0.017	0.021	0.017	0.038	0.019	0.019	0.019	0.020
Recent Mean B (units=1000)	62	68	58	62	68	58	68	31	63	63	63	62
Recent Mean C (units=1000)	1.169	1.403	1.169	1.169	1.169	1.169	1.169	1.169	1.169	1.169	1.169	1.169
Virgin (1978) Biomass (units=1000)	134	154	130	134	139	130	139	104	135	135	139	124
Recent Biomass / Virgin Biomass	47%	44%	45%	47%	49%	45%	49%	30%	47%	47%	45%	50%
Recruitment Biomass (units=1000)	1.47	1.70	1.43	1.47	1.53	1.43	1.53	1.15	1.48	1.48	0.66	3.19
Recruitment / Recent Biomass	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.05

Table C23. Sensitivity analysis results for the KLAMZ model fit to data for ocean quahog in the NJ assessment area.

	Like Basecase	No Survey	No LPUE	No Swept Area Biomass	Swept Area Biomass Only	Survey Only	LPUE Only
NMFS Dredge Survey 70+ mm							
N Active Observations	9	9	9	9	9	9	9
RMS Residuals	0.30	0.30	0.30	0.30	0.30	0.30	0.33
Likelihood Weight	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Neg. Log Likelihood	12.283	12.578	12.284	12.139	12.585	12.139	13.578
LPUE							
N Active Observations	13	13	13	13	13	13	13
RMS Residuals	0.11	0.11	0.11	0.11	0.12	0.12	#NUM!
Exponent	1.39	1.17	1.39	1.85	1.39	1.39	57.19
Likelihood Weight	1.00	1.00	0.00	1.00	0.00	0.00	1.00
Neg. Log Likelihood	0.266	0.270	0.267	0.262	0.282	0.281	#NUM!
Target Q Swept Area Total Biomass							
Q	0.84	1.00	0.84	0.63	1.00	0.64	0.02
Target Q Swept Area Biomass	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CV for Target Q	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Weight	1.00	1.00	1.00	0.00	1.00	0.00	0.00
Neg. Log Likelihood	1.0E-01	3.3E-05	1.0E-01	0.0E+00	3.8E-27	0.0E+00	0.0E+00
Status							
Recent Mean F	0.013	0.016	0.013	0.010	0.016	0.010	0.000
Recent Mean B (units=1000)	257	217	257	341	216	339	8,829
Recent Mean C (units=1000)	3.320	3.320	3.320	3.320	3.320	3.320	3.320
Virgin (1978) Biomass (units=1000)	355	316	355	436	315	435	8,913
Recent Biomass / Virgin Biomass	73%	69%	72%	78%	69%	78%	99%
Recruitment Biomass (units=1000)	3.91	3.48	3.90	4.80	3.47	4.78	98.07
Recruitment / Recent Biomass	0.02	0.02	0.02	0.01	0.02	0.01	0.01

Table C24. Sensitivity analysis results for the KLAMZ model fit to data for ocean quahog in the LI assessment area.

	Like Basecase	No Survey	No LPUE	No Swept Area Biomass	Swept Area Biomass Only	Survey Only	LPUE Only
NMFS Dredge Survey 70+ mm							
N Active Observations	9	9	9	9	9	9	9
RMS Residuals	0.26	0.27	0.26	0.24	0.27	0.24	0.24
Likelihood Weight	1.00	0.00	1.00	1.00	0.00	1.00	0.00
Neg. Log Likelihood	9.416	9.837	9.416	8.106	9.837	8.106	8.124
LPUE							
N Active Observations	8	8	8	8	8	8	8
RMS Residuals	0.07	0.07	0.07	0.09	0.07	0.09	NaN
Exponent	1.51	1.21	1.51	1.51	1.51	1.51	88.07
Likelihood Weight	1.00	1.00	0.00	1.00	0.00	0.00	1.00
Neg. Log Likelihood	0.065	0.066	0.065	0.099	0.068	0.099	NaN
Target Q Swept Area Total Biomass							
Q	0.79	1.00	0.79	0.00	1.00	0.00	0.01
Target Q Swept Area Biomass	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CV for Target Q	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Weight	1.00	1.00	1.00	0.00	1.00	0.00	0.00
Neg. Log Likelihood	1.8E-01	1.6E-07	1.8E-01	0.0E+00	1.1E-26	0.0E+00	0.0E+00
Status							
Recent Mean F	0.011	0.014	0.011	0.000	0.014	0.000	0.000
Recent Mean B (units=1000)	534	424	534	######	424	#####	30,600
Recent Mean C (units=1000)	6.012	6.012	6.012	6.012	6.012	6.012	6.012
Virgin (1978) Biomass (units=1000)	590	480	590	######	480	#####	30,657
Recent Biomass / Virgin Biomass	90%	88%	90%	100%	88%	100%	100%
Recruitment Biomass (units=1000)	6.50	5.28	6.50	######	5.28	#####	337.35
Recruitment / Recent Biomass	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table C25. Sensitivity analysis runs requested by the SARC using the KLAMZ model for ocean quahog and natural mortality x 4, natural mortality/4 and ± 50% catch..

	DMV Catch Plus 50%	DMV Catch Minus 50%	DMV 4xM	DMV M/4	DMV Like Basecase
Control Parameters					
M	0.02	0.02	0.08	0.005	0.02
Inflate Landings and Discard By %	50%	-50%	0%	0%	0%
Total Neg. Log Likelihood	5.09	4.944	6.491	4.362	4.6
NMFS Dredge Survey 70+ mm					
Neg. Log Likelihood	4.805	4.795	6.38	4.322	4.571
LPUE					
Exponent	0.72	1.19	1.07	0.81	0.85
Neg. Log Likelihood	0.009	0.011	0.092	0.013	0.009
Target Q Swept Area Total Biomass					
Q	0.75	1.22	0.93	0.92	0.93
Neg. Log Likelihood	0.277	0.138	0.019	0.027	0.02
Status					
Recent Mean F	0.023	0.013	0.02	0.019	0.019
Recent Mean B (units=1000)	77	47	62	63	62
Recent Mean C (units=1000)	1.754	0.585	1.169	1.169	1.169
Virgin (1978) Biomass (units=1000)	185	83	107	140	134
Recent Biomass / Virgin Biomass	42%	57%	59%	45%	47%
Recruitment Biomass (units=1000)	2.04	0.91	6.31	0.3	1.47
Recruitment / Recent Biomass	3%	2%	10%	0%	2%
Projection					
Biomass in 2009 (units=1000)	75	47	76	55	61
F in 2009 (units=1000)	0.02	0.01	0.02	0.02	0.02

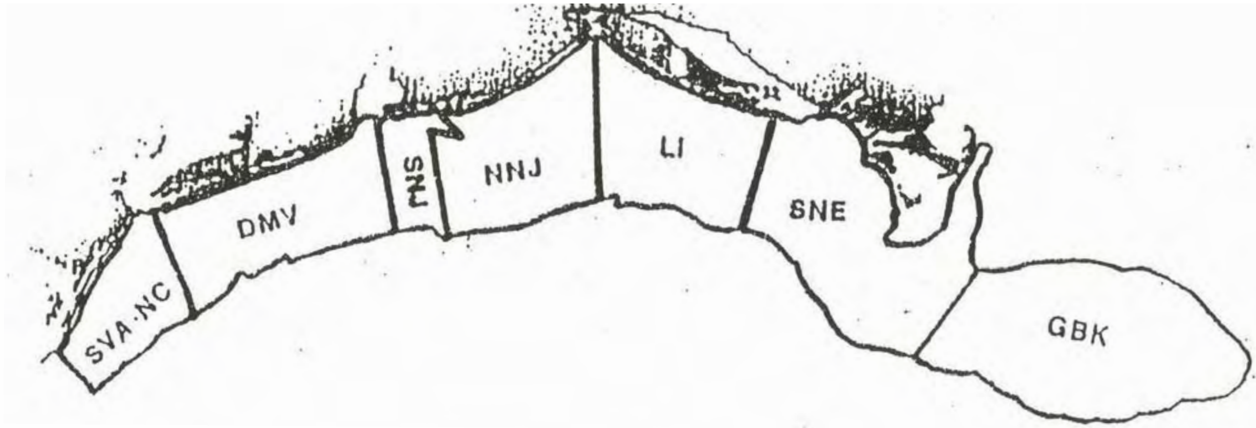
Table C26. Likelihood profile for swept area biomass Q in the KLAMZ model for ocean quahog in the DMV assessment ar

	Q=0.2	Q=0.4	Q=0.6	Q=0.8	Base case	Q=1.0	Q=1.2	Q=1.4	Q=1.5	Q=1.6
Total Neg. Log Likelihood	6.972	5.570	4.834	4.569	4.600	4.639	4.953	5.446	5.744	6.071
NMFS Dredge Survey 70+ mm										
RMS Residuals	0.35	0.32	0.31	0.31	0.31	0.32	0.33	0.35	0.35	0.36
Likelihood Weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Neg. Log Likelihood	6.958	5.557	4.823	4.559	4.571	4.630	4.944	5.437	5.736	6.063
LPUE										
RMS Residuals	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Exponent	3.34	1.74	1.21	0.95	0.85	0.79	0.69	0.61	0.58	0.56
Likelihood Weight	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Neg. Log Likelihood	0.015	0.013	0.011	0.010	0.009	0.009	0.009	0.008	0.008	0.008
Target Q Swept Area Total Biomass										
Q	0.20	0.40	0.60	0.80	0.93	1.00	1.20	1.40	1.50	1.60
Target Q Swept Area Biomass	0.20	0.40	0.60	0.80	1.00	1.00	1.20	1.40	1.50	1.60
CV for Target Q	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Weight	10000	10000	10000	10000	1	10000	10000	10000	10000	10000
Neg. Log Likelihood	3.1E-09	3.9E-09	2.8E-09	8.2E-11	0.020	3.4E-10	3.6E-09	9.8E-09	1.4E-08	2.1E-08
Status										
Recent Mean F	0.004	0.008	0.012	0.016	0.019	0.021	0.025	0.029	0.031	0.033
Recent Mean B (units=1000)	289	145	96	72	62	58	48	41	39	36
Virgin (1978) Biomass (units=1000)	357	214	167	144	134	130	120	114	111	109
Recent Biomass / Virgin Biomass	81%	67%	58%	50%	47%	45%	40%	36%	35%	33%
Recruitment Biomass (units=1000)	3.93	2.36	1.84	1.58	1.47	1.43	1.32	1.25	1.22	1.20
Recruitment / Recent Biomass	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03

Table C27. Fishing mortality and stock biomass (mt meats 70+ mm) estimates with CV's and confidence intervals for ocean quahog from the catch-swept area and KLAMZ models. Calculations include adjustments for dredge efficiency and for untrawlable stations (too rocky, coded "151") used to measure the proportion suitable quahog habitat in the GBKassessment area. "Traditional" areas include survey strata <75 m (41 fathoms) traditionally Used to estimate ocean quahog abundance. "Deep" means deep water strata 75-110 m (41-60 fathoms). "All regions" excludes the Gulf of Maine. Calculations assume lognormal error distributions and covariance are ignored. CV's are for arithmetic scale estimates, standard errors are for log transformed estimates.

Multiplier for CI's (e.g. 1.96 for 95% CI)	1.96
Assumed CV for Catch	5%

Model/Area	Recent Catch (1997-1999 Average)	CV	Log Scale SE	Recent Biomass (1997-1999 Average)	CV	Log Scale SE	Recent Biomass-Lower Bound	Recent Biomass-Upper Bound	Virgin Biomass	CV	Recent Biomass / Virgin Biomass	CV	Recent Fishing Mortality (F)	CV	Log Scale SE	Recent Fishing Mortality-Lower Bound	Recent Fishing Mortality-Upper Bound
Catch-Swept																	
SVA	0	0%	0.000	22	37%	0.356	11	45	NA	NA	NA	NA	0.000	0%	0.000	0.000	0.000
DMV	1,169	5%	0.050	58,248	35%	0.338	30,056	112,885	NA	NA	NA	NA	0.020	35%	0.341	0.010	0.039
NJ	3,320	5%	0.050	226,968	32%	0.314	122,569	420,287	NA	NA	NA	NA	0.015	33%	0.318	0.008	0.027
LI Traditional + Deep Strata	6,012	5%	0.050	437,038	32%	0.314	236,336	808,180	NA	NA	NA	NA	0.014	33%	0.318	0.007	0.026
SNE Traditional + Deep	7,334	5%	0.050	343,108	45%	0.425	149,089	789,618	NA	NA	NA	NA	0.021	45%	0.428	0.009	0.049
GBK Traditional + Deep	0	5%	0.050	623,958	29%	0.289	354,264	1,098,963	NA	NA	NA	NA	0.000	0%	0.293	0.000	0.000
All regions	18,190	5%	0.050	1,689,342	17%	0.169	1,212,953	2,352,833	NA	NA	NA	NA	0.011	18%	0.176	0.008	0.015
All regions less GBK	18,190	5%	0.050	1,065,384	21%	0.205	712,503	1,593,036	NA	NA	NA	NA	0.017	21%	0.211	0.011	0.026
KLAMZ Stock Assessment																	
SVA	NA	NA	NA	76	10%	0.101	62	93	320	2%	24%	0%	0.000	0%	0.000	0.000	0.000
DMV	NA	NA	NA	62,446	18%	0.177	44,161	88,303	133,971	8%	47%	2%	0.019	19%	0.188	0.013	0.028
NJ	NA	NA	NA	257,461	24%	0.234	162,594	407,678	355,055	17%	73%	4%	0.013	27%	0.261	0.008	0.022
LI Traditional + Deep Strata	NA	NA	NA	533,789	17%	0.169	383,010	743,925	590,317	15%	90%	1%	0.011	18%	0.182	0.008	0.016
SNE Traditional + Deep	NA	NA	NA	339,601	13%	0.127	264,996	435,210	369,894	12%	92%	1%	0.022	13%	0.133	0.017	0.029
GBK Traditional + Deep	NA	NA	NA	622,270	38%	0.364	304,730	1,270,698	622,270	38%	100%	0%	0.000	0%	0.000	0.000	0.000
All regions	NA	NA	NA	1,815,643	14%	0.144	1,369,454	2,407,208	2,071,826	13%	88%	NA	0.010	18%	0.177	0.007	0.014
Total less GBK	NA	NA	NA	1,193,374	10%	0.099	982,913	1,448,897	1,449,557	8%	82%	NA	0.015	18%	0.177	0.011	0.022



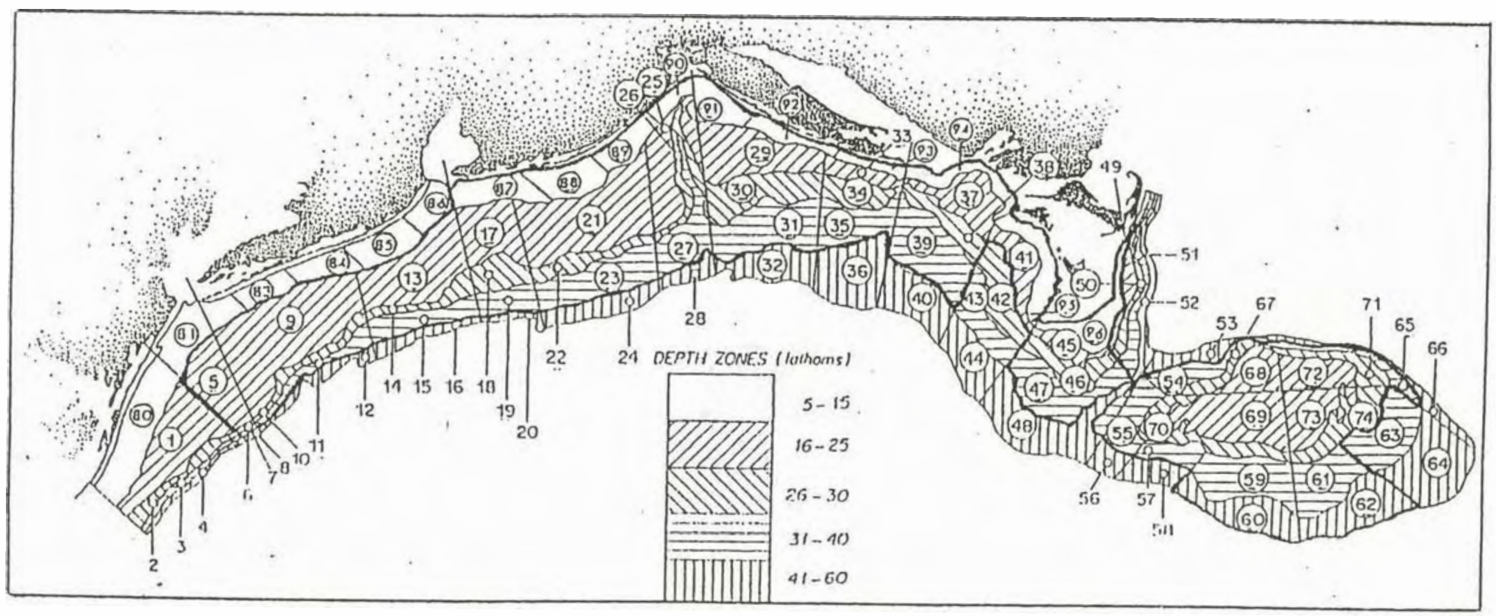


Figure C1. Regions and strata used in the NMFS clam survey.

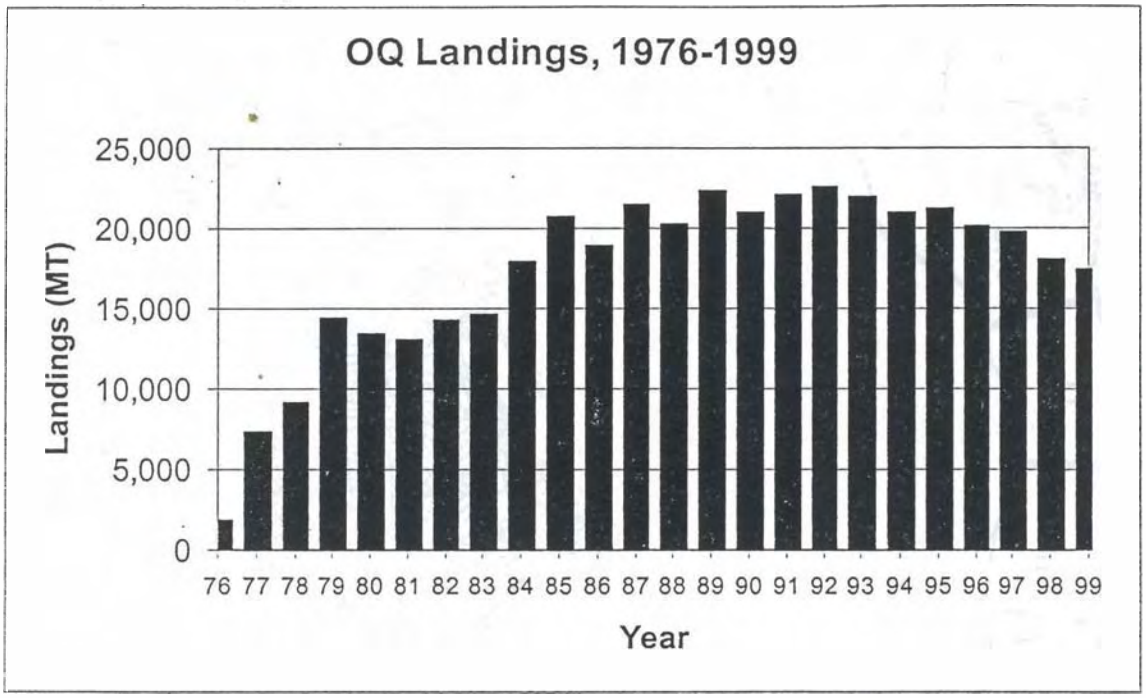


Figure C2. Landings of Ocean quahogs from EEZ waters, 1976-1999.

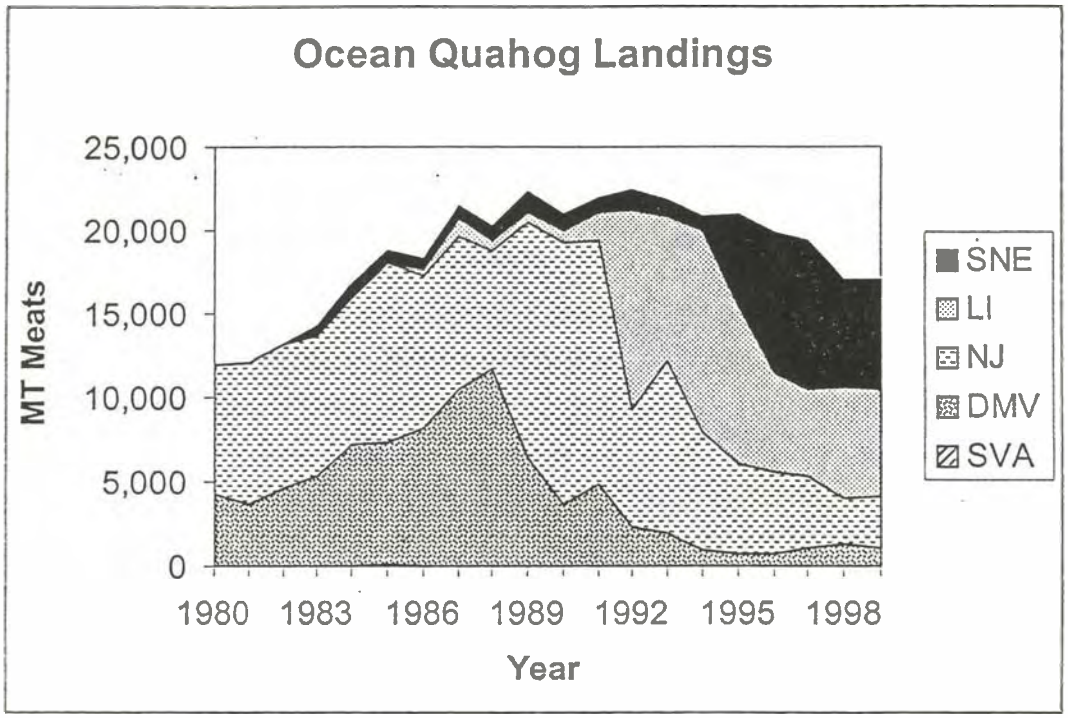


Figure C3. Ocean quahog landings in weight (calculated from number of bushels reported in logbooks) for the US EEZ, by stock assessment region. GBK not shown because landings and fishing effort were zero.

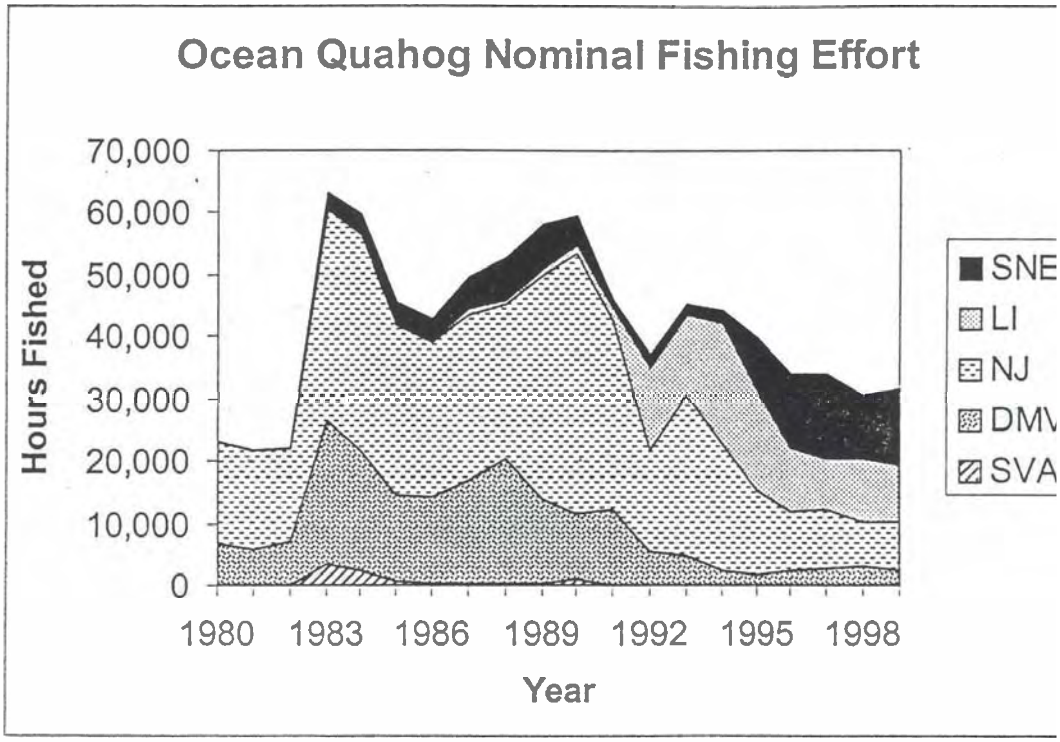


Figure C4. Nominal fishing effort for ocean quahog in the US EEZ, by stock assessment region from logbooks. GBK not shown because landings and fishing effort were zero.

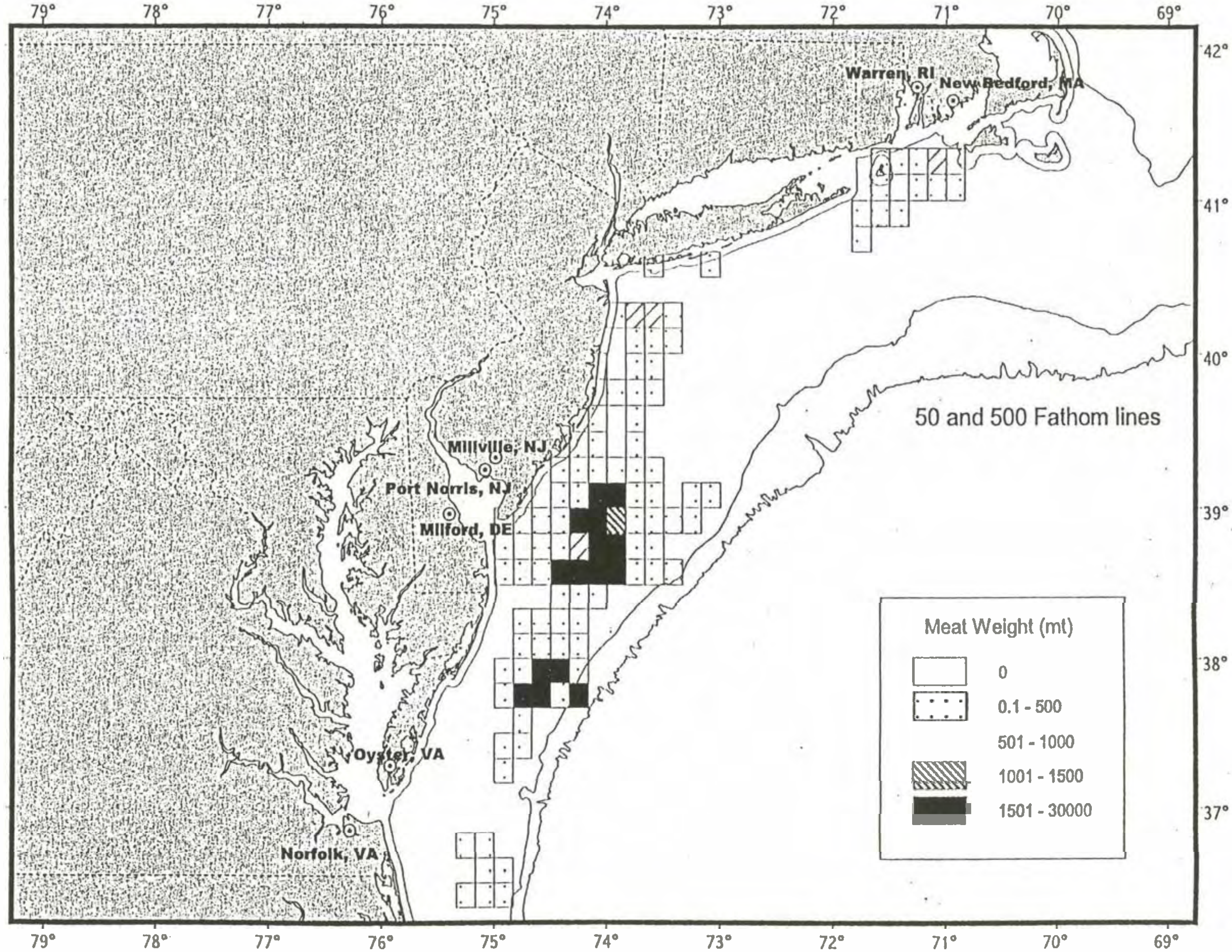


Figure C5.
Cumulative landings of ocean quahogs by 10' squares, 1980 - 1985. Dots indicate the location of ocean quahog processor

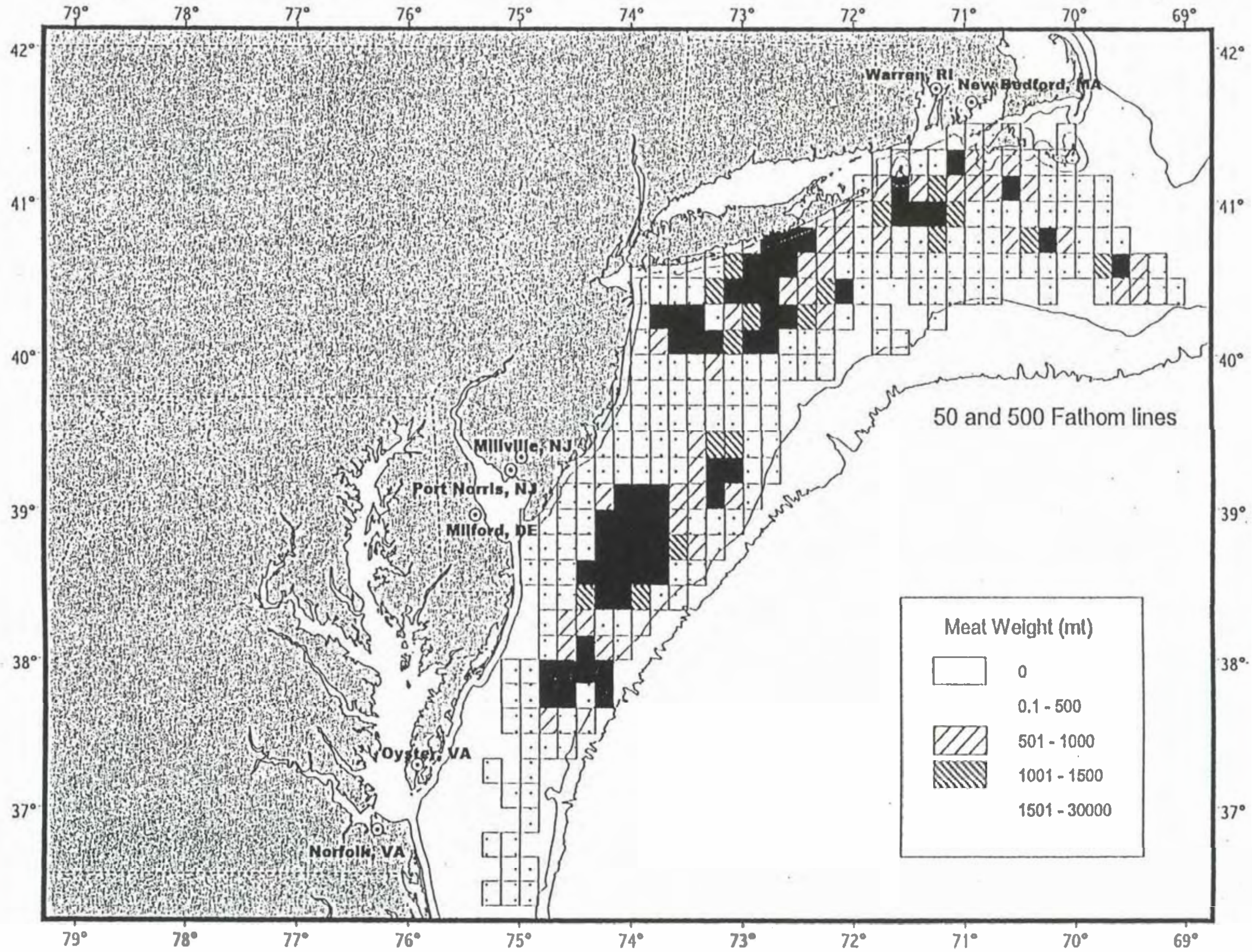


Figure C6.
Cumulative landings of ocean quahogs by 10' squares, 1980 - 1999. Dots indicate the location of ocean quahog processors

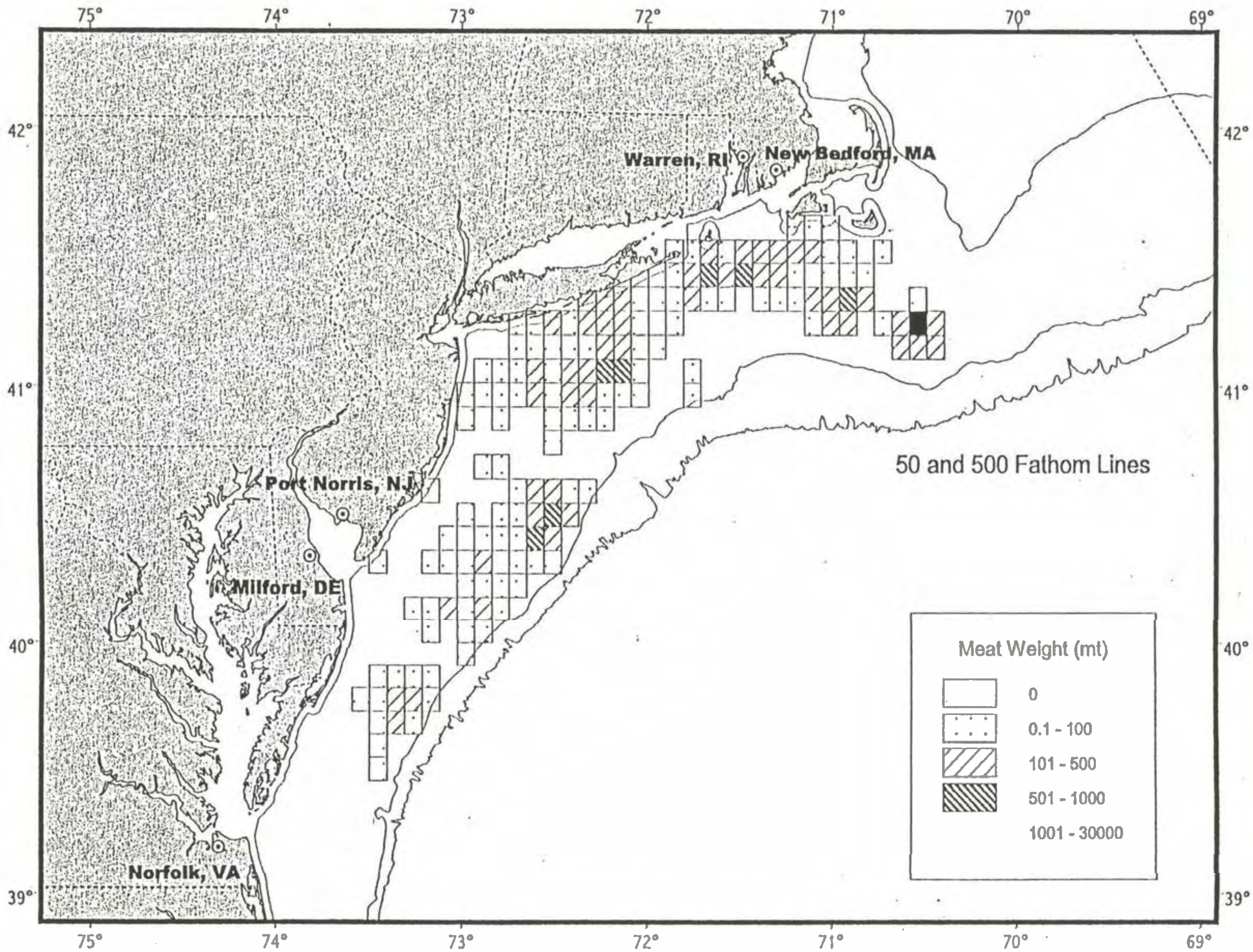


Figure C7. Landings of ocean quahogs by 10 ' squares, 1997. Dots indicate the location of ocean quahog processors.

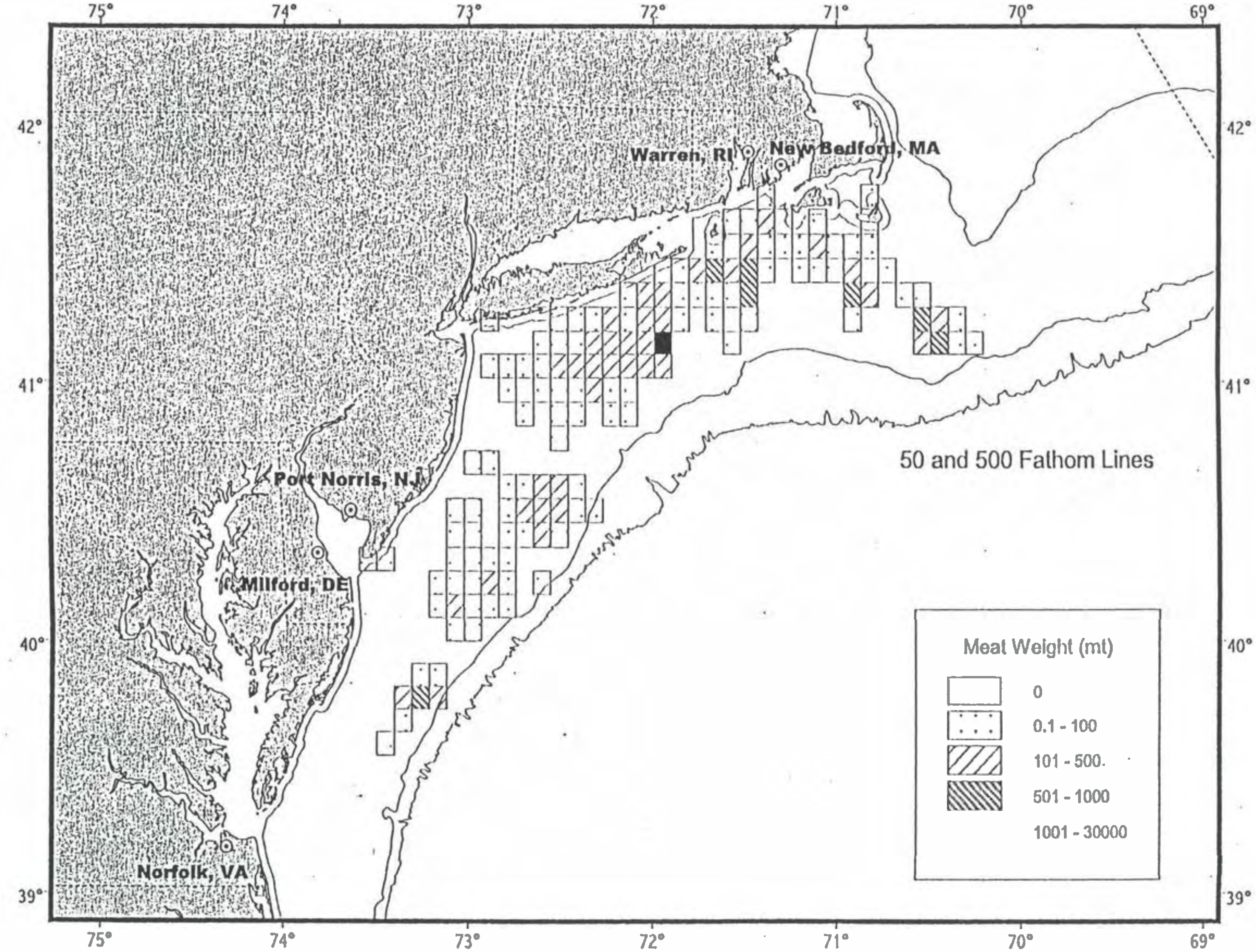


Figure C8. Landings of ocean quahogs by 10 ' squares, 1998. Dots indicate the location of ocean quahog processors.

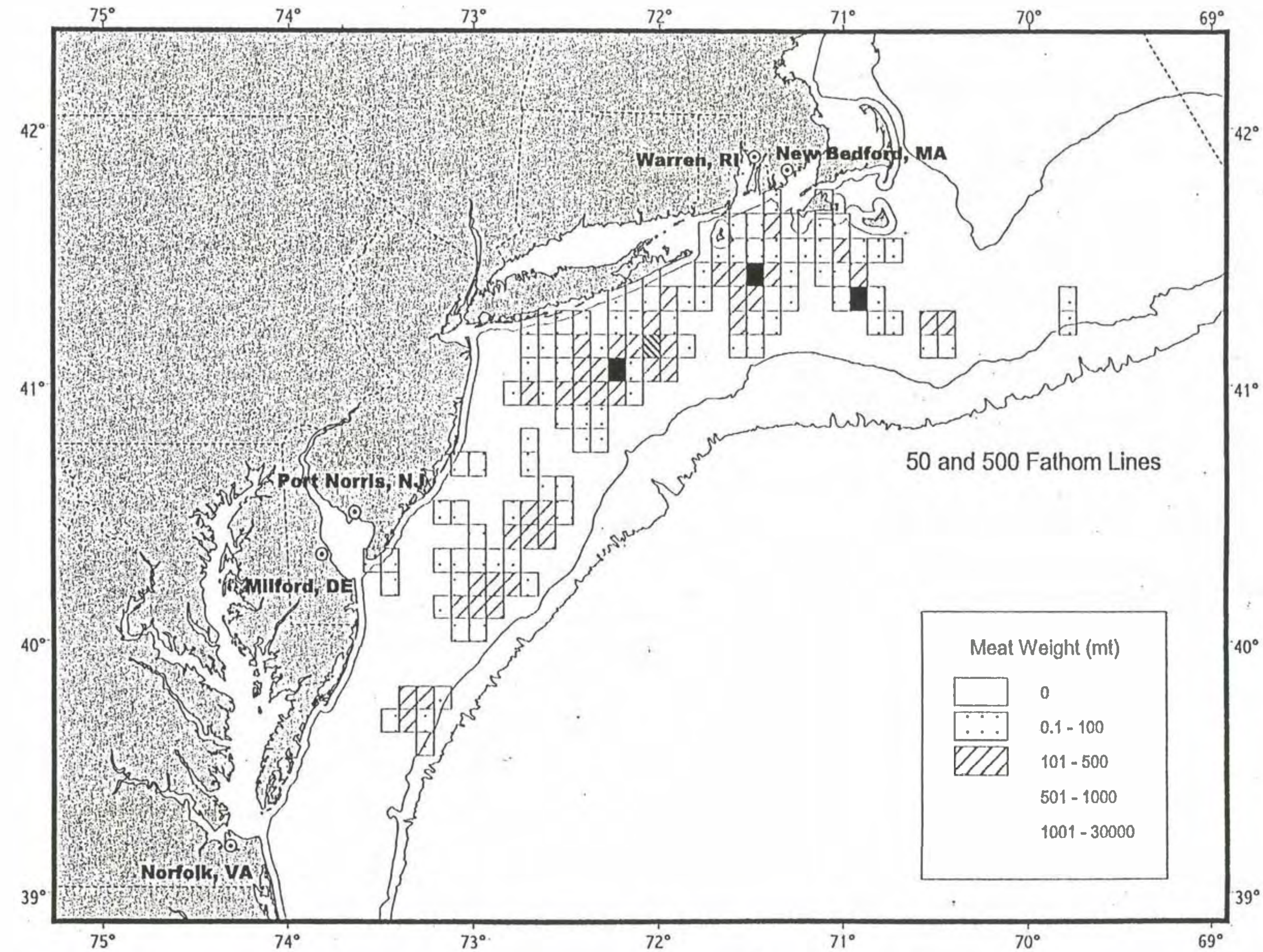


Figure C9. Landings of ocean quahogs by 10 ' squares, 1999. Dots indicate the location of ocean quahog processors.

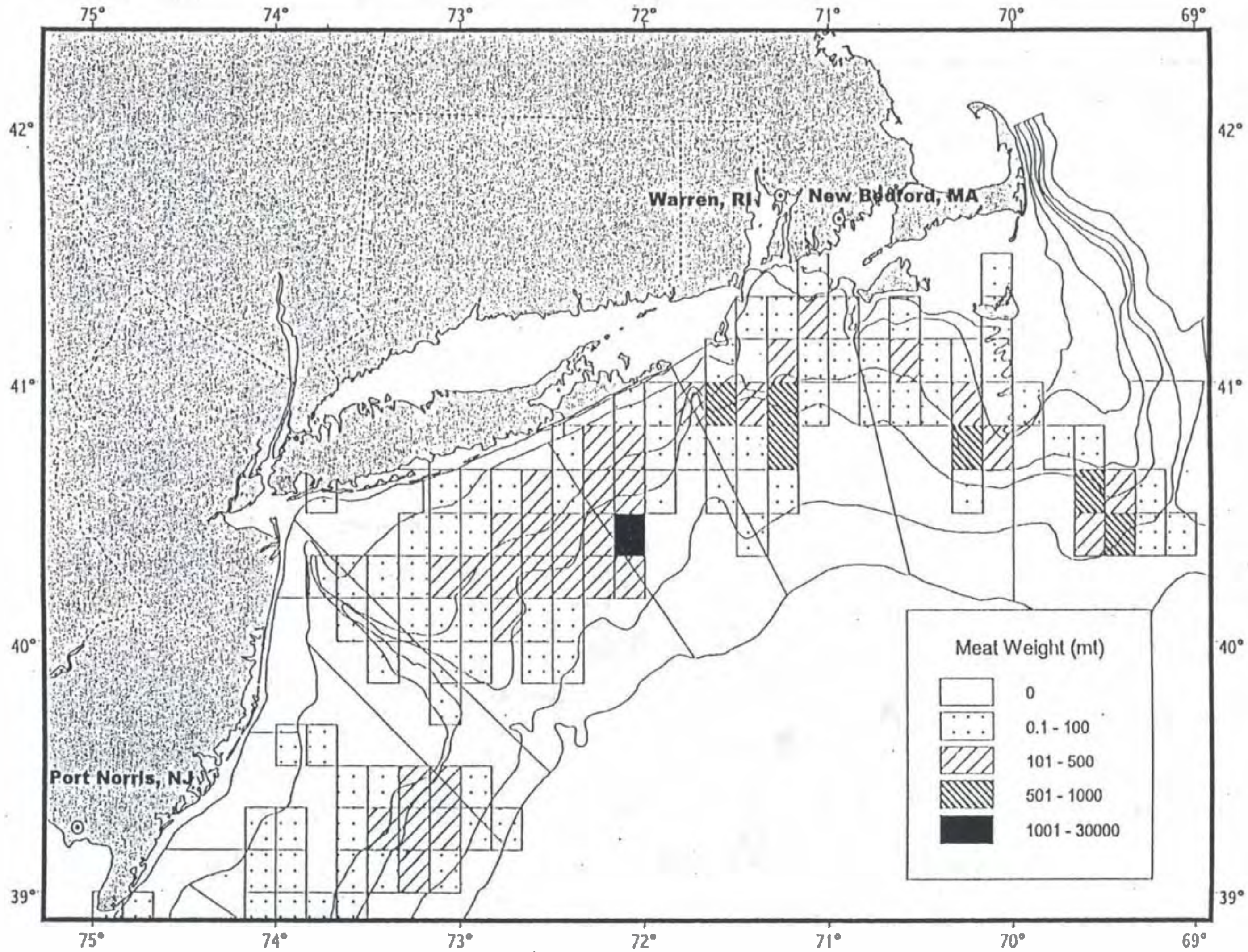


Figure C10. Landings of ocean quahogs by 10 ' squares, 1998. NMFS Clam strata are also shown. Dots indicate the location of ocean quahog processors.

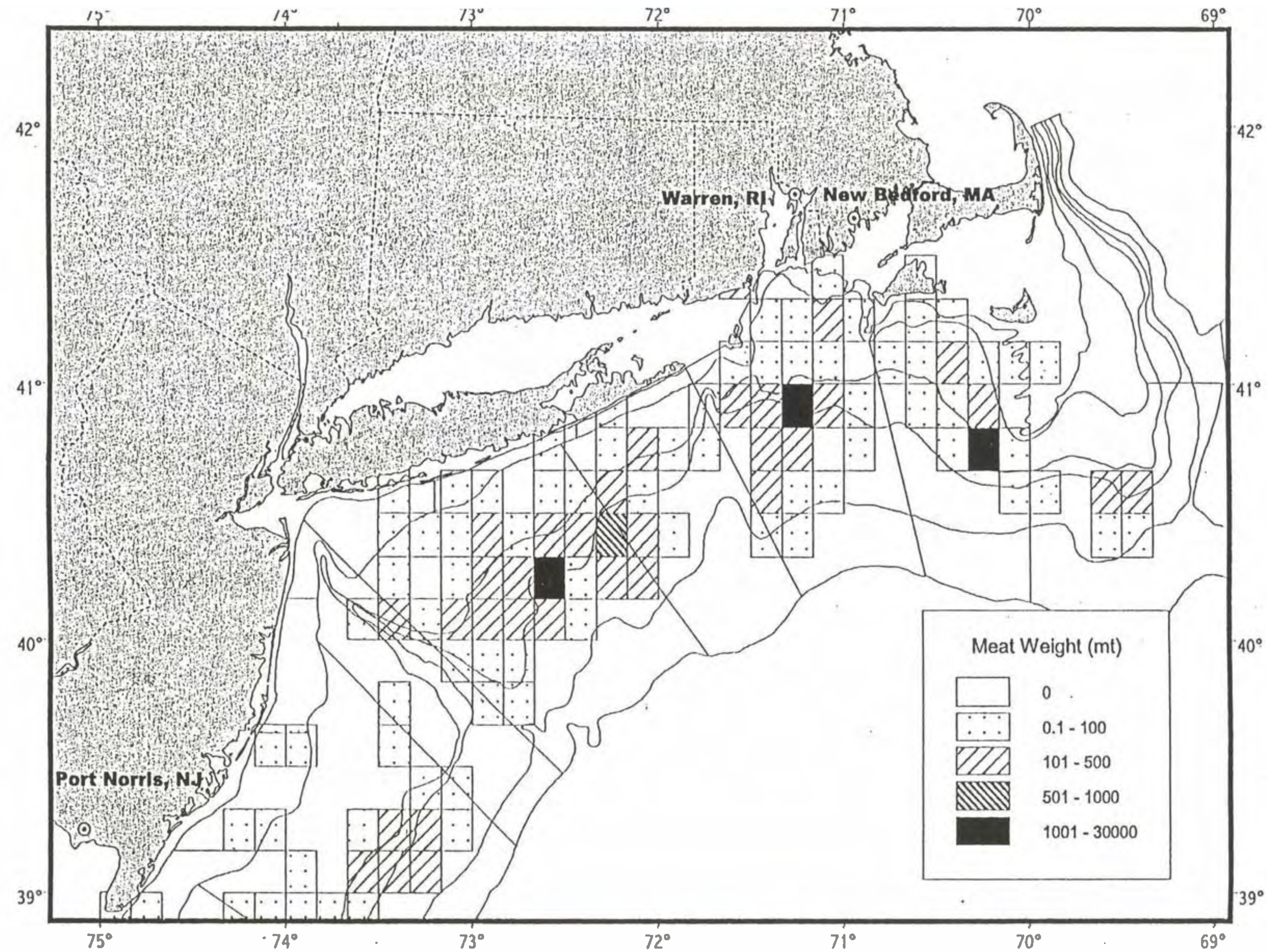


Figure C11. Landings of ocean quahogs by 10 ' squares, 1999. NMFS Clam strata are also shown. Dots indicate the location of ocean quahog processors.

Figure C12.
Distribution of commercial ocean quahog landings during 1990-1999 (bushels).
Catch per tow during NMFS DE-II nonrandom stations using a 1 inch mesh liner, 1992-1994 (numbers).

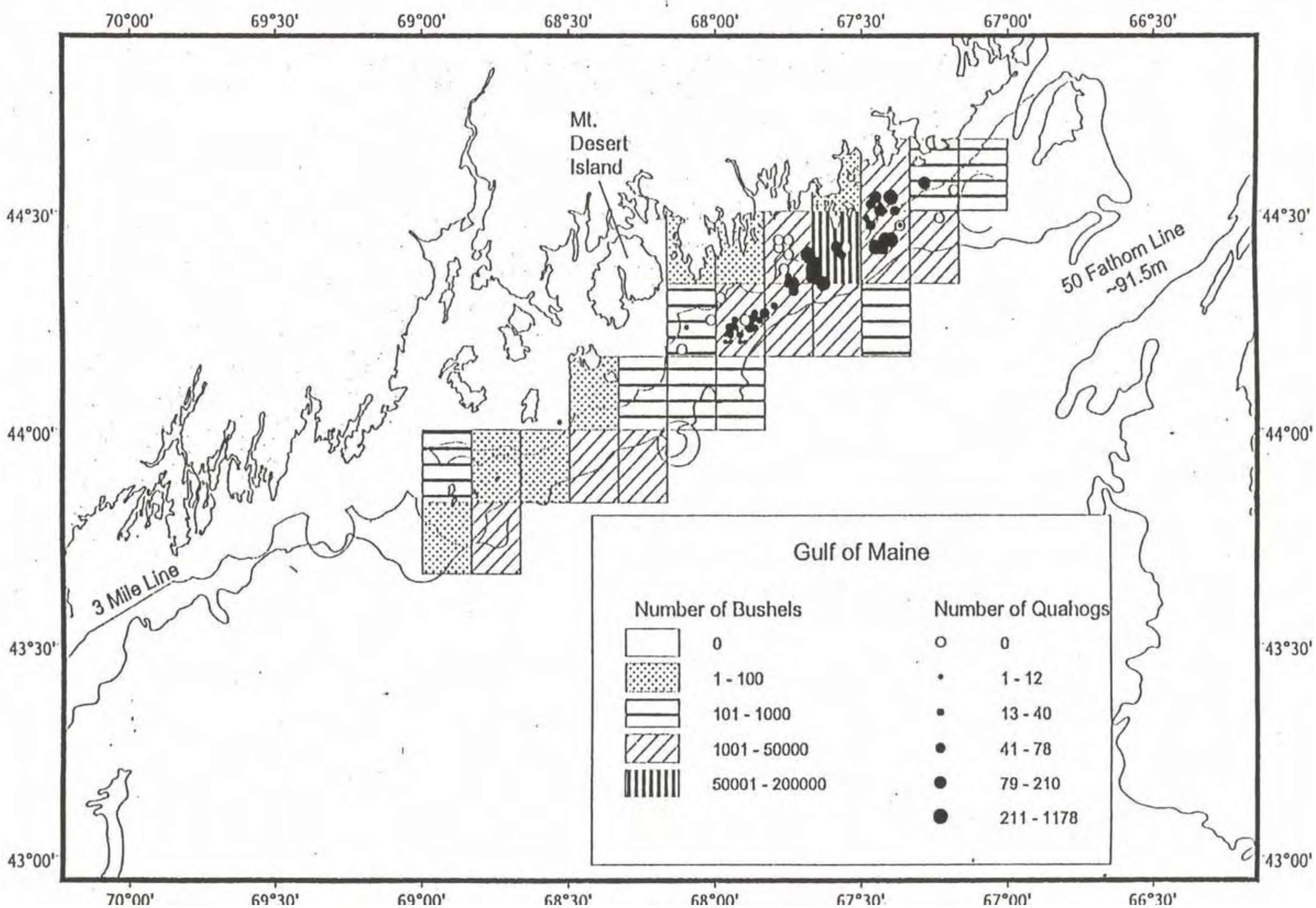
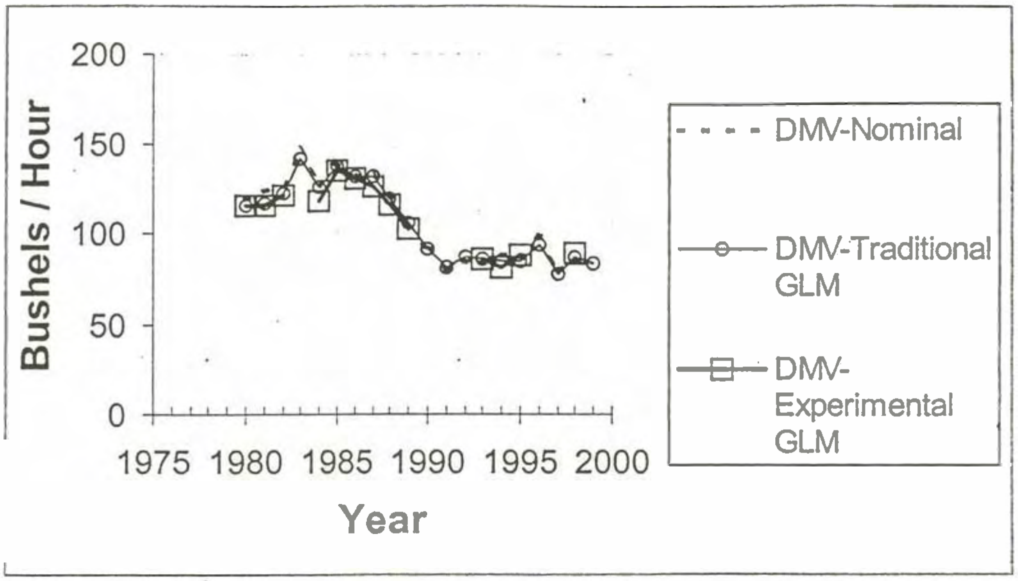


Figure C13. Trends in nominal and standardized LPUE from traditional and experimental GLM models) for ocean quahog in the DMV stock assessment region.



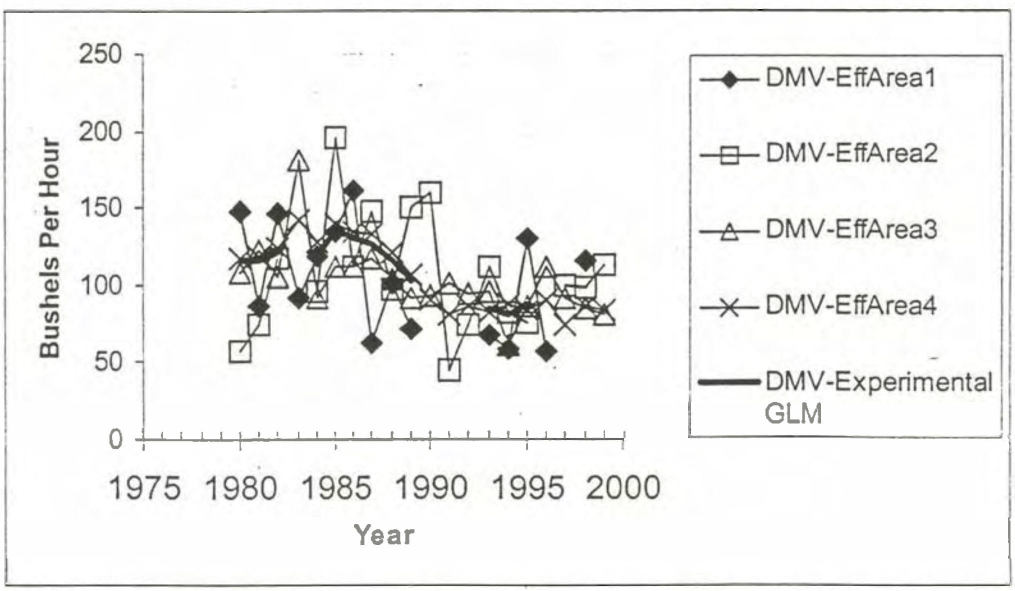
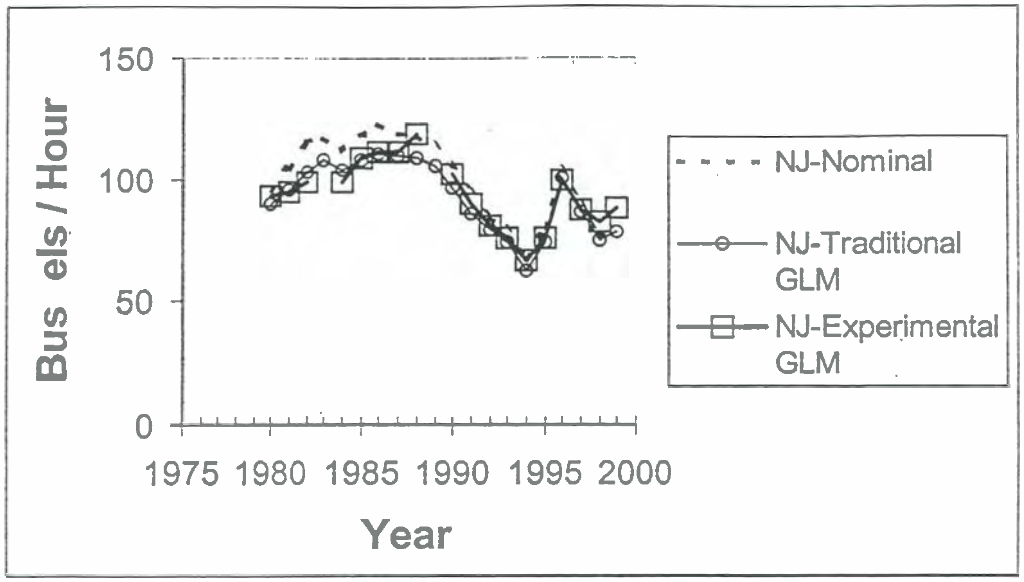


Figure C14. Trends in nominal and standardized LPUE (from traditional and experimental GLM models) for ocean quahog in the NJ stock assessment region.



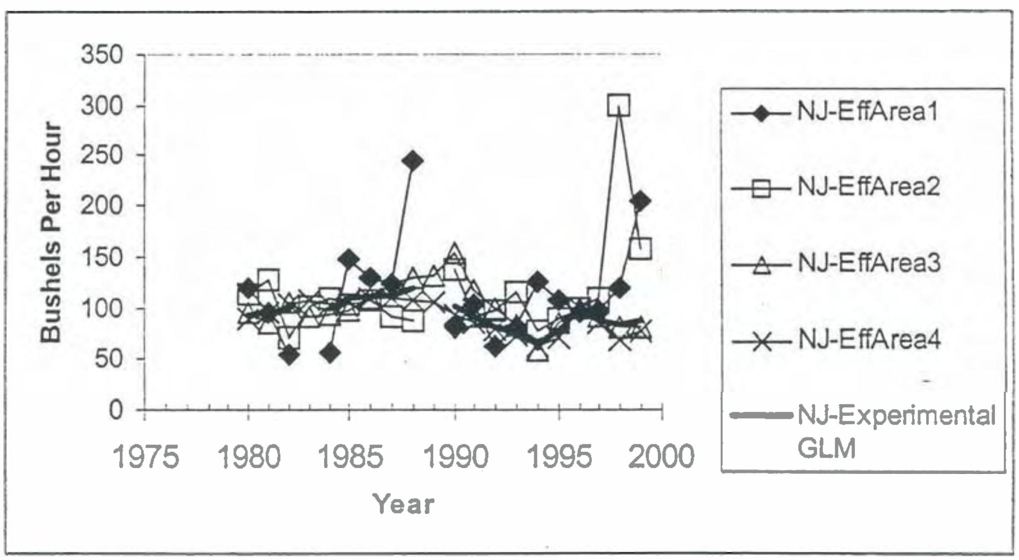
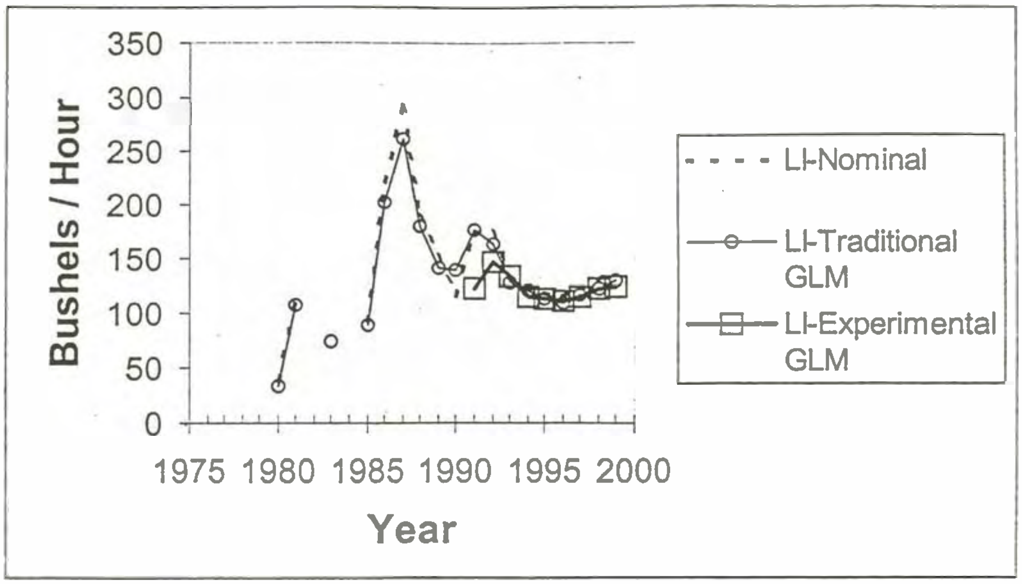


Figure C15. Trends in nominal and standardized LPUE (from traditional and experimental GLM models) for ocean quahog in the LI stock assessment region.



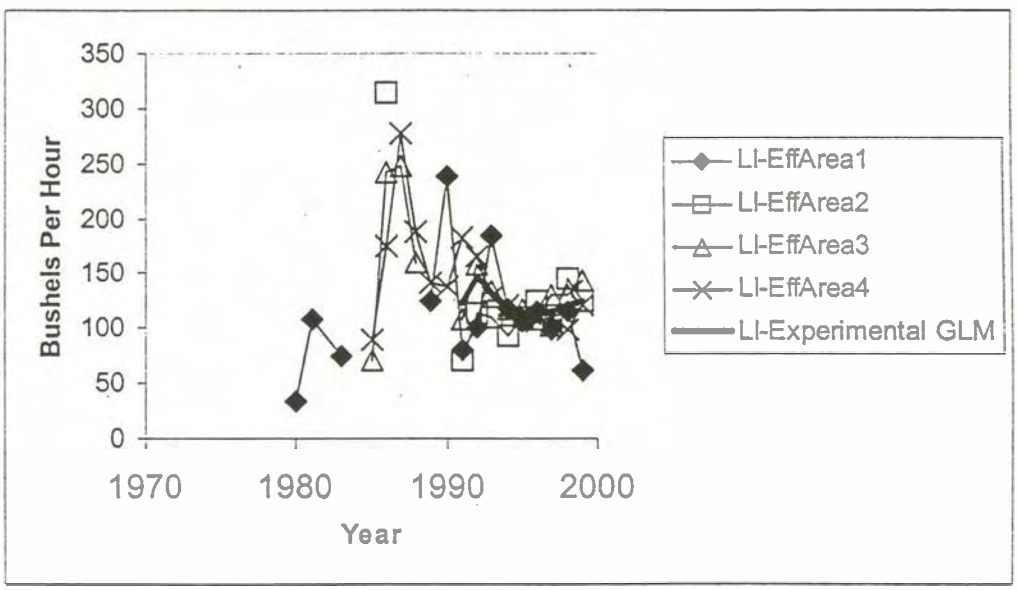
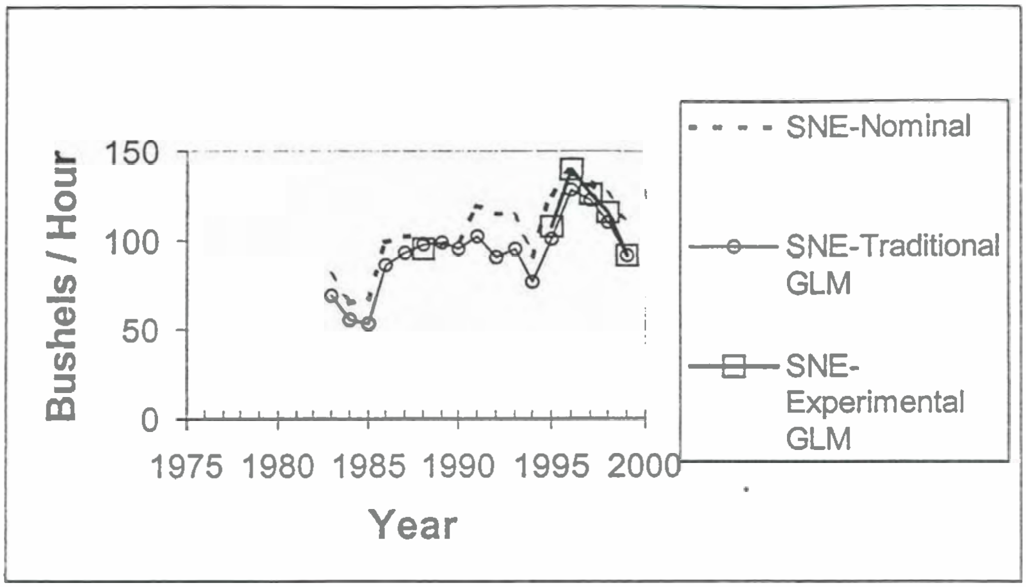


Figure C16. Trends in nominal and standardized LPUE (from traditional and experimenta GLM models) for ocean quahog in the SNE stock assessment region.



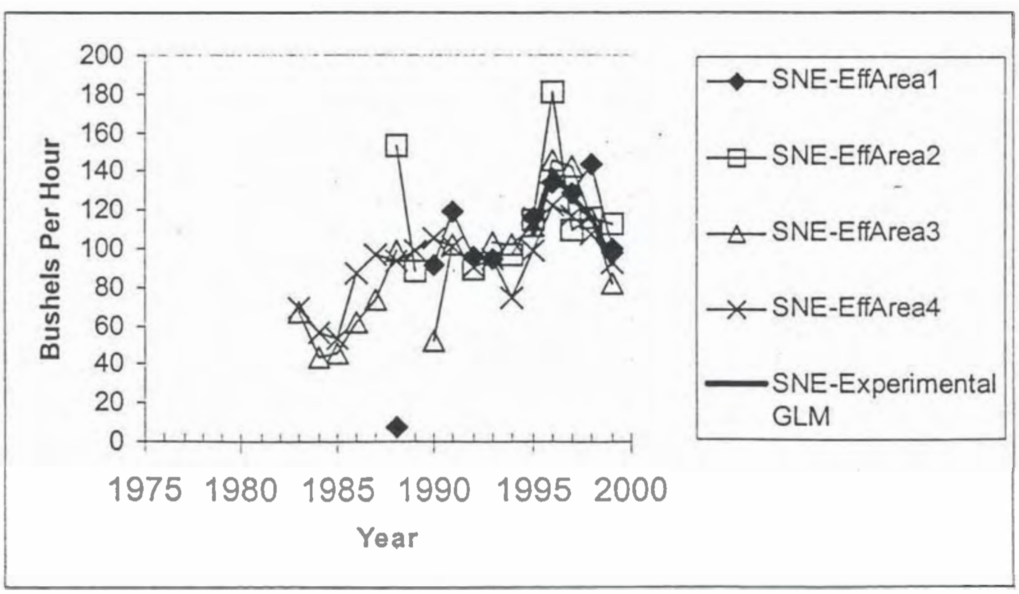
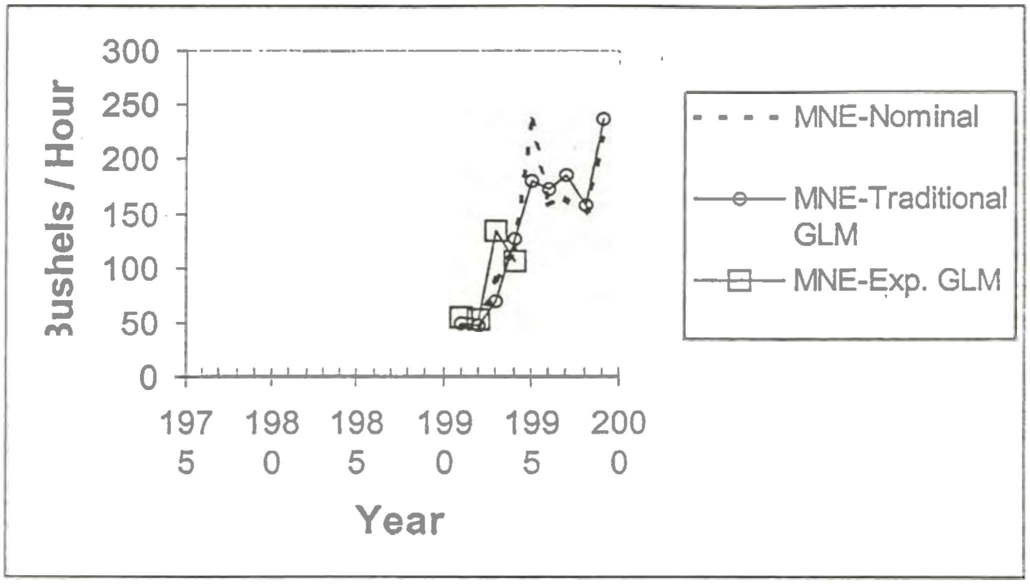


Figure C17. Trends in nominal and standardized LPUE (from traditional and experimental GLM models) for ocean quahog in the MNE stock assessment region. Nominal LPUE values for MNE were rescaled (multiplied by 24) to facilitate comparison with GLM values.



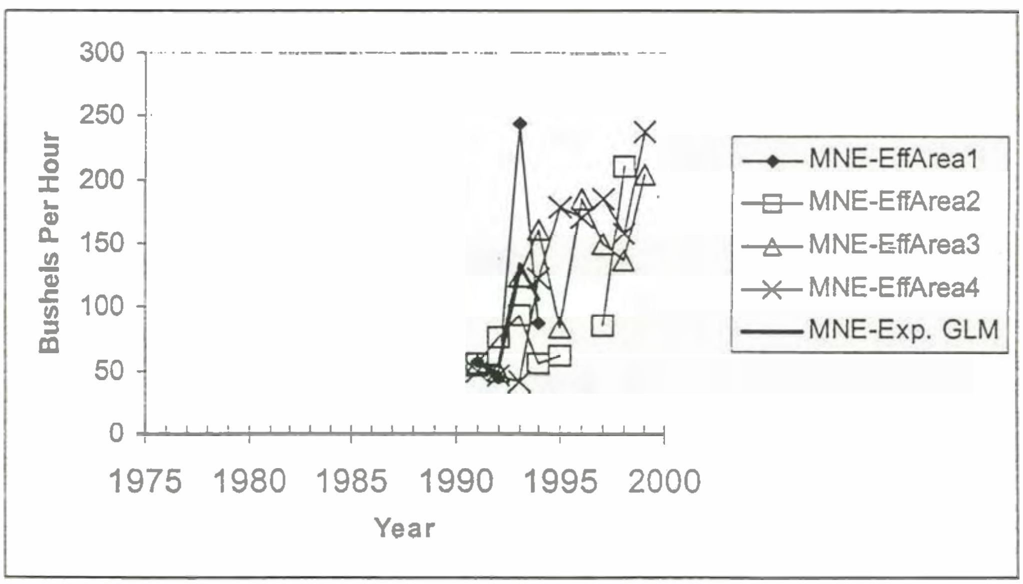


Figure C18. Proportions of total hours of fishing effort from logbooks for ocean quahog in the DMV stock assessment region by effort area and year. Areas (ten minute squares) assigned to effort area 4 had the highest cumulative fishing effort (total hours fished in the fourth quartile). Areas assigned to effort area 1 had the lowest cumulative fishing effort (total hours fished in the first quartile).

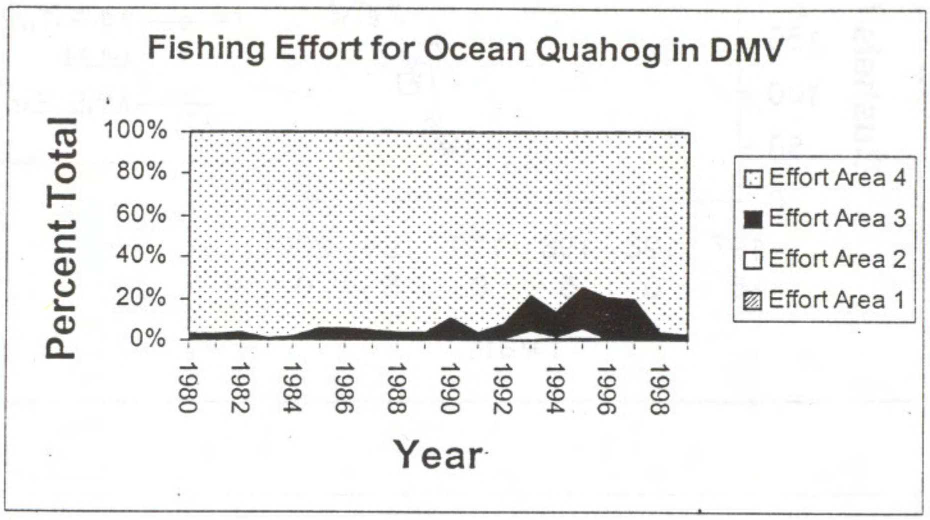


Figure C19. Proportions of total hours of fishing effort from logbooks for ocean quahog in the NJ stock assessment region by effort area and year. Areas (ten minute squares) assigned to effort area 4 had the highest cumulative fishing effort (total hours fished in the fourth quartile). Areas assigned to effort area 1 had the lowest cumulative fishing effort (total hours fished in the first quartile).

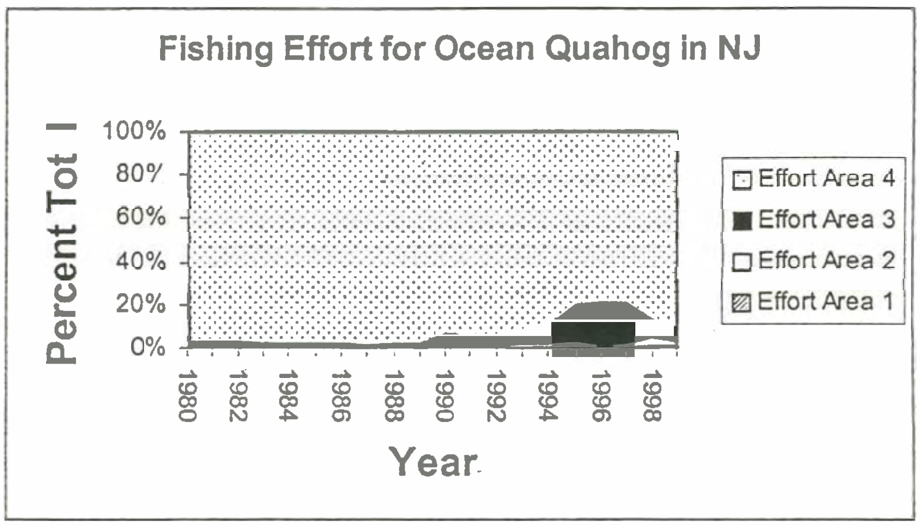


Figure C20. Proportions of total hours of fishing effort from logbooks for ocean quahog in the LI stock assessment region by effort area and year. Areas (ten minute squares) assigned to effort area 4 had the highest cumulative fishing effort (total hours fished in the fourth quartile). Areas assigned to effort area 1 had the lowest cumulative fishing effort (total hours fished in the first quartile).

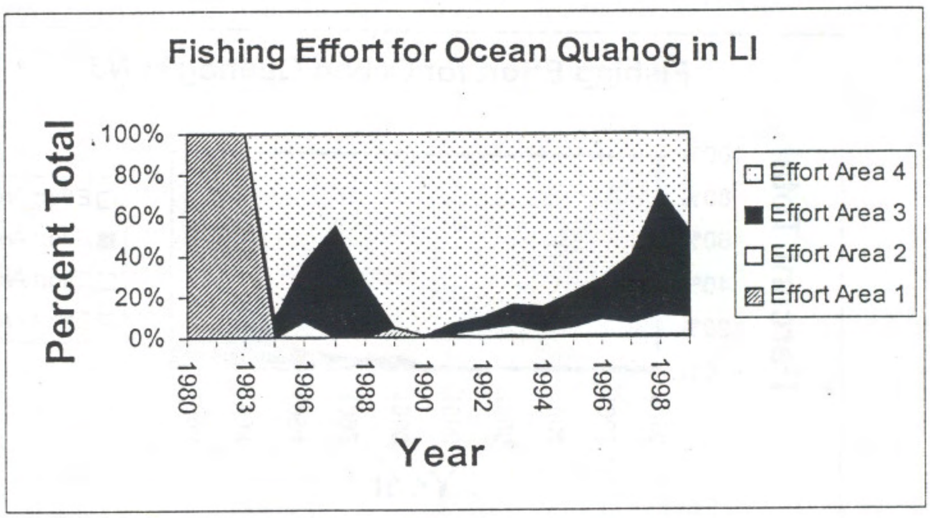


Figure C21. Proportions of total hours of fishing effort from logbooks for ocean quahog in the SNE stock assessment region by effort area and year. Areas (ten minute squares) assigned to effort area 4 had the highest cumulative fishing effort (total hours fished in the fourth quartile). Areas assigned to effort area 1 had the lowest cumulative fishing effort (total hours fished in the first quartile).

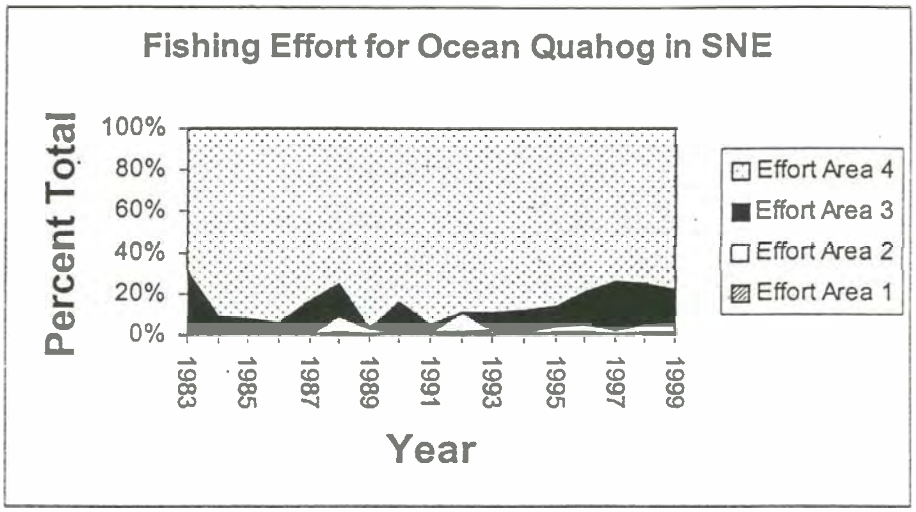
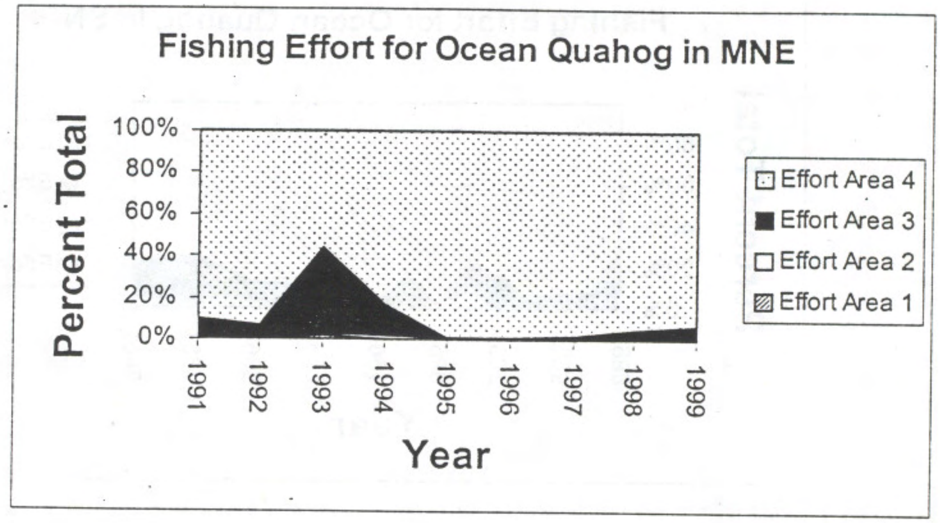


Figure C22. Proportions of total hours of fishing effort from logbooks for ocean quahog in the MNE stock assessment region by effort area and year. Areas (ten minute squares) assigned to effort area 4 had the highest cumulative fishing effort (total hours fished in the fourth quartile). Areas assigned to effort area 1 had the lowest cumulative fishing effort (total hours fished in the first quartile).



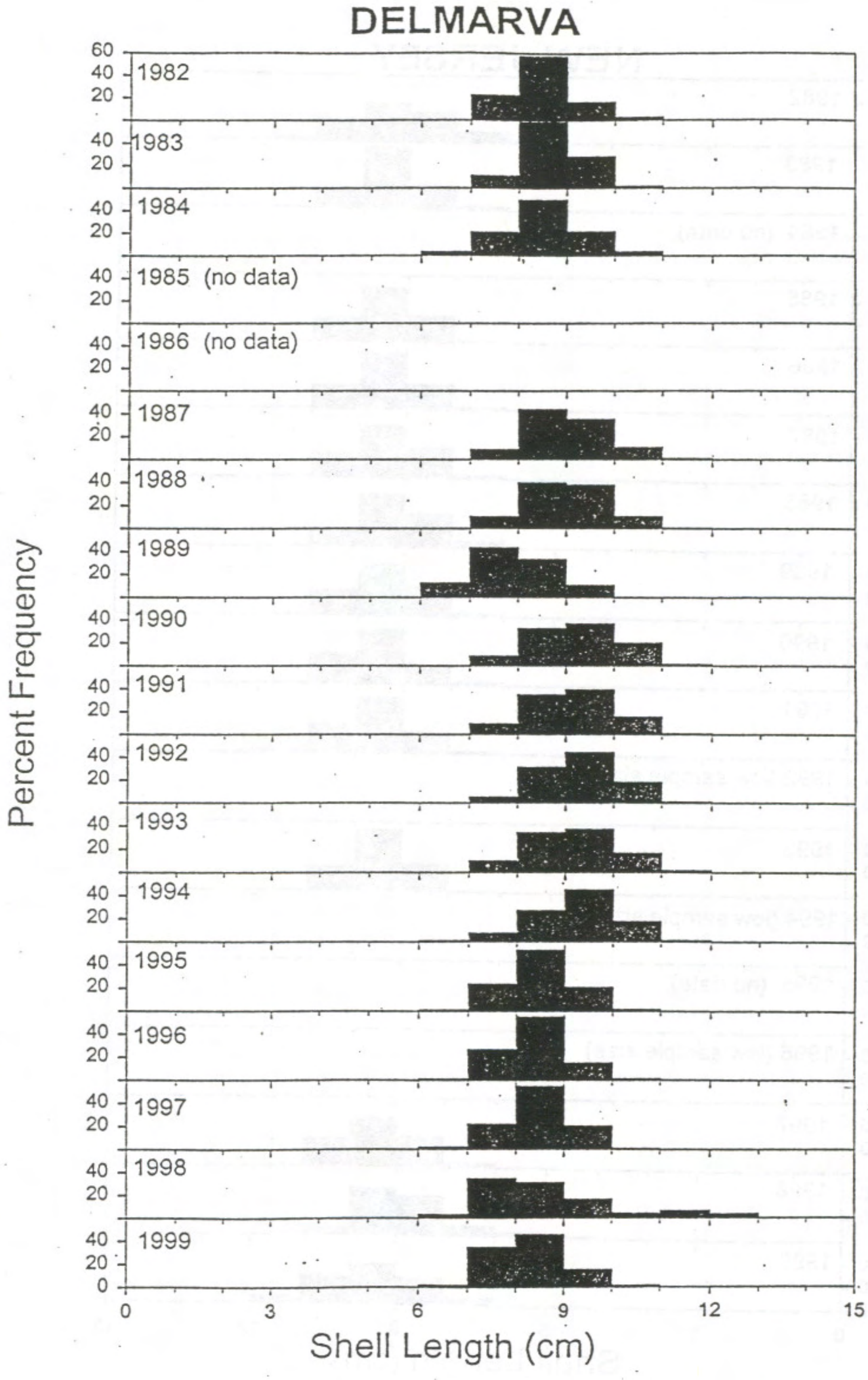


Figure C23. Ocean quahog length frequency distributions derived from port samples. Trips were catch-weighted.

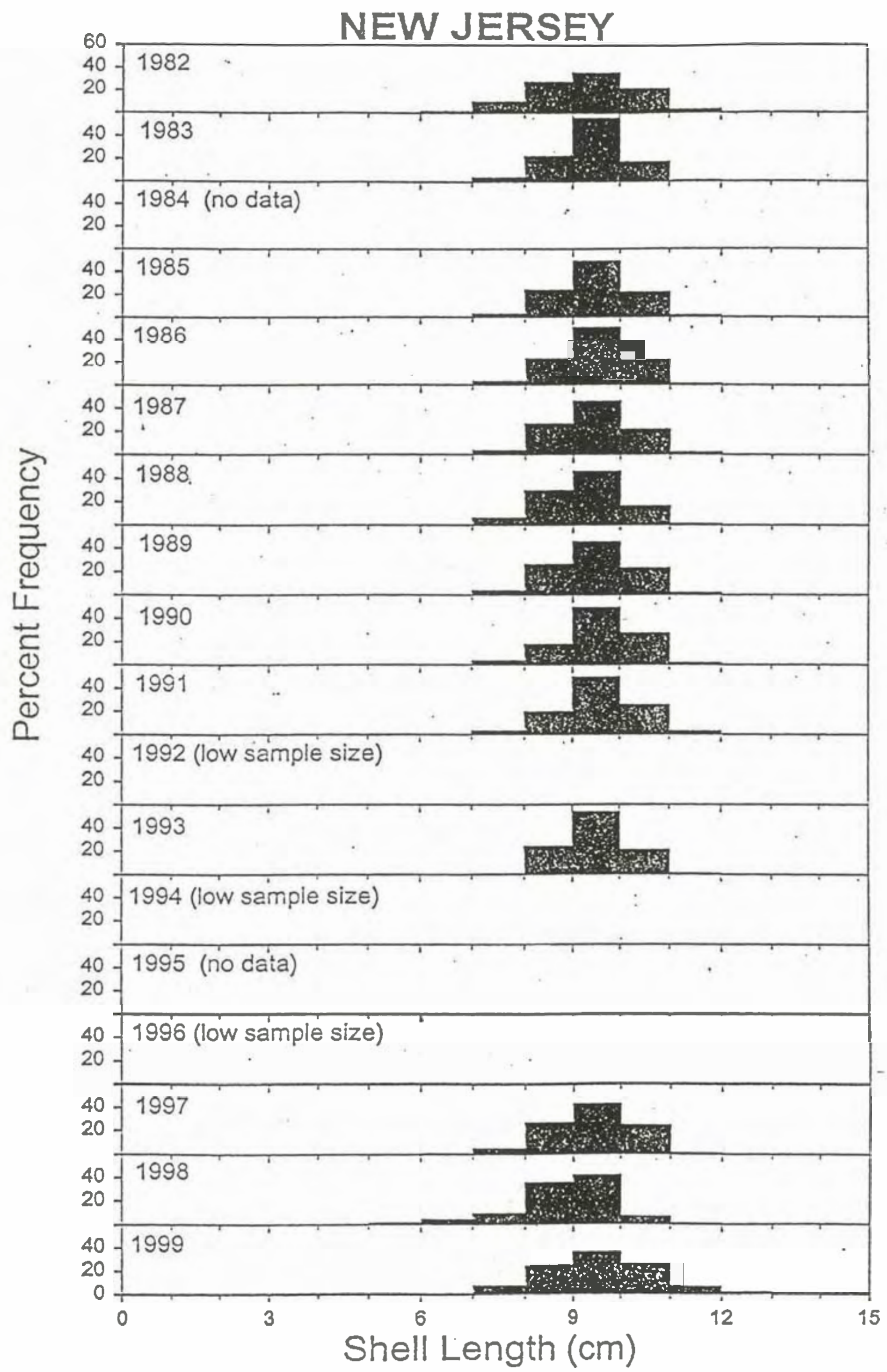


Figure C24. Ocean quahog length frequency distributions derived from port sampl
Trips were catch-weighted.

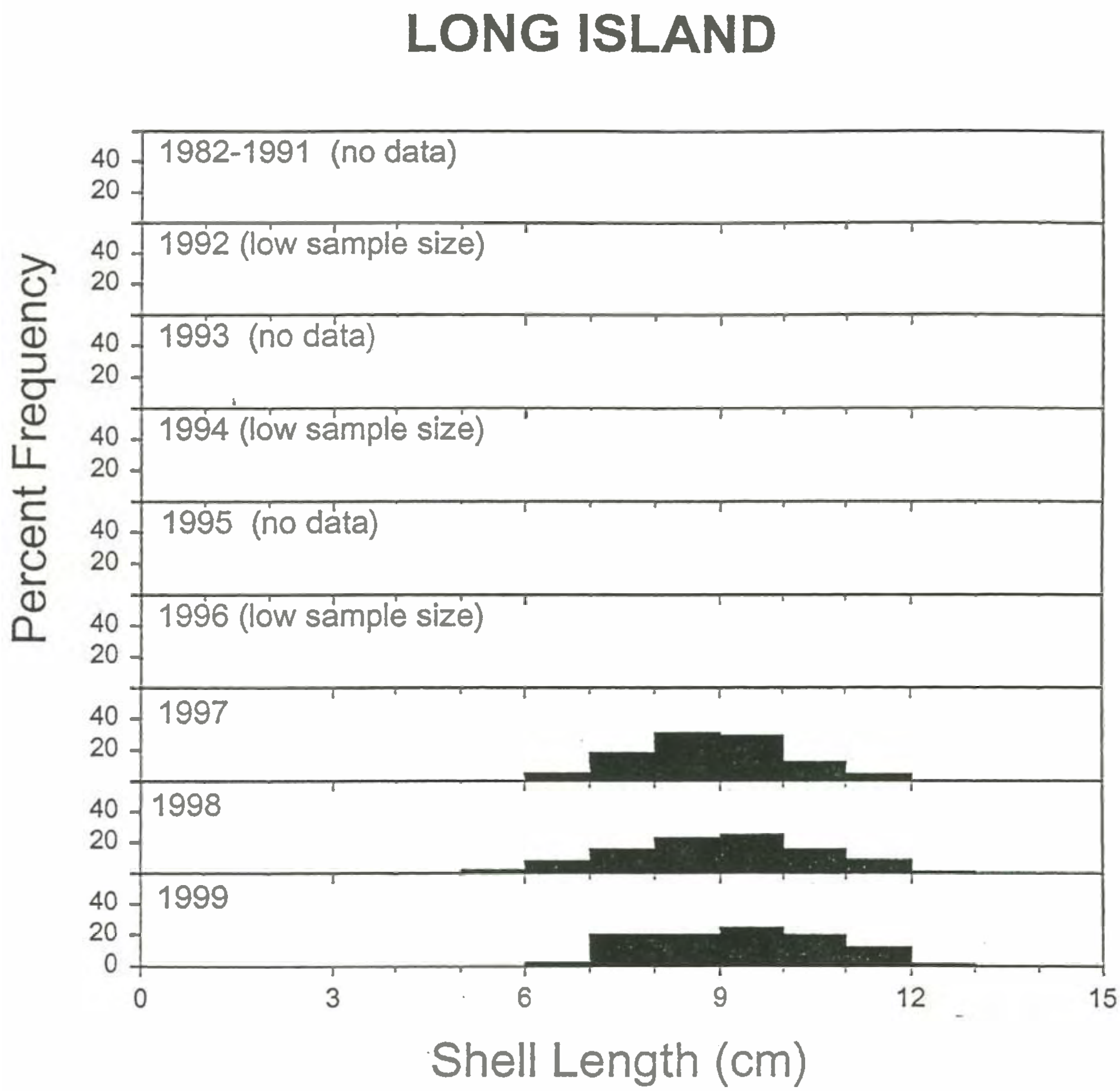


Figure C25. Ocean quahog length frequency distributions derived from port samples. Trips were catch-weighted.

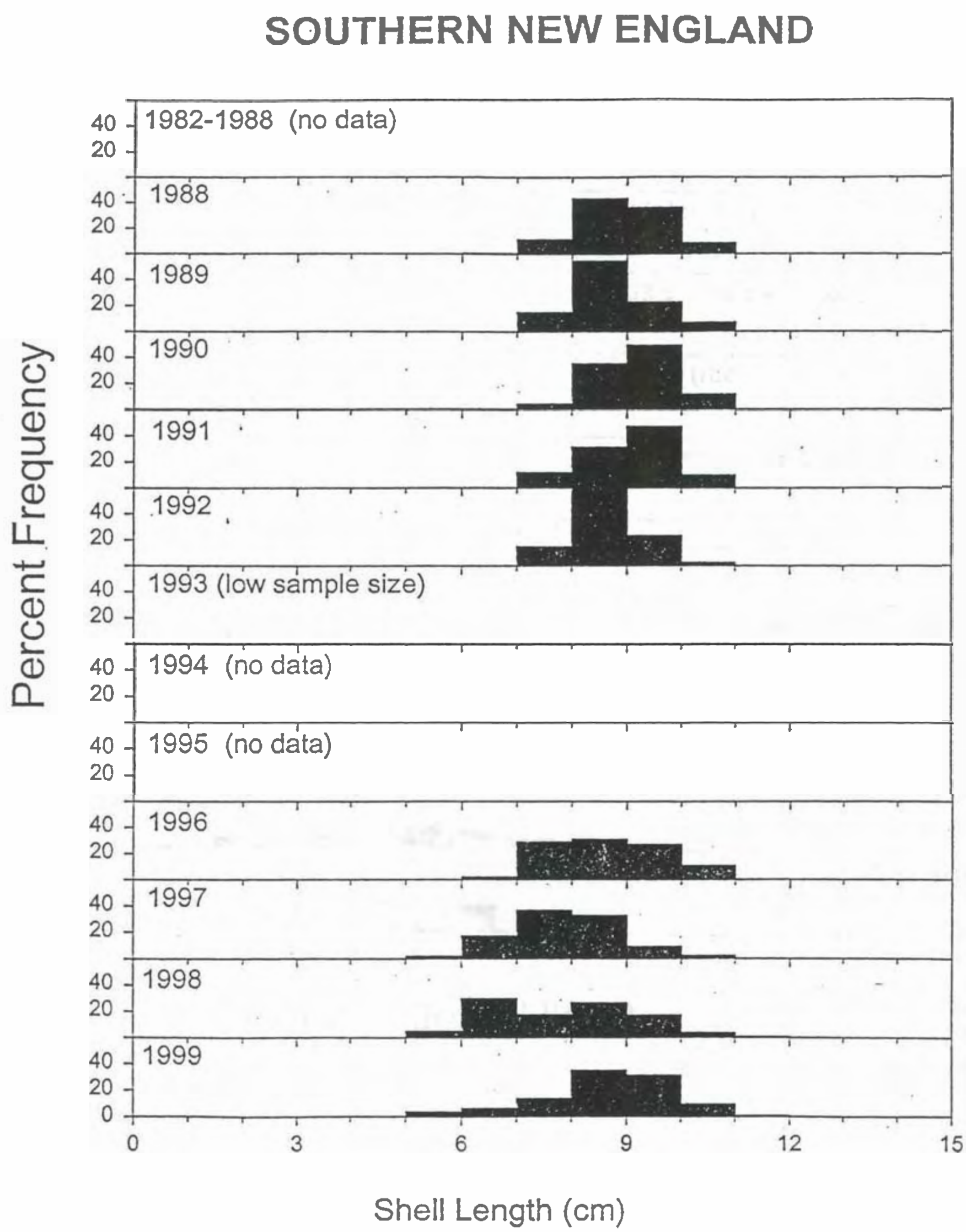


Figure C26. Ocean quahog length frequency distributions derived from port samples. Trips were catch-weighted.

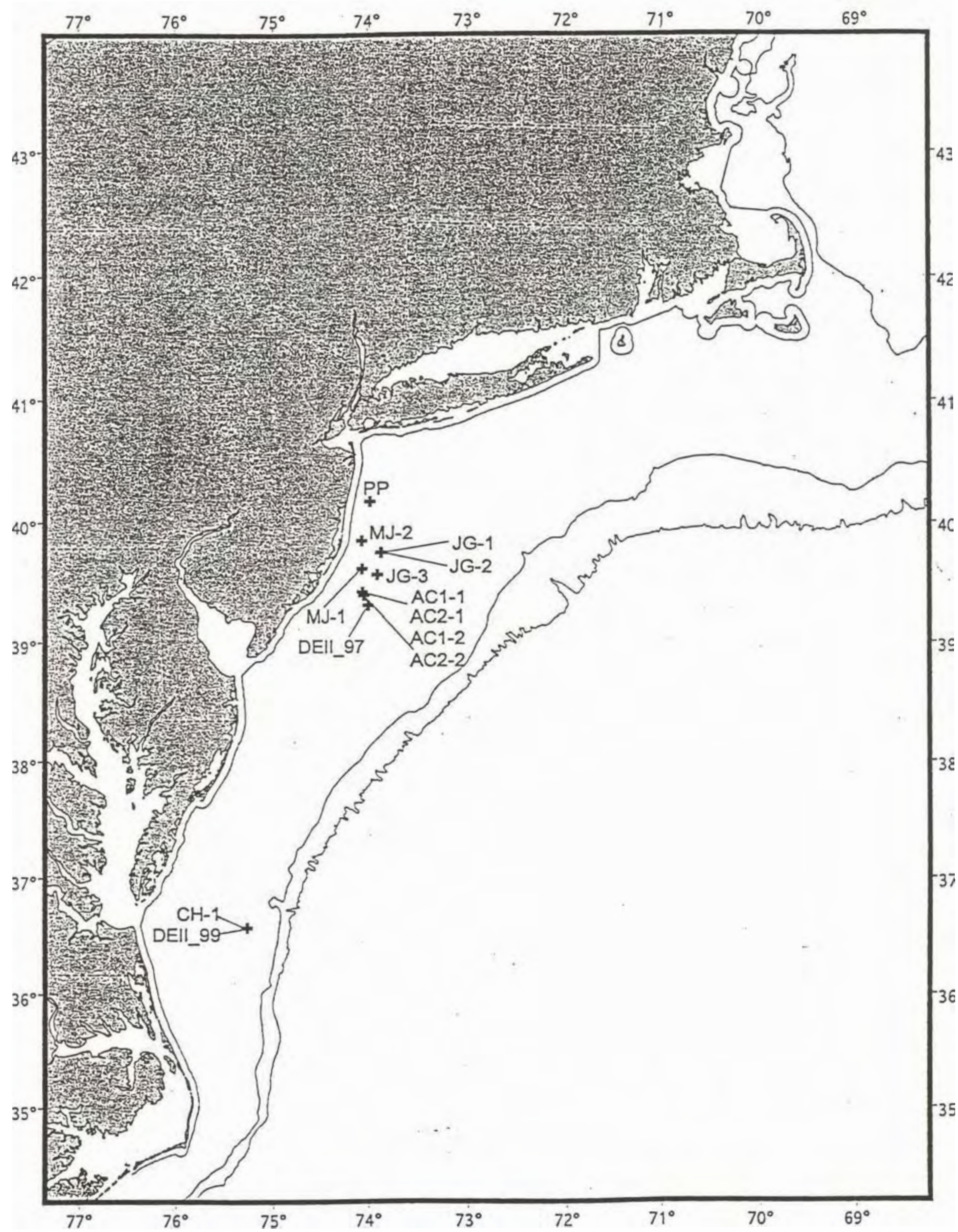


Figure C27. Locations of depletion experiments on Surf Clams, 1997-2000.

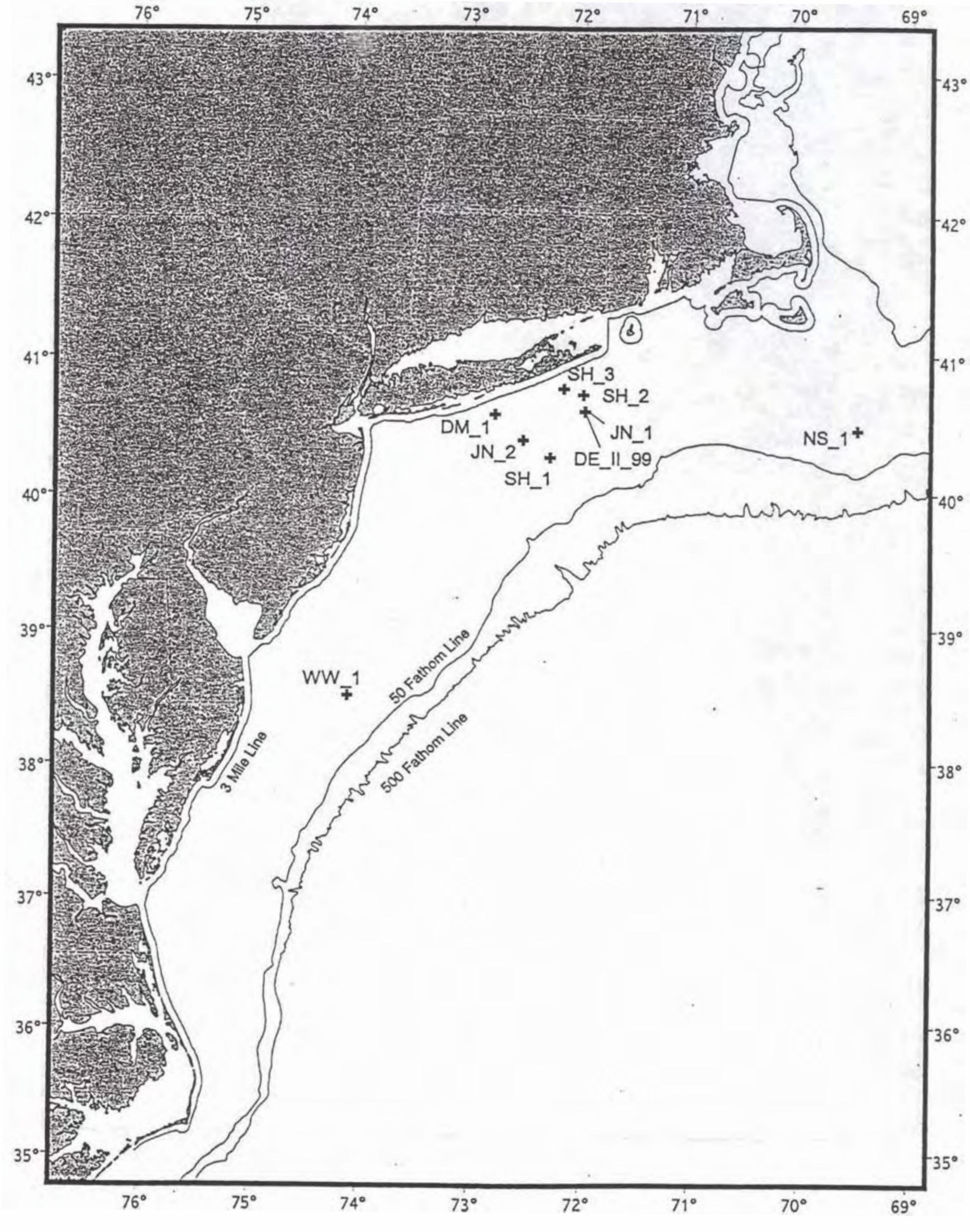
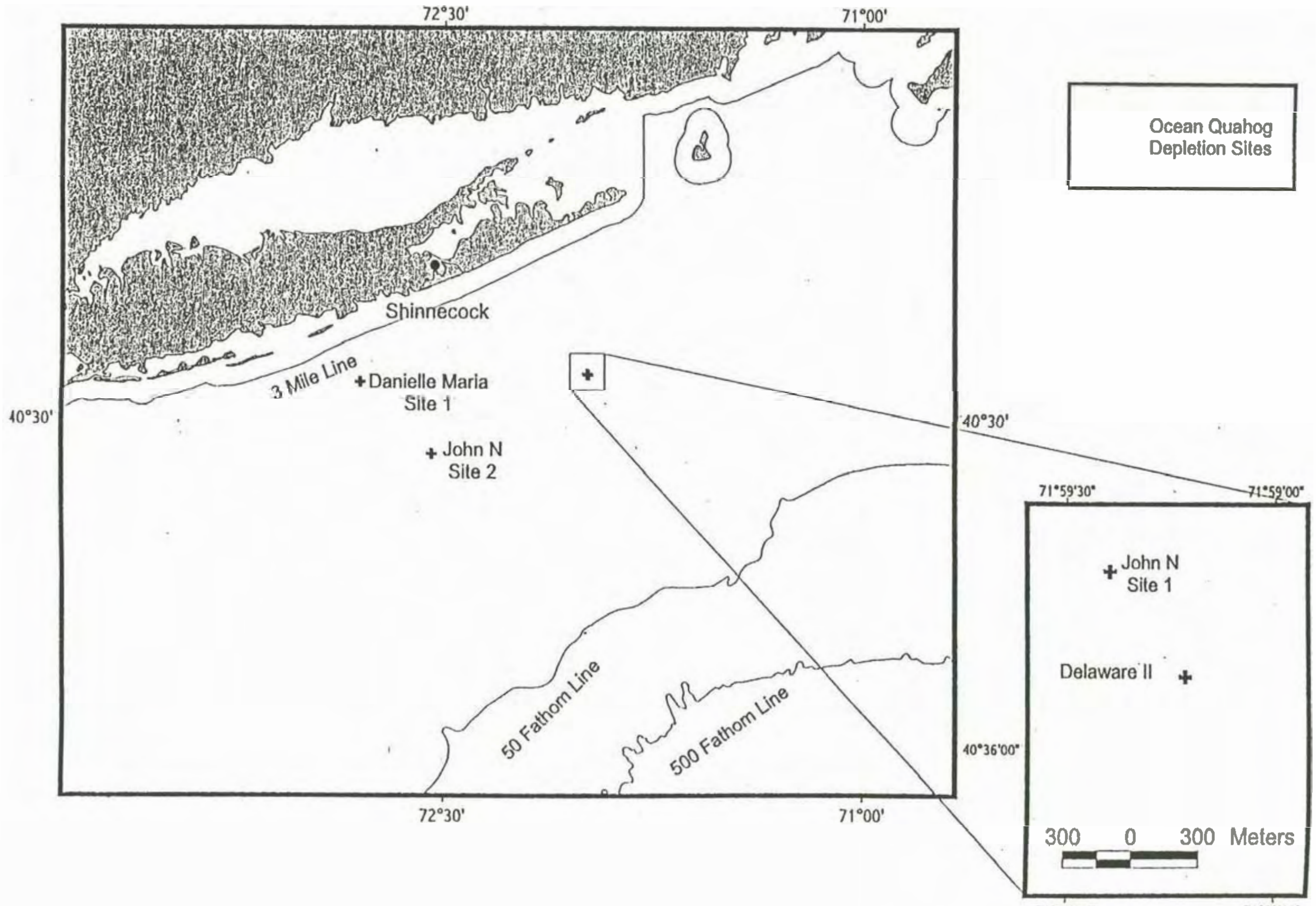


Figure C28. Locations of depletion experiments on Ocean Quahogs, 1997-2000.

Figure C29. Ocean Quahog Depletion Sites, June 1999 (R/V DE-11), March 2000 (F/V John N), and May 2000 (F/V Danielle Maria).



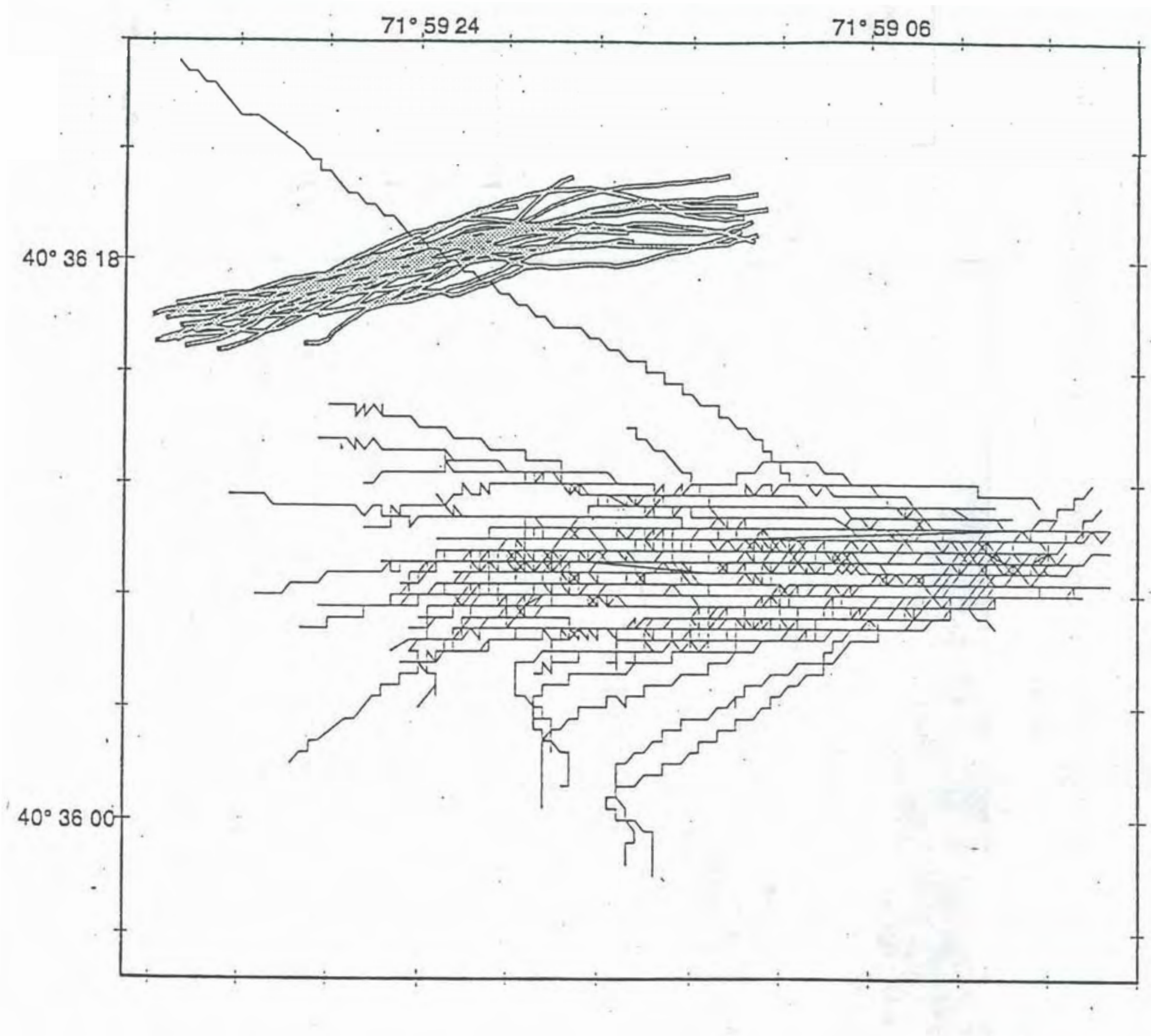


Figure C30. Ocean quahog depletion tow paths, (N=22), by the F/V John N. Experiment 1, March 2000. Thin lines are setup tows conducted by the R/V DE-II, June 1999.

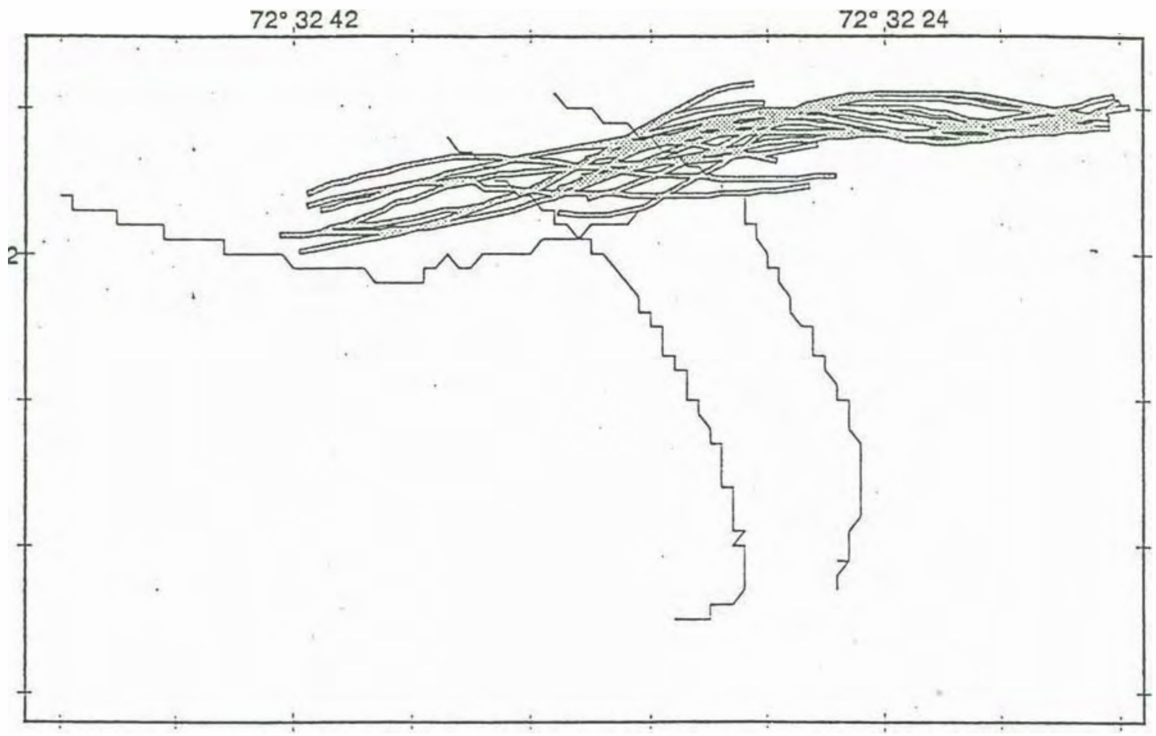


Figure C31. Ocean quahog depletion tow paths, (N=16), by the F/V John N. Experiment 2, March 2000. Thin lines are setup tows conducted by the R/V DE-II, June 1999.

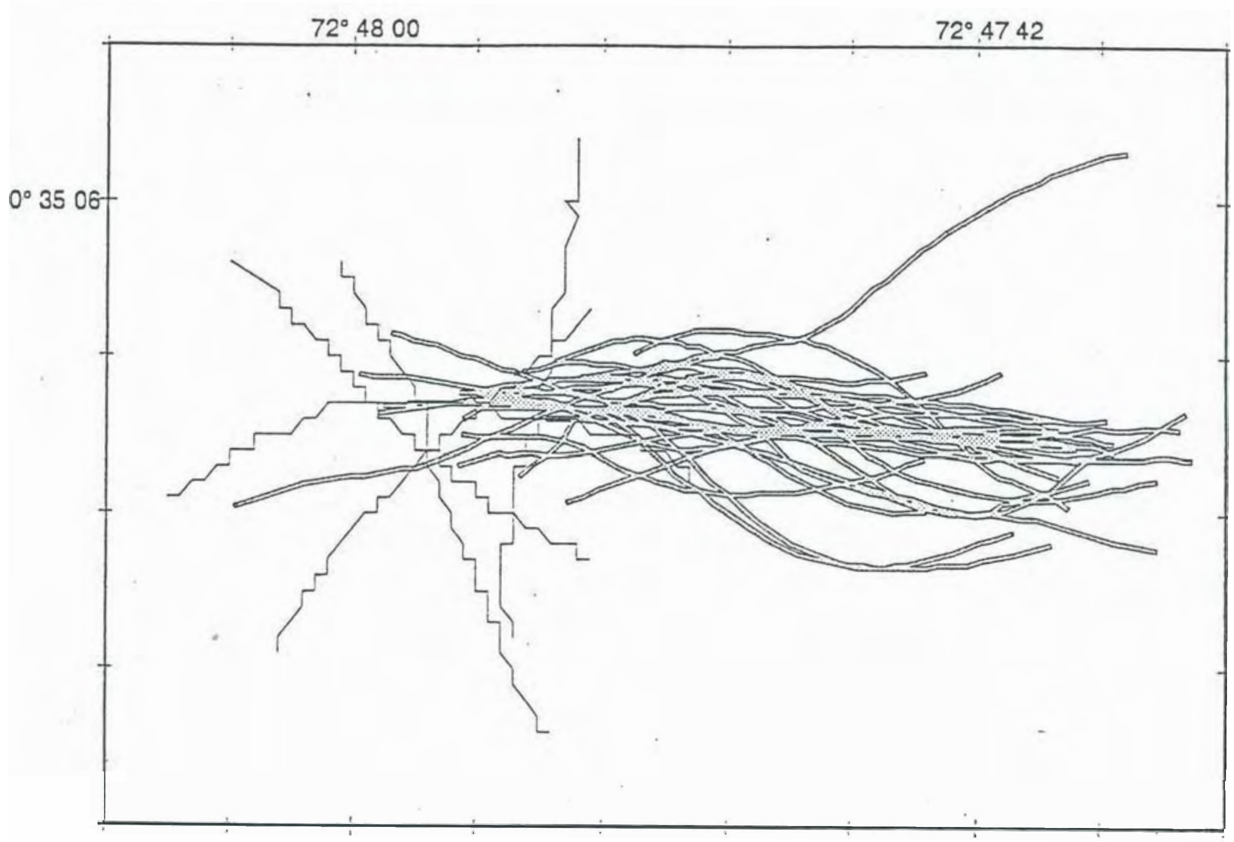


Figure C32. Ocean quahog depletion tow paths, (N=27), by the F/V Danielle Maria, May 2000. Thin lines are setup tows conducted by the R/V DE-II, June 1999.

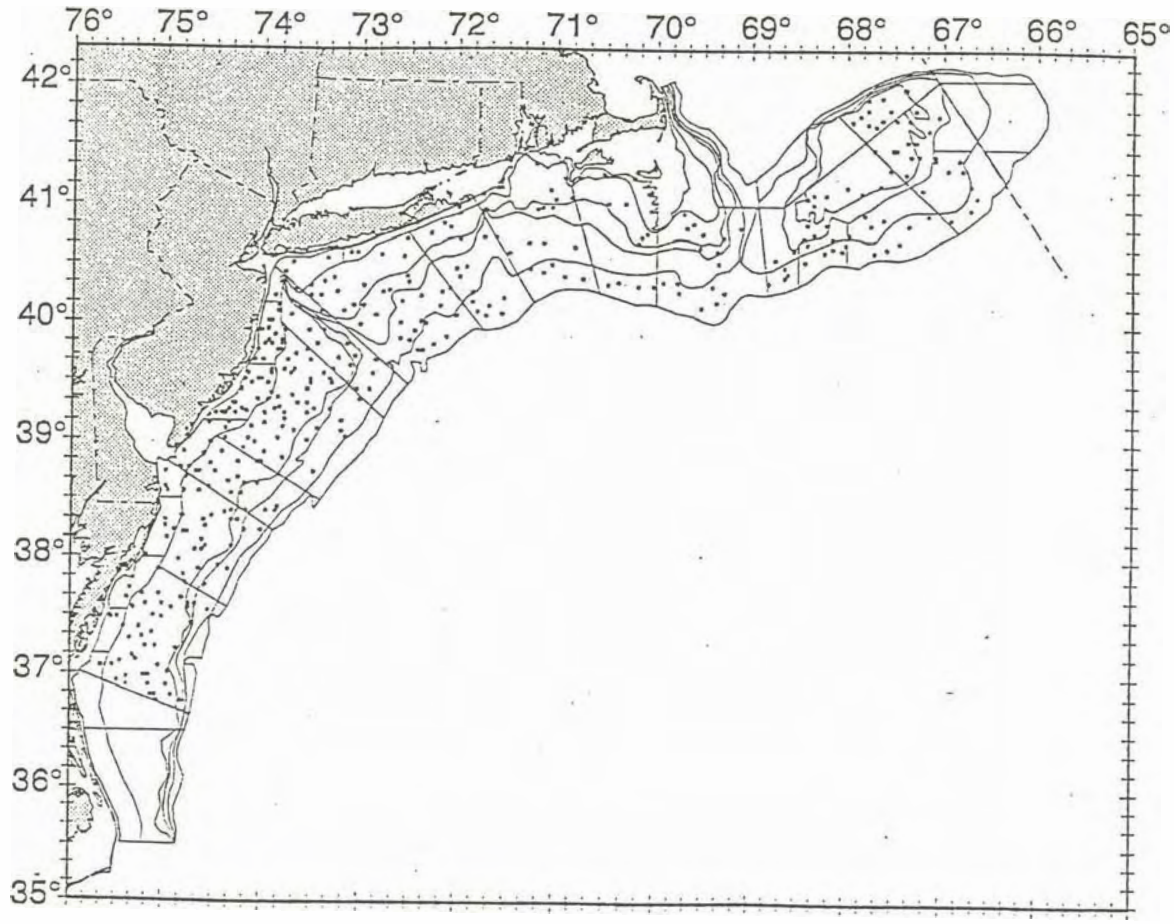


Figure C33. Stations sampled during the 1999 stratified, random clam survey.

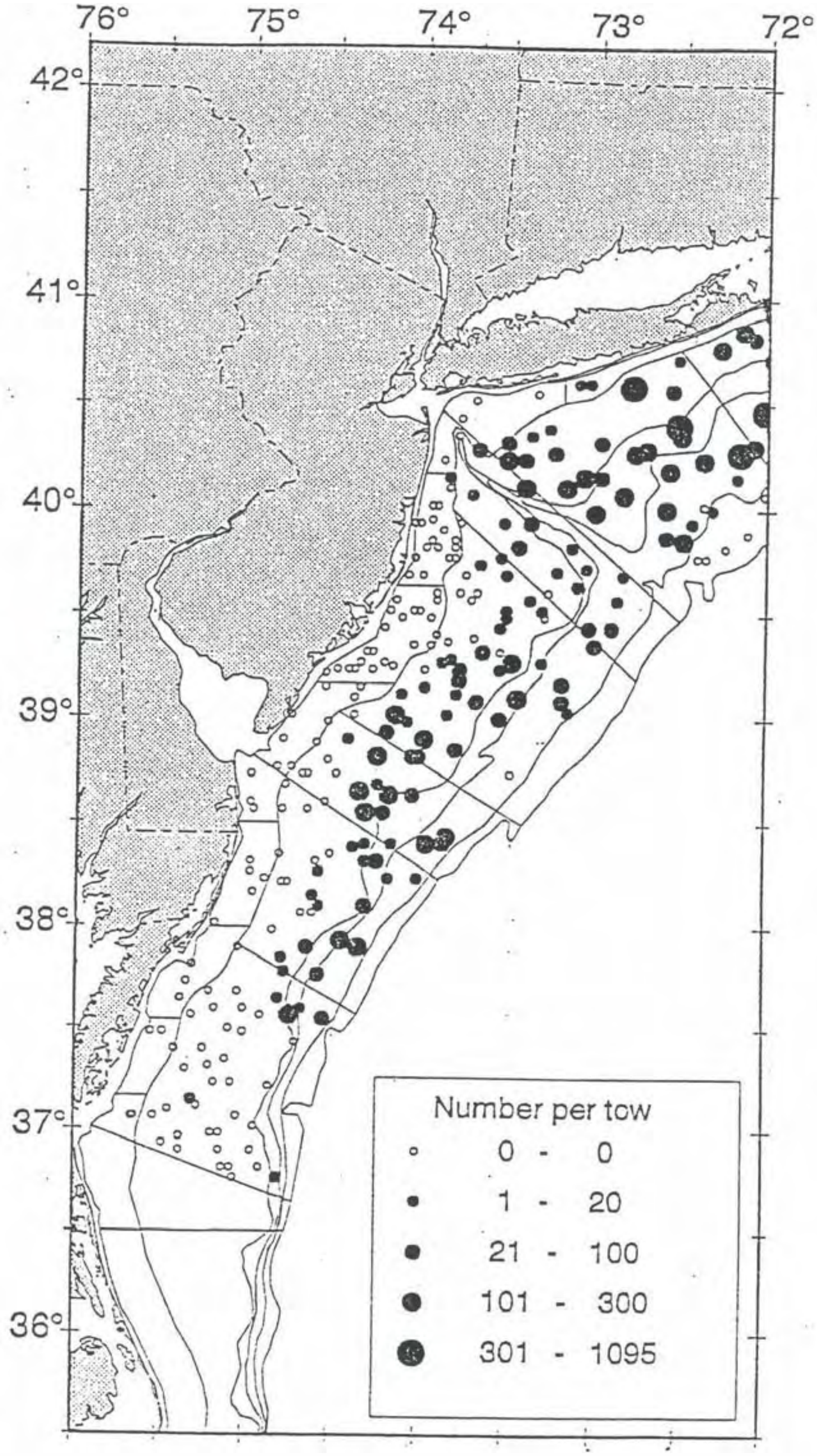


Figure C34. Distribution of ocean quahog abundance per tow (>=70 mm), during the 1999 NEFSC survey, adjusted to 0.15 n. mi. tow distance with sensor data. Blade depth = 4 inches. NEFSC clam strata boundaries are 10-30m, 31-50m, 51-60m, 61-80m, and 81-120m. The 200m bathymetric line is also shown.

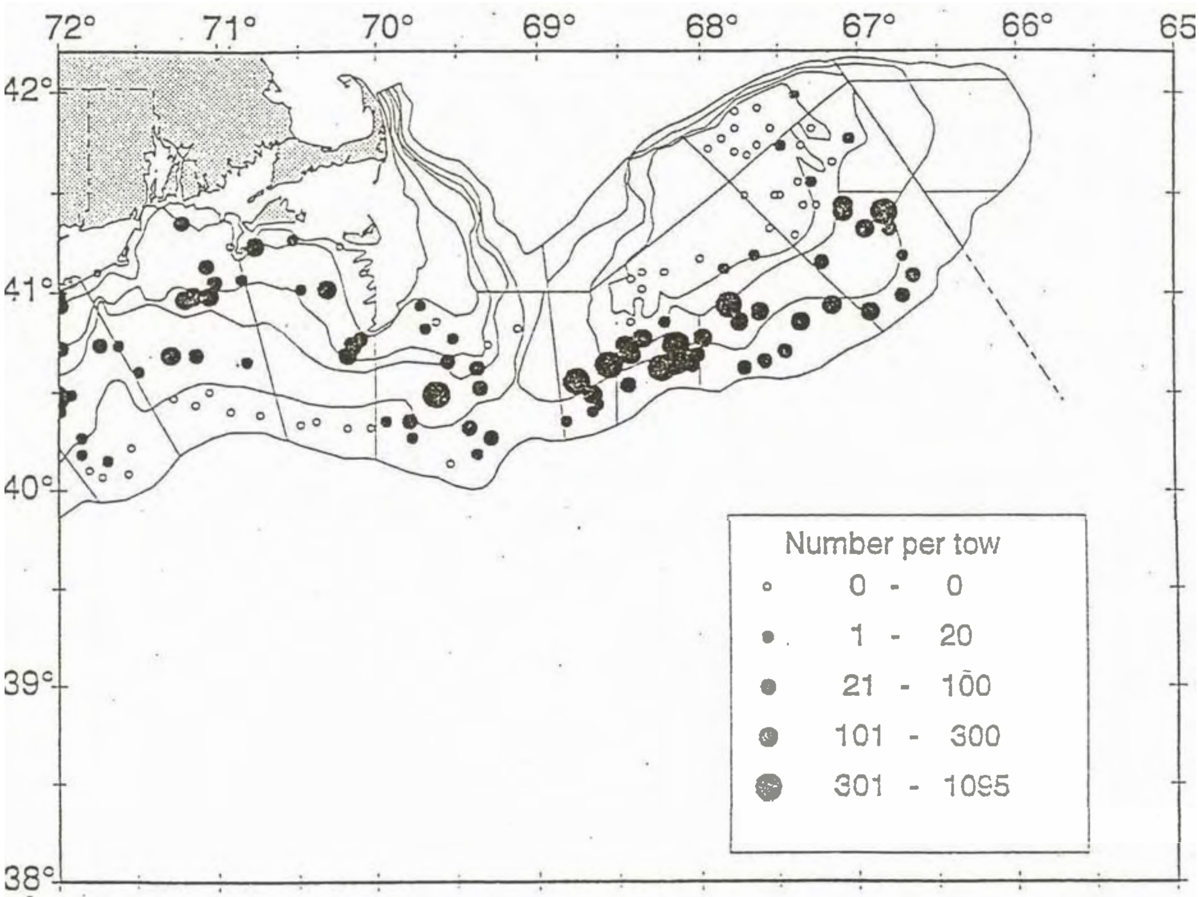


Figure C35. Distribution of ocean quahog abundance per tow (>=70 mm), during the 1999 NEFSC survey, adjusted to 0.15 n. mi. tow distance with sensor data. Blade depth = 4 inches. NEFSC clam strata boundaries are 10-30m, 31-50m, 51-60m, 61-80m, and 81-120m. The 200m bathymetric line is also shown.

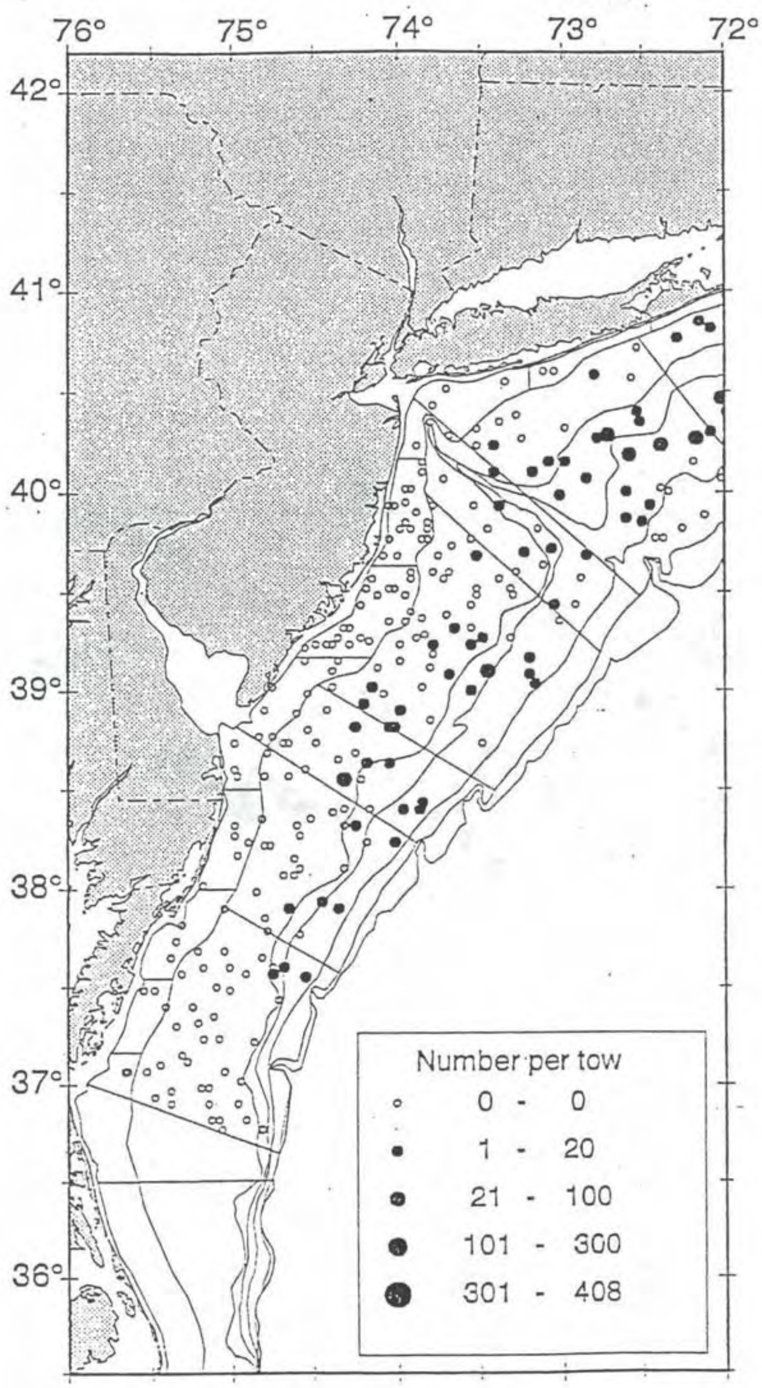


Figure C36. Distribution of ocean quahog abundance per tow (<70 mm), during the 1999 NEFSC survey, adjusted to 0.15 n. mi. tow distance with sensor data. Blade depth = 4 inches. NEFSC clam strata boundaries are 10-30m, 31-50m, 51-60m, 61-80m, and 81-120m. The 200m bathymetric line is also shown.

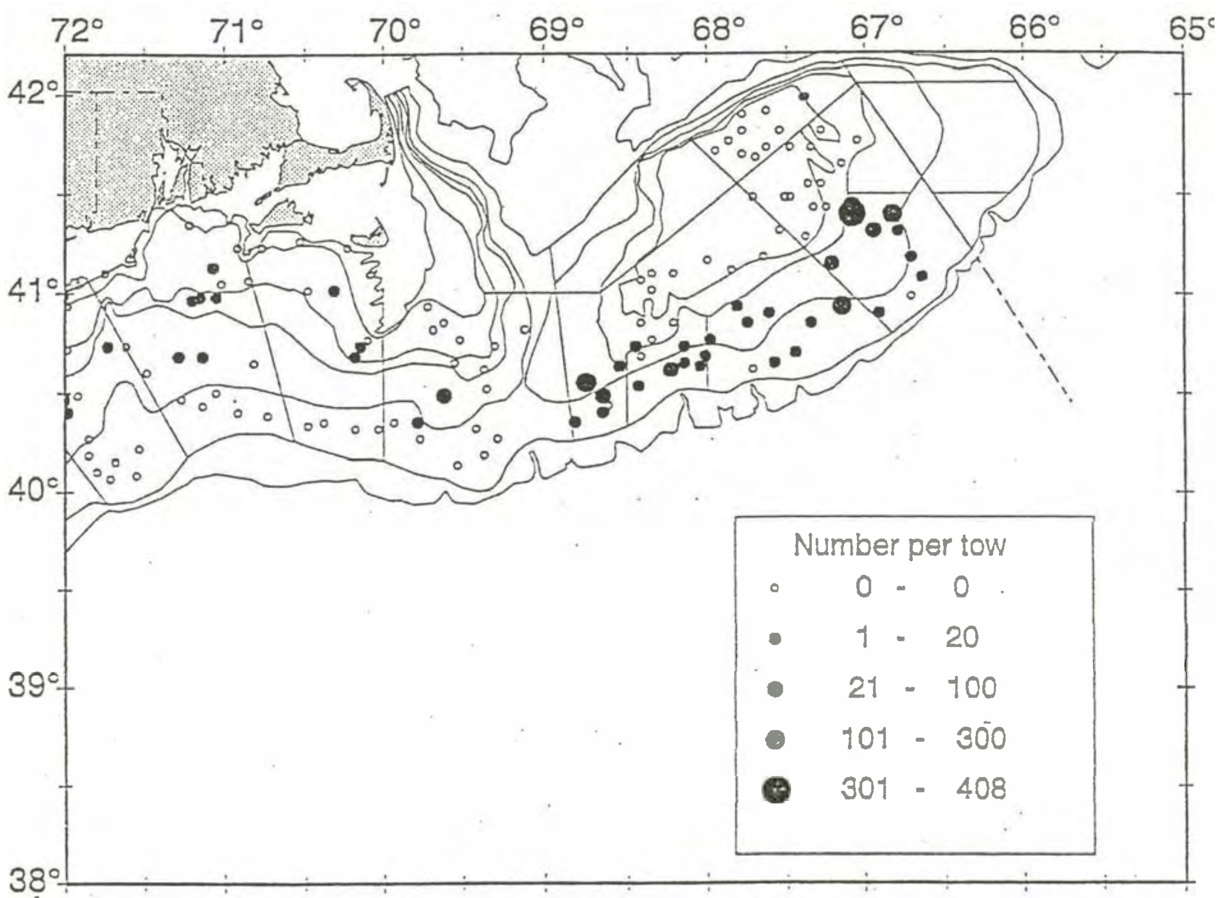


Figure C37. Distribution of ocean quahog abundance per tow (70 mm), during the 1999 NEFSC survey, adjusted to 0.15 n. mi. tow distance with sensor data. Blade depth = 4 inches. NEFSC clam strata boundaries are 10-30m, 31-50m, 51-60m, 61-80m, and 81-120m. The 200m bathymetric line is also shown.

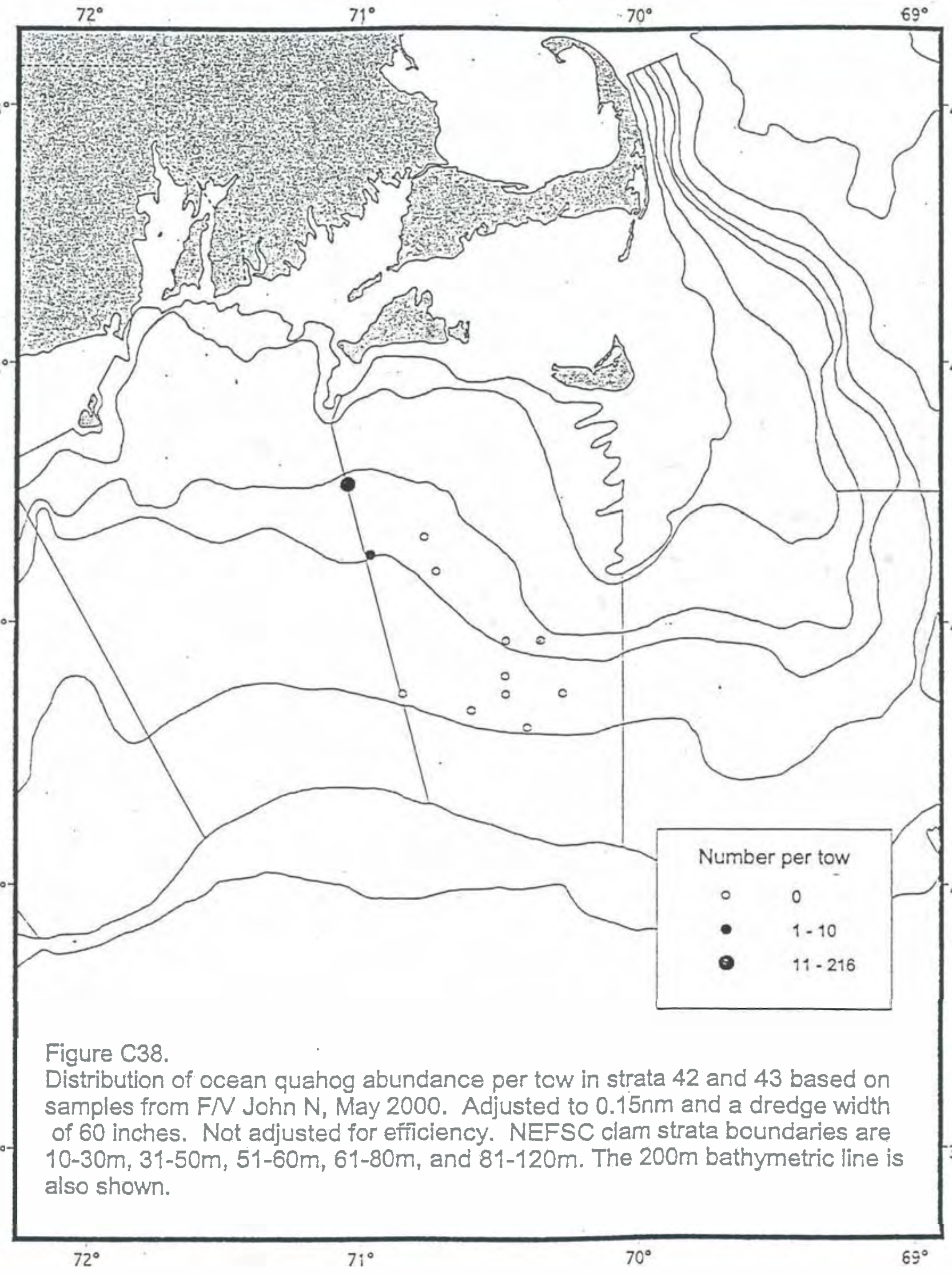


Figure C38.
Distribution of ocean quahog abundance per tow in strata 42 and 43 based on samples from F/V John N, May 2000. Adjusted to 0.15nm and a dredge width of 60 inches. Not adjusted for efficiency. NEFSC clam strata boundaries are 10-30m, 31-50m, 51-60m, 61-80m, and 81-120m. The 200m bathymetric line is also shown.

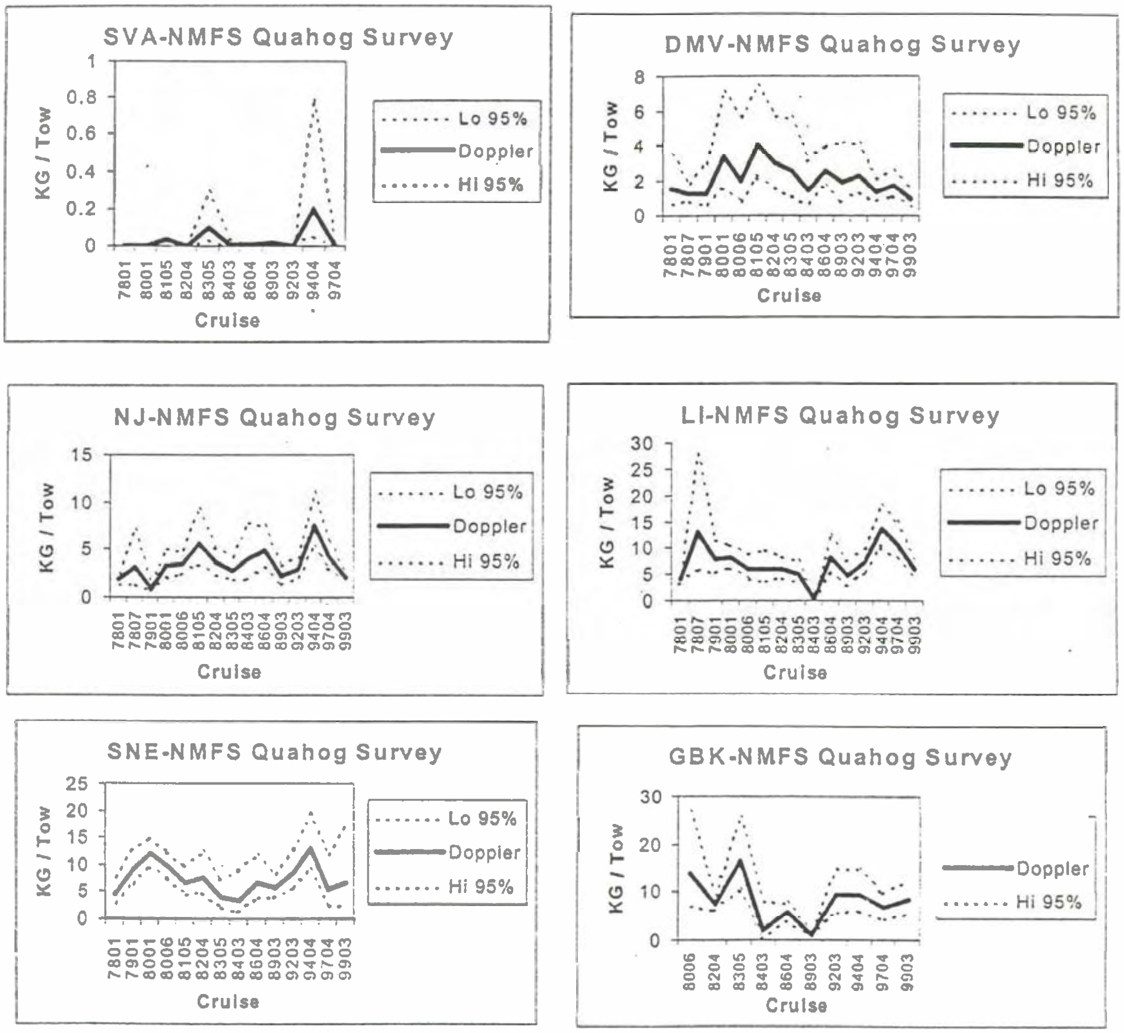


Figure C39. NMFS clam survey trend data (numbers per standard tow and KG meats per standard tow) used for ocean quahog is used in the KLAMZ model. Data standardiz to a 0.15 nm tow using doppler distances. Densities were calculated as stratified means based on GIS estimates of the area (nm2) of NMFS survey strata sampled in the survey. KG per tow was estimated using updated length-weight conversion parameters applied to numbers of clams in 1 mm size groups. For consistency, deep water strata and tows in water >84 m during the 1999 survey were omitted.

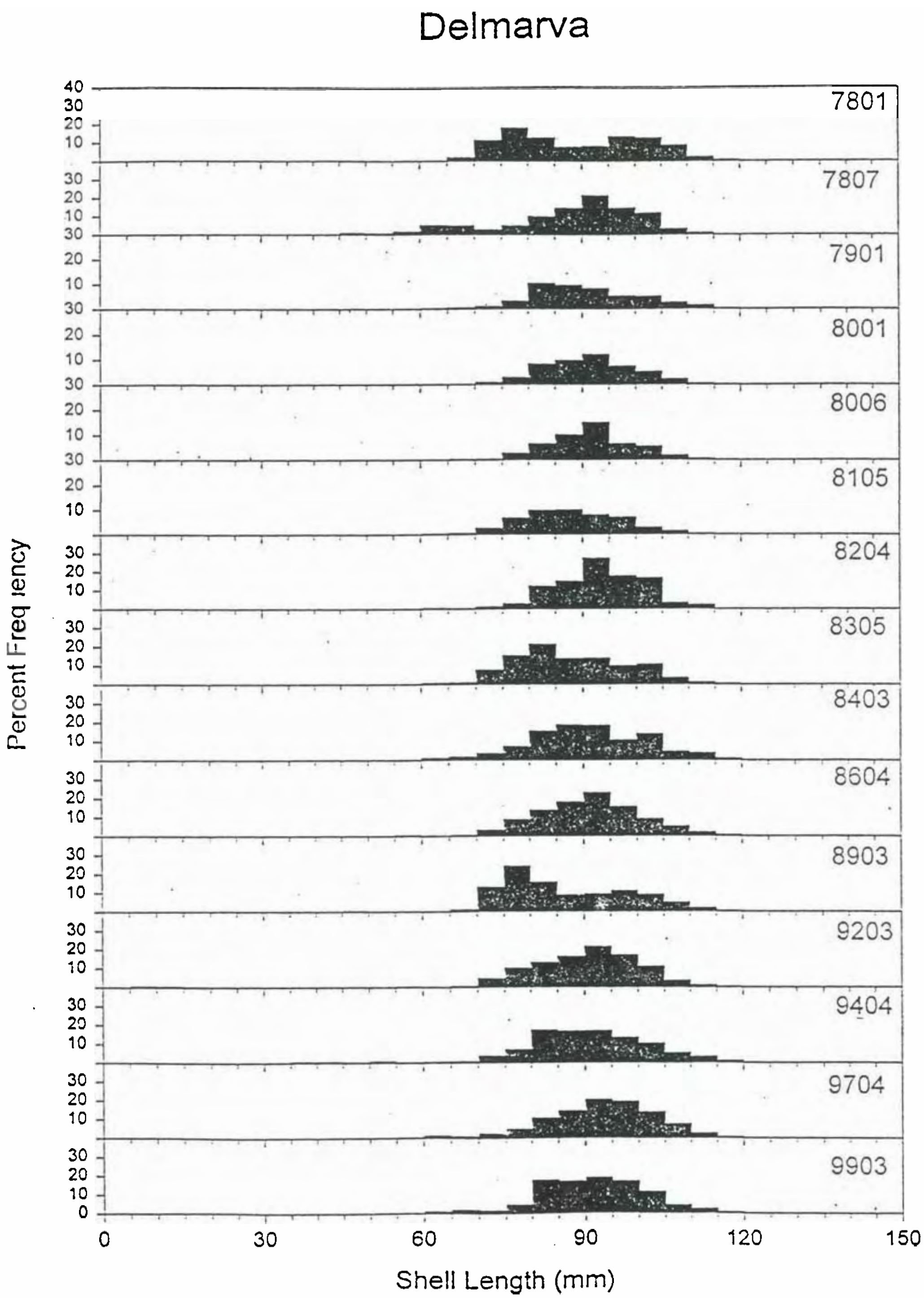


Figure C40. Percent length frequencies of ocean quahogs taken during NMFS surveys off Delmarva, 1978-1999. A smaller liner was used in the dredge before 1980 (NEFSC 2000). Data are standardized by doppler distance during 5 minute timed tow.

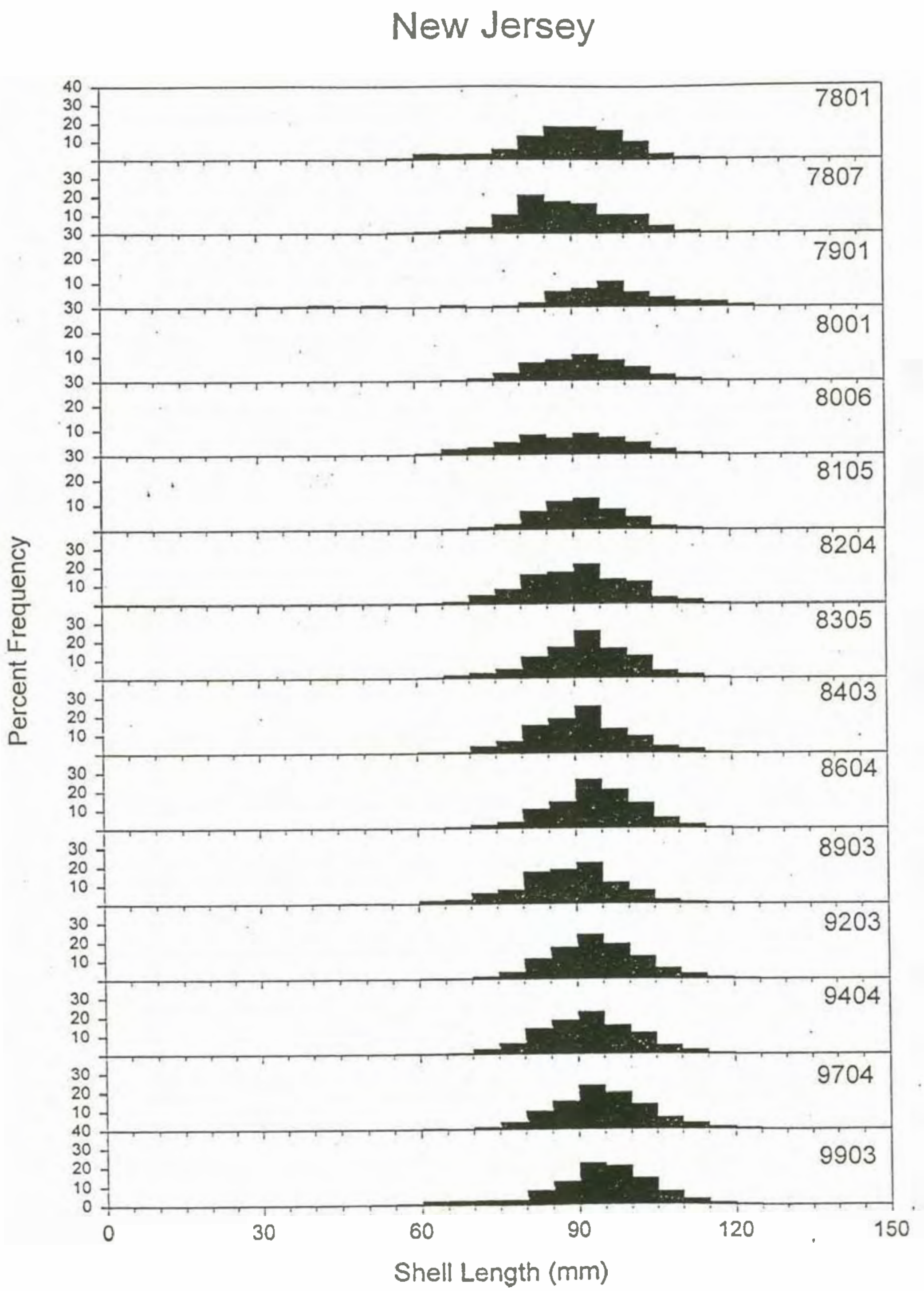


Figure C41. Percent length frequencies of ocean quahogs taken during NMFS surveys off New Jersey, 1978-1999. A smaller liner was used in the dredge before 1980 (NEFSC 2000). Data are standardized by doppler distance during 5 minute timed tow.

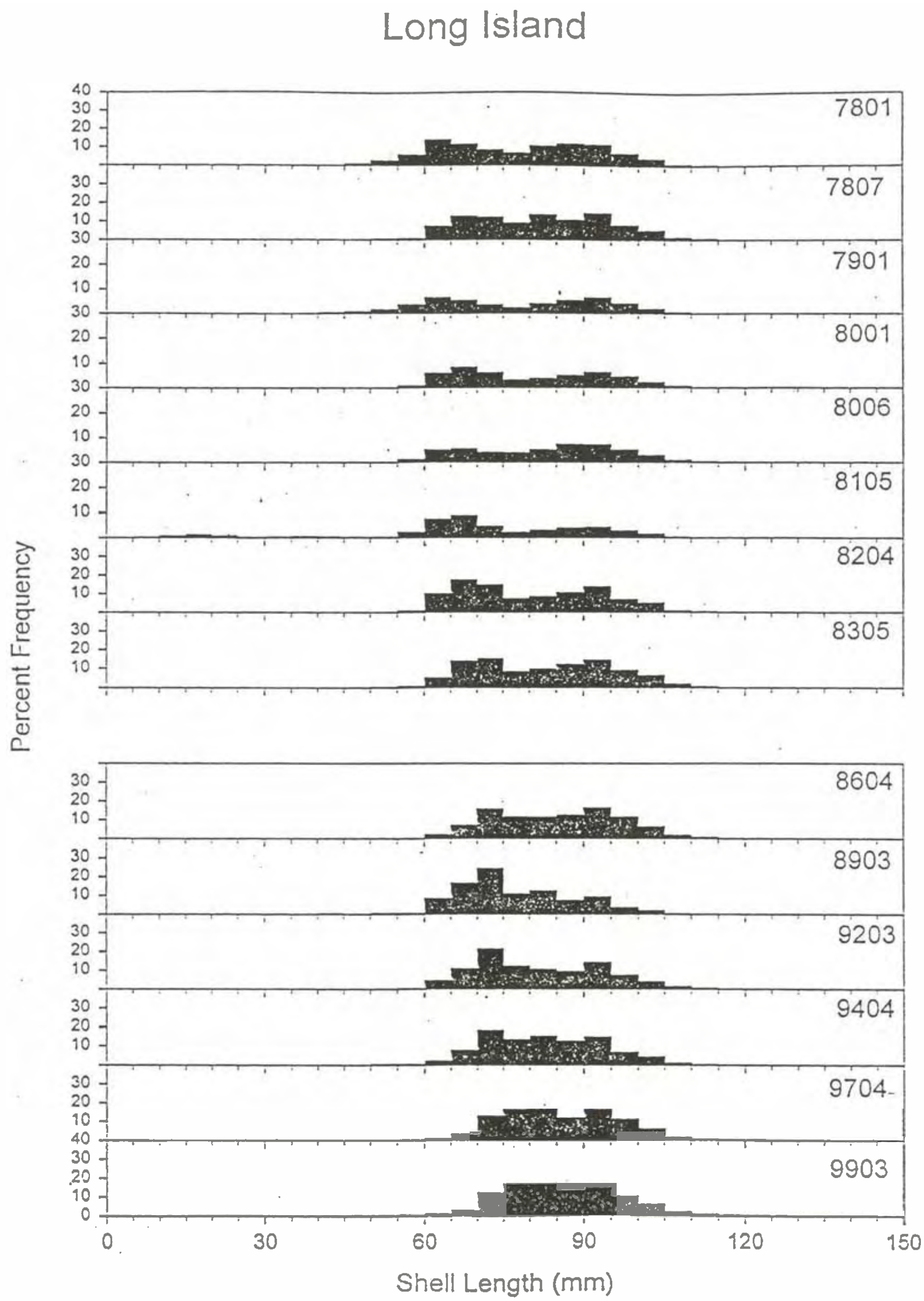
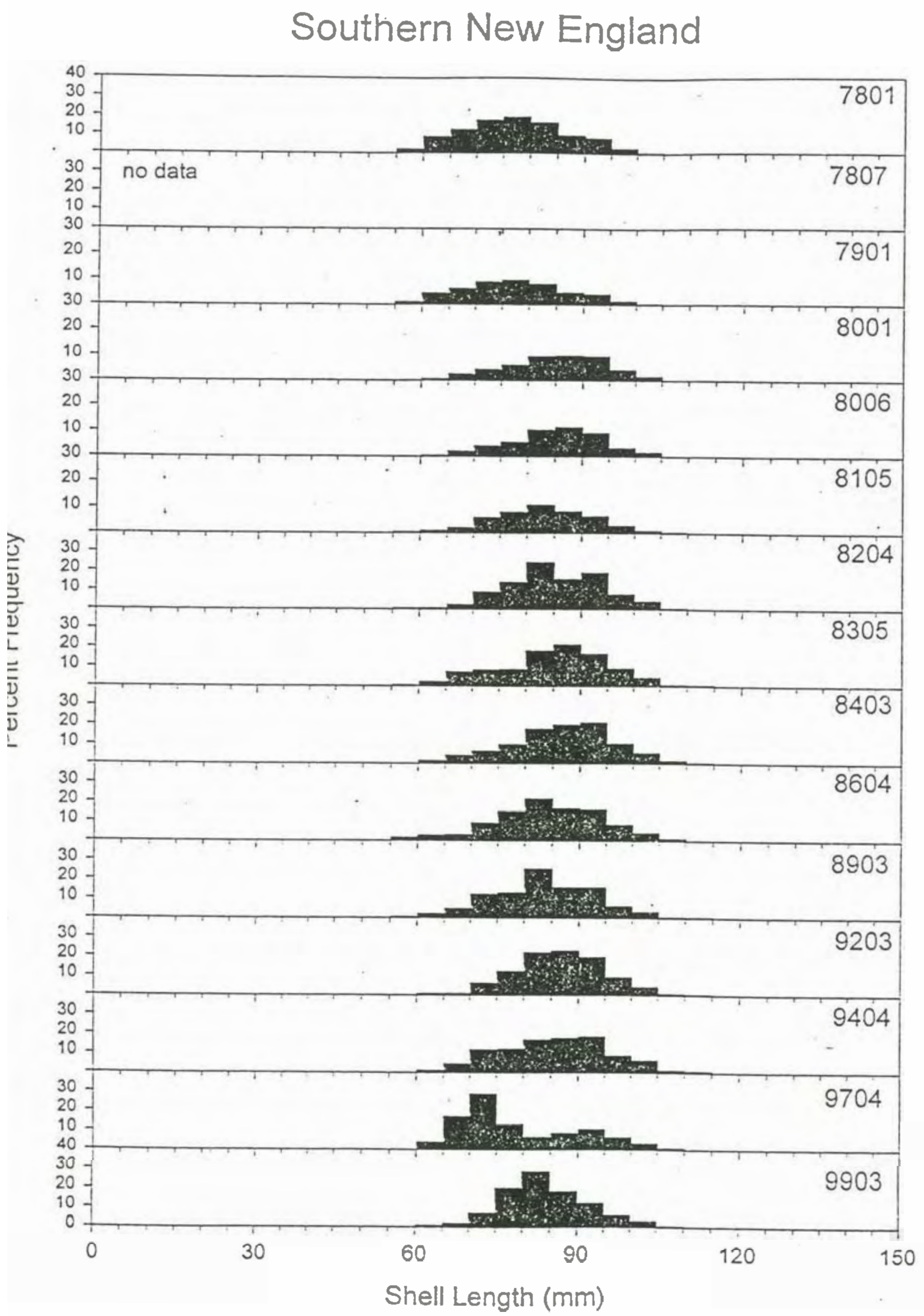


Figure C42. Percent length frequencies of ocean quahogs taken during NMFS surveys off Long Island, 1978-1999. A smaller liner was used in the dredge before 1980 (NEFSC 2000). Data are standardized by doppler distance during 5 minute timed tow. 1984 survey incomplete.



gure C43. Percent length frequencies of ocean quahogs taken during NMFS surveys off Southern New England, 1978-1999. A smaller liner was used in the dredge before 1980 (NEFSC 2000). Data are standardized by doppler distance during 5 minute timed tow.

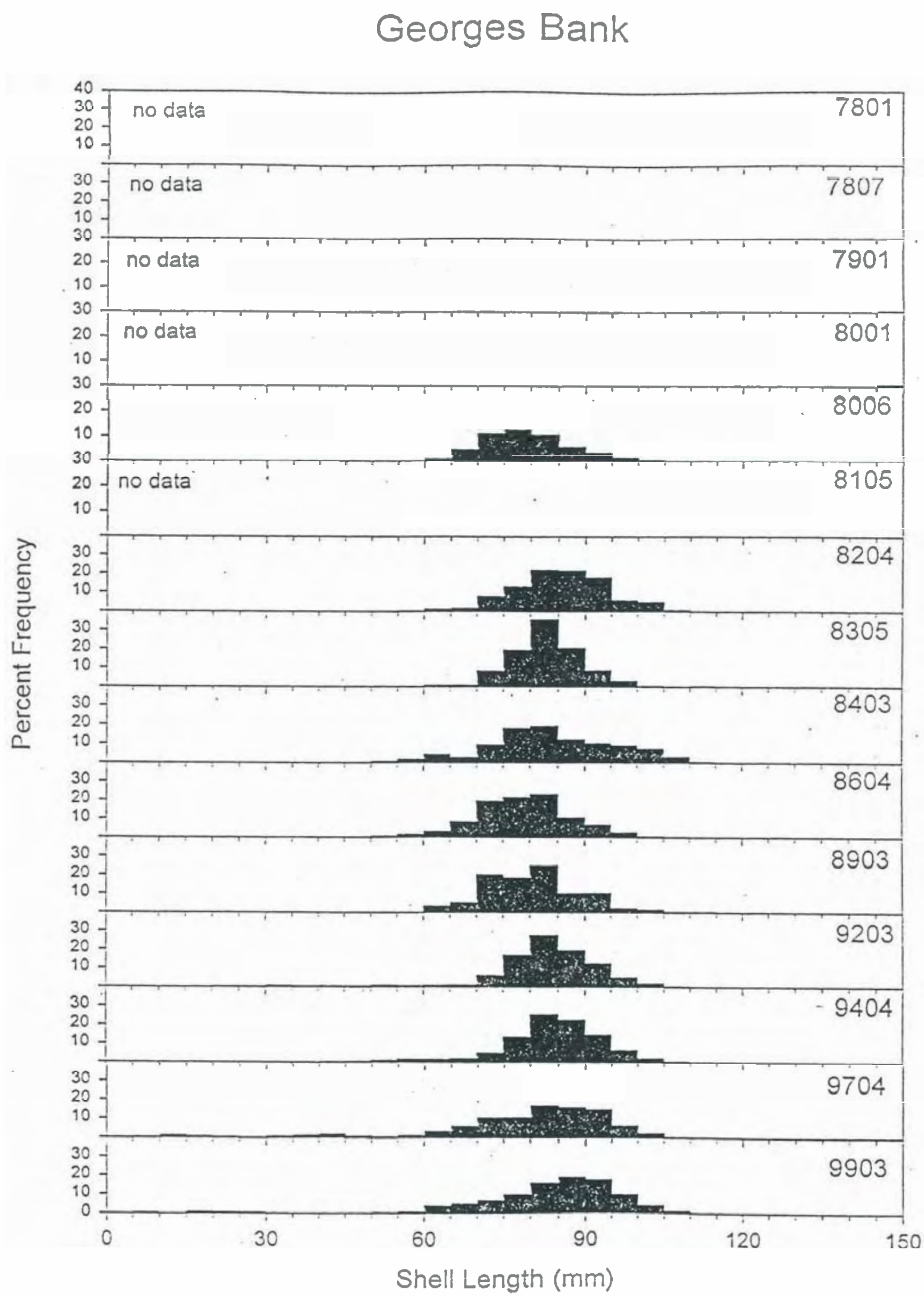


Figure C44. Percent length frequencies of ocean quahogs taken during NMFS surveys off Georges Bank, 1978-1999. A smaller liner was used in the dredge before 1980 (NEFSC 2000). Data are standardized by doppler distance during 5 minute timed tov

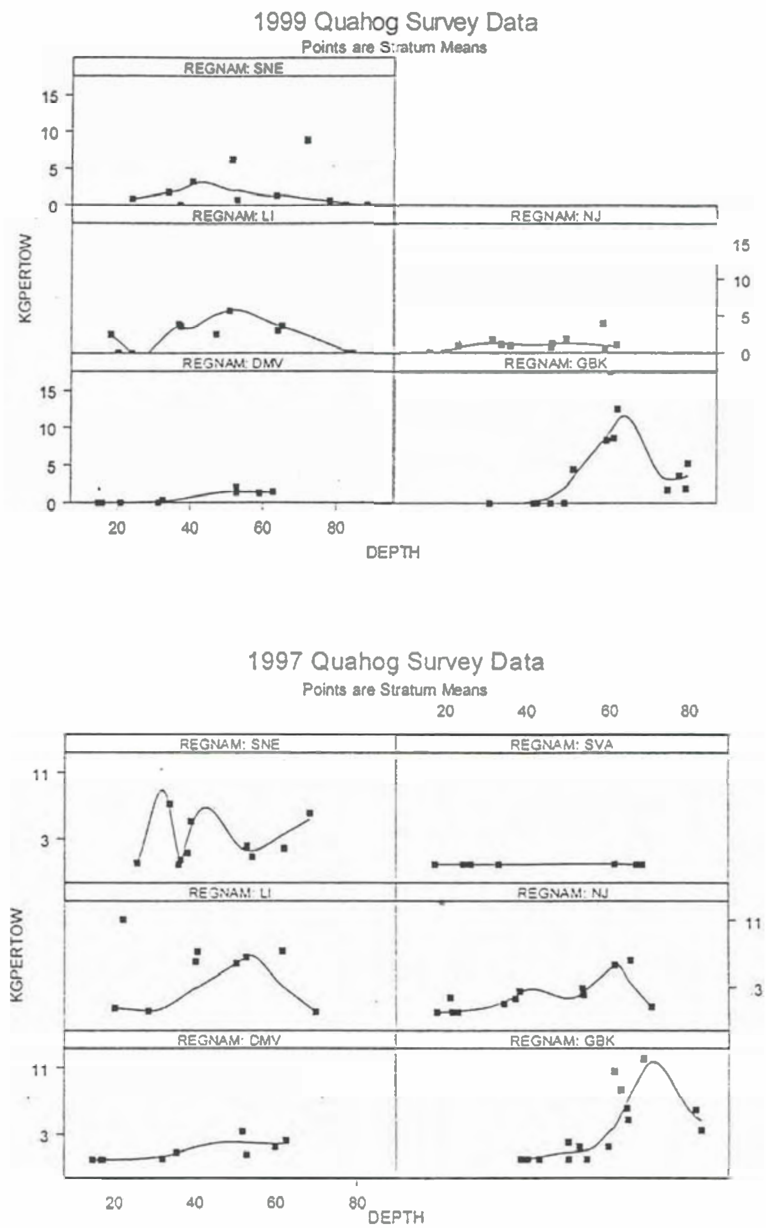


Figure C45. Survey data for ocean quahog in the 1997 and 1999 NMFS clam survey. Data points are stratum mean catch rates (KG tow) and include strata not normally used in tabulating survey data for quahog. Lines were fit by loess regression and are meant only to show trends.

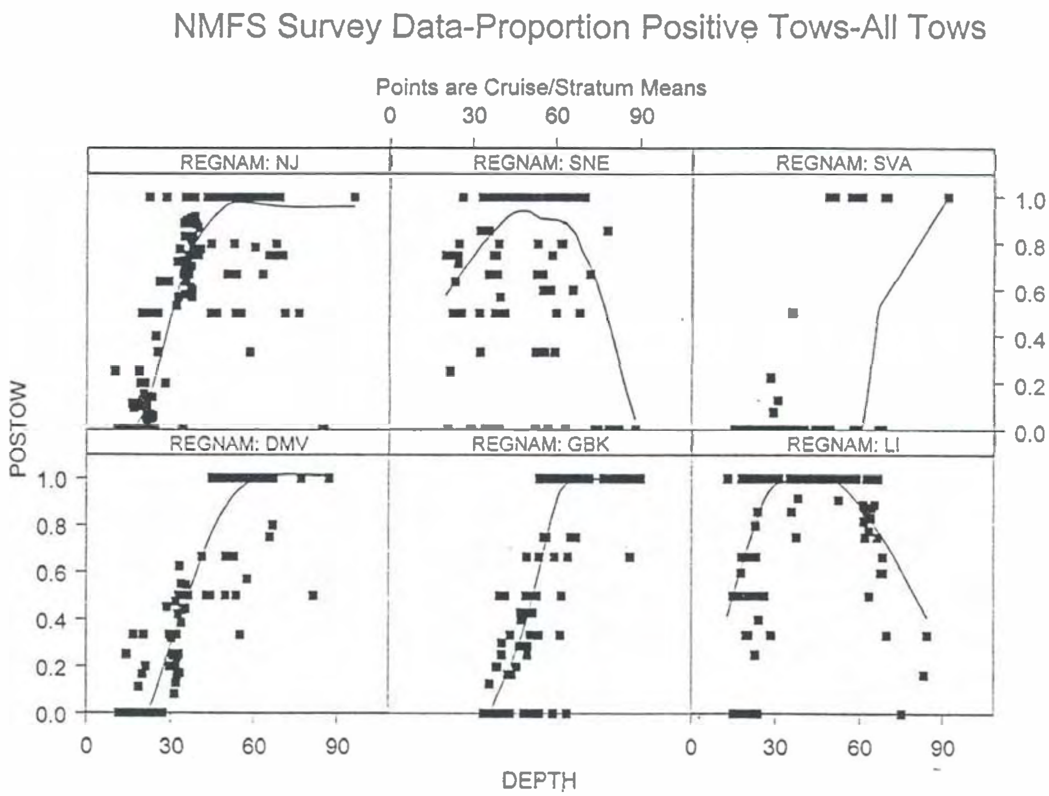


Figure C46. Survey data for ocean quahog in all NMFS clam surveys. Data points are proportion positive tows for all individual stratum/cruise combinations in the clam database. Line were fit by loess regression to show trends. Instances where the line seems to miss the data are due to data points that are obscured by other data points. The line for SVA, for example, seems to miss a few data points at 20-60m with proportions greater than zero but, in reality, fits a much larger number of data points at 20-60 m with proportions of zero that are obscured in the plots.

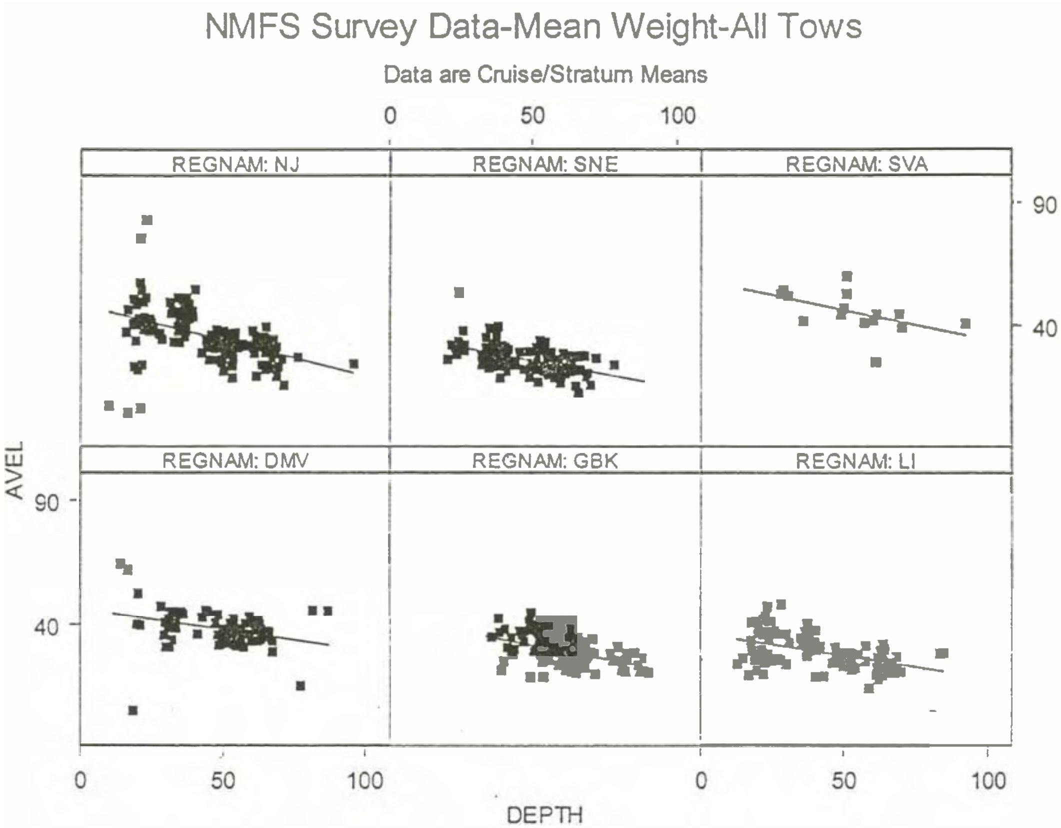


Figure C47. Survey data for ocean quahog in all NMFS clam surveys. Data points are mean weights of quahog calculated for all individual stratum/cruise combinations in the database. Lines were fit by linear regression and have statistically significant slope estimates.

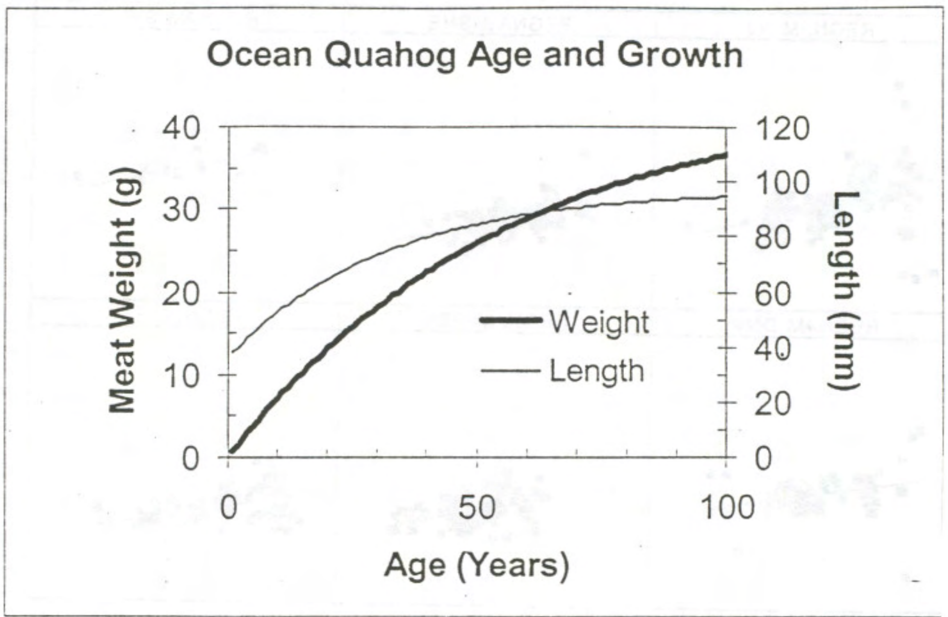


Figure C48. Age and growth relationships used for ocean quahog in the KLAMZ

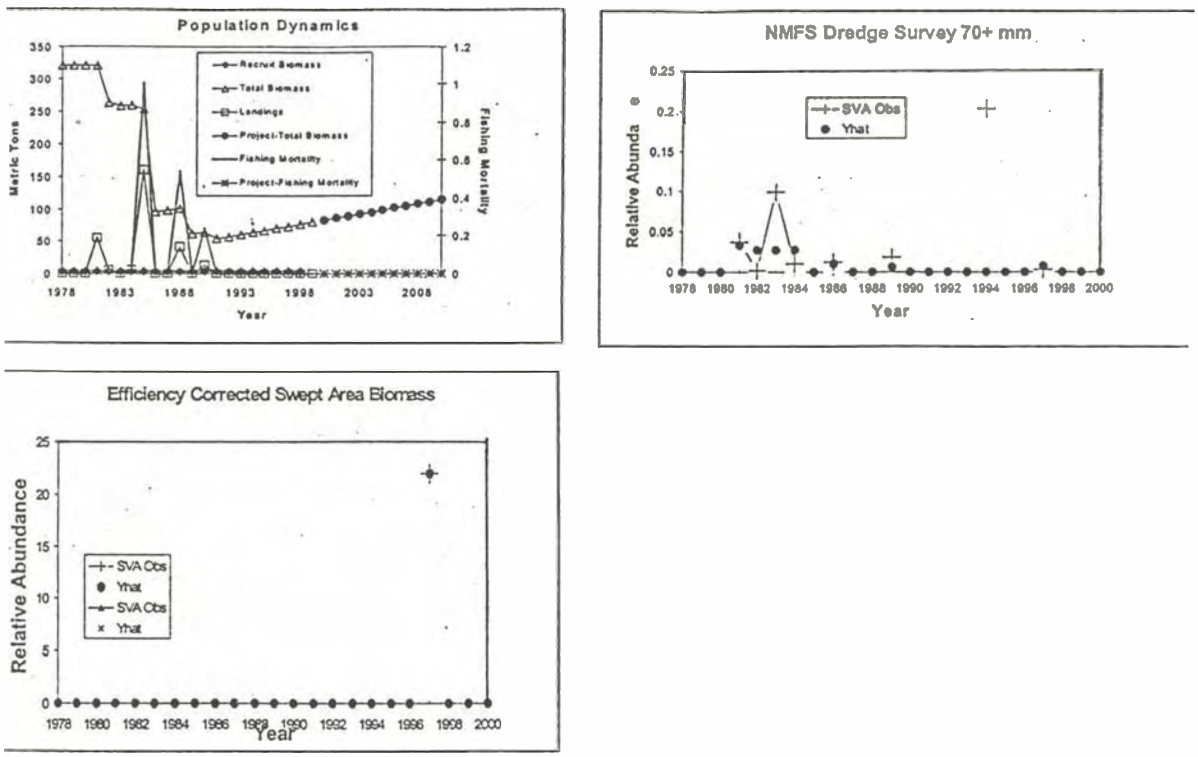


Figure C49. KLAMZ model results for ocean quahog in the SVA stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.

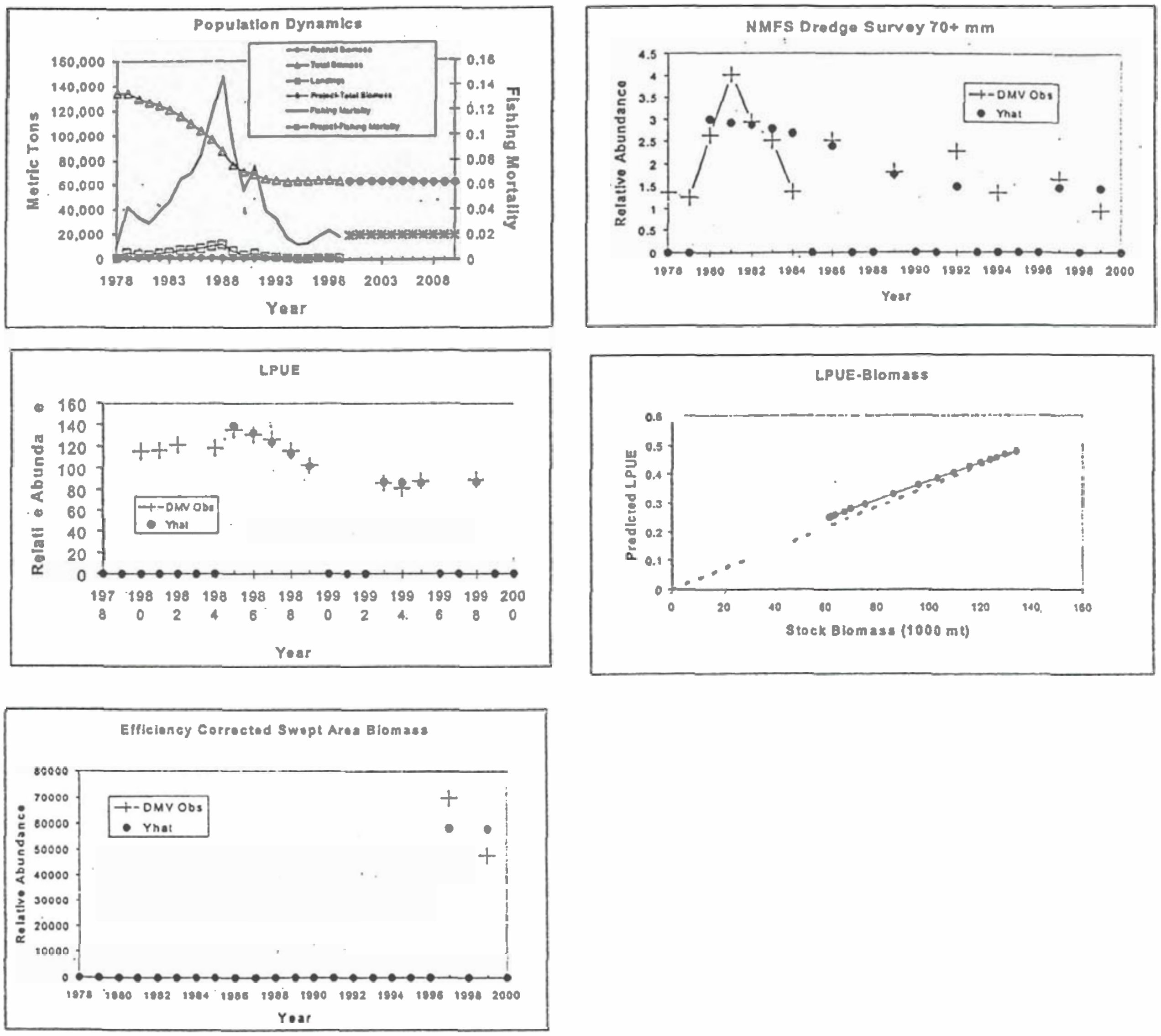


Figure C50. KLAMZ model results for ocean quahog in the DMV stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. The plot of predicted LPUE vs. stock biomass depicts the possibly nonlinear, saturating relationship between commercial catch rates and stock biomass. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.

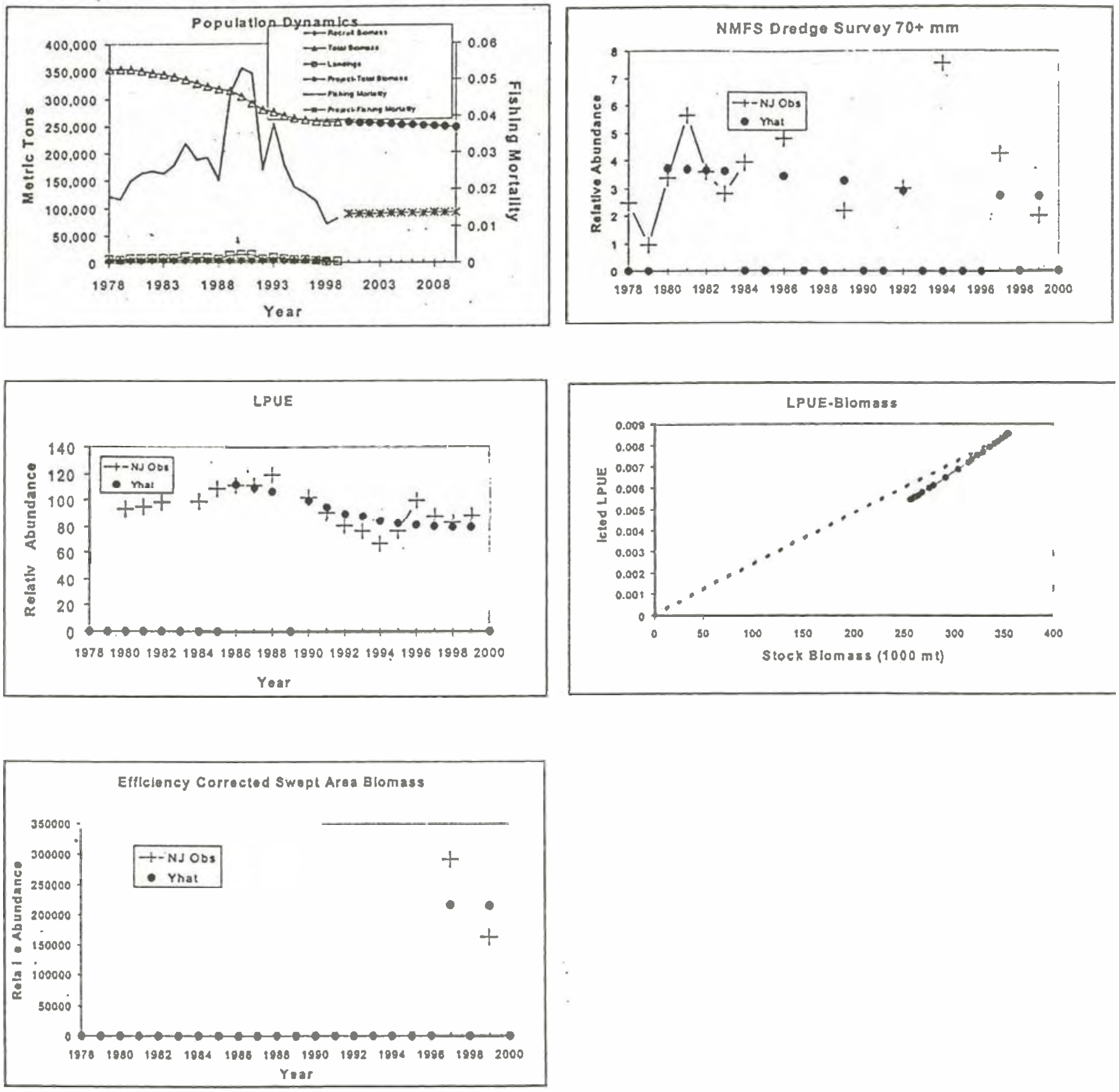


Figure C51. KLAMZ model results for ocean quahog in the NJ stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. The plot of predicted LPUE vs. stock biomass depicts the possibly nonlinear, saturating relationship between commercial catch rates and stock biomass. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.

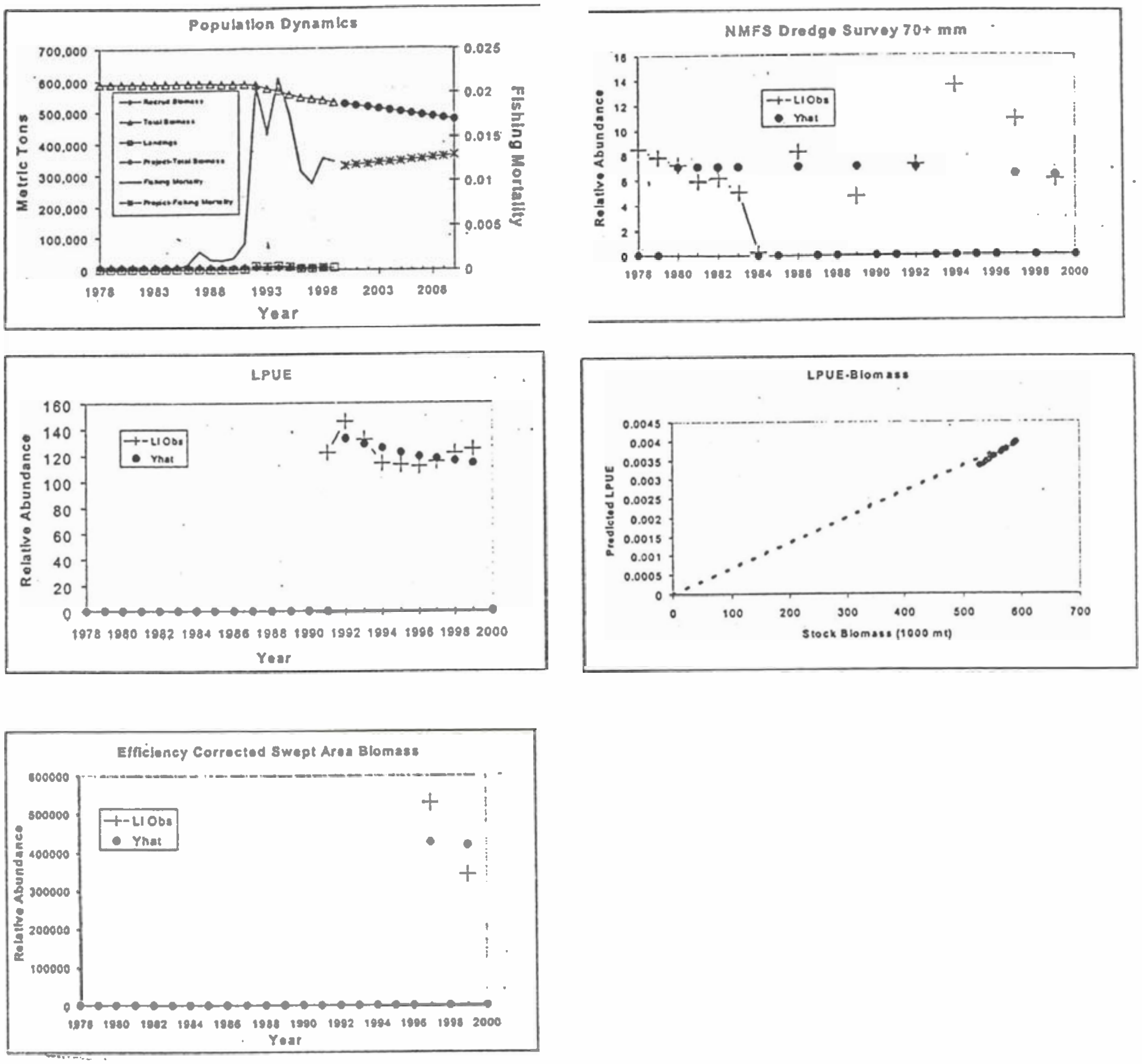


Figure C52. KLAMZ model results for ocean quahog in the LI stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. The plot of predicted LPUE vs. stock biomass depicts the possibly nonlinear, saturating relationship between commercial catch rates and stock biomass. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.

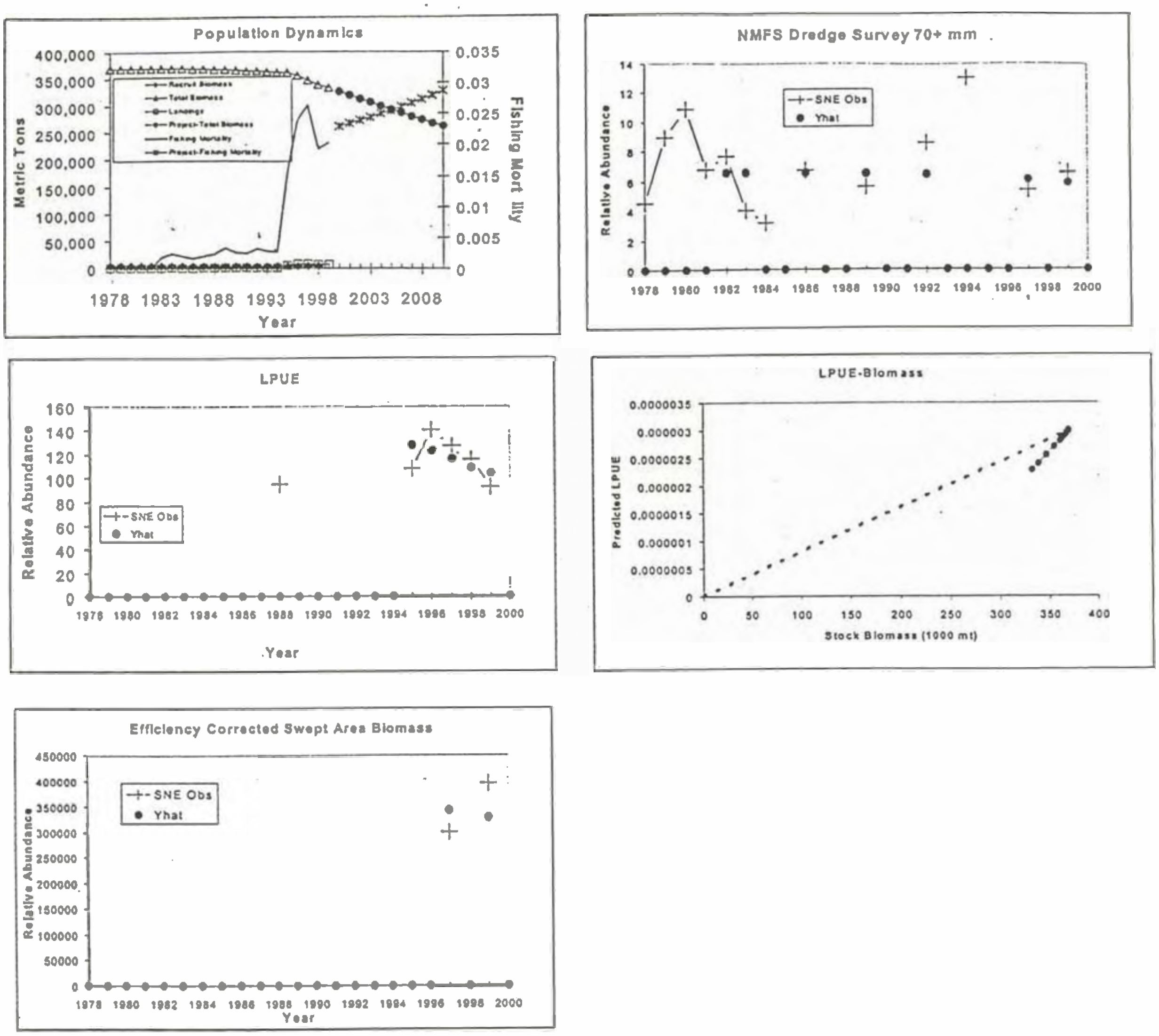


Figure C53. KLAMZ model results for ocean quahog in the SNE stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. The plot of predicted LPUE vs. stock biomass depicts the possibly nonlinear, saturating relationship between commercial catch rates and stock biomass. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.

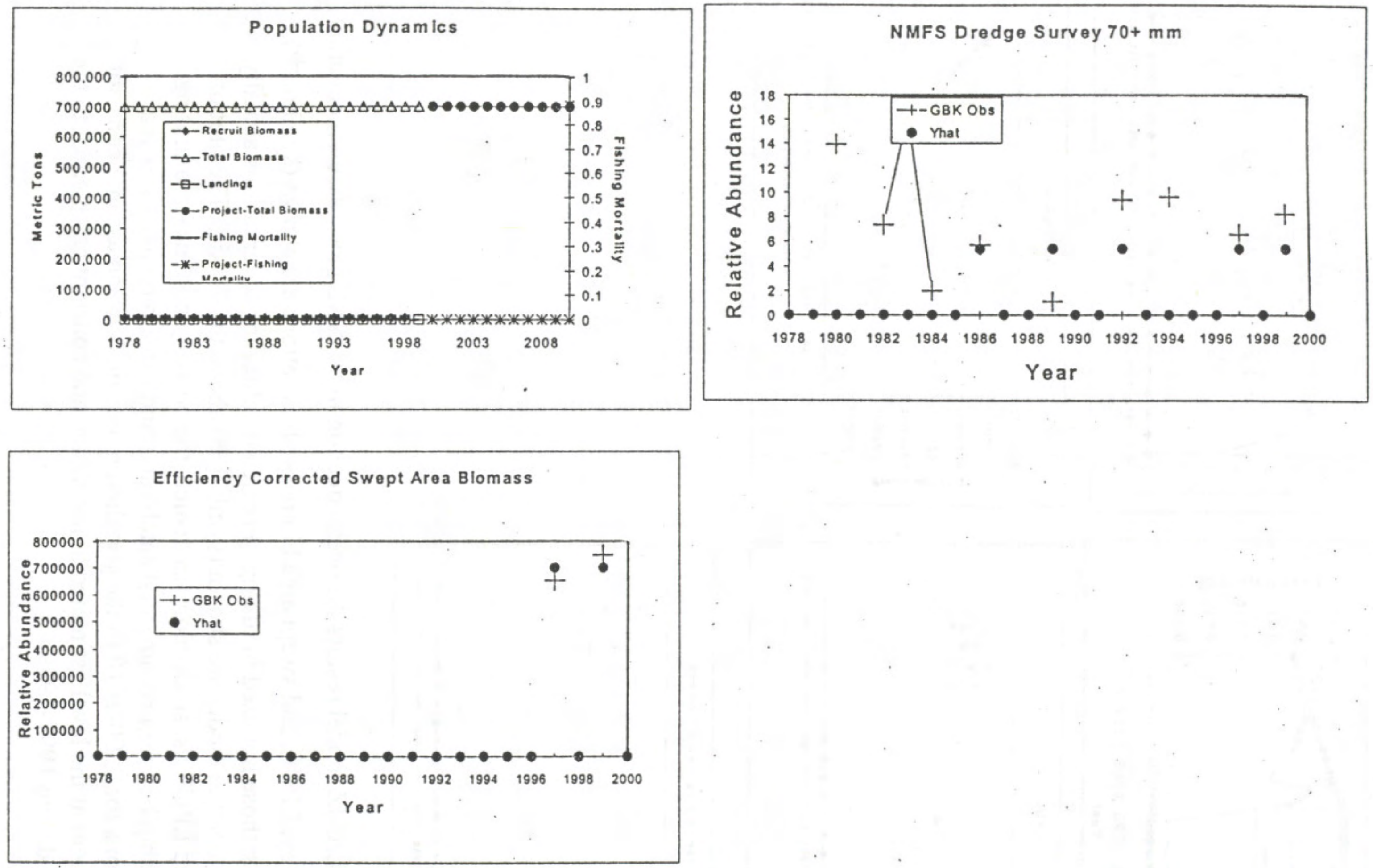
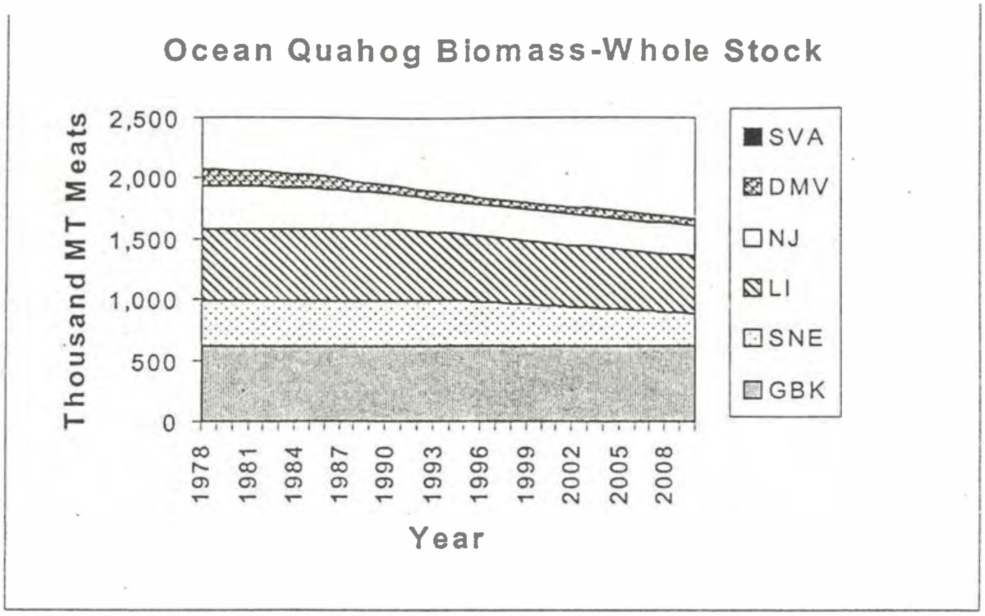
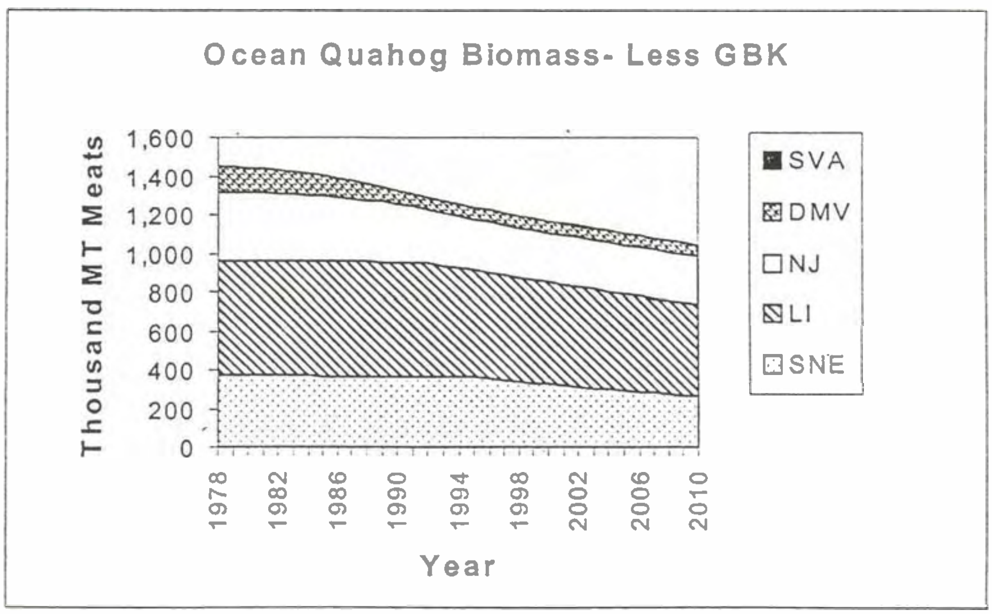


Figure C54. KLAMZ model results for ocean quahog in the GBK stock assessment area. All survey, LPUE, and swept area biomass observations are shown (symbol +), including those not used in tuning. Predicted values for observations actually used to tune the model are shown (symbol ●) above the 7-axis. Ten year projections for 2000-2010 in the population dynamics graph assume constant recruitment at the level estimated in the model and constant catch equal to the average during 1997-1999.





'igure C55. Estimated (1978-1999) and projected (2000-2001) biomass estimates for ocean quahog in the EEZ stock (top) and whole stock lesss GBK (bottom), by stock assessment area. Projections assume recruitment at constant historical levels and recent (mean 1997-1999) catch levels.

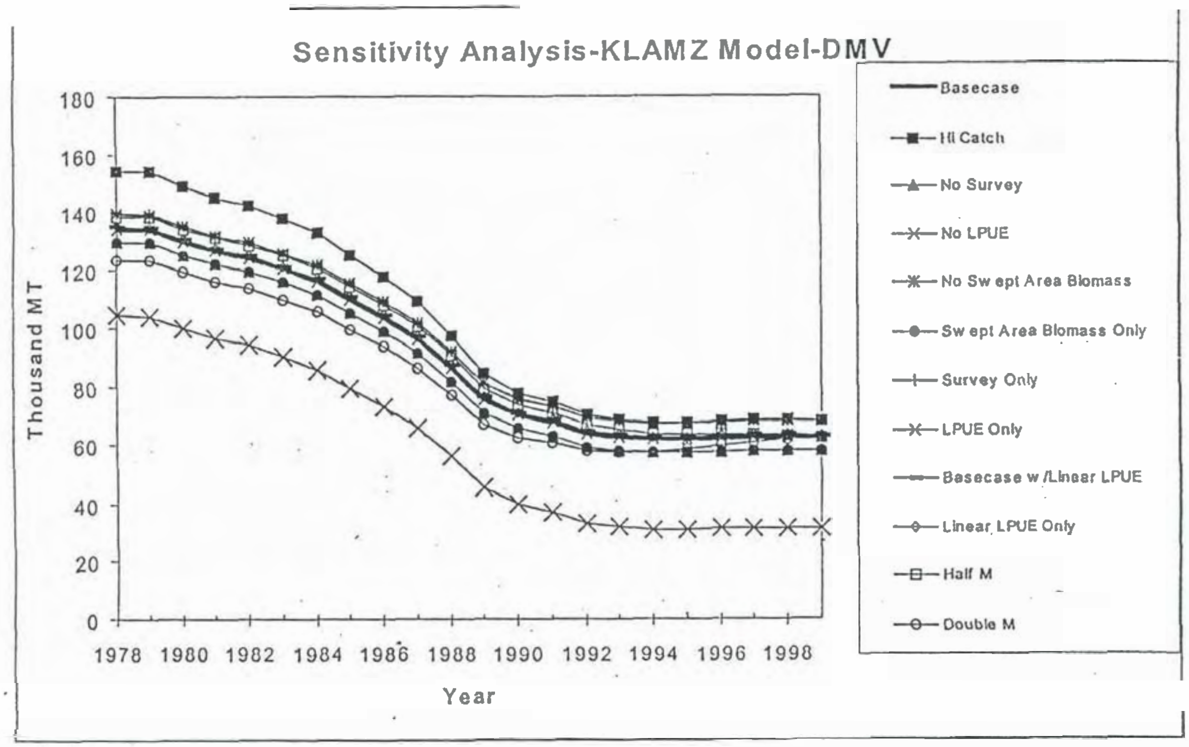


Figure C56. Biomass estimates from sensitivity analysis runs with the KLAMZ model for ocean quahog in the DMV stock assessment region.

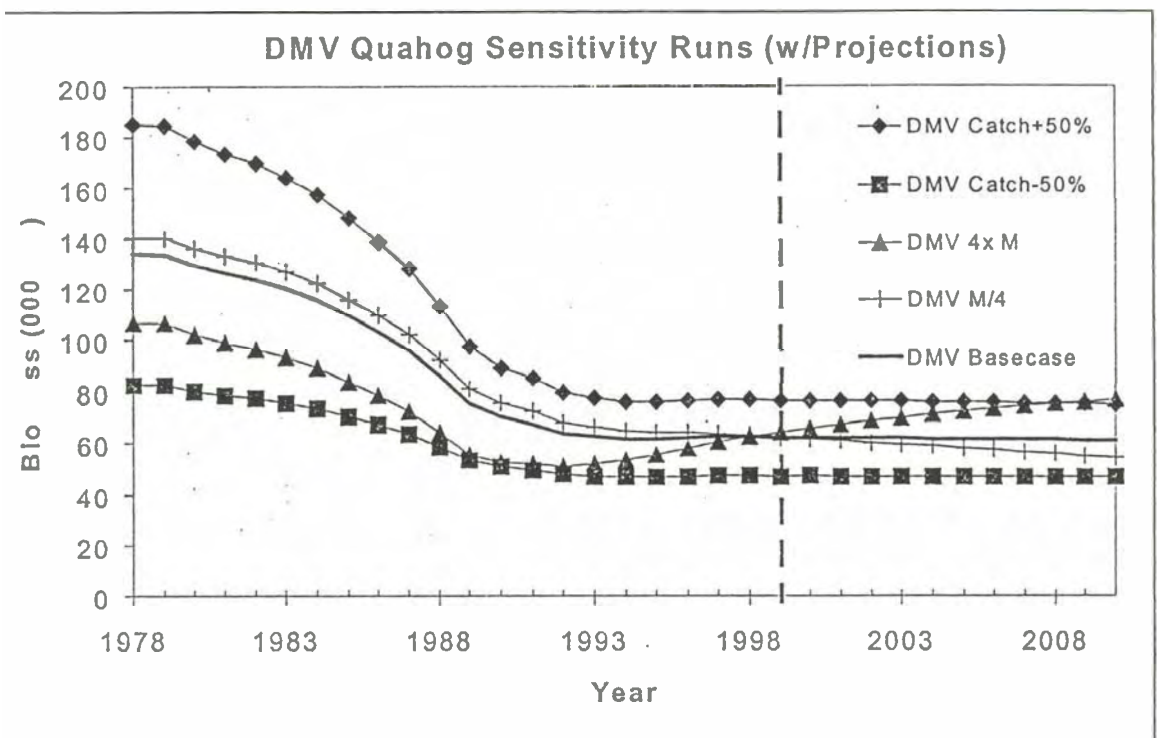


Figure C57. Sensitivity analysis runs with the KLAMZ model for ocean quahog in the DMV stock assessment area. Results include biomass estimates for 1978-1999 and projections for 2000-2010 from the basecase run and runs with two levels of natural mortality (four times and one-quarter the default rate) and two levels of catch (±50%).

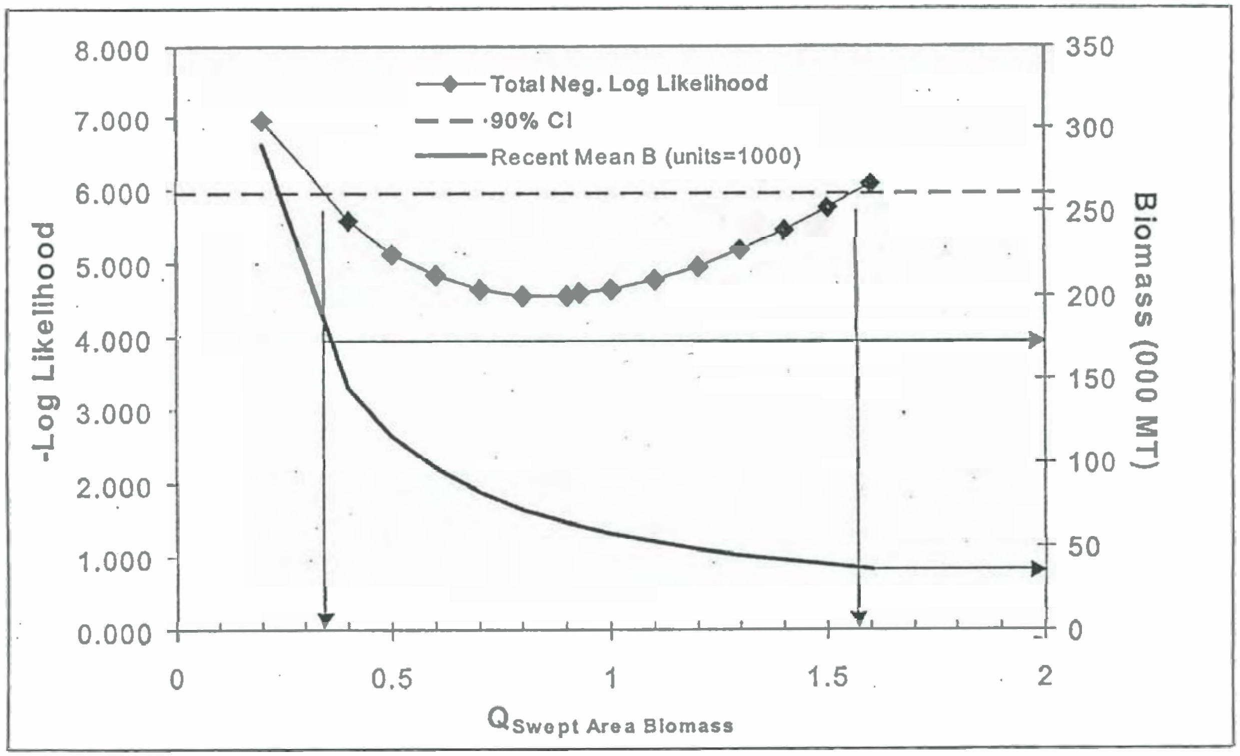


Figure C58. Likelihood profile for the swept area biomass scaling parameter Q and recent (mean 1997-1999) biomass estimated in the KLAMZ model for ocean quahog in the DMV area. Arrows show the upper and lower bounds for approximate 90% confidence intervals around the maximum likelihood estimates of Q and recent biomass.

D. SUMMER FLOUNDER

TERMS OF REFERENCE

The following terms of reference were addressed for summer flounder:

a) Update the estimates of population size, recruitment and fishing mortality through 1999 and characterize uncertainty in these parameters.

b) Provide projections of stock size and catches consistent with target reference points established in the FMP.

c) Evaluate stock status with respect to established target and threshold overfishing levels.

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 (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 to the FMP (August 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 to the FMP (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), and the biomass threshold as 76,650 mt (169 million lbs). In the last stock assessment (Terceiro 1999), those references points were updated using the most 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).

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 metric tons (mt; 40 million lbs, Table D1). The reported landings in 1999 of 4,826 mt (about 10.6 million lbs) were about 1% under the adjusted 1999 quota of 4,867 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

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 1994-1999, 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 calendar quarter of the year, with nearly 50% of the landings taken during the first quarter in 1999.

The distribution of 1992-1999 landings by three-digit statistical area is presented in Table D2. Areas 526, 537, 538, and 539 (Southern New England), areas 611, 612, 613 and 616 (New York Bight), areas 621, 622, and 626 (Delmarva region), and areas 631 and 632 (Norfolk Canyon area) have generally accounted for over 80% of the Northeast Region commercial landings. A summary of length frequency and age sampling of summer flounder landings sampled by the NEFSC commercial fishery weighout system in the Northeast Region (NER: ME to VA) is presented in Table D3. 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, pee-wee, and unclassified), with the sampling distribution generally reflecting the distribution of weighout landings by market category. The proportion of large market category fish in the NER landings has increased since 1996, while the proportion of small market category landings has become very small.

The age composition of the NER commercial landings for 1994-1999 was 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).

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 D4). Mean weights at age are presented in Table D5.

North Carolina

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 sampled 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 D6). 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 (1988-1999) 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 D7-D8.

Commercial Fishery Discards

Analysis of variance of sea sample data for summer flounder was used to identify stratification variables for an expansion procedure to estimate total landings and discard from sea sample 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. The kept and discard estimation procedure expanded transformation bias-corrected geometric mean catch 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 for comparison with reported landings. For strata with no sea 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 (1992-1999). Estimates at length and age are stratified by gear only for 1994-1999, again due to sample size considerations.

While estimates of catch rates from the NER sea sample 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 kept ratios for the sea sample 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 higher in the sea sample data. Overall, sea sample and VTR discard to kept ratios were comparable during 1994-1999 (Tables D9-D10).

Finally, the change from the interview/weighout data reporting system to the VTR/mandatory dealer report system has required a change in the estimation of effort (days fished) used as a multiplier with the sea sample geometric mean discard rate in the procedure used to estimate total discard for 1994-1999. An initial examination of days fished and catch per unit effort (CPUE; landings per day fished) for cod conducted at SAW 24 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 1997), 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 1995-1999 (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 1994-1999.

Two adjustments were made to the dealer/VTR matched data subset days fished estimates to fully accounted for summer flounder fishery effort during 1994-1999. 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 sea sample 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. NER discard estimates for 1989-1999 are summarized in Table D11. 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.

Existing sea sample data were used to develop estimates of commercial fishery discard for 1989-1999. 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 sea sample 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 sea sample, 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 sea sample mean weights at age to derive fishery discard numbers at age. Classification to age for 1989-93 was done by semiannual (quarters 1 and 2 pooled, quarters 3 and 4 pooled) periods using NEFSC sea sample 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 1994-1999, only NEFSC winter, spring, and fall survey age-length keys were used. Sea sample sampling intensity is summarized in Table D11. Estimates of discarded numbers at age, mean length and mean weight at age are summarized in Tables D12-D14.

In 1999, total commercial fishery discards were estimated to be 1,935 mt, the highest total in the 1989-1999 time series of estimates. The number of commercial fishing trips sampled with summer flounder catch was 66 in 1999 (86 trips when split by statistical area), the lowest number that has been sampled since 1994. An estimated 1,476 mt of summer flounder were discarded in the trawl fishery and an estimated 459 mt discarded in the scallop dredge fishery. Eighty percent of this total, or 1,548 mt, was assumed to die (Table D11). The reason for discarding in both 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 tows. In 1999, the minimum size regulation was provided as the reason for discarding for 61% of the observed 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. 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 D12).

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 D15-D16. Recreational fishery landings decreased 41% by number and 33% by weight from 1998 to 1999, although the fishery still landed 113% (3,804 mt, 8.4 million lbs) of the 3,360 mt (7.4 million lbs) quota established for 1999. Recreational landings accounted for 19% of the total summer flounder recreational catch in numbers, with 81% released alive (Table D17).

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 1999, aggregate sampling intensity averaged 147 mt of landings per 100 fish measured (Table D18).

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 account 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 recent increases in minimum size (to 14.5 in [37 cm] in 1997, and 15 in [38 cm] in 1998-1999), reductions in fishing mortality, and patterns in recruitment to the stock, the age composition of the recreational landings includes mainly fish at ages 2 and 3 , and many fewer at ages 0 and 1, during 1997-1999 (Table D19). 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.

<u>Recreational Fishery Discards</u>

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) of the total catch (Table D17).

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 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 and 15.0 in (38 cm) in 1998-1999. Applying the same logic employed to classify the 1982-1996 recreational released catch to size and age for 1997 and 1998 implies that the recreational fishery released catch now includes fish of ages 2 and 3. As in previous years, for 1997-1999 it was 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 and 38 cm in 1998-1999 (Table D20). Investigation of data from the CT DEP Volunteer Angler Survey (VAS), comparing the length frequency of CT VAS released fish with the MRFSS data on the length frequency of landed fish less than the minimum size, suggests this assumption was valid for 1997-1999.

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 SAW 25 (NEFSC 1997) and previous assessments of summer flounder, a 25% hooking mortality rate was assumed reasonable for summer flounder released alive by anglers.

Two recent investigations of summer flounder recreational fishery release mortality suggested that a revision in the assumed rate was 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 recent release mortality studies conducted specifically for summer flounder, a 10% release mortality rate was assumed in the Terceiro (1999) and in the current assessments.

As a result, 10% of the total B2 catch at age was added to estimates of summer flounder landings at age to provide estimates of summer flounder recreational fishery discard at age (Table D20), total recreational fishery catch at age in numbers and mean weights at age (Tables D21-D22). The number of fish discarded and assumed dead in the recreational fishery (1.7 million fish, 688 mt) was 41% by number and 18% by weight of the total landed (4.1 million fish, 3,804 mt) in the recreational fishery in 1999.

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 1982-1999 (Table D23; Figure D1). 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% in 1998 and 1999. 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 winter trawl, and recreational (Maine to North Carolina) fisheries (Tables D24-25; Figure D2). The recreational fishery share of the total summer flounder catch has increased since 1995 (Figure D3).

BIOLOGICAL DATA

Ageing

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 NC DMF fishery biology staffs. Research and age structure 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, 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 NC DMF 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 ageing 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-ageing 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 ageing 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 utilized in analyses in the SAW 25 assessment (NEFSC 1997).

A third summer flounder ageing workshop was held at NEFSC in February, 1999, to continue the exchange of age structures and review of ageing protocols for summer flounder (Bolz et al., In press). The participants of the latest workshop concluded that the majority of ageing 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 (50^{th} 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 ageing convention used in the SAW 11 and subsequent assessments (Smith et al. 1981, Almeida et al. 1992, Szedlmayer and Able 1992), the median age of maturity (50^{th} 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 since the maturity schedules have been based on simple gross morphological examination of the gonads and therefore may not accurately reflect (e.g, 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 1994 (NEFSC 1994). In light of the recent completion of a URI study to address this research recommendation, the maturity data for summer flounder for 1982-1998 have been re-visited to determine if changes in the maturity schedule used in the assessment are warranted.

The research at the University of Rhode Island (URI) by Drs. Jennifer Specker and Rebecca Rand Merson (hereafter referred to as the "URI 1999" study) has 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). 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.

The estimated median lengths at maturity are comparable for the SAW 11, O'Brien et al. (1993) and current analysis of NEFSC maturity data, with L_{50} values for males ranging from 23.8 to 27.5 cm, for females from 25.2 to 29.9 cm, and for the sexes combined (both) from 24.8 to 27.9 cm. The predicted proportions mature at length curves are comparable for the SAW 11, O'Brien et al. (1993), and NEFSC 1982-1989 and 1990-1998 maturity data. The URI 1999 maturity schedule is shifted to larger sizes relative to the other curves, with an L_{50} that is about 25% larger (34.7 cm versus a mean of 28.0 cm) than the others. The SAW 11, O'Brien et al. (1993) and NEFSC curves for male summer flounder are very similar.

A comparison of the maturity curve parameters, mean lengths, and calculated proportions mature at age from the current work using NEFSC data from the two time periods shows higher proportions mature at age (about 20% higher for ages 0 and 1, about 6% higher for age 2) than those used in the SAW 11 and subsequent assessments. The SAW 11 assessment review noted that the mean weights at age obtained from the NEFSC Fall survey mean lengths at age were substantially smaller than mean weights at age from the fisheries for ages 0 and 1, but larger for ages 2 and older. This likely resulted from selection of the largest individuals of ages 0 and 1 by the fisheries (therefore fisheries mean weights were larger), and from temporal differences between the fishery (averaged over the year) and survey (fall) mean weights for the fully recruited age 2 and older fish (therefore survey weights were larger). While the survey weights were more likely to reflect the characteristics of the spawning stock during the spawning, the lack of samples for fish at ages 5 and older precluded the use of the survey mean weights at age for all ages, a problem which persists. As a result, the SAW 11 and subsequent assessments have used fishery mean weights at age for both the catch and spawning stock.

The URI 1999 maturity schedule was applied to the NEFSC 1982-1989 and 1990-1998 autumn survey mean lengths at age to calculate proportions mature at age, for comparison with the proportions mature calculated using the NEFSC schedule for the respective time periods. The URI 1999 schedule results in about a 75% lower proportion mature at age-0 (10% versus 40%), 13% less at age-1 (64% versus 83%), and about the same proportion mature for ages 2 and older (Table 3). Thus, the potential effect of applying the URI 1999 maturity criteria in the assessment would be to decrease the proportion of ages 0 and 1 female summer flounder judged to be mature. The URI 1999 study examined only female summer flounder, and it is not evident that the same differences found between the biochemcial and morphological criteria for maturity of female fish would apply to male summer flounder, due to the different biochemical and histological processes that occur in the maturation of male fish (R.R. Merson, personal communication, 3/7/2000).

The SARC concluded that some contribution to spawning from ages 0 and 1 should be included in the assessment. Given the relatively minor changes in the absolute magnitude of spawning stock biomass that would result from consideration of recent work, the SAW 11 schedule was retained for the 2000 assessment. The SARC feels 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. The SARC 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 D26-D27) suggest that total stock biomass peaked during 1976-1977, and in 2000 was at about 85% of that peak (Figure D4). Age composition data from the NEFSC spring survey indicate a substantial reduction in the number of ages in the stock between 1976-1990 (Table D28). 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 begun to expand. There is strong evidence in the 1998-2000 NEFSC spring surveys of increasing abundance of age-3 and older fish, due to increased survival of the 1994 and subsequent year classes (Table D28).

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 (Figure 10). Furthermore, the autumn survey catches age-0 summer flounder in abundance, providing an index of summer flounder recruitment. 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 is the most abundant in recent years, and that subsequent, weaker year classes are experiencing increased survival. The 1998 and 1999 autumn survey indices are the highest of the 1982-1999 aged series (Table D29, Figure D4).

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 were found in strata 1-12, south of the New York and Rhode Island coasts, in slightly deeper waters. Significant numbers of large summer flounder were 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. 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 (Figure D4). The Winter 2000 survey kg per tow index is the highest of the 1992-2000 series (Table D30, Figure D4).

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. In

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 1972-1995. 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 (Table D40, Figure D7).

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 1979-1996. With the Bay included, the series is available only for 1988-1996, 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 1988 and 1993, with strongest year classes recruiting during 1980-1984, 1990, 1991, and 1994 (Table D41, Figure D7).

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 suggest a weak year class in 1988, and strongest year classes in 1987, 1992, and 1996. the highest index of the series. (Table D42. Figure D7). The survey normally takes place in mid-June, but was delayed until mid-July in 1999. The SARC noted that the sampling that produced the 1999 index therefore inconsistent with the other indices in the time series, and the 1999 value was excluded from the VPA calibration.. A summary of the available recruitment at age-0 indices from the states and NEFSC is presented in Table D43 and Figures D7-D9.

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°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 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.

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

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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 through1999 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 (r ; 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 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 current ASPIC analysis are considered to be unreliable.

VIRTUAL POPULATION ANALYSIS (VPA)

Sensitivity of VPA Results

Terminal F values in 1999 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 1.3.3 VPA. As recommended by the MAFMC S&S Committee during the review of the Terceiro (1999) assessment (M. Terceiro, personal communication, August 1999), and by the National Research Council Summary Review of the Summer Flounder Stock Assessment (NRC 2000), ages 0-6 were included in the analysis as true ages, with ages 7 and older combined as a plus group. Stock sizes in 2000 were directly estimated for ages 1-6, while the age 7+ group was calculated from Fs estimated in 1999. 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 3-5. F on the age 7+ group was assumed equal to the F for age 6. Winter, spring, and mid-year (e.g., RIDFW 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 VPA estimates of stock size, and examination of VPA diagnostics including the partial variance accounted for by each index, patterns in residuals, and the mean squared residual (MSR) of the calibration 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 includes fewer indices (n=34) than were used in the Terceiro (1999) assessment (n=36). The MA DMF seine survey recruitment index, MA DMF spring survey age 2 index, and RI DFW fall survey age 1 index (tuned to age 2) were included in the Terceiro (1999) assessment but are excluded from the current VPA. In addition, the 1999 value of the NC DMF Pamlico Sound recruitment index was excluded, because of concerns that the time of sampling was not consistent with prior years. Finally, the CT DEP fall survey index for aggregated ages 5-7+ was added to the current VPA tuning, and the NEFSC winter survey age 5 index was expanded to include ages 5-7+. A summary of the input catch and comparison with VPA estimated catch biomass is presented in Table D44. The final 2000 assessment VPA, including input data and assumptions, solution statistics, residuals, and estimates of F at age, stock number, and biomass at age is presented in Table D45.

Estimates of Fishing Mortality

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 0.25 since 1994; the partial recruitment of age-2 fish has decreased from 1.00 in 1993 to 0.72 during 1998-1999 (Table D45). 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 1982-1997 (55%-83% exploitation), far in excess of the revised FMP Amendment 12 overfishing definition, $F_{threshold} = F_{target} = F_{max} = 0.26$ (21% exploitation). The fishing mortality rate has declined substantially since 1997 and was estimated to be 0.32 (25% exploitation) in 1999, 23% higher than the overfishing definition (Table D45, Figure D10).

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 1995 year class is estimated at 46 million fish, the largest since 1986. The 1996, 1997, and 1998 year classes are estimated to be of about average size at 32 to 38 million fish (VPA 1982-1999 arithmetic mean = 40 million, standard error = 16 million; geometric mean = 37 million; median = 38 million). The 1999 year class is currently estimated to be the smallest since 1988, at 19 million fish (Table D45, Figures D11-D12). Recent recruitment per unit of SSB has been lower than that observed at comparable abundance of SSB observed during the early 1980s.

Total stock biomass (January 1 biomass, calculated from January 1 numbers at age and January 1 mean weights at age estimated from fishery catch mean weights at age) estimated by VPA (1982-1999) reached 48,300 mt in 1983, before falling to 16,100 mt in 1989. Total stock biomass has increased substantially since 1991, has been stable since 1994 at about 41,000 mt, and in 1999 was estimated to be 41,400 mt (Table D45, Figure D11).

Spawning stock biomass (SSB) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has since increased with improved recruitment and decreased fishing mortality to 29,300 mt in 1999 (Table D45, Figures D11-D12). The age structure of the spawning stock has expanded, with 78% at ages 2 and older, and 10% 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 D13).

Precision of F and SSB 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 1999 fishing mortality rate and spawning 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 spawning stock biomass, the cumulative plot indicates the probability that it was less than a given level (e.g., some desired minimum spawning stock biomass).

The precision and bias of the 1999 fishing mortality rates, 1 January 2000 stock sizes, and 1 November 1999 spawning stock biomass estimates are presented in Table D46. Bias was less than 8% for all parameters estimated. The bootstrap estimate of the 1999 spawning stock biomass was relatively precise, with a corrected CV of 9%. The bootstrap mean (29,564 mt) was slightly higher than the VPA point estimate (29,347 mt). The bootstrap results suggest a high probability (>90%) that spawning stock biomass in 1999 was at least 26,000 mt, reflecting only variability in survey observations. Bootstrap results also suggest a high probability (>90%) that Jan 1, 1999 total stock biomass was at least 37,500 mt (Figure D14).

The corrected coefficients of variation for the Fs in 1999 on individual ages were 27% for age 0, 17% for age 1, 15% for age 2, 14% for age 3, 23% for age 4, 45% for age 5, 16% for age 6, and 16% for ages 7 and older. The distribution of bootstrap Fs was not strongly skewed, resulting in the bootstrap mean F for 1999 (0. 3287) being about equal to the point estimate from the VPA (0.3176). There is a 80% chance that F in 1999 was between about 0.28 and 0.38, given variability in survey observations (Figure D14).

Retrospective analysis of VPA

Retrospective analysis of the summer flounder VPA was carried out for terminal catch years 1994-1999. Expansion of the catch at age to ages 7 and older caused convergence problems for retrospective VPA configurations in the years 1995-1997. In the retrospective configuration, only the NEFSC surveys and MA DMF and CT DEP fall surveys are included in the calibration of terminal year + 1 stock size estimates, to duplicate the 2000 assessment. In order to account for the very low stock sizes at ages 5-7+ as indicated by survey indices during 1995-1997, given the estimates of catch at those ages, the VPA estimates unreasonable fishing mortality rates for ages 5-7+ in 1997, age 5 in 1996, and ages 4-7+ in 1995. Estimates of zero for ages 5 and 7 stock numbers in 1995 precluded the calculation of SSB. There were no convergence problems for the years 1982-1994, or for the 1998 and 1999 terminal years (Table D47, Figure D15).

The retrospective analysis indicates underestimation of fully recruited F (ages 3-4) for 1992-1994, following the pattern first observed in the SAW 25 assessment. Fishing mortality was retrospectively slightly overestimated for 1995-1997, notwithstanding the convergence problems for those terminal years noted above. Spawning stock biomass was slightly underestimated for 1993 and 1994, and generally stable for 1995-1998. Summer flounder recruitment at age-0 was underestimated for 1993, overestimated for 1994-1995, and underestimated for 1996-1998. (Table D47, Figure D15).

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 Report of the Eleventh SAW (NEFC 1990). The 1990 analysis estimated F_{max} = 0.23. In the SAW 25 assessment (NEFSC 1997) 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 = 0.26 (Figure D16).

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 reference points for FMP Amendment 12 (see Introduction). Current yield per recruit analysis indicates that $F_{threshold} = F_{target} = F_{max}$ = 0.26, yield per recruit (YPR) at F_{max} is 0.55219 kg/recruit, and January 1 biomass per recruit (BPR) at Fmax is 2.8127 kg/recruit. The median number of summer flounder recruits estimated from VPA for the 1982-1998 period from the Terceiro (1999) assessment was 37.844 million fish. Based on this recruitment, maximum sustainable yield (MSY) would 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}, is therefore 53,222 mt (118 million lbs).

Given the recent stability of values for partial recruitment to the fisheries, mean weights at age, and median recruitment to the stock compared to the Terceiro (1999) assessment, the SARC elected to retain the Terceiro (1999) biological reference points (F_{max} = 0.26, B_{MSY} = 106,444 mt) for this assessment (Figure D17).

FORECASTS

Stochastic forecasts were made to provide estimates of stock size and catches in 2001-2002 consistent with target reference points established in the FMP. The forecasts assume that recent patterns of discarding will continue over the time span of the forecasts. 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 forecasts was estimated as the geometric mean of F at age for 1998-1999, to reflect recent conditions in the fisheries. Mean weights at age were estimated as the geometric means of 1998-1999 values. Separate mean weight at age vectors were developed for the January 1 biomass, landings, and discards.

One hundred forecasts were made for each of the 500 bootstrapped realizations of 2000 stock sizes from the final 2000 VPA, using algorithms and software described by Brodziak and Rago (MS 1994) as implemented in FACT 1.3.3. Recruitment during 2000-2002 was generated randomly from a cumulative frequency distribution of VPA recruitment series for 1989-1999 (median recruitment = 37.8 million fish). Other input parameters were as in Table D48; uncertainty in partial recruitment patterns, discard rates, or components other than survey variability was not reflected.

For the forecast which assumes the published 2000 quota of 8,400 mt will be landed, the forecast estimates a median (50% probability) F = 0.28 and a median total stock biomass on January 1, 2001 of 55,900 mt (Table D48). There is a 75% probability that the target F for 2000 (i.e., F_{max} = 0.26) will be exceeded. Landings of 9,281 mt and discards of 1,109 mt in 2001 provide a median F = 0.26 and a median total stock biomass level on January 1, 2002 of 55,900 mt, above the biomass threshold of one-half B_{MSY} = 53,200 mt. (Table D48, Figures D17-D18). For the forecast which assumes that median F in 2000 will be 0.26, landings of 7,979 mt and discards of 1,039 mt in 2000 provide a median total stock biomass on January 1, 2001 of 56,300 mt.

CONCLUSIONS

Assessment results

The fishing mortality rate has declined from 1.31 in 1994 to 0.32 in 1999 (Figure D10). However, the stock is overfished and overfishing is occurring relative to the FMP overfishing definition. The 1999 estimate of fishing mortality is 23% above the FMP overfishing definition ($F_{threshold}$ = F_{target} = F_{max} = 0.26; Figure D17). There is an 80% chance that the 1999 F was between 0.28 and 0.38 (Figure D14).

Total stock biomass has increased substantially since 1991 and has been stable since 1994 at about 41,000 mt. The 1999 biomass was estimated to be 41,400 mt, still 23% below the FMP biomass threshold (Figures D11, D17). The NEFSC spring survey (1968-2000) stock biomass index peaked during 1976-1977, and in 2000 was at about 90% of that peak (Figure D19). There is an 80% chance that total stock biomass in 1999 was between 37,500 and 45,500 mt (Figure D14). The FMP biomass target (B_{MSY}) required to produce maximum sustainable yield (MSY=20,900 mt) is estimated to be B_{MSY} = 106,400 mt, and the FMP biomass threshold of one-half B_{MSY} = 53,200 mt (Figure D17).

Spawning stock biomass (SSB; Age 0+) declined 72% from 1983 to 1989 (18,800 mt to 5,200 mt), but has increased five-fold, with improved recruitment and decreased fishing mortality, to 29,300 mt in 1999 (Figure D11). The age structure of the spawning stock has expanded, with 78% at ages 2 and older, and 10% 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 D13).

The 1995 year class is estimated at 46 million fish, the largest since 1986. The 1996, 1997, and 1998 year classes are estimated to be of about average size at 32 to 38 million fish (VPA 1982-1999 arithmetic mean = 40 million; median = 38 million). The 1999 year class is currently estimated to be the smallest since 1988, at 19 million fish (Figure D11), but may be underestimated given recent retrospective patterns. Recent recruitment per unit of SSB has been lower than that observed at comparable abundance of SSB observed during the early 1980s.

If the landings for 2000 do not exceed 8,400 mt, the total allowable landings (TAL) in 2001 should be 9,281 mt (20.5 million lbs) to meet the FMP target F rate of F_{max} = 0.26 (Figure D18).

SARC COMMENTS

The SARC reviewed the VPA results and diagnostics, noting that the VPA configuration run with ages to 5+ gave similar results in terms of biomass to the final VPA with ages expanded to 7+. It was noted that the partial recruitment pattern was more flat-topped in the VPA with 5+ ages, but the SARC recommended using the VPA run including ages 0 to 7+. The SARC accepted the VPA run which calculated fully recruited F using the average of ages 3-5. The SARC discussed the approach used for selecting indices used in the final VPA run, and the relative influences of the catch and age 0 indices on the estimation of recruitment in 1999.

The SARC discussed the appropriateness of the SFA reference points based on yield per recruit analysis. The validity of the B_{msy} (B_{target}) was discussed, and there was discussion as to whether a stock recruit relationship could be used to better define the biomass target. The SARC concluded that a strong relationship between NEFSC spring survey index (SSB) and the Maryland recruitment (R) index, (possible proxies for SSB and R over a longer time series than is currently summarized from the VPA) did not exist. The SARC recommended that the Southern Demersal Working Group continue to investigate alternative methods of estimating biological reference points.

RESEARCH RECOMMENDATIONS

The following major data and analytic needs for future assessments were identified:

1) Expand the NEFSC sea sampling program collection of data 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) estimation of discard in the scallop dredge fishery. Maintaining adequate sea sampling 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) Conduct research to determine the discard mortality rate of commercial fishery summer flounder discards, currently assumed to be 80% based on advice from the commercial fishing industry.

3) Update the American Littoral Society (ALS) tag return mortality estimates for the 1997-1998 and 1998-1999 recreational fishing seasons.

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

5) Utilize existing data from the ALS, BOAT/US, and Virginia Gamefish Tagging Programs to supplement the current data and analyses used to characterize the length frequency of the recreational fishery discard.

6) The present maturity ogive for summer flounder is based on simple gross examination of ovaries. Recently completed work by the University of Rhode Island to better determine the maturity of young summer flounder should be continued, for both male and female summer flounder, in future years to determine if the results of the URI 1999 study would be expected to be applicable over the full VPA time series. There is also 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.

7) Commercial fishery landings sampling intensity and coverage improved significantly during 1997, 1998, and 1999, and at least this level of coverage should be continued in the future.

8) RI DFW monthly fixed station survey length frequencies are currently converted to age by using length cut-of points. Investiage the utility of applying the appropriate NEFSC or MA DMF age-length keys to these data.

9) Investigate the use of NEFSC survey mean weights at age as stock weights at age in yield per recruit, VPA, and projection analyses.

10) Continue to review the use of alternative methods for the estimation of reference points for summer flounder, including biomass dynamics and parametric and non-parametric stock-recruit models.

MAJOR SOURCES OF ASSESSMENT UNCERTAINTY

The following major sources of uncertainty in the current assessment were identified:

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 minimum 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 1982-1999.

3) The intensity of sea sampling of the commercial fishery has declined since 1995. The intensity of sea sampling should be increased to at least the 1995 intensity to maintain confidence in future commercial fishery discard estimates.

4) The current assumptions accepted to allow characterization of the length and age composition of the recreational live discard are based on data from a limited geographic area (Long Island, New York, 1988-1992; Connecticut, 1997-1999). Sampling of recreational fishery discards on a annual, synoptic basis is needed.

LITERATURE CITED

Almeida, F.P., R.E. Castaneda, R. Jesien, R.C. Greenfield, and J.M.Burnett, 1992. Proceedings of the NEFC/ASMFC Summer Flounder, *Paralichthys dentatus*,Ageing Workshop. NOAA Tech. Memo. NMFS-F/NEC-89. 7p.

Anthony, V. 1982. The calculation of $F_{0.1}$: a plea for standardization. Northwest Atlantic Fisheries Organization, Serial Document SCR 82/VI/64, Halifax, Canada.

Applegate, A., S. Cadrin, J. Hoenig, C. Moore, S. Murawski, and E. Pikitch. 1998. Evaluation of existing overfishing definitions and recommendations for new overfishing definitions to comply with the Sustainable Fisheries Act. Overfishing Definition Review Panel Final Report. 179 p.

Bolz, G., R. Monaghan, K. Lang, R. Gregory, and J. Burnett. In press. Proceedings of the summer flounder ageing workshop, 1-2 February 1999, Woods Hole, MA. NOAA Tech. Memo.

Brodziak, J., and P. Rago. MS 1994. A general approach for short-term Stochastic projections in age-structured fisheries assessment methods. Population Dynamics Branch, Northeast Fisheries Science Center, Woods Hole, MA 02543.

Bugley, K., and G. Shepherd. 1991. Effect of catch-and-release angling on the survival of black sea bass. N. Amer. J. Fish. Mgmt. 11:468-471.

Burns, T.S., R. Schultz, and B.E. Brown. 1983. The commercial catch sampling program in the northeastern United States. In Doubleday, W.G., and D. Rivard [ed.]. 1983. Sampling commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66: 290 p.

Clark, S.H. 1978. Application of bottom-trawl survey data to fish stock assessments. NOAA, NMFS, Woods Hole Laboratory Reference Document No. 78-21. 13 p.

Conser, R.J. and J.E. Powers. 1990. Extension of the ADAPT VPA tuning method designed to facilitate assessment work on tuna and swordfish stocks. Int. Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 32: 461-47.

DeLong, A., K. Sosebee, and S. Cadrin. 1997. Evaluation of vessel logbook data for discard and CPUE estimates. SAW 24 SARC Working Paper Gen 5. 33 p.

Dery, L. M. Summer flounder, *Paralichthys dentatus*. *In:* Almeida, F. P., and T. F. Sheehan, eds.Age determination methods for Northwest Atlantic species.http://www.wh.whoi.edu/fbi/age-man.html (February 1997)..

Diodati, P.J., and R.A. Richards. 1996. Mortality of striped bass hooked and released in salt water. Trans. Am. Fish. Soc. 125(2):300-307.

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Phila. Soc. for Ind. and Appl. Math. 38.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Canadian Atl. Fish. Sci. Adv. Comm. (CAFSAC) Res. Doc. 88/29. 12 p..

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. 81: 898-902.

IPHC. 1988. Annual Report, 1987. International Pacific Halibut Commission. Seattle, Washington. 51 p.

Jones, W.J., and J. M. Quattro. 1999. Genetic structure of summer flounder (*Paralichthys dentatus*) populations north and south of Cape Hatteras. Marine Biology 133: 129-135.

Lucy, J.A., and T.D. Holton. 1998. Release mortality in Virginia's recreational fishery for summer flounder, *Paralichthys dentatus*. Virginia Marine Resource Report Number 97-8, 48 p.

Lux, F.E., and L.R. Porter. 1966. Length-weight relation of the summer flounder (*Paralichthys dentatus* (Linneaus). U.S. Bureau Comm. Fish., Spec. Sci. Rept. Fish., No. 531, 5 p.

Malchoff, M.H., and J. Lucy. 1998. Short-term hooking mortality of summer flounder in New York and Virginia. Interim report for Cornell Univ/DEC Project MOU 000024, 6 p.

Merson, R.R., C.S. Casey, B. Soffientino, C. Martinez, M. Chandlee, and J.L. Specker. In Press. Oocyte development in summer flounder (*Paralichthys dentatus*): seasonal changes and steriod correlates. J. Fish. Biol.

Morse, W.W. 1981. Reproduction of summer flounder, *Paralichthys dentatus (L.)* J. Fish. Biol. 19: 189-203.

National Research Council (NRC). 2000. Summary Review of the Summer Flounder Stock Assessments. Ocean Studies Board, May 2000. 6 p.

Northeast Fisheries Center (NEFC). 1990. Report of the Eleventh NEFC Stock Assessment Workshop Fall 1990. NEFC Ref. Doc. No. 90-09. 121 p.

Northeast Fisheries Science Center (NEFSC). 1993. Report of the 16th Northeast Regional Stock Assessment Workshop (16th SAW). NEFSC Ref. Doc. No. 93-18. 116 p.

Northeast Fisheries Science Center (NEFSC). 1996a. Report of the 20th Northeast Regional Stock Assessment Workshop (20th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 95-18. 211 p.

Northeast Fisheries Science Center (NEFSC). 1996b. Report of the 22nd Northeast Regional Stock Assessment Workshop (22nd SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 96-13. 242 p.

Northeast Fisheries Science Center (NEFSC). 1997. Report of the 25th Northeast Regional Stock Assessment Workshop (25th SAW): Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NEFSC Ref. Doc. No. 97-14. 143 p.

O'Brien, L., J. Burnett, and R.K. Mayo. 1993. Maturation of nineteen species of finfish off the northeast coast of the United States, 1985-1990. NOAA Technical Report 113: 66 p.

Parrack, M.L. 1986. A method of analyzing catches and abundance indices from a fishery. Int. Comm. Conserv. Atlantic Tunas, Coll. Vol. Sci. Pap. 24: 209-221.

Pauly, D. 1980. On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. J. Cons. int. Explor. Mer 42: 116-124.

Prager, M.H. 1994. A suite of extensions to a non-equilibrium surplus-production model. Fishery Bulletin, U.S. 92:374-389.

Prager, M.H. 1995. Users manual for ASPIC: a stock-production model incorporating covariates. SEFSC Miami Lab. Doc. MIA-92/93-55.

Smith, R.L, L.M. Dery, P.G. Scarlett, and A. Jearld, Jr. 1981. Proceedings of the summer flounder (*Paralichthys dentatus*) age and growth workshop, 20-21 May 1980, Northeast Fisheries Center, Woods Hole, Massachusetts. NOAA Tech. Memo. NMFS-F/NEC-11. 30 p.

Specker, J., R.R. Merson, C. Martinez, and B. Soffientino. 1999. Maturity status of female summer flounder and monkfish. URI/NOAA Cooperative Marine Education and Research Program (CMER) Final Report, Award Number NA67FE0385. 9 p.

Szedlmayer, S.T., and K.W. Able. 1992. Validation studies of daily increment formation for larval and juvenile summer flounder, *Paralichthys dentatus*. Can. J. Fish. Aquat. Sci. 49:1856-1862.

Terceiro, M. 1999. Stock assessment of summer flounder for 1999. Northeast Fisheries Science Center Reference Document 99-19, 178 p.

Thompson, W.F., and F.H. Bell. 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific halibut) Comm. 8: 49 p.

Veber, A.M. MS 1984. Summer flounde in Great South Bay: survival o sublegals caught by hook-and-lin and released. New York Stat Department of Environmental Conservation, Division of Marin Resources. Stony Brook, NY. 27 p.

Vigley, S., M. Terceiro, A. DeLong, and K Sosebee. 1997. Proration of 1994-96 commercial landings of cod, haddock, and yellowtail flounder. SAW 24 SARC Working Paper Gen 4. 32 p.

Vilk, S.J., W. G. Smith, D.E. Ralph and J. Sibunka. 1980. The population structure of summer flounder between New York and Florida based on linear discriminant analysis. Trans. Am. Fish. Soc. 109:265-271.

Table D1. Summer Flounder Commercial Landings by State (thousands of lb) and coastwide of lb, Mt).

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total '000 lb	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
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

* = 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 D1 Continued.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD+	VA+	NC+	Total '000 lb	mt
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	1718	263	823	1863	11	211	2616	2988	11208	5084
1999	6	0	805	1637	231	804	1918	8	234	2196	2801	10640	4826

* = less than 500 lb; na = not available;

Sources: 1980-1999 State and Federal reporting systems, 1995-98 NC DMF Trip Ticket System

Table D2. 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	417	354
538	228	255	341	332	267	270	229	275
539	217	157	223	258	242	284	372	419
611	117	35	181	283	166	141	204	232
612	404	393	169	221	344	297	317	405
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	279	122
621	1028	526	258	279	318	266	285	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	502	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	3728	3555

Table D3. 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	3,728	37
1999	10,460	3,244	3,555	34

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

Table D4. 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	1,716	2,019	437	71	15	1	0	0	4,455
1999	0	123	1,571	1,525	586	161	26	8	0	0	3,999

Table D5. 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

Table D6. 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	1,355	6
1999	11,703	412	1,271	11

Table D7. 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

Table D8. Mean weight (kg) at age of summer flounder landed in the North Carolina commercial winter trawl fisher

Year	AGE 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

Table D9. Summary NER Sea Sample 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
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

Table D10. 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

Table D11. Summary of Northeast Region sea sample data to estimate summer flounder discard at age in the commercial fishery. Estimates developed using sea sample length samples, age-length data, and estimates of total discard in mt. An 80% discard mortality rate is assumed. 1995-1999 lengths converted to age using 1995-1999 NEFSC trawl survey ages; n/a = not available

Year	Gear	Lengths	Ages	Sea Sample 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
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

Table D12. Estimated summer flounder discard at age in the in the commercial fishery. 1995-1999 lengths converted to age using 1995-1999 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

Table D13. Estimated summer flounder discard mean length at age in the commercial fishery. 1995-1999 lengths converted to age using 1995-1999 NEFSC trawl su

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

Table D14. Estimated summer flounder discard mean weight at age in the in the commercial fishery. 1995-1999 lengths converted to age using 1995-1999 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

Table D15. 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	1993	1993	1994	1995	1996	1997	1998	1999
North																		
Shore	167	144	62	10	70	39	42	4	16	9	26	36	49	19	22	27	43	34
P/C	138	201	5	3	48	7	1	1	1	8	1	10	24	6	7	22	26	19
P/R	1,293	747	568	382	2,562	648	379	137	99	173	211	250	596	449	717	669	983	770
TOTAL	1,598	1,092	635	395	2.680	694	422	142	116	190	238	296	669	474	746	718	1.052	823
Mid																		
Shore	682	3.296	977	272	478	251	594	84	96	505	200	176	195	175	137	195	241	157
P/C	5,745	3,321	2,381	1,068	1.541	1,143	1,164	141	412	589	374	872	773	267	1,167	907	330	281
P/R	5,731	12,34	11.76	8,454	5,924	5,499	7,271	1,141	2,658	4,573	3,983	3,969	4,372	2,312	4,999	5,059	4,945	2,616
TOTAL	12,15	18,96	15.12	9,794	7,943	6,893	9,029	1,366	3,166	5,667	4,557	5,017	5,340	2,754	6,303	6,161	5,516	3,054
South																		
Shore	272	523	316	504	689	115	306	91	150	51	50	113	180	48	46	32	29	23
P/C	53	52	110	81	20	1	1	1	1	1	1	1	2	1	5	2	2	1
P/R	1.392	367	1,292	292	289	162	355	117	361	159	156	236	197	100	274	247	345	214
TOTAL	1,717	942	1,718	877	998	278	662	209	512	211	207	350	379	149	325	281	376	238
All																		
Shore	1.121	3,963	1,355	786	1,237	405	942	179	262	565	276	325	424	242	205	254	313	214
P/C	5,936	3,574	2,496	1.152	1,609	1.151	1.166	143	414	598	376	883	799	274	1,179	931	358	301
P/R	8,416	13,45	13,62	9.128	8.775	6,309	8,005	1,395	3,118	4.905	4,350	4,455	5.165	2.861	5,990	5,975	6,273	3,600
TOTAL	15,47	20,99	17,47	11,06	11,62	7,865	10,113	1,717	3,794	6,068	5.002	5,663	6.388	3,377	7.374	7,160	6,944	4,115

Table D16. 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	1993	1994	1995	1996	1997	1998	1999
North																		
Shore	87	59	17	7	25	21	32	2	16	6	20	25	30	14	15	17	56	27
P/C Boat	85	87	4	2	45	4	<1	<1	<1	6	<1	7	14	5	13	17	23	18
P/R Boat	875	454	388	328	2,597	582	289	141	89	150	175	181	424	371	531	445	847	735
TOTAL	1,047	600	409	337	2,667	607	322	144	106	162	196	213	468	390	559	479	926	780
Mid																		
Shore	295	1,254	399	140	293	129	329	52	56	306	126	88	112	108	80	127	172	136
P/C Boat	3,112	2,196	1,426	609	1,093	1,098	799	125	264	364	267	534	478	185	746	712	278	286
P/R Boat	3,085	8,389	5,686	4,187	3,521	3,596	5,003	985	1,665	2,673	2,536	2,453	2,849	1,699	3,155	3,898	4,097	2,473
TOTAL	6,492	11,839	7,511	4,936	4,907	4,823	6,131	1,162	1,985	3,343	2,929	3,075	3,439	1,992	3,981	4,737	4,547	2,895
South																		
Shore	87	134	98	230	425	34	113	57	76	25	25	59	100	29	24	18	18	13
P/C Boat	12	12	23	20	7	1	<1	<1	<1	<1	<1	<1	1	<1	2	1	1	<1
P/R Boat	629	102	471	142	96	54	166	71	161	80	91	136	103	84	138	143	191	115
TOTAL	728	248	592	392	528	89	280	129	238	106	117	196	204	114	164	162	210	129
All																		
Shore	469	1,447	514	377	743	184	474	111	148	337	171		242	151	119	162	246	176
P/C Boat	3,209	2,295	1,453	631	1,145	1,103	801	127	266	371	269	172	493	191	761	730	302	305
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	2,770	3,376	2,154	3,824	4,486	5,135	3,323
TOTAL	8,267	12,687	8,512	5,665	8,102	5,519	6,733	1,435	2,329	3,611	3,242	3,484	4,111	2,496	4,704	5,378	5,683	3,804

Table D17. 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	6,944	14,951	21,895	0.683
1999	4,115	17,285	21,400	0.808

Table D18. 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
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

Table D18 continued.

Year	Subregion	Landings (A+B1; mt)	Number of Summer Flounder Measured	mt/100 Lengths
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
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	926	857	108
	Mid	4,547	3,205	142
	South	210	1,259	17
	TOTAL	5,683	5,321	107
1999	North	780	442	176
	Mid	2,895	1,584	183
	South	129	564	23
	TOTAL	3,804	2,590	147

Table D19. 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	760	2,901	2,704	513	63	3	0	0	6,944
1999	0	201	1,987	1,523	325	60	19	0	0	4,115

ıble D20. 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 1997-1999 allocated to age groups in same relative proportions as fish less than the annual EEZ minimum size in the subregional 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	543	824	128	1,495	0	129	330	58	517
1999	84	569	954	122	1,729	11	215	407	55	688

able D21. Estimated recreational catch at age of summer flounder ('000; catch type A + B1 + B2). Includes catch type B2 (fish released alive) allocated to ages 0 and 1 (1982-1996) and ages 0 to 3 (1997-1999) 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	1,303	3,725	2,832	513	63	3	0	0	8,439
1999	84	770	2,941	1,645	325	60	19	0	0	5,844

Table D22. 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

Table D23. 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	2,220	6,354	5,228	978	137	18	1	0	0	14,981
1999	181	2,186	6,267	4,024	1,162	359	55	14	<1	0	14,248

Table D24. 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

'able D25. 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

Table D26. NEFSC spring trawl survey (offshore strata) mean number summer flounde per tow: delta mean, and delta values fitted to an ARIMA model with theta value = 0.240. ***NOTE: 2000 index is from preliminary, unaudited data.***

YEAR	DELTA MEAN	FITTED MEAN	FITTED UPPER 95% ci	FITTED LOWER 95% ci
1968	0.15	0.15		
1969	0.19	0.17		
1970	0.09	0.13		
1971	0.22	0.23	0.39	0.13
1972	0.47	0.44	0.76	0.26
1973	0.75	0.75	1.29	0.44
1974	1.40	1.30	2.23	0.76
1975	1.98	1.89	3.24	1.10
1976	2.72	2.46	4.21	1.43
1977	2.82	2.51	4.30	1.46
1978	2.58	1.92	3.30	1.12
1979	0.40	0.73	1.25	0.43
1980	1.31	1.18	2.02	0.69
1981	1.50	1.46	2.51	0.85
1982	2.23	1.72	2.95	1.00
1983	0.95	1.08	1.85	0.63
1984	0.66	0.93	1.59	0.54
1985	2.38	1.80	3.08	1.05
1986	2.15	1.78	3.05	1.04
1987	0.93	1.11	1.91	0.65
1988	1.46	1.08	1.85	0.63
1989	0.32	0.51	0.87	0.30
1990	0.71	0.71	1.22	0.42
1991	1.11	1.01	1.73	0.59
1992	1.19	1.15	1.92	0.68
1993	1.26	1.17	1.96	0.70
1994	0.92	1.02	1.71	0.61
1995	1.09	1.15	1.92	0.69
1996	1.80	1.48	2.47	0.88
1997	1.06	1.18	1.98	0.71
1998	1.16	1.25	2.08	0.75
1999	1.56	1.47	2.62	0.94
2000	2.22	2.01	3.54	1.14

Table D27. NEFSC spring trawl survey (offshore strata) mean weight (kg) of summer flounder per tow: delta values fitted to an ARIMA model with theta value = 0.240.
NOTE: 2000 index is from preliminary, unaudited data.

YEAR	DELTA MEAN	FITTED MEAN	FITTED UPPER 95% ci	FITTED LOWER 95% ci
1968	0.16	0.16		
1969	0.16	0.15		
1970	0.09	0.13		
1971	0.28	0.23	0.37	0.15
1972	0.21	0.26	0.42	0.17
1973	0.52	0.53	0.84	0.33
1974	1.27	1.08	1.72	0.68
1975	1.63	1.51	2.40	0.95
1976	1.94	1.77	2.81	1.12
1977	1.84	1.66	2.64	1.05
1978	1.50	1.22	1.94	0.77
1979	0.35	0.55	0.87	0.35
1980	0.79	0.73	1.16	0.46
1981	0.81	0.81	1.29	0.51
1982	1.15	0.91	1.45	0.58
1983	0.52	0.59	0.93	0.37
1984	0.38	0.51	0.81	0.32
1985	1.21	0.89	1.42	0.56
1986	0.85	0.76	1.20	0.48
1987	0.39	0.48	0.77	0.30
1988	0.66	0.51	0.81	0.32
1989	0.24	0.30	0.47	0.19
1990	0.27	0.30	0.47	0.19
1991	0.37	0.36	0.57	0.23
1992	0.45	0.43	0.67	0.28
1993	0.48	0.46	0.72	0.30
1994	0.46	0.47	0.73	0.31
1995	0.46	0.50	0.77	0.32
1996	0.68	0.63	0.97	0.40
1997	0.62	0.66	1.02	0.42
1998	0.77	0.79	1.24	0.51
1999	1.00	1.03	1.62	0.66
2000	1.71	1.48	2.41	0.90

Table D28. NEFSC spring trawl survey (offshore strata 1-12, 61-76) stratified mean number of summer flounder per tow at age. ***NOTE: 2000 indices are from preliminary unaudited data, aged with a preliminary 2000 age-length key.***

	AGE										
Year	1	2	3	4	5	6	7	8	9	10	ALL
1976	0.03	1.70	0.68	0.28	0.01	0.01	0.01				2.72
1977	0.61	1.30	0.70	0.10	0.09	0.01		0.01			2.82
1978	0.70	0.95	0.66	0.19	0.04	0.03	0.03			0.02	2.62
1979	0.06	0.18	0.08	0.04	0.03			0.01			0.40
1980	0.01	0.71	0.31	0.14	0.02	0.06	0.03	0.02		0.01	1.31
1981	0.59	0.53	0.17	0.08	0.05	0.03	0.02	0.01			1.48
1982	0.69	1.41	0.12	0.02							2.24
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	1.49	0.43	0.20	0.02	0.01						2.15
1987	0.46	0.43	0.02	0.01							0.92
1988	0.59	0.79	0.07	0.02							1.47
1989	0.06	0.23	0.02	0.01							0.32
1990	0.62	0.03	0.06								0.71
1991	0.79	0.27		0.02							1.08
1992	0.76	0.41	0.01		0.01						1.19
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	0.20	1.08	0.63	0.11	0.19	0.02					2.22
Mean	0.50	0.66	0.22	0.07	0.04	0.02	0.02	0.01	0.01	0.02	1.46

Table D29. 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+	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	2.09
1985	0.59	0.80	0.46	0.05		0.02	1.92
1986	0.39	0.83	0.11	0.11			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			0.89
1991	0.76	0.84	0.09		0.01		1.70
1992	0.99	1.04	0.25	0.03	0.01		2.32
1993	0.23	0.80	0.03	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	0.02	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
Mean	0.45	1.04	0.43	0.10	0.02	0.01	2.02

Table D30. 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, mean weight (kg), and mean number at age per tow. ***Note: 2000 indices are from preliminary, unaudited data, aged with a preliminary 2000 age-length key.***

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	16.008		12.741	

Year	Age								
	1	2	3	4	5	6	7	8+	Total
1992	7.15	4.74	0.33	0.04	0.01	0.03	0.00	0.00	12.29
1993	6.50	6.70	0.31	0.05	0.02	0.02	0.00	0.00	13.60
1994	3.76	7.20	0.82	0.26	0.00	0.01	0.00	0.00	12.05
1995	6.07	4.59	0.25	0.02	0.00	0.00	0.00	0.00	10.93
1996	22.17	8.33	0.60	0.12	0.03	0.00	0.00	0.00	31.25
1997	3.86	4.80	1.04	0.43	0.11	0.04	0.00	0.00	10.28
1998	1.68	3.25	2.29	0.42	0.10	0.01	0.00	0.01	7.76
1999	2.11	4.80	2.90	0.84	0.28	0.06	0.04	0.03	11.06
2000	0.75	6.68	5.03	2.50	0.77	0.18	0.09	0.02	16.01
Mean	5.97	5.65	1.55	0.52	0.16	0.04	0.02	0.01	13.90

Table D31. 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
Mean		0.321	0.668	0.176	0.073	0.030	0.023	0.012	0.031	1.219

Table D32. 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
Mean	0.041	0.556	0.578	0.086	0.018	0.014	0.000	0.000	0.00	1.165

Table D33. 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	0.282	0.028	0.052	0.000	0.000	0.000	0.377
1986	0.000	0.751	0.090	0.074	0.008	0.005	0.000	0.000	0.928
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	0.240	0.580	0.376	0.198	0.015	0.000	0.000	1.409
Mean	0.000	0.349	0.241	0.085	0.034	0.004	0.002	0.001	0.716

Table D34. 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	0.238	0.351	0.485	0.078	0.000	0.008	0.000	0.000	1.160
1986	0.170	1.170	0.268	0.068	0.004	0.000	0.000	0.000	1.680
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
Mean	0.060	0.636	0.510	0.099	0.017	0.005	0.001	0.000	1.328

Table D35. 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	0.130	0.202	0.390	0.074	0.013	0.000	0.000	0.000	0.000	0.000	0.809
1981	0.305	0.972	1.743	0.199	0.013	0.003	0.002	0.002	0.001	0.001	3.241
1982	0.024	0.210	0.519	0.072	0.005	0.000	0.000	0.000	0.000	0.001	0.831
1983	0.026	0.117	0.365	0.096	0.012	0.001	0.000	0.001	0.000	0.001	0.619
1984	0.122	0.423	0.698	0.092	0.013	0.003	0.000	0.000	0.000	0.000	1.351
1985	0.341	0.218	0.337	0.048	0.004	0.001	0.000	0.001	0.000	0.000	0.950
1986	0.554	1.199	1.538	0.179	0.014	0.000	0.003	0.001	0.001	0.001	3.490
1987	0.140	0.521	0.600	0.126	0.014	0.001	0.003	0.003	0.001	0.000	1.409
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	0.036	0.029	0.003	0.000	0.000	0.000	0.000	0.000	0.069
1990	0.051	0.260	0.473	0.042	0.003	0.000	0.000	0.000	0.000	0.000	0.829
1991	0.002	0.059	0.127	0.034	0.007	0.000	0.000	0.000	0.000	0.000	0.229
1992	0.065	0.394	0.684	0.185	0.033	0.003	0.004	0.001	0.001	0.000	1.370
1993	0.024	0.153	0.399	0.140	0.021	0.002	0.000	0.001	0.000	0.000	0.740
1994	0.005	0.045	0.127	0.013	0.001	0.000	0.000	0.000	0.000	0.000	0.191
1995	0.031	0.175	0.392	0.140	0.013	0.005	0.000	0.004	0.000	0.001	0.761
1996	0.166	0.606	1.158	0.147	0.010	0.001	0.000	0.001	0.000	0.001	2.090
1997	0.080	0.557	1.052	0.173	0.012	0.003	0.000	0.002	0.000	0.000	1.879
1998	0.008	0.087	0.360	0.087	0.004	0.001	0.000	0.001	0.000	0.001	0.549
1999	0.241	0.931	1.888	0.254	0.020	0.005	0.000	0.002	0.000	0.000	3.341
Mean	0.116	0.365	0.662	0.108	0.011	0.001	0.001	0.001	0.000	0.000	1.266

Table D36. RIDFW monthly fixed station trawl survey summer flounder index of abunda

Year	Mean number/tow	Mean kg/tow	Mean age 0 number/tow	Mean age 1 number/tow	Mean age 2+ number/tow
1990	0.600	0.610	0.000	0.287	0.317
1991	0.180	0.150	0.013	0.118	0.052
1992	0.740	0.640	0.016	0.344	0.377
1993	0.490	0.720	0.019	0.075	0.396
1994	0.400	0.320	0.016	0.190	0.190
1995	1.020	0.940	0.000	0.394	0.622
1996	2.080	1.570	0.109	0.922	1.047
1997	1.920	1.640	0.038	0.824	1.054
1998	0.970	0.890	0.000	0.279	0.690
1999	2.030	1.870	0.185	0.903	0.942
Mean	1.043	0.935	0.040	0.434	0.569

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

able D37. 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	5.60	2.71	0.18	0.05	10.19
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
Mean	1.83	4.22	1.47	0.20	0.06	7.77

Table D38. DEDFW Delaware Bay 16 foot trawl survey: index of summer flounder recruitment at age-0.

Year	Mean number per tow	Year	Mean number per tow
1980	0.12	1990	0.23
1981	0.06	1991	0.07
1982	0.11	1992	0.31
1983	0.03	1993	0.02
1984	0.08	1994	0.29
1985	0.06	1995	0.17
1986	0.10	1996	0.03
1987	0.14	1997	0.02
1988	0.01	1998	0.03
1989	0.12	1999	0.05
	Mean	0.1	

Table D39. 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	2.03	0.14	0.22	0.08	0.00	2.47
1995	0.95	1.00	0.28	0.10	0.09	2.42
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
Mean	0.64	0.59	0.45	0.18	0.06	1.92

'able D40. 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
Mean	4.5		

Table D41. 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
Mean	1.8			

Table D42. 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	Year	Mean number per tow
1987	19.86	1993	5.13
1988	2.61	1994	8.17
1989	6.63	1995	5.59
1990	4.27	1996	30.67
1991	5.85	1997	14.14
1992	9.14	1998	9.96
		1999	3.24

Mean 9.64

Table D43. 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
CT Autumn					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
RI Trawl	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
MA Seine			3	3	1	19	5	5	2	3	11	4	0	2	1	13	7	0	12	13
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
DE: 16 ft Trawl	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
DE: 30 ft Trawl												1.44	0.47	0.04	2.03	0.95	0.46	0.03	0.11	0.20
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
VIMS Rivers only	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
NC Pamlico								19.86	2.61	6.63	4.27	5.85	9.14	5.13	8.17	5.59	30.67	14.14	9.96	3.24
NEFSC Autumn			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

Table D44. 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				
ear	Landings	Discard	Catch	Landings	Discard	Catch	Landings	Discard	Catch	VPA Catch	VPA:Catch ratio
982	10,400	n/a	10,400	8,267	296	8,563	18,667	296	18,963	18,602	0.981
983	13,403	n/a	13,403	12,687	376	13,063	26,090	376	26,466	25,142	0.950
984	17,130	n/a	17,130	8,512	415	8,927	25,642	415	26,057	26,874	1.031
985	14,675	n/a	14,675	5,665	92	5,757	20,340	92	20,432	21,828	1.068
986	12,186	n/a	12,186	8,102	578	8,680	20,288	578	20,866	21,561	1.033
987	12,271	n/a	12,271	5,519	522	6,041	17,790	522	18,312	18,551	1.013
988	14,686	n/a	14,686	6,733	342	7,075	21,419	342	21,761	23,442	1.077
989	8,125	709	8,834	1,435	45	1,480	9,560	754	10,314	10,388	1.007
990	4,199	1,214	5,413	2,329	234	2,563	6,528	1,448	7,976	7,759	0.973
991	6,224	1,052	7,276	3,611	429	4,040	9,835	1,481	11,316	11,730	1.037
992	7,529	690	8,219	3,242	344	3,586	10,771	1,034	11,805	12,167	1.031
993	5,715	846	6,561	3,484	736	4,220	9,199	1,582	10,781	10,991	1.019
994	6,588	906	7,494	4,111	577	4,688	10,699	1,483	12,182	12,541	1.029
995	6,977	308	7,285	2,496	714	3,210	9,473	1,022	10,495	10,643	1.014
996	5,770	463	6,233	4,704	615	5,319	10,474	1,078	11,552	11,777	1.019
997	3,994	326	4,320	5,378	627	6,005	9,372	953	10,325	10,212	0.989
998	5,084	389	5,473	5,683	517	6,200	10,767	906	11,673	11,484	0.984
999	4,826	1,548	6,374	3,804	688	4,492	8,630	2,236	10,866	10,831	0.997
lean	8,877	768	9,346	5,320	453	5,773	14,197	922	15,119	15,362	1.014

Table D45. Virtual Population Analysis (VPA) for summer flounder, 1982-1999.

Fisheries Assessment Toolbox Summer flounder: SD31 - 10 Run Number 1 6/28/00 5:47 PM
FACT Version 1.3.3
Summer flounder: SD31 - 10 1982 - 2000
Input Parameters and Options Selected

Natural mortality is a matrix below
Oldest age (not in the plus group) is 7
For all years prior to the terminal year (17), back calculated stock sizes for the following ages used to estimate total mortality (Z) for age 6 : 3 4 5
This method for estimating F on the oldest age is generally used when a flat-topped partial recruitment curve is thought to be characteristic of the stock.
F for age 7 + is then calculated from the following ratios of F[age 7 +] to F[age 6]

1982	1	1991	1
1983	1	1992	1
1984	1	1993	1
1985	1	1994	1
1986	1	1995	1
1987	1	1996	1
1988	1	1997	1
1989	1	1998	1
1990	1	1999	1

Stock size of the 7 + group is then calculated using the following method:
CATCH EQUATION
Partial recruitment estimate for 2000

0	0.01
1	0.2
2	0.8
3	1
4	1
5	1
6	1

Objective function is Sum w*(LOG(OBS)-LOG(PRED))**2
Indices normalized (by dividing by mean observed value) before tuning to VPA stocksizes
Downweighting is None or Uniform
Biomass estimates (other than SSB) reflect mean stock sizes.
SSB calculated as in the NEFSC projection program

Table D45 continued.

The Indices that will be used in this run are:

1	NEC_W1	10	NEC_F2	18	CT_S4	26	NJ2
2	NEC_W2	11	NEC_F3	19	CT_F2	27	DE2
3	NEC_W3	12	NEC_F4	20	CT_F3	28	DE3
4	NEC_W4	13	MA_S3	21	CT_F4	29	CT_Y0
5	NEC_W5:7	14	MA_F3	22	CT_F5:7	30	VA_RY0
6	NEC_S1	15	MA_F4	23	RI_X1	31	NC_Y0
7	NEC_S2	16	CT_S2	24	RI_X2	32	MD_Y0
8	NEC_S3	17	CT_S3	25	NJ1	33	NJ_Y0
9	NEC_S4					34	NEC_Y0

STOCK NUMBERS (Jan 1) in thousands

	1982	1983	1984	1985	1986	1987	1988
0	74269	80323	48380	48579	53444	43922	13034
1	42907	55971	61306	35265	37893	41999	34931
2	16205	17554	20090	26141	15641	15515	18812
3	2203	4084	4500	2465	5134	2803	2896
4	807	957	1370	806	420	781	804
5	162	364	157	372	212	58	148
6	158	28	06	42	76	46	25
7	70	73	14	11	19	69	26
0+	136779	159353	135823	113683	112840	105194	70606

	1989	1990	1991	1992	1993	1994	1995
0	27270	30358	28704	32363	33556	38269	46142
1	9952	21458	23176	22595	25258	26311	29850
2	9999	5814	9599	7982	8368	10514	12165
3	2226	1576	1144	1391	1083	1783	2278
4	438	291	390	265	121	374	571
5	75	39	38	123	80	33	121
6	11	12	05	03	37	25	03
7	05	04	02	01	05	09	02
0+	49976	57552	63057	64722	68509	77318	91133

	1996	1997	1998	1999	2000
0	37782	37510	32201	19189	00
1	37242	30787	30684	26323	15547
2	18166	24225	22903	23113	19574
3	3352	7297	12554	13002	13253
4	744	1129	3125	5548	7004
5	109	232	424	1673	3491
6	29	25	45	223	1045
7	05	09	02	56	167
0+	98429	101213	10193	89128	60080

Table D45 continued.

FISHING MORTALITY

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	0.08	0.07	0.12	0.05	0.04	0.03	0.07	0.04	0.07
1	0.69	0.82	0.65	0.61	0.69	0.60	1.05	0.76	0.60
2	1.18	1.16	1.90	1.43	1.52	1.48	1.93	1.65	1.00
3	0.63	0.89	1.52	1.57	1.68	1.05	1.69	1.83	1.20
4	0.60	1.61	1.10	1.14	1.79	1.47	2.17	2.22	1.82
5	1.57	3.95	1.11	1.38	1.32	0.65	2.36	1.64	1.91
6	0.63	1.03	1.48	1.53	1.83	1.17	1.93	2.08	1.33
7	0.63	1.03	1.48	1.53	1.83	1.17	1.93	2.08	1.33

	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.04	0.05	0.04	0.05	0.01	0.00	0.00	0.00	0.01
1	0.87	0/79	0.68	0.57	0.24	0.23	0.10	0.08	0.10
2	1.73	1.80	1.35	1.33	1.09	0.77	0.46	0.37	0.36
3	1.26	2.24	0.86	0.94	0.92	0.89	0l65	0.62	0.42
4	0.96	0.99	1.10	0.93	1.46	0.97	0.78	0.42	0.26
5	2.53	1.00	0.97	2.06	1.22	1.28	1.44	0.44	0.27
6	1.22	2.11	0.91	0.96	1.04	0.93	0.68	0.58	0.32
7	1.22	2.11	0.91	0.96	1.04	0.93	0.68	0.58	0.32

Average F for 3,5

	1982	1983	1984	1985	1986	1987	1988	1989	1990
3,5	0l93	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65

	1991	1992	1993	1994	1995	1996	1997	1998	1999
3,5	1.58	1.41	0.98	1.31	1.20	1.04	0.96	0.49	0.32

Biomass Weighted F

1982	1983	1984	1985	1986	1987	1988	1989	1990
0.49	0.60	0.76	0.66	0.68	0.69	1.18	0.82	0.48

1991	1992	1993	1994	1995	1996	1997	1998	1999
0.86	0.70	0.54	0.46	0.30	0.32	0.28	0.27	0.27

Table D45 continued.

BACK CALCULATED PARTIAL RECRUITMENT

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	0.05	0.02	0.06	0.03	0.02	0.02	0.03	0.02	0.04
1	0.44	0.21	P.34	0.39	0.38	0.41	0.44	0.34	0.32
2	0.75	0.29	1.00	0.91	0.83	1.00	0.82	0.74	0.52
3	0.40	0.23	0.80	1.00	0.92	0.71	0.71	0.83	0,63
4	0.38	0.41	0.58	0.72	0.98	0.99	0.92	1.00	0.95
5	1.00	1.00	0.58	0.88	0.72	0.44	1.00	0.74	1.00
6	0.40	0.26	0.78	0.97	1.00	0.79	0.82	0.94	0.70
7	0.40	0.26	0.78	0.97	1.00	0.79	0.82	0.94	0.70

	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	0.02	0.02	0.03	0.02	0.01	0.00	0.00	0.00	0.03
1	0.34	0.35	0.50	0.28	0.17	0.18	0.07	0.14	0.23
2	0.69	0.80	1.00	0.64	0.75	0.60	0.32	0.59	0.85
3	0.50	1.00	0.64	0.45	0.63	0.69	0.45	1.00	1.00
4	0.38	0.44	0.82	0.45	1.00	0.75	0.54	0.69	0.63
5	1.00	0.44	0.72	1.00	0.83	1.00	1.00	0.72	0.65
6	0.48	0.94	0.67	0.47	0.71	0.72	0.47	0.95	0.76
7	0.48	0.94	0.67	0.47	0.71	0.72	0.47	0.95	0.76

Jan 1 BIOMASS (using Jan 1 mean weights)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	14705	15020	9144	11222	10208	8521	3415	3927	6011
1	13687	18191	18882	11497	13717	14028	12086	3792	6416
2	7551	9602	10306	12888	8368	8425	9876	5789	2327
3	3421	3325	3892	2064	4368	2447	2485	1796	1448
4	1738	1291	1740	1084	583	1173	1132	566	369
5	472	614	258	690	392	129	324	149	69
6	431	74	13	102	211	120	82	28	34
7	269	189	55	52	78	243	99	13	19
0+	42274	48306	44291	39597	37886	35085	29499	16060	16692

	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	2325	5631	6275	11060	15735	10655	5214	6956	1267
1	7416	5897	8714	9814	13045	16610	11884	9880	8160
2	5279	4406	4795	5804	7275	10599	13833	12391	12458
3	1121	1288	1132	1733	1854	2870	5129	9302	9908
4	567	340	172	655	851	950	1303	3343	6169
5	76	271	129	70	284	195	432	732	2719
6	12	06	102	63	11	76	56	108	572
7	06	05	13	33	07	16	26	10	198
0+	16801	17845	21333	29232	39060	41969	37877	42722	41449

Table D45 continued.

Table D45 continued.

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

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	5668	5854	3507	4341	4207	3574	1251	1767	2324
1	6150	7180	8615	5534	5890	6863	4123	1487	3415
2	2862	3654	2003	3735	2257	2257	1797	1404	1023
3	1596	1774	1130	.629	1248	1133	682	430	578
4	795	268	696	458	140	380	196	87	83
5	104	17	114	230	120	81	44	37	14
6	211	26	05	27	47	50	16	04	12
7	135	68	13	12	15	78	17	02	05
0+	17521	18841	16084	14967	13924	14417	8126	5216	7454
2+	5703	5807	3962	5092	3827	3980	2752	1962	1715

	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	1297	2453	2751	4200	5724	3997	2558	2681	876
1	2804	3353	4270	5273	7990	9570	7838	8557	5399
2	1220	1025	1459	1670	2547	4411	8073	7349	7787
3	403	224	655	938	950	1468	3126	5475	6972
4	270	137	68	307	236	437	618	2458	5435
5	10	122	57	14	98	62	134	601	2262
6	04	01	42	33	05	29	31	60	395
7	02	01	05	12	02	06	13	05	129
0+	6010	7315	9307	12447	17552	19981	22390	28186	29354
2+	1909	1509	2286	2947	3838	6414	11994	16948	22979

Table D46. VPA Bootstrap results: precision of estimates.

The number of bootstraps: 500 - Bootstrap Output Variable: N hat (1 January 2000)

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. for NLLS SOLN	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	15547	15743	3696	0.24	196	165	1.26	15350	0.240814	11378	20519
N 2	19574	19770	3292	0.17	197	147	1.01	19376	0.169913	15538	23869
N 3	13252	13224	2246	0.17	-28	100	-0.21	13280	0.169123	10512	16266
N 4	7001	7040	1110	0.16	39	50	0.55	6962	0.159505	5512	8391
N 5	3489	3551	831	0.24	62	37	1.79	3427	0.242539	2489	4573
N 6	1045	1070	341	0.33	25	15	2.40	1020	0.334451	648	1526

Bootstrap Output Variable: F t

	NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. for NLLS SOLN	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	0.0105	0.0109	0.0027	0.25	0.0004565	0.0001192	4.356	0.0100232	0.27	0.0079	0.0143
Age 1	0.0963	0.0978	0.0159	0.17	0.0015432	0.0007105	1.603	0.0947265	0.17	0.0794	0.1191
Age 2	0.3562	0.3644	0.0538	0.15	0.0082244	0.0024050	2.309	0.3479931	0.15	0.2978	0.4294
Age 3	0.4188	0.4242	0.0573	0.14	0.0054703	0.0025629	1.306	0.4132965	0.14	0.3602	0.5052
Age 4	0.2634	0.2708	0.0580	0.22	0.0073568	0.0025958	2.793	0.2560510	0.23	0.2059	0.3515
Age 5	0.2706	0.2910	0.1138	0.42	0.0203488	0.0050913	7.1519	0.2502897	0.45	0.1906	0.4048
Age 6	0.3176	0.3287	0.0499	0.16	0.0110587	0.0022310	3.482	0.3065457	0.16	0.2669	0.3695
Age 7	0.3176	0.3287	0.0499	0.16	0.0110587	0.0022310	3.482	0.3065457	0.16	0.2669	0.3695

Bootstrap Output Variable: F full t

NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. for NLLS SOLN	Bias Estimate	Bias Std Error	Percent Bias	NLLS Est Corrected for Bias	C.V. for Corrected Estimate	Lower 80% CI	Upper 80% CI
0.3176	0.3287	0.0499	0.16	0.01106	0.00223	3.48	0.30655	0.16	0.2669	0.3695

Bootstrap Output Variable: SSB spawn t

NLLS Estimate	Bootstrap Mean	Bootstrap Std Error	C.V. for NLLS SOLN	Bias Estimate	Bias Std Error	Percent Bias	NLLS Est Corrected for Bias	C.V. for Corrected Estimate	Lower 80% CI	Upper 80% CI
29347.1583	29564.4364	2737.2859	0.09	217.28	122.42	0.74	29129.88	0.09	25970.06	32823.7670

Table D47. VPA retrospective analysis for summer flounder.

Fishing Mortality

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1994	0.93	2.15	1.24	1.36	1.59	1.06	2.07	1.89	1.63	1.52	1.11	0.63	0.82					
1995	0.93	2.15	1.24	1.36	1.59	1.06	2.07	1.89	1.63	1.55	1.35	1.86	1.29	2.76				
1996	0.93	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.63	1.58	1.42	0.99	1.36	1.40	1.82			
1997	0.93	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	6.16		
1998	0.93	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.31	1.21	1.06	0.98	0.53	
1999	0.93	2.15	1.24	1.36	1.59	1.06	2.07	1.90	1.65	1.58	1.41	0.98	1.31	1.20	1.04	0.96	0.49	0.32

Spawning Stock Biomass

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1994	17497	18833	16086	14969	13926	14422	8136	5259	7592	6234	7343	8218	1070					
1995	00	00	00	00	00	00	00	00	00	00	00	00	00	00				
1996	17497	18833	16086	14968	13926	14418	8124	5215	7449	5998	7256	9104	12210	17791	19842			
1997	17497	18833	16086	14968	13926	14418	8124	5216	7453	6007	7293	9281	12718	18801	21274	22573		
1998	17497	18833	16086	14968	13926	14418	8124	5216	7453	6008	7313	9284	12412	17689	20148	21854	25251	
1999	17497	18833	16086	14968	13926	14418	8125	5216	7453	6009	7314	9305	12445	17550	19978	22386	28182	29347

Population Numbers Age: 0

Terminal Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1994	74267	80323	48381	48579	53445	43959	13043	27628	30753	27848	29651	26338	48495					
1995	74267	80323	48381	48579	53444	43861	13040	27267	31099	28410	31391	31746	39569	54374				
1996	74267	80323	48381	48579	53444	43920	13032	27269	30331	28636	32022	32765	39742	49230	28162			
1997	74267	80323	48381	48579	53444	43922	13033	27270	30360	28663	32213	33882	40580	51021	31313	24676		
1998	74267	80323	48381	48579	53444	43921	13033	27270	30355	28704	32374	33301	38567	47337	36877	28239	22323	
1999	74267	80323	48381	48579	53444	43921	13033	27270	30358	28793	32362	33556	38269	46138	37775	37508	32200	19188

Table D48 Input parameters and short term stochastic forecast results for summer flounder. Starting stock sizes on January 1, 2000 are as estimated by VPA bootstrap procedure. Age-0 recruitment levels in 2000-2002 are estimated as the median of 500 random estimates selected from VPA estimated numbers at age 0 (000s) during 1982-1999. Fishing mortality was apportioned among landings and discard based on the proportion of F associated with landings and discards at age during 1998-1999. Mean weights at age (landings and discards) are weighted (by fishery) geometric means of 1998-1999 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 2000	Fishing Mortality Pattern	Proportion Landed	Proportion Mature	Mean Weights January 1 Total Biomass	Mean Weights Landings	Mean Weights Discards
0	37775	0.01	0.08	0.38	0.119	0.241	0.152
1	15522	0.18	0.43	0.72	0.316	0.505	0.370
2	19694	0.72	0.74	0.90	0.540	0.643	0.564
3	13179	1.00	0.93	1.00	0.751	0.868	1.016
4	7066	1.00	0.95	1.00	1.091	1.372	1.610
5	3504	1.00	0.95	1.00	2.674	2.160	2.382
6	1037	1.00	0.95	1.00	2.482	2.649	2.612
7+	164	1.00	0.95	1.00	3.733	3.720	3.600

2000 Landings = 8,400 mt; 2000-2002 median recruitment from 1982-1999 VPA estimates (37.8 million)

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

	2000				2001				2002			
Option	F	Land.	Disc.	B	F	Land.	Disc.	B	F	Land.	Disc.	B
1	0.28	8.4	1.1	47.1	0.26	9.3	1.1	55.9	0.26	10.9	1.4	66.1
2	0.26	8.0	1.0	47.1	0.26	9.4	1.1	56.3	0.26	11.0	1.4	66.4

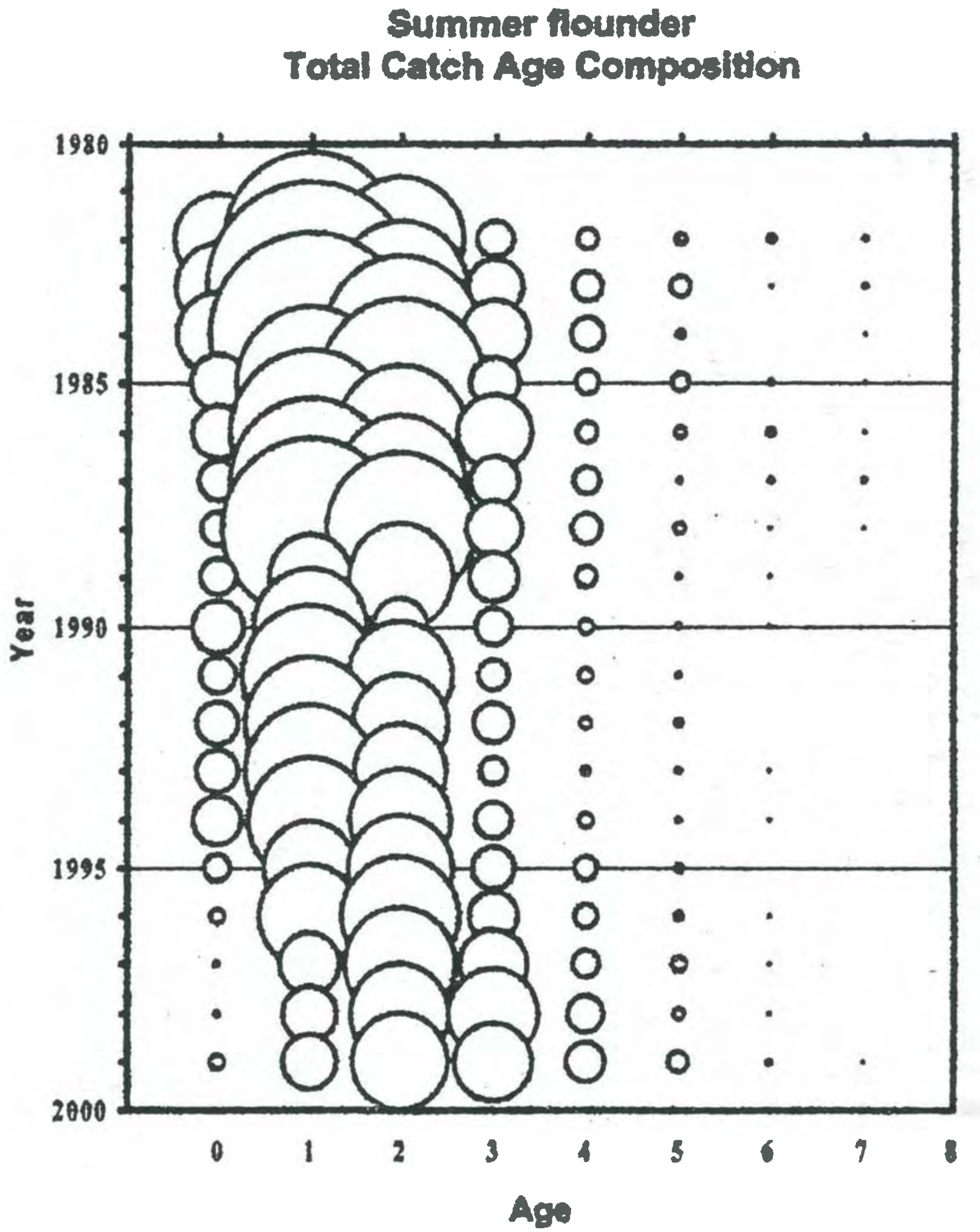


Figure D1. Total catch age composition for summer flounder: 1982-1999

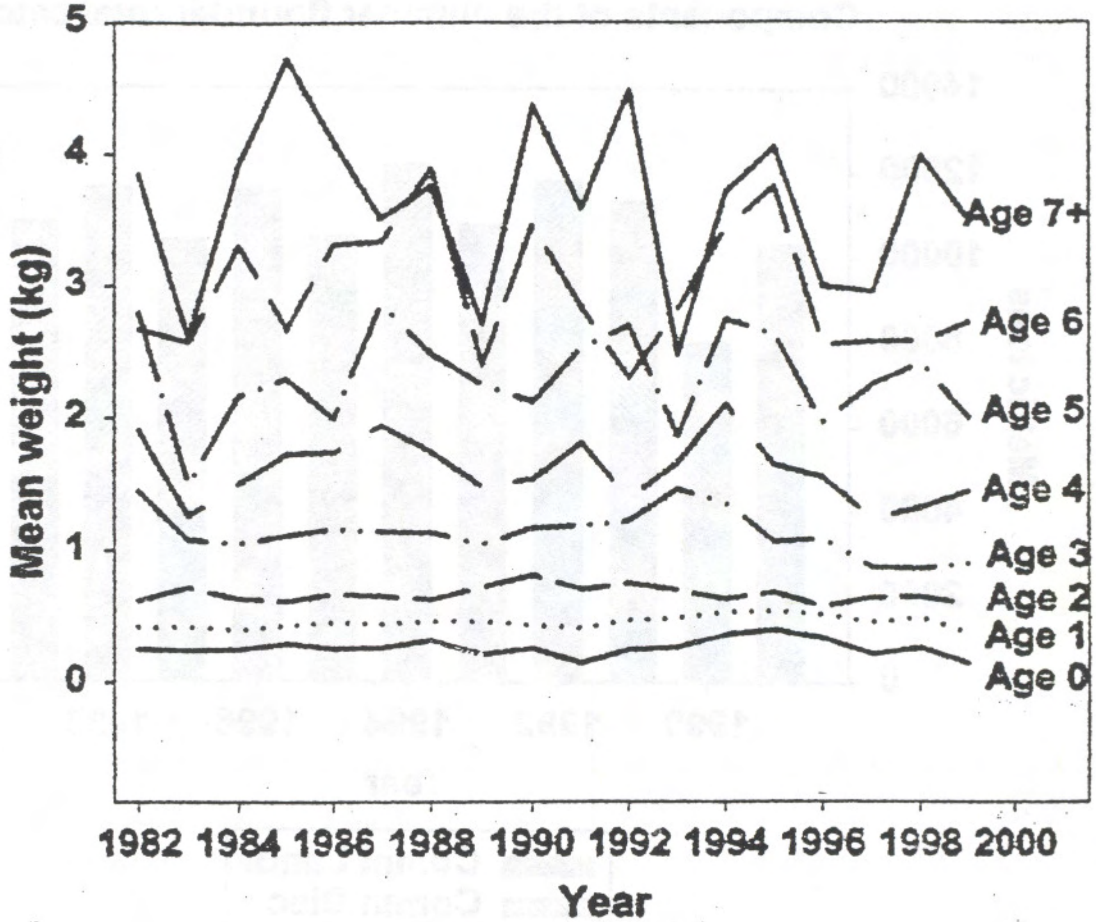


Figure D2. Trends in mean weight at age in the total catch of summer flounder.

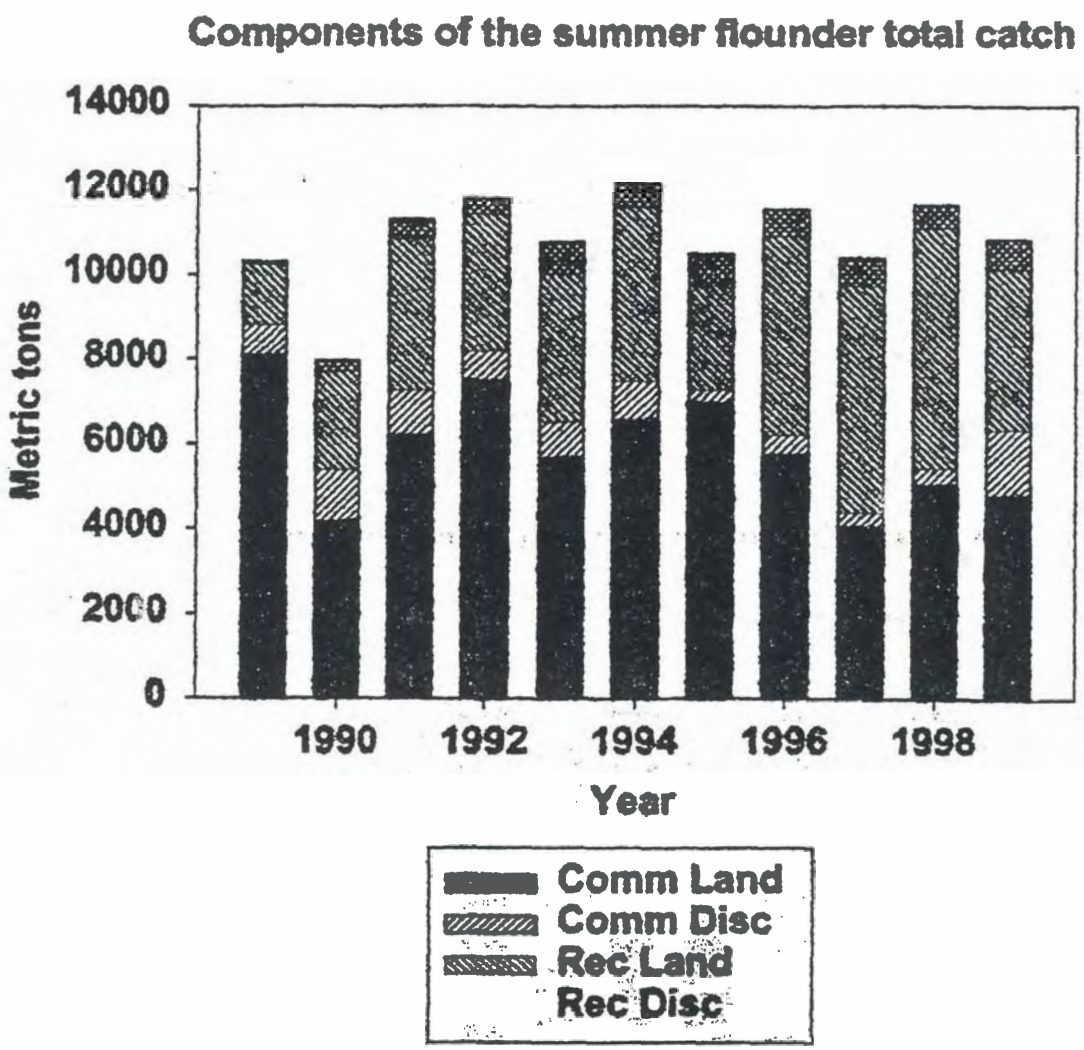


Figure D3. Components of the summer flounder total catch.

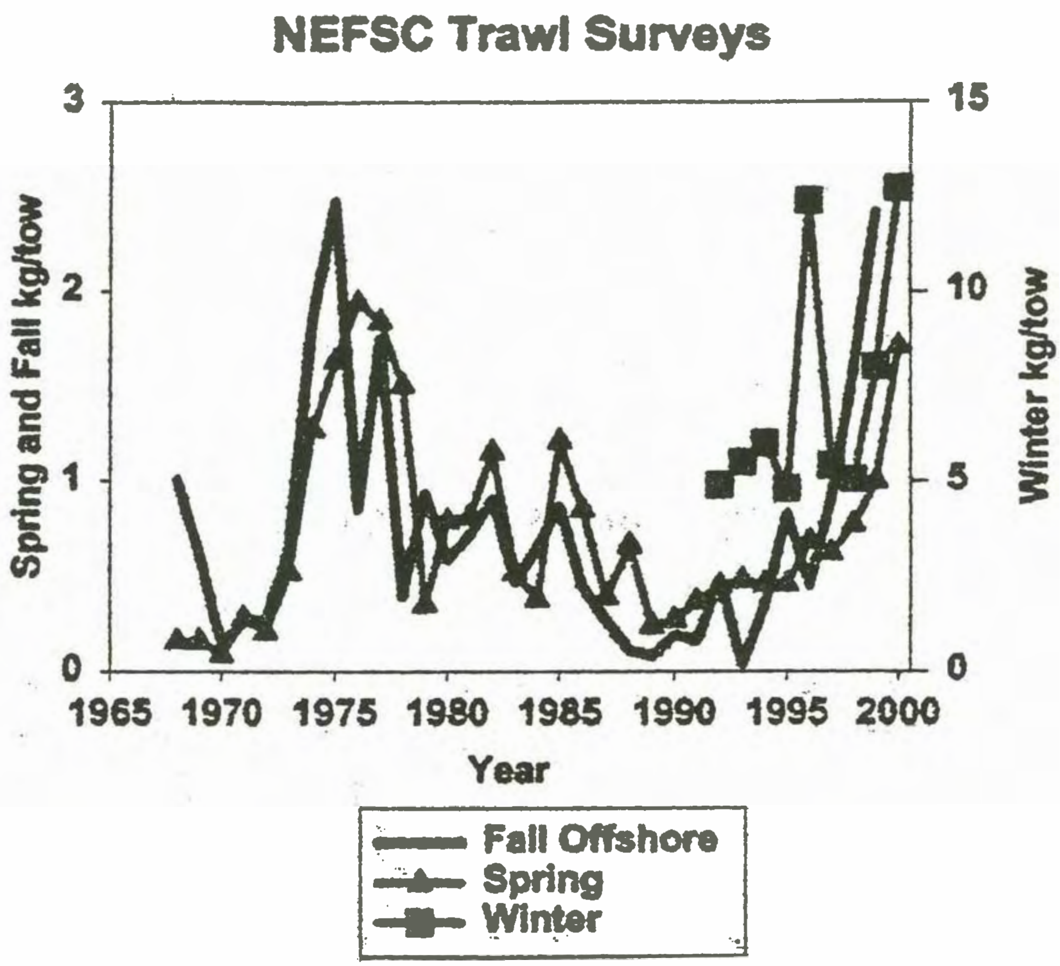


Figure D4. Trends in NEFSC trawl survey biomass indices for summer flounder.

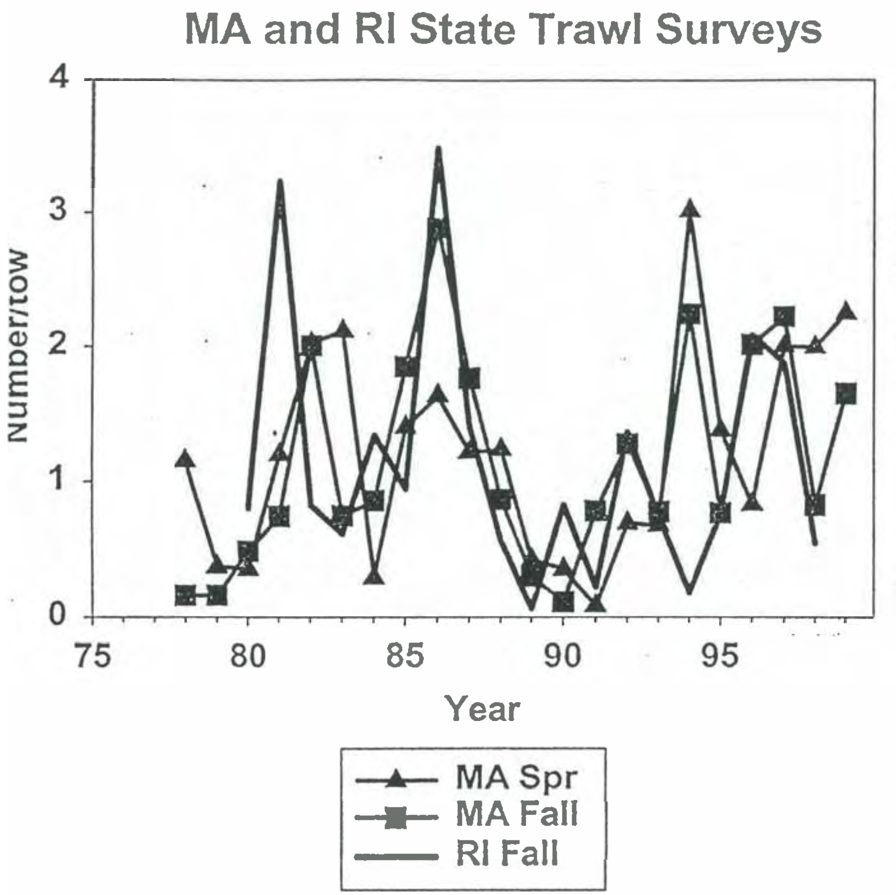


Figure D5. Trends in MA and RI trawl survey abundance indices for summer flounder.

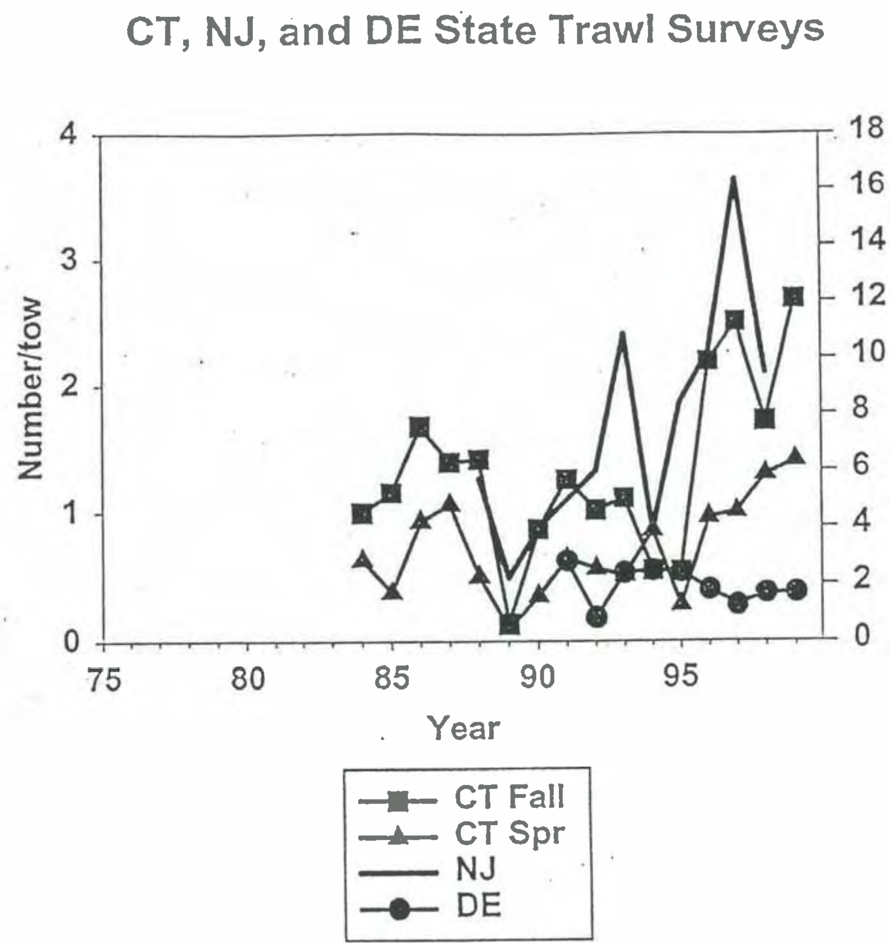


Figure D6. Trends in CT, NJ, and DE trawl survey abundance indices for summer flounder.

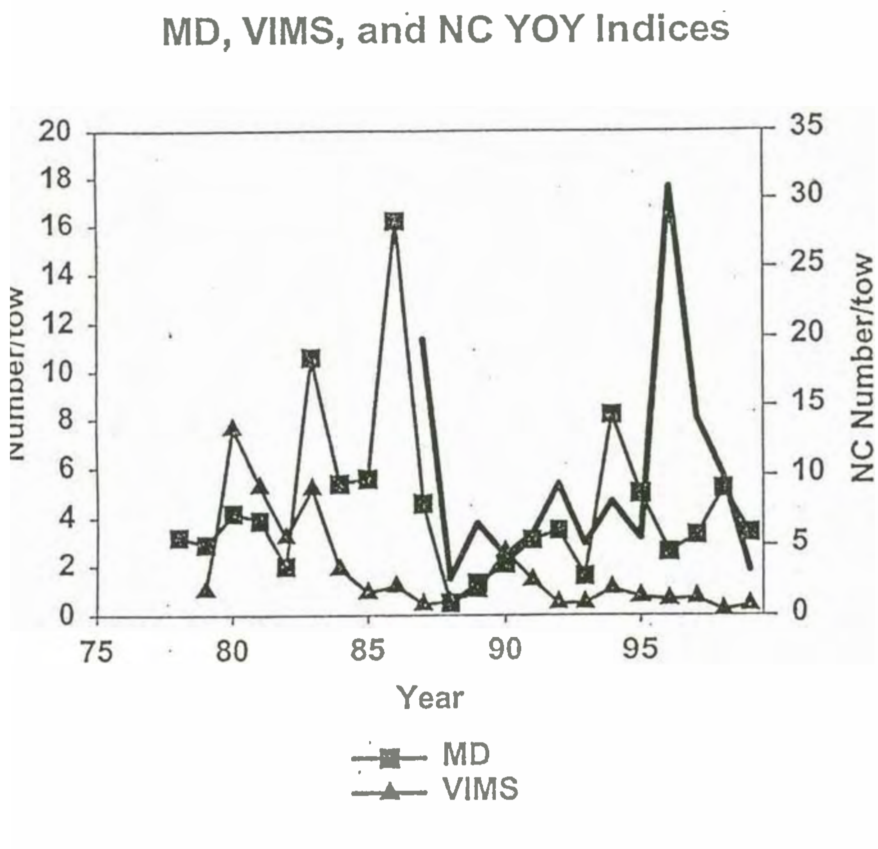


Figure D7. Trends in MD, VIMS, and NC trawl survey recruitment indices for summer flounder.

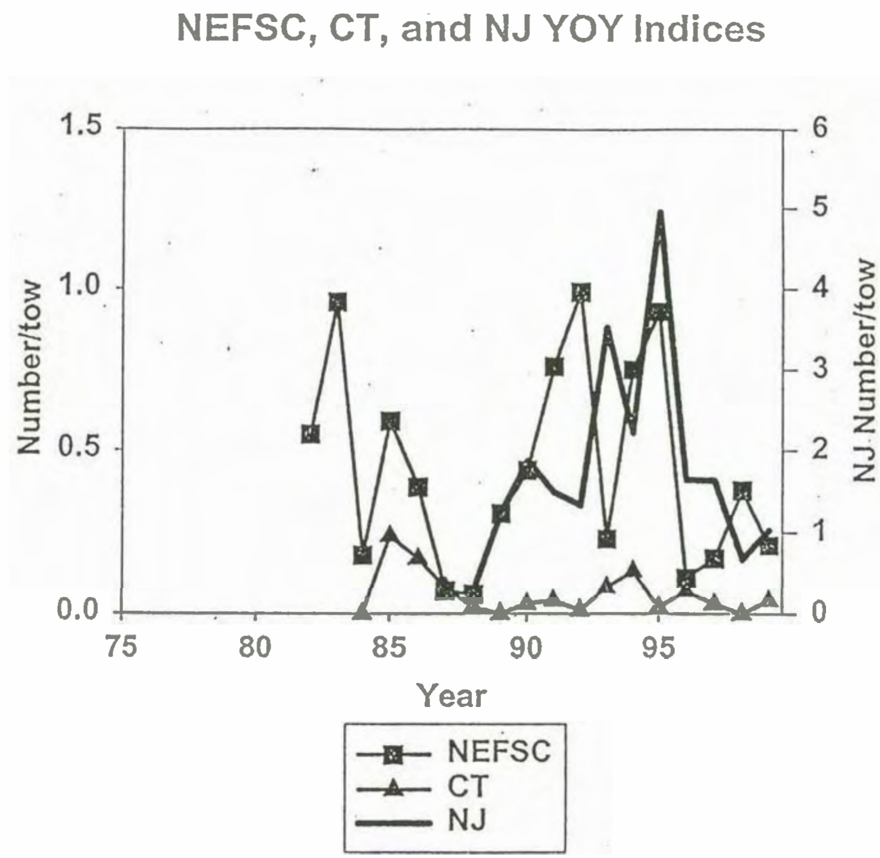


Figure D8. Trends in NEFSC, CT, and NJ trawl survey recruitment indices for summer flounder.

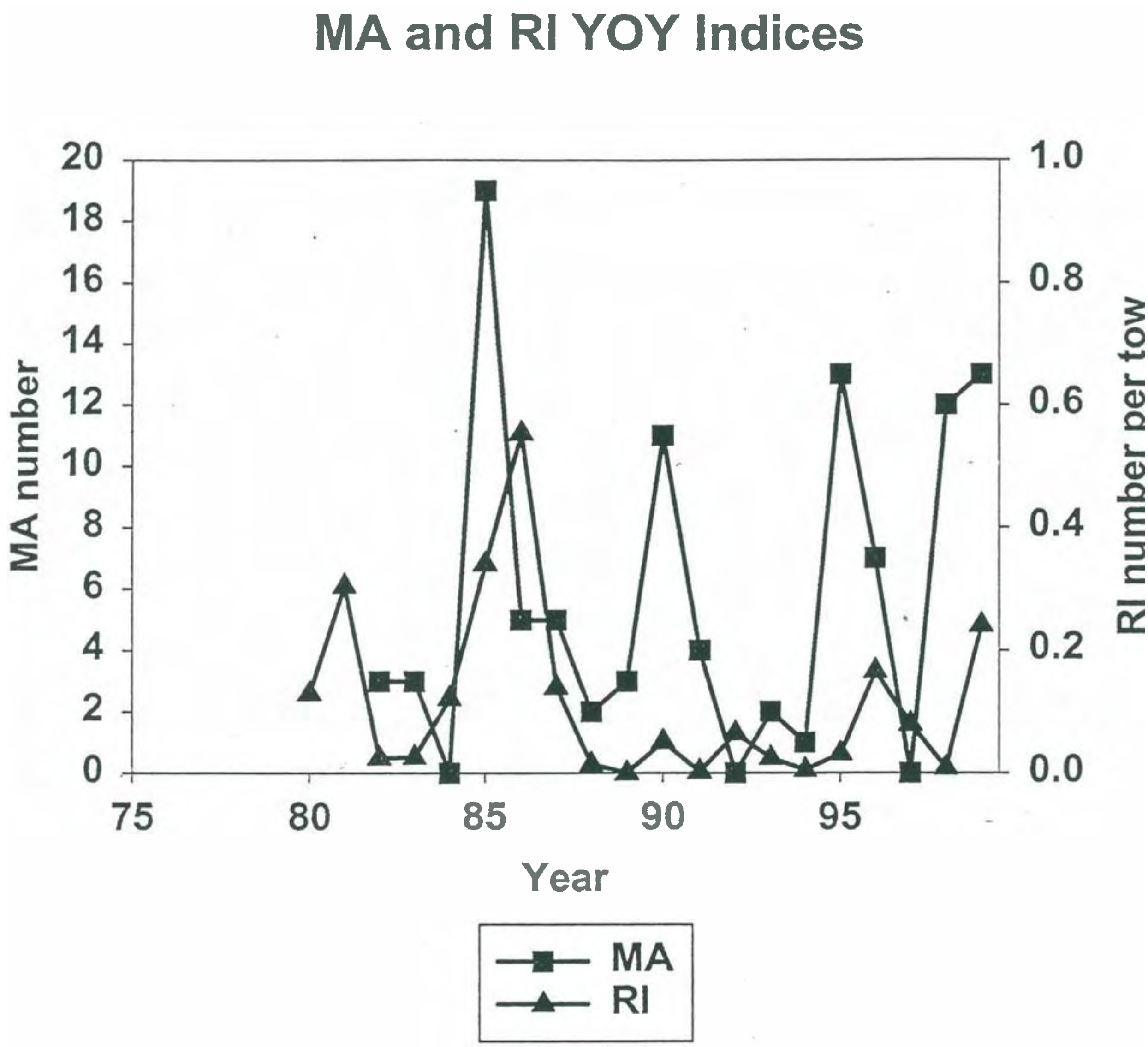


Figure D9. Trends in MA and RI survey recruitment indices for summer flounder.

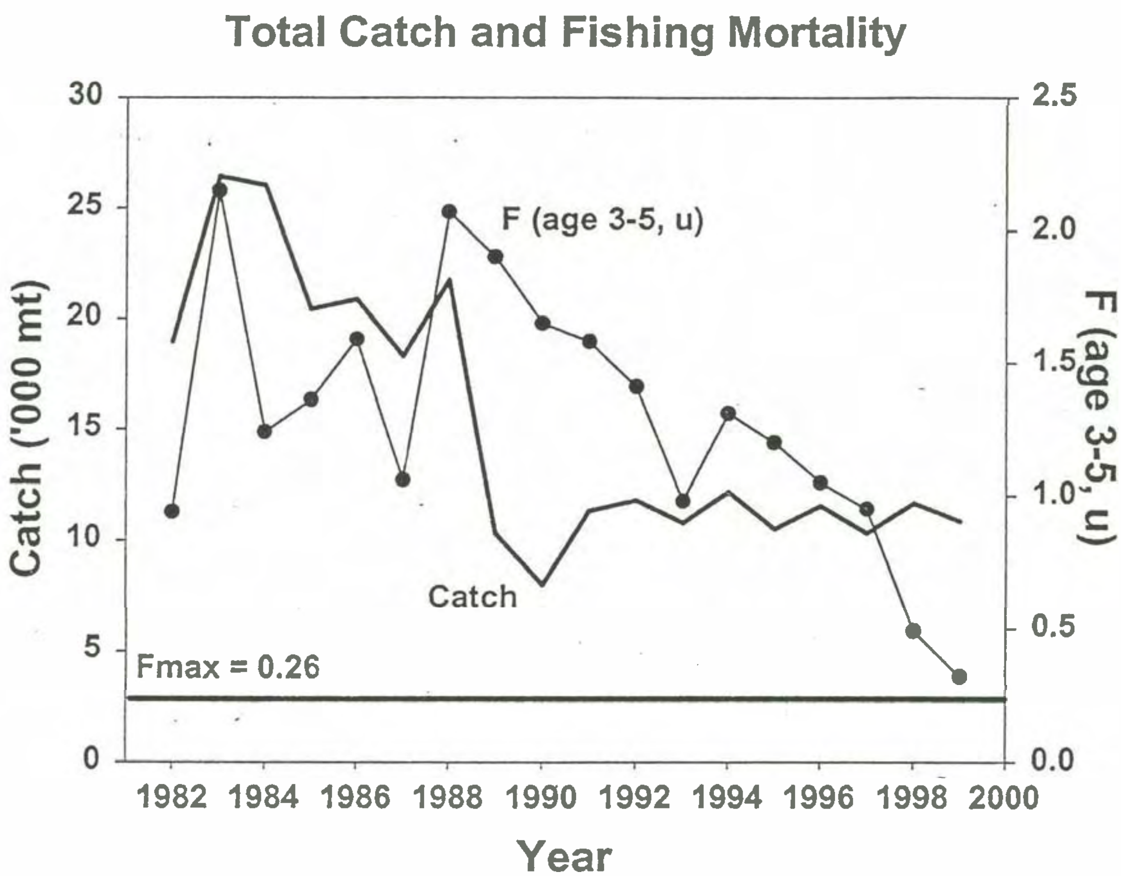


Figure D10. Total catch (lands and discards, thousands of metric tons) and fishing mortality rate (F, ages 3-5, unweighted) for summer flounder.

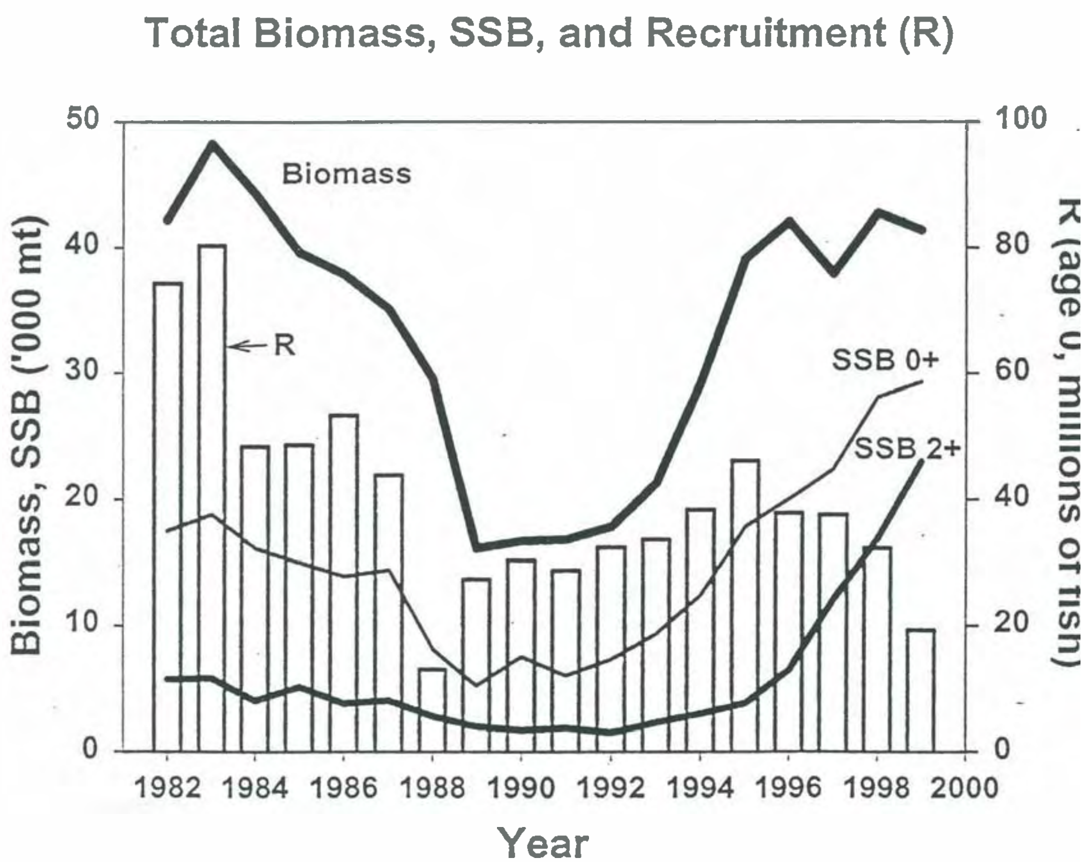
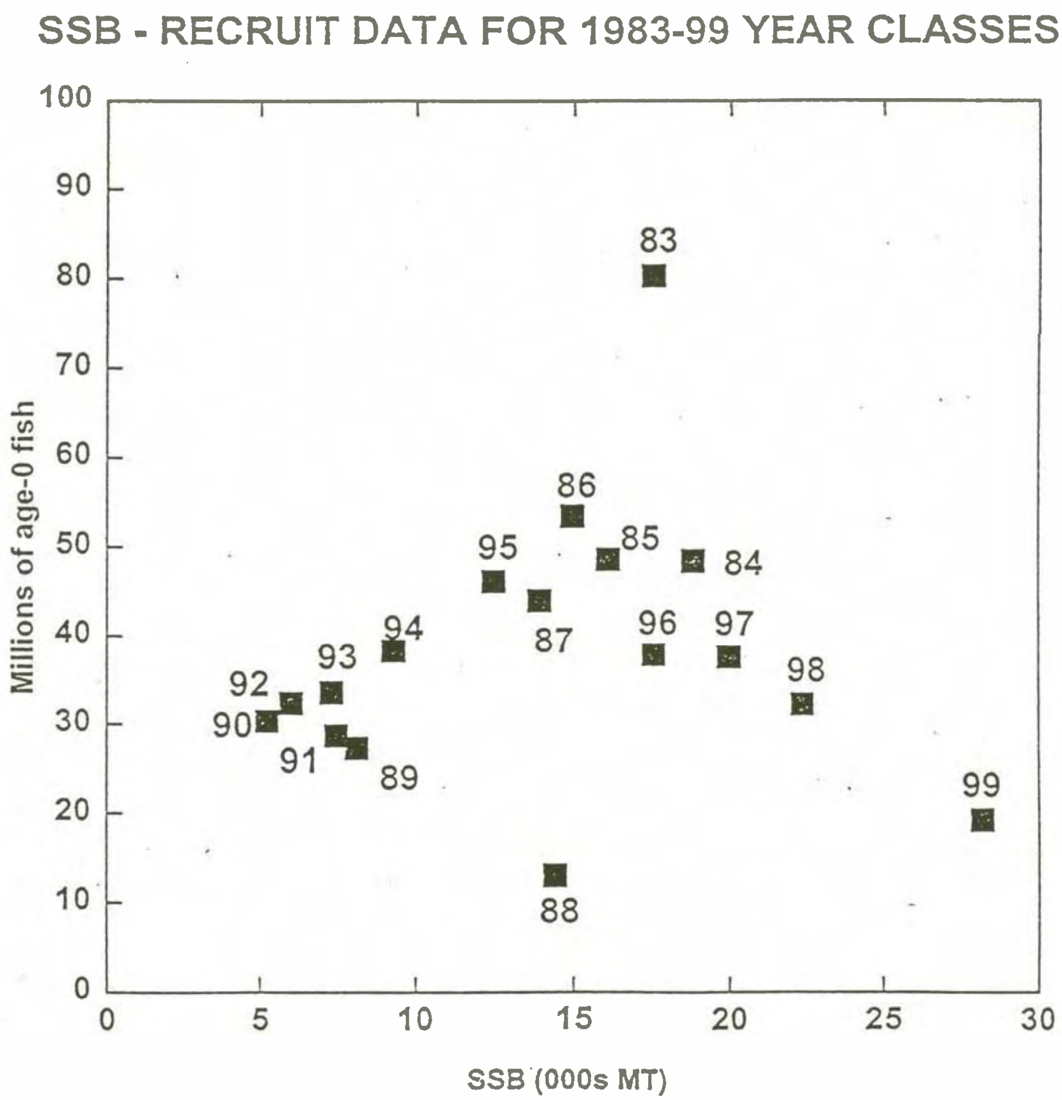


Figure D11. Total stock biomass ('000 mt), spawning stock biomass (SSB ages 0-7 and 2-7+, '000 mt), and recruitment (millions of fish at age-0) for summer flounder.



gure D12. VPA spawning stock biomass and recruitment estimates for summer flounder.

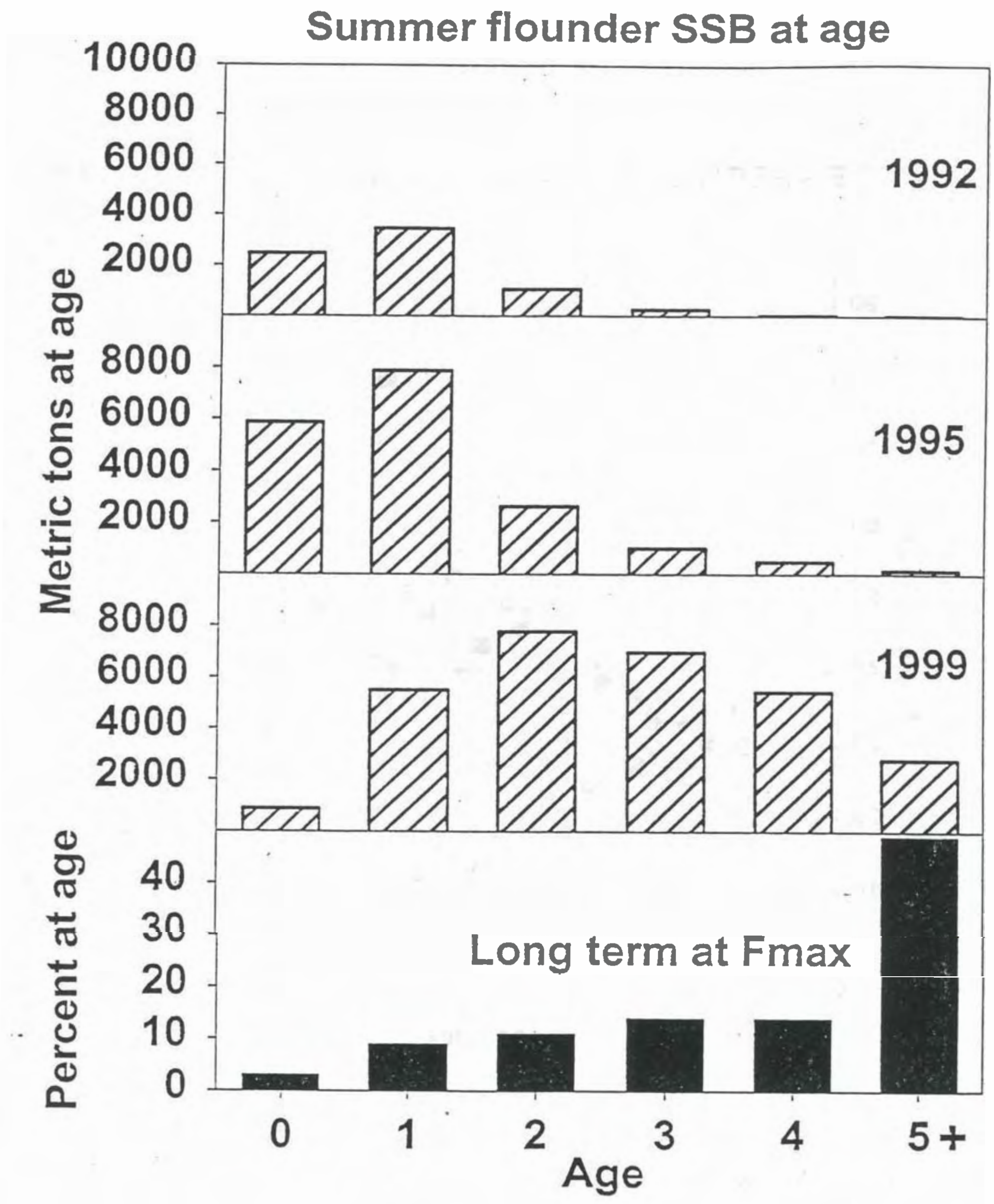


Figure D13. Spawning stock biomass at age for summer flounder.

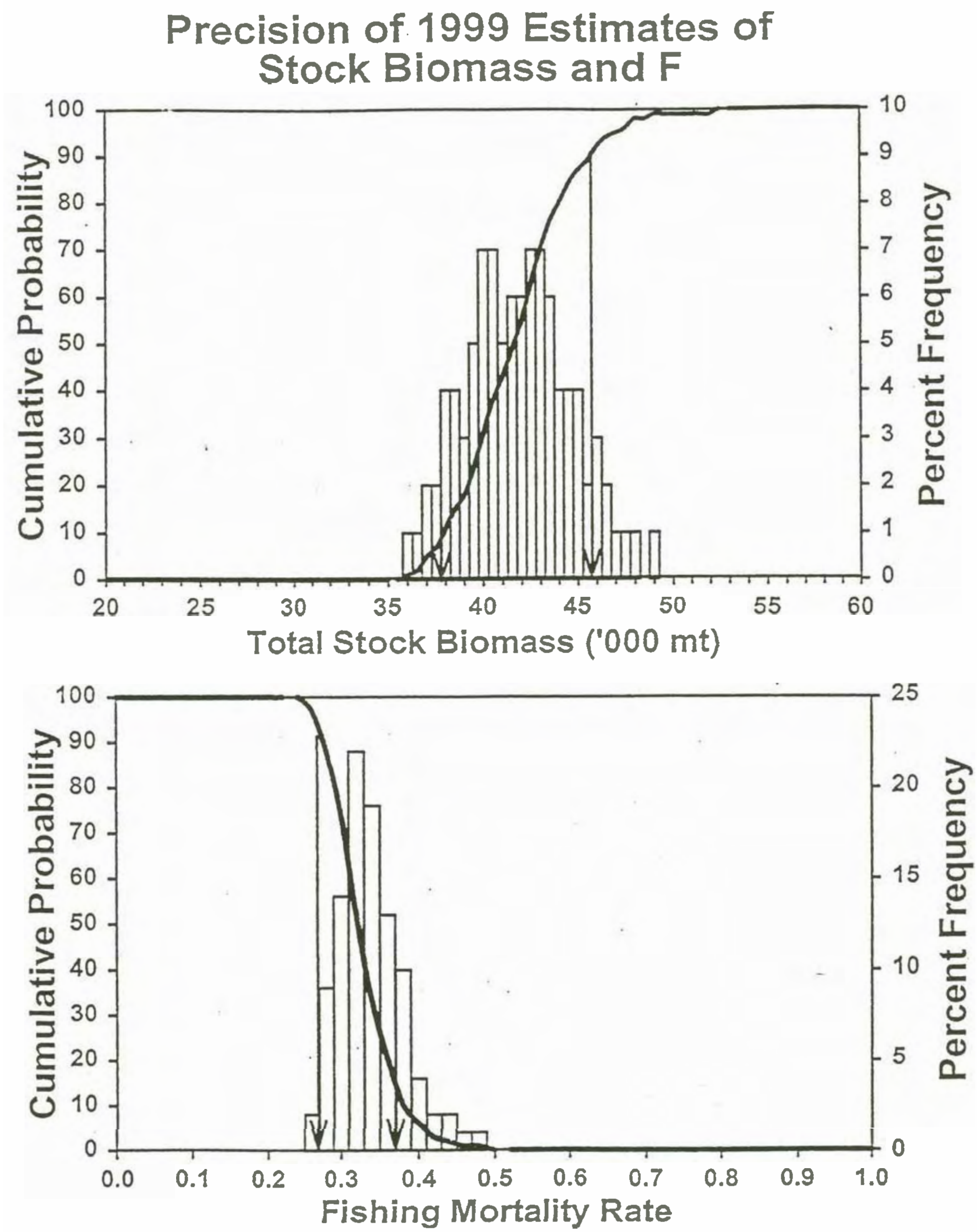


Figure D14. Precision of the estimates of January 1, 1999 total stock biomass (B) and fully recruited fishing mortality on age 3-5 (F) in 1999 for summer flounder.

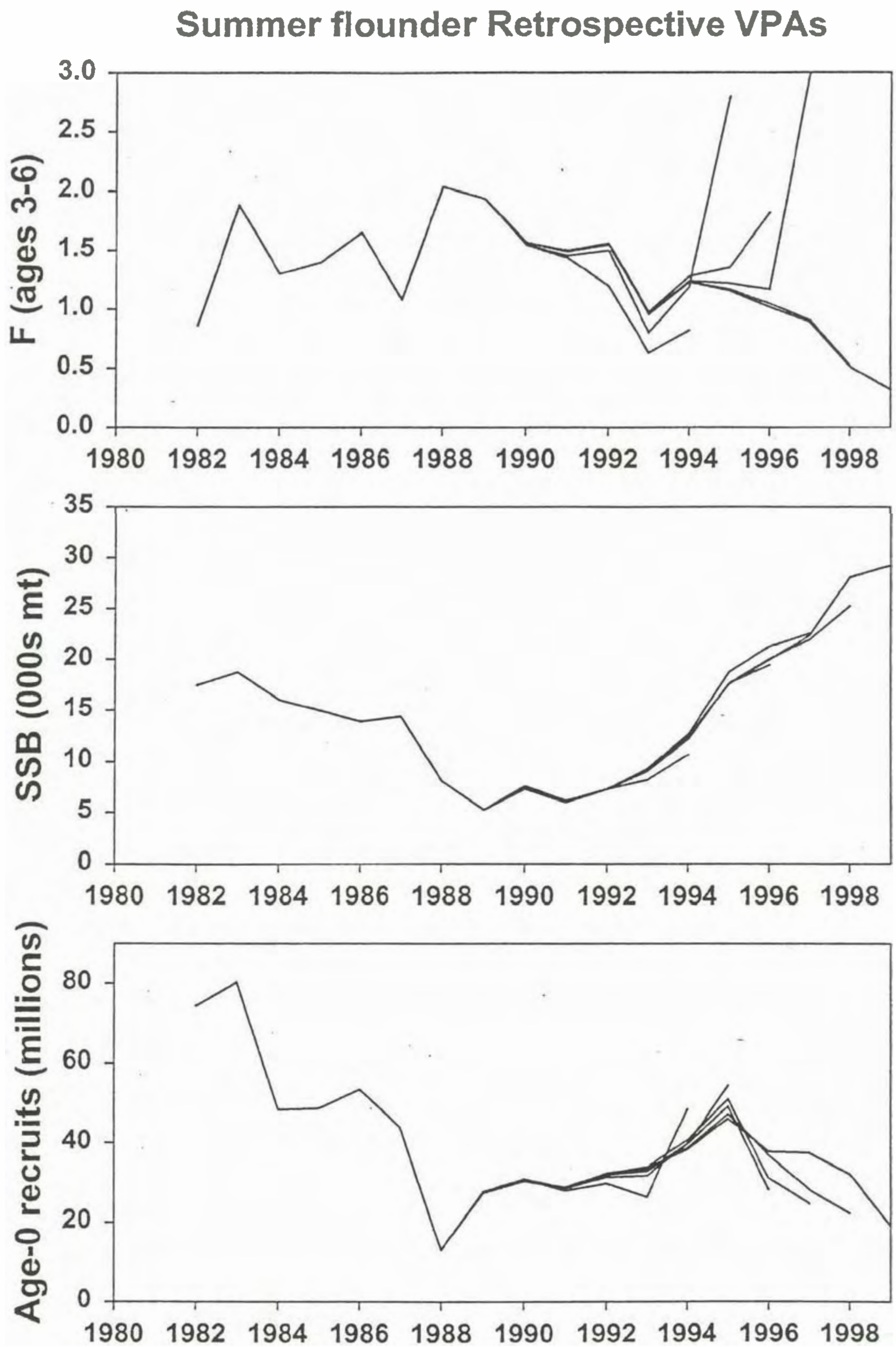


Figure D15. Retrospective VPAs for summer flounder.

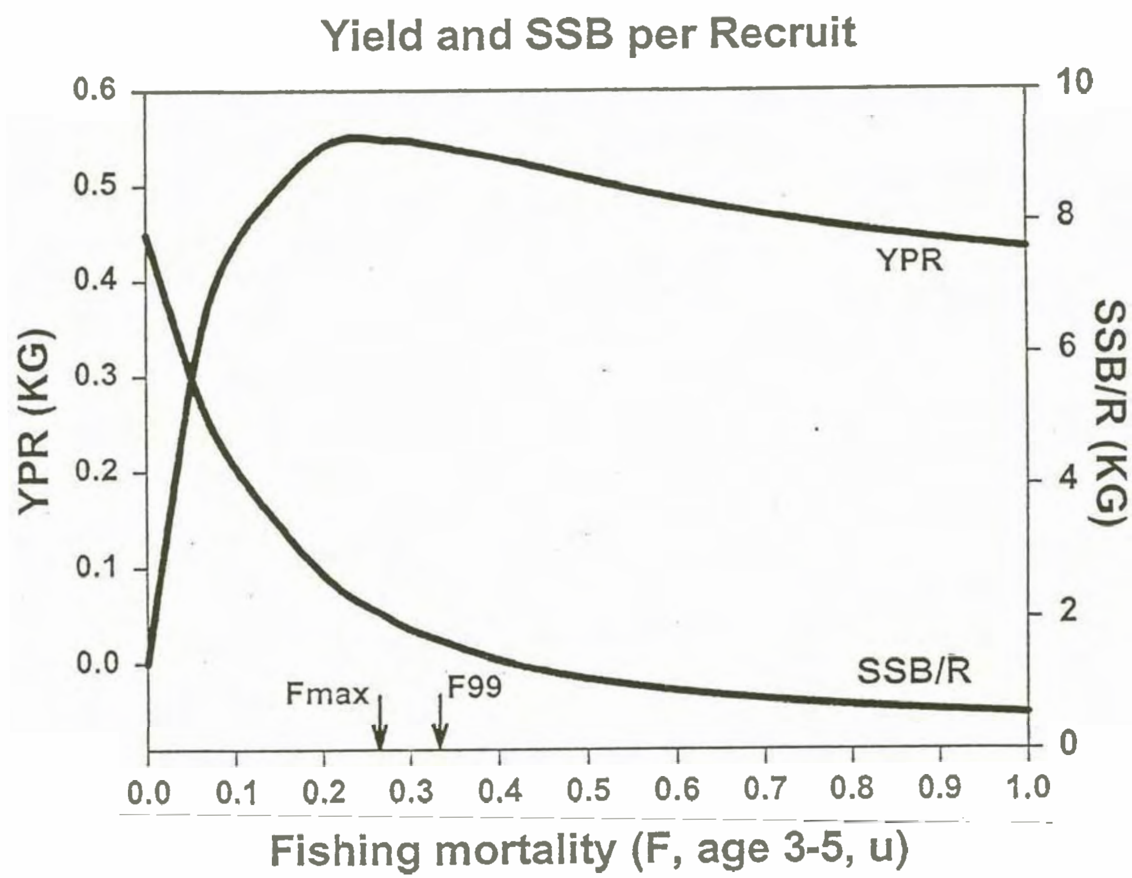


Figure D16. Yield per recruit (YPR) and spawning stock biomass per recruit (SSB/R).

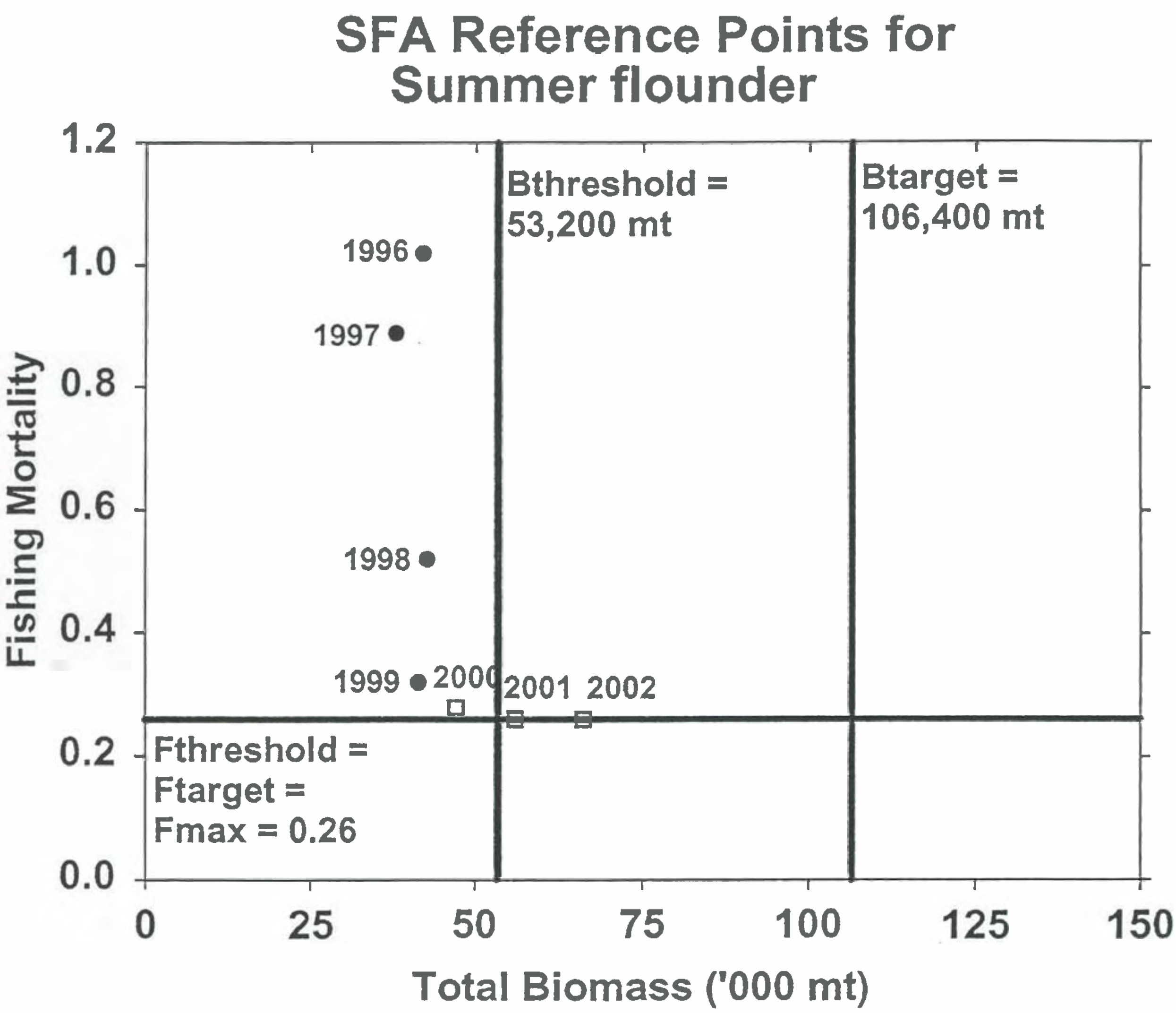


Figure D17. MAFMC FMP Amendment 12 SFA reference points for summer flounder, with 1996-1999 VPA estimates of F and total stock biomass, and forecast estimates of F and total stock biomass for 2000-2002.

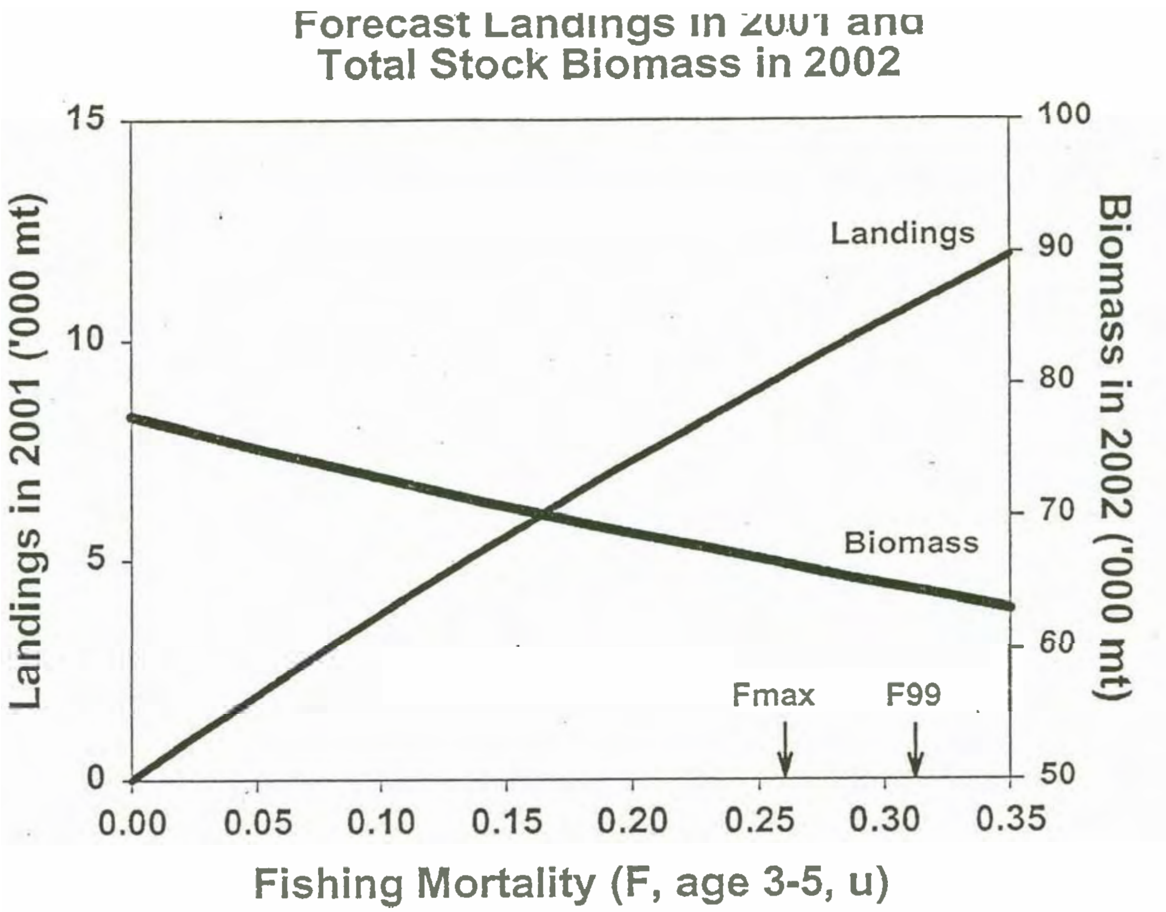


Figure D18. Forecast landings in 2001 and total stock biomass on January 1, 2002 over a range of fishing mortalities in 2001.

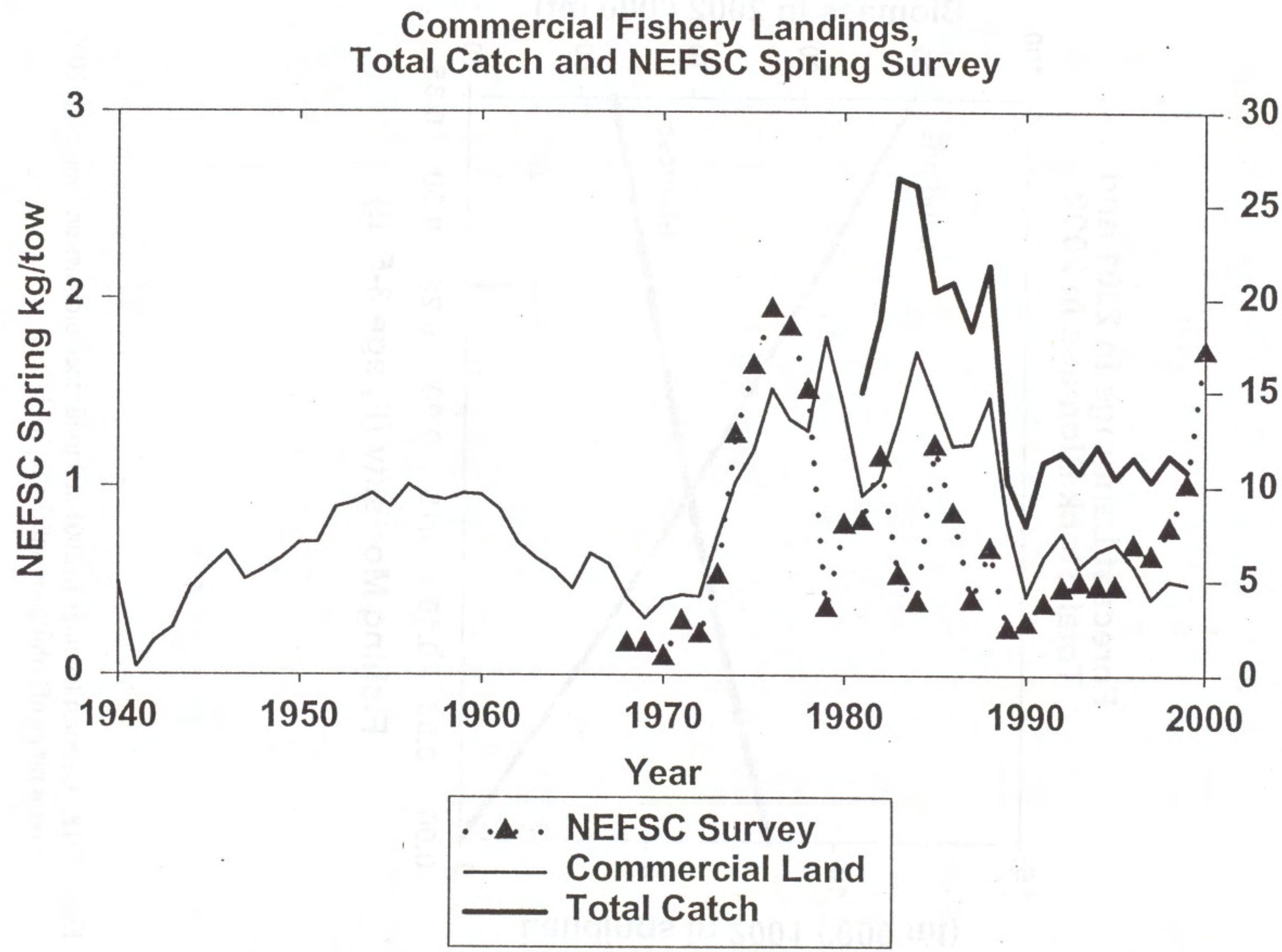


Figure D19. Long term trends in commercial fishery landings (1940-1999), total fishery catch (1981-1999), and NEFSC spring survey biomass index (1968-2000) for summer flounder.

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