Northeast Fisheries Science Center Reference Document 92-07

Report of the Fourteenth Northeast Regional Stock Assessment Workshop (14th SAW)

NOAA/National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts 02543-1097

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SUMMARY

The **Fourteenth Northeast Regional Stock Assessment Workshop** (14th SAW) was held in Woods Hole Massachusetts in two sessions. The Stock Assessment Review Committee (SARC) session took place 15 - 19 June and the Plenary session 15 - 16 July 1992. More than eighty individuals attended all or parts of the sessions (Table 1). Organizations represented included the States of Massachusetts, Rhode Island, and New York; academic and private institutions; industry; Atlantic States Marine Fisheries Commission; New England and Mid-Atlantic Fishery Management Councils; U.S. Fish and Wildlife Service; and Southeast Fisheries Science Center, Northeast Regional Office, and Northeast Fisheries Science Center of the National Marine Fisheries Service.

The objective of the SARC was to provide a thorough technical review of presented analyses for American lobster, tilefish, monkfish (goosefish), American plaice, short- and long- finned squids, and sea scallops. In the **Stock Assessment Review Committee, Consensus Summary of Assessments**, are presented background, major sources of uncertainty and how uncertainty may affect determination of stock status, as well as the committee's recommendations.

A major objective of the Plenary was to prepare the **Advisory Report on Stock Status** based on the SARC report. The Advisory Report summarizes the technical information in the SARC Report, and notes the stock level and exploitation rate for the species/stocks reviewed and the recommendations of the Plenary. The Advisory Report is intended to serve as scientific advice to fishery managers on resource status.

As a result of discussions relative to the Advisory Report, the Plenary recommended the formation of a Sea Scallop Workshop to resolve the issues that were not finalized within the time-frame of the SAW-14 SARC.

Special topics at the Plenary session included an overview of the Sea Sampling Analysis Working Group and presentation of a simulation model for comparing different discard estimators; an overview of multi-species assessment methods, and a presentation on multi-species fish dynamics on Georges Bank; and a paper on standardization of SAW documentation. To save time, it was agreed to delete from the agenda the overview of the National Stock Assessment Workshop as a report on the topic will be available soon.

In discussion of SAW documentation, the Plenary adopted the presenter's recommendation to "develop revised protocols for improving SAW Plenary and SARC procedures, with the expectation that many of these revisions will be introduced at the 15th SAW", and recommended that the SAW Steering Committee establish a SAW Procedures Study Group for this purpose.

The Plenary recommended that the SAW Steering Committee consider four species/stocks to review at the next SARC session, a number of species to review in the near-future, and two topics to address at the next Plenary; as well as the establishment of a Biological Reference Points Working Group.

It was recommended to hold the SAW-15 SARC session in December 1992 and the SAW-15 Plenary session in January 1993.

Table 1. List of Participants

National Marine Fisheries Service

Northeast Fisheries Science Center

Frank Almeida
Vaughn Anthony
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Nicole Buxton
Daphne Cassidy
Darryl Christensen
Steve Clark
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Christine Esteves
Shawn Eusebio
Michael FogartyKevin Freidland
Wendy Gabriel
Michael Glazer
Richard Greenfield
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Marvin Grosslein
Dan Hayes
Thomas Helser
Joseph Idoine
Ambrose Jearld
Robin Jenness
Sylvia Kane
Marjorie Lambert
Kathy Lang
Ralph Mayo
Margaret Mary McBride
Bill Michaels
Tom Morrissey
Steve Murawski
Helen Mustafa
Loretta O'Brien
Bill Overholtz
Jack Pearce
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Barbara Pollard
Anne Richards
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Greg Power
Cheryl Ryder
Frank Serchuk
Daniel Sheehan
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Tim Smith
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Scott Steinback
Mark Terceiro
John Walden
Jim Weinberg
Alan White
Susan Wigley

Northeast Regional Office

Pete Colosi
Kevin Footer
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Southeast Fisheries Science Center

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Paul Rago

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John Mason

Mid-Atlantic Fishery Management Council

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Tom Hoff
Dave Keifer
Richard Seagraves

New England Fishery Management Council

Andrew Applegate
Lou Goodreau
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Rhode Island Division of Fish and Wildlife

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Ed Enos
Bryan Noel

Monomet Bird Observatory

Connie Gagnon
Jay Wennemer

B.G. Lobster and Shrimp Corp.

Bill Carroll

New Bedford Co-op

John Bullard

Conservation Law Foundation

Eleanor Dorsey

THE PLENARY

INTRODUCTION

The **Plenary of the Fourteenth Northeast Regional Stock Assessment Workshop** was held in Woods Hole, Massachusetts, 15 - 16 July 1992. About 60 individuals from a number of organizations in New England and the Mid-Atlantic attended this session. The Plenary Agenda is presented in Table P1.

Opening remarks were given by Allen E. Peterson, Jr., Science and Research Director of the Northeast Fisheries Science Center, NMFS. Mr. Peterson thanked Dr. Michael Parrack (Southeast Fisheries Science Center) for chairing this SAW (both, SARC and Plenary sessions) and welcomed the participants. Mr. Peterson reflected on the formation and evolution of the SAW process and discussed the importance of the process as a "whole", emphasizing that conclusions cannot be drawn until the entire SAW process is complete.

The major objective of the Plenary was the preparation of the **Advisory Report on Stock Status** based on the report of the Stock Assessment Review Committee (SARC). In discussion, several participants pointed out that there was insufficient time during the five day SARC to resolve all technical issues and to complete the draft SARC report. The fact that many papers were not available for review before the SARC meeting and some analyses still needed work at the time of presentation, affected the SARC procedure and delayed the preparation of documentation. As a consequence, sections of the **SARC Consensus Summary of Assessments** (SAW/14/Plenary/1) submitted to the Plenary have not been as thoroughly reviewed as usual, thus, contributing to discussion not normally a part of the Plenary meeting.

The Atlantic States Marine Fisheries Commission (ASMFC) Lobster Scientific Committee reviewed a draft of the SARC report the day before the Plenary. Their comments, generally of an editorial nature, were presented during the Plenary in the form of a letter (Appendix 1). The content of this letter was discussed. Although in further discussion, it was suggested that the SARC report be revised, it was concluded that, except for editorial changes, the SARC report would stand as is.

During the preparation of the Advisory report, the Plenary recommended the formation of a Sea Scallop Workshop to be held during the week after the Plenary to resolve the issues that were not brought to consensus within the time-frame of the SARC session. These issues are reflected in the Terms of Reference for this Workshop:

(1) develop consensus best estimates of current fishing mortality, based on analyses conducted to date,

(2) evaluate levels of precision associated with these estimates, particularly with regard to the overfishing definition, and

(3) develop scientific terms of reference for additional analyses to be undertaken at future Stock Assessment Review Committee meetings that will consider sea scallop.

As the preparation of the Advisory report took more time than anticipated, it was agreed to delete from the agenda the Overview of the National Stock Assessment Workshop topic (a report on the topic will be available soon) and condense the presentation of other special topics: Overview of Multi-Species Assessment Methods; Multi-Species Fish Dynamics on Georges Bank; and Standardization of SAW Documentation (SAW/14/Plenary/2). Summaries of these presentations are contained in this report.

In discussing the Standardization of SAW Documentation topic, the Plenary decided to accept the presenter's recommendation to "develop revised protocols for improving SAW Plenary and SARC procedures, with the expectation that many of these revisions will be introduced at the 15th SAW", and to recommend that the SAW Steering Committee establish a SAW Procedures Study Group for this purpose.

The Plenary recommended, for SAW Steering Committee consideration, four species/stocks to review at the next SARC session; to consider a number of other species to review in the near future; and two topics to address at the SAW-15 Plenary. One of the topics would require the establishment of a Biological Reference Points Working Group (#36).

It was recommended to hold the next SARC session during nine days of the second and third weeks in December 1992 and the Plenary session during the last week of January 1993.

Table P1.

14TH NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP

PLENARY

Carriage House, Quissett Campus
Woods Hole, Massachusetts

July 15 - 16 1992

AGENDA

Chairman		M. Parrack
Wednesday, July 15		
10:00	Opening Remarks	A. Peterson
10:15	SARC Report	M. Parrack
10:45	Advisory Report on Stock Status Discussion and Preparation	
12:00	Lunch	
1:00	Continue Preparation of Advisory Report	
5:00	Adjourn	
Thursday, July 16		
9:00	Review and Complete Advisory Report	M. Parrack
9:30	Report of the Sea Sampling W.G. A simulation model for comparing different discard estimators	D. Christensen D. Hayes J. Brodziak
10:45	Coffee	
11:00	Overview of the National Stock Assessment Workshop Overfishing definitions and stock rebuilding program	A. Rosenberg
12:00	Lunch	
1:00	Standardization of SAW Documentation	F. Serchuk

Table P1. (Continued)

2:00	Multi-Species Assessments Overview of multi-species assessment methods	S. Murawski
2:45	Coffee	
3:00	Multi-Species fish dynamics on Georges Bank	M. Fogarty
3:45	SAW-15 Terms of Reference and Timing	
4:15	Other Business	
4:45	Closing Remarks	

REPORT OF THE SEA SAMPLING ANALYSIS WORKING GROUP

Overview

Darryl Christensen reported that after two years of negotiation the sea sampling contract has been signed. For the period from April 1992 through March 1993, 2295 sampling days at sea are scheduled. Of these, 1795 days are marine mammal related and 550 days are for other domestic fisheries (Table PA1). Though the sampling effort for the mammal program is committed, the contract is flexible so that if emergencies arise the effort within the other domestic fisheries can be redirected. Almost all the trips are outside state waters.

A Simulation Model for comparing Different Discard Estimators

Jon Brodziak and Dan Hayes presented preliminary results on the development of a simulation model for assessing the efficiency of the various estimators of discards proposed during SAW 12. These estimators included: cluster-sampling, mean per unit, ratio, and regression estimators (Cochran 1977; Brodziak 1991; Hayes 1991; Wigley 1991). Based on previous survey data, each component of the process is modeled (Figure PA1). Then for each estimator, simulations of the sampling process are generated so that the efficiency of the estimator (and of the sampling design) can be appraised. To date good progress has been made on constructing a model that reflects the observed dynamics of the sea sampling surveys. A first assessment of the discard estimators should be available by next year.

Discussion

Concern was expressed that changing the sea sampling schedule to address an emergency would adversely affect planned assessments that are counting on discard estimates. It was agreed that if changes are made, then those effected should be notified as soon as possible.

It was suggested that expressing sampling effort in terms of sea days rather than trips may give a misleading impression of actual sampling intensity. The number of trips, which is the sample size, will be rather small for some fisheries. If discard rates vary significantly among trips then the estimates of discards may be rather imprecise.

References

Brodziak, J. 1991. Bootstrap estimators of discard rates using domestic sea sampling data. Report of the Twelfth Northeast Regional Stock Assessment Workshop, NEFC Ref. Doc. 91-03, Res. Doc. 8.

Cochran, W.G. 1977. Sampling techniques. Wiley, New York, 427 pp.

Hayes, D. 1991. Exploratory analysis of four methods for estimating discards from sea sampling data. Report of the Twelfth Northeast Regional Stock Assessment Workshop, NEFC Ref. Doc. 91-03, Res. Doc. 11.

Wigley, S. 1991. Cod discards in the Gulf of Maine: an exploration of the sea sampling database. Report of the Twelfth Northeast Regional Stock Assessment Workshop, NEFC Ref. Doc. 91-03, Res. Doc. 9.

Table PA1.

Sea Sampling Days At Sea Schedule
Completed and/or Planned

Current Contract Year April 1992 Through March 1993

GOM Sink Gillnet	1414		
GOM Small Pelagic Gillnet	50		
Large Pelagic Drift Gillnet	30		
Large Pelagic Longline	251		
Marine Mammal Related			1745
Scallop 1/month	131	131	
Shrimp Trawl	49		
GOM Large Mesh	74		
GOM Small Mesh	22	145	
Experimental Whiting	24		
Georges Bank	131	155	
So. New England YT/offshore	33		
So. New England inshore	14	47	
Mid Atlantic Inshore	44		
Mid-Atlantic Offshore	28	52	
Total Other Domestic			550
Total All Fisheries			2295

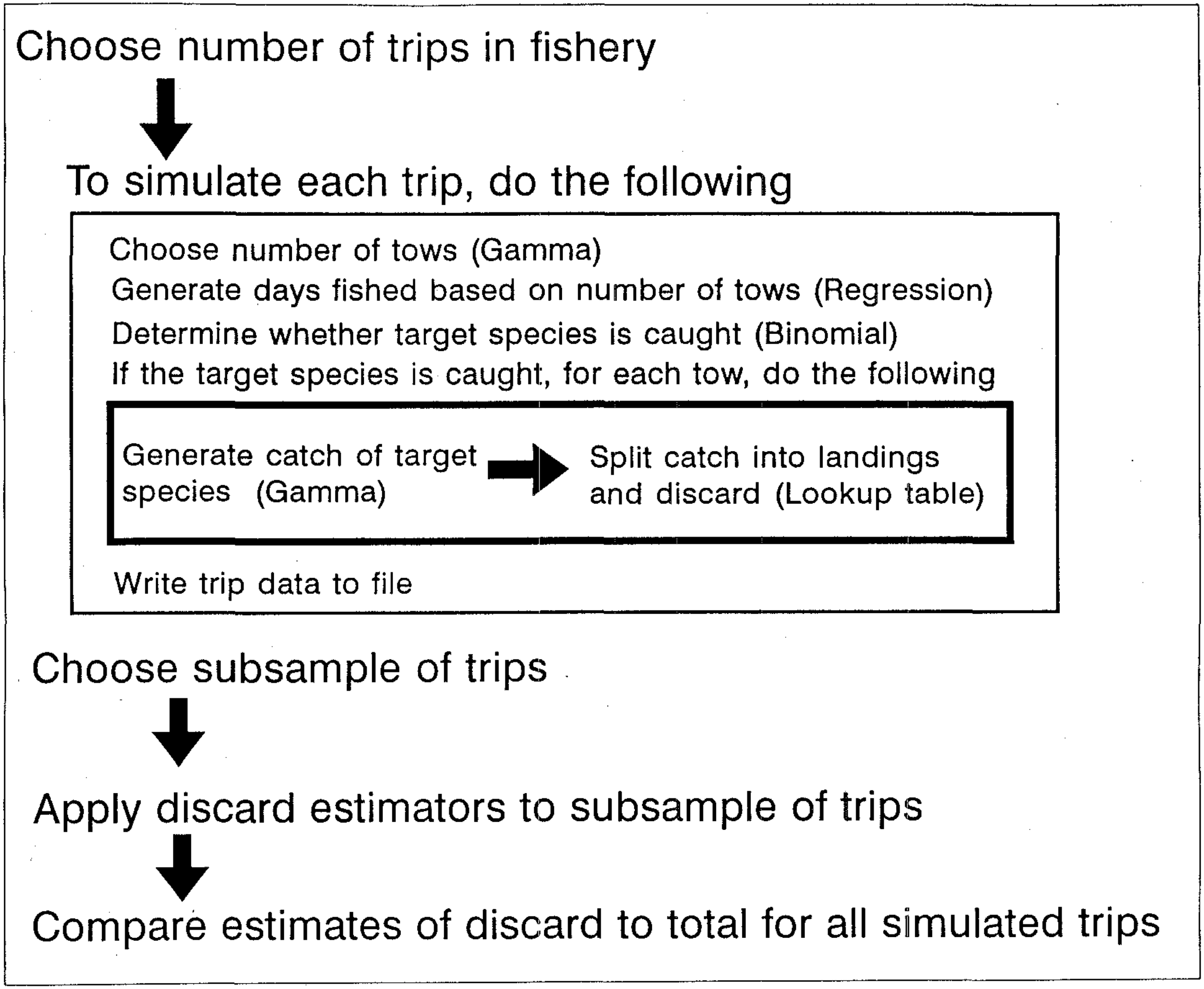
Choose number of trips in fishery
To simulate each trip, do the following
Choose number of tows (Gamma)
Generate days fished based on number of tows (Regression)
Determine whether target species is caught (Binomial)
If the target species is caught, for each tow, do the following
Generate catch of target species (Gamma)
Split catch into landings and discard (Lookup table)
Write trip data to file
Choose subsample of trips
Apply discard estimators to subsample of trips
Compare estimates of discard to total for all simulated trips

Figure PA1.

OVERVIEW OF MULTI-SPECIES ASSESSMENT METHODS

In his presentation, Steve Murawski discussed issues relating to multi-species vs. single-species stock assessments. Multi-species assessment issues arise in several contexts with regards to northeast USA fisheries. Mixed-species assessments seek to account for fishery interactions (bycatch and discards), such as in the Gulf of Maine, where small-mesh fisheries catch undersized finfish that are targeted by other large-mesh fisheries. Predator-prey relationships are not considered explicitly in this type of assessment. Mixed-species, multi-fishery assessments can be of great value, for example, in evaluating the relative gains in yield and percent spawning stock biomass per recruit for individual stocks and species groups, as a result of changing effort patterns or gear selection characteristics. These analyses are now both technically feasible and sufficient data currently exist to provide managers with this advice. Preliminary mixed-species assessments have been or are currently being developed for Gulf of Maine groundfish and the summer flounder, scup, black sea bass fisheries of the Mid-Atlantic Bight.

The second major focus of multi-species assessments involves the evaluation of the effects of inter-species predation on the attainment of management objectives. Most objectives currently articulated in FMPs relate to single-species objectives of yield or spawning stock biomass per recruit. Work conducted in the early 1970s on the northeast fisheries indicated that biological interactions among the various species were perhaps the major factor that limited the total yield of all continental shelf fisheries (e.g., groundfish, herring, mackerel, etc.) to less than the sum of the maximum sustainable yields of each stock taken individually (the total is less than the sum of its parts). More recently, assessment programs including biological interactions have been undertaken in a variety of areas, and particularly in the North Sea. One notable result of the intensive North Sea studies is that when predator-prey interactions are included in standard assessment calculations, the effects can change our perceptions of the implications of management actions. For example, single-species yield-per-recruit analyses for North Sea cod predict higher long-term yields with an increase in trawl fishery mesh size. When the effects of predators are included, however, greater mesh sizes result in larger numbers of big predators in the system, which in turn lead to <u>lower</u> long-term yields to the cod stock. The North Sea results cannot be considered as a general result -- these analyses need to be considered on a case-by-case basis. They do point out, however, that predation effects cannot necessarily be ignored in developing assessment advice.

Given the profound changes in the abundance and species composition of northeast shelf resources over the past decade, it is important to understand the implications for fishery yields from the system. Several studies of biological interactions among northeast fishery resources have been completed, or are currently being undertaken. Recent increases in the abundance of spiny dogfish and skates may be associated with the declines in groundfish. The role of elasmobranchs in the groundfish system is unclear, and may well be important in understanding the extent to which groundfish stocks can be rehabilitated in the presence of high elasmobranch stock sizes. Reductions in fishing mortality rates will result in rebuilding of the groundfish resource, but it is unclear if in fact the groundfish populations reach their former abundance (e.g. haddock), given potential competition for food with and predation by elasmobranchs. Likewise, increases in pelagic fish biomass (Atlantic mackerel and herring) may have effects on the productivity of other system components.

Both mixed-species and multi-species assessments will become increasingly important in the future, as managers seek to maximize productivity and optimize the utilization of northeast resources. The addition of sea sampling data collections now makes feasible the analysis of mixed-species, multi-fishery problems, as could not be accomplished in prior years. The routine provision of mixed-species assessment advice can be anticipated in the future. Accounting for biological interactions in management advice will be more problematic, since the data demands are greater for these types of studies, and a modeling framework has yet been developed with which to conduct the necessary studies. Recent project proposals to NOAA's Coastal Ocean Program seek to initiate the necessary analytical studies to understand the role of inter-species predation in determining the productivity of various species in the northeast shelf fishery ecosystem.

MULTI-SPECIES FISH DYNAMICS ON GEORGES BANK

Michael Fogarty presented an overview of some of the research objectives of the NEFSC Food Chain Dynamics Investigation which were included in a NOAA Coastal Ocean Program (COP) proposal. The "Georges Bank Predation" proposal was ranked highly last year by the COP's Coastal Fisheries Ecosystem (CFE) Technical Advisory Committee, and is presently being expanded into a COP/CFE Implementation Plan for final review this August.

This proposal addresses the hypothesis that an increase in predation, and possibly competition, over recent years contributed to a shift in the stable equilibrium of commercially important species (e.g., haddock and cod) resulting in reduced resilience to fishing pressure. The importance of predation will be examined in relation to COP/CFE objectives of (1) recruitment processes, (2) species interactions, and (3) compensatory mechanisms. The NEFSC Food Chain Dynamics Investigation, in collaboration with other scientists, will address these issues with a combination of retrospective analyses, laboratory experiments, process-oriented field studies, and modeling exercises. The goal is to provide advice to fisheries management for increasing long-term economic benefit through alternative harvesting strategies which account for multi-species interactions.

Considerable data exists on the physical and biological oceanography of Georges Bank, and the region is typically characterized as highly productive. As much of its productivity is consumed by fish, Georges Bank is considered a predator-controlled system. Historical trends in the fisheries have been documented over the last three decades. High levels of harvesting occurred on Georges Bank through the 1960s and early 1970s. With the introduction of the Fishery Conservation Magnuson Act, dramatic drop in fishing effort occurred in 1976. Although fishing effort was reduced after 1976, there were no obvious increases in yield during the 1980s (Figure PC1). Over-harvesting appears to have altered the community structure which presumably may have increased predation or competitive pressures, preventing the recovery of commercially important groundfish. Trends showed that as principal groundfish of commercial importance steadily declined, under-utilized species (i.e., other groundfish and elasmobranchs) increased in biomass (Figure PC2).

An example was given of potential competitive interactions between skates and principal groundfish as suggested by their inverse correlation in biomass on Georges Bank. Insight may be gain from a comparison with Browns Bank which appears to have a constant biomass of principal groundfish and a decline of skates, unlike Georges Bank. Dietary overlap studies and definition of feeding guilds should provide insight as to whether potential competition exists. Laboratory experiments should also provide better estimates of evacuation rates at various temperatures which will be used to refine comparisons of consumption between regions.

A general consensus has emerged that predation is a dominant force that regulates the recruitment of marine fish. Ongoing research suggests that mackerel and herring predation may impact on the survival of age-0 sand lance, cod, and haddock. For example, the exploitation and subsequent decline of mackerel and herring in the early 1970s coincided with a dramatic increase in the sand lance population (Figure PC3). The recovery of mackerel and herring during the 1980s appeared to have resulted in a reduction in sand lance abundance. This inverse correlation has been attributed to predation on juvenile sand lance by mackerel and herring (Fogarty et. al. 1991). Existing empirical evidence and correlations also suggest that mackerel and herring predation may influence the recruitment of cod and haddock.

A shift in community structure may have affected the ability of haddock to recover. Yearly changes in yield as a function of fishing mortality relative to the equilibrium yield show that yield was relatively stable during the 1931 - 1964 period (close circles), followed by a reduction in yield after 1964 (open circles) (Figure PC4). Fisheries managers may have to consider an alternative management approach of increased harvesting of under-utilized species in order for over-exploited species to recovery.

Discussion

Fisheries managers have expressed considerable interest in whether we can rebuild fisheries by reducing predators (e.g., under-utilized species). Additional modelling and analysis is necessary to define the synergistic effects of predation and harvesting on fish community dynamics. It is clear, however that ecosystem level effects must be considered in devising management strategies.

References

Fogarty, M.J., E.B. Cohen, W.L. Michaels, and W.W. Morse. 1991. Predation and the regulation of sand lance populations: an exploratory analysis. ICES mar. Sci. Symp., 193: 120-124.

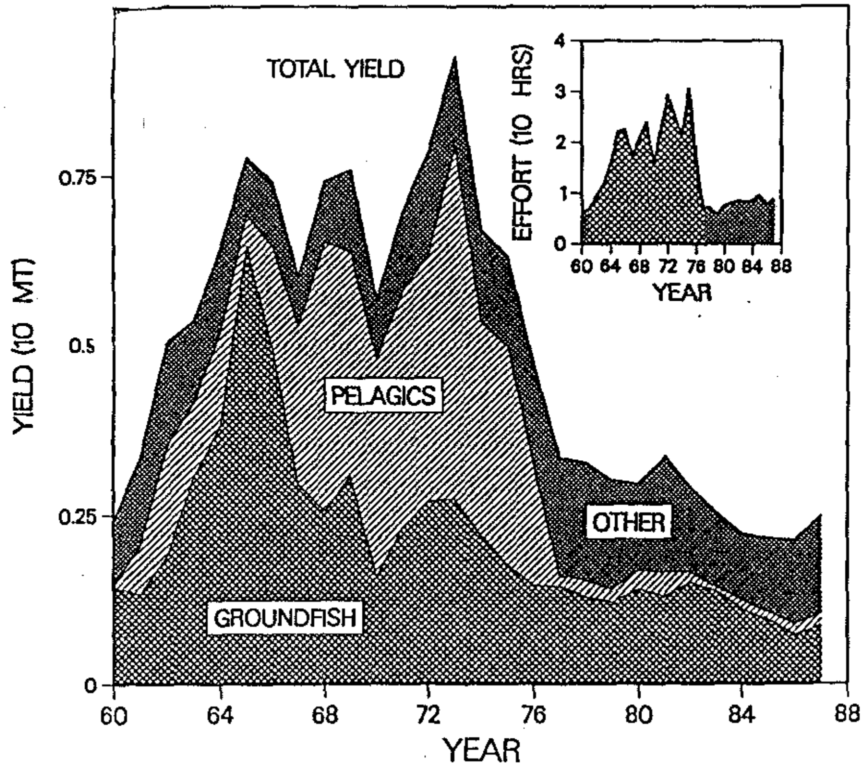

Figure PC1.

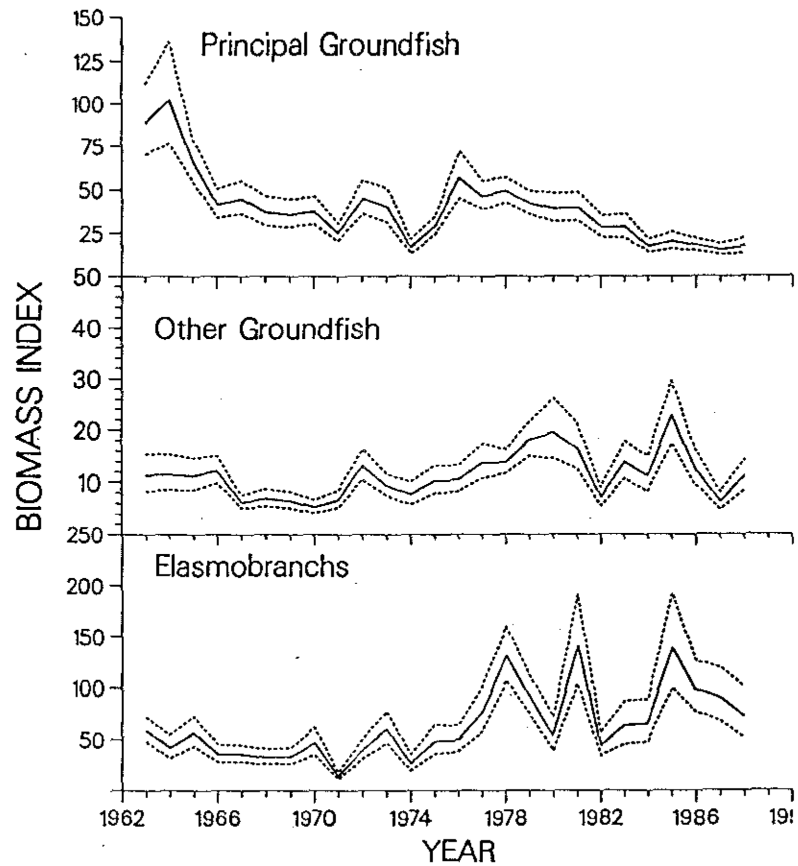

Figure PC2.

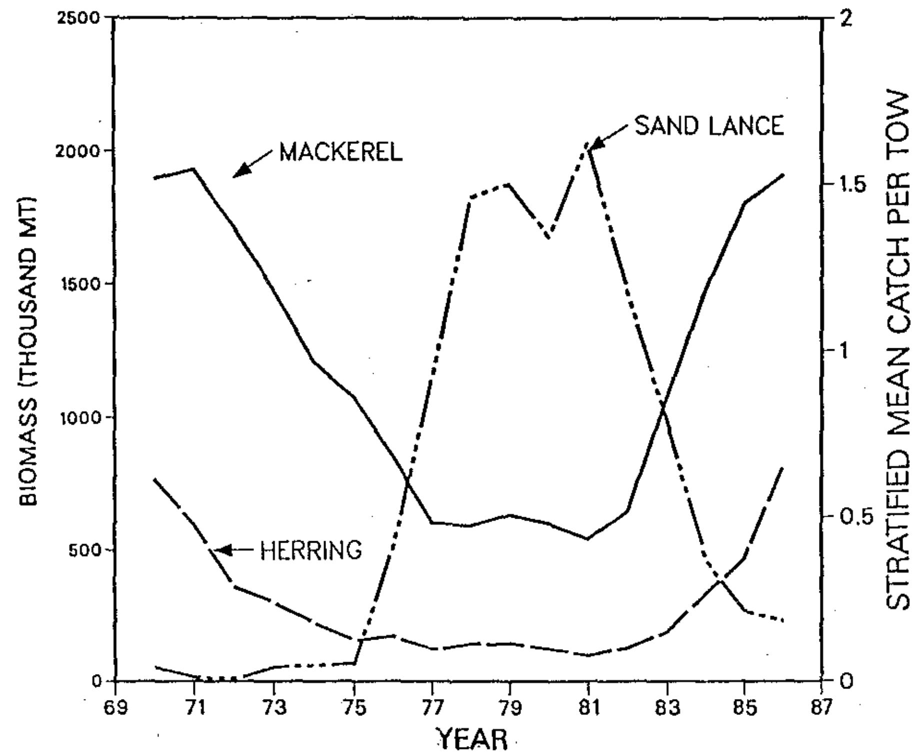

Figure PC3.

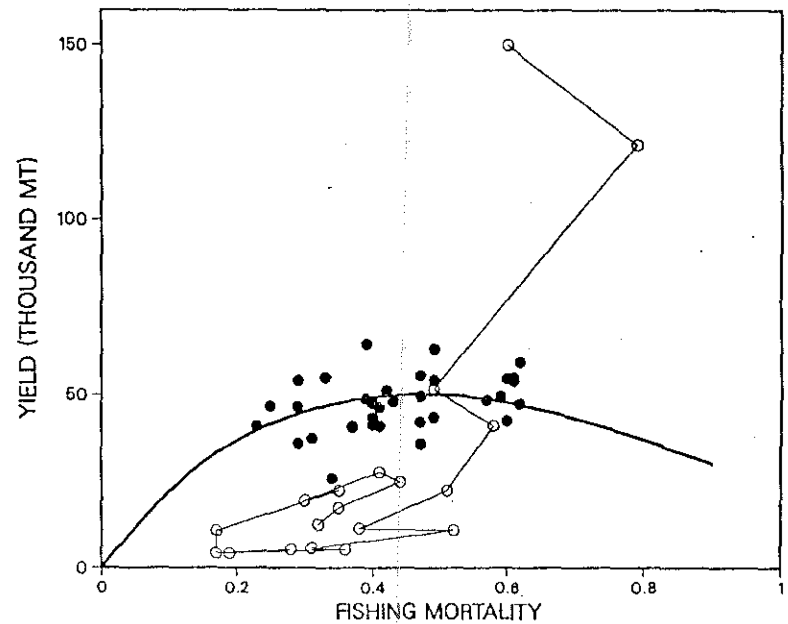

Figure PC4.

STANDARDIZATION OF SAW DOCUMENTATION

Background and Recommendation

During the plenary session of SAW 13 (January 1992), it was recommended that the SAW 14 Plenary address a special topic on *Standardization of SAW Documentation*. Working Paper SAW/14/PL/2, presented by Dr. Fred Serchuk, addressed this topic. Ensuing discussion addressed not only the documentation issue but many more general issues regarding procedural matters governing the entire SAW process (SARC and Plenary).

SAW/14/PL/2 provided a comprehensive overview of the SAW documentation process including:

(1) Background and evolution of the suite of documents that comprise the current SAW documentation.

(2) Review of the presentation of scientific advice in other organizations, i.e. ICES, NAFO, and CAFSAC.

(3) Evaluation of the form and format of advice from recent SAWs.

(4) Recommendation that a *SAW Documentation Study Group* be established to address some of the deficiencies and weaknesses identified in (3), above.

The Plenary discussion reflected little disagreement with the SAW/14/PL/2 recommendation regarding the need for a study group, i.e. item (4), above. However, the Plenary consensus was that the study group should not limit its scope to documentation alone, but rather it should consider broader procedural issues concerning the entire SARC/SAW process. The Plenary recommended that:

A SAW Procedures Study Group be established to develop revised procedures for the preparation and review of assessments and the presentation of SAW advice. The Study Group should consider the strengths and weaknesses of the current process as delineated in SAW/14/PL/2 and in the discussion points raised during the SAW 14 Plenary (outlined below).

Members of the Study Group should include the present and immediate-past SAW Chairmen (as Co-Conveners); one representative each from NEFSC, NER, NEFMC, MAFMC, and ASFMC; and two at-large members with in-depth experience with both the SARC and SAW Plenary processes.

The Study Group should develop new and/or revised protocols for improving SARC and SAW Plenary procedures, with the expectation that many of these revisions will be introduced at the 15th SARC (December 1992) and at the subsequent SAW Plenary (January 1993). The Study Group will meet at least once and submit a written report of their findings to the SAW Steering Committee ***no later than 30 September 1992*** *so that any recommendations accepted by the Steering Committee can be implemented at the 15th SARC/SAW.*

Discussion

Most of the discussion during the Plenary session centered on procedural and logistical problems associated with the SARC process rather than with the SAW Plenary process *per se*. Salient points from the discussion are briefly summarized below.

(a) Insufficient lead time for assessments

Terms of reference and the SARC agenda are often finalized too late to allow sufficient time to fully complete the assessment process. Sufficient lead time is needed not only to carry out the assessment analysis, but appreciable time is also needed to prepare complete working documents and to distribute the documents to SARC members well in advance of the meeting. Both the quality and the timely availability of documents have suffered at recent SARC meetings due to inadequate lead time.

(b) Duration of the SARC meeting

The five-day format of the SARC meeting is inadequate to fully deal with the number of assessments that have been tabled during recent meetings. The SARC process has been successful in improving the quality of assessments by not only reviewing assessments, but by suggesting constructive alternatives when problems are found. Revised analyses are then re-considered later in the meeting. This process is time consuming and a two-week format may be necessary to do it properly. However, a two-week format may make it difficult to attract the outside committee members (e.g. from other NMFS Science Centers) who have greatly strengthened the process to date.

(c) Use of assessment working groups

Although some assessments presented to the SARC have been carried out by assessment working groups (WG), e.g. summer flounder, most assessments are carried out by individuals or by small, informal groups. More widespread use of assessment WGs, meeting well in advance of the SARC, may alleviate some of the problems discussed in both (a) and (b), above. Having more scientists involved in an assessment should provide better reviewed assessments coming into the SARC, alleviating the needed for many re-analyses during a SARC meeting. A self-contained WG report would be reviewed by the SARC for each assessment rather than several different documents (as is now common). Further WG members would likely include several scientists from outside the NEFSC, helping to promote the final agreed-upon assessment as a SAW product, rather than the current perception of an NEFSC product.

(d) Review of work done outside the SARC/SAW process

Currently it is not uncommon for various management related analyses to be carried out outside the SAW process, e.g. work done by the Plan Development Teams (PDTs), support for some quota management Fishery Management Plans (FMPs), etc. Often this is done because products are needed between SAW meetings or because of other scheduling constraints. If these analyses are not reviewed by the SARC (even after the fact), there is a potential for inconsistent use of data and/or methods in the SARC-reviewed and in the unreviewed work. Any such inconsistencies, whether real or perceived, diminish the credibility of all of the scientific advice rendered.

FIFTEENTH SAW TERMS OF REFERENCE AND TIMING

A list of possible species/stocks to review and special topics to address next was developed for the consideration of the SAW Steering Committee.

Species/Stocks Suggested to Review

The Plenary identified the following species for review at the next session of the Stock Assessment Review Committee (SARC):

Sea Scallops	Herring
Cod (Gulf of Maine and Georges Bank)	Redfish

Suggested Special Topics

- o Mesh Selection for Groundfish
- o Biological Reference Points Working Group (W.G. #36)

Timing

It was suggested that the SAW-15 Stock Assessment Review Committee session be held during nine days of the second and third weeks in December 1992 and the Plenary session during the last week in January 1993.

Discussion

Species suggested to review at the next SARC session:

Sea Scallops -- Although the possibility to step back from sea scallops (the species has been on the SARC agenda several times) was discussed, it was noted that management would welcome additional information. The extent of this review, however, will depend on the outcome of the SAW Workshop on Consensus Assessments for Atlantic Sea Scallop, scheduled to meet 22-24 July. This workshop was formed based on discussions relative to the Advisory Report on Stock Status to resolve the issues that were not brought to consensus within the time-frame of the SARC session.

Sea Herring -- ASMFC suggested a review of the analysis of the Sea Herring Working Group at the next SARC session. The updated assessment will include the New Brunswick fishery.

Cod (Gulf of Maine and Georges Bank) -- NEFSC suggested a review of assessments for both stocks of cod at the next SARC session as recent catch information and a new estimate of fishing mortality will be available. Information on discards and the recreational fishery, however, will not be available at that time.

Redfish -- Although an analytical assessment would not be presented, NEFSC indicated that current information suggests a declining resource. A review of this information during the next session may be useful.

Species suggested to review in the near-future:

Squids -- MAFMC indicated that additional biological information is needed for real-time management of squid. Long-term needs should be re-examined at SAW-16.

Witch Flounder -- NEFSC indicated that the Gulf of Maine witch flounder assessment has been updated and should be reviewed in the near future.

Surf Clams and Ocean Quahogs -- NEFSC suggested that these species be considered for a future review. As recent survey indices will be available, the advantage of a technical review and input for scientists is important.

Pollack -- NEFSC suggested a review of pollack at SAW-16 when additional information will be available.

Silver Hake -- NEFSC suggested that this species be reviewed in about a year when remaining analytical questions have been resolved.

In addition to the above species, NEFSC has indicated that important pieces of information are available on a number of other species (the list includes scup and black sea bass). Review of this information would depend on the flexibility of the SARC schedules.

Special Topics:

Mesh Selection for Groundfish -- The NERO study on mesh selection will be completed next fall. A presentation at the next Plenary on the topic may be possible.

Biological Reference Points Working Group (SAW W.G. #36) -- Discussion relative to overfishing definitions, indicated a need for further biological guidance toward understanding %MSP. Formation of a working group to address this issue was, thus, recommended. It was suggested that this Working Group present at the next Plenary session an overview of the issue as well as proposed terms of reference.

STOCK ASSESSMENT REVIEW COMMITTEE

CONSENSUS SUMMARY OF ASSESSMENTS

INTRODUCTION

The **Stock Assessment Review Committee (SARC) of the 14th Northeast Regional Stock Assessment Workshop (SAW)** met at the Northeast Fisheries Science Center, Woods Hole, Massachusetts during June 15 - 19, 1992. The ten member SARC was composed of experts from a number of organizations within and outside the region (Table S1). In addition to the SARC, more than forty individuals attended the meeting.

The SARC agenda included review of analyses for seven species/stocks of animals distributed in waters from the Gulf of Maine through the Mid-Atlantic (Table S2). Fifteen papers were presented by scientists involved in the work on the species/stocks under review (Table S3). Presentations included full or revised assessments of American Lobster, monkfish (goosefish), American plaice, and short- and long-finned squids; a preliminary assessment of tilefish; a progress report from the ASMFC lobster working group, with a model for calculating lobster populations in- and offshore, and a model for estimating mortality rates and stock sizes of lobster populations; goosefish biology; discard estimates of American Plaice; and current resource conditions of sea scallop populations, with an evaluation of sampling size composition of commercial landings and methods for estimating their population size, mortality rates, and catch per unit effort.

The SARC technically evaluated all information presented and determined the best current assessment of each resource, the major sources of uncertainty in the assessment, and how these uncertainties might affect the picture of stock status. In response to technical questions that were raised, the Committee considered it necessary to perform analyses in addition to those presented. These analyses were intended either to implement specific recommendations for improving the existing analyses or to explore sources and effects of uncertainties.

Table S1.

SAW-14 STOCK ASSESSMENT REVIEW COMMITTEE

Andrew Applegate/ Howard Russell	New England Fishery Management Council
Peter Colosi	Northeast Regional Office, NMFS
Tom Hoff	Mid Atlantic Fishery Management Council
John Finn	University of Massachusetts
Michael Fogarty	Northeast Fisheries Science Center, NMFS
Wendy Gabriel	Northeast Fisheries Science Center, NMFS
Michael Parrack (Chair)	Southeast Fisheries Science Center, NMFS
Anne Richards	Northeast Fisheries Science Center, NMFS
Frederic Serchuk	Northeast Fisheries Science Center, NMFS
Susan Wigley	Northeast Fisheries Science Center, NMFS

Table S2.

14TH NORTHEAST REGIONAL STOCK ASSESSMENT WORKSHOP

STOCK ASSESSMENT REVIEW COMMITTEE MEETING

NEFSC Aquarium Conference Room
Woods Hole, MA

June 15 (9:00 AM) - June 19, 1992

AGENDA

Monday, June 15

OPENING	Chairman	M. Parrack
SPECIES/STOCK	SOURCE/PRESENTER(S)	SUGGESTED RAPPORTEUR(S)
Lobster	WG/J. Idoine, M. Fogarty, R. Conser (NEFSC) B. Estrella (MA DMF)	H. Russell/ J. Finn
Tilefish	NEFSC/G. Shepherd	S. Wigley/ A. Richards

Discussion, SARC analyses, clarification

Tuesday, June 16

Monkfish (Goosefish)	NEFSC/J. Idoine, F. Almeida UMA/D. Hartley	F. Serchuk/ A. Applegate
American Plaice	NEFSC/L.O'Brien, R. Mayo	J. Finn/ W. Gabriel

Reports, discussion, SARC analyses, clarification

Wednesday, June 17

Squids *Illex*	NEFSC/J. Brodziak	T. Hoff/ P. Colosi
Loligo	NEFSC/J. Brodziak	P. Colosi/ T. Hoff

Reports, discussion, SARC analyses, clarification

Thursday, June 18

Sea Scallops	NEFSC/S.Wigley, D. Hayes	A. Richards/ W. Gabriel

Reports, discussion, SARC analyses, clarification

Table S2 (continued).

Friday, June 19

Additional SARC Analyses and Discussion

Complete and Review Rapporteurs' Reports

Complete Draft **Consensus Summary of Assessments**

Table S3.

SAW-14 SARC PAPERS

SAW/14/SARC/1	Stock Assessment of the Long-finned Squid, *Loligo pealei*, in the Northwest Atlantic for 1991	J. Brodziak
SAW/14/SARC/2	Stock Assessment of the Short-finned Squid, *Illex illecebrosus* in the Northwest Atlantic for 1991	J. Brodziak
SAW/14/SARC/3	Preliminary Stock Assessment of Tilefish in the Middle Atlantic Bight	G. Shepherd M. Lambert
SAW/14/SARC/4	Current Resource Conditions in USA Georges Bank and Mid-Atlantic Sea Scallop Populations: Results of the 1991 NEFSC Sea Scallop Research Vessel Survey	S. Wigley F. Serchuk N. Buxton
SAW/14/SARC/5	Evaluation of NEFSC Sampling of the Size Composition of Commercial Sea Scallop Landings	D. Hayes S. Wigley
SAW/14/SARC/6	Progress Report of the Atlantic States Marine Fisheries Commission Lobster Technical Group	Working Group
SAW/14/SARC/7	Goosefish Biology	F. Almeida J. Burnett D. Hartley J. Idoine K. Lang K. Sosebee M. Terceiro
SAW/14/SARC/8	Assessment of Goosefish, *Lophius americanus* from Gulf of Maine to Cape Hatteras	J. Idoine K. Sosebee
SAW/14/SARC/9	Assessment of American Plaice in the Gulf of Maine-Georges Bank Region, 1992	L. O'Brien R. Mayo N. Buxton M. Lambert
SAW/14/SARC/10	Discard Estimates of American Plaice in the Gulf of Maine Northern Shrimp fishery and the Gulf of Maine-Georges Bank Large Mesh Otter Trawl Fishery	R. Mayo L. O'Brien N. Buxton

AMERICAN LOBSTER

American lobster biomass indices for all areas fluctuated without trend since 1965 while landings and fishery effort increased. Landings per trap haul increased in Maine and were steady in Massachusetts. Female stock abundance is estimated to have increased since 1980 in the Gulf of Maine and remained constant on offshore areas of Georges Bank and Southern New England. The fishing mortality rate (F)in the Gulf of Maine (0.8) is less than that of over-fishing rate (the F resulting in 10% of maximum egg production per recruit: F=1.0). The calculated fishing mortality rate on the offshore part of Georges Bank and Southern New England (0.7) is higher than the over-fishing rate (0.44). Other estimates of F presented to the SARC based on additional unsupported assumptions (steady state, population dynamics and small inshore area unit stocks) were higher for the Gulf of Maine and lower for Georges Bank-Southern New England.

Background

The American lobster, Homarus americanus, is distributed in the Northwest Atlantic from Labrador to Cape Hatteras in coastal regions out to depths of 700 m (Fogarty, et al, 1982). An overview of the fishery is given in Appendix C of SAW/14/SARC/6. Lobsters are locally abundant in coastal regions within the Gulf of Maine and off southern New England and less abundant in more southerly areas. Coastal lobsters are concentrated in rocky areas where shelter is readily available, although occasional high densities occur in other substrates (e.g., mud, peat). Offshore, lobsters are most abundant in the vicinity of submarine canyons along the Continental Shelf edge.

Stock Definition

The structure of the American lobster stock has been investigated based on differences in morphological characteristics, parasite infestation, and biochemical and genetic markers. Separate inshore and offshore lobster stocks have been inferred from parasite infestation studies. Low sample sizes may have contributed to the lack of statistical significance in some of the studies. Examination of morphometric and meristic differences between inshore and offshore populations were inconclusive; levels of correct classification using discriminant functions were not high. Most important, studies using electrophoretic techniques and mitochondrial DNA have shown (1) little clear evidence of stock separation and (2) low levels of genetic variability.

Mark-recapture studies (Figure SA1) corroborate electrophoretic and mitochondrial DNA results; they do not demonstrate separations. These studies show seasonal coastward movements of offshore lobsters during spring and a return migration in autumn as well as lateral movements along the outer continental shelf between the Georges Bank and Southern New England. Reported movements for coastal lobsters are more limited (Saila and Flowers, 1968) but this undoubtedly reflects both the smaller mean size and the relatively short time at large in many of the inshore studies. Studies of larger (>127 mm CL) inshore lobsters in the Gulf of Maine do show longer distance movements in a southwesterly direction.

Large scale hydrographic factors suggest that areas within the Gulf of Maine may be connected by a common larval supply. Contribution of larvae to the Gulf of Maine from northeastern Georges Bank is possible through larval drift. Similarly, it is probable that offshore lobsters from the southern New England region contribute larvae to the coastal regions.

Growth and maturation rates markedly differ among regions. There are sharp demarcations between coastal lobster populations in the Gulf of Maine, offshore lobsters in the Georges Bank-Southern New England area, and the warmer-water populations south of Cape Cod. These differences impact stock production and reproduction and the ability to determine stock dynamics.

Table S3 (continued).

SAW/14/SARC/11	Status of the Sea Scallop Fisheries off the Northeastern United States, 1991	S. Wigley F. Serchuk
SAW/14/SARC/12	Estimation of Population Size and Mortality Rates of Atlantic Sea Scallops Using a Modified Delury Model	D. Hayes S. Wigley
SAW/14/SARC/13	Standardized CPUE Estimates for Sea Scallops Using the General Linear Model (GLM) Procedure	S. Wigley D. Hayes
SAW/14/SARC/14	Assessment of the American Lobster, <u>Homarus americanus</u>, in the Gulf of Maine and Offshore Georges Bank/Southern New England area	J. Idoine B. Estrella S. Cardin J. Krouse
SAW/14/SARC/15	A Modified Delury Model for Estimating Mortality Rates and Stock Sizes of American Lobster Populations	R. Conser J. Idoine

The SARC considered analyses based on two principal groupings: (1) Gulf of Maine and (2) Georges Bank-Southern New England. Sufficient statistics were not available during the SARC meeting to include the inshore Southern New England component within the Georges Bank and Southern New England area analysis.

History of the Fishery

The American lobster has supported important commercial fisheries in the northeastern United States and the Canadian Maritime Provinces for over a century. The lobster fishery is seasonal and is primarily prosecuted using traps, although incidental catches are taken in otter trawls. A recreational fishery is prosecuted in coastal areas. Landings have increased since 1965 (Figure SA2, Table SA1). Both effort and landings increased in recent years (Figure SA3).

Landings of lobster from offshore areas peaked at nearly 4,000 mt during 1970 - 1972 subsequently declining to 2,000 mt around 1980. More recently, landings increased to about 5,0000 mt in 1990 and 1991. Throughout the time series, the offshore landings remained at a nearly constant 15% to 20% of total landings.

Landings from offshore areas are made by vessels using traps and trawls. Prior to 1950, lobsters were primarily taken offshore as incidental trawl catches in the demersal fisheries. The trawl landings increased from 400 mt during the 1950s to about 2,000 mt in the 1960s. Subsequently, trawl landings declined from 3,200 mt in 1971 to a little over 300 mt in recent years.

Landings of trawl-caught lobsters declined, but offshore trap landings rose markedly. In 1969, technological advances permitted the introduction of trap fishing to the deeper offshore areas. Landings rose from 50 mt in 1969 to 2,900 mt in 1972. They remained stable at about 2,000 mt through 1983. More recently, offshore trap landings rose to over 4,000 mt in 1990 and 1991.

Data Sources

Domestic landings and effort from the commercial fishery (Table SA1) are recorded by the NEFSC annual canvas and weighout collections. The magnitude of recreational landings is not known. The probability of death of released lobsters (females with eggs and shorts) on offshore ground has not been estimated, but is assumed to be zero; the level of discarding is not recorded.

Abundance indices were developed from NMFS fall research vessel survey observations, 1965 - 1991. The stratified mean number caught per tow was used to index stock sizes (numbers) and stratified mean weight per tow was used to index biomass.

Methodology

Two length based methods of calculating fishing mortality were employed in the ASMFC Lobster Technical Group analyses: 1) VPA approach (Jones 1974) and (2) a modified DeLury length-based model (Conser 1991, 1992).

The VPA analysis requires the total catch at length, natural mortality, von Bertalanffy growth parameters (L and K), that migration does not occur, and that the stock be in a steady state. Appendix A of SAW/14/SARC/6 describes the assumptions used. Length samples from commercial landings were expanded to numbers at length (weighted by the hail weight of the catches over a quarter) by sex. Analyses were done separately for the following areas: (1) offshore Georges Bank/Southern New England (6 years); (2) coastal Maine (1 year); (3) Cape Cod Bay (11 Years); (4) outer Cape Cod (11 years); and (5) Buzzards Bay (11 years). Separate growth parameters from each sex were used for areas one, four (Cooper and Uzmann 1980) and five (Russell et al. 1978) and single growth models (i.e., sexes combined) were used for areas two (Krouse 1977) and three (Fair 1977).

The DeLury model was applied to stock size indices for offshore Georges Bank/Southern New England as described in Appendix B of SAW/14/SARC/6. The procedure assumed that migration does not occur and requires the rate of natural mortality; M=0.1 was used. Recruits were assumed to be smaller than legal size at the beginning of the survey year (1 October) and greater than or equal to legal size by the end of the survey year (30 September) i.e., from 66-80 mm (carapace length). Fully-recruited lobsters are greater than or equal to legal size at the beginning of the survey year. Separate indices of abundance were computed for recruits and those fully-recruited. Both groups were assumed to be equally catchable to the survey trawl (a single q). The two component population model was fit by constrained, weighted least squares to estimate the survey cruise catchability coefficient and "smoothed" abundance indices for recruits and post recruits. The smoothed abundance index for each year was derived by the q estimated by least squares to calculate abundance. Total mortality was computed as the ratio of successive abundance calculations. The assumed level of M was subtracted from the total mortality calculation to find the fishing mortality rate.

Assessment Results

The weight landed per trap haul from inshore Maine increased during the last decade, but no CPUE trend is evident in Massachusetts. The NEFSC autumn survey biomass index has fluctuated without trend, 1965 - 1990, while landings have increased (Figure SA3).

Length-cohort calculations of fishing mortality were made assuming steady state population dynamics and unit stocks for: Cape Cod Bay and Massachusetts Bay, Buzzards Bay, outer Cape Cod to approximately 3 miles offshore, the Maine coast to about 12 miles offshore, and offshore Georges Bank-Southern New England (GB-SNE). Estimates of F for inshore regions were high (F 2.0) except for outer Cape Cod (F 0.5) but substantially lower for offshore GB-SNE (F 0.5, ASMFC 1992).

The effects of survey cruise gear changes (SAW/14/SARC/6, Appendix B.3) and various least square weights (SAW/14/SARC/6, Appendix B.5) were investigated for the DeLury model. DeLury model estimates of GB-SNE female abundance, both stock size and biomass, fluctuated without trend, 1980 - 1990 (SAW/14/SARC/6, Appendix B.1). Calculated F for fully recruited females is 0.86 in 1989, a four-fold increase over the F in 1980 of 0.22. This seems inconsistent with abundance estimates, fishery CPUE, and abundance indices. Migration between inshore and offshore areas is confounded with these F calculations; the magnitude and direction of the consequent bias is unknown.

SARC Analyses

The SARC noted that the result of applying the length-cohort procedure to data of a single year is questionable due to the steady-state assumption. The SARC also noted that applying any procedure to small areas under a unit stock assumption is not consistent with tagging results (Figure SA1), as well as electrophoretic and mitochondrial DNA results. This conclusion places length based cohort analysis estimates in serious doubt and to a lesser degree negatively impacts DeLury estimates for GB-SNE.

The SARC requested a DeLury calculation for the entire Gulf of Maine region (offshore and inshore) to provide a way of assessing the resource as a whole. The SARC analysis result is provisional; further refinement of the constraints and survey and commercial information is required.

The calculations (Table SA3) indicate that female abundance (stock size and biomass) has increased due to abundant recruitment. Fishing mortality rates have decreased. The fishing mortality rate on females is approximately 0.8. This calculation is substantially lower than the cohort analysis calculation for the immediate coastal area alone because the cohort analysis calculation does not account for migration and assumes steady state population dynamics.

A substantial fraction of the inshore component of the lobster resource inhabits regions (highly productive, hard bottom) that cannot be sampled with otter trawls. Lobsters are smaller in these areas than offshore and the densities are markedly higher. The present assumption (equal catchabilities) probably overestimates the catchability of the recruit component in this case and the selection cannot be estimated by the method (SAW/14/SARC/6, Appendix B.3). Accordingly, the sensitivity of the estimates to reductions in the ratio of the catchability of recruits to fully recruited individuals was explored by the SARC. These simulations indicate a nearly linear inverse relationship between the estimated fishing mortality rates and the ratio of the catchabilities (SAW/14/SARC/6, Appendix B.6). Therefore, if the two catchabilities are not equal as assumed, and they probably are not, the estimates of F are inaccurate. The estimations are probably biased low.

Overfishing Definition

Overfishing in the Gulf of Maine occurs with an F greater than 1.0 (Botsford 1992) and on offshore Southern New England-Georges Bank with an F greater than 0.44. DeLury model estimates indicate that fishing mortality (Table SA2) is 20% less than the overfishing level in the Gulf of Maine and 57% greater than the overfishing level in the southern area. Although they are the best that are now available, they are very preliminary and thus will likely change, perhaps substantially, as the calculation method is refined or as other methods are used.

Major Sources of Uncertainty

The need to obtain an integrated view of the resource as a whole was discussed. The DeLury approach provided a useful framework for an assessment of the resource as a whole. However, the estimates derived from the DeLury method without adjustment for differential vulnerability of recruit stage lobsters are underestimates. The technique required a prior knowledge of natural mortality and gear selections by size. Estimates are very sensitive to those parameters.

The definition of stock structure needs to be considered. Existing information on biochemical genetics, morphometrics, life history characteristics, and tagging studies needs to be summarized for review. At present, the lack of stock definition adds considerable uncertainty. In particular, the analyses conducted by the ASMFC Lobster Technical Committee and those conducted during the SARC do not include the inshore component of landings in the Southern New England region.

Recommendations

o Decisions regarding to which stock unit landings should be assigned, must be made and integrated into the assessment.

o Stock structure must be determined independent of data-analysis methods' restraints.

o Some DeLury method is required which is sensitive to a prior knowledge (M, selection factors, etc), this knowledge should be addressed in depth.

o The inshore Southern New England component should be included into the Georges Bank-Southern New England offshore component in future analysis.

o The performance of the stock assessment methods applied to lobster should be studied, particularly in regard to lobster life history characteristics and assumed a priori knowledge.

References

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Table SA1. Lobster Fishery Statistics (Landings in 1000 mt, Traps in 1000 traps).

	Maine		Massachusetts		Connecticut		New York		Total US Landings			
		Landings	Traps	Landings	Traps	Trap Landings	Hauls[1]	Landings	Traps	Inshore	Offshore	Total
1922	0.0		1062.3	47.5	0.0		0.0					
1923	0.0		620.8	42.6	0.0		0.0					
1924	0.0		732.6	39.7	0.0		0.0					
1925	0.0		713.6	39.0	0.0		0.0					
1926	0.0		655.5	39.9	0.0		0.0					
1927	0.0		756.7	44.2	0.0		0.0					
1928	0.0		811.4	40.9	0.0		0.0					
1929	0.0		746.1	40.2	0.0		0.0					
1930	3572.5	205.0	1165.2	62.1	0.0		0.0					
1931	2473.1	168.0	968.4	68.5	0.0		0.0					
1932	2791.1	208.0	892.5	70.0	0.0		0.0					
1933	2718.0	180.0	652.8	57.4	0.0		0.0					
1934	2478.2	183.0	801.7	57.8	0.0		0.0					
1935	3543.0	185.0	831.8	57.2	0.0		0.0					
1936	2360.3	185.0	829.0	59.0	0.0		0.0					
1937	3386.5	186.0	955.6	64.0	0.0		0.0					
1938	3529.8	258.0	1031.5	70.4	0.0		0.0					
1939	3053.3	260.0	1060.7	64.2	0.0		0.0					
1940	3522.7	222.0	1010.1	62.8	0.0		0.0					
1941	4119.1	194.0	1015.5	60.6	0.0		0.0					
1942	3873.2	187.0	771.9	39.5	0.0		0.0					
1943	5285.6	209.0	1061.9	49.6	0.0		0.0					
1944	6478.4	252.0	1267.0	63.3	0.0		0.0					
1945	8816.4	378.0	1342.1	73.4	0.0		0.0					
1946	8653.8	473.0	1467.5	101.7	0.0		0.0					
1947	8423.2	516.0	1661.7	103.2	0.0		0.0					
1948	7339.0	439.0	1456.5	94.4	0.0		0.0					
1949	8882.4	462.0	1613.6	99.4	0.0		0.0					
1950	8457.7	430.0	1410.8	98.9	0.0		0.0					
1951	9566.2	383.0	1685.8	82.4	0.0		0.0					
1952	9233.0	417.0	1557.3	86.8	0.0		0.0					
1953	10274.4	490.0	1735.5	93.6	0.0		0.0					
1954	9975.7	488.0	1620.8	118.5	0.0		0.0					
1955	10467.5	532.0	1567.8	93.5	0.0		0.0					
1956	9465.7	533.0	1487.7	91.4	0.0		0.0					
1957	11245.8	565.0	1669.2	95.2	0.0		0.0					
1958	9820.3	609.0	1428.7	95.5	0.0		0.0					
1959	10288.7	717.0	1685.5	97.8	0.0		0.0					
1960	11063.9	745.0	1513.2	88.9	0.0		0.0					

Table SA1 (Continued)

	Maine		Massachusetts		Connecticut		New York			Total US Landings		
		Landings	Traps	Landings	Traps	Trap Landings	Hauls[1]	Landings	Traps	Inshore	Offshore	Total
1961	9637.4	752.0	1847.8	108.7	0.0		0.0					
1962	10173.8	767.0	1695.1	92.0	0.0		0.0					
1963	10510.2	731.0	1300.4	90.3	0.0		0.0					
1964	9869.0	754.0	1890.2	104.8	0.0		0.0					
1965	8693.4	789.0	1405.2	113.3	0.0		0.0		11200.0	2500.0	13700.0	
1966	9179.1	776.0	1488.0	120.9	0.0		0.0		11600.0	1800.0	13400.0	
1967	7599.1	715.0	1407.5	130.7	0.0		0.0		10000.0	2000.0	12100.0	
1968	9449.4	747.0	1666.1	141.1	0.0		0.0		12200.0	2500.0	14800.0	
1969	9141.5	805.0	1632.5	141.5	0.0		0.0		12200.0	3100.0	15300.0	
1970	8375.4	1180.0	1715.0	152.3	0.0		0.0		11600.0	3900.0	15500.0	
1971	8091.9	1278.0	1743.3	162.3	0.0		0.0		11300.0	3900.0	15300.0	
1972	7492.5	1448.0	1612.6	175.6	0.0		0.0		10600.0	3900.0	14600.0	
1973	7855.2	1172.0	1669.5	169.7	0.0		0.0		10500.0	2600.0	13200.0	
1974	7584.9	1790.0	1761.1	157.0	0.0		0.0		10300.0	2700.0	12900.0	
1975	7843.0	1771.0	2346.3	211.1	0.0		0.0		11000.0	2700.0	13300.0	
1976	8757.5	1754.0	2161.8	222.3	0.0		188.4	36.4	11700.0	2600.0	14800.0	
1977	8520.7	1739.0	2463.7	218.0	0.0		229.6	28.5	11900.0	2500.0	14600.0	
1978	8817.4	1723.0	3302.9	257.5	0.0		249.4	29.9	12900.0	2700.0	15900.0	
1979	10201.3	1810.0	3459.7	291.5	412.3	1.1	283.6	32.4	14700.0	2200.0	17200.0	
1980	10129.1	1846.0	3718.6	278.1	442.7	1.1	289.9	32.7	14900.0	1900.0	17000.0	
1981	10414.7	1825.0	4210.4	299.4	430.9	1.1	308.8	38.4	15900.0	1800.0	17900.0	
1982	10526.4	2143.0	4311.1	319.1	454.5	0.9	387.1	38.6	16100.0	2300.0	18800.0	
1983	10127.1	2340.0	4628.2	334.9	877.3	1.6	551.0	51.2	17600.0	2400.0	20200.0	
1984	9007.4	2175.0	4477.0	354.9	980.7	1.7	686.2	64.4	16500.0	4200.0	20800.0	
1985	9277.7	1766.0	5533.6	375.2	764.8	1.7	653.6	67.1	18000.0	2600.0	20800.0	
1986	9083.6	1595.0	5706.6	399.8	709.4	1.6	597.3	60.1	17800.0	3000.0	20900.0	
1987	9096.8	1909.0	6029.9	427.0	896.8	1.9	677.4	68.7	17300.0	3300.0	20700.0	
1988	9983.8	2053.0	6469.6	433.4	1082.3	2.1	846.0	70.8	19200.0	3000.0	22200.0	
1989	10796.7	2001.0	6627.1	430.5	1169.4	2.3	776.2	100.0	20700.0	3300.0	24000.0	
1990	12943.6	2094.0	0.0	0.0	1490.1	2.8	1201.9	101.5	22600.0	5000.0	27600.0	

1 Connecticut trap hauls are in millions.

Table SA2. Fishing mortality rates for American Lobster

Year	Fish Mortality Rate (F) Georges & SoNE (off shore)	Gulf of Maine (inshore to offshore)
1980	0.22	0.56
1981	0.25	1.22
1982	0.27	1.21
1983	0.28	0.60
1984	0.40	0.58
1985	0.58	0.79
1986	0.50	0.74
1987	0.59	0.63
1988	0.63	0.87
1989	0.86	0.79
1990		0.71
3 year mean	0.69	0.79
F (10% max agg production)	0.44[1)]	1.00[2]

1) Fogarty and Idoine 1988
2) Botsford

Table SA3. Gulf of Maine lobster (females) abundance and fishing mortality rate estimates.

SURVEY YEAR	STOCK SIZE ESTIMATES (millions - Oct 1) RECRUITS	FULLY-RECRUITED	Z on sizes 1+	F on size 1	F on sizes 2+
1980	3.650	27.101	0.61	0.17	0.56
1981	1.942	16.685	1.23	0.36	1.22
1982	20.960	5.427	0.64	0.36	1.21
1983	19.266	13.978	0.46	0.18	0.60
1984	9.575	21.089	0.55	0.17	0.58
1985	18.483	17.713	0.61	0.23	0.79
1986	19.455	19.716	0.58	0.22	0.74
1987	7.154	21.846	0.62	0.19	0.63
1988	22.202	15.529	0.61	0.26	0.87
1989	24.481	20.477	0.59	0.24	0.79
1990	23.281	24.941	0.57	0.21	0.71
1991	35.190	27.252			

RECRUITS = SIZECLASS 1
FULLY-RECRUITED = SIZECLASS 2+

Note that the recruit population estimate for the last year (1991) is NOT a least squares estimate. It is calculated from the observed survey index, the least squares estimate of q, and the calculated selectivity.

SURVEY YEAR	BIOMASS ESTIMATES (mt - Oct 1) RECRUITS	FULLY-RECRUITED	TOTAL BIOMASS	EXPLOITED BIOMASS
1980	1073	24153	25225	24471
1981	596	16425	17021	16602
1982	7026	4053	11079	6138
1983	6754	9310	16064	11314
1984	3269	19362	22631	20332
1985	6123	15331	21454	17148
1986	6175	13680	19855	15512
1987	2339	11673	14012	12367
1988	7922	10991	18913	13341
1989	8323	16504	24827	18973
1990	9012	19395	28406	22068
1991	13323	19655	32978	23608

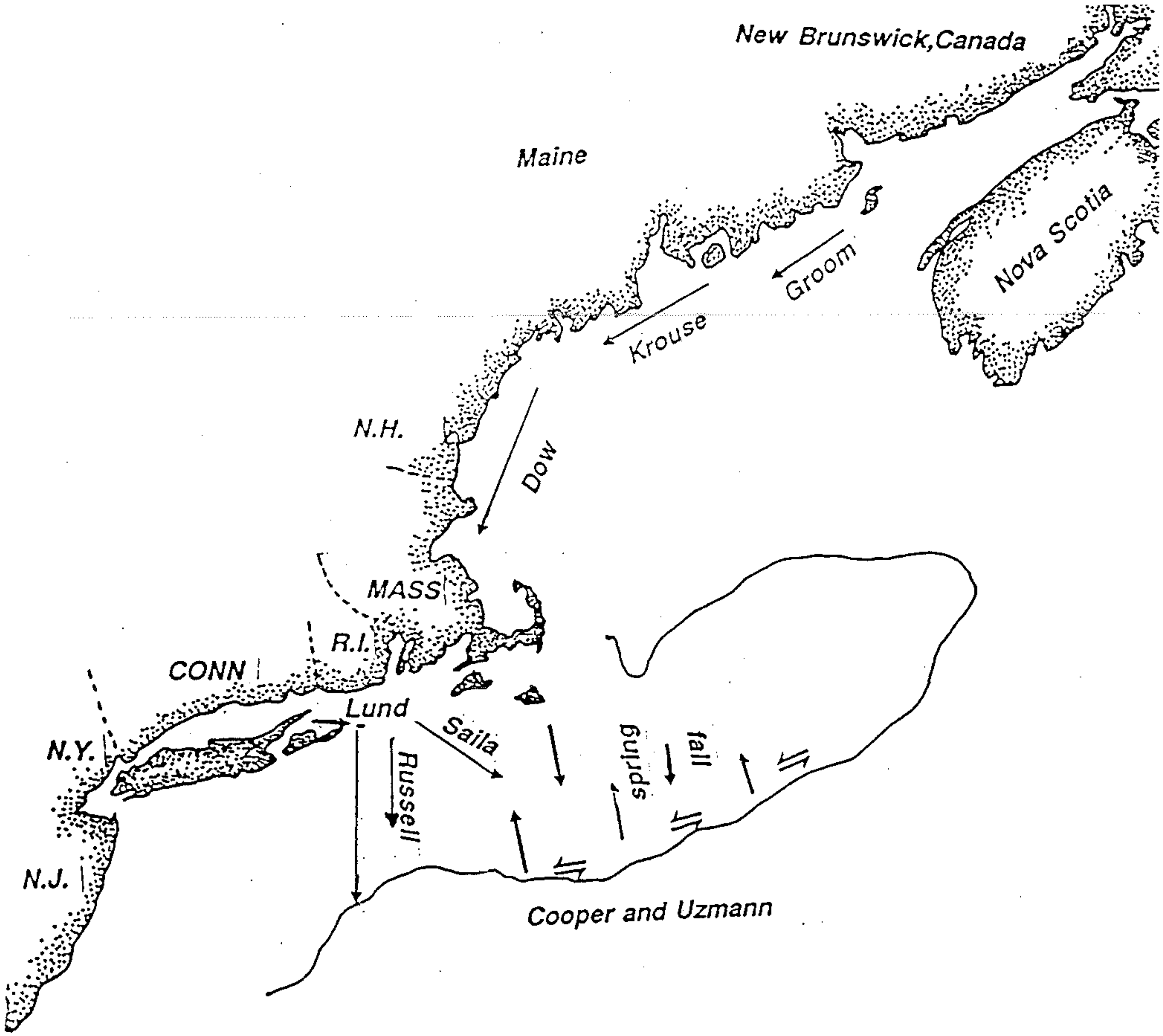

Figure SA1 (after Krouse, 1980). Movement patterns of American lobsters recovered from various tagging studies along the northeast coast of the US. [includes Cooper and Uzmann(1971); Dow(1974); Groom(1978); Krouse(1977); Lund *et al.*(1973); Morrisey(1971); Russell(1975); and Saila and Flowers(1968)]

LOBSTER LANDINGS

Inshore and Offshore

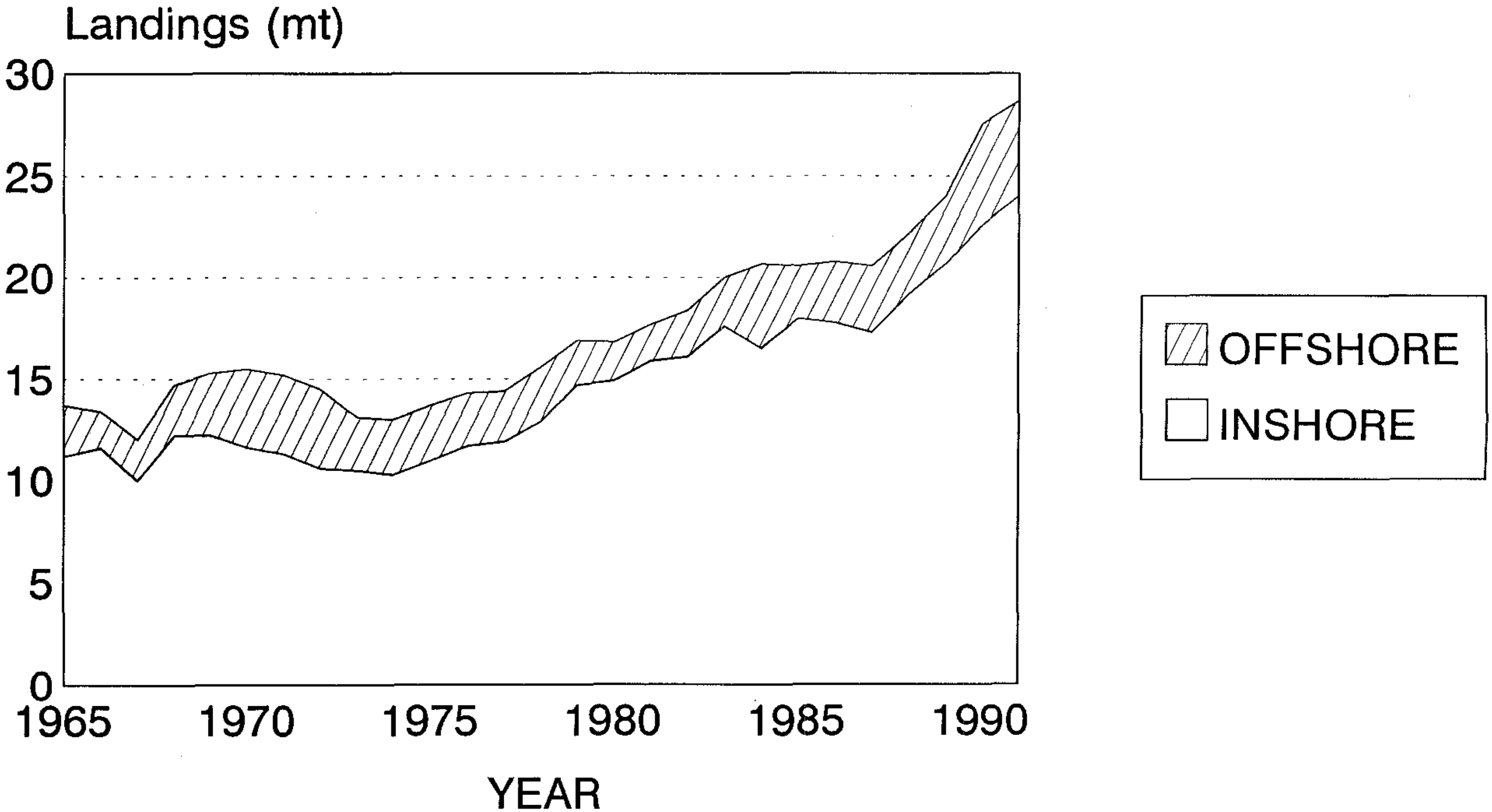

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Figure SA2

American Lobster
Landings and Survey Index

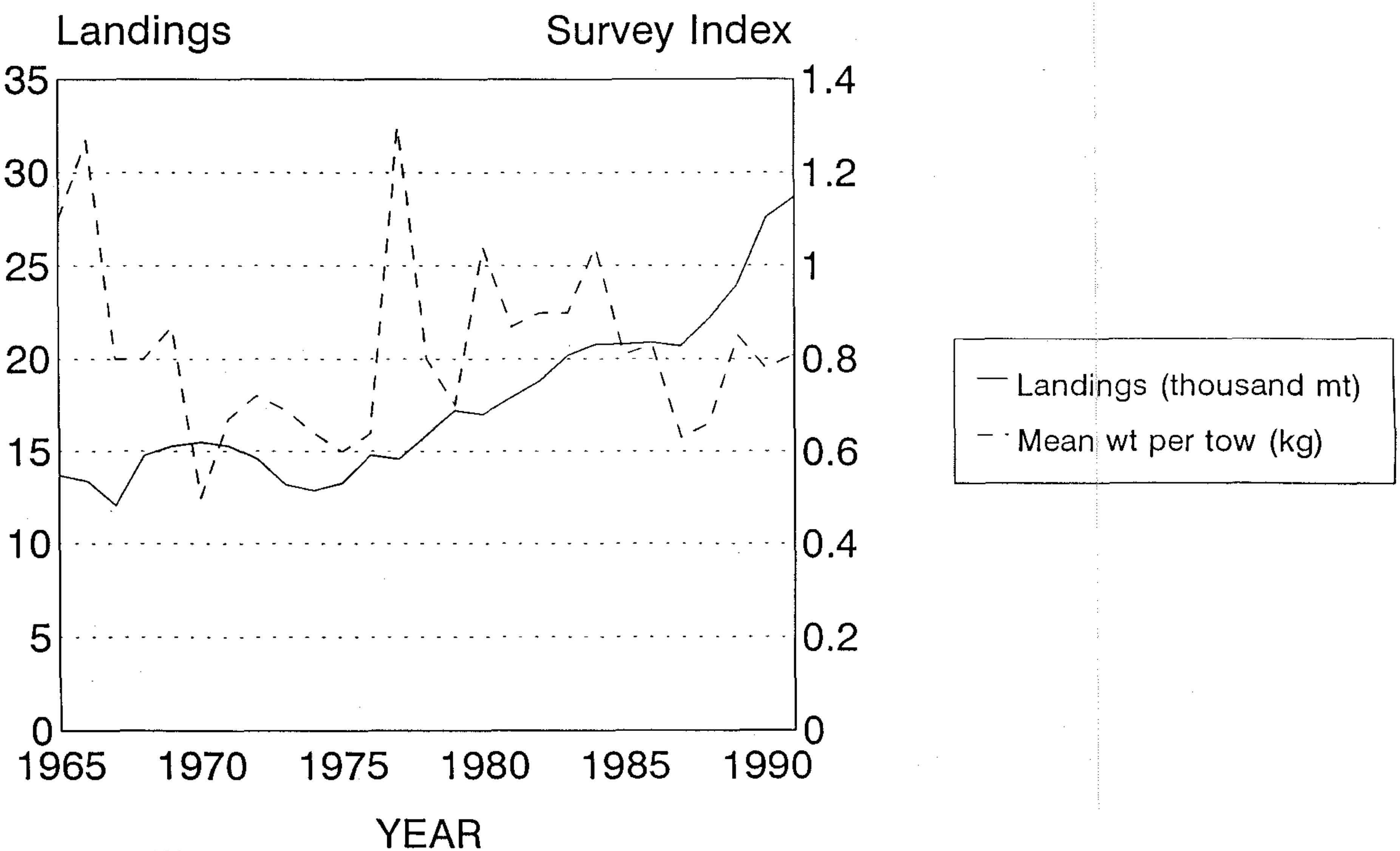

Figure SA3.

TILEFISH

The SARC reviewed a catch and effort analysis and surplus production model for tilefish of the Middle Atlantic and Southern New England region (SAW/14/SARC/3). An index level assessment of tilefish based on nominal yield and effort statistics indicates that abundance has declined in recent years to one fourth of its 1977 - 1984 average. The landings and number of vessels targeting tilefish has also decreased. The SARC believes that the tilefish resource is at a low level and over-exploited.

Background

Stock Definition

Tilefish (Lopholatilus chamaeleonticeps) is a deepwater demersal species distributed along the outer continental shelf from southern New England to Florida and into the Gulf of Mexico. The population along the Atlantic coast is considered a unit stock, with the Gulf of Mexico population being a separate stock (Katz et al. 1983).

History of the Fishery

Commercial exploitation of tilefish began in 1915. The resource was lightly exploited until the 1970s when a directed longline fishery began. Commercial landings peaked in 1979. Catches declined throughout the 1980s (except 1987) to a low in 1989. The 1991 catch is also low, but higher than that of the two previous years. Although there was a limited recreational fishery on the late 1970s, measurable recreational landings no longer occur. Currently, there are no management regulations on tilefish.

Data Sources

Nominal yield and fishing effort was taken from weighouts, 1973 - 1991. There are no discards. Although annual estimates of age composition for tilefish are available for 1977 - 1982, there are none after 1982. Size and age samples no longer are collected. Tilefish are not caught by the NEFSC research cruise survey gear.

The maximum age of tilefish is reported to be 35 years, with maturation occurring at age 5 or 6 and recruitment at ages 4 to 6. The fishery operates primarily on fish ages 6 to 14 (Turner et al. 1986).

Methodology

To derive relative abundance indices, standardized catch per unit effort (CPUE) indices were calculated for the longline fishery for 1973 to 1991. Standardization of CPUE was necessary due to gear modifications (changes in hook spacing and type, as well as the advent of automated baiting technology) and area\season variation in catch.

A General Linear Model (GLM) was fit to nominal longline yield and effort to develop standardized measures of effort and abundance indices for 1977 to 1991. The CPUE for 1973 to 1976, estimated by Turner (1986), was also used. The model included terms for ton class, area, and quarter of the year, interactions were not included. The year coefficients were re-transformed after correcting for bias (1/2 the variance of the estimate added prior to taking anti-logarithms) to calculate standardized CPUE abundance estimates. Standardized effort was calculated from standardized CPUE and total longline catch.

The equilibrium general surplus production model (Pella & Tomlinson 1969) was fit by weighted least squares (Fox 1975). Combinations of the model were fit using a constant $m=1.0$ (Gompertz growth function) or 2.0 (logistic growth function), effort averaged over 4, 5 or 6 years, and weighted vs. unweighted. A non-equilibrium logistic surplus-production model was also fit by least squares (Prager 1991) and bootstrap variance estimates computed.

Assessment Results

Visual analysis (Figure SB1) indicated that all longline trips landing tilefish target that species. All abundance indices (Table SB1) indicate that stock biomass steadily decreased about 7.5 fold since 1973. There is some indication that abundance might have stabilized at the lowest level in the series during the last three years (1989 - 1991) in response to a decrease in yield and effort. Yield increased one order of magnitude from 1973 to 1979, then steadily decreased until 1989. Standardized effort increased 30 times from 1973 to 1987 and is currently (1991) 24% less than that peak.

An equilibrium surplus production model estimated MSY at 2195.8 mt, optimum effort at 738.3 days fished, and the CPUE at optimum effort at 2.974 mt/df (Figure SB2). The SARC noted the poor fit and questioned the equilibrium assumption contained within the model and if the resource would support that removal level. The consensus of the SARC was that although the non-equilibrium model assumptions were met, either a solution had not been located (only a local minimum) or the data was too course to support estimation of the model's parameters.

SARC Analyses

The following SARC analyses were performed:

- o The level of interview coverage in the longline fishery was determined, and is presented in (Figure SB3).

- o A GLM was fit to interview data only, 1982-1991. The r-squared value dropped from 0.51 to 0.13 and the number of observations decreased to 274. Never the less, trends CPUE were comparable to those based on non-interviewed data.

- o A GLM, with terms for year and each vessel identification only, fit to weighouts (interviewed and non-interviewed) increased the r^2 from 0.51 to 0.57. Trends in CPUE, and 95% confidence intervals (Table SB2), are presented in Figure SB4.

- o Individual vessel participation was examined over the period 1977 to 1991; there has been a steady decrease in the number of vessels in the tilefish longline fishery; a record low of 7 vessels occurred in 1991.

Uncertainty

The SARC identified the following areas of uncertainty:

- o Fishery effort information, including time set, number of sets, mainline length, hook spacing, hook size and type, etc. is not monitored thus adding an unknown level of uncertainty to abundance indices.

- o The fishing power of newer vessels in the fishery may be more than that of older vessels; factors that determine fishery efficiency are not available.

- o The life history characteristics of the species (long lived, slow growing) are best reflected by size or age structured assessment methods; in such cases, these methods can monitor abundance with certainty, but the data to support these methods are not collected.

Recommendations

- o The interview coverage of the fishery is low. Sea sampling trips could be initiated to provide information of catch composition, gear performance, and fishing patterns. These data might allow detection of changes in abundance, and might serve to corroborate trends observed in the abundance indices.

- o Size samples should be collected from landings and size or age structured models be used to assess the stock.

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Table SB1. Nominal statistics (mt and days fished) and CPUE standardization results for tilefish. Model 1 includes terms for year, ton class, area, and quarter of the year. Model 2 includes terms for year and each individual vessel.

	Nominal				General Linear Models			
					Model 1			Model 2
	Total	Longline			Year	Standardized		Year
Year	Yield	Yield	Effort	CPUE	Coeff.	CPUE	Effort	Coeff.
1973	390	371	53.6	6.92	7.48	5.2	72.0	
1974	606	553	111.8	4.95	5.35	3.7	150.1	
1975	750	599	155.1	3.86	4.17	2.9	208.6	
1976	1076	1019	233.6	4.36	4.72	3.3	313.5	
1977	2087	1751	400.5	4.37	3.84	2.6	662.1	6.92
1978	3414	3091	645.9	4.79	5.45	3.8	823.5	6.14
1979	3841	3390	776.6	4.37	4.80	3.3	1025.4	4.79
1980	3684	3587	919.6	3.90	4.22	2.9	1234.1	4.45
1981	3358	3231	862.8	3.74	4.55	3.1	1031.0	4.32
1982	1957	1886	797.3	2.37	2.69	1.9	1018.0	2.76
1983	1813	1779	987.0	1.80	2.05	1.4	1260.0	2.13
1984	1933	1919	1491.6	1.29	1.40	1.0	1990.2	1.49
1985	1972	1909	1623.0	1.18	1.39	1.0	1994.1	1.50
1986	1763	1693	1053.3	1.61	1.65	1.1	1489.8	1.73
1987	3212	3029	1396.1	2.17	1.98	1.4	2221.2	2.28
1988	1371	1328	1037.7	1.28	1.12	0.8	1721.6	1.44
1989	471	437	485.0	0.90	1.02	0.7	622.1	1.14
1990	872	852	860.1	0.99	1.17	0.8	1057.3	1.33
1991	1187	1164	1305.2	0.89	1.00	0.7	1690.0	1.00

Table SB2. Tilefish retransformed GLM year coefficients and 95% confidence intervals for GLM model incorporating year and vessel.

YEAR	YR coeff.	Lower 95% CI	Upper 95% CI
1977	6.923	3.389	10.457
1978	6.142	3.930	8.355
1979	4.794	2.593	6.995
1980	4.448	2.249	6.647
1981	4.324	2.128	6.521
1982	2.762	0.560	4.963
1983	2.128	-0.080	4.336
1984	1.489	-0.726	3.704
1985	1.503	-0.703	3.709
1986	1.733	-0.477	3.943
1987	2.280	0.770	4.484
1988	1.438	-0.776	3.651
1989	1.147	-1.101	3.395
1990	1.331	-0.905	3.566
1991	1.000	-	-

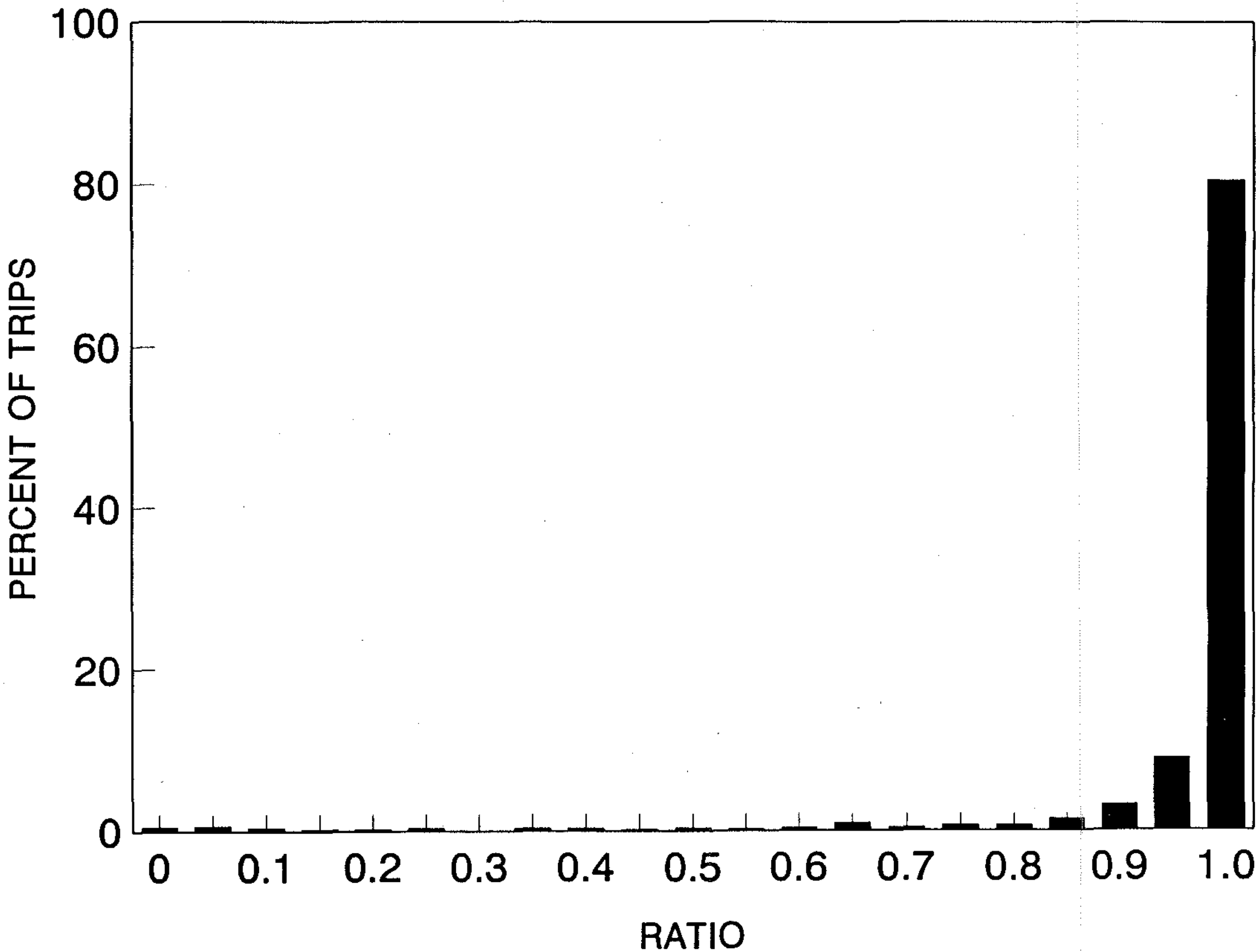

Figure SB1. Percent frequency of the ratio of tilefish weight to weight of all species landed per longline trip, 1977-1991.

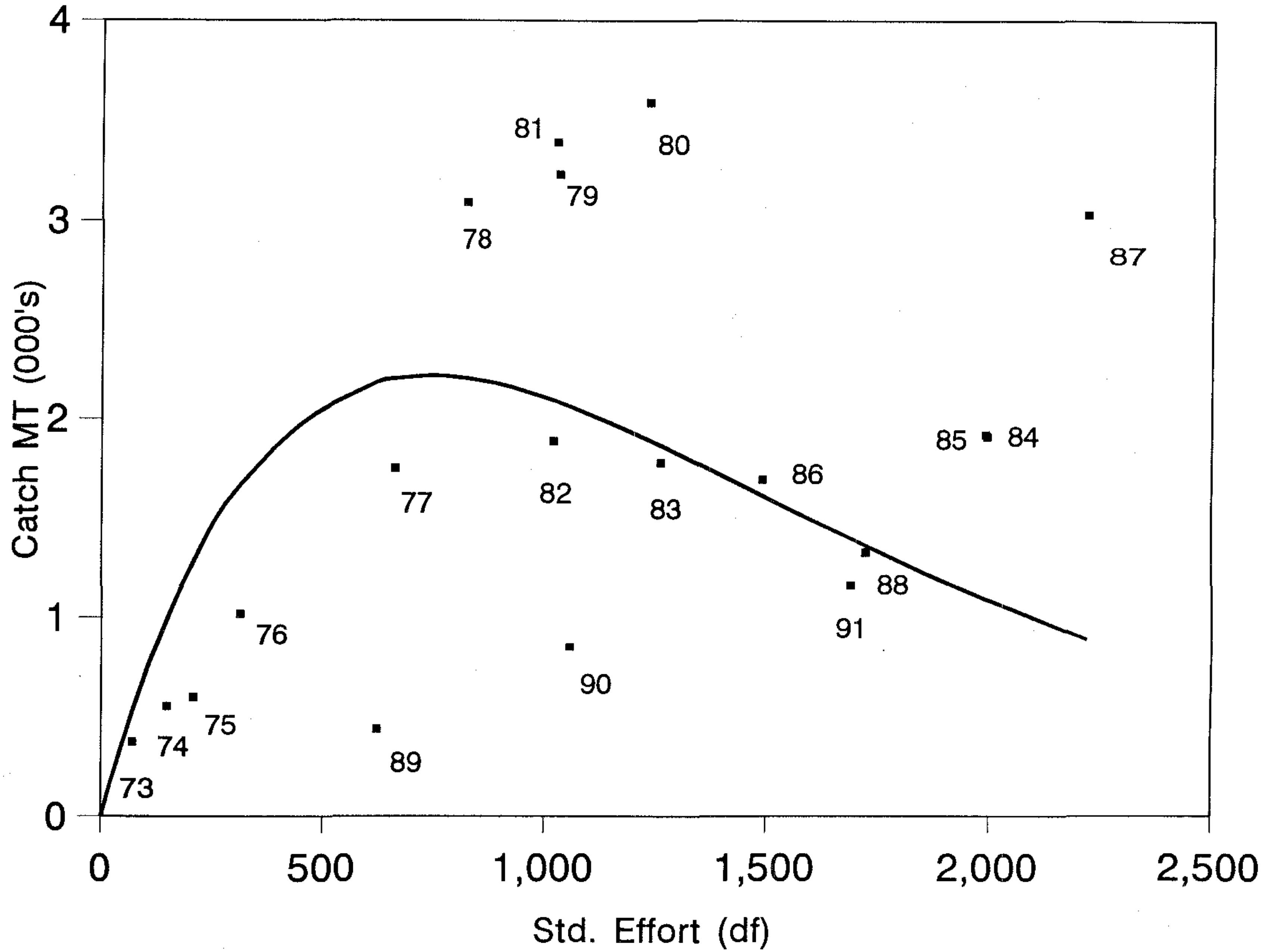

Figure SB2. Equilibrium surplus production model for the tilefish longline fishery.

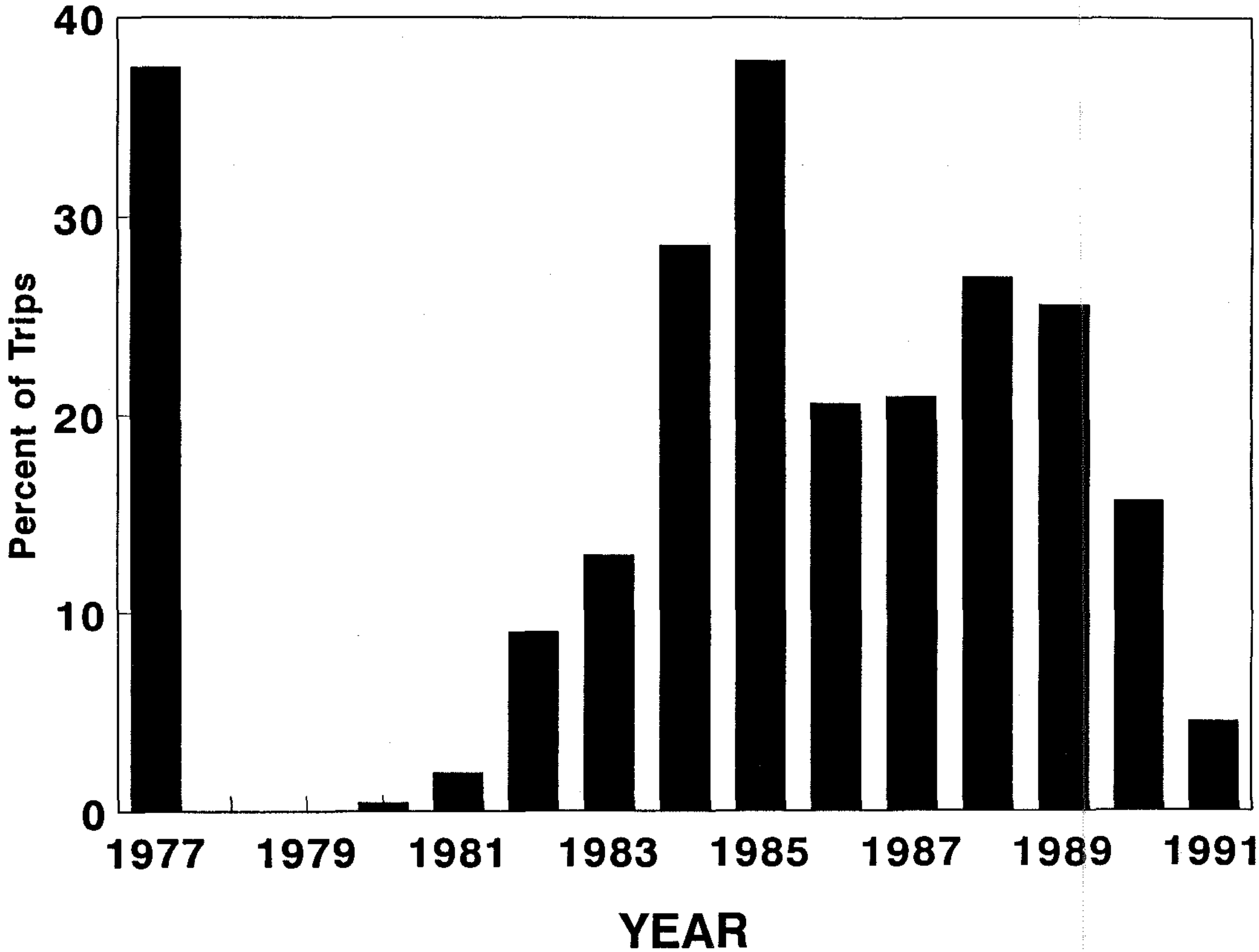

Figure SB3. Level of interview coverage of tilefish longline fishery 1977-1991. New Jersey covered via logbooks during 1973-1982.

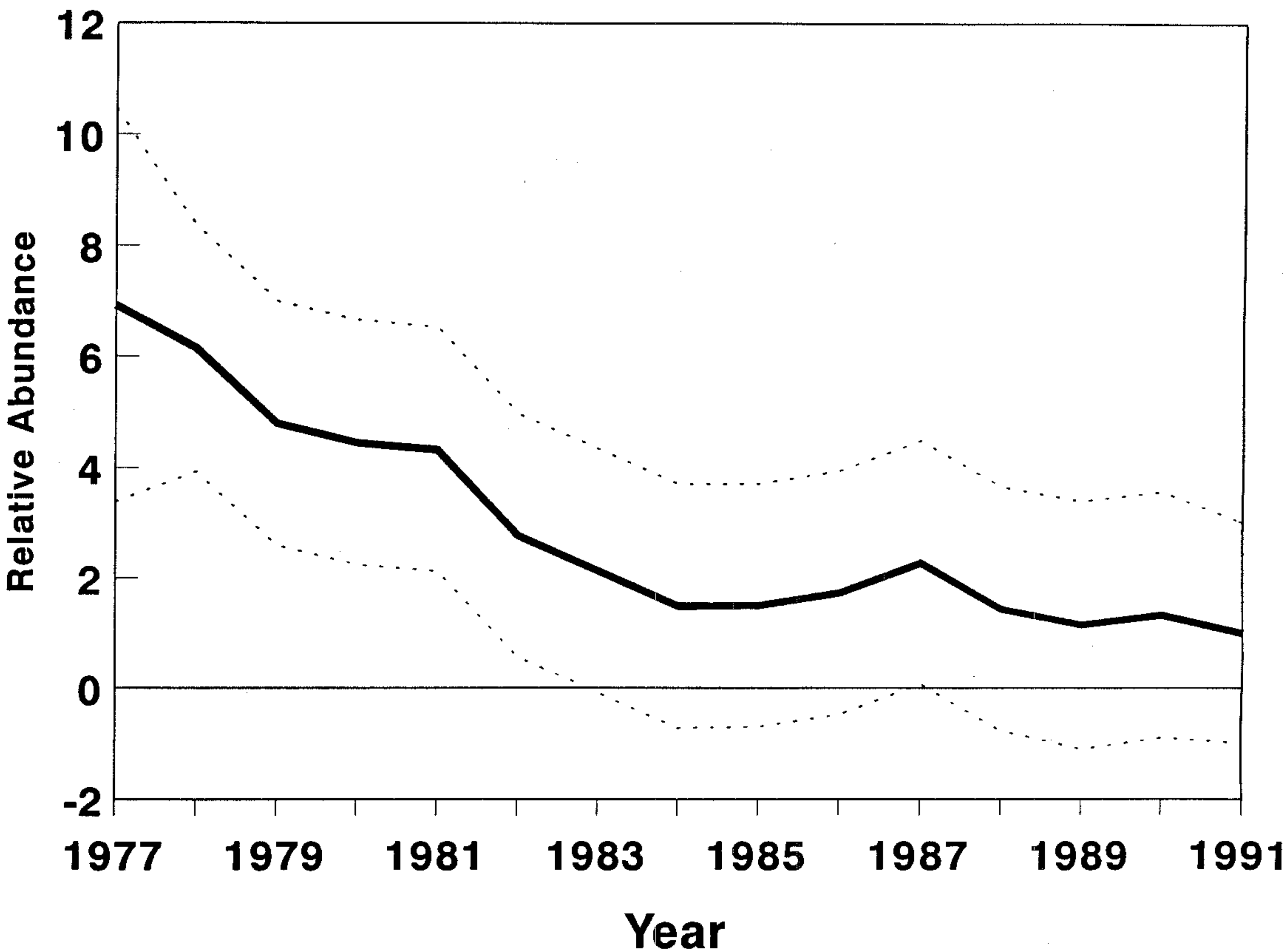

Figure SB4. Tilefish relative abundance and 95% CI based on year coefficient from year,vessel GLM model.

GOOSEFISH

An initial assessment of the goosefish resource based on commercial fishery landings, research cruise observations, and life history data is presented in SAW/14/SARC/7 and SAW/14/SARC/8. Due to large increases in landings, rapidly escalating ex-vessel price, a significant decline in biomass indices across all areas, an apparent reduction in average size, and small size at first recruitment, the SARC believes that goosefish are at least heavily exploited and that further research might find the resource to be over-exploited.

Background

Fishery Description

Goosefish (Lophius americanus), occur over most of the continental shelf from the Gulf of St. Lawrence to Cape Hatteras. Landings from commercial fishing (Figure SC1) steadily increased since 1970 to 4500 mt in 1991. Currently only 18% - 20 % of trips landing goosefish are composed of more than 10% goosefish. Although the landings are mostly a by-catch of the groundfish and flounder trawl fishery and the scallop fishery, otter trawl and set gillnet boats apparently target goosefish.

The proportion of landings between the Gulf of Maine/northern Georges Bank (northern area) and southern Georges Bank/Mid-Atlantic (southern area) areas has been relatively stable. For the last three years, the landings from the southern area represented about 60% of the total.

Almost all of the nominal landings were removed by otter trawls through 1979, then scallop dredge landings (goosefish by-catch) were equal (Figure SC2). However, it was customary for the by-catch to be sold separately, so a portion of the by-catch landings might have been missed by the landings collection method in past years.

Scallop dredge trips that land goosefish are more frequent for the southern areas and sink gillnet trips are more frequent in the Gulf of Maine. There also appears to be an increase in sink gillnet landings in the most recent year.

Few trips target goosefish (Table SC1), but some targeting (trips landing between 50% or more goosefish) occurs. Directed trips are increasing.

Goosefish are caught over a wide area (Table SC2). During the late 1970s, the bulk of the landings were removed from Gulf of Maine, Georges Bank, and Southern New England. By the late 1980s, landings were also removed from Mid-Atlantic areas. Landings from statistical areas 537 and 616 increased substantially during 1991. Landings by otter trawl vessels from area 537 increased three-fold; landings from area 616 increased six-fold.

Recent landing increases might be a result of increasing prices (Figure SC3). Ex-vessel prices rose during the early eighties, then quickly rose further recently. The increasing demand for parts other than tails potentially contribute to the trend. Landings of livers have risen steadily while landings of cheeks and belly-flaps have been reported only recently. The increase in the grading of goosefish tails by size may also be related to this trend. Categorization of landings into market size groups substantially increased since 1988.

Data Sources

NEFSC bottom trawl survey observations for 1971-1990 were used to discern goosefish distributions in relation to geographical area, season, bottom temperature, and depth.

These data combined with Massachusetts Division of Marine Fisheries 1975-1992 trawl survey data were used to examine size-maturity relations and the spacial distribution of goosefish by maturity stage. Only spring survey observations were used to minimize the misidentification of immature and "resting" fish.

A joint University of Massachusetts (UMA)-NEFSC ageing study was based on bony structures from 97 fish from the Gulf of Maine-northern Georges Bank area.

Total weight-tail weight conversions were estimated from NEFSC bottom trawl survey and port samples of Gulf of Maine commercial landings. In addition, 12 fish from the Marine Biological Laboratory (MBL)-NEFSC study were used along with 48 fish collected south of Martha's Vineyard by the UMA-NEFSC study. Lengths ranged from 15 to 100 cm and weights from 0.043 kg to 14.3 kg.

NEFSC bottom trawl research cruise observations from 1968 - 1992 spring surveys and 1963 - 1991 fall surveys were used to index goosefish abundance trends. Data from summer scallop dredge research surveys, 1984 - 1991, were also used.

Methodology

Goosefish distributions as related to season, temperature and depth were visually interpreted from plots.

Maturity stage classifications were done macroscopically at sea following Burnett et al (1989; data selection followed the criteria of Halliday (1987). Probit analysis (Finney 1971, SAS 1982), including the Chi-square goodness-of-fit test, was used to estimate the percent mature at length. Estimated transformations were used to convert size at maturity from total length to tail length since tails are landed rather than whole fish. Possible differences in the distribution of mature and immature fish were investigated by visually analyzing plots of the presence or absence of fish greater than 42 cm in length (mature) and those 42 cm and less (immature).

Unweighted linear least squares was used to obtain length and weight conversions. Since goosefish tails are landed rather than whole goosefish, whole size to tail size conversions must be based on measurements of tails that are as similar as possible to those dressed by fishermen. This was done by measuring tail lengths from the anterior insertion of the fourth cephalic dorsal spine to the end of the caudal fin. Tail weights were obtained in a corresponding manner. The cut that removed the tail from the body was made between the third and fourth cephalic dorsal spines, the same location used by most fishermen.

Methods currently being used to interpret age from bony structures (primarily otolith and vertebrae) are described in Appendix 1 of SAW/14/SARC/7. The SARC noted the large degree of uncertainty involved in goosefish age interpretations. The von Bertalanffy growth model was fit by non-linear unweighted least squares (SAS 1982). The model was fit to the combined data even though goosefish growth is believed to be sexually dimorphic (Armstrong 1987).

The yield per recruit was modeled by the Beverton-Holt method. The natural mortality rate for goosefish is unknown so an instantaneous rate 0.2 was simulated. Since goosefish are taken in scallop dredges and small mesh trawls, the size at full recruitment is very small, about 12 cm - 13 cm; one year old. Ages at full exploitation from two to four years were modeled. Estimated asymptotic length (143.6 cm) was transformed to asymptotic weight according to the conversion of Wilk et al. (1978). Maximum age was assumed to be 15 years.

Abundance trends were discerned visually from plots of NEFSC bottom trawl and scallop dredge research cruise stratified mean numbers per tow indices of abundance.

Results

Distribution

Spatial and temporal distributions of goosefish were examined from NEFSC bottom trawl survey data. Generally, capture rates were low; 93% of all catches were 5 fish or less. Goosefish were distributed to the offshore limit of the survey. The extent of the goosefish distribution offshore of the survey is not known.

During spring and autumn, goosefish are distributed north and south of Georges Bank. In the northern area, spring and autumn distributions patterns were similar, suggesting no seasonal variation. South and west of Nantucket Shoals, however, seasonal patterns differed suggesting movement between inshore and offshore shelf waters. South of Block Island Sound, goosefish were found primarily in the offshore waters in autumn and further inshore during spring. South of Chesapeake Bay goosefish regularly appear in survey catches in the spring, but not in the autumn.

The stock structure of goosefish populations off the U.S. Atlantic shelf is unknown; but, survey distribution patterns suggest northern and southern components with the shallow waters of central Georges Bank as a boundary zone (SAW/14/SARC/7). This is a separation of convenience and does not imply that these components are different stocks. The components are:

	NEFSC Survey Strata		**Statistical Areas**
	Offshore	Inshore	
Gulf of Maine - No. Georges Bank	20-40	52, 55-90	511-515, 521-522, 561
So. Georges Bank - Middle Atlantic	1-19, 61-76	1-46	525-526, 562, 537-543, 611-636

Goosefish observed on NEFSC bottom trawl surveys were distributed in waters with bottom temperatures between 1.0° and 22.8° C and in depths of 5 - 494 m (SAW/14/SARC/7).

Spring goosefish catches in the northern region occurred with bottom water temperatures of 1.0°-10.1°C. Largest catches were taken with 6° C bottom temperatures. Goosefish occurred in 25 m to 388 m depths but two peaks occurred, one at about 80-90 m, and a second at about 190 m. During the autumn, goosefish occurred with bottom temperatures from 4.2°-21.2°C with a 8°C average. A bi-modal depth distribution was again evident with peaks at about 90 m and 190 m.

During the spring, in the southern area goosefish occurred in 2.3°-16.7°C bottom water temperatures, but peak goosefish occurrence was observed at 6°C and 11°C. Primary concentrations were in depths less than 100 m, however, consistent catches were made to depths greater than 250 m. During the autumn, goosefish occurred with temperatures between 5.1° and 22.8° C and peak concentration occurred at about 12° C. Densities were highest in inshore waters of about 70 m, although fish were found on the shelf slope in depths greater than 250 m.

Goosefish Habitat Preference

	Northern Area		Southern Area	
Bottom temperature (°C)	Range	Peak occurrence	Range	Peak occurrence
Spring	1.0-10.0	6.0	2.3-16.7	6.0,11.0
Fall	4.2-21.2	8.0 (Aug)	5.1-27.8	12.0
Water Depth (m)				
Spring	25-388	80-90,190	5-494	<100
Fall	11-355	90,190	8-434	70

Maturation

Both sexes begin to mature at 30 cm total length, with males generally attaining 100% maturity by 50 cm and females by 60 cm (SAW/14/SARC/7). Goosefish inhabiting the southern area seem to spawn earlier than those of the northern area. 50% maturity occurs at 43 cm and 46 cm (males and females) in the northern area and at 37 cm and 42 cm in the southern area (Table SC3). These results of the southern area are comparable to those reported by Armstrong (1987).

Since goosefish tails are landed rather than whole fish, tail length at maturity was computed from transformation equations described later. These conversions indicate 50% maturity occurs at about 30 cm and 32 cm (males and females) in the northern area and 25 cm and 29 cm in the southern area.

Spatial distribution patterns indicate that there are specific spatial/temporal points where either mature or immature goosefish exclusively occur, although overlapping distributions are most common. The distribution of sexually immature goosefish in the northern area was the same as that of mature individuals (Figures SC4 and SC5). Both were found in the shallow inshore waters, the northern edge of Georges Bank, and in the deep basins of the Gulf. Mature goosefish appeared to concentrate along the 100 m contour during the autumn and migrate into the deep basin of the Gulf by spring. Almost all of the individuals observed during the autumn south of Delaware Bay along the shelf break were sexually immature. Goosefish were not found inshore of about 60 m. Both mature and immature goosefish were observed in the spring offshore (≥100 m). Only mature individuals occurred south of Chesapeake Bay in depths less than about 100 m. A mixture of immature and mature fish were observed along the shelf break.

Growth

A description of the processing and ageing methods currently under examination was presented and the difficulties in determining the age of goosefish were discussed in detail. In a UMA/NEFSC study begun in February 1992, 97 goosefish from the Gulf of Maine-northern Georges Bank region were aged using a variety of age structures (primarily otoliths and vertebrae). Due to the low sample size, fish of both sexes and unsexed fish were combined for growth analysis, recognizing that dimorphic growth has been documented for the species (Armstrong 1987). The von Bertalanffy growth model was fitted to size-at-age data using nonlinear regression (SAS 1982).

In spite of the small sample size, a significant ($p<0.05$) fit was obtained. Growth parameters were comparable to those of Armstrong (1987) for goosefish south of Georges Bank; the lower value of L_{inf} in this study is a result of the lack of large, old fish in the small age sample, while the higher value of K in this study is an artifact of growth to a lower asymptotic length. A summary of growth parameters available for goosefish inhabiting Atlantic waters is provided below:

Anglerfish Growth Parameters

Species	Area	Sex	K	Linf	t0	Author
L americanus	SNE-MidAtl	male	0.1	146	0.0	Armstrong 1987
"	"	female	0.1	158	0.2	" "
"	Gulf of Maine	both	0.1	136	0.7	UMA/NEFSC
L. piscatorius	Africa	male	0.1	134	0.5	Dupouy and Kergoat (1985)
"	"	female	0.1	188	0.3	" "
"	North Sea	both	0.2	121		Anon 1990
"	Celtic Sea	both	0.1	140		" "
L. upsicephalus	South Africa	both	0.1	73		Griffiths and Hecht 1986
L. budegassa	Celtic Sea	both	0.1	94		Anon 1991

Size Conversions

Since goosefish are landed dressed (tail only), transformation equations are needed to estimate the proportion of immature fish in the landings and other statistics. The sample size is meager and few large individuals were measured, so the confidence intervals are likely very wide.

A total to tail length conversion for 252 goosefish collected from inshore areas in the Gulf of Maine (Lyons and Creaser 1986) is similar to a linear regression calculated from 54 UMA/NEFSC samples:

$$\text{Total Length (mm)} = 1.324 \text{ Tail Length} + 29.660 \quad \text{or}$$
$$\text{Tail Length} = 0.755 \text{ Total Length} - 22.402$$

The relations between whole weight and tail weight were estimated to be:

$$W_{total}(gm) = 3.3288\, W_{tail} + 112.6987 \quad \text{or}$$
$$W_{tail} = 0.3004\, W_{total} - 33.8557$$

The above relationships and two from Wilk et al (1987) provide a size conversion table (Table SC4).

Abundance Trends

Northern area autumn biomass indices (abundance in weight, Table SC5) indicate a significant decrease since the late 1970s; biomass apparently decreased to less than one third of the late 1970s level by 1991. Spring indices show a similar pattern. Autumn cruise data show that biomass fell by half from 1984 to 1991.

Southern area weight indices indicate a nine fold decrease in biomass from 1966 to 1991; the 1991 autumn index is 11% of the 1966 level. The 1991 summer weight abundance index is about 70% of the 1984 level.

Indices in terms of numbers of fish did not exhibit a corresponding downward trend in either area thus indicating a decrease in the average size of individuals occurred. Research cruise length frequency plots (SAW/14/SARC/8) show the truncation of the size distribution through time in both areas, but particularly in the northern area. The truncation is reflected to a small degree in average length (Figure SC6).

These abundance trends give reason to suspect that resource biomass is decreasing. The ongoing decrease concomitant with the landings increases described earlier (that were driven by large increases in ex-vessel price) provides substantial evidence that the resource is at least heavily exploited and that the possibility of over-exploitation should not be ruled out.

Yield Per Recruit

The analysis calculated F_{max} to be low 0.2 for the northern area (Figure SC7). These results also indicate that substantial yield gains could result from fishing practices that release young fish (up to age 4) alive.

Sources of Uncertainty

- The yield per recruit model is based, to a large degree, on a growth model generated from interpretations of the age of fish from visual inspections of their bony parts. Annular marks on goosefish tend to be unclear and difficult to decipher. Validation of age interpretations over the full range of sizes is lacking.

- The extent of the resource beyond the shelf break is unknown, thus, substantial biomass might or might not exist beyond the fishery and research cruise coverage.

- The SARC Chairman pointed out that abundance and stock production estimates do not exist so: (1) whether or not current removals are in excess of stock production is uncertain; (2) appropriate removal levels cannot be projected.

- The SARC Chairman pointed out that an estimate of the reproductive (adult) stock size is absent, hence the probability of continued reproductive success and consequent existence of the stock under current conditions (escalating removals and declining biomass) cannot be assessed.

Recommendations

- Size frequency samples must be collected from the landings if the resource is to be assessed adequately.

- Age interpretations need to be validated over the entire size range if they are to be the bases of accurate growth modeling.

- An effort should be made to determine the seaward extent of the resource beyond the shelf break.

- Accurate abundance estimates (both juveniles and adults) and stock production estimates are acutely needed.

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Table SC1. Number of trips landing goosefish.

Year	Area & Gear	Percent of weight landed comprised of goosefish 10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	TOTAL
1987	North											
	Trawl	7535	894	250	147	63	47	34	27	17	14	9028
	Scallop dredge	234	118	50	15	4	5	1	1	1	2	431
	Sink gill net	2179	105	26	14	9	4	4	3	1	2	2347
1987	South											
	Trawl	7157	352	104	48	27	20	11	10	3	4	7736
	Scallop dredge	813	309	137	42	18	8	5	9	3	5	1349
	Sink gill net	47	2	0	1	1	0	0	0	1	0	52
1988	North											
	Trawl	8269	1063	306	128	65	33	28	28	12	10	9942
	Scallop dredge	308	147	75	35	17	6	7	1	2	0	598
	Sink gill net	2796	74	28	20	11	6	5	5	2	4	2951
1988	South											
	Trawl	7472	389	109	34	24	20	15	11	5	8	8087
	Scallop dredge	989	463	150	62	29	16	6	5	3	10	1733
	Sink gill net	49	4	0	1	0	0	0	0	0	0	54
1989	North											
	Trawl	9275	932	310	143	94	51	39	17	5	11	10877
	Scallop dredge	341	178	125	91	47	31	22	8	6	2	851
	Sink gill net	3013	74	34	14	4	4	9	4	4	1	3161
1989	South											
	Trawl	8385	408	149	74	46	24	25	13	10	3	9137
	Scallop dredge	1678	545	232	165	78	47	15	13	5	9	2787
	Sink gill net	100	0	1	1	0	0	0	0	0	0	102
1990	North											
	Trawl	8772	687	219	125	84	51	23	19	18	20	10018
	Scallop dredge	435	246	115	38	31	26	7	10	0	3	911
	Sink gill net	3007	86	33	19	10	4	4	2	1	8	3174
1990	South											
	Trawl	8799	322	132	64	38	20	19	6	2	4	9406
	Scallop dredge	2472	805	223	76	36	19	5	8	2	9	3655
	Sink gill net	123	7	5	1	3	1	1	1	3	0	145
1991	North											
	Trawl	9913	875	243	97	63	36	19	24	13	12	11295
	Scallop dredge	790	318	134	51	33	16	4	2	0	1	1349
	Sink gill net	4679	137	42	15	18	13	7	2	9	3	4925
1991	South											
	Trawl	9749	511	182	111	81	53	52	28	21	33	10821
	Scallop dredge	3098	620	188	90	45	25	10	5	2	2	4085
	Sink gill net	353	48	10	9	8	3	5	13	3	14	466

Table SC2. Landings of goosefish tails (mt) by year and statistical area, 1964–1991.

	STATISTICAL AREA																								
YEAR	340	350	451	462	463	464	465	466	467	500	510	511	512	513	514	515	520	521	522	525	526	533	534	537	538
1964	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.5	<0.1	–	–	–	–	–	–	–	0.6	–
1965	–	–	–	–	–	–	–	–	–	0.1	–	–	–	–	10.9	–	–	–	0.1	–	–	–	–	0.5	<0.1
1966	–	–	–	–	–	–	–	–	–	–	–	–	–	–	71.4	–	–	18.6	0.1	–	–	–	–	0.2	–
1967	–	–	–	–	–	–	–	–	–	–	–	–	–	–	111.3	–	–	51.2	–	–	–	–	–	–	0.5
1968	–	–	–	–	–	–	–	–	–	–	–	–	–	–	102.6	–	–	33.3	–	–	–	–	–	–	0.1
1969	–	–	–	–	–	–	–	–	–	–	–	–	–	0.1	69.4	–	–	7.9	–	–	–	–	–	<0.1	–
1970	–	–	–	–	–	–	–	–	–	–	–	–	–	1.1	42.9	<0.1	–	15.7	–	–	–	–	–	0.3	0.1
1971	–	–	–	–	–	–	–	–	–	–	–	–	–	0.6	35.2	–	–	28.4	–	–	–	–	–	0.1	0.6
1972	–	–	–	–	–	–	–	–	–	–	–	–	0.3	3.0	97.7	–	–	27.6	0.3	<0.1	0.2	–	–	0.7	0.4
1973	–	–	–	–	–	–	–	–	–	–	–	–	–	16.8	164.1	0.3	–	20.7	0.6	0.2	2.2	–	–	8.4	1.1
1974	–	–	–	–	–	–	–	–	–	–	–	–	0.3	30.3	229.7	–	–	56.9	4.2	0.2	1.9	–	<0.1	6.1	1.3
1975	–	–	–	–	–	–	0.1	0.1	–	–	–	–	7.3	52.4	309.1	1.4	–	107.9	18.7	8.3	14.2	–	–	20.0	5.3
1976	–	–	–	–	–	2.0	0.2	–	–	–	–	0.7	7.5	142.1	281.6	2.7	–	133.8	48.0	43.2	19.5	–	–	16.6	11.8
1977	–	–	–	<0.1	–	1.2	0.8	–	0.2	–	–	1.1	21.0	168.4	306.6	9.7	–	213.0	125.4	45.0	59.6	–	–	34.8	9.8
1978	–	–	–	0.1	0.9	1.9	0.3	<0.1	–	–	–	1.2	34.5	246.3	267.6	26.0	–	311.1	134.8	39.1	67.7	–	–	45.7	13.4
1979	–	–	–	–	–	1.7	0.1	–	–	–	<0.1	7.8	34.4	263.3	266.3	18.5	0.1	259.6	180.5	97.4	98.1	–	–	110.5	6.0
1980	–	–	–	–	–	1.6	1.4	–	–	–	–	6.5	23.0	270.9	199.9	30.3	–	210.4	137.3	98.1	142.2	–	–	106.1	10.3
1981	–	–	–	–	0.4	1.6	4.0	–	–	–	<0.1	9.0	42.4	238.4	150.0	30.1	–	185.6	88.8	47.8	122.4	–	–	131.7	6.0
1982	–	–	0.1	–	–	4.3	3.9	–	–	–	<0.1	20.2	94.8	290.6	206.3	62.6	1.7	186.3	120.0	127.8	122.5	0.1	–	232.9	15.5
1983	–	–	–	0.1	–	1.2	11.0	–	–	–	–	18.9	128.5	322.8	177.5	87.7	–	161.8	97.7	62.9	95.4	–	–	245.8	8.2
1984	–	–	–	–	–	3.3	14.6	–	–	–	–	16.8	104.8	330.2	181.3	172.0	–	159.5	115.2	85.1	89.5	–	–	212.3	8.3
1985	0.5	<0.1	–	–	–	0.9	9.2	–	–	–	–	36.4	141.5	299.8	197.4	220.9	–	178.2	129.5	59.5	101.8	<0.1	–	227.5	7.0
1986	1.9	0.1	–	–	–	3.2	14.2	–	0.1	–	–	40.5	165.6	294.7	183.3	167.4	–	185.7	96.5	172.8	232.0	–	–	233.3	7.5
1987	1.5	0.2	–	–	–	2.8	4.0	–	–	–	–	29.6	145.2	362.6	184.2	254.8	–	196.7	113.5	59.7	252.7	–	–	199.0	12.7
1988	0.2	<0.1	–	–	–	0.4	4.6	–	–	–	–	23.6	115.4	300.7	172.6	175.4	–	319.5	219.8	212.4	279.6	–	–	185.5	7.4
1989	1.6	0.2	–	–	–	0.3	0.9	–	–	–	–	16.0	91.8	246.5	149.8	171.0	–	528.4	453.4	292.3	876.8	–	–	253.2	7.1
1990	–	–	–	–	–	6.8	–	–	–	–	–	12.2	83.7	280.5	163.9	124.0	–	475.5	409.7	223.0	534.3	–	–	219.6	2.0
1991	–	–	–	–	–	9.7	0.3	–	–	–	–	10.6	103.4	314.0	160.1	162.4	–	398.2	365.5	176.6	565.5	–	–	750.7	3.1

Table SC2 (continued).

YEAR	539	541	561	562	610	611	612	613	614	615	616	621	622	623	625	626	627	631	632	635	636	637	639
								STATISTICAL AREA															
1964	5.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1965	4.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1966	3.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1967	1.8	–	–	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1968	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1969	1.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1970	2.9	–	–	–	–	<0.1	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1971	1.9	–	–	–	–	<0.1	–	0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1972	4.3	–	–	–	–	0.5	–	1.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1973	12.5	–	0.2	0.1	0.3	8.7	0.1	7.7	–	–	0.2	–	–	–	–	–	–	–	–	–	–	–	–
1974	12.0	<0.1	–	0.7	–	3.9	0.2	3.7	–	–	0.3	–	–	–	–	–	–	–	–	–	–	–	–
1975	23.1	–	2.5	3.6	–	3.9	–	5.5	–	–	0.4	–	–	–	–	–	–	–	–	–	–	–	–
1976	5.0	–	1.9	26.3	–	0.3	0.3	3.8	–	0.1	1.6	–	0.3	–	–	–	–	–	–	–	–	–	–
1977	5.9	–	14.1	71.7	–	1.2	–	8.8	–	2.5	2.4	–	–	–	–	0.1	–	–	–	–	–	–	–
1978	4.5	–	22.7	60.5	–	0.7	18.0	34.6	1.1	15.8	8.8	39.6	15.3	–	1.5	25.0	–	–	4.2	–	–	–	–
1979	62.5	–	38.1	163.5	–	6.2	65.5	125.8	1.7	166.2	74.7	16.0	5.4	–	<0.1	9.1	–	–	–	–	–	–	–
1980	96.3	<0.1	60.8	136.2	–	8.1	120.9	227.3	2.5	133.9	12.3	27.8	62.7	–	–	–	–	–	–	–	–	0.8	–
1981	74.3	–	65.6	81.5	–	8.2	15.3	63.5	0.2	23.0	59.4	5.3	9.5	–	–	–	–	–	–	–	–	0.1	<0.1
1982	82.4	–	47.2	91.8	–	5.6	10.7	176.3	0.1	37.9	69.4	18.1	47.5	–	0.5	42.7	–	0.6	7.0	0.4	<0.1	–	–
1983	113.9	–	45.9	36.0	–	7.1	21.5	279.2	0.2	108.5	140.5	21.5	33.2	–	3.5	30.4	–	1.1	12.9	0.1	–	–	–
1984	74.3	–	59.0	47.5	–	6.5	11.0	200.2	0.2	144.5	29.8	30.8	91.7	–	2.2	29.8	0.4	1.9	10.0	1.4	–	–	–
1985	88.4	–	41.9	74.3	–	4.9	18.0	199.0	4.2	203.3	88.1	32.6	62.5	–	3.2	48.2	–	0.9	7.1	<0.1	–	–	–
1986	56.4	–	28.7	63.1	–	9.3	31.8	104.4	0.1	100.5	64.7	12.7	63.0	–	0.5	20.7	–	1.1	3.5	<0.1	–	–	–
1987	42.7	–	55.6	57.3	–	12.6	20.7	134.4	<0.1	66.7	74.4	44.0	88.8	0.4	0.1	31.6	–	0.7	8.2	<0.1	0.3	–	–
1988	30.2	–	72.5	143.6	–	6.2	15.1	114.2	0.5	82.9	84.1	52.3	66.4	–	1.2	43.8	–	0.2	6.4	–	–	–	–
1989	40.4	–	135.3	337.6	–	3.1	12.6	155.8	0.6	150.6	145.6	37.4	35.0	–	0.2	39.9	–	0.1	9.0	0.1	–	–	–
1990	42.9	–	65.1	471.4	–	1.7	19.1	114.3	<0.1	122.8	126.4	106.3	62.8	0.5	0.2	20.4	–	3.4	11.6	0.1	–	–	–
1991	60.6	–	72.0	194.4	–	5.0	30.3	131.0	2.3	122.1	443.0	48.8	99.2	0.2	1.5	37.0	–	14.3	14.1	1.0	–	–	–

Table SC3. Goosefish [1] length at maturity.

		Total Length % Mature			Converted to tail length according to Lyons and Creaser (1986) % Mature			Converted to tail legth according to UMass/NEFSC (1992) % Mature		
	Sex	50	75	99	50	75	99	50	75	99
Northern Area										
Spring	M	43.3	48.5	61.3	29.6 (11.6)	33.1 (13.0)	41.9 (16.5)	30.5 (12.0)	34.4 (13.5)	44.0 (17.3)
	F	46.2	55.2	71.1	31.5 (12.4)	37.7 (14.8)	48.6 (19.1)	32.6 (12.9)	39.4 (15.5)	51.4 (20.3)
Summer	M	35.2	38.8	47.5	24.0 (9.5)	26.5 (10.4)	32.4 (12.8)	24.3 (9.6)	27.1 (10.7)	33.6 (13.2)
	F	41.5	48.1	64.4	28.3 (11.2)	32.8 (12.9)	44.0 (17.3)	29.1 (11.5)	34.1 (13.4)	46.4 (18.3)
Autumn	M	44.5	51.8	69.5	30.4 (12.0)	35.4 (13.9)	47.5 (18.7)	31.4 (12.3)	36.9 (14.5)	50.2 (19.8)
	F	47.7	56.8	78.8	32.6 (12.8)	38.8 (15.3)	53.9 (21.2)	33.8 (13.3)	40.6 (16.0)	57.3 (22.5)
Southern Area										
Winter	M	31.4	33.0	36.8	21.4 (8.4)	22.5 (8.9)	25.1 (9.9)	21.5 (8.5)	22.7 (8.9)	25.5 (10.1)
(1992)	F	37.8	40.1	45.6	25.8 (10.2)	27.4 (10.8)	31.1 (12.3)	26.3 (10.4)	28.0 (11.0)	32.2 (12.7)
Spring	M	37.1	42.1	54.2	25.3 (10.0)	28.7 (11.3)	37.0 (14.6)	25.8 (10.1)	29.5 (11.6)	38.7 (15.2)
	F	42.4	48.7	64.3	28.9 (11.4)	33.3 (13.1)	43.9 (17.3)	29.8 (11.7)	34.5 (13.6)	46.3 (18.2)
Summer	M	44.0	48.2	58.5	30.0 (11.8)	32.9 (13.0)	40.0 (15.7)	31.0 (12.2)	34.2 (13.4)	41.9 (16.5)
	F	46.7	51.0	61.3	31.9 (12.6)	34.8 (13.7)	41.9 (16.5)	33.0 (13.0)	36.3 (14.3)	44.0 (17.3)
Autumn	M	35.7	39.6	49.1	24.4 (9.6)	27.0 (10.6)	33.5 (13.2)	24.7 (9.7)	27.7 (10.9)	34.8 (13.7)
	F	38.8	46.0	63.8	26.5 (10.4)	31.4 (12.4)	43.6 (17.2)	27.1 (10.7)	32.5 (12.8)	45.9 (18.1)

[1] Values outside parentheses in centimeters, values in parentheses in inches.

Table SC4. Length and weight [1)]relationships. Values outside parentheses are cm. or kg.and those inside parentheses are in. or lbs.

Tail Length	Total Length	Total Weight	Tail Weight
12.7 (5)	18.7 (7.4)	0.114 (0.3)	<0.001 (0.0)
15.2 (6)	22.4 (8.8)	0.194 (0.4)	0.024 (0.1)
17.8 (7)	26.1 (10.3)	0.304 (0.7)	0.057 (0.1)
20.3 (8)	29.8 (11.7)	0.448 (1.0)	0.101 (0.2)
22.9 (9)	33.5 (13.2)	0.631 (1.4)	0.156 (0.3)
25.4 (10)	37.2 (14.7)	0.857 (1.9)	0.224 (0.5)
27.9 (11)	40.9 (16.1)	1.132 (2.5)	0.306 (0.7)
30.5 (12)	44.6 (17.6)	1.458 (3.2)	0.404 (0.9)
33.0 (13)	48.4 (19.0)	1.853 (4.1)	0.523 (1.2)
35.6 (14)	52.1 (20.5)	2.299 (5.1)	0.657 (1.4)
38.1 (15)	55.8 (22.0)	2.811 (6.2)	0.810 (1.8)
40.6 (16)	59.5 (23.4)	3.392 (7.5)	0.985 (2.2)
43.2 (17)	63.2 (24.9)	4.047 (8.9)	1.182 (2.6)
45.7 (18)	66.9 (26.3)	4.781 (10.5)	1.402 (3.1)
48.3 (19)	70.6 (27.8)	5.597 (12.3)	1.647 (3.6)
50.8 (20)	74.3 (29.3)	6.500 (14.3)	1.919 (4.2)
53.3 (21)	78.0 (30.7)	7.494 (16.5)	2.217 (4.9)
55.9 (22)	81.7 (32.2)	8.583 (18.9)	2.544 (5.6)
58.4 (23)	85.4 (33.6)	9.772 (21.5)	2.902 (6.4)
61.0 (24)	89.1 (35.1)	11.064 (24.4)	3.290 (7.3)

[1)]Tail length - total length conversions are from Lyons and Creaser (1986)
Total length - total weight conversions are from Wilk et al. (1978)
Total weight - tail weight conversions are from SAW/14/SARC/7

Table SC5. NEFSC Survey Indices for Goosefish.

Spring Bottom Trawl Survey

	Stratified Mean Weight per Tow			Number per Tow		
	North	South	Total	North	South	Total
1968	0.882	1.142	1.106	0.159	0.211	0.186
1969	1.304	0.938	1.115	0.189	0.221	0.206
1970	1.654	1.005	1.319	0.309	0.175	0.24
1971	0.833	0.762	0.796	0.132	0.204	0.169
1972	3.189	1.883	2.821	0.532	0.371	0.449
1973	6.022	6.221	6.125	1.018	2.828	1.951
1974	4.444	3.782	4.103	1.003	1.192	1.100
1975	3.052	3.111	3.085	0.808	1.085	0.964
1976	7.915	4.050	5.924	1.485	1.123	1.298
1977	3.315	4.104	3.750	0.593	0.835	0.726
1978	2.289	2.464	2.379	0.427	0.821	0.630
1979	2.877	2.457	2.646	0.365	0.827	0.620
1980	5.106	2.676	3.767	0.994	1.228	1.153
1981	5.721	6.083	5.920	1.086	2.315	1.762
1982	2.868	2.803	2.832	0.380	1.135	0.796
1983	1.618	0.955	1.253	0.424	0.270	0.339
1984	1.766	0.747	1.205	0.340	0.182	0.253
1985	1.876	0.327	1.023	0.307	0.159	0.226
1986	1.922	0.823	1.316	0.302	0.283	0.292
1987	1.547	0.496	0.963	0.260	0.108	0.175
1988	2.044	0.427	1.111	0.591	0.440	0.504
1989	1.631	0.365	0.890	0.753	0.243	0.454
1990	0.973	1.005	0.991	0.329	0.247	0.282
1991	1.769	0.582	1.083	0.691	0.384	0.514

Summer Scallop Dredge Survey

	Stratified Mean Length per Tow		
	North	South	Total
1984	62.771	31.023	32.262
1985	54.002	32.987	34.151
1986	56.902	21.999	24.359
1987	51.191	18.756	19.149
1988	56.137	30.445	31.137
1989	47.557	33.644	35.037
1990	47.008	25.786	27.051
1991	33.824	21.047	21.991

Autumn Bottom Trawl Survey

	Stratified Mean Weight per Tow			Number per tow		
	North	South	Total	North	South	Total
1963	3.797	3.779	3.788	0.770	1.249	0.988
1964	1.484	5.486	3.271	0.342	1.636	0.920
1965	2.192	5.163	3.419	0.294	1.148	0.647
1966	2.738	6.986	4.492	0.459	1.926	1.065
1967	1.093	1.122	1.108	0.165	0.541	0.359
1968	1.856	1.021	1.424	0.274	0.406	0.342
1969	3.027	1.246	2.107	0.305	0.497	0.426
1970	1.976	1.357	1.657	0.347	0.352	0.35
1971	2.580	0.786	1.656	0.454	0.282	0.365
1972	1.405	4.918	3.215	0.362	4.113	2.295
1973	2.878	1.986	2.419	0.569	1.176	0.881
1974	1.882	0.710	1.278	0.317	0.218	0.266
1975	1.701	2.043	1.877	0.297	0.745	0.528
1976	3.045	1.084	1.965	0.380	0.314	0.344
1977	4.965	1.873	3.372	0.664	0.448	0.553
1978	4.891	1.372	2.952	0.647	0.308	0.460
1979	4.805	2.275	3.388	0.515	0.836	0.695
1980	4.139	1.868	2.888	0.632	0.874	0.766
1981	2.136	2.858	2.534	0.459	1.163	0.847
1982	0.867	0.646	0.745	0.130	0.610	0.395
1983	1.603	2.150	1.910	0.427	0.776	1.622
1984	2.790	0.740	1.662	0.464	0.311	0.380
1985	1.435	1.318	1.371	0.375	0.623	0.511
1986	2.185	0.552	1.285	0.559	0.359	0.449
1987	1.047	0.274	0.601	0.287	0.482	0.400
1988	1.555	0.554	0.977	0.315	0.232	0.267
1989	1.340	0.625	0.927	0.499	0.460	0.477
1990	0.971	0.426	0.657	0.700	0.354	0.500
1991	1.347	0.783	1.021	0.680	0.883	0.768

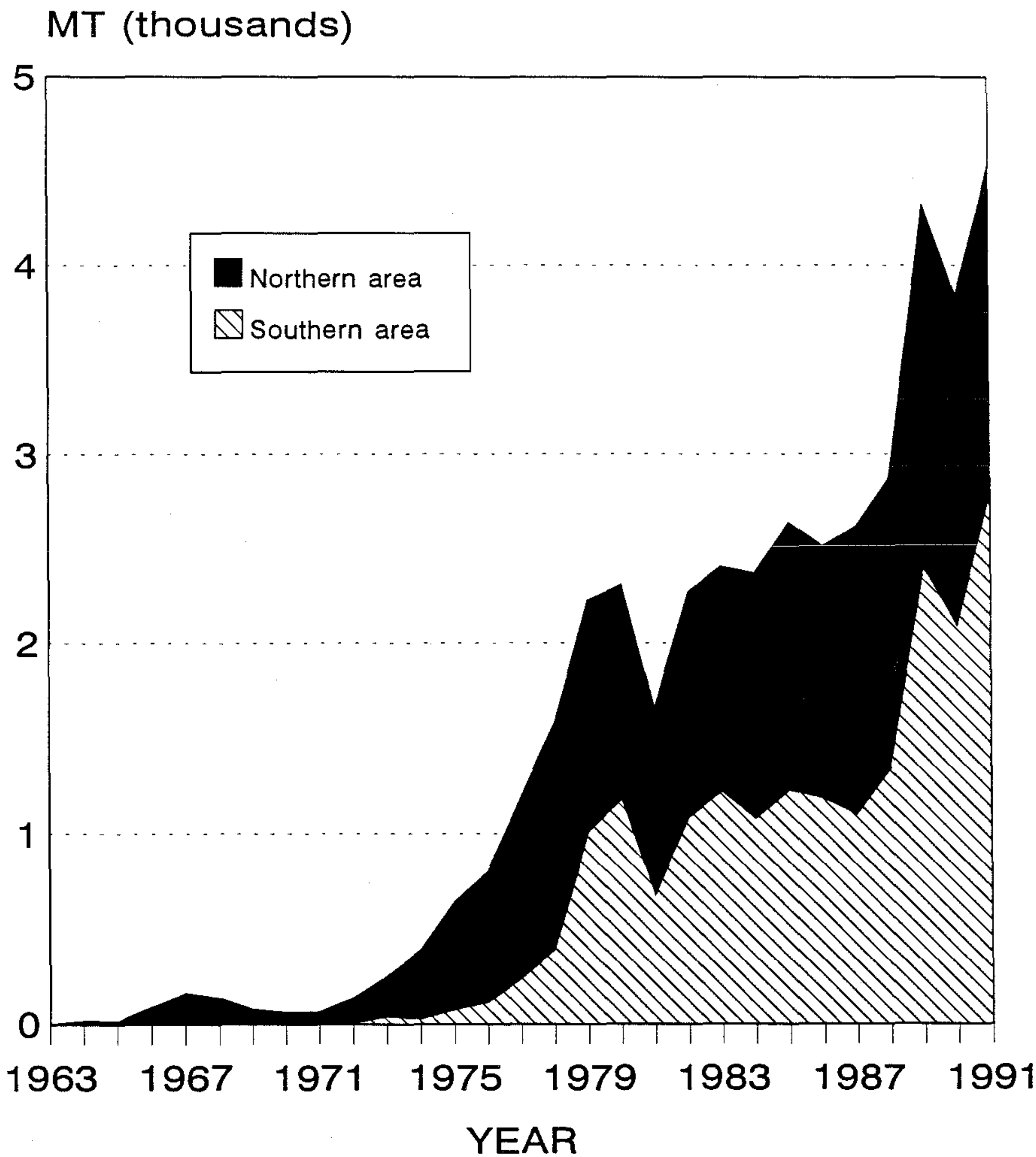

Figure SC1. Landings of goosefish tails.

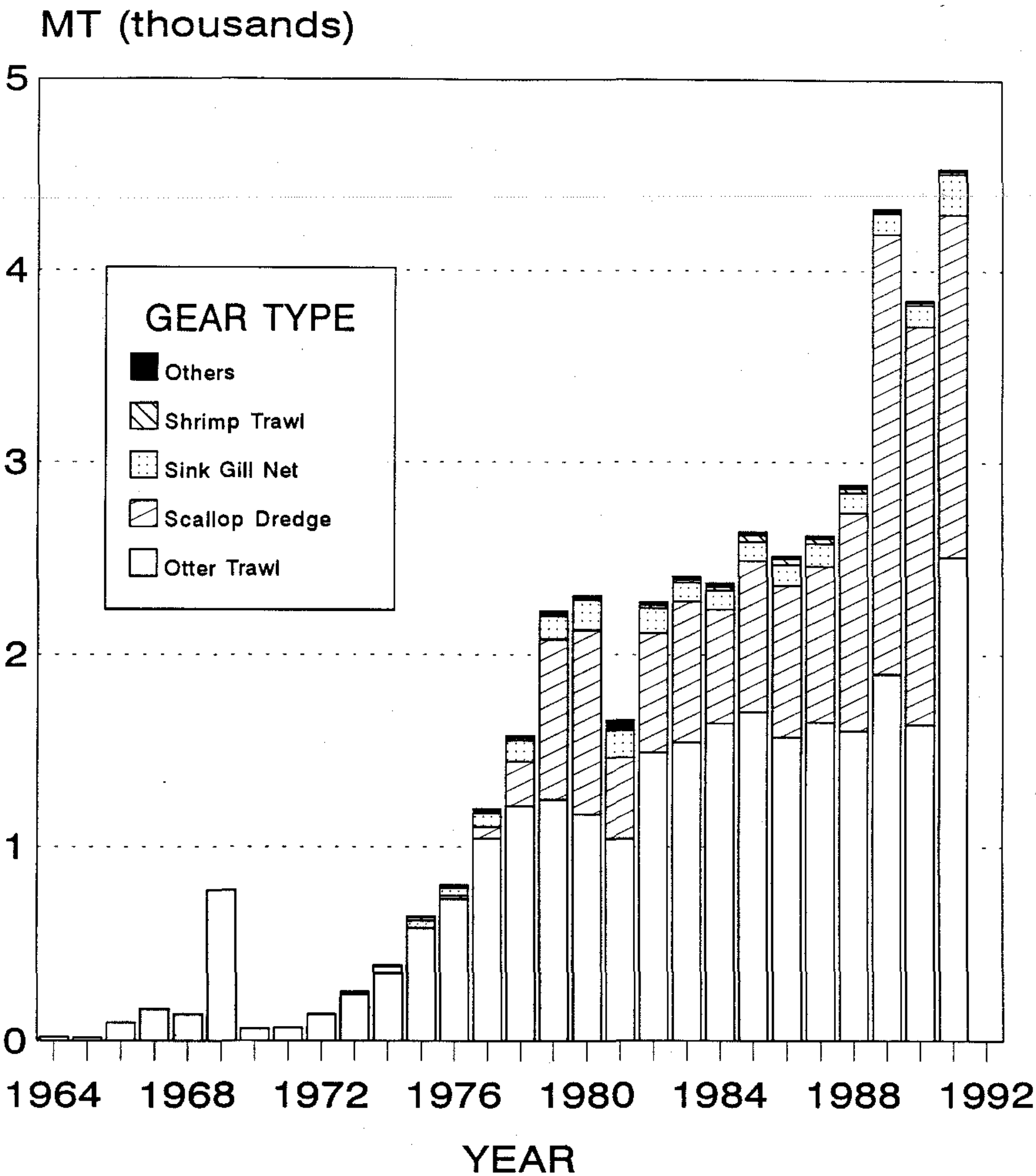

Figure SC2. Goosefish landings (tails) by gear.

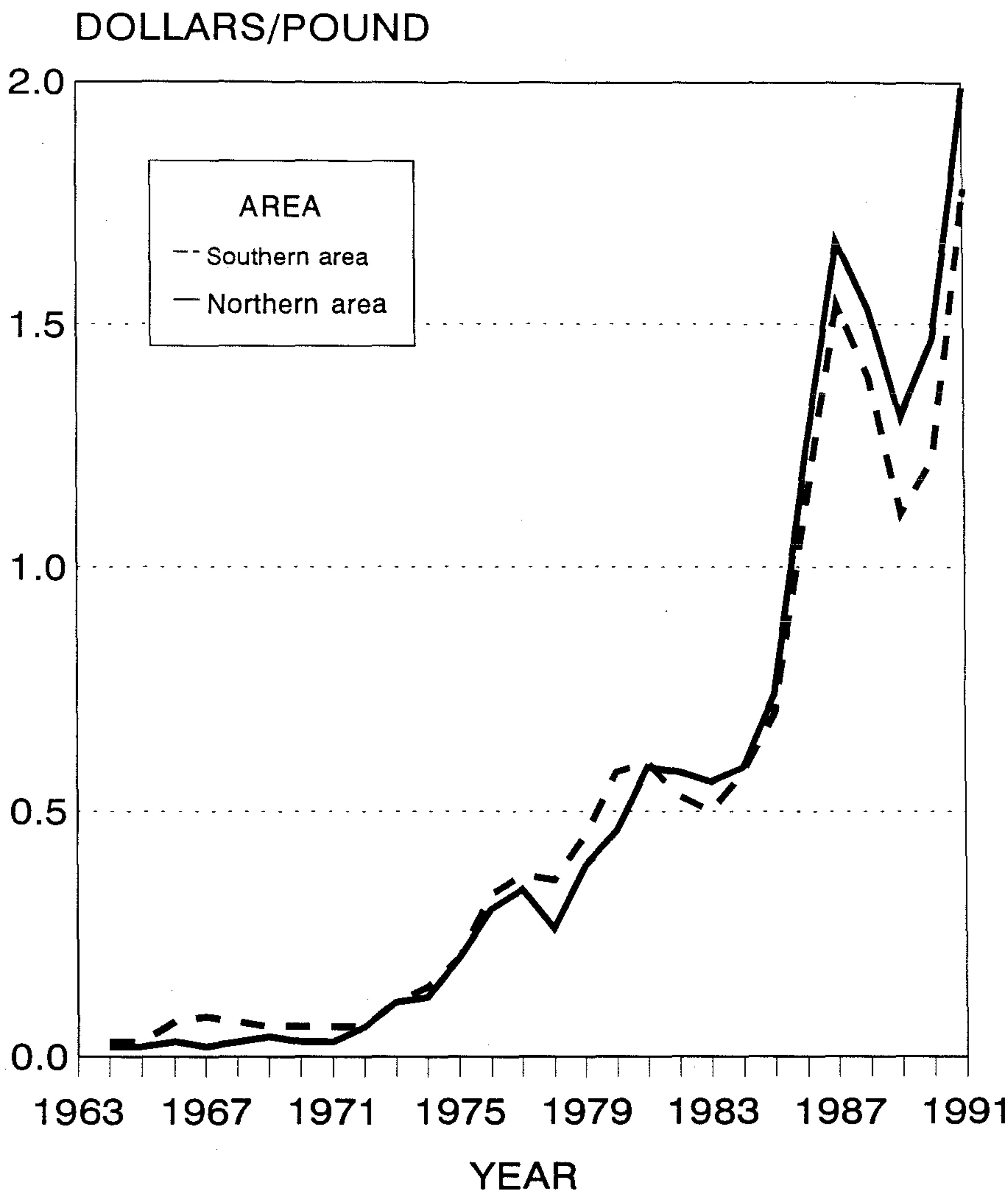

Figure SC3. Goosefish ex-vessel price (tails).

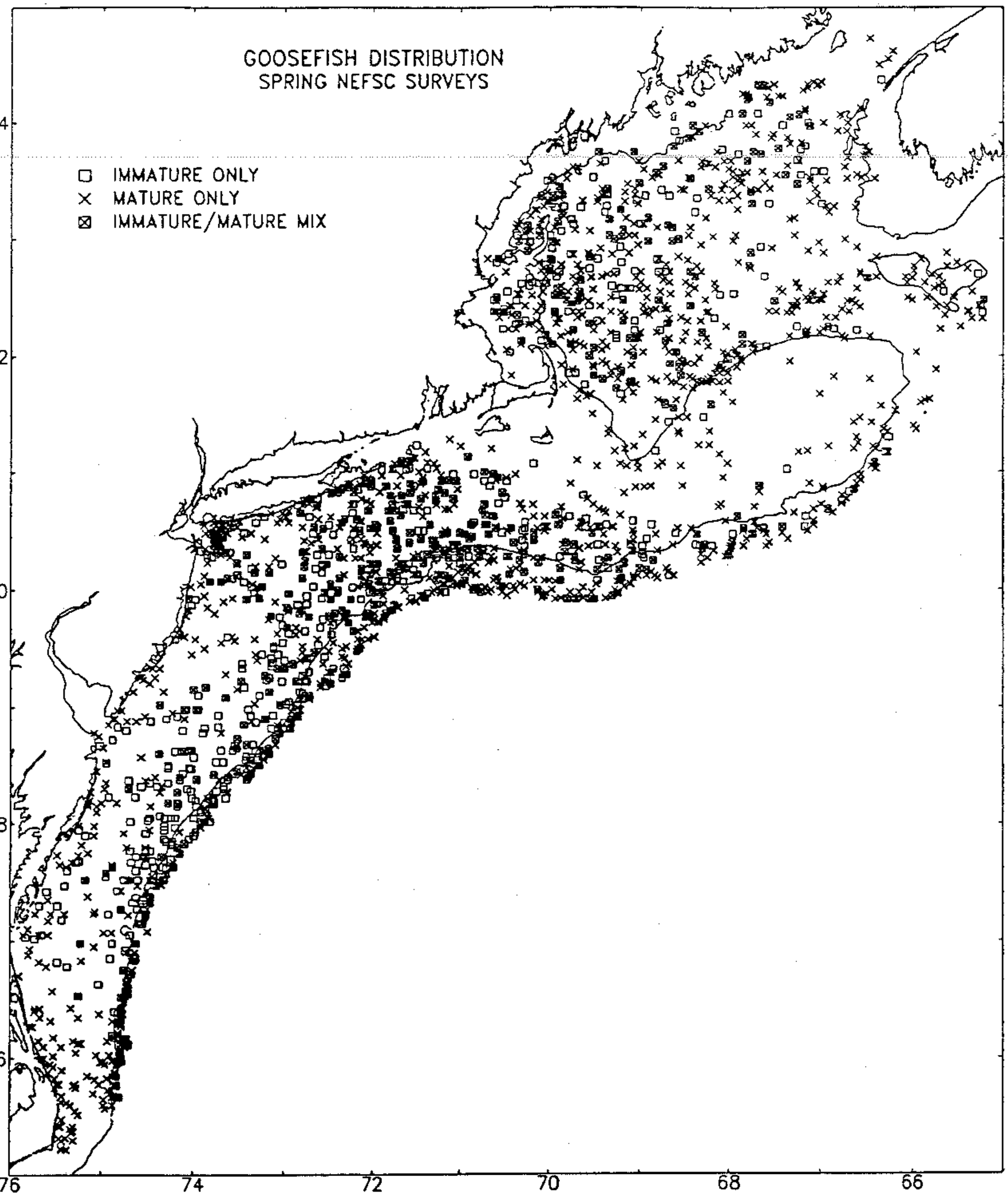

Figure SC4. Distribution of catches (presence/absence only) of immature and mature goosefish from NEFSC spring bottom trawl surveys 1968-1991.

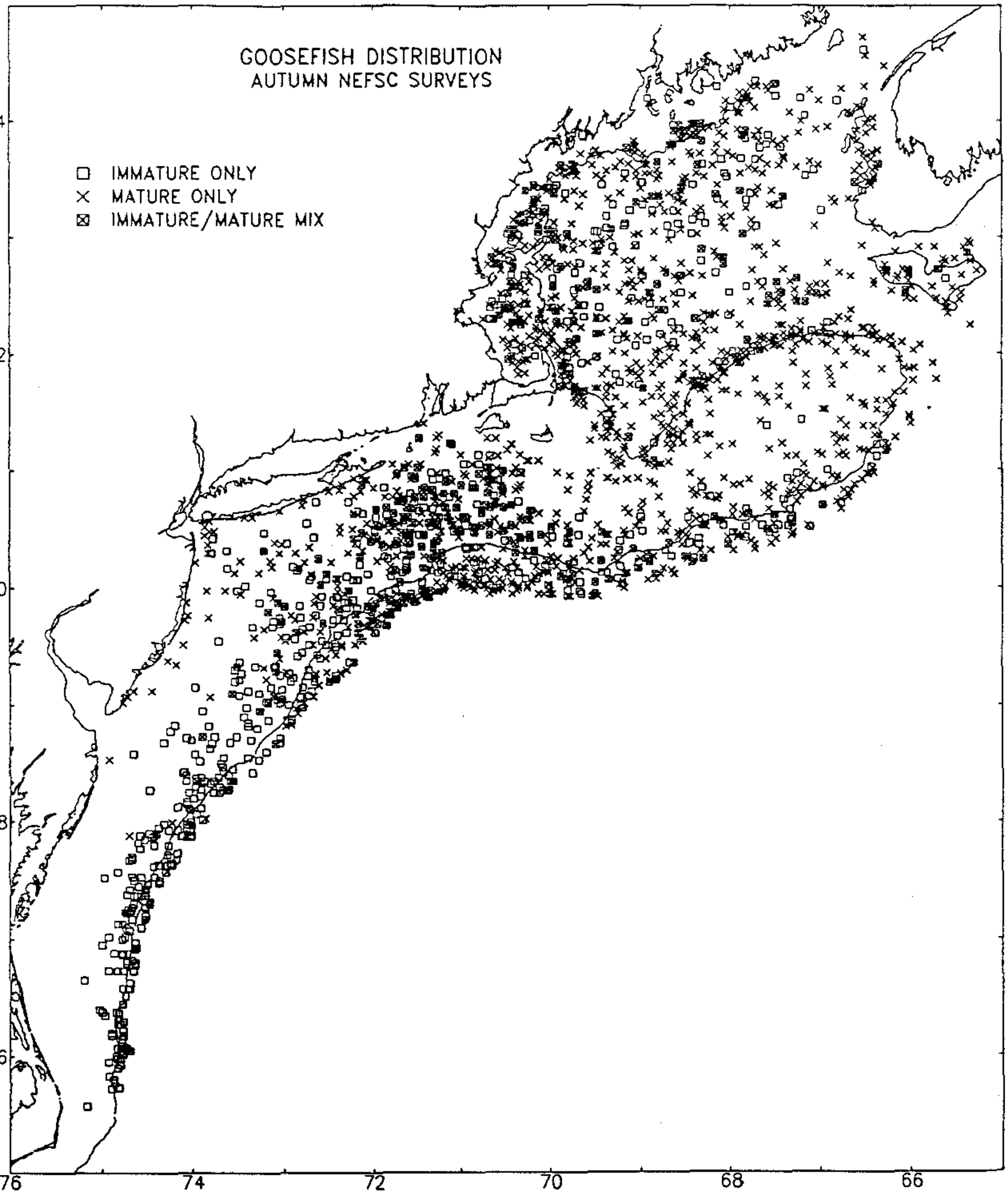

Figure SC5. Distribution of catches (presence/absence only) of immature and mature goosefish from NEFSC autumn bottom trawl surveys 1963-1991.

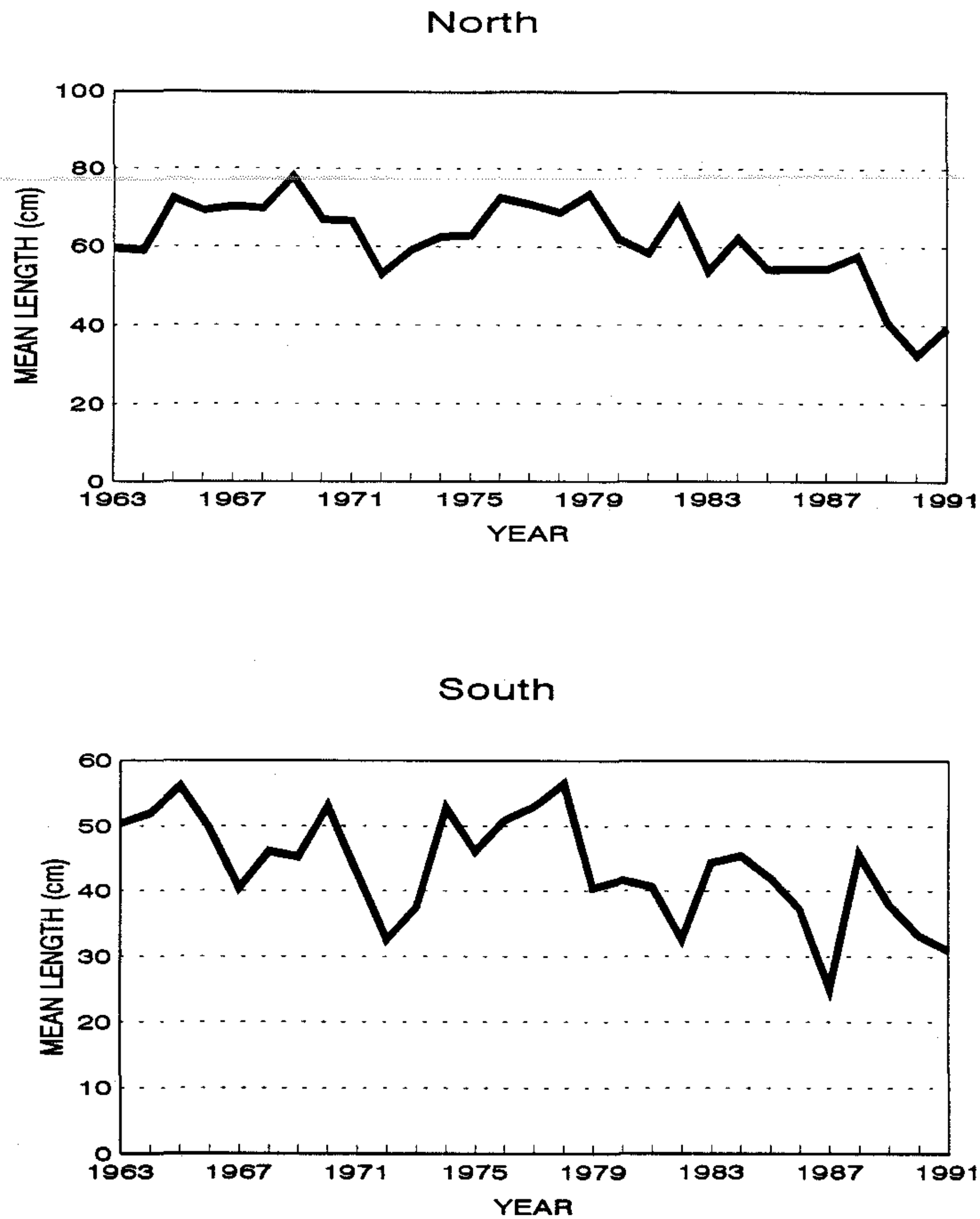

Figure SC6. NEFSC autumn groundfish survey mean lengths.

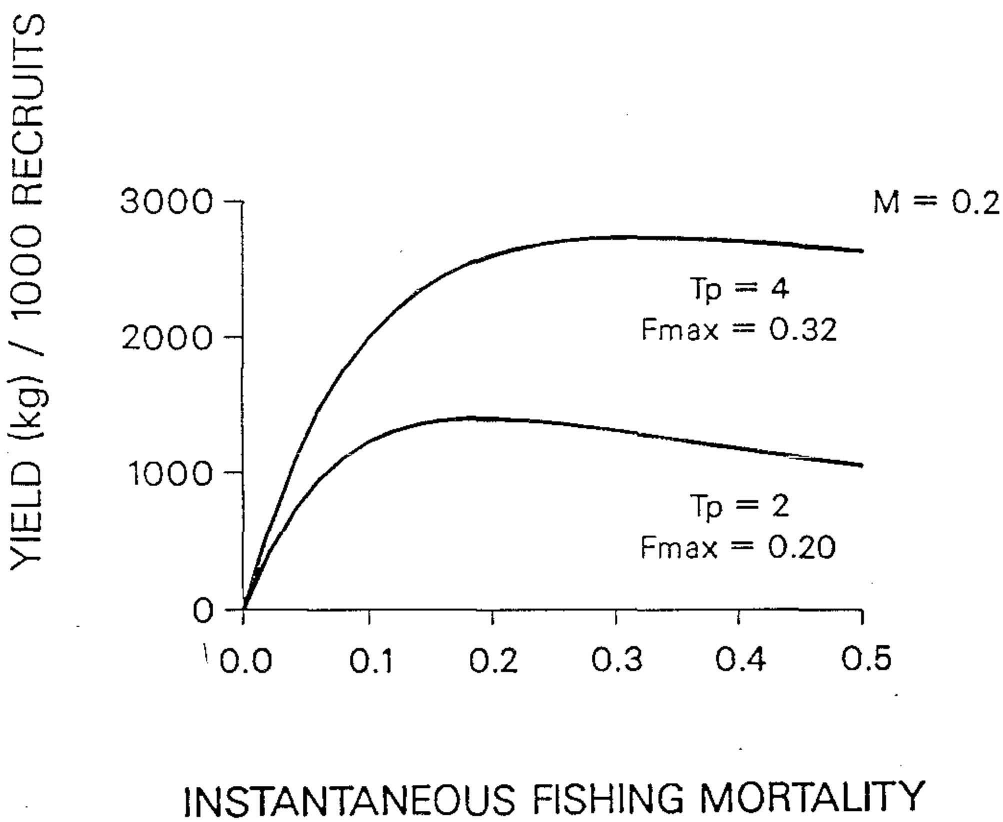

Figure SC7. Yield per recruit for Gulf of Maine - northern Georges Bank goosefish.

AMERICAN PLAICE

An analytic assessment of the stock of American plaice was presented to the SARC (SAW/14/SARC/14). Estimates of discard at age from the shrimp and large mesh otter trawl fisheries and estimates of landings at age from all fisheries were combined in a catch at age matrix. Virtual population analysis, incorporating NEFSC survey data as abundance indices was used to estimate age-specific population abundance and fishing mortality rates from 1988-1991.

Fishing mortality rates (F) on fully-recruited ages (6+) have averaged about 0.5 during 1988-1991 and about 0.7 during 1985 - 1987. Spawning stock biomass declined since 1980 to low levels in 1987-1991. The 1987 year class was large, and contributed nearly 30% of 1991 stock size (numbers) at age 4. The current fishing mortality rate is above the commonly used reference levels ($F_{0.1}, F_{max}, F_{20\%}$).

Background

American plaice (Hippoglossoides platessoides) is distributed along the continental shelf from southern Labrador to Montauk Point, New York. In U.S. waters, plaice is most abundant in the deeper (> 50 m) waters of the Gulf of Maine and off the northern edge of Georges Bank (SAW/14/SARC/9). Research survey distributions indicate continuous occurrences over the areas of the Gulf of Maine and Georges Bank. Consequently, American plaice was analyzed as a single stock.

As other flounder stocks became depleted, the American plaice fishery developed in the mid-1970s. Landings increased from low levels in 1970-1975 to peak levels in 1979-1982 (Table SD1). Landings then steadily declined to low levels in 1989, and have since increased only slightly. The vast majority of landings have been taken in the Gulf of Maine and on Georges Bank. Otter trawls account for 93-97% of the landings each year (Table SD2). Remaining landings are taken primarily by shrimp trawls and sink gill nets.

The resource is managed under the New England Fishery Management Council's Northeast Multispsecies Fishery Management Plan. A mesh size of 5.5" was required in the Gulf of Maine-Georges Bank large mesh regulatory area in 1985. In 1988, the minimum landing size increased from 12" to 14". Separator panels were required in shrimp trawl gear by the Atlantic States Marine Fisheries Commission in April, May and December of 1989, 1990 and 1991 to reduce by-catch of American plaice and other flatfish. While there is anecdotal evidence to suggest that these panels have been effective in reducing by-catch and discard of plaice under certain conditions, controlled tests have been generally inconclusive (Ad hoc Shrimp Gear Committee 1989; Kenney et al. 1990).

Data Sources

Commercial landings for 1980-1991 were derived from the NEFSC commercial landings files; associated length composition data were obtained from NEFSC weighout data base by quarter, market category and statistical area. Age-length keys from NEFSC spring and autumn survey data were applied to commercial landings at length data from quarters 1-2 and quarters 3-4, respectively, to generate landings at age. The results of Fisher's exact tests indicated no differences between survey- and commercially-derived age-length keys. The SARC did, however, express concern about the small number of survey age samples in the commercially landed length ranges.

NEFSC sea sampling data were used to estimate number and length frequency of discards in the 1989-1991 shrimp fishery. NEFSC survey length frequency data were used to develop indirect estimates of discard in the large mesh otter trawl fishery (1980-1991) and the earlier portion of the shrimp fishery (1980-1988). The mortality of discards is assumed to be 100%.

Estimates of the proportion mature and median maturity at age (O'Brien et al. MS 1992) were assumed constant 1980-1991:

Age (years)						
1	2	3	4	5	6	7+
	0.000.04	0.24	0.72	0.95	0.99	1.00

The instantaneous natural mortality rate (M) assumed to be constant at 0.2 (Pitt 1972).

Commercial CPUE indices were estimated for the Gulf of Maine-Georges Bank otter trawl fishery for 1964-1991 for all trips landing American plaice and trips landing 50% or more of American plaice (Table SD3).

Indices of biomass and abundance were estimated from the NEFSC spring and autumn bottom trawl surveys, adjusted for vessel differences, for 1980-1991.

Methodology

Discards in the shrimp fishery in 1989-1991 were estimated from sea sampling data. The shrimp fishery was stratified by two areas: (1) north of 43° 15' (Maine fleet), and (2) south of 43° 15' (New Hampshire and Massachusetts fleet) and two seasons (SAW/14/SARC/10). For each year, mean weight discarded per trip within each of four season-area strata (winter/spring by areas 1/2) was expanded to annual estimates by multiplying by number of trips within each stratum. The number discarded at length was estimated by applying seasonal length frequencies obtained from sea sampling data.

Discards in the shrimp fishery in earlier years were estimated indirectly, from NEFSC bottom trawl survey data, based on relationships developed between length frequency distributions of survey and sea sampled discard observations for 1989-91. Survey length frequency data (1989-1991) were filtered to simulate mesh selectivity (1.8" mesh) at length and percent culled at length. To develop an average scaling factor, survey estimates of discardable numbers at length were regressed on numbers of discards at length per trip estimated from 1989-1991 sea sampling data. The scaling factor was applied to filtered survey length frequencies to obtain annual estimates of shrimp discard raised to the number of shrimp trips between 1980 and 1988. Shrimp effort was low in the early 1980s (Table SD4), so the errors involved in estimating discards should be small for this period as well.

For estimates of discards in the large mesh otter trawl fishery, survey length frequency data were filtered using a mesh selection ogive for 5.1" (1980 - 1982) and 5.5" (1985 - 1991)mesh and a cull selection vector. Catch per tow at length was subdivided into simulated landing and discard components. A ratio of the landable component to the observed landed numbers at length was used to expand the discardable portion of the survey length frequencies to represent fishery discards at length.

Associated survey age-length keys were used to estimate numbers discarded at age from numbers discarded at length (Table SD5). Discard and landings at age (Table SD6) were combined to produce the total catch at age matrix (Table SD5).

The ADAPT methodology (Parrack 1986, Gavaris 1988, Conser and Powers 1990) was used for calibrating the VPA with the survey abundance indices. Indices for ages 1-7 from the NEFSC spring bottom trawl survey and indices for ages 2-7 from the autumn bottom trawl surveys were used to tune the VPA. The autumn indices were compared to population numbers one year older at the beginning of the following year. Stock sizes and fishing mortality for ages 3-8 were estimated in the terminal year 1992. The fishing mortality for age 8 and 9+ in 1991 was assumed to be the average F of ages 6 and 7. The initial partial recruitment for ages 1 and 2 was estimated from a separable VPA.

Assessment Results

Landings per day fished declined since the early 1980s for all tonnage classes and trip types, but increased slightly in 1991 in most series.

Strong year classes occurring in 1979 and 1987 are apparent in both the spring and autumn indices (Table SD7). Strong 1984 and 1987 year classes were also indicated in abundance indices estimated from the Massachusetts DMF inshore spring and autumn bottom trawl survey (Table SD8).

VPA results for ages 1-5 before 1989 depend primarily on indirect discard estimates so that they are more uncertain than those since.

The estimated fishing mortality rate on fully recruited ages (6+) in 1991 was 0.58, and has varied between 0.36 - 0.87 in the last decade (Table SD9). Stock numbers at age declined from 204 million in 1980 to 58 million in 1986. The 1987 year class is the largest in the 12 year series and was the largest component of stock biomass in 1990 and 1991 and will remain so in 1992. Due to the recruitment of this year class and the above average 1989 cohort, stock size increased to 105 million in 1990, and then declined to 91 million in 1991 as mortality reduced their abundance. The abundance of the 1979 cohort, the second strongest at 43 million fish, was rapidly decreased by fishing during 1983 - 1984.

Mean stock biomass declined overall from 1980 to 1987 and then gradually increased as the 1987 year class increased in weight. Spawning stock biomass exhibited a similar trend of decline from 1980-1989 and increase in 1990-1991 as the 1987 year class grew and matured.

Spawning stock biomass at the start of the season (mt) was:

Year											
1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
47544	41073	35674	30527	22434	13838	9442	7504	7979	7724	9892	13408

SARC Analyses

Yield- and spawning-stock-biomass-per-recruit-based biological reference points were calculated using partial recruitment pattern from 1989-1990. Weight at age in the catch and stock were assumed equal to mid-year weight in catch; proportion mature at age was estimated from O'Brien et al. (MS 1992), with peak spawning assumed to occur in February. Fishing mortality was apportioned among landings and shrimp by-fishery discard (Table SD10). Total catch per recruit reflects the sum of all fishing mortalities. Catch per recruit was subdivided into yield (landed) and discard per recruit, based on the proportion of F associated with landings vs. discards at each age. Based on yield-per-recruit analysis, $F_{0.1}$= 0.17 while F_{max}= 0.28. Based on spawning-stock-biomass-per-recruit analysis, $F_{20\%}$= 0.49 (Figure SD1). The current calculation of fishing mortality level (F_{1991}=0.6) is higher than any of these reference points.

Catch and spawning stock biomass projections were made for 1992-1993. Recruitment in 1992-1993 was the geometric mean of the 1980-1990 stock size at age 1. The 1991 F was used for 1992. 1992 stock sizes were projected from VPA 1991 abundance estimates (Table SD9). Four levels of fishing mortality were projected for 1993: F (0.58), $F_{0.1}$, F_{max} and $F_{20\%}$ (Table SD10). At the current (1991) F level, spawning (and total) stock biomass will probably not increase in 1993 and might decrease. At a conservative fishing level, $F_{0.1}$ say, increases will occur, but slowly.

Major Sources of Uncertainty

- o Direct estimates of discards from large mesh otter trawl fishery may change results.
- o Estimates of shrimp trawl discards in early years may cause underestimates of year classes abundance in 1979 and 1987.

Recommendations

- o Incorporate large mesh sea sampling discard data into future discard estimates.
- o Examine all sources of sea sampling data prior to 1989.
- o Apportion catch by the proportion landed and proportion discarded in catch projections; simulate effect of removal of shrimp fishery on stock status and biological reference points.
- o Include Massachusetts state survey as abundance indices in the VPA.
- o Continue ageing of commercial samples to improve representativeness of age-length keys.

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Table SD1. Commercial Landings (metric tons, live) of American plaice from the Gulf of Maine, Georges Bank, Southern New England and the Mid-Atlantic, 1960-1991.

	Gulf of Maine			Georges Bank					Southern New England				Mid-Atlantic			Grand Totals		
	USA	Can	Total	USA	Can	USSR	Other	Total	USA	USSR	Other	Total	USA	Other	Total	USA	Other	Total
1960	620	1	621	689	-	-	-	689	-	-	-	0	-	-	0	1309	1	1310
1961	692	-	692	830	-	-	-	830	-	-	-	0	-	-	0	1522	0	1522
1962	694	-	694	1233	44	-	-	1277	-	-	-	0	-	-	0	1927	44	1971
1963	693	-	693	1489	127	24	-	1640	-	-	-	0	-	-	0	2182	151	2333
1964	811	-	811	2800	177	-	11	2988	-	-	-	0	-	-	0	3611	188	3799
1965	967	-	967	2376	180	112	-	2668	-	-	-	0	-	-	0	3343	292	3635
1966	955	2	957	2388	242	279	1	2910	-	-	-	0	-	-	0	3343	524	3867
1967	1066	6	1072	2166	203	1018	10	3397	-	-	-	0	4	-	4	3236	1237	4473
1968	904	5	909	1695	173	193	5	2066	637	145	-	782	18	2	20	3254	523	3777
1969	1059	7	1066	1738	71	63	17	1889	505	349	-	854	130	-	130	3432	507	3939
1970	895	-	895	1603	92	927	658	3280	88	18	40	146	8	-	8	2594	1735	4329
1971	648	5	653	1511	36	228	296	2071	11	112	206	329	6	2	8	2176	885	3061
1972	569	-	569	1222	22	358	-	1602	3	71	-	74	-	-	0	1794	451	2245
1973	687	-	687	910	38	289	-	1237	5	158	-	163	-	-	0	1602	485	2087
1974	945	2	947	1039	27	16	2	1084	92	4	-	96	-	-	0	2076	51	2127
1975	1507	-	1507	913	25	148	-	1086	3	-	-	3	-	-	0	2423	173	2596
1976	2550	-	2550	948	24	3	-	975	10	-	-	10	1	-	1	3509	27	3536
1977	5647	-	5647	1408	35	50	-	1493	6	78	-	84	7	-	7	7068	163	7231
1978	7287	30	7317	2193	77	-	-	2270	15	-	-	15	8	-	8	9503	107	9610
1979	8835	-	8835	2478	23	-	-	2501	13	-	7	20	4	-	4	11330	30	11360
1980	11139	-	11139	2399	43	-	5	2447	10	-	-	10	1	-	1	13549	48	13597
1981	10327	1	10328	2482	15	-	2	2499	26	-	2	28	46	-	46	12881	20	12901
1982	11147	-	11147	3935	27	-	1	3963	35	-	2	37	9	-	9	15126	30	15156
1983	9142	7	9149	3955	30	-	-	3985	40	-	-	40	4	-	4	13141	37	13178
1984	6833	2	6835	3277	6	-	-	3283	17	-	-	17	7	-	7	10134	8	10142
1985	4766	1	4767	2249	40	-	-	2289	12	-	-	12	2	-	2	7029	41	7070
1986	2990	-	2990	1109	34	-	-	1143	4	-	-	4	2	-	2	4105	34	4139
1987	2766	-	2766	1032	48	-	-	1080	2	-	-	2	1	-	1	3801	48	3849
1988	2271	-	2271	1097	108	-	-	1205	13	-	-	13	1	-	1	3382	108	3490
1989	1645	-	1645	702	68	-	-	770	1	-	-	1	3	-	3	2351	68	2419
1990	1806	-	1806	637	51	-	-	688	2	-	-	2	2	-	2	2447	51	2498
1991	2936	-	2936	1310	-	-	-	1310	15	-	-	15	-	-	0	4261	0	4261

Table SD2. Percentage of landings of American plaice by gear type, 1980-1991.

	GEAR TYPE					
Year	Otter Trawl	Shrimp Trawl	Sink Gill Net	Scottish Seine	Danish Seine	Other
1980	96.75	0.71	0.80	0.00	1.47	0.28
1981	96.48	2.15	0.71	0.00	0.53	0.13
1982	96.26	2.01	0.77	0.53	0.31	0.11
1983	96.26	1.72	0.31	1.12	0.26	0.33
1984	97.19	1.02	0.16	0.63	0.58	0.43
1985	96.92	1.56	0.14	0.50	0.79	0.08
1986	96.09	2.51	0.25	0.33	0.68	0.14
1987	95.45	2.56	0.58	0.36	0.90	0.15
1988	96.24	1.67	0.57	0.40	0.97	0.15
1989	95.49	1.37	1.15	0.85	0.99	0.14
1990	93.43	2.15	1.97	0.86	1.15	0.42
1991	94.82	0.92	0.92	1.20	0.90	1.24

Table SD3. USA Commercial landings (L), days fished (DF), and landings per day fished (L/DF), by vessel tonnage class (Class 2: 5-50 GRT;Glass 4: 151-500 GRT), of American plaice for otter trawl trips landing plaice from the Gulf of Maine-Georges Bank Area, 1964-1991. Data are also provided for otter trawl trips in which plaice comprised 50% or more of the total trip catch, by weight ['directed trips'].

	TON CLASS 2			TON CLASS 3			TON CLASS 4			TOTALS		
YEAR	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF
						ALL TRIPS						
1964	729.7	2207.5	0.33	1640.3	6016.4	0.27	157.1	1370.4	0.11	2527.1	9594.3	0.28
1965	898.5	2333.1	0.39	1591.4	6052.1	0.26	274.3	1754.9	0.16	2764.2	10140.1	0.29
1966	871.4	2221.7	0.39	1816.1	6664.4	0.27	421.3	2828.9	0.15	3108.8	10140.1	0.29
1967	787.1	1883.1	0.42	2026.8	6016.0	0.34	283.3	2121.2	0.13	3097.2	10020.3	0.34
1968	603.3	2277.7	0.26	1711.4	5640.2	0.30	232.9	1954.4	0.12	2547.6	9872.3	0.27
1969	783.9	2434.4	0.32	1681.5	5761.4	0.29	303.6	1640.0	0.19	2769.0	9835.8	0.29
1970	634.7	3690.0	0.17	1556.3	5783.9	0.27	281.9	1505.5	0.19	2472.9	10979.4	0.24
1971	484.1	2989.1	0.16	1442.0	5823.2	0.25	215.6	1176.6	0.18	2141.7	9988.9	0.22
1972	389.4	2972.9	0.13	1252.0	6806.6	0.18	135.0	1120.7	0.12	1776.4	10900.2	0.16
1973	466.0	2703.0	0.17	931.1	5675.7	0.16	161.7	1056.9	0.15	1558.8	9435.6	0.16
1974	687.3	3161.3	0.22	1053.0	5766.4	0.18	192.8	1310.3	0.15	1933.1	10238.0	0.19
1975	1076.6	3733.5	0.29	992.3	5868.2	0.17	227.3	1393.8	0.16	2296.2	10995.5	0.23
1976	1715.4	3680.3	0.47	1421.4	5776.2	0.25	184.3	1334.0	0.14	3321.1	10790.5	0.36
1977	3667.4	3805.7	0.96	2577.5	6862.8	0.38	354.3	1358.6	0.26	6599.2	12027.1	0.70
1978	4494.9	4648.2	0.97	3862.5	8187.4	0.47	513.8	1769.1	0.29	8871.2	14604.7	0.71
1979	4942.8	5264.5	0.94	4553.0	8549.1	0.53	639.4	2313.9	0.28	10135.2	16127.5	0.71
1980	5909.9	5900.6	1.00	4749.0	8784.4	0.54	1042.6	2832.0	0.37	11701.5	17517.0	0.76
1981	5779.1	4935.6	1.17	5153.3	8847.7	0.58	1167.4	3307.4	0.35	12099.8	17090.7	0.84
1982	5782.7	5929.6	0.98	6437.3	10602.2	0.61	1808.5	4425.2	0.41	14028.5	20957.0	0.74
1983	4472.8	5312.0	0.84	5738.0	10378.2	0.55	2131.4	4960.8	0.43	12342.2	20651.0	0.63
1984	3097.5	5285.0	0.59	4723.9	12641.8	0.37	1753.6	5164.8	0.34	9575.0	23091.6	0.44
1985	1858.9	4704.0	0.40	3259.9	13665.9	0.24	1546.4	6092.7	0.25	6665.2	24462.6	0.29
1986	1168.1	4385.6	0.27	1971.3	11202.2	0.18	969.1	5806.7	0.17	4108.5	21394.5	0.20
1987	919.6	4485.8	0.21	1816.8	10943.8	0.17	826.8	5567.0	0.15	3563.2	20996.6	0.18
1988	899.1	4709.4	0.19	1539.0	10711.6	0.14	635.5	5500.3	0.12	3073.6	20921.3	0.15
1989	574.9	3794.6	0.15	1158.7	9218.6	0.13	438.4	4669.8	0.09	2172.0	17683.0	0.13
1990	696.2	4060.5	0.17	1145.5	8788.5	0.13	412.7	5063.1	0.08	2254.4	17912.1	0.13
1991	973.6	4299.5	0.23	2236.2	10370.2	0.22	749.0	5653.8	0.13	3958.8	20323.5	0.21
						50% TRIPS						
1964	201.6	115.8	1.74	429.6	166.9	2.57	0.0	0.0	0.00	631.2	282.7	2.30
1965	268.5	161.7	1.66	413.8	180.5	2.29	3.8	2.0	1.91	686.1	344.2	2.04
1966	218.6	133.9	1.63	527.3	249.9	2.11	1.2	1.5	0.82	747.1	385.3	1.97
1967	155.2	78.7	1.97	685.6	365.5	1.88	15.8	6.0	2.64	856.6	450.2	1.91
1968	55.0	30.5	1.80	557.9	291.6	1.91	3.9	2.0	1.93	616.8	324.1	1.90
1969	135.6	61.0	2.22	320.9	154.8	2.07	0.7	1.0	0.68	457.2	216.8	2.11
1970	10.0	9.2	1.09	309.6	143.6	2.16	31.2	14.6	2.14	350.8	167.4	2.13
1971	3.5	3.6	0.98	147.7	1.6	2.06	20.7	6.3	3.28	171.9	81.5	2.18
1972	8.6	7.5	1.15	92.8	2.5	1.28	1.1	2.4	0.45	102.5	82.4	1.26
1973	17.3	23.1	0.75	70.6	42.2	1.67	6.5	3.0	2.16	94.4	68.3	1.54
1974	110.0	99.2	1.11	142.3	3.4	1.52	10.2	8.5	1.20	262.5	201.1	1.34
1975	158.5	119.3	1.33	103.2	70.4	1.47	20.8	15.7	1.32	282.5	205.4	1.38
1976	496.9	371.6	1.34	184.2	101.6	1.81	3.8	5.0	0.75	684.9	478.2	1.46
1977	1516.3	570.0	2.66	520.8	203.5	2.56	12.9	7.4	1.74	2050.0	780.9	2.63
1978	981.1	806.1	2.46	721.1	273.5	2.64	6.6	5.0	1.32	2708.8	1084.6	2.51
1979	2865.8	1418.6	2.02	1219.3	435.8	2.80	14.5	9.2	1.58	4099.6	1863.6	2.25
1980	3083.4	1499.5	2.06	1188.3	443.2	2.68	57.0	19.0	3.00	4328.7	1961.7	2.24
1981	3391.9	1416.5	2.39	1651.0	585.7	2.82	69.3	22.1	3.13	5112.2	2024.3	2.54
1982	3276.6	1838.5	1.78	2078.2	976.9	2.13	132.2	60.3	2.19	5487.0	2875.7	1.92
1983	2087.0	1248.1	1.67	1344.2	761.9	1.76	105.5	58.2	1.81	3536.7	2068.2	1.71
1984	1189.8	964.1	1.23	707.7	539.9	1.31	108.1	58.0	1.86	2005.6	1562.0	1.29
1985	538.4	567.2	0.95	226.0	255.2	0.89	46.5	52.1	0.89	810.9	874.5	0.93
1986	179.4	237.7	0.75	112.7	166.3	0.68	33.3	33.9	0.98	325.4	437.9	0.75
1987	178.5	244.3	0.73	126.1	251.3	0.50	17.4	31.3	0.56	322.0	526.9	0.63
1988	149.2	298.3	0.50	212.0	401.1	0.53	4.0	8.8	0.46	365.2	708.2	0.52
1989	80.4	136.3	0.59	31.7	48.4	0.66	2.4	2.5	0.97	114.5	187.2	0.62
1990	111.8	192.0	0.58	138.0	210.2	0.66	0.0	0.0	0.00	249.8	402.2	0.62
1991	277.7	365.3	0.76	529.7	812.9	0.65	26.7	33.7	0.79	834.1	1211.9	0.69

Table SD4. Total number of trips in the Gulf of Maine northern shrimp fishery, American plaice discard estimates (000's) in the Gulf of Maine northern shrimp fishery and discard and landings in the Gulf of Maine-Georges Bank large mesh otter trawl fishery.

	Shrimp Fishery		Large Mesh Fishery		Total
Year	Trips	Discards	Discards	Landings	Catch
1980	688	295	5,253	14,749	20,299
1981	2151	583	1,768	19,972	22,323
1982	3515	1,004	1,478	20,658	23,139
1983	4361	1,557	1,960	17,598	21,115
1984	6753	989	1,985	12,936	15,910
1985	6529	1,019	275	10,145	11,439
1986	8195	1,010	397	6,916	8,324
1987	10960	1,365	1,131	5,509	8,006
1988	8542	1,045	820	5,085	6,950
1989	9113	2,340	1,120	3,079	6,540
1990	8970	3,274	2,030	2,721	8,025
1991	7227	3,409	4,038	6,418	13,866

Table SD5. Numbers of American plaice discarded (000's) at age by the large mesh and shrimp otter trawl fisheries, total numbers discarded at age, and total numbers discarded and landed at age.

NUMBER DISCARDED AT AGE BY YEAR - LARGE MESH

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
1980	0.0	9.0	146.9	1349.3	2575.2	1125.5	44.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5253.3
1981	0.0	4.5	291.0	718.3	511.9	195.3	18.3	29.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1768.3
1982	0.0	3.6	327.5	627.1	424.3	89.9	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1476.8
1983	0.0	0.9	61.3	513.1	875.1	420.8	78.4	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1960.3
1984	0.0	0.2	68.9	263.2	580.1	758.2	309.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1985.7
1985	0.0	5.0	50.0	194.1	25.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	274.9
1986	0.0	1.3	33.1	88.3	213.4	60.3	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	397.3
1987	0.0	1.0	59.8	298.6	380.9	318.8	72.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1131.4
1988	0.0	4.2	68.3	456.4	236.8	48.4	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	820.3
1989	0.0	0.4	73.9	491.8	377.6	136.6	34.7	5.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1120.5
1990	0.0	1.0	29.3	1047.7	829.1	111.9	10.4	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2030.1
1991	0.0	1.6	97.8	812.6	2334.9	769.2	22.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4038.4

NUMBER DISCARDED AT AGE BY YEAR - SHRIMP FISHERY

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
1980	0.0	5.6	84.5	105.4	79.9	19.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	295.4
1981	0.0	34.9	169.3	226.2	114.3	30.6	3.1	2.9	1.9	0.0	0.0	0.0	0.0	0.0	0.0	583.0
1982	0.0	55.9	310.4	244.2	326.3	33.5	33.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1003.9
1983	0.1	15.1	427.8	399.1	449.9	178.2	22.5	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1493.7
1984	0.7	50.3	214.8	308.0	297.1	88.6	29.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	988.6
1985	0.1	48.9	304.2	358.9	200.5	78.1	28.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1019.5
1986	0.1	116.6	265.7	442.9	146.0	38.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1010.0
1987	0.3	94.0	461.5	441.4	296.4	67.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1364.9
1988	0.0	141.7	426.3	323.7	130.9	17.9	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1045.4
1989	0.0	1382.4	1249.8	848.5	276.2	83.2	58.6	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3906.7
1990	0.0	29.2	1516.5	1767.0	456.2	64.0	15.5	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3849.0
1991	0.0	68.9	310.4	497.3	261.9	47.3	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1186.3

NUMBER DISCARDED AT AGE BY YEAR - TOTAL DISCARDS

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
1980	0.0	14.6	231.4	1454.7	2655.1	1145.4	44.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5548.7
1981	0.0	39.4	460.3	944.4	626.1	225.9	21.4	32.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	2351.3
1982	0.0	59.5	637.9	871.3	750.6	123.4	38.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2480.6
1983	0.1	16.0	489.0	912.2	1325.1	599.0	100.9	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3454.0
1984	0.7	50.5	283.7	571.2	877.2	846.8	338.5	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2974.2
1985	0.1	53.9	354.2	553.0	225.8	78.6	28.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1294.4
1986	0.1	117.8	298.8	531.2	359.4	98.4	1.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1407.3
1987	0.3	95.0	521.2	740.0	677.3	385.8	76.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2496.3
1988	0.0	145.9	494.6	780.1	367.7	66.3	11.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1865.7
1989	0.0	1382.8	1323.7	1340.3	653.8	219.8	93.2	13.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	5027.1
1990	0.0	30.2	1545.8	2814.7	1285.3	175.9	25.9	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5879.0
1991	0.0	70.5	408.3	1309.9	2596.8	816.4	22.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5224.7

Table SD5 (continued).

TOTAL NUMBERS LANDED AND DISCARDED

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	TOTAL
1980	0.0	14.6	231.4	1476.6	3424.8	4274.2	3947.7	3631.9	1185.4	1138.6	849.9	323.0	155.4	215.3	686.7	21555.5
1981	0.0	39.4	1047.6	2275.9	4957.3	5325.8	3639.2	2412.8	1575.2	645.1	439.8	196.4	146.4	44.6	233.5	22979.1
1982	0.0	59.5	751.1	3004.8	4245.2	4418.7	3519.0	3292.8	2037.6	1256.1	736.7	317.2	33.6	137.1	229.5	24039.0
1983	0.1	16.0	489.7	1349.9	5059.8	4869.4	3910.3	2263.9	1270.7	697.1	449.6	454.7	229.7	58.6	168.4	21287.8
1984	0.7	50.5	287.2	824.4	2174.7	5665.4	3203.3	1919.0	577.2	273.8	307.2	64.9	57.2	0.0	646.8	16052.4
1985	0.1	53.9	364.4	1003.9	1511.7	2407.7	2164.5	1445.4	1513.0	392.4	139.6	103.1	97.1	5.0	378.2	11579.9
1986	0.1	117.8	306.5	739.6	2043.9	1520.9	1459.7	816.8	605.5	214.7	173.5	91.8	5.8	26.7	200.4	8323.8
1987	0.3	95.0	522.7	974.8	1190.5	2134.4	1430.6	757.3	416.5	122.1	131.4	192.7	26.7	0.0	272.4	8267.4
1988	0.0	145.9	494.6	1205.0	1740.3	1573.4	988.5	553.9	115.8	205.9	38.4	86.4	0.0	0.0	316.5	7464.8
1989	0.0	1382.8	1323.7	1400.4	1484.5	859.7	559.8	502.3	202.5	344.6	39.9	67.7	7.3	21.3	196.0	8392.6
1990	0.0	30.2	1545.8	2993.7	2208.6	1170.5	695.4	328.4	216.0	142.9	13.0	9.4	3.4	0.0	215.6	9572.9
1991	0.0	70.5	408.3	1377.8	4071.9	4092.2	1239.2	359.9	196.5	34.5	7.5	37.4	0.0	0.0	213.6	12109.5

Table SD6. Landings at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial landings of American plaice from the Gulf of Maine-Mid-Atlantic Area, 1980-1991.

	AGE														
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
							LANDINGS IN NUMBERS (000'S) AT AGE								
1980	0.0	0.0	0.0	21.9	769.7	3128.8	3903.1	3629.1	1185.4	1138.6	849.9	323.0	155.4	215.3	686.7
1981	0.0	0.0	587.3	1331.5	4331.2	5100.0	3617.9	2380.9	1573.3	645.1	439.8	196.4	146.4	44.6	233.5
1982	0.0	0.0	113.2	2133.6	3494.6	4295.3	3481.1	3292.8	2037.6	1256.1	736.7	317.2	33.6	137.1	229.5
1983	0.0	0.0	0.7	437.7	3734.7	4270.3	3809.4	2252.1	1270.7	697.1	449.6	454.7	229.7	58.6	168.4
1984	0.0	0.0	3.4	253.2	1297.5	4818.6	2864.8	1913.4	577.2	273.8	307.2	64.9	57.2	0.0	646.8
1985	0.0	0.0	10.2	450.9	1285.9	2329.1	2135.9	1445.1	1513.0	392.4	139.6	103.1	97.1	5.0	378.2
1986	0.0	0.0	7.7	208.4	1684.5	1422.5	1458.3	816.7	605.5	214.7	173.5	91.8	5.8	26.7	200.4
1987	0.0	0.0	1.5	234.7	513.2	1748.6	1354.0	757.3	416.5	122.1	131.4	192.7	26.7	0.0	272.4
1988	0.0	0.0	0.0	424.9	1372.7	1507.1	977.3	553.9	115.8	205.9	38.4	86.4	0.0	0.0	316.5
1989	0.0	0.0	0.0	60.1	830.7	640.0	466.6	489.0	202.3	344.6	39.9	67.7	7.3	21.3	196.0
1990	0.0	0.0	0.0	178.9	923.4	994.6	669.4	327.2	216.0	142.9	13.0	9.4	3.4	0.0	215.6
1991	0.0	0.0	0.0	67.9	1475.1	3275.8	1216.5	359.9	196.5	34.5	7.5	37.4	0.0	0.0	213.6
							LANDINGS AT AGE (mt)								
1980	0.0	0.0	0.0	6.2	271.1	1386.6	2561.7	3008.1	1231.8	1347.4	1167.9	508.0	269.1	390.9	1448.2
1981	0.0	0.0	78.1	276.2	1484.8	2317.6	2831.6	2121.5	1545.0	728.9	551.6	265.9	256.8	81.8	358.4
1982	0.0	0.0	22.6	620.0	1165.8	1844.5	2007.0	3163.8	2319.5	1502.2	1143.6	551.0	65.4	224.2	523.5
1983	0.0	0.0	0.1	149.3	1719.6	2483.6	2596.1	1864.2	1325.5	867.4	650.1	638.4	404.8	107.9	379.8
1984	0.0	0.0	0.6	83.9	549.4	2913.2	1957.3	1713.4	688.1	310.1	420.5	133.6	93.1	0.0	1278.8
1985	0.0	.0	1.4	103.7	397.9	1097.7	1207.0	1126.4	1430.1	483.6	208.1	183.5	137.5	12.1	681.0
1986	0.0	0.0	1.2	50.7	509.3	585.3	885.8	638.8	674.8	252.8	220.5	136.7	12.6	40.9	397.4
1987	0.0	0.0	0.3	62.5	179.9	769.8	766.5	597.1	380.4	146.8	179.3	251.6	41.8	0.0	473.1
1988	0.0	0.0	0.0	120.1	529.9	795.2	659.8	450.5	111.2	269.0	59.5	114.4	0.0	0.0	475.8
1989	0.0	0.0	0.0	17.5	333.7	306.7	283.5	424.8	189.1	300.7	56.1	91.5	12.7	34.7	376.8
1990	0.0	0.0	0.0	69.7	395.9	550.4	457.8	303.3	209.1	153.3	21.8	11.9	5.3	0.0	325.6
1991	0.0	0.0	0.0	27.0	651.2	1787.6	881.2	332.9	225.2	36.0	13.0	47.3	0.0	0.0	379.5
							MEAN WEIGHT AT AGE (kg)								
1980	0.000	0.000	0.000	0.285	0.352	0.443	0.656	0.829	1.039	1.183	1.374	1.573	1.732	1.815	2.109
1981	0.000	0.000	0.133	0.207	0.343	0.454	0.783	0.891	0.982	1.130	1.254	1.354	1.755	1.836	1.534
1982	0.000	0.000	0.200	0.291	0.334	0.429	0.577	0.961	1.138	1.196	1.552	1.737	1.944	1.636	2.281
1983	0.000	0.000	0.184	0.341	0.460	0.582	0.682	0.828	1.043	1.244	1.446	1.404	1.762	1.843	2.255
1984	0.000	0.000	0.180	0.331	0.423	0.605	0.683	0.895	1.192	1.133	1.369	2.058	1.628	0.000	1.977
1985	0.000	0.000	0.136	0.230	0.309	0.471	0.565	0.779	0.945	1.233	1.491	1.780	1.416	2.430	1.800
1986	0.000	0.000	0.157	0.243	0.302	0.411	0.607	0.782	1.114	1.178	1.271	1.489	2.177	1.531	1.983
1987	0.000	0.000	0.211	0.266	0.351	0.440	0.566	0.788	0.913	1.202	1.365	1.305	1.565	0.000	1.737
1988	0.000	0.000	0.000	0.283	0.386	0.528	0.675	0.813	0.960	1.307	1.549	1.323	0.000	0.000	1.503
1989	0.000	0.000	0.000	0.292	0.402	0.479	0.608	0.869	0.934	0.873	1.407	1.353	1.729	1.628	1.923
1990	0.000	0.000	0.000	0.390	0.429	0.553	0.684	0.927	0.968	1.073	1.677	1.264	1.531	0.000	1.510
1991	0.000	0.000	0.000	0.398	0.441	0.546	0.724	0.925	1.146	1.043	1.729	1.264	0.000	0.000	1.777

Table SD6 (continued).

MEAN LENGTH AT AGE (cm)

1980	0.00	0.00	0.00	32.61	34.66	37.12	41.69	44.78	47.92	49.86	52.20	54.36	56.02	56.66	59.09
1981	0.00	0.00	25.84	28.82	34.02	36.93	43.25	45.16	46.66	48.82	50.31	51.84	55.62	56.98	53.78
1982	0.00	0.00	29.03	32.42	33.73	36.36	39.54	46.32	48.83	49.88	53.87	55.72	58.00	54.98	60.65
1983	0.00	0.00	28.66	34.24	37.21	39.80	41.87	44.20	47.54	50.23	52.92	52.18	56.11	56.88	60.11
1984	0.00	0.00	28.47	33.85	36.31	40.27	41.76	45.25	49.91	49.33	52.18	59.00	54.87	0.00	59.33
1985	0.00	0.00	26.13	30.46	33.14	37.35	39.26	43.51	46.33	49.99	53.10	56.43	52.07	62.00	56.46
1986	0.00	0.00	27.31	30.92	33.03	36.11	40.49	43.69	48.58	49.57	50.69	53.34	60.00	54.00	58.15
1987	0.00	0.00	29.88	31.96	34.60	36.57	39.70	44.05	45.95	49.81	51.96	51.38	54.03	0.00	55.83
1988	0.00	0.00	0.00	32.45	35.58	38.99	41.78	44.28	46.79	51.18	54.05	41.83	0.00	0.00	53.23
1989	0.00	0.00	0.00	32.87	36.09	37.99	40.66	45.01	46.16	45.20	52.12	51.94	56.00	55.00	56.63
1990	0.00	0.00	0.00	35.79	36.80	39.51	42.00	45.64	46.64	48.22	55.48	51.00	54.00	0.00	53.32
1991	0.00	0.00	0.00	36.06	37.13	39.44	42.80	46.13	49.29	47.87	56.00	51.00	0.00	0.00	56.19

Table SD7. Stratified mean number per tow by age and stratified mean weight per tow (kg) of American plaice in NEFSC spring and autumn bottom trawl surveys, adjusted for vessel differences, in the Gulf of Maine - Georges Bank[1] area, 1980-1991.

	AGE GROUP																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	no/tow	wt/tow
Spring																	
1980	0.00	0.57	3.55	4.49	3.00	2.89	1.60	1.12	0.25	0.31	0.23	0.04	0.02	0.02	0.04	18.15	4.66
1981	0.00	0.13	3.49	4.31	3.55	2.67	1.74	1.45	0.79	0.41	0.34	0.07	0.09	0.07	0.09	19.20	6.03
1982	0.00	0.06	1.04	1.79	3.17	2.13	1.34	0.92	0.49	0.35	0.19	0.07	0.01	0.04	0.02	11.60	3.80
1983	0.00	0.20	3.68	3.33	4.48	2.64	1.18	0.58	0.32	0.15	0.15	0.11	0.05	0.02	0.04	16.92	4.60
1984	0.00	0.02	0.35	0.57	0.90	1.30	0.58	0.22	0.10	0.01	0.02	0.01	0.01	0.00	0.03	4.10	1.42
1985	0.00	0.03	0.32	0.98	0.86	0.73	0.86	0.46	0.42	0.12	0.07	0.04	0.02	0.02	0.02	4.94	1.88
1986	0.00	0.01	0.46	0.34	1.01	0.59	0.29	0.21	0.10	0.04	0.04	0.00	0.00	0.00	0.00	3.09	0.92
1987	0.00	0.12	0.72	1.18	0.81	0.61	0.29	0.19	0.09	0.03	0.04	0.04	0.01	0.00	0.00	4.13	1.08
1988	0.00	0.20	0.99	0.84	0.76	0.31	0.23	0.12	0.01	0.09	0.01	0.01	0.00	0.00	0.00	3.58	0.84
1989	0.00	0.05	1.59	1.27	0.86	0.49	0.29	0.16	0.03	0.07	0.01	0.01	0.00	0.00	0.00	4.81	0.75
1990	0.00	0.00	0.57	2.65	1.02	0.54	0.17	0.06	0.04	0.05	0.00	0.00	0.00	0.00	0.00	5.09	0.75
1991	0.00	0.03	0.71	1.63	2.33	0.92	0.15	0.07	0.04	0.02	0.00	0.02	0.00	0.00	0.01	5.91	1.05
Autumn																	
1980	0.00	1.58	2.22	2.72	2.85	1.53	1.03	0.93	0.57	0.31	0.20	0.11	0.04	0.07	0.08	14.24	5.12
1981	0.00	0.43	2.79	2.22	2.62	2.30	1.55	0.63	0.58	0.07	0.20	0.20	0.02	0.02	0.12	13.76	6.37
1982	0.00	0.20	0.91	1.65	1.27	0.57	0.48	0.30	0.17	0.19	0.08	0.03	0.00	0.00	0.02	5.88	2.49
1983	0.06	0.50	1.01	2.02	2.92	1.36	0.68	0.34	0.17	0.10	0.03	0.05	0.06	0.01	0.03	9.34	3.45
1984	0.02	0.22	2.24	1.56	1.21	1.07	0.51	0.12	0.10	0.00	0.03	0.01	0.02	0.00	0.01	7.12	2.02
1985	0.01	0.92	0.84	2.68	1.07	0.81	0.41	0.19	0.05	0.03	0.00	0.00	0.00	0.03	0.00	7.04	2.04
1986	0.10	0.51	1.48	0.89	1.45	0.47	0.43	0.16	0.12	0.04	0.01	0.02	0.01	0.00	0.00	5.68	1.60
1987	0.01	0.53	1.27	0.99	0.43	0.69	0.25	0.10	0.04	0.04	0.01	0.02	0.00	0.00	0.00	4.38	1.09
1988	0.00	2.84	2.97	2.39	0.78	0.47	0.10	0.07	0.00	0.03	0.00	0.02	0.00	0.00	0.00	9.69	1.46
1989	0.05	0.48	4.45	2.86	0.98	0.19	0.10	0.02	0.02	0.02	0.02	0.00	0.01	0.02	0.00	9.22	1.17
1990	0.01	1.52	2.26	7.49	2.89	0.59	0.25	0.11	0.07	0.02	0.02	0.01	0.01	0.00	0.01	15.46	2.90
1991	0.02	0.47	2.48	2.03	1.59	0.73	0.30	0.04	0.07	0.00	0.01	0.00	0.00	0.00	0.01	7.71	1.55

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

Table SD8. Stratified mean number per tow by age of American plaice in Massachusetts State spring and autumn bottom trawl surveys in Massachusetts Bay and Cape Cod Bay (Regions 4 + 5), 1982-1991.

YEAR	0	1	2	3	4	5	6	7	8	9	10	11
Spring												
1982	0.00	7.18	49.25	33.35	17.14	5.00	2.42	1.12	0.26	0.15	0.03	0.07
1983	0.00	1.93	18.76	22.42	21.46	10.22	2.37	0.73	0.20	0.19	0.06	0.10
1984	0.00	2.15	27.44	21.32	10.57	4.64	1.21	0.18	0.09	0.01	0.03	0.07
1985	0.00	21.56	17.16	24.22	9.50	3.77	2.24	0.65	0.76	0.12	0.04	0.03
1986	0.00	27.06	110.27	26.91	14.43	2.84	0.61	0.05	0.08	0.06	0.00	0.16
1987	0.00	34.36	17.26	15.79	3.90	1.76	0.51	0.10	0.02	0.00	0.00	0.00
1988	0.00	81.47	63.57	17.85	8.72	1.54	0.47	0.09	0.00	0.00	0.00	0.00
1989	0.00	8.07	127.26	44.97	11.99	3.03	1.31	0.20	0.03	0.03	0.00	0.05
1990	0.00	7.73	25.37	56.71	16.48	3.43	0.53	0.11	0.10	0.13	0.00	0.00
1991	0.00	2.10	19.98	34.77	18.98	3.24	0.18	0.07	0.01	0.00	0.00	0.00
Autumn												
1982	0.17	13.24	15.46	10.22	5.11	1.14	0.56	0.14	0.05	0.05	0.01	0.08
1983	1.29	52.17	18.98	10.02	8.30	1.39	0.32	0.15	0.05	0.06	0.00	0.01
1984	0.11	3.14	13.24	4.27	1.83	0.77	0.24	0.04	0.05	0.00	0.00	0.00
1985	0.00	60.97	9.45	14.21	1.56	0.14	0.03	0.02	0.00	0.00	0.00	0.00
1986	0.23	41.27	40.08	12.07	5.30	0.39	0.13	0.01	0.00	0.00	0.00	0.00
1987	0.24	46.36	14.60	3.00	0.52	0.23	0.07	0.01	0.04	0.00	0.00	0.00
1988	0.00	85.63	41.28	13.98	1.34	0.45	0.08	0.00	0.00	0.00	0.00	0.00
1989	0.03	57.56	122.25	31.03	2.33	0.13	0.01	0.01	0.00	0.00	0.00	0.00
1990	0.08	31.99	14.20	20.12	3.93	0.21	0.03	0.00	0.00	0.00	0.00	0.00
1991	0.04	24.07	90.36	40.05	11.51	1.17	0.14	0.00	0.00	0.00	0.00	0.00

Table SD9. Estimates of instantaneous fishing mortality (F), beginning year stock sizes (millions of fish, 1 January), mean biomass (000s MT) and spawning stock biomass (000s MT) for American plaice as estimated from virtual population analysis (VPA), calibrated using the ADAPT procedure, 1980-1991.

(a) Fishing Mortality

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.0004	0.0020	0.0037	0.0009	0.0043	0.0045	0.0080	0.0037	0.0031	0.0692
2	0.0070	0.0332	0.0473	0.0384	0.0209	0.0389	0.0318	0.0447	0.0237	0.0350
3	0.0450	0.0880	0.1257	0.1125	0.0840	0.0943	0.1036	0.1342	0.1377	0.0868
4	0.1663	0.2090	0.2353	0.3223	0.2671	0.2185	0.2822	0.2417	0.3755	0.2511
5	0.2540	0.4211	0.2917	0.4647	0.7342	0.5344	0.3567	0.5377	0.5821	0.3216
6	0.3421	0.3577	0.5492	0.4558	0.6449	0.7047	0.7405	0.6782	0.5155	0.4203
7	0.4542	0.3632	0.6449	0.8558	0.4249	0.6916	0.6379	1.1879	0.6142	0.5423
8	0.3918	0.3632	0.6008	0.5567	0.5472	0.7129	0.7135	0.8116	0.5548	0.4760
9	0.3918	0.3632	0.6008	0.5567	0.5472	0.7129	0.7135	0.8116	0.5548	0.4760

	1990	1991
1	0.0011	0.0058
2	0.1030	0.0182
3	0.1035	0.1257
4	0.1919	0.1998
5	0.3215	0.6516
6	0.4696	0.6739
7	0.4690	0.4762
8	0.4751	0.5751
9	0.4751	0.5751

Mean F (unweighted) summed through age 9

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.2281	0.2445	0.3444	0.3738	0.3638	0.4125	0.3987	0.4946	0.3735	0.2976
2	0.2565	0.2748	0.3870	0.4204	0.4088	0.4635	0.4475	0.5559	0.4198	0.3261
3	0.2922	0.3093	0.4355	0.4749	0.4642	0.5242	0.5069	0.6290	0.4764	0.3677
4	0.3334	0.3462	0.4871	0.5353	0.5276	0.5958	0.5741	0.7115	0.5328	0.4146
5	0.3668	0.3737	0.5375	0.5780	0.5797	0.6713	0.6324	0.8054	0.5643	0.4472
6	0.3950	0.3618	0.5989	0.6063	0.5410	0.7055	0.7014	0.8723	0.5598	0.4787

	1990	1991
1	0.2900	0.3668
2	0.3261	0.4119
3	0.3580	0.4682
4	0.4004	0.5253
5	0.4421	0.5904
6	0.4722	0.5751

Mean F (weighted by N) summed through age 9

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	0.1350	0.1756	0.2413	0.2746	0.2864	0.2553	0.1974	0.1720	0.0986	0.1028
2	0.1712	0.2018	0.2773	0.3331	0.3404	0.3200	0.2713	0.2912	0.1988	0.1127
3	0.2197	0.2562	0.3193	0.3907	0.4345	0.3926	0.3550	0.4116	0.3529	0.2069
4	0.2940	0.3187	0.3970	0.4562	0.5315	0.5215	0.4473	0.5402	0.4913	0.3424
5	0.3444	0.3812	0.4728	0.5255	0.6200	0.6503	0.5602	0.6881	0.5629	0.4162
6	0.3903	0.3610	0.5960	0.5612	0.5460	0.7050	0.7057	0.8153	0.5503	0.4738

	1990	1991
1	0.1118	0.1801
2	0.1572	0.2108
3	0.1738	0.3029
4	0.2747	0.3609
5	0.3970	0.6367
6	0.4715	0.6090

Table SD9 (continued).

(b) Stock Numbers (Jan 1) in millions

■	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	43.366	21.967	17.598	18.799	12.935	13.274	16.284	28.552
2 ■	36.710	35.492	17.949	14.354	15.377	10.544	10.819	13.226
3 ■	37.119	29.846	28.110	14.016	11.309	12.329	8.303	8.581
4 ■	24.704	29.055	22.376	20.296	10.254	8.513	9.186	6.129
5 ■	21.059	17.127	19.302	14.479	12.039	6.427	5.602	5.672
6 ■	15.058	13.374	9.203	11.805	7.448	4.730	3.084	3.210
7 ■	10.996	8.756	7.657	4.351	6.127	3.200	1.914	1.204
8 ■	4.042	5.716	4.986	3.290	1.514	3.280	1.312	0.828
9 ■	11.393	6.143	6.555	5.270	3.502	2.386	1.524	1.460
1+■	204.446	167.476	133.737	106.659	80.504	64.684	58.028	68.861

■	1988	1989	1990	1991	1992
1 ■	52.164	22.850	30.552	13.588	0.000
2 ■	23.290	42.576	17.457	24.986	11.061
3 ■	10.355	18.621	33.661	12.894	20.088
4 ■	6.143	7.388	13.978	24.850	9.310
5 ■	3.941	3.455	4.705	9.446	16.661
6 ■	2.712	1.803	2.051	2.793	4.031
7 ■	1.334	1.326	0.969	1.050	1.166
8 ■	0.301	0.591	0.631	0.497	0.534
9 ■	1.662	1.956	1.113	0.733	0.566
1+■	101.902	100.567	105.118	90.837	63.417

Sum of Stock Numbers through Age 9

■	1980	1981	1982	1983	1984	1985	1986	1987
1 ■	204.446	167.476	133.737	106.659	80.504	64.684	58.028	68.861
2 ■	161.080	145.509	116.140	87.861	67.570	51.410	41.744	40.309
3 ■	124.371	110.017	98.191	73.507	52.193	40.866	30.925	27.083
4 ■	87.251	80.171	70.080	59.491	40.884	28.536	22.622	18.503
5 ■	62.548	51.116	47.704	39.195	30.630	20.023	13.436	12.374
6 ■	41.489	33.990	28.402	24.716	18.592	13.596	7.834	6.702

■	1988	1989	1990	1991	1992
1 ■	101.902	100.567	105.118	90.837	63.417
2 ■	49.738	77.716	74.566	77.249	63.417
3 ■	26.448	35.140	57.109	52.263	52.356
4 ■	16.093	16.519	23.448	39.369	32.268
5 ■	9.949	9.131	9.469	14.519	22.958
6 ■	6.009	5.676	4.764	5.072	6.297

(c) MEAN BIOMASS (000s MT)

■	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	0.747	0.497	0.366	0.221	0.152	0.180	0.221	0.362	0.708
2 ■	1.791	3.419	1.781	0.460	0.897	0.516	0.541	0.704	1.023
3 ■	5.070	4.460	5.926	2.407	1.900	1.741	1.131	1.167	1.740
4 ■	5.399	7.631	5.461	6.102	2.663	1.969	2.041	1.293	1.607
5 ■	6.754	5.639	6.435	5.659	4.303	2.103	1.705	1.625	1.408
6 ■	7.579	7.996	3.711	5.801	3.203	1.743	1.213	1.177	1.298
7 ■	6.690	5.905	4.968	2.217	4.069	1.649	1.014	0.513	0.742
8 ■	3.170	4.288	3.904	2.407	1.271	2.033	0.958	0.476	0.203
9 ■	13.097	6.177	6.674	5.475	4.087	2.393	1.487	1.346	1.656
1+■	50.296	46.012	39.225	30.749	22.544	14.327	10.311	8.662	10.383

Table SD9 (continued).

■	1989	1990	1991
1 ■	0.341	0.360	0.184
2 ■	1.707	0.813	1.392
3 ■	2.202	4.732	1.959
4 ■	1.897	3.724	6.739
5 ■	1.128	1.877	3.199
6 ■	0.728	1.000	1.339
7 ■	0.798	0.654	0.706
8 ■	0.401	0.444	0.396
9 ■	1.834	1.090	0.827
1+■	11.035	14.695	16.741

Sum of Mean Biomass through age 9

■	1980	1981	1982	1983	1984	1985	1986	1987	1988
1 ■	50.296	46.012	39.225	30.749	22.544	14.327	10.311	8.662	10.383
2 ■	49.549	45.515	38.859	30.528	22.392	14.147	10.090	8.301	9.675
3 ■	47.758	42.096	37.078	30.068	21.495	13.631	9.550	7.597	8.653
4 ■	42.688	37.635	31.152	27.661	19.595	11.890	8.418	6.430	6.913
5 ■	37.290	30.004	25.691	21.558	16.932	9.921	6.377	5.137	5.306
6 ■	30.536	24.366	19.257	15.900	12.629	7.818	4.672	3.512	3.898

■	1989	1990	1991
1 ■	11.035	14.695	16.741
2 ■	10.694	14.335	16.557
3 ■	8.987	13.521	15.165
4 ■	6.785	8.789	13.206
5 ■	4.888	5.065	6.467
6 ■	3.760	3.188	3.268

(d) Spawning Stock Biomass at Start of the Spawning Season (males & females (000s MT))

■	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1 ■	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2 ■	0.075	0.145	0.076	0.019	0.038	0.022	0.023	0.030	0.043	0.072
3 ■	1.290	1.146	1.536	0.622	0.488	0.448	0.292	0.303	0.452	0.566
4 ■	4.236	6.044	4.349	4.950	2.135	1.562	1.642	1.031	1.318	1.516
5 ■	7.126	6.157	6.843	6.232	4.980	2.348	1.838	1.815	1.586	1.207
6 ■	8.488	8.983	4.329	6.646	3.803	2.092	1.465	1.406	1.504	0.828
7 ■	7.740	6.709	5.957	2.757	4.680	1.995	1.214	0.671	0.885	0.938
8 ■	3.622	4.871	4.645	2.840	1.497	2.467	1.163	0.587	0.239	0.466
9 ■	14.966	7.018	7.939	6.460	4.813	2.904	1.805	1.662	1.953	2.131
1+■	47.544	41.073	35.674	30.527	22.434	13.838	9.442	7.504	7.979	7.724

■	1990	1991
1 ■	0.000	0.000
2 ■	0.035	0.059
3 ■	1.221	0.508
4 ■	2.938	5.327
5 ■	2.009	3.648
6 ■	1.149	1.598
7 ■	0.759	0.820
8 ■	0.516	0.469
9 ■	1.266	0.980
1+■	9.892	13.408

The above SSBs by age (a) and year (y) are calculated following the algorithm used in the NEFSC projection program, i.e.

$$SSB(a,y) = W(a,y) \times P(a,y) \times N(a,y) \times \exp[-Z(a,y)]$$

where $Z(a,y) = 0.25 \times M(a,y) + 0.25 \times F(a,y)$
$N(a,y)$ - Jan 1 stock size estimates (males & females)
$P(a,y)$ - proportion mature (generally females)
$W(a,y)$ - weight at age at the beginning of the spawning season

The W(a,y) are assumed to be the same as the mid-year weight at age estimates (see "WT AT AGE" table in input section).

Table SD10. Input parameters and projection results for American plaice: landings and spawning stock biomass (mt). Starting stock sizes on 1 January 1992 are as estimated from VPA. Partial recruitment is based on geometric mean of F at age. Recruitment levels in 1992-1993 are estimated as the geometric mean of numbers at age during 1980-1990. (± 1 standard error). Average weight at age in stock, landings and discards is the arithmetic mean of catch, landings and discard weights at age, 1989-1991. Proportion of F, M before spawning= 0.167.

a)

					Average Weights		
Age	Stock size in 1992	Fishing Mortality Pattern	Proportion Landed	Proportion Mature	Stocks	Landings	Discard
1	22933	0.0184	0.00	0.00	0.015	0.000	0.015
2	11061	0.1263	0.00	0.04	0.054	0.000	0.053
3	20088	0.1994	0.05	0.24	0.159	0.360	0.147
4	9310	0.4618	0.49	0.72	0.323	0.424	0.240
5	16661	0.6764	0.79	0.95	0.478	0.526	0.282
6	4031	1.0000	0.90	0.99	0.643	0.672	0.305
7	1166	1.0000	0.98	1.00	0.901	0.907	0.305
8	534	1.0000	1.00	1.00	1.016	1.016	0.305
9+	566	1.0000	1.00	1.00	1.420	1.420	0.305

b)

	1992 (F_{sq} = F_{1992})				1993			
Recruitment in 1992-93	F	Land.	Disc.	SSB	F	Land.	Disc.	SSB
Low=19982	0.58	4441	907	13962	F_{sq} = 0.58	4796	778	13604
					$F_{0.1}$ = 0.17	1656	251	14370
					F_{max} = 0.28	2607	403	14160
					$F_{20\%}$ = 0.49	4196	671	13768
Mid=22933	0.58	4441	907	13962	F_{sq} = 0.58	4796	786	13609
					$F_{0.1}$ = 0.17	1656	254	14375
					F_{max} = 0.28	2607	407	14165
					$F_{20\%}$ = 0.49	4196	678	13773
High=26285	0.58	4441	908	13962	F_{sq} = 0.58	4796	796	13614
					$F_{0.1}$ = 0.17	1656	257	14381
					F_{max} = 0.28	2607	412	14171
					$F_{20\%}$ = 0.49	4196	687	13779

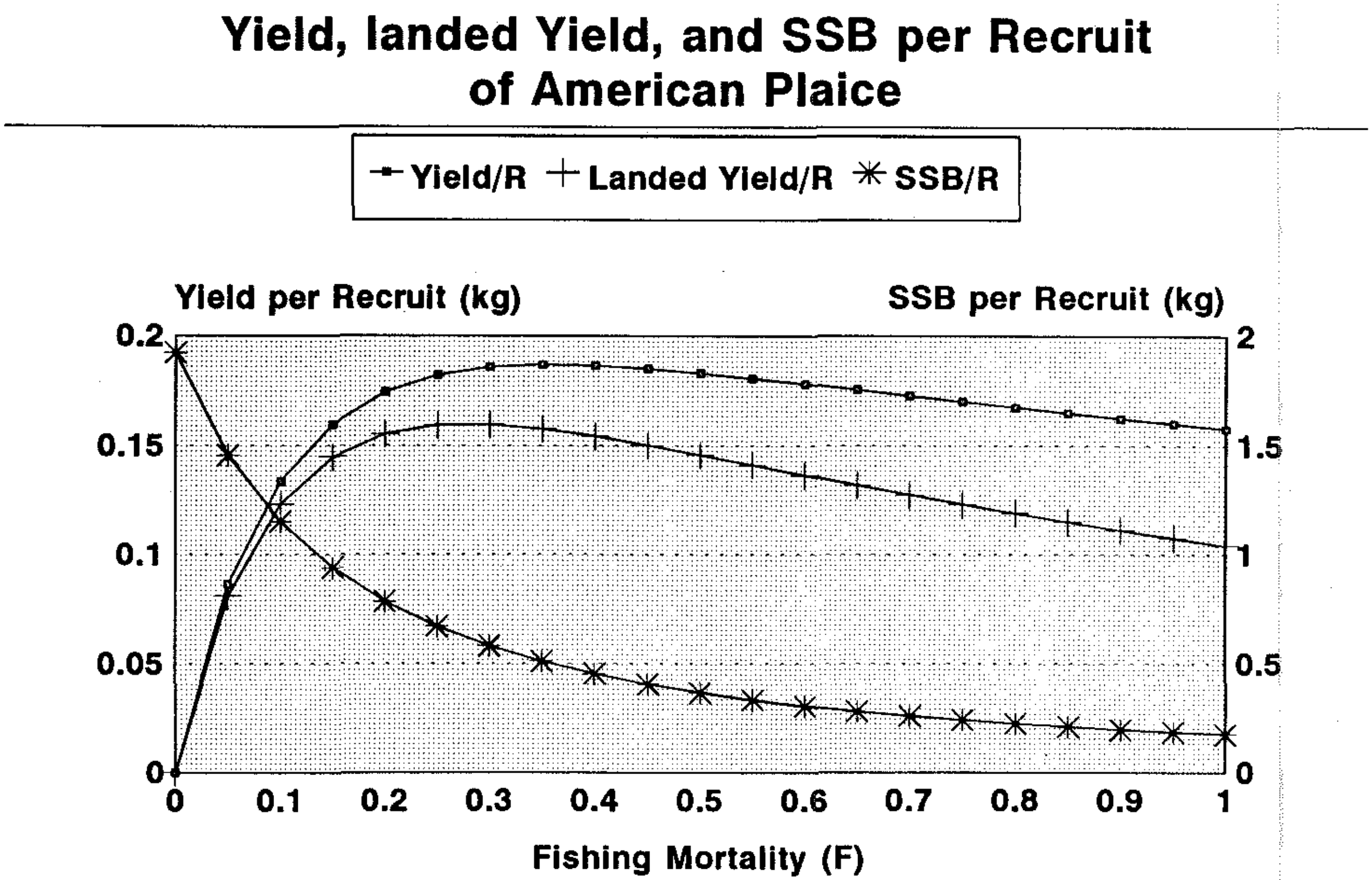
Yield, landed Yield, and SSB per Recruit
of American Plaice
Yield/R
Landed Yield/R
SSB/R
Yield per Recruit (kg)
SSB per Recruit (kg)
0.2
0.15
0.1
0.05
0
2
1.5
1
0.5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fishing Mortality (F)

Figure SD1.

SHORT FIN SQUID

An updated, index level assessment was presented in SAW/14/SARC/2. The general conclusion of the SARC was that the relative abundance of the short-finned squid population has improved from the low levels observed in the mid-1980s. Current levels of US domestic landings are high. The SARC found no evidence of over-exploitation.

Background

The short-finned squid (Illex illecebrosus) population is a single stock throughout the area of exploitation from Cape Hatteras to Newfoundland. Illex migrate offshore in late autumn and return to nearshore waters in the summer to feed. Most Illex squid hatched in the winter spawn in the summer of the following year and most hatched in the summer spawn in the winter of the following year (Mesnil 1977; Lange and Sissenwine 1981). Major Illex spawning grounds are south of Cape Hatteras (Rowell and Trites 1985), although spawning occurs in other areas as well.

Domestic landings of Illex began in the 1800s as a bait fishery. From 1928 to 1967, Illex and Loligo squid landings from Maine to North Carolina (including Loligo pealei) averaged roughly 2,000 mt annually. Directed foreign fishing for Illex began in 1972, and from 1972 to 1982 total Illex landings averaged 19,000 mt (Table SE1). From 1983 to 1991, Illex landings have averaged 8,400 mt. Since 1982 directed foreign effort has been curtailed, and at present, the Illex fishery is an entirely domestic.

1991 domestic landings were a record 11,929 mt valued at $6,950,000, an increase of 5% over 1990 landings and 63% above the 1982 - 1990 average.

The majority of the 1991 landings (99.9%) were removed with bottom otter trawls on 172 trips. Most of these landings occurred in statistical area 62 where 10,470 mt. of Illex squid were landed in 122 trips. Other fishing gears (lobster and shrimp trawls and scallop dredges) caught less than 0.1% of landings in 13 trips.

The Illex fishery is regulated under the Atlantic mackerel, squid, and butterfish FMP. The 1991 allowable biological catch was 18,000 mt.

Data Sources

Landings were obtained from joint venture, interview, and trip weighout records, and 1973-1988 ICNAF and NAFO statistical bulletins. Normal landings and effort statistics used in the CPUE analysis were taken from domestic fishery weighout records.

Discards in the directed Illex fishery are believed to be minimal.

Yearly length frequency data consisted of dorsal-mantle length measurements of 2961, 920, 1690, 411, 866, 600, 759, 159, 324, and 751 squid collected from 1982 to 1991.

Research survey data for 1967 - 1991 were used to calculate stratified mean number per tow of all sizes, pre-recruits (<10cm), and recruits (>10cm) from both the fall and spring bottom trawl surveys.

Age at 50% maturity is 18 months (NEFSC 1991). The corresponding size is 20cm (7.9 in.). Maximum age is about 24 months.

Methodology

The assessment is based on methods and data sources previously described (NEFSC 1991). Survey indices, landings, and commercial CPUE were used to discern the historical pattern of abundance and to indicate the response of the stock to exploitation.

The SAW/12/SARC recommendation to take a statistical approach to the analysis of CPUE data was addressed. A general linear model (GLM) was fit to nominal yield and effort data to determine a standardized unit of effort for the domestic fishery. Nearly all domestic Illex landings are caught with bottom otter trawls, so trips that did not use this gear were excluded from the analysis. The effects of year, area, and tonnage class were modeled; interactions between these main effects were not considered. Years from 1982 to 1991 were included. Three tonnage classes were analyzed: vessels between 5 and 50 GRT, vessels between 51 and 150 GRT, and vessels between 151 and 500 GRT. Data from vessels below 5 GRT were not available for individual fishing trips. Vessels above 500 GRT were excluded because they landed less than 2% of the total.

Illex landed yields (weight) from Cape Hatteras to the Gulf of Maine and NAFO Subareas 2,3, and 4 during 1982 to 1991 were converted to catches (numbers) of squid using commercial length frequency samples.

A transformation (Lange and Johnson 1981) was used to convert sample lengths into weights. The calculated average weights were then divided into yields to compute the numbers landed.

The method of Collie and Sissenwine (1983) was used to calculate abundance during 1982-1991 from catches and research survey cruise observations with a prior knowledge of the natural mortality rate, pre-recruit selectivity to the research gear, and size at recruitment to the research gear.

Assessment Results

CPUE abundance indices developed from nominal fishery statistics (Figure SE1) exhibit fluctuation, without trend, 1981 - 1991. Spring research cruise survey indices indicate the same; but, the coefficients of variation of these indices are much larger than those of the fall survey. The fall research cruise survey index is positively correlated with directed (r=0.70) and total (r=0.67) CPUE indices during 1982 - 1990 (NEFSC 1991). High abundance was observed on fall cruises during 1976 - 1981 and 1987 - 1990 (Figure SE2); such abundance probably supported the increase in fishery effort in 1990 and 1991 (Figure SE3). Research cruise survey data indicate that present abundance is greater than 1982 - 1986 and near the 1967 - 1991 average.

Stock size calculations were found to be highly dependent on the assumed level of natural mortality (1.5, 1.6, 5.1), but the trends were the same as the research cruise indices.

Overfishing occurs if the three year moving average of the fall research cruise pre-recruit index is in the lowest quartile of the 1963 - 1991 series (MAFMC 1991). If $(r_y+r_{y-1}+r_{y-2})/3 \leq B$, where the r_i are the fall pre-recruit indices and B is the largest index of the lowest one-quarter of indices, then over-fishing has occurred. The fall research cruise pre-recruit indices are:

Year:	67	68	69	70	71	72	73	74	75	76	77
Index:	0.1	0.2	0.1	0.3	1.1	0.1	1.8	6.2	1.1	5.1	2.6
Year:	78	79	80	81	82	83	84	85	86	87	88
Index:	0.7	0.7	1.1	0.2	1.1	0.2	0.4	0.3	0.5	1.3	0.7
Year:	89	90	91								
Index:	1.9	1.2	0.4								

Therefore, for 1991:

$$\frac{1.91+1.2+0.4}{3} > 0.3$$

so over-fishing did not occur. For 1992:

$$\frac{1.2+0.4+r_{92}}{3} \leq 0.3$$

so unless $r_{92} \leq -0.7$, which is not possible, overfishing will not occur.

SARC Analyses

The results of studies that addressed recommendations of SAW/12/SARC, i.e., to use GLMs to determine a standardized unit of effort, to use MULTIFAN to convert size samples to age samples, and to estimate total population size (SAW/14/SARC/2) were extensively discussed. The SARC expressed concern regarding the use of MULTIFAN in cases where the required prior knowledge is uncertain.

The SARC also noted that abundance estimation methods with results that are highly sensitive to unknown a priori knowledge may not be particularly useful in some cases.

Major discussion focused on the speculation of Illex availability both to the survey and the fishery since the U.S. EEZ is likely to be the edge of the distribution. No additional analyses were performed during the SARC.

Major Sources of Uncertainty

- Availability to the commercial fishery and to the survey may be highly variable because only the edge of the stock's distribution is probably available to the fleet. This results in substantial year to year variation in catch rates. The research survey probably does not cover the range of the stock either.

- The definition of cohorts is extremely uncertain so the estimation of abundance from age data is not feasible. Size based assessment methods have not been applied so the response of the stock to exploitation is unknown.

Recommendations

- Evaluate Canadian assessments of Illex and incorporate (available) Canadian data.

- If feasible, obtain individual vessels' records for evaluation of CPUE abundance indices. Include CIs on CPUE indices of abundance.

- Attempt to develop a population model that correctly reflects Illex life history (two spawnings per year, heavy predation, terminal spawners, rapid changes in life history parameters) and the impact of environmental variability.

- Develop a survey specifically designed to estimate the relative abundance of Illex.

Literature Cited

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NEFSC. 1991. Report of the Spring 1991 NEFSC Stock Assessment Workshop. NEFSC Reference Document. Woods Hole, MA.

Rowell, T. and R. Trites. 1985. Distribution of larval and juvenile Illex in the Blake Plateau region. Vie Milieu. 35(3).

Table SE1. Illex squid landings (metric tons).

Year	Cape Hatteras to the Gulf of Maine: Domestic	Foreign	Total	NAFO Subareas 2, 3, and 4: Total
1963	810	0	810	–[1]
1964	358	2	360	–[1]
1965	444	78	522	–[1]
1966	452	118	570	–[1]
1967	707	285	992	–[1]
1968	678	2,593	3,271	–[1]
1969	562	975	1,537	–[1]
1970	408	2,418	2,826	–[1]
1971	455	159	614	–[1]
1972	472	17,169	17,641	–[1]
1973	530	18,625	19,155	641
1974	148	20,480	20,628	283
1975	107	17,819	17,926	17,696
1976	229	24,707	24,936	41,767
1977	1,024	23,771	24,795	83,480
1978	385	17,310	17,695	94,064
1979	1,780	15,742	17,522	162,092
1980	349	17,529	17,878	69,606
1981	631	14,723	15,354	32,862
1982	5,902	12,350	18,252	12,908
1983	9,944	1,776	11,720	421
1984	9,547	676	10,223	715
1985	4,997	1,053	6,050	673
1986	5,176	250	5,422	111
1987	10,260	0	10,260	1,694
1988	1,966	1	1,967	846
1989	6,802	0	6,802	6,537[3]
1990	11,316	0	11,316	10,867[3]
1991	11,929	0	11,929	–[2]

[1] ICNAF squid landings not reported by species prior to 1973
[2] Preliminary Illex landings from NAFO subareas 2, 3, and 4 in 1991 are not yet available.
[3] Preliminary landings.

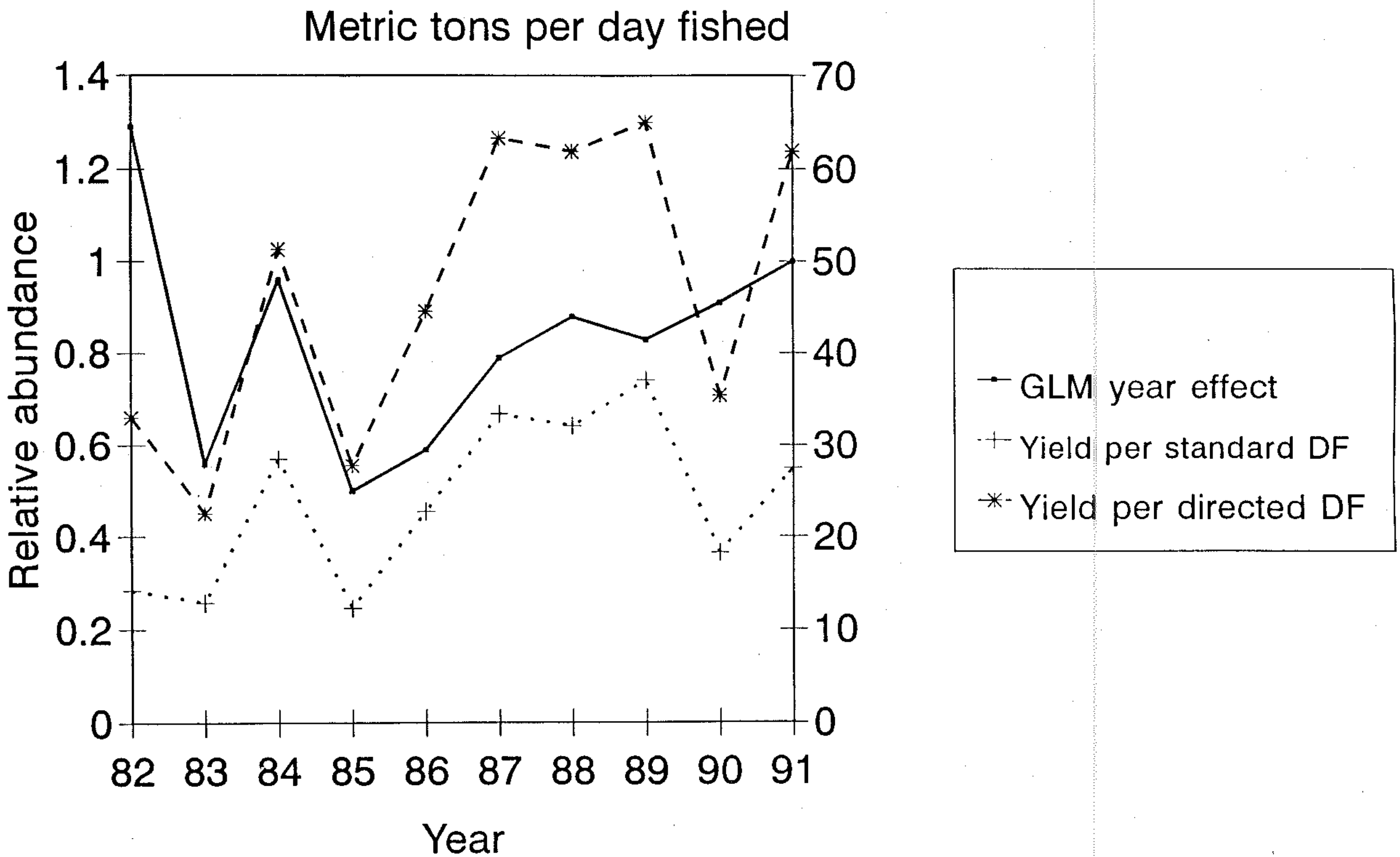

Figure SE1. Indices of Illex squid abundance.

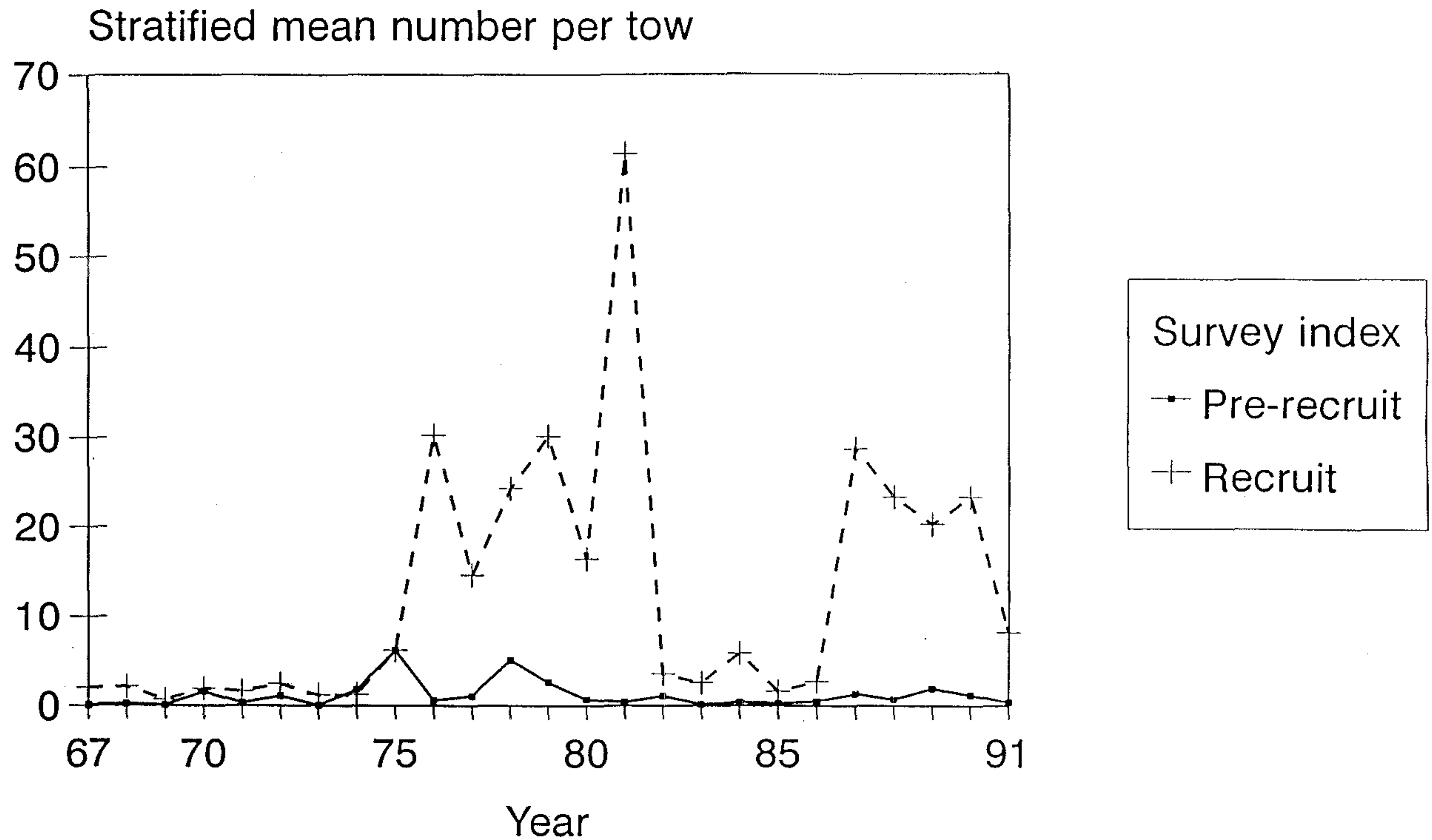

Figure SE2. Fishery independent indices of abundance for pre-recruit (≤10 cm) and recruited (>10 cm) *Illex* squid based on the NEFSC fall bottom otter trawl survey.

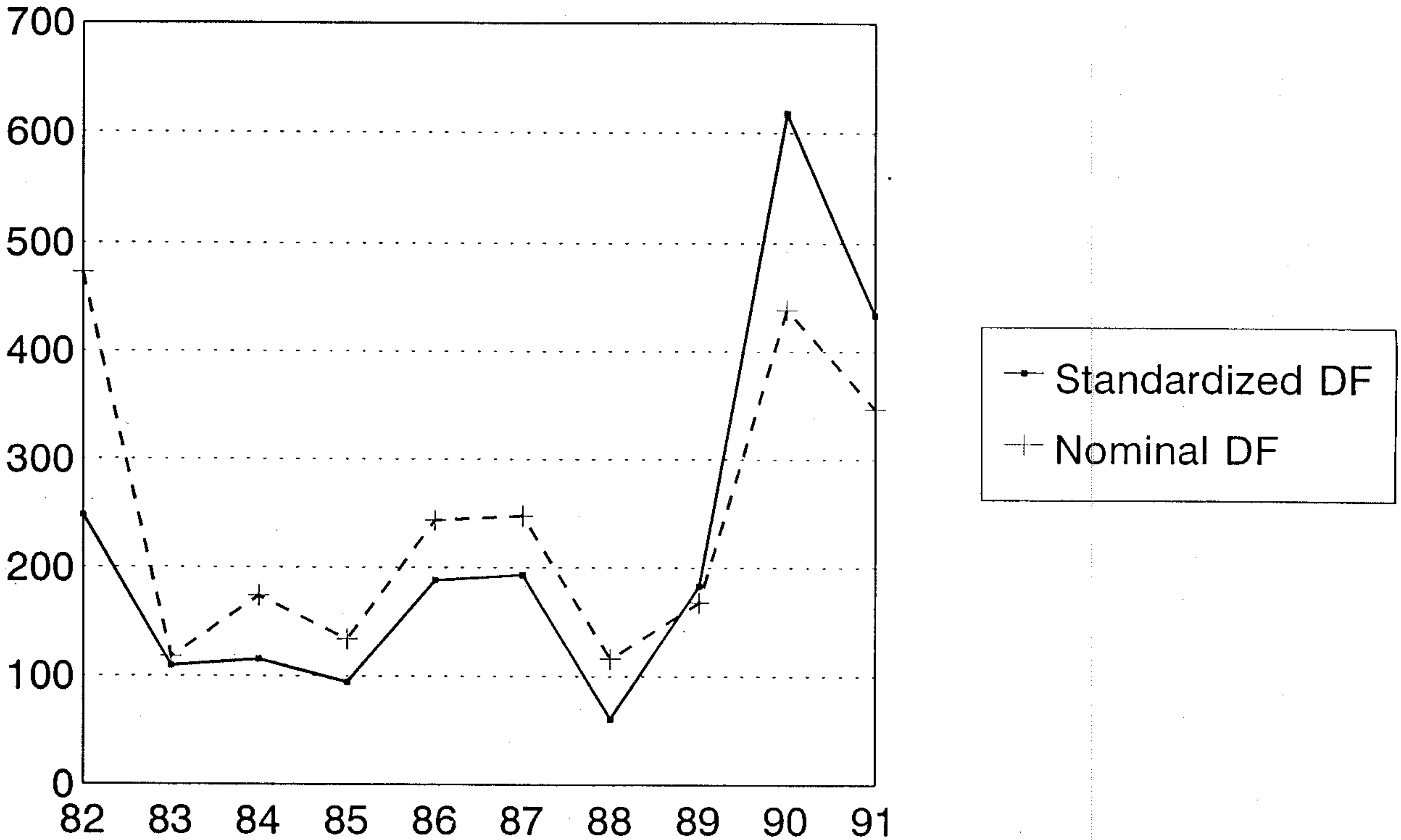

Figure SE3. Fishing effort for Illex squid.

LONG FIN SQUID

An index level assessment of the long-finned squid resource based on fishery statistics and research cruise survey observations indicates that abundance is above average in recent years (SAW/14/SARC/1). The SARC found no evidence of over-exploitation.

Background

Long-finned squid (Loligo pealei) range from Nova Scotia to the northern coast of South America. Loligo are assumed to constitute a unit stock throughout their range of commercial exploitation in the Northwest Atlantic from Nova Scotia to Cape Hatteras. North of Cape Hatteras, Loligo migrate offshore during late autumn to overwinter and migrate inshore during the spring and early summer. Larger squid move inshore before smaller squid (Mesnil 1977). Most spring-spawned hatchlings return to spawn in the summer of the following year. Hatchlings spawned in late-summer return to spawn in the spring two years later.

The domestic fishery began off the Northeastern United States in the late 1800s for bait. Modest landings occurred from the mid 1920s to the mid 1960s from Maine through North Carolina. A directed foreign fishery developed in 1967, expanded significantly in the 1970s,and decreased in the 1980s with the implementation of foreign fishing regulations. Since 1983, domestic landings have increased to levels previously attained by foreign fleets (Table SF1).

The vast majority of landings (97%) in 1991 were made with bottom otter trawl gear from statistical areas 53, 61 and 62. Other gears such as floating traps, mid-water trawls and pound nets take small amounts of Loligo.

Data Sources

The 1991 commercial landings and fishing effort were obtained from general canvass statistics and weighouts to update the information given in the last assessment report of the 12th SAW (NEFSC 1991). Length frequency samples (1982 - 1991) from commercial landings were also used; annual sample sizes were 3109, 4601, 4264, 2834, 2461, 2449, 3153, 7195, 6507, and 3526.

Methodology

Nominal yield per day fished from otter trawl trips by vessels over five GRT landing 75% or more (by weight of Loligo) were used to index abundance. A general linear model (GLM) was fit to nominal otter trawl yield and effort from statistical areas 53, 61, and 62. The model included terms for year, area, ton class, and quarter of the year. Interaction terms were not modeled. The estimated year effects were considered as possible abundance indices. Expected values were computed and divided into yields to calculate standardized fishing effort.

Research cruise abundance indices from both spring and fall surveys were calculated as the stratified mean numbers per tow. A pre-recruit index was calculated for Loligo 8 cm or less, an index for recruited Loligo (those larger than 8 cm), and a total.

The numbers landed was estimated from yields and length samples. The length frequencies were transformed to weight frequency samples with a weight-length conversion (lange and Johnson 1981) and the average weight calculated. Numbers caught were calculated as the quotient of yield and average weight for each month and two digit statistical area.

The method of Collie and Sissenwine (1988) was used to calculate abundances and mortalities from research cruise abundance indices and estimated catches.

Assessment Results

A generalized linear model explained very little of the variation in nominal yield and effort statistics (r^2=0.11), thus, the SARC did not consider those results (estimated year effects) to be an abundance index. Research cruise survey indices and yield per day fished on trips targeting Loligo (Table SF2) indicate that the resource probably is not stressed. There is no indication of declining abundance; recent research cruise indices are above average.

Calculations of population abundances and fishing mortalities (Table SF3) were found to be extremely sensitive to the assumed level of natural mortality. A prior knowledge of that parameter did not exist, so the SARC did not consider the results to be accurate estimates.

Overfishing for Loligo occurs when the three years moving average of fall research cruise pre-recruit indices is within the lowest quartile of the 1967 - 1991 time series (MAFMC 1990), i.e., if: $(r_y+r_{y-1}+r_{y-2})/3 \leq B$, where the r_i are the fall pre-recruit indices and B is the largest pre-recruit index of the lowest one-quarter. In 1991, there were 25 indices in the series. The highest of the lowest one-quarter (6) is 133.3, thus, if $271.9+175.7+184.8/3 \leq 133.3$ over-fishing occurred in 1991. Since 244.1>133.3 Loligo was not over-fished in 1991. In 1992, the highest index in the lowest quartile will be 152.0, the seventh lowest level in the 1967 - 1992 time series. The over-fishing definition is thus:

$$\{ 275.7+184.8+[1992 \text{ index}]\ 1/3 \leq 152.0$$

The solution gives the condition for overfishing in 1992, namely:

$$[1992 \text{ index}] \leq -4.5$$

which is not possible.

SARC Analyses

Additional runs of the GLM were conducted by the SARC. Various combinations of area, time and tonnage and percent directed trip cut-off points were employed in the GLM to attempt to remove the high level of unexplained variation in the catch and effort.
The attempts were not successful.

Major Sources of Uncertainty

- Abundance and mortality estimates are unavailable so statements about the status of this resource are very uncertain.
- The degree to which the inclusion of night tows in the CPUE indices affect the estimation of relative abundance is unknown. The variation in nominal yield and effort statistics has not been explained.

Recommendations

- o Examine the use of other population models better suited to the life history characteristics of Loligo to assess the abundance and exploitation history of the resource.

- o Continue development of abundance indices from nominal catch effort data. Continue investigation of appropriate measures of directivity that improve the GLM fits. Add terms in the GLM for each vessel identification. Test for the presence of interactions between main effects.

- o Investigate factors that may affect survey catchability, such as differences between day and night tows and sampling vessel differences. Investigate states' inshore survey data for incorporation into future assessments.

- o Investigations initiated by SAW 12 continued this year to use the proportion of zero Loligo tows in the NEFSC fall survey as a predictor of the domestic CPUE index. In addition, NEFSC spring and fall recruit indices were correlated to domestic CPUE, 1982 to 1991, to examine their use as a prediction tool. Although the results are not directly applicable to the assessment of Loligo, such investigations may generate useful insight into resource dynamics, and thus are useful.

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Table SF1. Annual *Loligo* squid catches (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the USA[1] and foreign fleets, 1963-91.

Year	USA	Foreign	Total
1963	1,294	0	1,294
1964	576	2	578
1965	709	99	808
1966	772	226	948
1967	547	1,130	1,167
1968	1,084	2,327	3,411
1969	899	8,643	9,542
1970	653	16,732	17,385
1971	727	17,442	18,169
1972	725	29,009	29,734
1973	1,105	36,508	37,613
1974	2,274	32,576	34,850
1975	1,621	32,180	33,801
1976	3,602	21,682	25,284
1977	1,088	15,586	16,674
1978	1,291	9,355	10,646
1979	4,252	13,068	17,320
1980	3,996	19,750	23,746
1981	2,316	20,212	22,528
1982	5,464	15,805	21,269
1983	15,943	11,720	27,663
1984	11,592	11,031	22,623
1985	10,155	6,549	16,704
1986	13,292	4,598	17,890
1987	11,475	2	11,477
1988	19,072	3	19,075
1989	23,007	5	23,012
1990	15,469	0	15,469
1991	19,392	0	19,392

[1]Includes joint venture catches made by USA catcher vessels

Table SF2. Abundance indices for *Loligo* squid.

Research cruise abundance indices

Year	Spring			Fall			Yield[3] per day fished (directed)
	Pre-recruit[1]	Recruit[2]	Total	Pre-recruit[1]	Recruit[2]	Total	
1967				116.0	18.5	134.5	
1968	5.4	19.9	25.3	111.7	64.8	176.5	
1969	1.8	12.1	13.9	150.6	87.0	237.3	
1970	16.7	8.3	25.0	50.8	34.7	85.5	
1971	19.1	13.8	32.9	133.3	30.0	163.3	
1972	34.8	26.5	61.3	207.0	64.4	271.4	
1973	18.1	21.8	39.9	259.0	113.0	372.0	
1974	184.3	33.1	217.4	175.3	76.4	251.7	
1975	118.2	38.1	156.3	510.6	103.8	614.4	
1976	144.5	43.8	188.3	307.9	110.8	418.7	
1977	9.5	8.3	17.8	297.7	90.8	388.5	
1978	35.5	12.9	48.4	94.6	52.6	147.2	
1979	91.4	18.0	109.4	160.1	37.9	198.0	
1980	38.4	14.6	53.0	280.9	84.7	365.6	
1981	26.3	18.8	45.1	166.1	66.1	232.2	
1982	45.6	24.8	70.4	208.2	53.4	261.6	5.37
1983	16.9	29.2	46.1	251.1	122.3	373.4	11.04
1984	52.0	22.6	74.6	152.0	147.7	299.7	8.89
1985	58.0	21.2	79.2	310.7	131.5	442.2	7.96
1986	66.4	27.8	94.2	360.4	92.6	453.0	7.32
1987	11.9	17.3	29.2	32.1	24.6	56.7	7.85
1988	86.8	33.9	120.7	320.0	93.7	413.7	11.23
1989	86.9	57.3	144.2	271.9	148.7	420.6	11.78
1990	94.2	30.8	125.0	275.7	95.9	371.6	7.00
1991	123.0	46.1	169.1	184.8	120.1	304.9	8.49
Avg.	54.9	24.1	79.0	216.8	81.1	297.9	

[1] 8 cm dorsal-mantle length or less.
[2] greater than 8 cm dorsal-mantle length.
[3] nominal yield per day fished from trips by trawlers over 5 G.R.T. landing 75% or more *Loligo* by weight.

Table SF3. Calculations of total population sizes and fishing mortality rates (F) for Loligo squid by the method of Collie and Sissenwine (1983).

			Semi-annual natural mortality rate		
			M=.54 RSS=18.96	M=.72 RSS=17.78	M=.84 RSS=16.97
Year	Season	Total catch[1]	Population size[1] (F)	Population Size[1] (F)	Population Size[1] (F)
1982	January-June	113.54	338.57 (.41)	580.37 (.22)	1519.87 (.08)
1982	July-December	118.27	808.37 (.16)	1371.82 (.09)	3511.70 (.03)
1983	January-June	181.49	451.72 (.51)	721.92 (.29)	1802.79 (.11)
1983	July-December	155.58	508.89 (.36)	980.69 (.17)	2806.48 (.06)
1984	January-June	142.48	478.97 (.35)	862.85 (.18)	2400.94 (.06)
1984	July-December	139.40	433.30 (.39)	839.38 (.18)	2426.12 (.06)
1985	January-June	104.18	424.92 (.28)	810.75 (.14)	2316.56 (.05)
1985	July-December	131.50	538.23 (.28)	1082.44 (.13)	3198.73 (.04)
1986	January-June	88.96	410.13 (.24)	806.59 (.12)	2368.13 (.04)
1986	July-December	111.22	514.43 (.24)	1006.83 (.12)	2907.22 (.04)
1987	January-June	76.81	252.62 (.36)	481.71 (.17)	1375.36 (.06)
1987	July-December	68.49	229.78 (.35)	421.92 (.18)	1176.12 (.06)
1988	January-June	143.82	493.64 (.34)	898.57 (.17)	2461.63 (.06)
1988	July-December	105.20	740.32 (.15)	1495.34 (.07)	4422.01 (.02)
1989	January-June	174.58	635.50 (.32)	1207.34 (.16)	3430.60 (.05)
1989	July-December	86.13	588.60 (.16)	1213.77 (.07)	3590.52 (.02)
1990	January-June	74.32	535.49 (.15)	1059.42 (.07)	3060.19 (.02)
1990	July-December	70.61	699.93 (.11)	1388.19 (.05)	4034.00 (.02)
1991	January-June	74.13	738.31 (.11)	1400.11 (.05)	3980.95 (.02)

[1] Millions of squid

ATLANTIC SEA SCALLOPS

An updated sea scallop assessment was presented which continued to address recommendations developed at the January 1991 Special Session of the SARC and at the 12th SAW. New analyses included (1) general linear model (GLM) approach to estimate standardized fishing effort by region (SAW/14/SARC/13) ; (2) a comparison of size composition of commercial samples with size composition of NEFSC survey catches (SAW/14/SARC/5); and (3) continued exploration of a DeLury method to estimate stock sizes and fishing mortality rates (SAW/14/SARC/12).

The sea scallop fishery in the Mid-Atlantic and Georges Bank regions was supported by above-average recruitment in recent years. U.S. normal yield per day fished declined 16% on Georges Bank and 20% on Mid-Atlantic grounds in 1991. Total U.S. effort reached record high levels in 1991, a 15% increase over the previous high in 1990. Estimates of fishing mortality (F) from experimental DeLury models exceed biological reference points.

In the Mid-Atlantic, survey indices of harvestable-size scallops declined substantially in 1991. The 1988 cohort, which will recruit in mid-1992, is moderately strong only in the Delmarva area and on the southern edge of its distribution off Virginia-North Carolina.

On Georges Bank, the fishery will be supported by a strong 1988 cohort, recruiting during 1992-1993.

Background

Atlantic sea scallops (Placopecten magellanicus) occur in waters from Newfoundland and Nova Scotia to North Carolina and are one of the most valuable living marine resources of the Northeast region. The fishery is conducted year round. The primary fishing gear is the scallop dredge (accounting for more that 95% of the landings in most years), with relatively small amounts take by otter trawl.

The fishery operates in several more or less distinct areas. Georges Bank (Area 5Z) is a major fishing ground for both Canadian and American fleets, accounting for about half the landings on average. It comprises three sub-areas: the South Channel (Areas 521, 522, and 526), the Southeast Part (Area 525) and the Northern Edge and peak (Areas 523 and 524/561, 562). Canadian landings are currently only taken from the latter sub-area. The Mid-Atlantic area (Area 6) has increased in importance in recent years. It comprises three sub-areas: New York Bight (Area 6A), Delmarva (Area 6B) and Virginia/North Carolina (Area 6C). Finally, the Gulf of Maine area in recent years has accounted for less than 10% of total landings.

Total commercial landings (US and Canada) peaked in 1978, declined to a ten-year low in 1984 and then increased to near-peak levels in 1991 (Table SG1). Total USA scallop landings in 1991 were the second highest on record, after 1990 (SAW/14/SARC/11).

In the analyses, explicit assumptions were made about stock structure, because areas of the fishery were treated separately.

Data Sources

Commercial fishery data

Data on landings (mt of meats) and effort (days fished) are available from the NEFSC weighout data base, with associated trip information on area, vessel tonnage class and dates fished.

There are three sources of data on size composition of the commercial catch. Vessel captains provide samples of 200 shells from the last tow of the trip to NEFSC port agents, who obtain shell height frequency data.

Similar data have been collected from shell-stocking vessels fishing in the Delmarva sub-area by the Virginia Institute of Marine Sciences, but these data are not yet available. Finally, data from the NEFSC domestic sea sampling program have been collected from eight trips, but are not yet audited. No age data are available.

Research survey data

Sea scallop research vessel surveys have been conducted by NEFSC in 1975 and annually since 1977 to assess population relative abundance, size composition and recruitment patterns (SAW/14/SARC/4). Because of Hurricane Bob, the Canadian portion of Georges Bank was not completely sampled in the 1991 survey.

Other input data

The natural mortality rate was assumed to be 0.1. Growth parameters were derived from Serchuk et al. (1979).

Methodology

General Linear Model of Catch Per Unit Effort

For each area (Georges Bank, Mid-Atlantic), a general linear model (GLM) of catch rate (mt per day fished) was fitted as a function of year (1982-1991), month, subarea (statistical areas as described above) and tonnage class (TC 3, 4) effects. Three formulations were evaluated: 1.) all main effects without interaction terms, 2.) all main effects with year-tonnage class interaction, 3.) all main effects with year-area interaction.

Size compositions of commercial vs. survey samples

For commercial samples, the proportion of scallops at shell height was estimated by subarea by averaging over samples taken in quarter 3 (survey season). Confidence intervals were calculated from square root transformed values. For survey samples, proportion of scallops at shell height was estimated by the strata set. Confidence intervals were calculated assuming that each tow was a cluster sample. Frequency distributions from the two sources and their associated confidence intervals were overlain and inspected visually for correspondences.

Examination of modified DeLury model

The modified DeLury model developed by the Sea Scallop Working Group was exercised to provide estimates of stock size and fishing mortality. The new analysis (1992) was applied to data aggregated over subarea. The old analysis (1991) was applied to each subarea separately. The assumptions used in MULTIFAN were revised (MULTIFAN was used to split survey data into two groups, age 3 and age 4+). This changed the apportioning of survey catches between age 3 and age 4+. In addition, in the new analysis, age 3 scallops were assumed to be fully recruited to the survey gear and age 4+ were assumed to be partially recruited. The previous analyses assumed the reverse i.e., partial recruitment of age 3 scallops and full recruitment of age 4+ scallops). In last year's and this analysis, the partial recruitment estimates for age 3 to the commercial fishery were based on two assumptions: (1) partial recruitment is a straight line that passes through 0% at 65 mm and 100% at 88 mm shell height, and (2) von Bertalanffy growth parameters K and L ; thus allowing for annually varying birth data but not growth rates. The effects of approximation of 1989 survey data from the northern edge and peak vs. exclusion of the subarea from the Georges Bank analysis were examined.

Assessment Results

The 1991 NEFSC scallop survey abundance indices indicate that both biomass and stock size in the Mid-Atlantic region has declined from the record-high levels of the late 1980s (Table SG2). The Georges Bank resource is now at its highest level since 1984 due, in large part, to a very strong 1988 year class.

In the Mid-Atlantic area, survey indices of harvestable-size and total scallops declined substantially in all regions, while indices of pre-recruit scallops increased significantly only in the Delmarva region (Table SG2). The exceptionally strong 1986 year class was heavily exploited in 1990/1991; and the 1987 year class, which is regionally variable in strength, now dominates the harvestable resource. The 1988 cohort appears moderately strong in Delmarva and very strong in Virginia-North Carolina (a subarea of erratic recruitment), and is expected to recruit to the commercial fishery beginning in mid-1992.

On Georges Bank, research cruise abundance indices markedly increased in the South Channel region, remained at high levels in the US Northern Edge and Peak areas and increased from record-low levels of 1990 in the Southeast Part (Table SG3). These indices indicate recruitment of the 1988 cohort appears to be outstanding in the South Channel region, and strong in the Southeast Part and Northern Edge and Peak regions of the Bank. This cohort is expected to have a major impact in supporting fishery landings during 1992 and 1993.

Total U.S. effort reached record high levels in 1991, with a 15% increase (nominal days fished) over the previous high in 1990. The largest proportional increase in effort was in the Mid-Atlantic region (Table SG4).

U.S. nominal landing yield per day fished (unstandardized, CPUE) indices declined in 1991 for all vessel classes in the Georges Bank and Mid-Atlantic fisheries (Table SG5). For Georges Bank, overall CPUE decreased by 16%. In the Mid-Atlantic, CPUE dropped 20% overall.

General linear models fit to normal fisheries statistics (SAW/14/SARC/13) failed to account for a significant amount of variation ($r^2 \leq 0.4$) thus the SARC concluded that estimated year effects were not appropriate abundance indices. In addition, since they did not include areas and month effects, standardized effort measures probably did not accurately measure effective effort.

SAW/12 requested an evaluation of the adequacy of the procedure for obtaining size samples from fishery. A comparison of survey and commercial landings size compositions do not estimate bias in the commercial samples because of differences in survey and commercial gear selectivity and culling practices. Research survey samples had a higher proportion of small scallops. Size ranges of the samples were similar, and strong year classes could be tracked in both data sources. Wide confidence intervals on proportion at length were common for fishery data and less common for survey data. A definitive analysis is not possible without direct samples from the fishery.

Last year, the modified DeLury method calculated the fishing mortality rate (F) to be 2.45 in the South Channel and 2.31 on Delmarva grounds in 1989 (Table SG6). These levels exceeded those of over-fishing (0.71), so SAW recommended reducing F. This year, F in 1990 is estimated to be 0.7-0.9 on Mid-Atlantic grounds, and 1.4-1.9 in the South Channel and southeastern part, but the SARC believes that the estimates are extremely uncertain (see SARC Analyses section).

Results of the modified DeLury analysis are highly sensitive to the combined changes of input parameters and data, e.g., dredge selectivity patterns, combining subareas into larger areas, and variability in survey observations. Within the time available, the SARC was unable to systematically evaluate and formalize the following three classes of requirements: (1) choices of appropriate procedures for development a priori knowledge required by the model from empirical observations. These topics include adjustment of survey data for dredge selectivity, imposition of age structure on survey length frequency data, development of estimates of catch in numbers from landings in weight, definition of appropriate levels of spatial and temporal resolution, etc.; (2) standards for invoking alternative fitting criteria; and (3) choices of appropriate procedures for development of statistics of interest from model output (e.g., estimation of fully-recruited F from model estimates of numbers of pre-recruits and fully recruited stock).

Until these aspects are formalized into agreed-upon, standardized procedures, model status (and any associated results) will continue to be experimental.

SARC Analyses

The SARC, to a limited degree, investigated the uncertainty about estimates of F. Last years data from Delmarva was considered. The estimation model was fit to it as before (M=0.1, log normal process error weighted double; so that the process error sum of squares was not only 10% of the total, etc.) and the predicted indices and residuals calculated. Parameters of the lognormal distribution were estimated from the residuals. Thus, for each 1,000 iterations, a set of residuals were drawn from the lognormal distribution and these were added to the predicted indices to give a "new" (i.e., proxy for observations) data set. The estimation model was then fit to the "new" data and F calculated. The frequency of estimates for each of the section assumptions (Figure SG1) show that although point estimates for the different section assumptions are very different and the distributions of estimates are very wide. This means that significant bias will occur if the wrong selection is chosen and that the estimator (even though conditional to several items) is not precise. It is also clear that if age 3 is partially recruited, the Delmarva 1989 F was high, higher than that of over-fishing. It is 0.9 probable that the 1989 F was 1.7 or larger and 0.75 probable that it was 1.9 or larger if all assumptions hold true. SARC did not have time to consider other components of variance (e.g, variance in the MULTIFAN estimates of mean shell height of the recruiting year-classes; variance in the input estimates of mean selectivity at length of the survey gear, etc.) so these estimates of variation are underestimates.

Sources of uncertainty in Fs other than variance and bias due to a incorrect selectivity assumption are not expressed in Figure SG1. Examples of other causes of bias include (there are still others):

Mis-specification of the survey selectivity pattern (e.g., flat-topped vs. dome shaped)

MULTIFAN complete mis-classification of a mode (e.g., as age 3 rather than age 4) rather than error in the precise position of the mode (variance).

Large mis-specification of natural mortality (e.g., 0.4 vs. 0.1)

These errors result from realities other than that assumed within the model structure.

Major Sources of Uncertainty

The following sources of uncertainty were considered significant for the current assessment and for sea scallop assessments in general:

- Estimation of commercial catch in numbers
- Partial recruitment to survey gear
- Age estimation from survey length frequency data (and commercial length frequency data)
- Estimation of fully-recruited F from DeLury model estimates of Z
- Effect of 1991 survey point, Mid-Atlantic region, on analytic results
- Missing survey data, Northeast Peak, Georges Bank

Recommendations

- o Improve sampling methods for estimating commercial catch in numbers (ideally at age), e.g., sampling at processor level or other alternative approaches to define partial recruitment to commercial fishery, to allow improved CPUE (GLM) analyses, and to improve catch in number estimates for DeLury or other estimates.

- o Conduct field experiments to define survey dredge selectivity: the ascending limb of the selectivity pattern is presently unknown. The gear selectivity pattern has an important influence on estimates from DeLury model.

- o Routinely age scallops from surveys and commercial catch. This would allow more accurate application of DeLury and other models for estimating numbers and F by age group (e.g., pre- vs. fully-recruited individuals).

- o Until ageing becomes routine, evaluate performance of MULTIFAN and other methods, including division of input data into two separately analyzed segments; or, use growth data to generate an age-length key, and fit with least-squares.

- o Investigate use of Canadian survey data to fill in gap in time series created by lack of sampling on Northeast Peak, Georges Bank.

- o Inspect 1992 survey index to resolve effect of 1991 survey data from Mid-Atlantic on analytic procedures

- o Continue development of modified DeLury model, systematically investigating sensitivity and appropriate scales of spatial resolution; and developing more formal procedures for its application. Investigate other model forms that make use of the same data types currently required by modified Delury model, but presently unavailable (or based on assumption). Consider maximum likelihood based estimators.

- o Evaluate sea sampling and VIMS data, when available, on size frequency distribution of commercially landed scallops for comparison with current NEFSC shell sampling program.

Literature Cited

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TABLE SG1. UNITED STATES AND CANADIAN SEA SCALLOP LANDINGS (METRIC TONS, MEATS) FROM THE NORTHWEST ATLANTIC (NAFO SUBAREA 5 AND STATISTICAL AREA 6), 1887 - 1991.

YEAR	USA [1]	YEAR	USA	CANADA [2]	TOTAL
1887	112	1948	7,546		7,546
1888 *	91	1949	8,299		8,299
1889	141	1950	9,063		9,063
1892	53	1951	8,503	91	8,594
1897	435	1952	8,451	91	8,542
1898	156	1953	10,713	136	10,849
1899 *	24	1954	7,997	91	8,088
1900 *	79	1955	10,036	136	10,172
1901	286	1956	9,102	317	9,419
1902	61	1957	9,523	771	10,294
1903 *	62	1958	8,608	1,179	9,787
1904	216	1959	11,178	2,378	13,556
1905	200	1960	12,065	3,470	15,535
1906 *	255	1961	12,456	4,565	17,021
1907 *	236	1962	11,174	5,715	16,889
1908	834	1963	9,038	5,898	14,936
1909 *	843	1964	7,704	5,922	13,626
1910 *	919	1965	9,105	7,052	16,157
1911 *	663	1966	7,237	7,669	14,906
1912 *	842	1967	4,646	5,025	9,671
1913 *	353	1968	5,473	5,243	10,716
1914 *	386	1969	3,363	4,320	7,683
1916 *	266	1970	2,613	4,097	6,710
1919	89	1971	2,593	3,908	6,501
1921	38	1972	2,655	4,177	6,832
1924	154	1973	2,401	4,223	6,624
1926	506	1974	2,722	6,137	8,859
1928	216	1975	4,422	7,414	11,836
1929	1,130	1976	8,721	9,780	18,501
1930	1,111	1977	11,103	13,091	24,194
1931	1,058	1978	14,482	12,189	26,671
1932	1,517	1979	14,256	9,207	23,463
1933	2,009	1980	12,566	5,239	17,805
1935	1,955	1981	11,742	8,018	19,760
1937	3,989	1982	9,044	4,330	13,374
1938	4,041	1983	8,707	2,895	11,602
1939	4,440	1984	7,739	2,042	9,781
1940	3,467	1985	6,742	3,851	10,593
1941 #	3,622	1986	8,661	4,705	13,366
1942	3,258	1987	13,227	6,810	20,037
1943	2,508	1988	13,198	4,405	17,603
1944	2,209	1989	14,776	4,676	19,452
1945	2,590	1990	17,174	5,130	22,304
1946	5,236	1991	16,998	5,833	22,831
1947	6,647				

1 USA landings: 1887-1960 from Lyles (1969); 1961-1975 from Fishery Statistics of the United States; 1963-1982 from ICNAF and NAFO Statistical Bulletins; 1964-1991 from Detailed Weighout Data, Northeast Fisheries Center, Woods Hole, Mass.

2 Canadian landings: 1951-1958 from ICNAF Statistical Bulletins and Caddy (1975); 1953-1988 from Mohn et al. (1989) for Georges Bank and from ICNAF/NAFO Bulletins for Gulf of Maine and Mid-Atlantic; 1989 from NAFO SCS Doc. 90/21; 1990, 1991 from DFO, Statistics Branch, Halifax.

* Maine landings only - from Baird (1956).

USA landings for 1941 from O'Brien (1961).

Table SG2. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFSC surveys in the Mid-Atlantic, 1975, 1977-1991. Data are presented by principal scallop regions in the Mid-Atlantic[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit ($\geq$70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
New York Bight	1975	28	39.4	34.7	74.1	0.10	0.62	0.72	75.3	46.9
	1977	101	1.4	56.7	58.1	<0.01	1.03	1.03	98.6	25.6
	1978	116	3.3	52.7	56.0	0.01	1.15	1.16	102.8	21.9
	1979	120	5.3	17.6	22.9	0.01	0.43	0.44	93.6	23.7
	1980	121	15.4	15.2	30.6	0.02	0.36	0.38	75.5	35.7
	1981	117	18.8	19.0	37.8	0.03	0.29	0.32	67.7	53.5
	1982	134	10.9	20.9	31.8	0.02	0.33	0.35	78.4	41.2
	1983	136	11.5	14.0	25.5	0.03	0.29	0.32	80.3	36.6
	1984	142	17.4	18.4	35.8	0.03	0.29	0.32	69.2	51.0
	1985	137	47.4	30.9	78.3	0.10	0.43	0.53	65.6	67.1
	1986	152	53.2	49.3	102.5	0.13	0.65	0.78	69.6	59.9
	1987	154	94.5	46.0	140.5	0.18	0.58	0.76	61.7	83.7
	1988	154	75.9	100.5	176.4	0.11	1.25	1.36	68.6	58.9
	1989	157	168.6	81.8	250.4	0.25	0.90	1.15	56.4	99.1
	1990	148	121.1	92.8	213.9	0.35	0.88	1.23	67.2	78.7
	1991	157	22.2	53.7	75.9	0.06	0.67	0.73	78.3	47.3
Delmarva	1975	15	36.2	24.0	60.2	0.11	0.44	0.55	75.2	49.3
	1977	10	10.7	47.5	58.2	0.03	0.91	0.94	92.2	28.1
	1978	45	27.3	75.8	103.2	0.09	1.58	1.67	91.6	28.0
	1979	43	25.4	64.6	90.0	0.04	0.95	0.99	78.8	41.2
	1980	43	81.1	35.9	117.0	0.13	0.68	0.81	63.3	65.7
	1981	41	4.7	14.3	19.0	0.01	0.32	0.33	90.3	26.2
	1982	44	10.0	18.6	28.6	0.04	0.43	0.47	89.8	27.8
	1983	49	25.7	16.5	42.2	0.09	0.37	0.46	77.0	41.7
	1984	52	19.8	19.3	39.1	0.03	0.38	0.41	69.8	43.7
	1985	54	70.4	35.8	106.2	0.15	0.43	0.58	58.9	82.5
	1986	62	123.5	83.5	207.0	0.37	0.93	1.30	68.5	72.3
	1987	61	52.9	59.5	112.4	0.16	0.74	0.90	74.1	56.7
	1988	62	75.9	39.1	115.0	0.15	0.62	0.77	64.6	67.9
	1989	62	113.1	97.2	210.3	0.24	1.09	1.33	67.5	71.6
	1990	62	27.7	80.9	108.6	0.06	0.87	0.93	76.9	53.0
	1991	61	53.5	29.3	82.8	0.16	0.47	0.63	71.3	59.4
Virginia-No. Carolina	1975	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1977	1	0.0	10.0	10.0	0.00	0.23	0.23	108.0	20.0
	1978	3	15.3	50.3	65.6	0.06	1.10	1.16	91.8	25.7
	1979	3	23.7	22.7	46.4	0.04	0.37	0.41	71.7	51.3
	1980	3	6.6	39.0	45.6	0.02	0.59	0.61	87.6	34.1
	1981	3	0.9	7.6	8.5	<0.01	0.20	0.20	107.7	18.8
	1982	7	0.4	3.7	4.1	<0.01	0.12	0.12	111.5	15.8
	1983	8	25.8	11.7	37.5	0.10	0.36	0.46	78.1	37.2
	1984	9	0.2	14.6	14.8	<0.01	0.27	0.27	98.7	25.3
	1985	10	1.7	7.3	9.0	<0.01	0.23	0.23	104.8	17.8
	1986	10	5.6	1.8	7.4	<0.02	0.04	0.06	69.1	55.9
	1987	10	0.1	2.1	2.2	<0.01	0.04	0.04	93.4	28.3
	1988	10	3.1	11.0	14.1	0.01	0.21	0.22	89.8	28.9
	1989	10	35.7	5.9	41.6	0.07	0.13	0.20	57.9	92.9
	1990	6	36.5	93.1	129.6	0.07	0.88	0.95	73.2	61.7
	1991	10	37.2	32.0	69.2	0.10	0.45	0.55	71.6	57.5
Mid-Atlantic (All Areas)	1975	43	38.8	32.6	71.4	0.10	0.59	0.69	75.3	47.2
	1977	112	2.8	55.1	57.9	0.01	1.00	1.01	97.7	25.9
	1978	164	7.8	56.8	64.6	0.02	1.23	1.25	99.4	23.4
	1979	166	9.1	26.2	35.3	0.02	0.52	0.54	86.5	29.8
	1980	167	27.1	19.2	46.3	0.04	0.42	0.46	70.1	45.8
	1981	161	16.1	18.0	34.1	0.02	0.30	0.32	70.1	48.2
	1982	185	10.6	20.3	30.9	0.03	0.34	0.37	80.4	38.1
	1983	193	14.3	14.4	28.7	0.04	0.30	0.34	79.4	37.8
	1984	203	17.6	18.5	36.1	0.02	0.31	0.33	69.5	49.2
	1985	201	51.0	31.5	82.5	0.11	0.43	0.54	64.1	69.8
	1986	224	65.2	54.8	120.0	0.17	0.69	0.86	69.3	63.3
	1987	225	85.7	47.9	133.6	0.17	0.61	0.78	63.6	78.0
	1988	226	74.9	88.3	163.2	0.12	1.12	1.24	68.1	59.9
	1989	229	156.9	83.6	240.5	0.24	0.93	1.17	58.1	93.5
	1990	216	103.2	90.6	193.8	0.29	0.88	1.17	68.2	74.9
	1991	228	28.0	49.0	77.0	0.08	0.63	0.71	76.8	49.4

[1] New York Bight: Strata 22-31, 33-35; Delmarva: Strata 10-11, 14-15, 18-19; VA-NC: Strata 6-7.

[2] Mean meat weight derived by applying the 1977-1982 USA Mid-Atlantic research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -12.1628 + 3.2539 ln Shell Height (mm) (n = 11943, r = 0.98) to the to the survey shell height frequency distributions.

Table SG3. USA sea scallop research survey relative abundance indices (standardized stratified mean number and mean weight per tow), [meats only, kg], mean shell height (mm), mean meat weight (g) per scallop, and average meat count (number of scallop meats per pound) of sea scallops from NEFSC surveys on Georges Bank, 1975, 1977-1991. Data are presented by principal scallop regions for the USA sector of Georges Bank[1]. Survey indices are presented for pre-recruit (<70 mm shell height), recruit (≥70 mm shell height), and total scallops per tow.

Area	Year	No. of Tows	Standardized Stratified Mean Number Per Tow			Standardized Stratified Mean Weight (kg) Per Tow[2]			Mean Shell Height	Average Meat Count
			Pre-recruit	Recruit	Total	Pre-recruit	Recruit	Total		
South Channel	1975	58	45.1	29.9	75.0	0.11	0.81	0.92	76.4	37.0
	1977	30	6.3	89.1	95.4	0.02	1.94	1.96	101.3	22.1
	1978	46	7.7	49.7	57.4	0.02	1.15	1.17	101.2	22.2
	1979	47	6.8	88.2	95.0	0.01	1.53	1.54	93.2	28.0
	1980	40	79.7	30.2	109.9	0.12	0.55	0.67	58.2	74.6
	1981	56	15.5	36.5	52.0	0.03	0.65	0.68	80.5	34.8
	1982	61	213.8	53.0	266.8	0.49	0.67	1.16	58.6	103.9
	1983	69	19.0	55.8	74.8	0.06	0.77	0.83	81.4	41.0
	1984	69	13.6	17.7	31.3	0.03	0.36	0.39	77.3	36.7
	1985	77	40.3	47.3	87.6	0.11	0.76	0.87	75.0	45.7
	1986	68	115.3	37.0	152.3	0.24	0.58	0.82	59.5	84.2
	1987	86	84.6	56.1	140.7	0.17	0.72	0.89	63.6	71.6
	1988	91	32.5	36.0	68.5	0.08	0.46	0.54	70.6	57.7
	1989	88	21.7	15.1	36.8	0.06	0.27	0.33	72.0	50.5
	1990	76	258.8	49.9	308.7	0.54	0.60	1.14	55.9	122.5
	1991	86	432.1	64.2	496.3	0.80	0.71	1.51	52.8	149.5
Southeast Part	1975	21	1.8	38.4	40.2	<0.01	1.02	1.02	110.3	17.8
	1977	21	3.2	27.2	30.4	0.01	0.68	0.69	103.6	20.0
	1978	18	2.2	27.1	29.3	<0.01	0.93	0.93	117.2	14.2
	1979	20	7.7	21.2	28.9	0.01	0.71	0.72	99.4	18.2
	1980	20	21.5	41.7	63.2	0.03	0.71	0.74	78.2	38.8
	1981	19	1.4	19.4	20.8	<0.01	0.46	0.46	102.5	20.5
	1982	22	0.8	9.8	10.6	<0.01	0.32	0.32	113.5	15.2
	1983	20	11.3	9.2	20.5	0.02	0.25	0.27	78.1	34.0
	1984	20	4.6	12.9	17.5	0.01	0.23	0.24	85.7	33.0
	1985	28	9.1	11.8	20.9	0.02	0.22	0.24	75.3	39.9
	1986	32	28.9	20.6	49.5	0.05	0.41	0.46	66.2	48.5
	1987	32	23.1	39.6	62.7	0.06	0.60	0.66	79.0	42.8
	1988	32	1.4	16.1	17.5	<0.01	0.32	0.32	96.9	24.6
	1989	31	23.6	11.8	35.4	0.07	0.23	0.30	70.2	54.4
	1990	32	1.6	8.4	10.0	<0.01	0.15	0.15	88.7	30.3
	1991	32	18.5	14.1	32.6	0.04	0.21	0.25	65.2	60.2
USA Northern Edge and Peak	1985	67	21.8	26.6	48.4	0.06	0.39	0.45	72.2	48.9
	1986	70	45.6	28.6	74.2	0.13	0.48	0.61	70.4	55.2
	1987	71	62.0	54.6	116.6	0.12	0.73	0.85	67.1	62.1
	1988	71	65.8	60.9	126.7	0.15	0.77	0.92	66.4	62.6
	1989	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S	N/S
	1990[4]	65	66.9	196.8	263.7	0.22	1.83	2.05	75.8	58.3
	1991	71	118.7	66.9	185.6	0.31	0.85	1.16	66.1	72.4
USA Georges Bank	1985	172	26.5	31.8	58.3	0.07	0.50	0.57	74.2	46.4
	1986	170	61.3	28.9	90.2	0.14	0.49	0.63	64.4	64.9
	1987	189	62.6	51.9	114.5	0.12	0.70	0.82	66.8	63.0
	1988	194	38.0	40.8	78.8	0.09	0.54	0.63	69.4	56.6
	1989[3]	119	22.4	14.0	36.4	0.06	0.26	0.32	71.4	52.3
	1990[4]	173	135.2	87.8	223.0	0.31	0.89	1.20	63.9	84.1
	1991	189	224.1	51.4	278.2	0.45	0.65	1.10	56.4	114.8

[1] South Channel: Strata 46-47, 49-55; Southeast Part: Strata 58-60; USA No. Edge & Peak: Strata 61, 621, 631, 651, 662, 71, 72, and 74.

[2] Mean meat weight derived by applying the 1978-1982 USA Georges Bank research survey sea scallop shell height meat weight equation, ln Meat Weight (g) = -11.7656 + 3.1693 ln Shell Height (mm) (n = 5863, r = 0.98) to the to the survey shell height frequency distributions.

[3] Combined South Channel and Southeast Part regions only.

[4] Stratum 72 not sampled, excluded from analyses.

TABLE SG4. USA COMMERCIAL SEA SCALLOP EFFORT (DAYS FISHED) FROM GEORGES BANK (AREA 5Ze), THE MID-ATLANTIC (STATISTICAL AREA 6), AND THE GULF OF MAINE (DIVISION 5Y), BY VESSEL TONNAGE CLASS, 1965 - 1991. DATA DERIVED FROM VESSELS USING SCALLOP DREDGES AND LANDING IN NEW ENGLAND AND MID-ATLANTIC PORTS.

	GEORGES BANK				MID-ATLANTIC				GULF OF MAINE				TOTALS			
YEAR	CLASS 2	CLASS 3	CLASS 4	TOTAL	CLASS 2	CLASS 3	CLASS 4	TOTAL	CLASS 2	CLASS 3	CLASS 4	TOTAL	CLASS 2	CLASS 3	CLASS 4	GRAND TOTAL
1965	-	1,921	216	2,138	48	3,622	313	3,982	261	20	-	281	309	5,563	529	6,401
1966	-	886	169	1,055	3	3,784	525	4,312	270	-	-	270	273	4,671	694	5,638
1967	-	1,468	402	1,870	5	2,224	452	2,681	239	3	-	242	244	3,695	854	4,793
1968	6	1,500	304	1,810	39	2,517	1,180	3,737	424	13	-	437	468	4,030	1,484	5,983
1969	-	1,953	760	2,713	4	1,142	701	1,847	511	54	-	565	514	3,149	1,461	5,125
1970	-	1,755	823	2,578	-	477	516	993	584	50	-	634	584	2,282	1,339	4,205
1971	-	1,424	989	2,413	-	240	480	719	1,063	116	37	1,216	1,063	1,780	1,506	4,348
1972	20	965	806	1,791	-	718	689	1,406	1,999	91	10	2,099	2,019	1,773	1,504	5,297
1973	-	1,103	740	1,842	-	128	428	556	2,365	129	31	2,524	2,365	1,360	1,198	4,922
1974	-	812	576	1,388	-	524	701	1,225	1,546	34	-	1,580	1,546	1,369	1,277	4,192
1975	11	594	495	1,100	3	819	924	1,746	2,393	14	-	2,407	2,407	1,428	1,419	5,253
1976	308	914	517	1,739	60	984	1,626	2,670	2,258	32	-	2,290	2,625	1,931	2,143	6,699
1977	1,028	2,314	1,121	4,463	71	818	1,216	2,105	1,371	4	-	1,376	2,471	3,136	2,337	7,943
1978	675	3,177	2,089	5,941	199	1,888	1,833	3,921	1,606	6	-	1,612	2,481	5,071	3,922	11,473
1979	445	4,057	4,405	8,907	150	2,566	1,564	4,280	1,854	79	45	1,977	2,449	6,702	6,014	15,165
1980	301	4,642	6,133	11,076	39	2,358	1,993	4,391	2,827	347	249	3,423	3,167	7,347	8,375	18,889
1981	165	4,619	8,578	13,361	3	1,240	1,194	2,437	2,700	265	233	3,198	2,868	6,124	10,005	18,996
1982	61	3,462	7,572	11,095	33	1,985	1,785	3,802	1,692	161	268	2,121	1,786	5,608	9,625	17,018
1983	215	3,228	7,027	10,470	37	3,791	3,091	6,918	4,063	390	256	4,709	4,314	7,408	10,374	22,097
1984	16	3,276	6,209	9,501	50	5,091	4,997	10,138	2,719	229	145	3,093	2,785	8,597	11,350	22,732
1985	14	2,650	6,610	9,273	32	4,286	5,539	9,856	2,074	220	148	2,442	2,119	7,155	12,298	21,571
1986	35	2,898	8,528	11,461	-	3,890	3,236	7,126	2,147	74	68	2,289	2,182	6,862	11,833	20,876
1987	9	2,412	7,777	10,198	-	5,509	7,129	12,637	3,349	139	8	3,496	3,358	8,059	14,914	26,331
1988	64	3,295	10,627	13,986	9	5,463	6,386	11,858	2,474	355	51	2,880	2,547	9,113	17,065	28,724
1989	150	2,776	11,923	14,849	65	6,114	8,622	14,801	3,266	211	21	3,498	3,481	9,101	20,566	33,148
1990	113	4,724	14,951	19,788	90	5,763	7,547	13,400	3,648	407	20	4,075	3,851	10,894	22,518	37,263
1991	149	4,108	17,505	21,762	147	9,015	8,198	17,360	3,474	321	97	3,892	3,770	13,444	25,800	43,014

Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

Source: NEFC Detailed Weighout Data for vessels using scallop dredges. Mid-Atlantic weighout data are only available from 1978 onward; Weighout data from Virginia ports are available for part of 1981 and from 1982 onward.

TABLE SG5. USA COMMERCIAL SEA SCALLOP CATCH RATES (MT OF MEATS PER DAY FISHED) FROM GEORGES BANK (AREA 5Ze), THE MID-ATLANTIC (STATISTICAL AREA 6), AND THE GULF OF MAINE (DIVISION 5Y), BY VESSEL TONNAGE CLASS, 1965 - 1991. DATA DERIVED FROM VESSELS USING SCALLOP DREDGES AND LANDING IN NEW ENGLAND AND MID-ATLANTIC PORTS.

	GEORGES BANK				MID-ATLANTIC				GULF OF MAINE				TOTALS [1]			
YEAR	CLASS 2	CLASS 3	CLASS 4	ANNUAL MEAN	CLASS 2	CLASS 3	CLASS 4	ANNUAL MEAN	CLASS 2	CLASS 3	CLASS 4	ANNUAL MEAN	CLASS 2	CLASS 3	CLASS 4	ANNUAL MEAN
1965	-	0.67	0.89	0.70	0.43	1.00	1.10	1.00	0.38	0.74	-	0.43	0.39	0.88	1.02	0.89
1966	-	0.83	0.88	0.84	0.23	0.93	1.01	0.94	0.34	-	-	0.34	0.34	0.91	0.98	0.91
1967	-	0.63	0.73	0.65	0.16	0.70	0.72	0.70	0.32	0.78	-	0.34	0.32	0.67	0.72	0.67
1968	0.27	0.55	0.57	0.55	0.20	0.63	0.69	0.65	0.26	0.34	-	0.26	0.25	0.60	0.67	0.60
1969	-	0.47	0.53	0.49	0.43	0.42	0.52	0.46	0.21	0.26	-	0.22	0.21	0.45	0.52	0.46
1970	-	0.57	0.51	0.55	-	0.40	0.52	0.47	0.20	0.34	-	0.22	0.20	0.53	0.51	0.50
1971	-	0.54	0.55	0.54	-	0.30	0.42	0.39	0.21	0.93	0.71	0.47	0.21	0.53	0.51	0.49
1972	0.46	0.48	0.42	0.46	-	0.40	0.53	0.47	0.24	0.36	0.49	0.25	0.25	0.44	0.47	0.40
1973	-	0.61	0.52	0.58	-	0.33	0.47	0.45	0.17	0.37	0.61	0.20	0.17	0.56	0.51	0.46
1974	-	0.69	0.61	0.66	-	0.76	0.77	0.77	0.14	0.36	-	0.15	0.14	0.71	0.70	0.65
1975	0.19	0.83	0.71	0.78	0.27	0.81	0.91	0.87	0.31	0.46	-	0.31	0.31	0.81	0.84	0.70
1976	0.85	1.02	1.03	0.99	0.31	1.06	1.18	1.13	0.15	0.45	-	0.17	0.24	1.03	1.14	0.98
1977	0.87	1.10	1.13	1.07	0.48	1.14	1.32	1.24	0.18	1.12	-	0.20	0.48	1.11	1.23	1.06
1978	0.55	0.94	1.05	0.95	0.76	0.89	1.28	1.10	0.15	0.56	-	0.15	0.31	0.92	1.16	0.98
1979	0.42	0.64	0.78	0.72	0.69	0.61	0.77	0.68	0.17	0.44	1.20	0.33	0.25	0.63	0.78	0.68
1980	0.24	0.42	0.55	0.50	0.34	0.39	0.51	0.46	0.21	1.24	1.82	1.01	0.21	0.45	0.58	0.50
1981	0.47	0.51	0.65	0.61	0.53	0.32	0.40	0.36	0.28	0.89	1.03	0.54	0.29	0.49	0.63	0.56
1982	0.43	0.52	0.58	0.56	0.20	0.37	0.49	0.43	0.22	0.47	0.69	0.39	0.23	0.46	0.56	0.52
1983	0.24	0.39	0.42	0.41	0.52	0.35	0.56	0.47	0.13	0.35	0.53	0.24	0.14	0.37	0.46	0.41
1984	0.18	0.31	0.32	0.32	0.32	0.33	0.39	0.36	0.19	0.29	0.38	0.22	0.20	0.32	0.35	0.33
1985	0.18	0.31	0.31	0.31	0.30	0.29	0.36	0.33	0.15	0.23	0.28	0.17	0.15	0.29	0.33	0.31
1986	0.19	0.35	0.40	0.39	-	0.42	0.50	0.46	0.11	0.17	0.34	0.14	0.12	0.39	0.43	0.40
1987	0.52	0.45	0.48	0.47	-	0.59	0.59	0.59	0.10	0.28	0.25	0.12	0.10	0.54	0.53	0.53
1988	0.33	0.41	0.44	0.43	0.80	0.48	0.49	0.49	0.15	0.21	0.39	0.17	0.16	0.44	0.46	0.44
1989	0.19	0.37	0.38	0.38	0.99	0.47	0.53	0.51	0.16	0.23	0.29	0.17	0.18	0.44	0.45	0.43
1990	0.45	0.51	0.50	0.50	0.68	0.44	0.44	0.45	0.13	0.19	0.35	0.14	0.15	0.46	0.48	0.46
1991	0.30	0.41	0.43	0.42	0.34	0.35	0.37	0.36	0.13	0.19	0.25	0.14	0.14	0.36	0.41	0.39

1 Annual mean catch rates for each area were derived by weighting individual tonnage class annual catch rates by the percentage of total annual landings accounted for by each vessel class, and summing the weighted catch rates over all three vessel class categories.

Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

Source: NEFC Detailed Weighout Data for vessels using scallop dredges. Mid-Atlantic weighout data are only available from 1978 onward;

Table SG6. Modified DeLury calculations of fishery mortalities (age 4+) for sea scallops

	Mid Atlantic		South Channel & Southeast Part		
	Descending PR	Flat PR	SAW 12	Flat PR	Descending PR
1980					
1981			1.99		
1982	.54	.73	2.18	1.64	1.36
1983	.56	.93	1.11	.88	.75
1984	.50	.94	0.58	.31	.16
1985	.31	.56	1.60	.99	.70
1986	.66	.93	1.76	.92	.63
1987	.40	.72	2.02	1.07	.86
1988	.35	.59	1.80	1.08	.77
1989	.62	.89	2.45	1.16	.63
1990	.73	.85		1.91	1.36
1991					

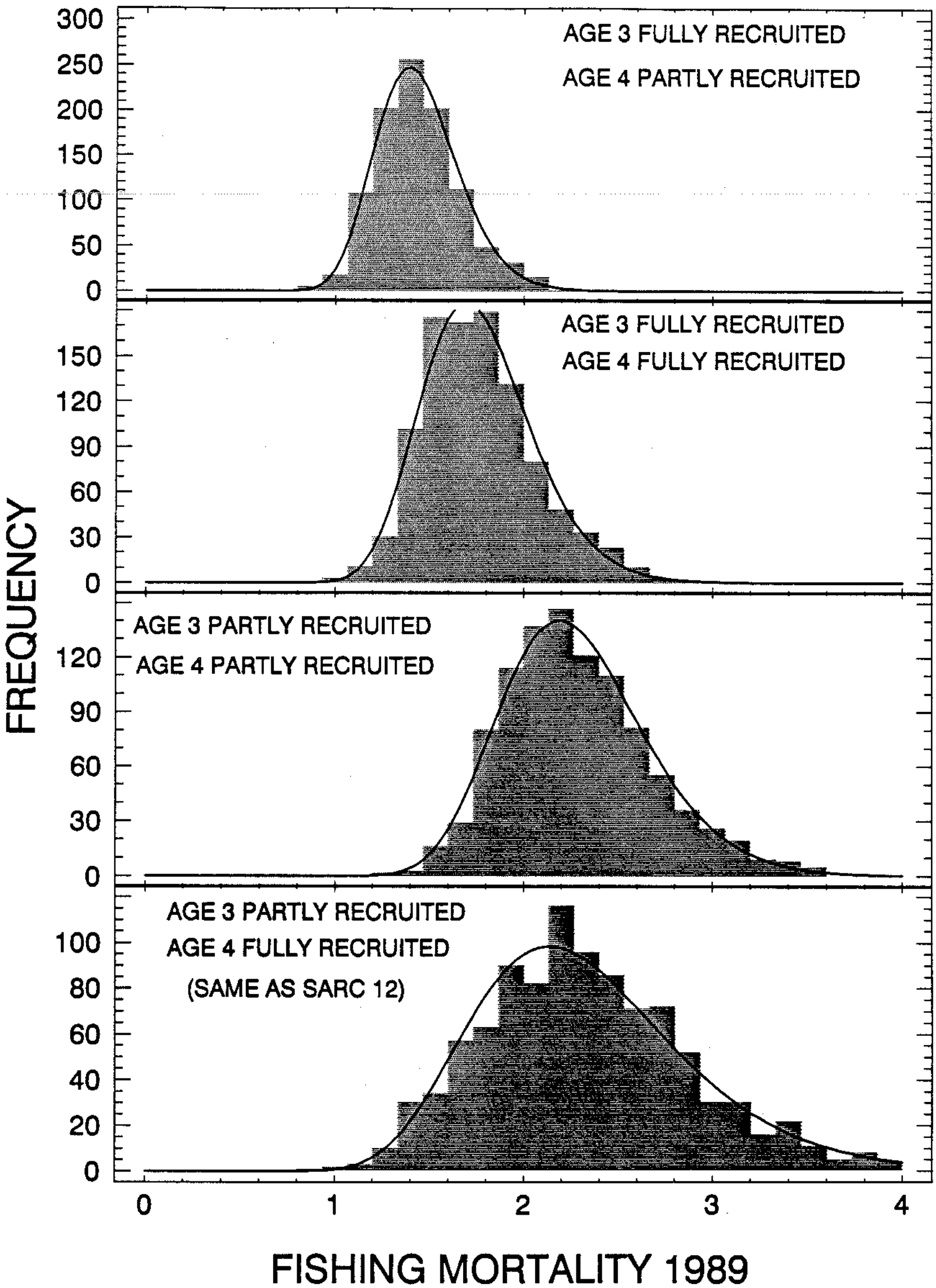


Figure SG1. Bootstrap estimates of the fishing mortality rate for Delmarva sea scallops.

ADVISORY REPORT ON STOCK STATUS

INTRODUCTION

The **Advisory Report on Stock Status** is a major product of the Northeast Regional Stock Assessment Workshop. It summarizes the technical information contained in the **Stock Assessment Review Committee (SARC) Consensus Summary of Assessments** and is intended to serve as scientific advice for fishery managers on resource status.

An important aspect of scientific advice on fishery resources is the determination of whether a stock is currently over-, fully-, or under-exploited. Since these categories specifically refer to the act of fishing, they are best thought of in terms of exploitation rates relative to reference values such as the replacement rate of fishing mortality, F_{rep}, or the rate of fishing mortality giving the maximum yield per recruit in the long-term, F_{max}. Another important factor for classifying the status of a resource is the current stock level, e.g., spawning stock biomass (SSB). It is possible that a stock that is not currently overfished in terms of exploitation rates, is still at a low biomass level due to heavy exploitation in the past such that future recruitment to the stock is jeopardized. Therefore, the SAW Plenary, where possible, classified stocks as high, medium, or low biomass compared to historic levels.

Definitions of overfishing developed by the Fishery Management Councils can be related to exploitation rate (e.g., threshold percentage of the maximum spawning potential of the stock, %MSP) or biomass level (e.g., threshold spawning biomass) or a combination of the two. The SAW used these Council reference points in classifying stocks. The figure below describes the contingencies identified by SAW for this classification.

STOCK LEVEL

EXPLOITATION RATE

	LOW	MEDIUM	HIGH
OVER EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIO MASS	REDUCE EXPLOITATION REBUILD AGE STRUCTURE	REDUCE EXPLOITATION INCREASE YIELD PER RECRUIT
FULLY EXPLOITED	REDUCE EXPLOITATION REBUILD STOCK BIOMASS	MAINTAIN EXPLOITATION RATE AND YIELD	MAINTAIN EXPLOITATION RATE AND YIELD
UNDER EXPLOITED	MAINTAIN LOW EXPLOITATION WHILE STOCK REBUILDS	INCREASE EXPLOITATION SLOWLY TO REFERENCE LEVEL	INCREASE EXPLOITATION TO REFERENCE LEVEL

Summary graphs of the assessment results for each stock have been prepared to encapsulate the status of resources. These graphs include the basic information on historical patterns in the fisheries and current status. Included on each graph, where possible, is the definition of overfishing reference level from the relevant fishery management plan.

The SAW Plenary session also drew specific conclusions concerning stock status and, where possible, developed recommendations based on scientific advice. These conclusions were derived by consensus during the meeting.

Current levels of fishing are reported as instantaneous rates of fishing mortality (F) which are proportional to fishing effort and as annual exploitation rates (E), the proportion of vulnerable fish in the stock removed by the fishery each year. Many of the biological reference points used in definitions of overfishing are expressed as instantaneous fishing mortality rates (F) because of their simple relationship to fishing effort. However, exploitation rates are clearer and easier to appreciate for some readers because they are in terms of proportions (or percentages) of the available fish in the stock removed each year due to fishing. The reader is referred to the introduction of the annual NEFSC **Status of the Fishery Resources Off the Northeastern United States** for more details concerning these parameters.

AMERICAN LOBSTER

Lobster landings more than doubled since 1965, while research vessel biomass indices fluctuated without trend (Figure AA1) implying that the increase in landings was not fueled by an increase in abundance. Nominal fishing effort has increased (Figure AA2).

The SARC analysis for the Gulf of Maine combined inshore and offshore components. An integrated approach is necessary because of larvae drift and adult migrations between inshore and offshore areas. The estimates of fishing mortality and abundance are uncertain for reasons outlined in the SARC report, so the results are preliminary and should be used cautiously (Figure AA3).

The average 1988 - 1990 fishing mortality estimate is 0.8 for the Gulf of Maine inshore and offshore. Fishing mortality is estimated to have increased slightly since 1983. These are probably underestimates for reasons outlined in the SARC report. For instance, the estimate of F assumes equal catchability between recruits and fully recruited classes, so if the relative catchability of recruits to fully recruited lobsters is just 70% instead of 100%, then fishing mortality is underestimated by 38%. This estimate is not inconsistent with former studies that assumed separate inshore populations which suggest higher Fs.

Overfishing for the Gulf of Maine is defined to occur when the F that results in 10% of the maximum egg production ($F_{10\%}$) is exceeded. The current definition, although provisional, is 1.0 at the current minimum size (83 mm carapace length). Uncertainty is associated with this estimate. Growth parameters for this analysis were derived for Bay of Fundy instead of the Gulf of Maine. The $F_{(10\%)}$ needs to be reevaluated with data from the Gulf of Maine.

Overfishing is defined to occur at Fs in excess of 0.44 for the Georges Bank/Southern New England area. The estimated fishing mortality rate for the offshore/mid-shelf component of Georges Bank and Southern New England is 0.7 and has increased four fold since 1980. This estimate is uncertain for the reasons outlined in the SARC report. A primary source of uncertainty results from the possibility of differential rates of migration between coastal and offshore groups.

Summary of Status

- Gulf of Maine abundance is high due to above average recruitment.
- Fishing mortality (F) is probably near the overfishing level ($F_{10\%}$) so F should be reduced; but, the estimate of $F_{10\%}$ is uncertain at this time. Well documented yield per recruit analyses show that substantial yield gains will occur by reducing F.
- Biomass on Georges Bank and Southern New England has decreased since 1983.
- Fishing mortality on Georges Bank and Southern New England steadily increased since 1980.
- The Georges Bank and Southern New England lobster resource is at least fully exploited and might be overfished (higher than that of 10% maximum egg production) and is overfished from a yield per recruit standpoint. Substantial yield per recruit gains would be realized by decreasing F.

Recommendations

- o Given the current minimum size, reduce fishing mortality on Georges Bank and Southern New England.
- o Include Southern New England inshore areas in the Georges Bank and Southern New England analysis.
- o Determine the estimation error associated with fishing mortality and biomass calculations.

American Lobster
Landings and Survey Index

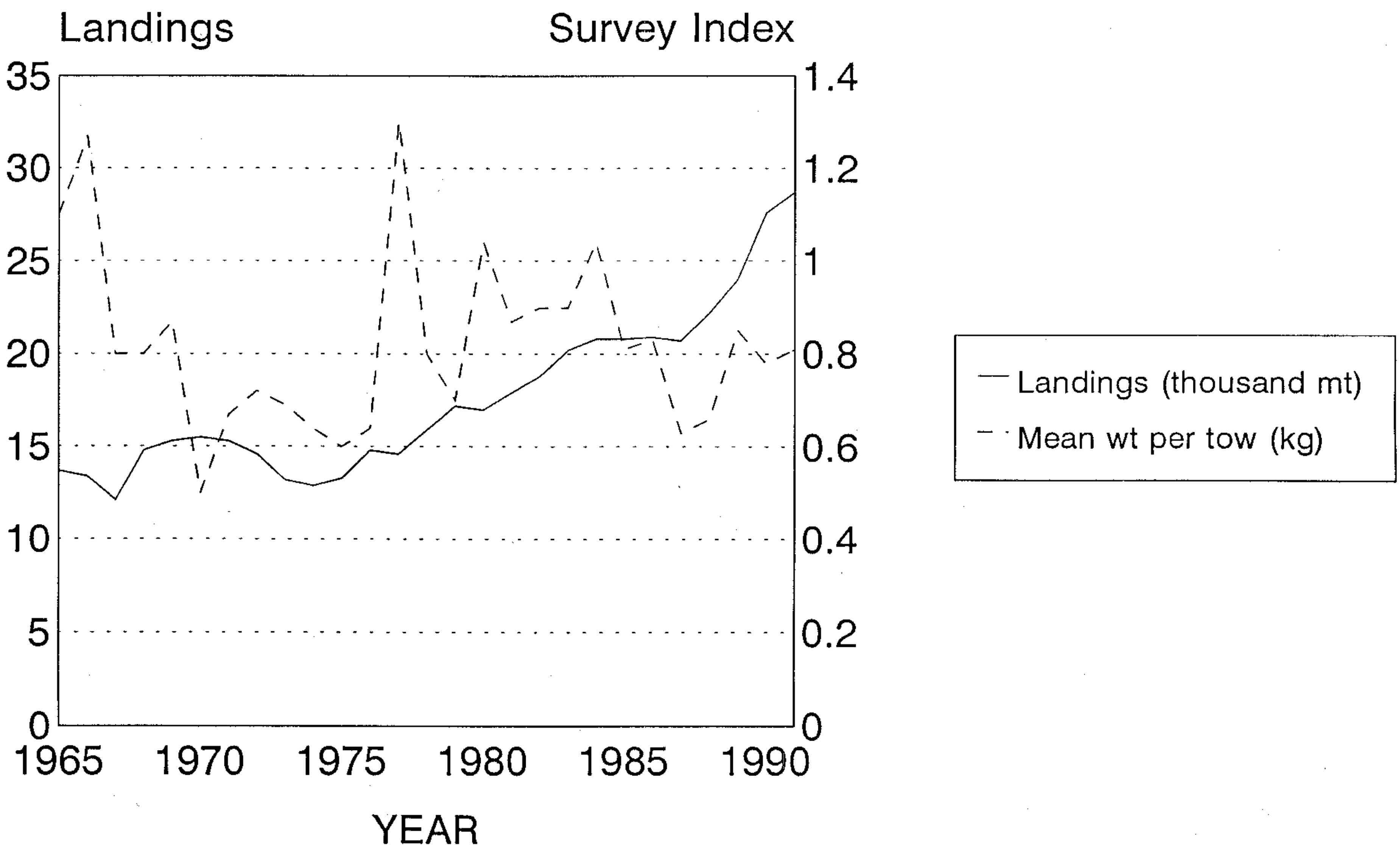


Figure AA1.

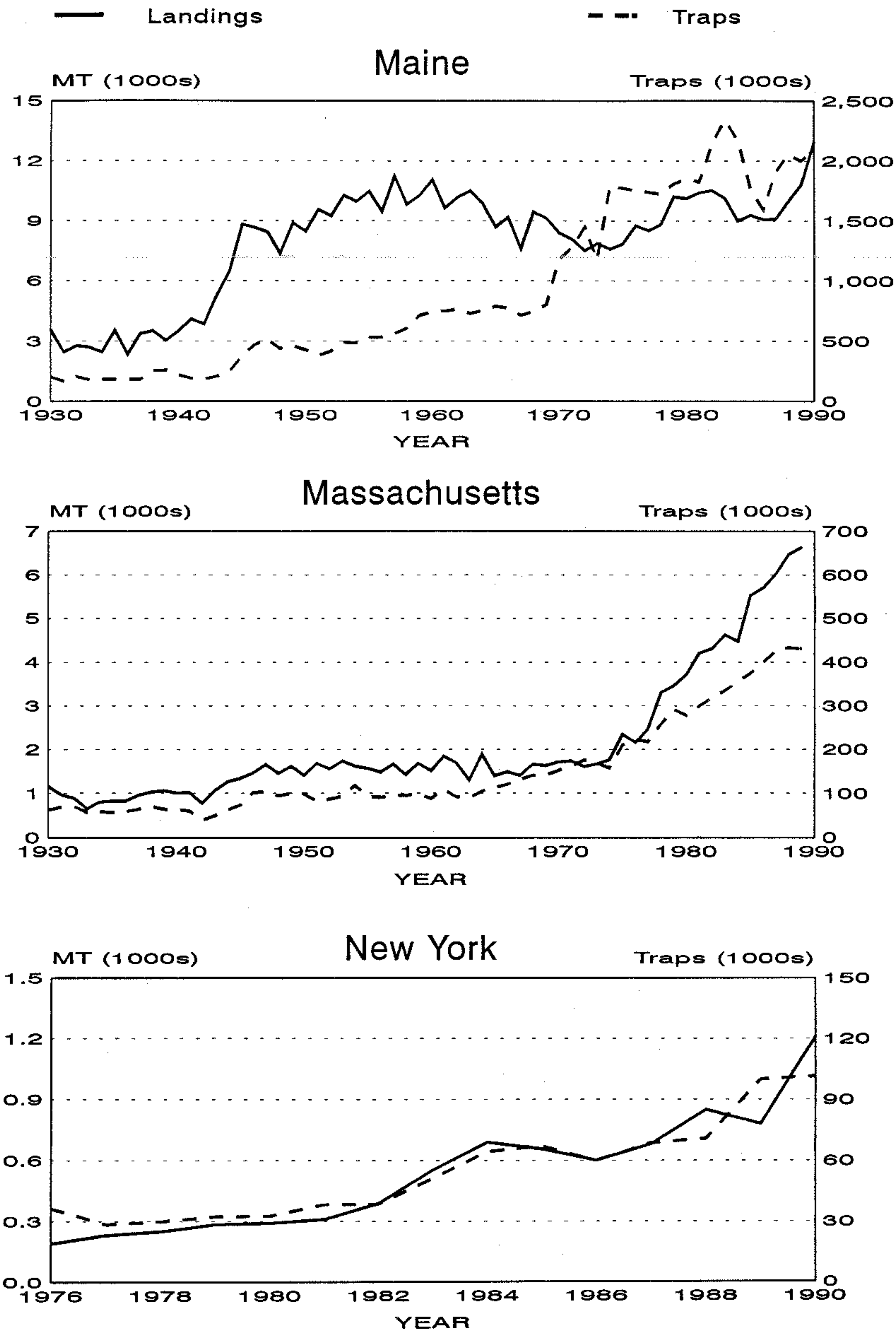
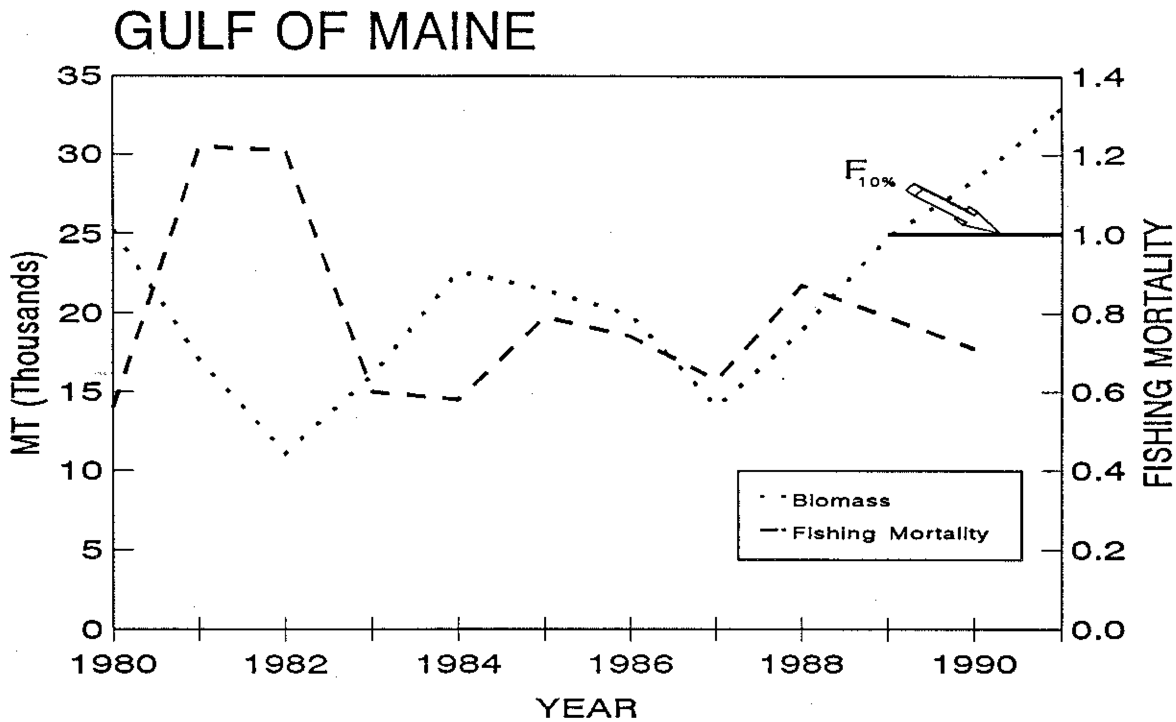


Figure AA2. Landings and nominal fishing effort of American lobster

LOBSTER



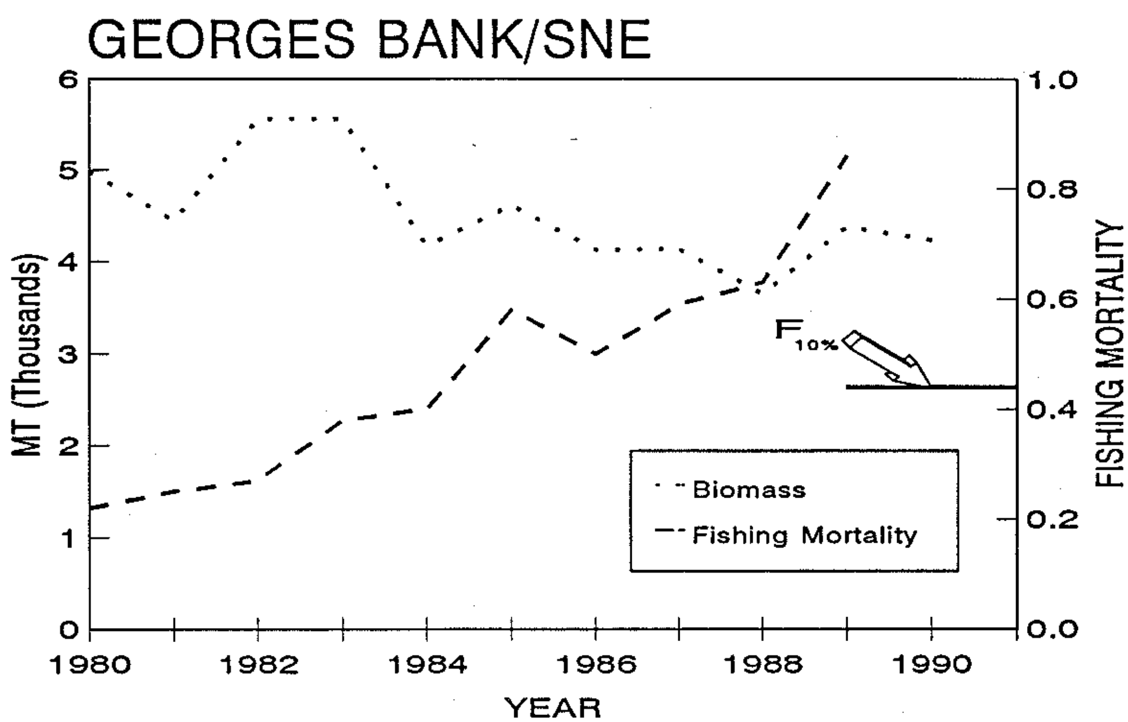


Figure AA3.

TILEFISH

An index level assessment of tilefish was based on nominal yield and effort statistics from deep-water areas of the outer continental shelf of southern New England and the Mid Atlantic. The directed longline fishery landed 1180 mt of tilefish in 1991. The index of abundance steadily decreased to 25% of its 1976 level by 1991 (Figure AB1).

Summary of Status

- Abundance has declined in recent years to the lowest in the time series by 1991.
- The yield has decreased from previous highs and the number of vessels targeting tilefish has decreased.
- Tilefish abundance is probably too low to support the 1981 - 1991 catch level.
- Abundance is low and the resource is over-exploited.

Recommendations

- Reduce exploitation to rebuild stock biomass.
- Obtain size samples of the landings so that adult abundance and stock production estimates can become available for management recommendations.

TILEFISH

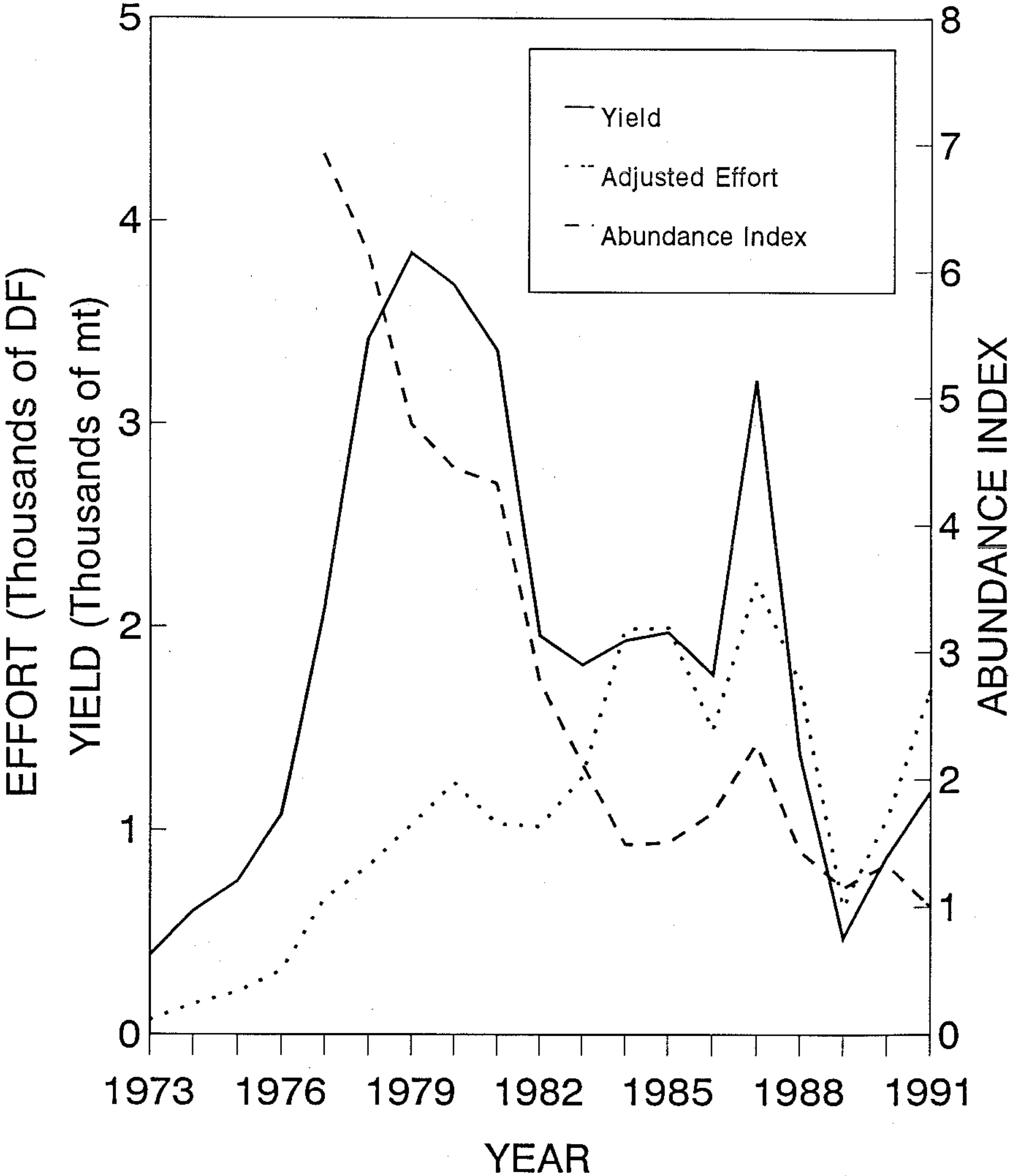


Figure AB1.

GOOSEFISH

Goosefish landings increased dramatically since 1970 (Figure AC1) due to the increased targeting of the species. Prices to fishermen increased four times during the last ten years. Scallop dredges and otter trawls currently account for equal portions of the landings. Landings are increasingly composed of very small fish.

Two areas (northern and southern) were defined for analysis purposes from research vessel distribution plots that show a shallow water ridge of low abundance longitudinally through the center of Georges Bank. Research cruise biomass indices declined in both areas since 1980 (Figure AC2), and a reduction in average size occurred (Figure AC3). Initial yield per recruit calculations indicate that F_{max} is low (0.2-0.3) and that large yield gains can be realized by increasing the age at recruitment (Figure AC4). Differential distributions of mature and immature goosefish occur south of Georges Bank. Decreasing biomass indices concomitant with landings of small fish suggest that the resource is at least fully-exploited and might be over-exploited. The increased targeting of goosefish and displacement of fishing effort from other fisheries into the unregulated goosefish fishery is problematic.

Summary of Status

- Research vessel data indicate that the 1991 stock biomass was less than one third of the late 1970s level and that biomass fell by one half from 1984 to 1991.
- Goosefish begin recruiting to the fishery at age 1.
- Average size has decreased in the northern area and to a lesser extent, in the southern area. The size distribution has become truncated in both areas.
- Goosefish are at least heavily exploited and further research might find the resource to be over-exploited.

Recommendations

- Preliminary yield per recruit analysis indicates that substantial yield gains can be realized by increasing the current size at recruitment to age four (30.5 cm tail length).
- Abundance estimates of juveniles and adults and estimates of fishing mortality rates are acutely needed; size samples from the landings are required to make these calculations.
- Discard mortality and discard rates need to be addressed through sea samples and other research.

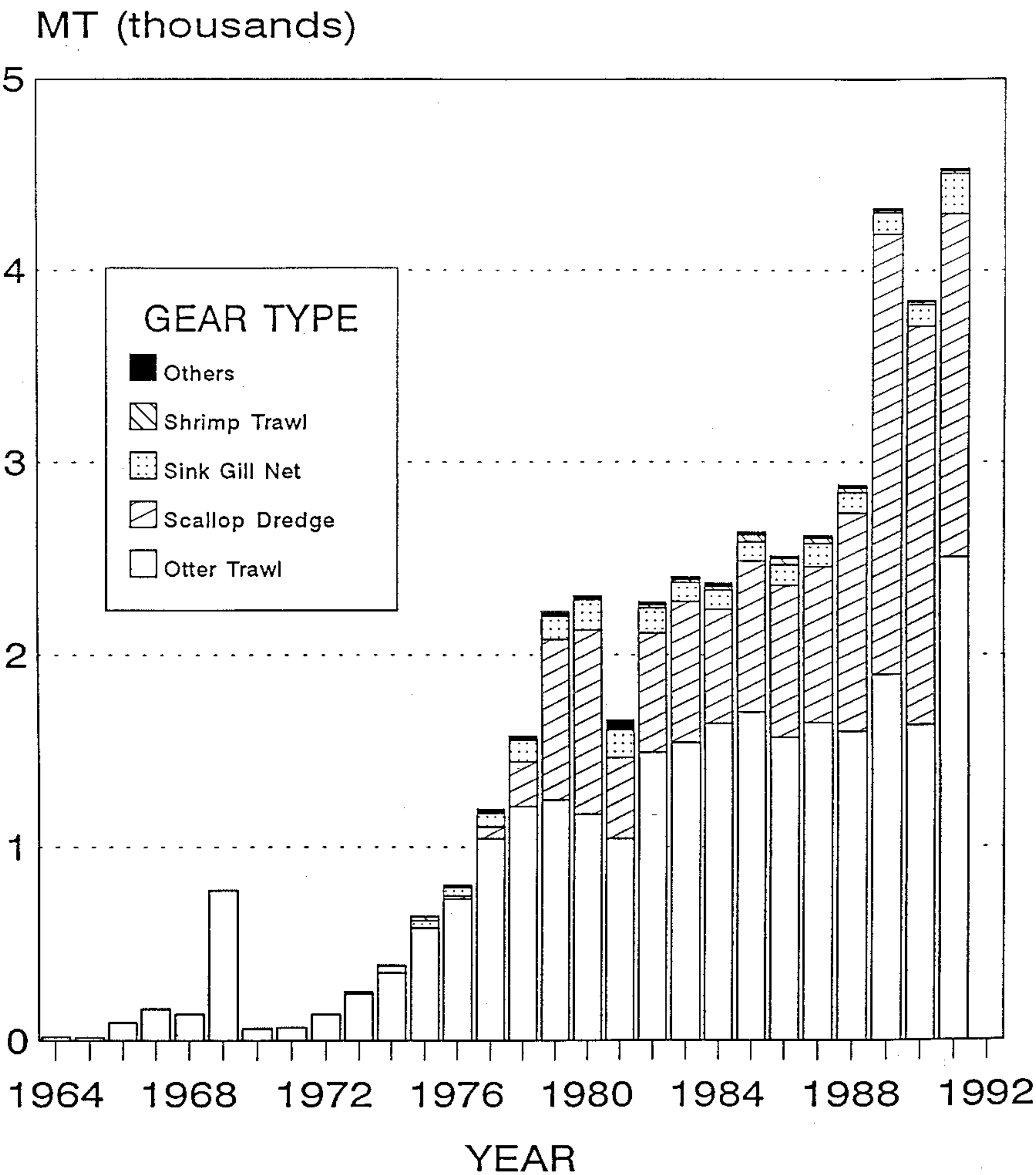


Figure AC1. Goosefish landings (tails) by gear.

GOOSEFISH

AUTUMN BOTTOM TRAWL SURVEY

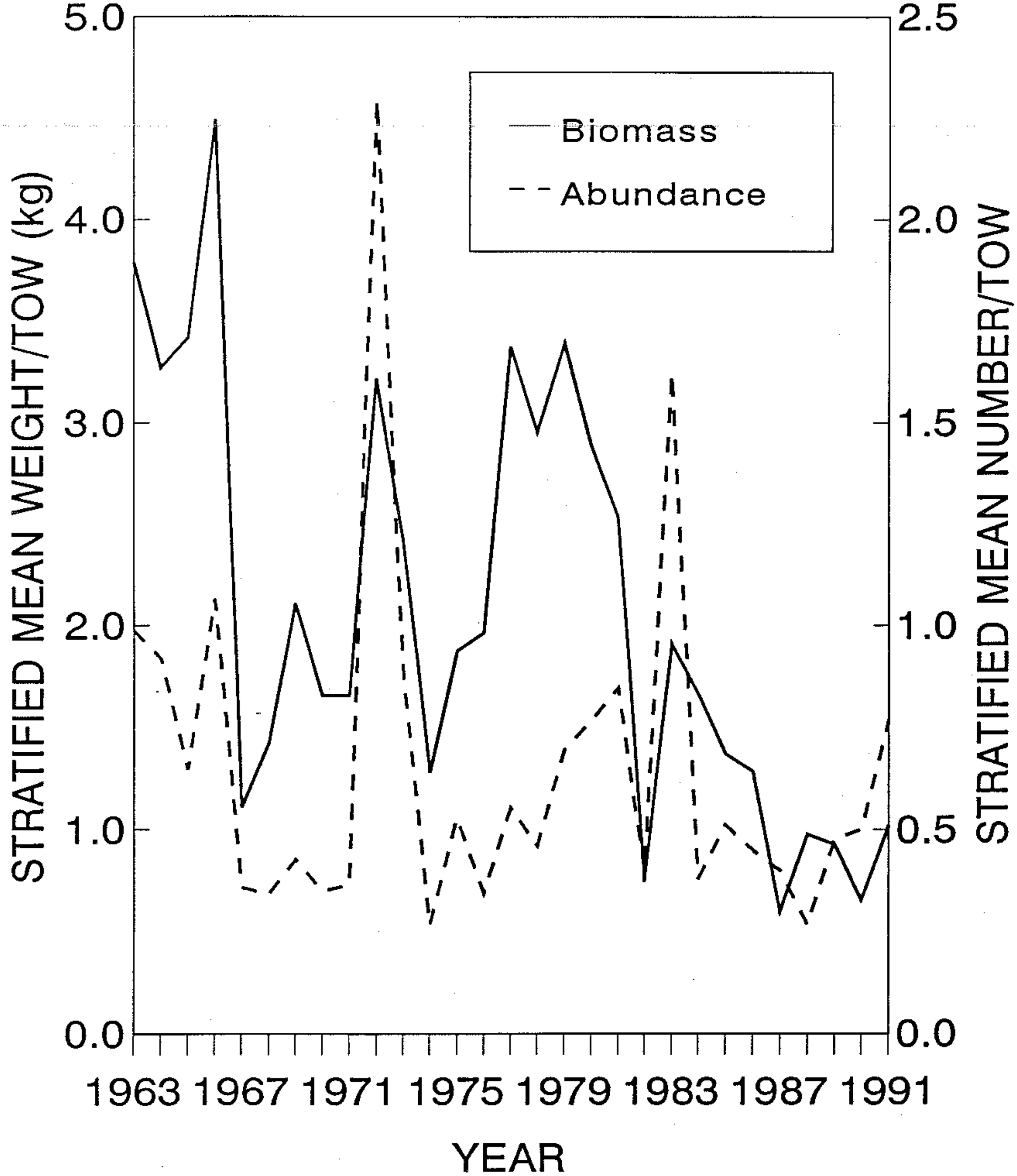


Figure AC2.

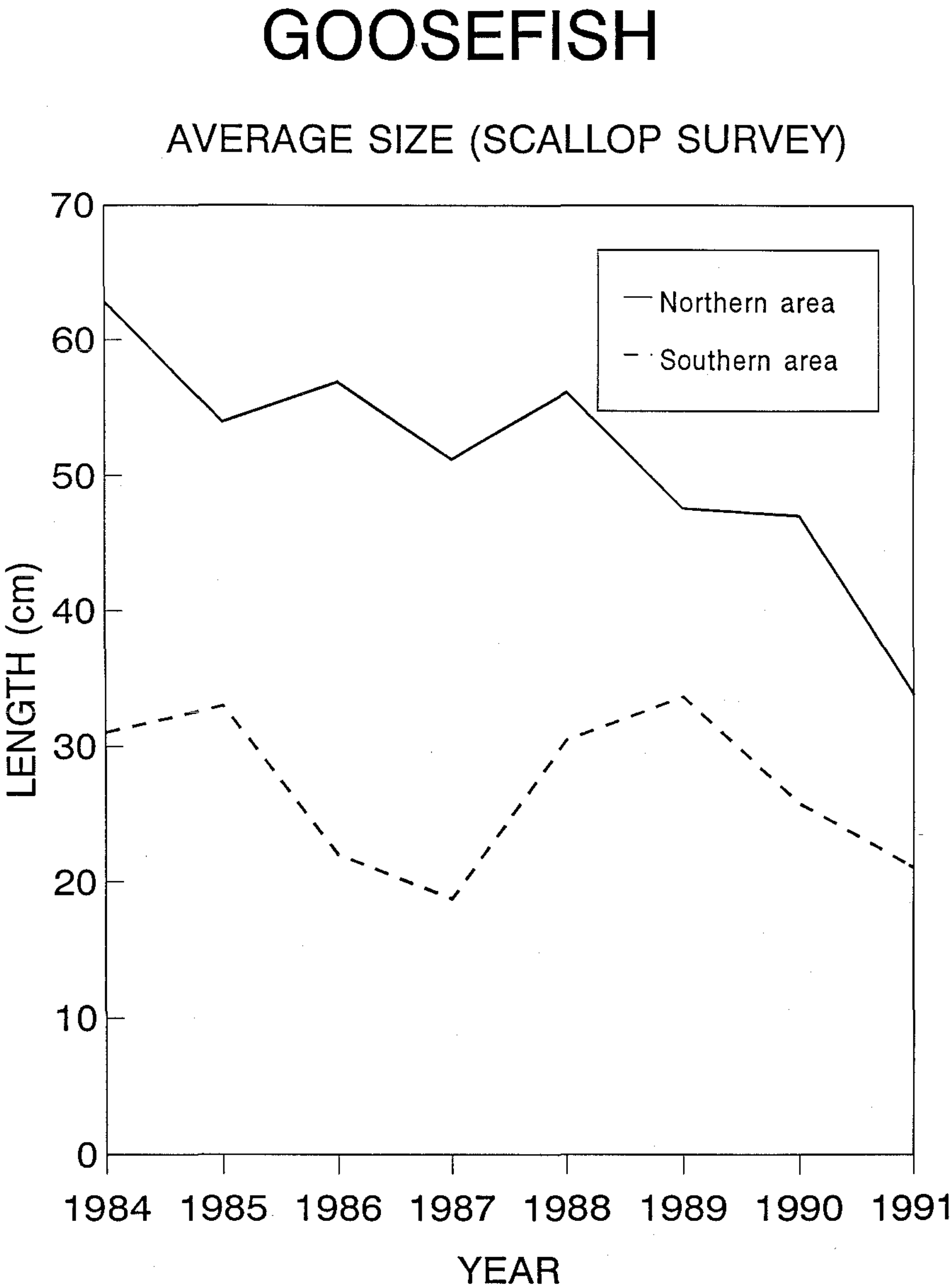

GOOSEFISH
AVERAGE SIZE (SCALLOP SURVEY)
LENGTH (cm)
YEAR
Northern area
Southern area
0
10
20
30
40
50
60
70
1984
1985
1986
1987
1988
1989
1990
1991

Figure AC3.

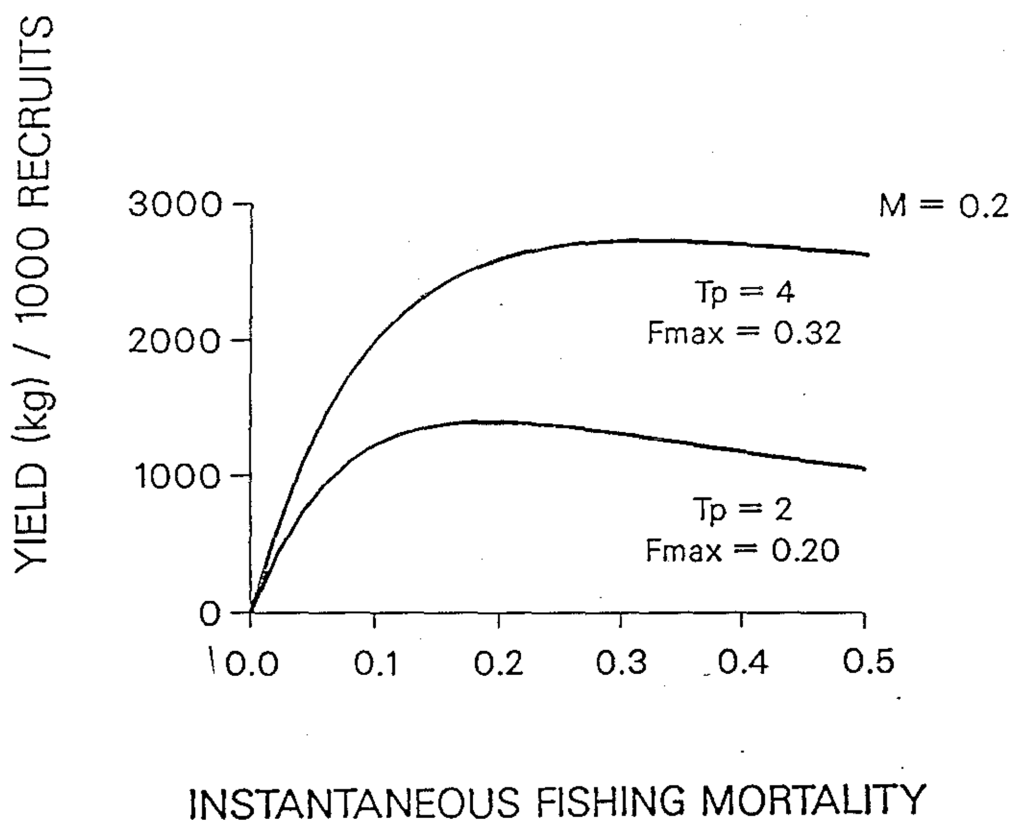


Figure AC4. Yield per recruit for Gulf of Maine - northern Georges Bank goosefish.

AMERICAN PLAICE

A first analytic assessment of plaice was presented this year that used all available data (discards estimates and landings, age samples and abundance indices). Adult biomass declined by 85% from 1980 to 1987, was constant until 1989, then doubled between 1989 and 1991 (Figure AD1). The 1987 year class was large and was about 25% of the 1991 abundance. The abundance of the 1988 and subsequent cohorts are less than that of the 1987 cohort. Fishing mortality rates on fully-recruited ages (6+) increased from 1980 to 1987, then decreased. The current fishing mortality rate is above $F_{0.1}$,F_{max} and $F_{20\%}$ (Figure AD2).

Summary of Status

- The 1991 and 1992 adult biomass is historically low and will remain low as the 1987 year class is fished out. It is currently 28% of the 1980 level.

- Projections indicate that the adult biomass will not decrease in 1993 under the current fishing mortality rate.

- The 1987 cohort is supporting the fishery and other cohorts that recruited after it are not above average.

- The 1991 fishing mortality rate was 0.58. Reference points are:

  F(0.1) = 0.17
  F(max) = 0.28
  F(20%) = 0.49

- The 1989 cohort, the third most abundant in the series, will recruit to the large mesh fishery in 1993. The average size of these fish will be less than the minimum size regulation, so discarding will occur.

Recommendations

- The stock is at a low level and is over-exploited. The fishing mortality rate should be reduced since it is above all commonly used reference points and spawning stock abundance is low.

- Discards are an important component of plaice removals and direct estimates were available for 1989 - 1991 only. Direct samples of discards are needed to continue the assessment so sea sampling where plaice are caught should continue.

AMERICAN PLAICE

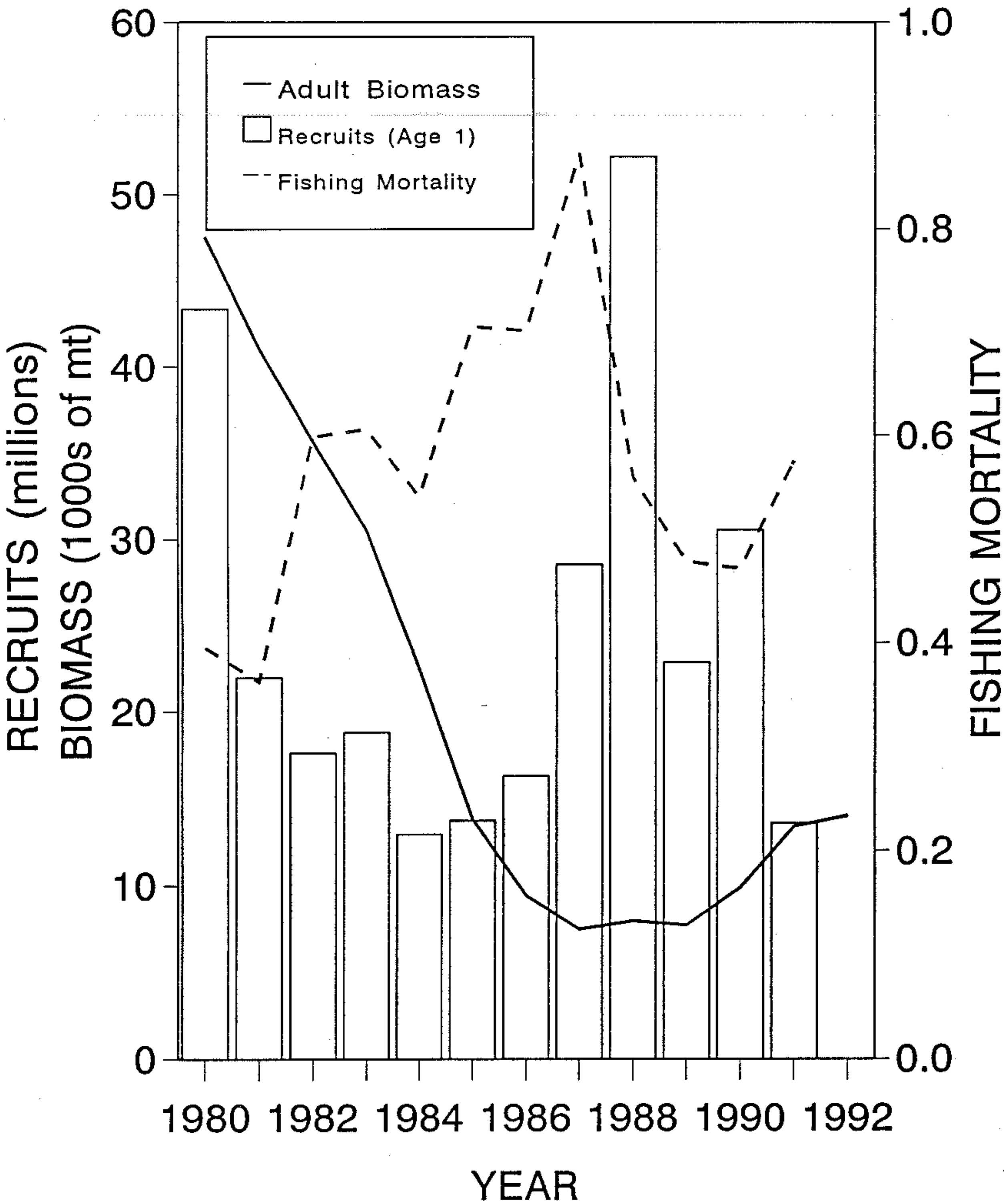
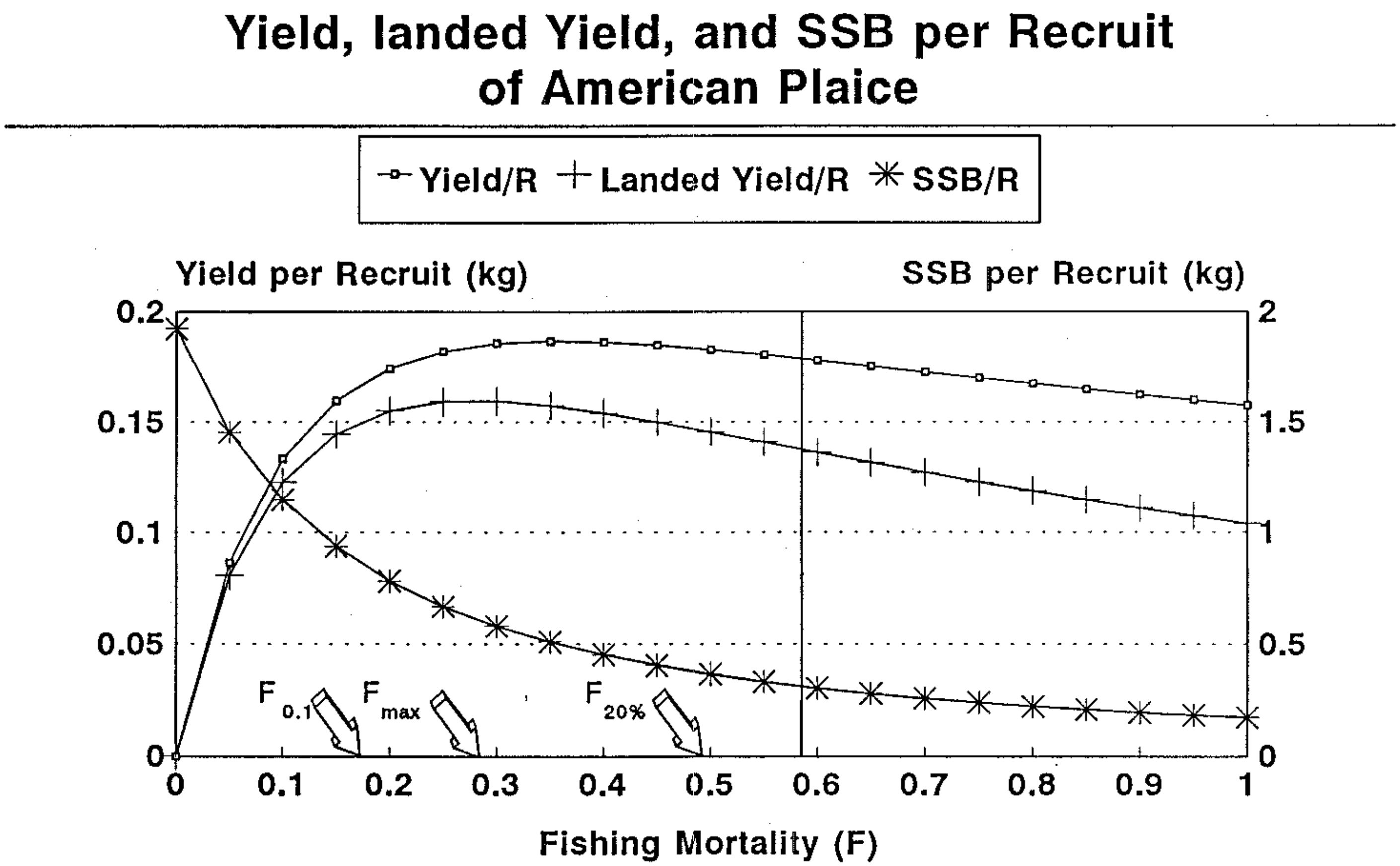


Figure AD1.



Yield, landed Yield, and SSB per Recruit
of American Plaice
Yield/R
Landed Yield/R
SSB/R
Yield per Recruit (kg)
SSB per Recruit (kg)
0.2
0.15
0.1
0.05
0
2
1.5
1
0.5
0
F 0.1
F max
F 20%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fishing Mortality (F)

Figure AD2.

SHORT FIN SQUID

The index level assessment of short fin (Illex) squid is based on both statistics from the fishery and fishery independent samplings. The short fin squid resource extends beyond the current fishing grounds and the research cruise coverage. Landings from U.S. waters decreased since the 1970s as foreign fishing ceased (Figure AE1). Landings were 12,000 mt in 1991; the allowable biological catch was 18,000 mt. Abundance indices varied without trend through the data series (Figure AE2, AE3), even though effort increased in 1990 and 1991 (Figure AE4). Research vessel data indicate that there were two period of high abundance, 1976 - 1981 and 1986 - 1990.

Summary of Status

- Abundance is medium and the stock is under-exploited.
- Although effort doubled from 1989 to 1990-91, abundance did not decrease due to high recruitment.
- According to the MAFMC definition, the resource was not overfished in 1991 and will not be in 1992.

Recommendations

- The fishery should be closely monitored to ensure that it can withstand the recent doubling of fishing effort.
- Further efforts should be made to obtain accurate and precise estimates of adult stock biomass and stock production.
- Existing data should be obtained or research vessel coverage should be increased to discern the offshore extent of the resource.

ILLEX
LANDINGS

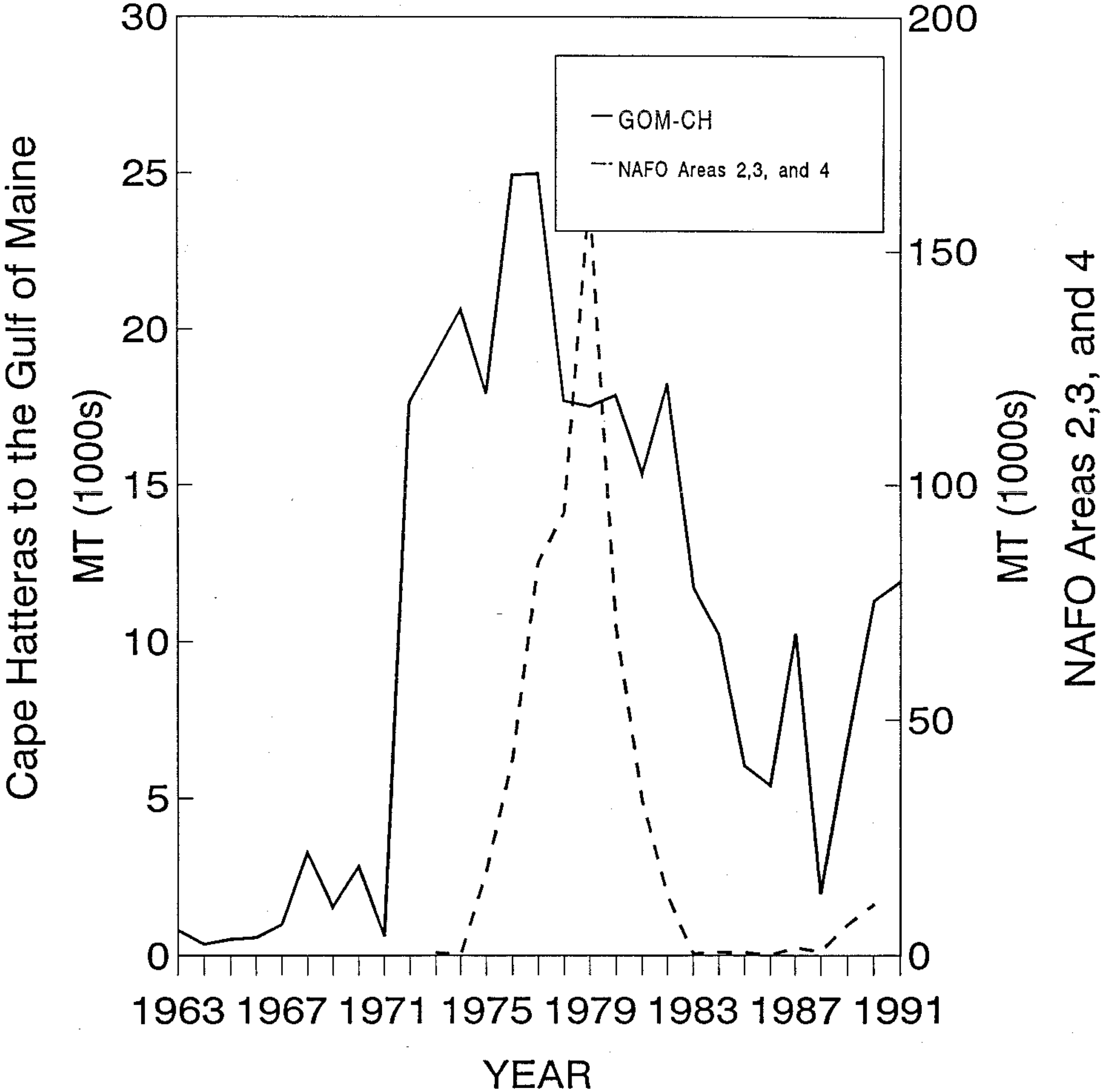


Figure AE1.

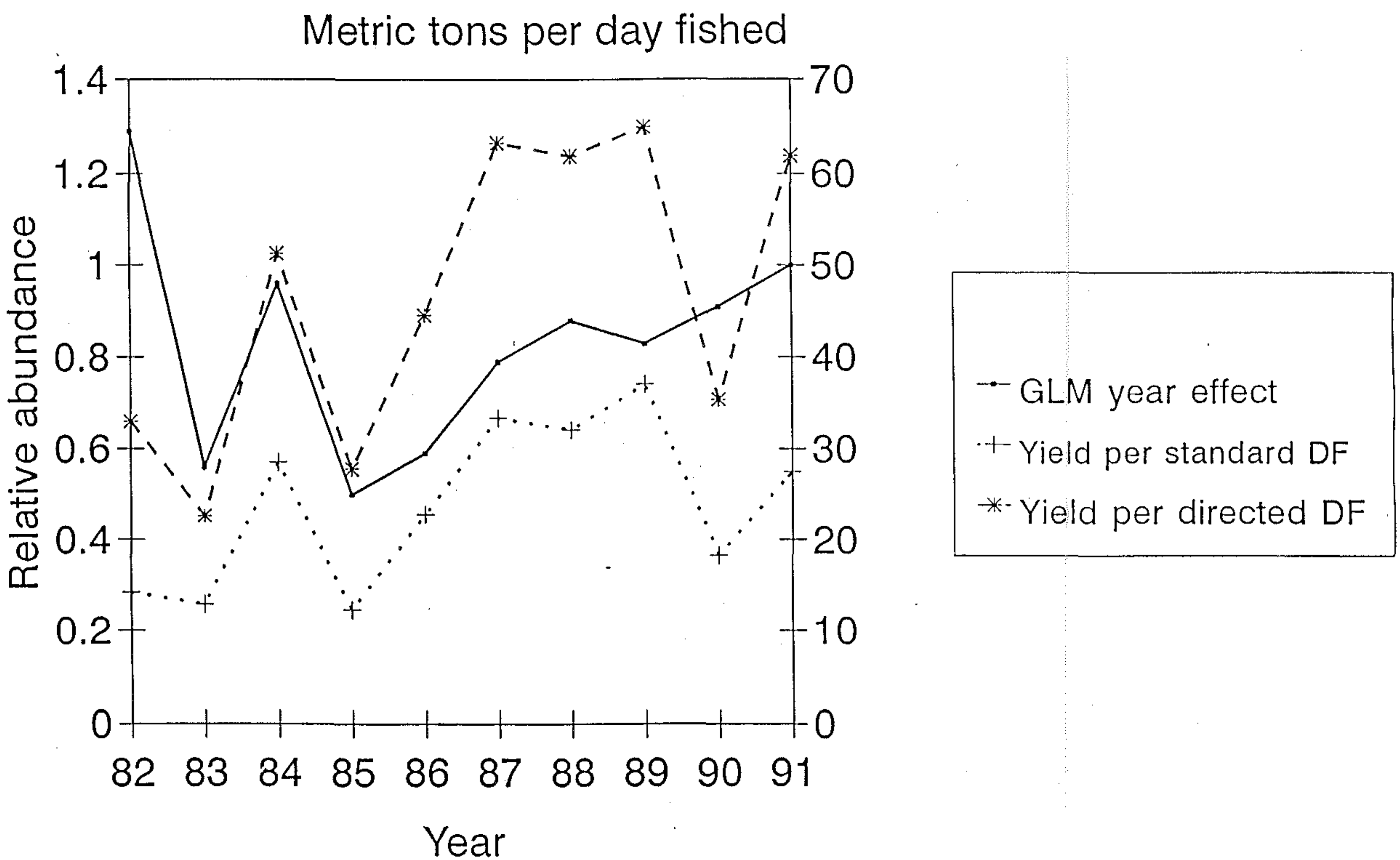


Figure AE2. Indices of Illex squid abundance.

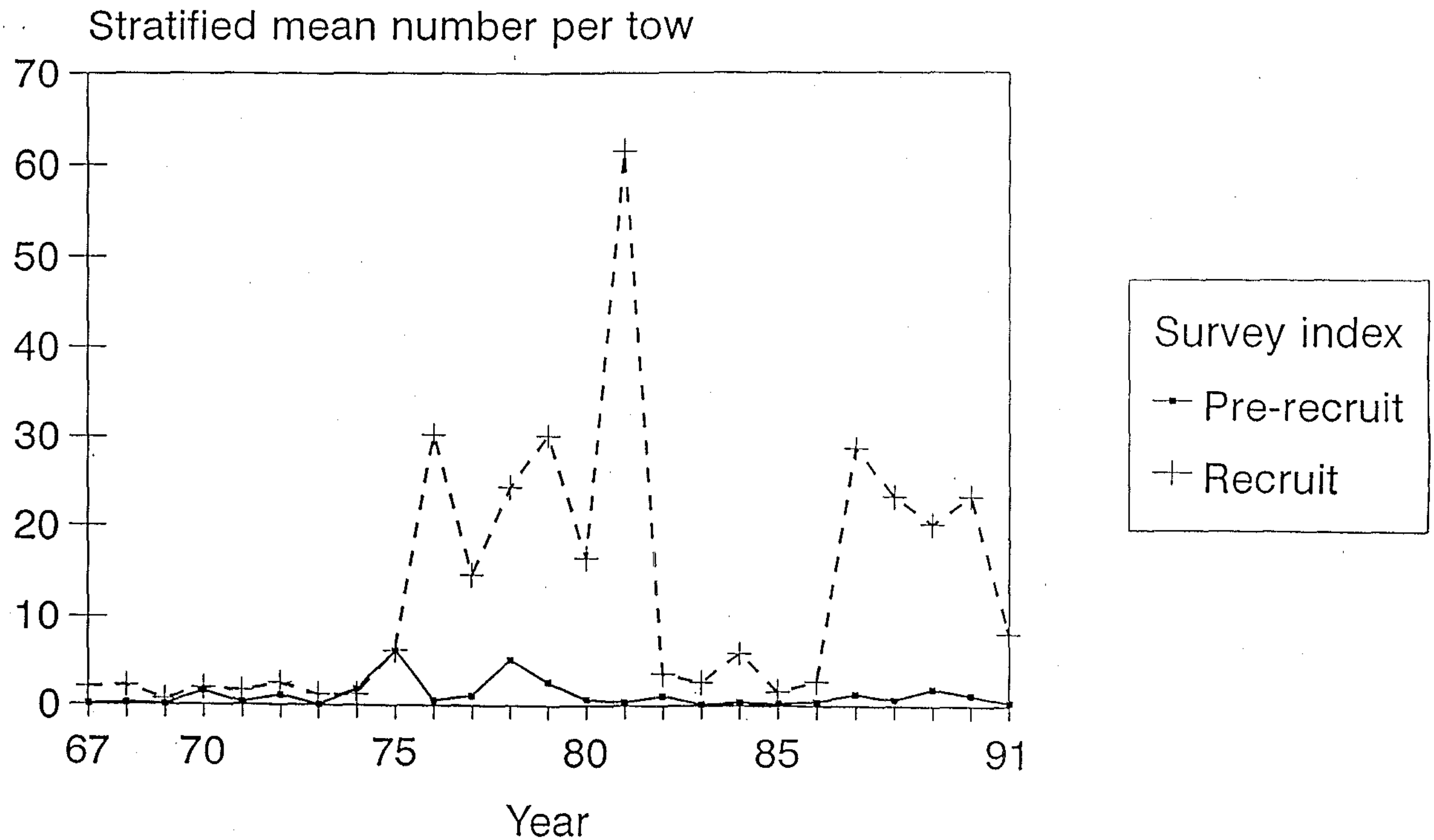


Figure AE3. Fishery independent indices of abundance for pre-recruit (10 cm) and recruited (10 cm) *Illex* squid based on the NEFSC fall bottom otter trawl survey.

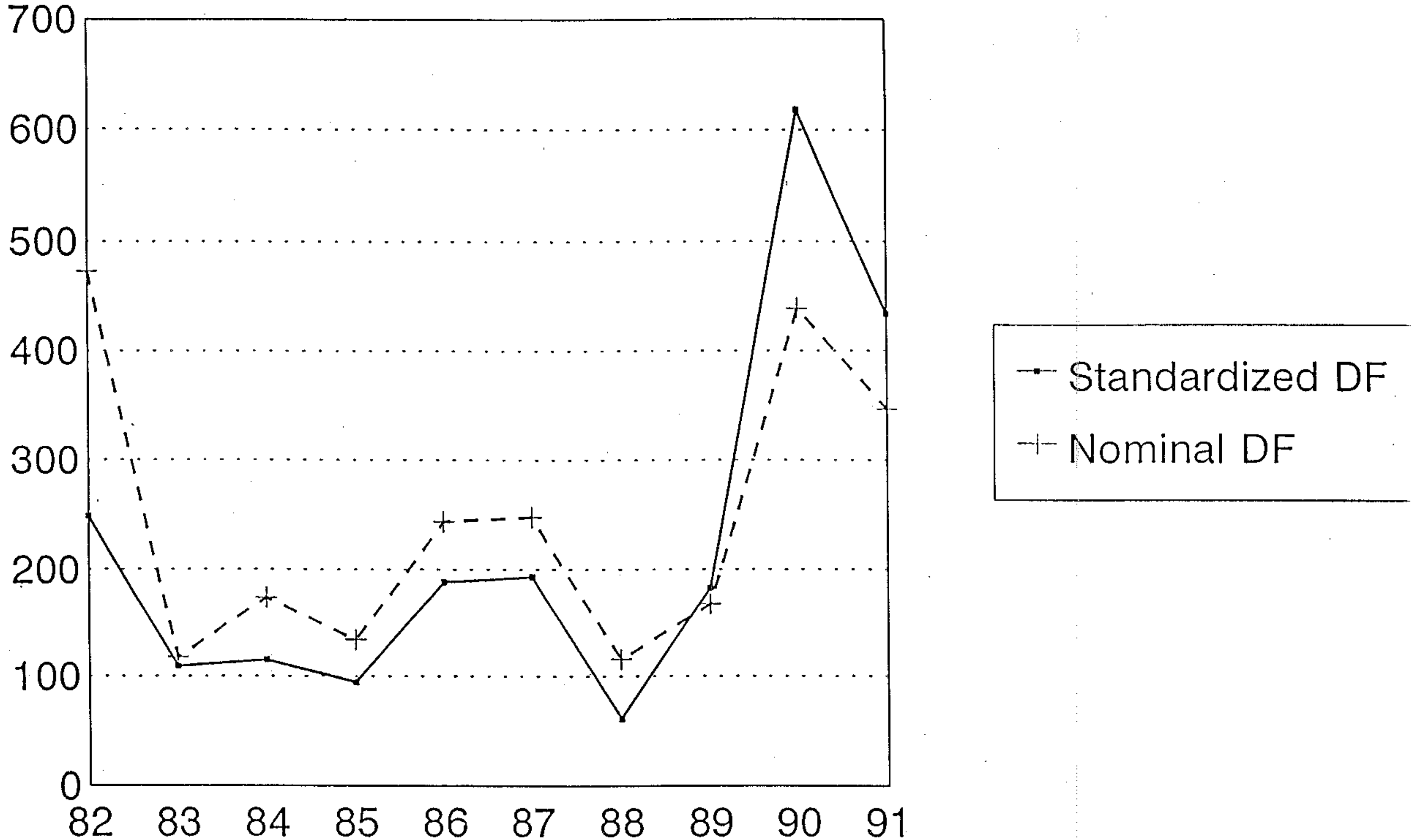


Figure AE4. Fishing effort for Illex squid.

LONG FIN SQUID

The index level assessment of long fin (Loligo) squid is based on yield and effort statistics from the fishery and research cruise survey observations. The species extends from Nova Scotia to South America, but the unit stock includes all U.S. territorial waters in the Atlantic except the Gulf of Mexico and the Caribbean Sea. The U.S. landings in 1991 were 19,400 mt (Figure AF1), less than the 37,000 mt allowable biological catch. Catches from inshore Massachusetts were less than expected in 1991 yet off shore catches were near record high levels.

Summary of Status

- Abundance and mortality estimates are unavailable so statements about the status of this resource are very uncertain.
- Ignoring the 1987 point as aberrant, the research vessel indices indicate abundance is high.
- The stock is at a moderate level of abundance and under-exploited.
- According to the MAFMC definition, the resource was not overfished in 1991 and will not be in 1992.

Recommendations

- Further efforts should be made to obtain accurate estimates of stock and adult stock biomass and stock production.
- The relation between inshore and offshore fisheries is poorly understood and warrants investigation.

LOLIGO

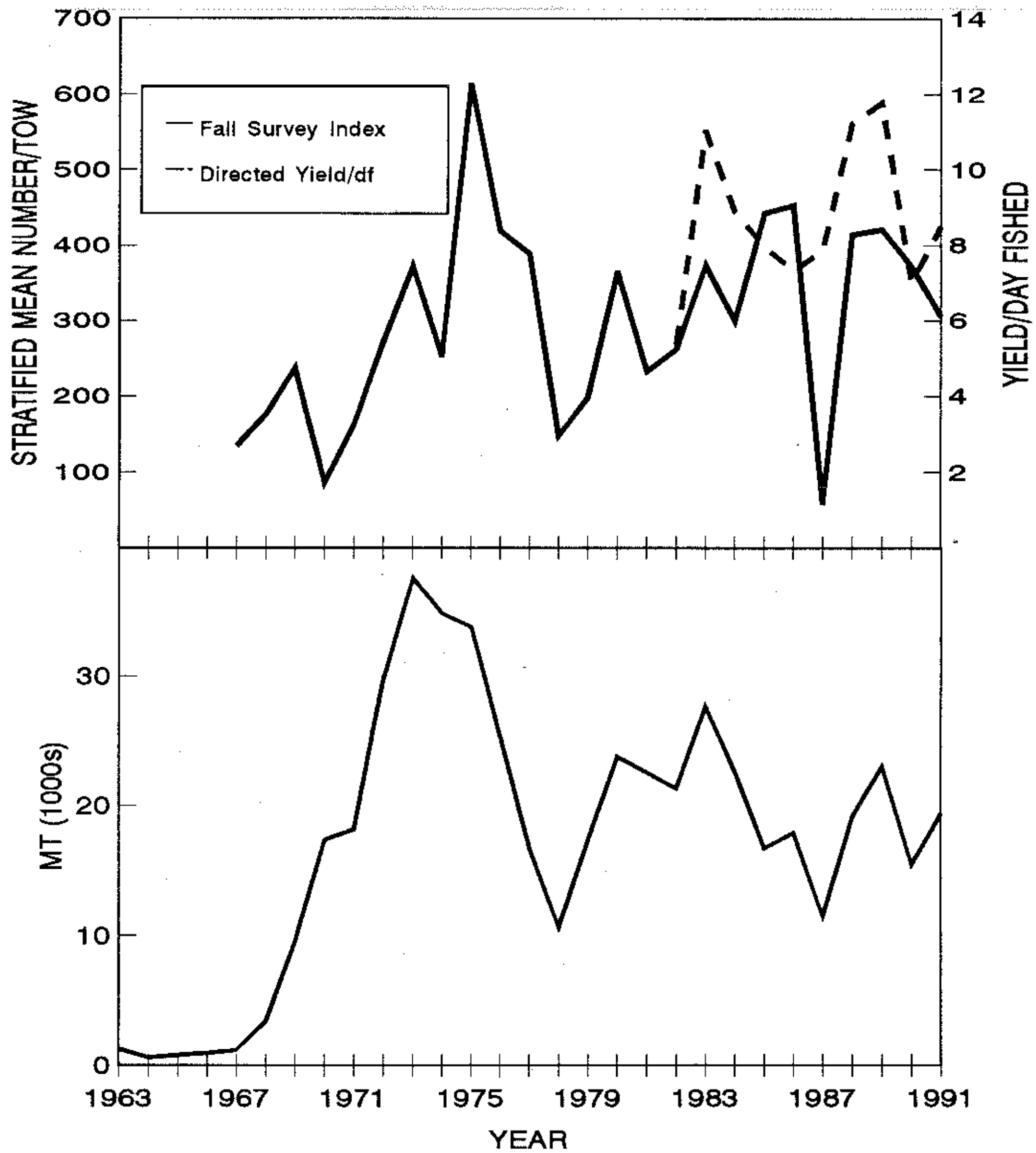


Figure AF1.

ATLANTIC SEA SCALLOPS

The sea scallop fishery has been supported by abundant recruitment in recent years. U.S. Landings increased to 17,000 mt by 1990 and remained constant in 1991. Fishing effort has steadily increased since 1975 reaching a record high in 1991 (Figure AG1). Nominal yield per day fished declined 16% on Georges Bank and 20% on Mid-Atlantic grounds in 1991. The fishery currently depends on the recruiting year class. The fishery will depend on the 1988 cohort during 1992-93. The year class is above average in the U.S. sector of Georges Bank (Figure AG2) but is of average abundance in the Mid-Atlantic (Figure AG3).

Last year a new method calculated fishing mortality to be very high, two to three times larger than the overfishing definition (F=0.7). Research on the calculation procedure indicates that revised assumptions result in lower estimates of fishing mortality, but the conclusion of overfishing remains.

Summary of Status

- Fishing effort steadily increased from 1975 to 1991, doubling during the last ten years.
- Catch rates have steadily decreased since 1977.
- The landings are almost entirely composed of the recruiting cohort each year so landings and catch per effort can decline very rapidly if a weak year class occurs.
- The recruiting year class is of above average abundance on Georges Bank but not in the Mid-Atlantic.
- The fishing mortality rate is higher than that of overfishing (0.71) on Georges Bank.

Recommendations

- The SAW/12 recommendation last year that fishing mortality be reduced holds this year as well, particularly for Georges Bank.
- A special workshop should be convened to reach a consensus on the estimate of current fishing mortality rates.
- Conduct field experiments to determine research survey dredge selectivity.
- Obtain size and or age samples from catches.

SCALLOPS

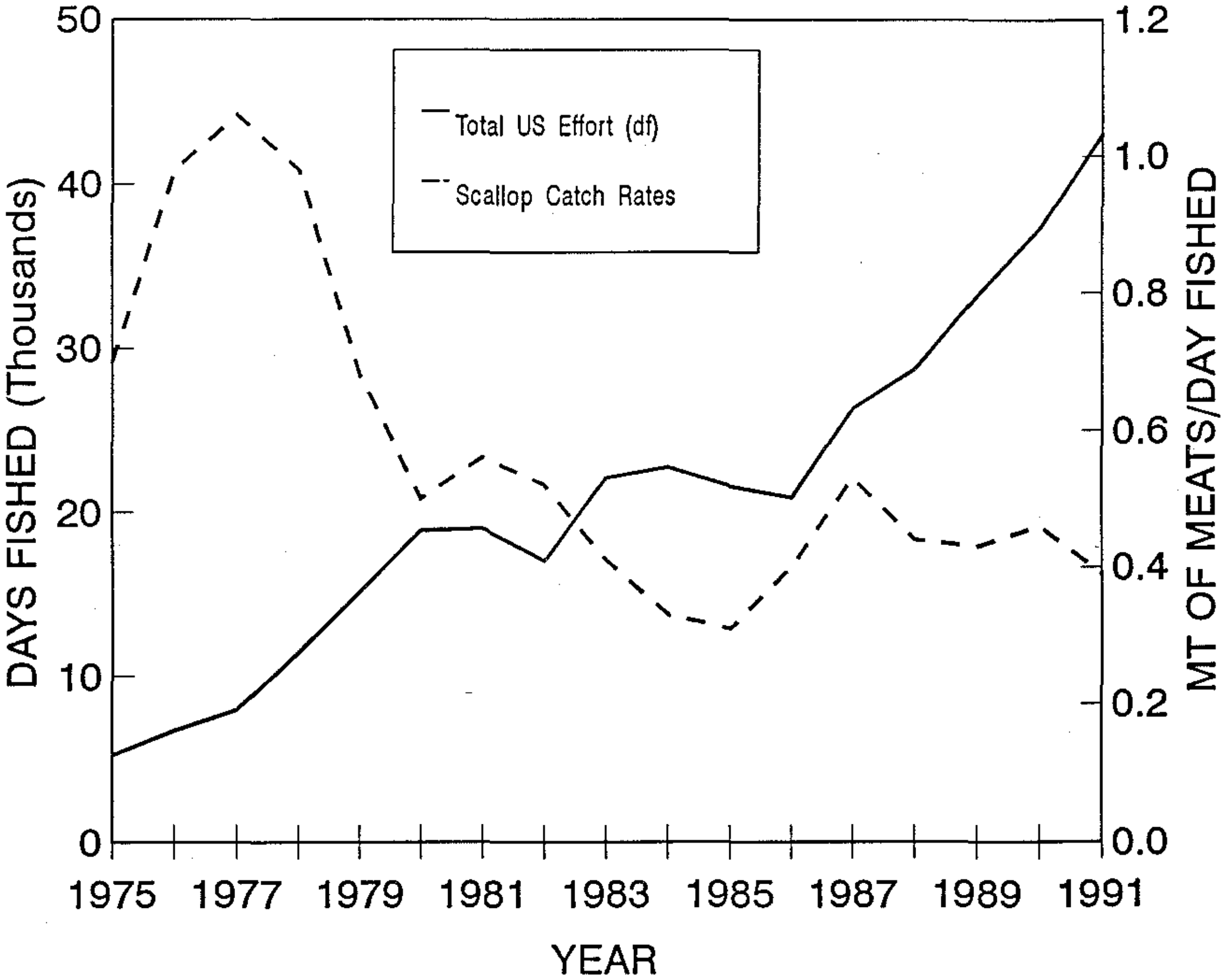


Figure AG1.

USA SEA SCALLOP RELATIVE ABUNDANCE INDICES

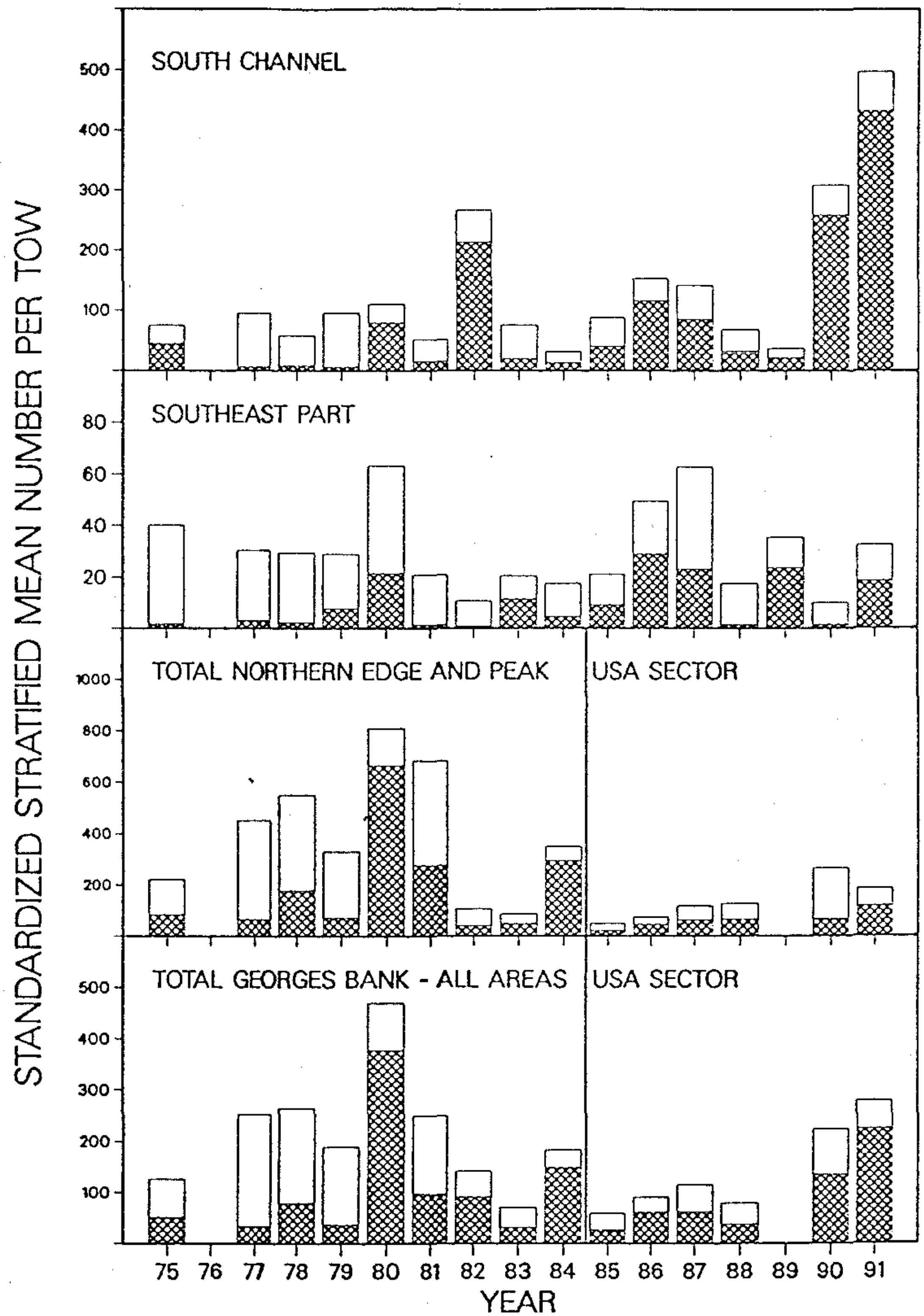


Figure AG2. Relative abundance indices of sea scallops, by principal scallop region on Georges Bank, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1991. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops (≥70 mm shell height).

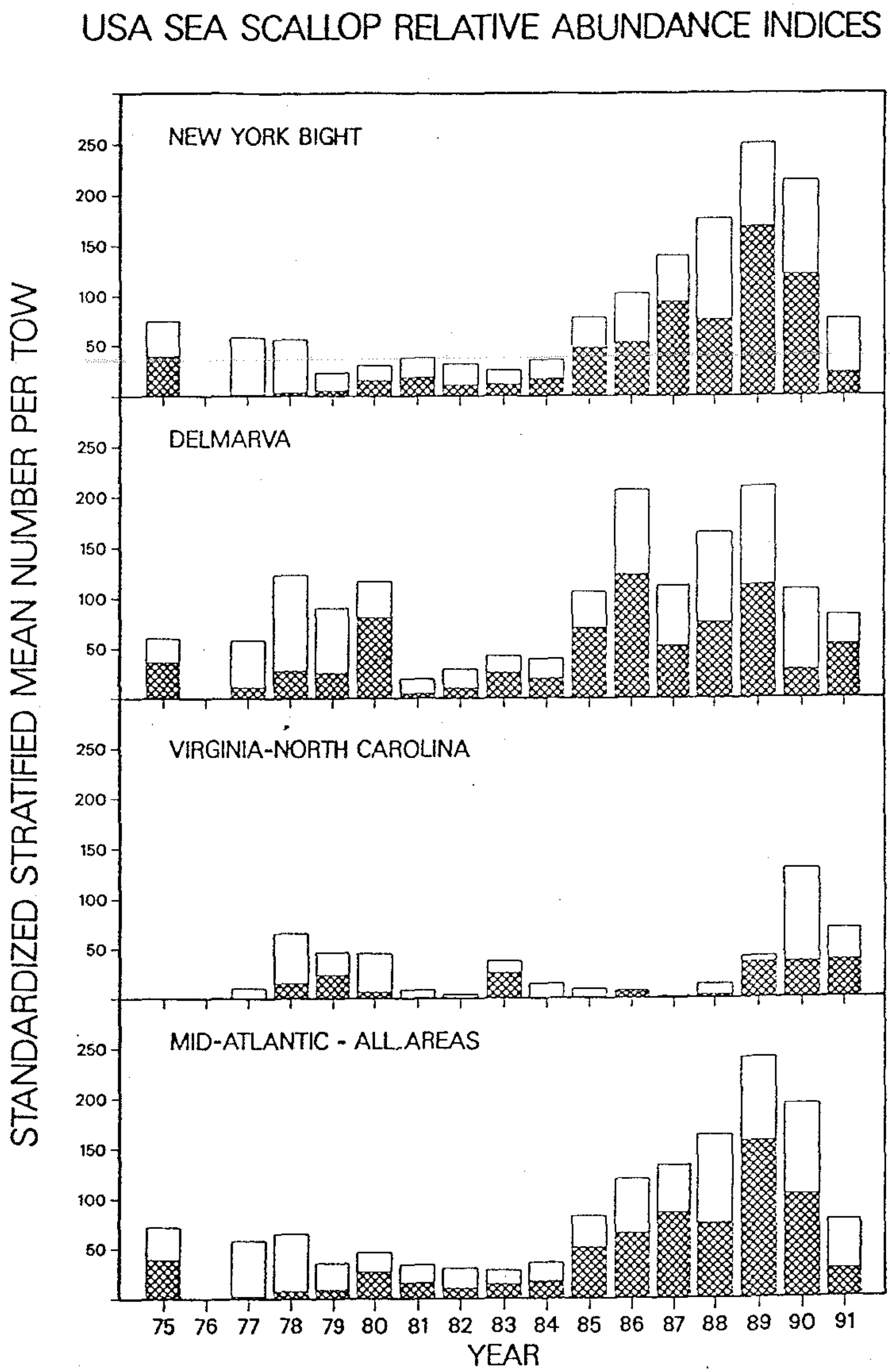


Figure AG3. Relative abundance indices of sea scallops, by principal scallop region in the Mid-Atlantic, from USA sea scallop research vessel surveys conducted during 1975 and 1977-1991. The shaded portion of each bar represents the relative abundance of pre-recruit scallops (<70 mm shell height); the upper, non-shaded portion of each bar represents the relative abundance of recruited or harvestable-size scallops ($\geq$70 mm shell height).

Appendix 1.

The Commonwealth of Massachusetts

Division of Marine Fisheries

18 Route 6A

Sandwich, Massachusetts 02563

PHILIP G. COATES
DIRECTOR

888-1155

July 15, 1992

Dr. Michael Parrack, Chairman
Stock Assessment Review Committee
Northeast Fisheries Science Center
Woods Hole, MA 02543

Dear Dr. Parrack:

The Atlantic States Marine Fisheries Commission Lobster Scientific Committee met at Woods Hole on July 14, 1992. Because a number of our committee members could not attend the SAW we seized the opportunity to review a draft of the SARC report on American lobster. The scientific committee believes that the Delury method has considerable merit and its members will help work toward refining the data input to resolve its underestimation of fishing mortality (F). We also believe that Cohort Analysis has merit and we have been looking at ways of improving its overestimation of F. There is consensus that the true level of F lies somewhere in between the current results generated by the two methods. For this reason, and to avoid misinterpretation of the report's findings, we feel that both methods and their respective results should be equally represented in the text. Consequently, we strongly urge that the following specific changes to the text of the SARC report be effected.

Page 1, paragraph 1 should read:

American lobster biomass indices for the entire U.S. American lobster resource fluctuated without trend since 1965 while landings and fishery effort increased. Catch per unit effort increased in Maine and was steady in Massachusetts. Female stock abundance is estimated to have increased since 1980 in the Gulf of Maine and remained constant on offshore areas of Georges Bank and Southern New England. The female fishing mortality rate (F) in the Gulf of Maine ranged from ≈0.8 by Delury method to ≈2.0 by Cohort Analysis compared to the over-fishing rate of F=1.0 (the F resulting in 10% of maximum egg production per recruit). The calculated fishing mortality rates on the offshore part of Georges Bank and Southern New England (≈0.7 for Delury method and 0.5 for Cohort Analysis) were higher than the overfishing rate (0.44).

Page 2, paragraph 4, sentence 1, should read:

The SARC requested analysis of two principal groupings: (1) Gulf of Maine and (2) offshore Georges Bank-Southern New England.

Page 3, paragraph 4, sentence 1 should exclude reference to Table SA2. Text does not match table content. Furthermore, we recommend removing Tables SA2 and SA3 from the report at this time since comparable tables of Cohort Analysis statistics are not yet available. This will eliminate any confusion which may arise from one statistical method being emphasized as more valid than another.

Page 5, paragraph 3, sentence 1 should exclude reference to Table SA3.
.... sentence 3 should read:

This calculation is substantially lower than the cohort analysis calculation.

Page 5, paragraph 5 should read:

Overfishing in the Gulf of Maine occurs with an F greater than 1.0 (using Botsford's model, pers. commun., 1992) and on offshore Southern New England-Georges Bank with an F greater than 0.44 (using Fogarty and Idoine's, 1988, model). The preliminary estimates of F for females generated by the Delury method were, tentatively, 20% less than the overfishing level in the Gulf of Maine and 57% greater than the overfishing level in offshore Southern New England-Georges Bank area. The preliminary estimates of F calculated with Cohort Analysis were 105% higher than the overfishing level in the inshore Gulf of Maine area and 14% higher for females from the Southern New England-Georges Bank area. These preliminary estimates are subject to change with future refinement of input data and should thus be interpreted cautiously.

We thank-you for your consideration of our committee's consensus review.

Sincerely,

Bruce T Estrella

Bruce T. Estrella
Chairman, ASMFC Lobster
Scientific Committee