

**Report of the Spring 1990
NEFC Stock Assessment Workshop
(Tenth SAW)**

NOAA/National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, MA 02543

July 1990

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EXECUTIVE SUMMARY

The 1990 Spring Stock Assessment Workshop (SAW) was held in Woods Hole, Massachusetts from 4 - 8 June. Eighty-six participants attended, representing state agencies of Maine, Massachusetts, Connecticut, New York, and Maryland; New England and Mid-Atlantic Fishery Management Council staffs; Department of Fisheries and Oceans, Canada; academic institutions; and NOAA's National Marine Fisheries Service, including the Northeast Fisheries Center (NEFC), Northeast Regional Office (NERO) and Southeast Fisheries Center (SEFC). Objectives were to review the status of silver hake, Atlantic mackerel, butterfish, long-finned (*Loligo*) squid, short-finned (*Illex*) squid, and ocean quahog stocks; review future directions and issues in assessments of pollock and offshore lobster stocks; review progress of several SAW working groups addressing problems of assessment methodology, scallop fishery analysis, sea sampling priorities and SAW documentation; and discuss topics of special interest, including Stock Assessment and Fishery Evaluation (SAFE) requirements and the Status of Fishery Resources Report, the status of Georges Bank sea herring and the 1989 Experimental Whiting Fishery on Georges Bank.

A recurring theme throughout the meeting was the need for changes in the SAW structure and outputs to better address management needs. This theme was introduced in the report of the SAW Documentation Working Group, which led to a recommendation for a basic restructuring of the SAW process to include:

- 1) a Steering Committee of senior administrators to set priorities, allocate resources, and oversee the assessment review and advisory process;
- 2) assessment working groups and individuals to prepare and present assessment results as Working Papers;
- 3) a Stock Assessment Review Committee of assessment experts to provide critical peer review of assessments and produce a consensus summary of stock status and assessment results; and
- 4) a Plenary Session for Scientific Advice, including most of the current SAW participants, that would review assessment summaries and (non-assessment) working group reports and use them to produce an advisory document to contribute to SAFE reporting requirements.

Such a restructuring would require additional dedicated resources to integrate the separate more specialized components.

SAFE requirements and the Status of Fisheries Resources Report (SOFR) were also reviewed. The SAW concluded that various combinations of infor-

mation from the SOFR, SAW reports and FMP-specific reports (reviewed by appropriate proposed SAW components) could for most species/stocks serve the purpose of the SAFE reports, although, again, additional resources would be required.

Revised assessments of Gulf of Maine - northern Georges Bank and southern Georges Bank-Mid-Atlantic stocks of silver hake were presented. Problem areas were highlighted by the presenters, and caution was recommended in interpretation of the preliminary results. In particular, systematic residual patterns were apparent in diagnostic statistics of two different tuning patterns. Consequently, results of virtual population analysis (VPA) results could not be accepted with confidence. The SAW observed that current fishing mortality rates are probably not lower (and may be higher) than those estimated in the previous assessment (1987). That earlier assessment was assumed to provide the best available information for spawning stock biomass per recruit (SSB/R) calculations. The SAW reiterated that target levels of SSB/R chosen "by analogy" (e.g., based on other species) are not appropriate, and reviewed an existing SSB/R analysis for silver hake.

Assessment updates for Atlantic mackerel, based on Monte Carlo projections from earlier VPA, indicated that catches of up to 400,000 mt in 1990-1991 would not result in a reduction in spawning stock biomass below 600,000 mt in 1992. Based on simulation results, catches under an $F_{0.1}$ harvest strategy averaged 380,000 mt. The SAW concluded that under existing exploitation levels, spawning stock biomass should remain above 600,000 mt for several years, even with poor recruitment.

For butterfish, the 1989 NEFC recruitment index is comparable to previous historically high levels (1975-81, 1983-85, 1988) and is double the 1968-1978 average. This indicates an increase in pre-recruit survival since 1979. The 1989 age 1+ index is 40% below the high indices observed in 1979-1985 but is more than double most indices before 1977. This suggests that stock abundance is sufficient to support catches at the MSY level (16,000 mt) although recent domestic catches have been only one-sixth of this amount.

For long-finned (*Loligo*) squid, NEFC autumn 1989 survey data suggest that current stock size is adequate to support catches during 1990 of between 38,000 - 44,000 mt, even at fishing mortality levels below those expected to produce highest equilibrium yield. Availability to the US fishery in 1990 may be low, however, resulting in lower catch per unit effort, as forecast from an index of spatial dispersion from the autumn 1989 trawl survey.

For short-finned (*Illex*) squid, autumn 1989 NEFC

survey results suggest that stock size is adequate to support catches during 1990 at or above the domestic allowable harvest (DAH) level of 15,000 mt. As for *Loligo*, levels are contingent on availability. A working group was recommended to evaluate reporting requirements for various fleet components of squid fisheries.

Ocean quahog resources continue to remain stable, reflecting low natural mortality rates, very poor recruitment, and modest overall harvest rates between 1965-1989. Preliminary biomass estimates based on DeLury methods for the Delmarva region indicate a standing stock of 370,000 mt of shucked meats, higher than swept-area estimates of 90,000 mt based on research surveys. Actual biomass of the ocean quahog resource off the Delmarva is probably between these two values. Revised growth equations confirm the slow growth and extreme longevity originally estimated for this resource.

The US pollock assessment will be updated when 1989 commercial age data become available. Trends in indices of abundance from research surveys differ for recent years depending on the data set used (US or Canadian). Differences may be related to an apparent net migration of pollock from the Gulf of Maine-Georges Bank region to the Scotian Shelf.

The offshore lobster assessment may be combined with assessments of inshore lobsters, based on recommendations of a newly-formed lobster assessment working group.

The report of the Methods Working Group elicited no consensus on :

- 1.) evaluation and interpretation of various methods currently in use to compute potential yields and biological reference points,
- 2.) the utility of various reference points in guiding the Councils in formulation of overfishing definitions, or
- 3.) operational "rules to live by" with respect to proposed biological reference points.

The SAW did observe that to avoid semantic arguments, it may be more appropriate to classify dy-

namic pool models as "stationary" rather than "equilibrium" approaches. The SAW emphasized the distinction between "overfished" and "overfishing" conditions. While overfishing in terms of a biological reference point may not be occurring, characteristics of overfished stocks (*e.g.*, very low stock sizes) may persist.

The collection of biological and economic data for the sea scallop fishery was reviewed as part of the Scallop Fishery Analysis Working Group. The SAW did not consider meat count sampling as an adequate method for collection of size composition data. Some data on crew size may be obtained from port agent interviews or special sampling. Technical issues were raised concerning a bioeconomic model. Cost data, presently unavailable, must be collected and incorporated into any bioeconomic model, along with dynamic vessel behavior and distinction between Mid-Atlantic and Georges Bank components of the fishery.

With respect to sea sampling priorities, the SAW generally agreed that except for the Gulf of Maine gillnet fishery, the level of coverage in the sea sampling program is unlikely to provide parameter estimates such as discard rates, and recommended that resources be made available to statistically analyze data from two fisheries to provide guidance for future sampling requirements. The SAW also recommended additional resources be allocated to monitor and coordinate biological sampling at sea and dockside, in order to evaluate sampling adequacy and adjust sampling priorities on a real-time basis.

A joint US-Canadian evaluation of the status of Georges Bank sea herring indicated that although recovery of the stock continues, there is insufficient information to provide a definitive estimate of population size. There is little evidence of occupation of historically important spawning grounds. It was judged premature to consider a directed fishery for this stock at this point.

The SAW noted that, based on data from the 1989 Experimental Whiting Fishery, very low bycatches of regulated species are being observed. The fishery should be monitored, however, to determine the impact on these and other stocks, *e.g.*, Atlantic herring.

INTRODUCTION

OVERVIEW

The Spring 1990 Northeast Fisheries Center (NEFC) Stock Assessment Workshop (Tenth SAW) was held at the Northeast Fisheries Center Aquarium Conference Room in Woods Hole, MA from 4 - 8 June, 1990. Eighty-six participants from marine fisheries management and scientific institutions and agencies attended all or part of the workshop. Reports from this series of workshops serve as the most current source of information on the status of the fishery resources in the New England and Mid-Atlantic areas, and are designed for use by groups with fisheries management responsibilities. The Tenth SAW included assessment of the status of seven stocks in the northeast region, and review of current issues and future directions for two additional assessments. In addition, four working group reports and three special topics regarding assessment approaches, development and implementation of various data collection and research projects, evaluation of available data for stock recovery, and future directions for the SAW in the provision of management advice were discussed.

TOPICS FOR THE TENTH SAW

The agenda for the Tenth SAW was based on topics recommended at the Autumn 1989 Stock Assessment Workshop (SAW-9), modified by changing management priorities and recommendations:

Assessment Revisions or Updates

- Revised silver hake assessment, Gulf of Maine-Northern Georges Bank stock
- Revised silver hake assessment, Southern Georges Bank-Mid-Atlantic stock
- Revised ocean quahog assessment
- Updated Atlantic mackerel assessment
- Updated butterfish assessment
- Updated *Loligo* assessment
- Updated *Illex* assessment
- Review issues and directions for pollock assessment
- Review issues and directions for offshore lobster assessment

Working Group Reports

- Report of Methods Working Group (WG #9)
- Report of Scallop Fishery Analysis Working Group (WG #23)

- Report of Sea Sampling Priorities Working Group (WG #24)
- Report of SAW Documentation Working Group (WG #25)

Special Topics

- Stock Assessment and Fishery Evaluations (SAFE) requirements and the Status of Fishery Resources report
- Georges Bank sea herring recovery
- Georges Bank experimental whiting fishery, 1989

IDENTIFICATION OF WORKING PAPERS

Working papers are listed in Appendix 1. Several were prepared in advance of or during the workshop for distribution to participants, were provisional in nature, and were not to be cited. Some of those working papers, however, were prepared for other purposes and were included because of their relevance to the workshop agenda.

FISHERY RESOURCES

REVISED ASSESSMENT OF THE STATUS OF SILVER HAKE, GULF OF MAINE-NORTHERN GEORGES BANK AND SOUTHERN GEORGES BANK-MID-ATLANTIC STOCKS

The silver hake resource off the northeast coast of the United States is currently assessed as two stocks: the "Northern Stock," occupying the eastern Gulf of Maine and Northern Georges Bank region; and the "Southern Stock" which is distributed from south-eastern Georges Bank to Cape Hatteras (Figure 1). Assessment information for each stock is given in the following sections.

Gulf of Maine-Northern Georges Bank Stock

Peak landings of 94,500 mt occurred in 1964, reflecting high USSR effort (Table 1, Figure 2). Landings subsequently declined more or less continually to only 3,400 mt in 1979 and have since fluctuated between 4,400 and 8,500 mt; for 1988, landings totaled 6,800 mt, and for 1989, landings totaled 4,600 mt. Since 1975 this stock has been exploited exclusively by the USA.

Commercial catch per unit effort (CPUE) for USA vessels, calculated for trips for which 50 percent or

more of the total catch consisted of silver hake, has generally paralleled landings trends, declining from peak values in the mid-1960s to relatively low levels during the 1980s. The index value of 4.5 mt per day for 1987 was the lowest observed in the time series. The index has since increased to 6.7 mt per day in 1989 (Table 1).

Commercial catch at age data are available for 1955-1988 (Table 2). Problems with the catch-at-age matrix include a lack of older fish in recent years and a shift in age composition and mean weights at age at younger ages (Table 3). The latter circumstance appears to be associated with a change in ageing procedures beginning in 1973, which resulted in increased proportions of age 1 and 2 fish. Weights at age for older (age 7+) fish were adjusted to reduce variability (Table 3).

NEFC spring and autumn survey indices (fitted to an ARIMA model) are consistent in indicating a gradual increase in abundance and biomass from minimal levels observed during the late 1960s (Figures 3, 4). Peak values were observed in the fitted indices in 1975-1976 and again in 1986-1987 reflecting strong recruitment from the 1973-1974 and 1985 year classes, respectively. The 1985 year class is the strongest to appear since 1973 and the 1988 year class also appears to be strong based on NEFC 1988 autumn survey catch per tow at age 0 (Table 4).

The ADAPT procedure was explored as a tuning method for virtual population analysis (VPA). (Note that results were preliminary and do not necessarily reflect the best "tuning" that could be accomplished with this method). This technique develops estimates of terminal F through minimization of differences between actual and predicted survey indices, the latter derived from estimates of stock size and catchability coefficients (q). In these analyses autumn survey catch per tow at age (delta method, Table 4) and commercial catch at age for 1973-1988 were employed in a series of trials to identify ages for which terminal F could be estimated with reasonable precision. Terminal Fs (in 1988) for ages 1-4 were estimated independently i.e., no partial recruitment pattern was assumed. Terminal Fs for ages 5 and older could not be estimated with acceptable precision since numbers of fish declined rapidly beyond age 4 or so, and accordingly terminal Fs for ages 5 and older were taken as the mean of age 3 and 4 terminal F estimates. Results indicated a very strong 1985 year class; F and partial recruitment for this cohort in 1988 were low, while the associated coefficient of variation (C.V.) was quite high.

The Laurec-Shepherd method was next examined as a tuning technique. This procedure utilizes fleet-specific catch per unit effort and total catch at age estimates to derive estimates of q and partial F by fleet which are then averaged to produce final F values (10

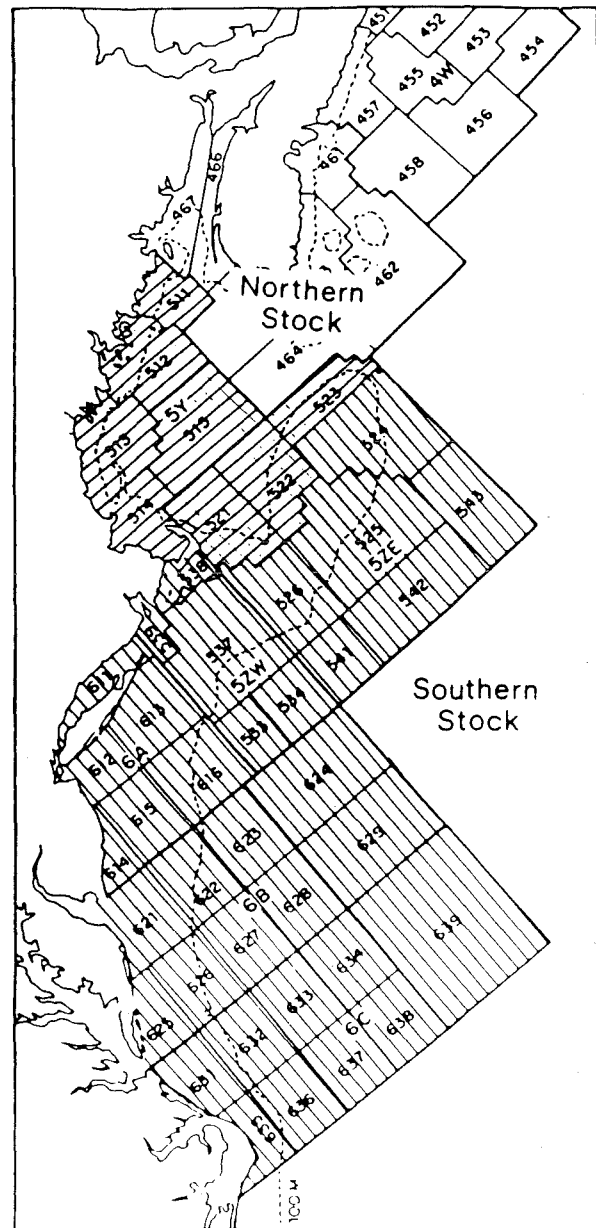


Figure 1. Stock definition of silver hake and fishery statistical areas (SA) off the northeast coast of the United States. Northern stock inhabits SA 511-515 and 521-523; the southern stock occupies areas 524-526 and 600+.

iterations are employed). In this analysis both autumn and spring survey data were used to calculate estimates of q and F. Because of the aforementioned problems with the catch-at-age matrix only estimates for ages 2 and 3 were judged to be usable. Initial trials indicated no clear temporal trends in q by age, although values for the earliest years (1974-1975) were judged to be unacceptably low in comparison to later values. Accordingly, analyses were re-run for 1976-1988 data which increased the precision somewhat; the final results were obtained by downweighting

Table 1. Silver hake catches (mt) from the Gulf of Maine - Northern Georges Bank stock

| Year | Bulgaria | Canada | Cuba | FRG | GDR | Japan | Poland | Romania | USSR | Other ¹ | USA Comm. | USA Total catch/day |
|------|----------|--------|-------|-----|-----|-------|--------|---------|--------|--------------------|--------------|------------------------|
| 1955 | - | - | - | - | - | - | - | - | - | - | 53,361 | 53,361 |
| 1956 | - | - | - | - | - | - | - | - | - | - | 42,150 | 42,150 |
| 1957 | - | - | - | - | - | - | - | - | - | - | 62,750 | 62,750 |
| 1958 | - | - | - | - | - | - | - | - | - | - | 49,903 | 49,903 |
| 1959 | - | - | - | - | - | - | - | - | - | - | 50,608 | 50,608 |
| 1960 | - | - | - | - | - | - | - | - | - | - | 45,543 | 45,543 |
| 1961 | - | - | - | - | - | - | - | - | - | - | 39,688 | 39,688 |
| 1962 | - | - | - | - | - | - | - | - | 36,575 | - | 42,427 | 79,002 |
| 1963 | - | - | - | - | - | - | - | - | 37,525 | - | 36,399 | 73,924 |
| 1964 | - | - | - | - | - | - | - | - | 57,240 | - | 37,222 | 94,462 |
| 1965 | - | - | - | - | - | - | - | - | 15,793 | - | 29,449 | 45,242 |
| 1966 | - | - | - | - | - | - | - | - | 14,239 | - | 33,477 | 47,716 |
| 1967 | - | - | - | - | 3 | - | - | - | 6,879 | - | 26,489 | 33,371 |
| 1968 | - | - | - | - | - | - | 60 | - | 10,434 | 12 | 30,873 | 41,379 |
| 1969 | - | - | - | - | 38 | 19 | 57 | 1 | 7,813 | 119 | 15,917 | 23,964 |
| 1970 | - | - | - | - | - | 5 | 11 | 10 | 12,279 | - | 15,223 | 27,528 |
| 1971 | 1,293 | - | 119 | - | - | 45 | 112 | - | 23,674 | - | 11,158 | 36,401 |
| 1972 | 1,737 | - | - | 357 | 178 | 1 | - | 42 | 16,469 | - | 6,440 | 25,224 |
| 1973 | 48 | - | - | 29 | 144 | 18 | - | - | 17,847 | - | 13,997 | 32,083 |
| 1974 | 61 | 1 | - | 48 | 27 | - | 27 | 135 | 13,476 | - | 6,905 | 20,680 |
| 1975 | - | 2 | 1,304 | 37 | 29 | - | 358 | 122 | 25,456 | - | 12,566 | 39,874 |
| 1976 | - | - | - | 81 | - | 1 | 4 | - | 65 | - | 13,483 | 13,634 |
| 1977 | - | - | - | - | - | - | - | - | 2 | - | 12,455 | 12,457 |
| 1978 | - | - | - | - | - | - | - | - | - | - | 12,609 | 12,609 |
| 1979 | - | - | - | - | - | - | - | - | - | - | 3,415 | 3,415 |
| 1980 | - | - | - | - | - | - | - | - | - | - | 4,730 | 4,730 |
| 1981 | - | - | - | - | - | - | - | - | - | - | 4,416 | 4,416 |
| 1982 | - | - | - | - | - | - | - | - | - | - | 4,656 | 4,656 |
| 1983 | - | - | - | - | - | - | - | - | - | - | 5,310 | 5,310 |
| 1984 | - | - | - | - | - | - | - | - | - | - | 8,289 | 8,289 |
| 1985 | - | - | - | - | - | - | - | - | - | - | 8,297 | 8,297 |
| 1986 | - | - | - | - | - | - | - | - | - | - | 8,502 | 8,502 |
| 1987 | - | - | - | - | - | - | - | - | - | - | 5,658 | 5,658 |
| 1988 | - | - | - | - | - | - | - | - | - | - | 6,767 | 6,767 |
| 1989 | - | - | - | - | - | - | - | - | - | - | 4,646 | 4,646 |

¹Non-member ICNAF countries.

earlier years. A separable VPA indicated that the partial recruitment vector was nearly flat-topped from ages 3-6. Therefore, the final VPA was run with F for ages 4-6 equal to the age 3 value of 0.52. Results were considerably different from those obtained from the VPA tuned using the ADAPT method. Most notably, the Laurec-Shepherd 1985 year class size estimate was appreciably smaller than that obtained based on preliminary ADAPT runs.

Discussion of Assessment of Silver Hake, Northern Georges Bank- Gulf of Maine Stock

There was considerable discussion as to the reliability of the catch at age matrix, particularly with respect to the lack of larger fish. It was noted that ageing techniques and data bases had changed begin-

ning in 1973 (USSR ages were used for earlier years) although this clearly does not explain more recent events. It was suggested that future analyses would be based on data for 1973 on (currently, survey catch-at-age data are available only for these years). It was also agreed that there was no reason to suspect problems with commercial sample coverage, since catches of older individuals (age 4+) also dropped to negligible levels in research vessel surveys and length frequencies of the largest market category (king whiting) have never been notably different from those for "unclassified" fish. Other possible problems included higher natural mortality; reduced availability of larger fish because of shifts in distribution, and discard, particularly in the northern shrimp fishery, which has not been included in the catch at age matrix. Since discarding appears to have been significant in recent years, the implication is that stock size at younger

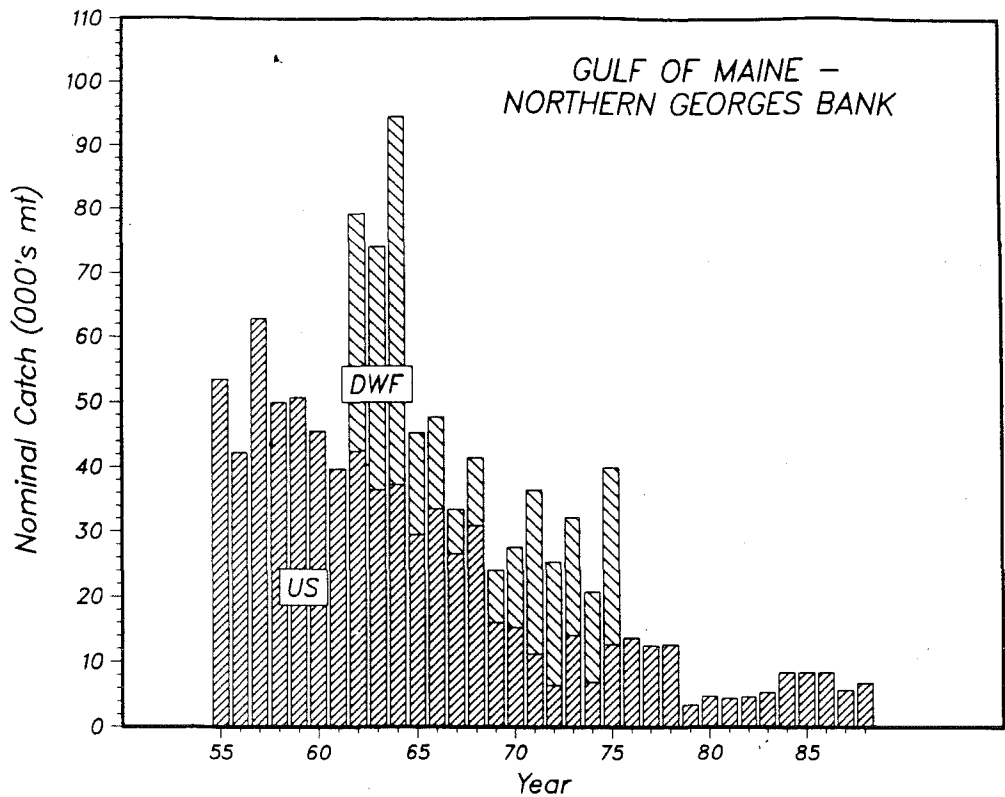


Figure 2. U.S. commercial and distant-water fleet components of the total catch from the Gulf of Maine-Northern Georges Bank silver hake stock.

Table 2. Commercial catch at age (millions of fish) of silver hake from the Gulf of Maine - Northern Georges Bank stock

| Year | Age | | | | | | | | | Total |
|------|------|------|-------|-------|------|------|------|------|------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | |
| 1955 | 17.0 | 19.9 | 50.2 | 69.2 | 30.4 | 13.7 | 6.5 | 3.3 | 1.5 | 211.8 |
| 1956 | 16.2 | 12.7 | 36.5 | 61.2 | 26.4 | 10.1 | 4.2 | 1.9 | .9 | 170.2 |
| 1957 | 52.8 | 19.5 | 58.8 | 84.8 | 41.6 | 17.9 | 6.7 | 3.1 | 1.3 | 286.6 |
| 1958 | 20.9 | 20.2 | 40.1 | 57.6 | 28.4 | 17.2 | 5.7 | 2.8 | 1.2 | 194.2 |
| 1959 | 10.1 | 30.0 | 58.2 | 54.2 | 26.8 | 12.8 | 6.2 | 3.2 | 1.1 | 202.7 |
| 1960 | 4.4 | 37.7 | 76.2 | 53.2 | 20.8 | 8.8 | 4.7 | 2.3 | .9 | 209.0 |
| 1961 | 1.1 | 23.2 | 59.7 | 51.5 | 18.9 | 8.0 | 4.1 | 1.9 | .8 | 169.1 |
| 1962 | 2.6 | 33.5 | 127.2 | 122.8 | 47.4 | 12.5 | 5.9 | 2.2 | 1.0 | 355.1 |
| 1963 | 14.9 | 48.3 | 136.9 | 103.0 | 29.2 | 10.3 | 4.6 | 2.5 | 1.3 | 351.0 |
| 1964 | 1.4 | 46.6 | 133.1 | 123.4 | 50.2 | 20.6 | 11.7 | 5.6 | 2.1 | 394.9 |
| 1965 | 4.0 | 23.9 | 84.2 | 54.0 | 18.3 | 7.4 | 4.0 | 2.2 | 1.2 | 199.2 |
| 1966 | 5.3 | 20.3 | 82.6 | 70.9 | 19.8 | 6.5 | 3.3 | 1.9 | 1.1 | 211.7 |
| 1967 | .7 | 5.3 | 32.5 | 54.9 | 20.3 | 5.3 | 2.4 | 1.1 | .5 | 123.0 |
| 1968 | 1.3 | 4.0 | 25.8 | 49.5 | 36.5 | 13.7 | 5.0 | 1.9 | .9 | 138.6 |
| 1969 | 3.1 | 10.6 | 16.8 | 21.3 | 16.2 | 9.1 | 5.0 | 1.9 | 1.0 | 85.0 |
| 1970 | 24.8 | 16.0 | 32.4 | 34.1 | 13.4 | 7.0 | 4.4 | 2.2 | .8 | 135.2 |
| 1971 | 4.0 | 24.3 | 73.8 | 49.8 | 19.8 | 7.1 | 2.9 | 1.9 | .8 | 184.4 |
| 1972 | 78.2 | 44.5 | 18.2 | 4.2 | 2.2 | .7 | .2 | .1 | .3 | 148.5 |
| 1973 | 33.4 | 91.5 | 24.2 | 4.5 | 1.8 | .4 | .1 | .1 | .2 | 156.1 |
| 1974 | 21.6 | 31.7 | 22.4 | 9.2 | 2.7 | 1.0 | .4 | .2 | .2 | 89.4 |
| 1975 | 8.7 | 60.1 | 63.4 | 20.3 | 7.9 | 2.3 | .5 | .2 | .4 | 164.0 |
| 1976 | 1.7 | 19.2 | 24.6 | 8.7 | 2.9 | 1.3 | .2 | .001 | .001 | 58.7 |
| 1977 | 1.8 | 8.7 | 22.6 | 14.9 | 3.0 | .5 | .2 | .001 | .001 | 51.6 |
| 1978 | 2.7 | 8.3 | 7.1 | 10.8 | 13.5 | 2.4 | .5 | .3 | .001 | 45.5 |
| 1979 | .7 | 3.5 | 2.3 | 1.4 | 1.8 | 2.3 | .4 | .001 | .001 | 12.4 |
| 1980 | 1.1 | 11.8 | 12.1 | 2.0 | .5 | .5 | .8 | .2 | .001 | 29.0 |
| 1981 | 4.9 | 8.4 | 7.4 | 4.0 | .6 | .2 | .2 | .2 | .001 | 25.9 |
| 1982 | 5.9 | 9.8 | 2.9 | 3.0 | 2.2 | .1 | .2 | .1 | .1 | 24.3 |
| 1983 | 2.6 | 14.1 | 4.0 | 1.8 | 1.7 | .7 | .2 | .1 | .001 | 25.2 |
| 1984 | 3.0 | 21.5 | 9.8 | 3.0 | 1.0 | .7 | .001 | .001 | .001 | 39.1 |
| 1985 | 10.4 | 6.8 | 13.9 | 3.9 | .4 | .7 | .1 | .001 | .001 | 36.1 |
| 1986 | 3.1 | 14.0 | 8.1 | 3.8 | 1.1 | .5 | .2 | .1 | .001 | 30.9 |
| 1987 | .5 | 13.2 | 11.1 | 1.6 | .9 | .1 | .001 | .001 | .001 | 27.4 |
| 1988 | .7 | 4.7 | 20.0 | 4.5 | 1.3 | .2 | .001 | .001 | .001 | 31.4 |

Table 3. Mean weight (kg) at age of silver hake from the Gulf of Maine - Northern Georges Bank stock

| Year | Age | | | | | | | | |
|------|------|------|------|------|------|------|------|-------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1955 | .046 | .132 | .200 | .258 | .331 | .416 | .530 | .573 | .654 |
| 1956 | .055 | .128 | .204 | .260 | .326 | .405 | .499 | .567 | .699 |
| 1957 | .064 | .120 | .193 | .260 | .322 | .384 | .453 | .513 | .644 |
| 1958 | .045 | .127 | .210 | .282 | .341 | .404 | .494 | .555 | .628 |
| 1959 | .051 | .129 | .190 | .269 | .348 | .430 | .521 | .574 | .656 |
| 1960 | .064 | .129 | .171 | .233 | .320 | .433 | .512 | .622 | .696 |
| 1961 | .065 | .146 | .186 | .239 | .303 | .410 | .516 | .637 | .685 |
| 1962 | .069 | .135 | .172 | .229 | .303 | .388 | .503 | .619 | .752 |
| 1963 | .080 | .121 | .176 | .229 | .308 | .431 | .573 | .770 | 1.055 |
| 1964 | .075 | .123 | .171 | .228 | .316 | .456 | .562 | .702 | .971 |
| 1965 | .059 | .147 | .175 | .233 | .320 | .448 | .570 | .744 | .882 |
| 1966 | .065 | .144 | .183 | .229 | .298 | .427 | .583 | .772 | .976 |
| 1967 | .072 | .155 | .218 | .266 | .317 | .385 | .478 | .744 | .882 |
| 1968 | .070 | .161 | .222 | .278 | .323 | .387 | .462 | .589 | .788 |
| 1969 | .064 | .154 | .201 | .291 | .325 | .375 | .442 | .506 | .878 |
| 1970 | .060 | .118 | .178 | .232 | .304 | .392 | .444 | .509 | .687 |
| 1971 | .077 | .122 | .165 | .211 | .262 | .344 | .437 | .524 | .680 |
| 1972 | .089 | .195 | .310 | .437 | .494 | .588 | .690 | .794 | .916 |
| 1973 | .119 | .173 | .262 | .414 | .472 | .544 | .943 | 1.026 | 1.151 |
| 1974 | .144 | .217 | .270 | .314 | .563 | .407 | .594 | 1.114 | 1.218 |
| 1975 | .102 | .167 | .238 | .361 | .484 | .604 | .748 | .867 | 1.285 |
| 1976 | .102 | .162 | .237 | .295 | .422 | .672 | .645 | .872 | 1.140 |
| 1977 | .120 | .172 | .221 | .277 | .403 | .536 | .717 | .899 | .995 |
| 1978 | .114 | .196 | .232 | .277 | .329 | .446 | .659 | .762 | .992 |
| 1979 | .104 | .139 | .201 | .258 | .351 | .349 | .513 | 1.069 | 1.096 |
| 1980 | .094 | .134 | .164 | .206 | .283 | .355 | .462 | .662 | 1.200 |
| 1981 | .115 | .147 | .188 | .215 | .238 | .305 | .410 | .666 | .811 |
| 1982 | .117 | .159 | .197 | .271 | .289 | .312 | .418 | .666 | .811 |
| 1983 | .129 | .175 | .249 | .311 | .310 | .431 | .425 | .666 | .811 |
| 1984 | .126 | .176 | .242 | .368 | .404 | .334 | .500 | .666 | .811 |
| 1985 | .142 | .200 | .256 | .325 | .412 | .610 | .574 | .666 | .811 |
| 1986 | .145 | .214 | .270 | .376 | .538 | .496 | .621 | .666 | .811 |
| 1987 | .092 | .149 | .251 | .321 | .578 | .568 | .579 | .666 | .811 |
| 1988 | .101 | .139 | .181 | .368 | .526 | .779 | .537 | .666 | .811 |

ages may in fact have been considerably higher in recent years than indicated. Reference was made to earlier assessment work (by Anderson) suggesting that the failure of this stock to increase during the early 1970s in spite of good recruitment, was attributable to discard in the northern shrimp (and whiting) fisheries. It is recommended that discard estimates be prepared from sea sampling program data and incorporated into the catch-at-age matrix.

Given problems with the catch at age matrix and the disparity of the results obtained from the two tuning procedures there was considerable uncertainty as to how to proceed, given the New England Fishery Management Council's need for a reasonable estimate of F. (The question arises as to what now constitutes the best scientific information; this problem is discussed further in the Southern Stock section.) A number of possible options were discussed including further work prior to conclusion of the SAW and additional work prior to the next SAW by a separate working group. Since use of autumn survey data only

in the Laurec-Shepherd case provided much more consistent results with ADAPT, it was felt that better consistency could be achieved with common data sets and assumptions although agreement on the size of the 1985 year class would be unlikely. Accordingly, it was agreed that a "quick fix" would be impossible and that additional analyses over a longer period would be needed.

Southern Georges Bank - Mid-Atlantic Stock

Total landings (including USA recreational) peaked at 307,100 mt in 1965 and then declined to only 27,500 mt in 1970 (Figure 5, Table 5). Landings subsequently increased to 109,800 mt in 1974 and then dropped sharply to less than 15,000 mt throughout the 1980s; the 1988 total was 9,200 mt, and preliminary data for 1989 indicate a total of approximately 13,000 mt. High

GULF OF MAINE –
NORTHERN GEORGES BANK

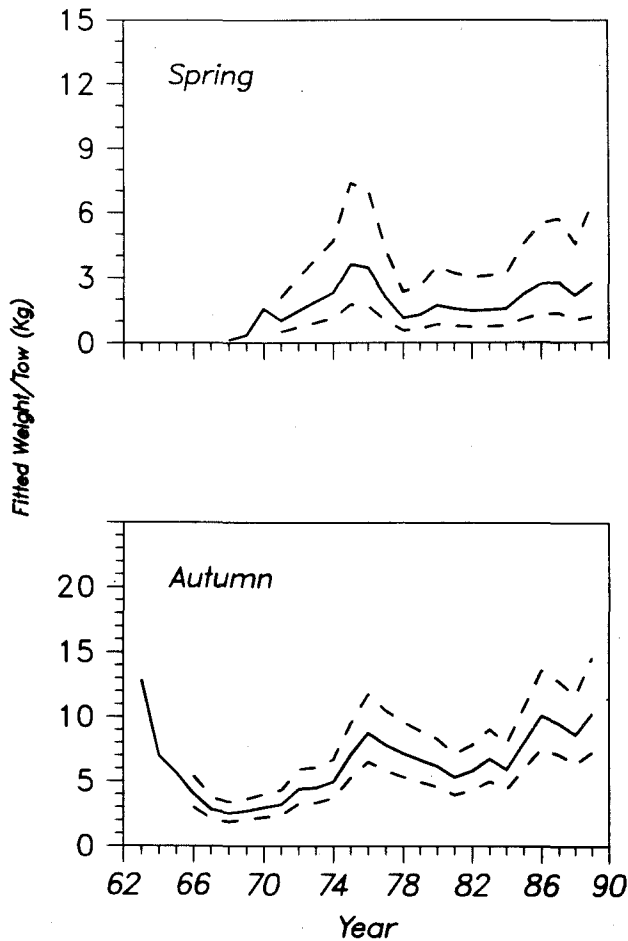


Figure 3. Fitted weight-per-tow indices from spring (upper) and autumn (lower) NEFC bottom trawl surveys during 1963-1989 with 80 percent confidence intervals.

GULF OF MAINE –
NORTHERN GEORGES BANK

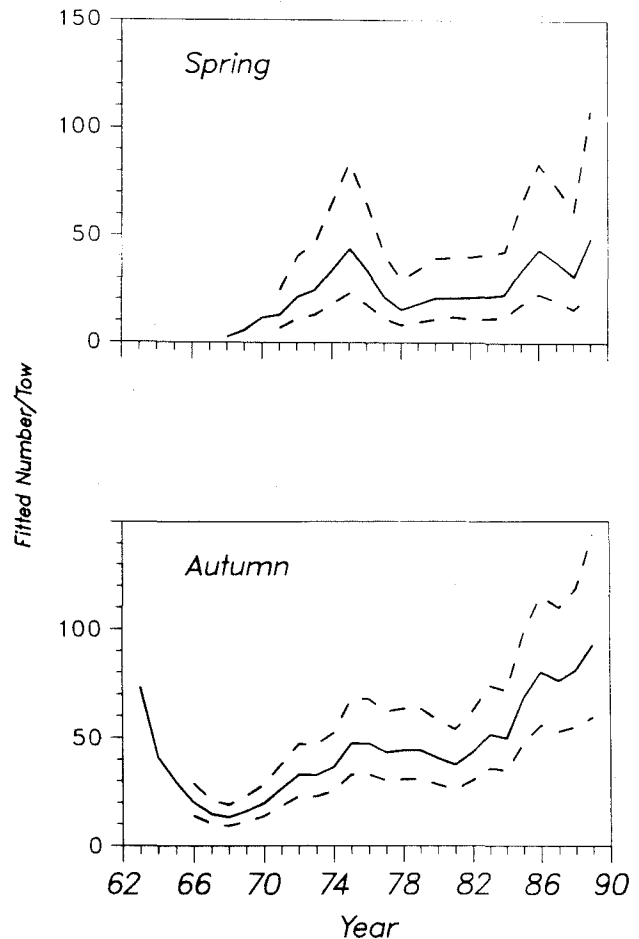


Figure 4. Fitted number-per-tow indices from spring (upper) and autumn (lower) NEFC bottom trawl surveys during 1963-1989 with 80 percent confidence intervals.

catches during the 1960s and early 1970s reflect effort by distant-water fleets; this has been minor since 1980.

The USA CPUE index has fluctuated considerably, declining from an average of 13.3 mt per day fished in the mid-1960s to only 2.5 mt per day fished in the early 1970s (Table 5). Index values then gradually increased to 13.1 t per day fished in 1982, dropped to only 6.8 t per day fished in 1985, and have since increased to 11.7 t/day fished in 1989. Thus CPUE has not paralleled landings trends, at least for recent years. Similarly, the correspondence between CPUE and stock biomass estimates developed from VPA has been generally poor.

The NEFC autumn survey (weight/tow) index dropped to a low level by 1970 and has since been relatively stable (Figure 6, Table 6). Spring survey data also reveal no appreciable changes in recent years (Figure 6). Abundance (numbers/tow) indices peaked during the mid to late 1970s, reflecting improved recruitment, but since the early 1980s the spring survey index has increased considerably while corresponding autumn values have declined (Figure 7, Table 6). The 1985 year class again appears to be a strong one although survey catches, particularly in autumn, have declined rapidly. The participants

Table 4. Stratified mean number per tow (Delta) at age for silver hake from the Gulf of Maine - Northern Georges Bank stock (strata 20-30, 36-40) from NEFC bottom trawl surveys in the spring and autumn

| Year | Age | | | | | | | | | | Total | | |
|---------------|-------|-------|-------|-------|------|------|------|------|-----|-----|--------|--------|-------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 0+ | 1+ | 2+ |
| Spring | | | | | | | | | | | | | |
| 1973 | - | 4.64 | 10.46 | 1.05 | .13 | .05 | .01 | - | - | - | 16.34 | 16.34 | 11.70 |
| 1974 | - | 34.59 | 3.62 | 1.73 | .39 | .11 | .05 | .05 | .01 | .02 | 40.57 | 40.57 | 5.98 |
| 1975 | - | 56.51 | 57.52 | 7.29 | 1.23 | .40 | .05 | - | - | - | 123.00 | 123.00 | 66.49 |
| 1976 | - | 10.53 | 23.58 | 12.78 | 1.48 | .51 | .28 | .04 | .02 | - | 49.23 | 49.23 | 38.70 |
| 1977 | - | 5.00 | 4.88 | 4.25 | 1.71 | .34 | .13 | .13 | .02 | .01 | 16.46 | 16.46 | 11.46 |
| 1978 | - | 3.57 | 1.55 | .29 | .16 | .04 | .01 | .01 | - | - | 5.63 | 5.63 | 2.06 |
| 1979 | - | 7.06 | 10.80 | .37 | .07 | .05 | .04 | .05 | .03 | - | 18.46 | 18.46 | 11.40 |
| 1980 | - | 3.67 | 16.65 | 5.71 | .40 | .11 | .10 | .08 | .02 | .04 | 26.77 | 26.77 | 23.10 |
| 1981 | - | 9.92 | 5.70 | 3.69 | 1.17 | .17 | .06 | - | .01 | - | 20.71 | 20.71 | 10.79 |
| 1982 | - | 11.32 | 5.77 | 1.64 | .77 | .54 | .09 | .01 | - | .04 | 20.18 | 20.18 | 8.86 |
| 1983 | - | 10.85 | 8.40 | .89 | .28 | .30 | .11 | .02 | - | - | 20.85 | 20.85 | 10.00 |
| 1984 | - | 3.80 | 5.28 | .98 | .11 | .08 | .08 | .03 | - | - | 10.36 | 10.36 | 6.56 |
| 1985 | - | 39.49 | 4.13 | 2.36 | .92 | .20 | .07 | .11 | - | - | 47.29 | 47.29 | 7.80 |
| 1986 | - | 87.10 | 5.81 | 1.74 | .57 | .14 | .06 | - | - | - | 95.42 | 95.42 | 8.32 |
| 1987 | - | 3.12 | 34.85 | 3.37 | .47 | .25 | - | - | .04 | - | 42.10 | 42.10 | 38.98 |
| 1988 | - | .93 | 1.76 | 4.92 | .61 | .12 | .05 | - | - | - | 8.39 | 8.39 | 7.46 |
| 1989 | - | | | | | | | | | | 120.86 | | |
| Autumn | | | | | | | | | | | | | |
| 1973 | 5.87 | 7.20 | 8.51 | 3.24 | .48 | .32 | .12 | - | - | .06 | 25.80 | 19.93 | 12.73 |
| 1974 | 18.30 | 3.56 | 2.97 | 1.80 | .25 | .22 | .11 | - | - | - | 27.20 | 8.90 | 5.34 |
| 1975 | 18.36 | 17.41 | 32.09 | 7.61 | 2.39 | .87 | .26 | .08 | .30 | - | 79.38 | 61.02 | 43.61 |
| 1976 | 6.48 | 3.26 | 14.61 | 20.36 | 8.60 | 1.40 | 1.08 | .51 | .01 | .03 | 56.34 | 49.86 | 46.60 |
| 1977 | 2.66 | 3.03 | 6.05 | 13.05 | 8.21 | 1.34 | .23 | .05 | - | - | 34.61 | 31.95 | 28.93 |
| 1978 | 19.65 | 5.22 | 4.77 | 3.39 | 4.92 | 6.46 | 1.27 | .12 | .21 | - | 46.00 | 26.35 | 21.13 |
| 1979 | 1.16 | 28.44 | 17.35 | 2.06 | .96 | 1.19 | 1.51 | .25 | .02 | .02 | 52.96 | 51.80 | 23.36 |
| 1980 | 5.47 | 3.56 | 12.11 | 11.89 | 2.73 | 1.02 | .83 | 1.52 | .42 | .08 | 39.61 | 34.14 | 30.58 |
| 1981 | 1.33 | 7.66 | 4.07 | 5.19 | 3.95 | .75 | .29 | .28 | .40 | .07 | 23.99 | 22.66 | 14.99 |
| 1982 | 9.59 | 14.46 | 8.63 | 3.18 | 2.67 | 2.57 | .24 | .07 | .07 | .07 | 41.54 | 31.95 | 17.49 |
| 1983 | 1.45 | 43.04 | 29.76 | 1.22 | .59 | .63 | .30 | .06 | .02 | .01 | 77.09 | 75.64 | 32.60 |
| 1984 | 8.42 | 6.02 | 7.38 | 2.23 | .50 | .18 | .10 | - | - | .01 | 24.84 | 16.42 | 10.40 |
| 1985 | 37.59 | 43.00 | 3.97 | 6.61 | 1.41 | .09 | .01 | .02 | - | - | 92.70 | 55.11 | 12.11 |
| 1986 | 14.52 | 87.78 | 6.34 | 11.58 | 2.45 | .20 | .04 | .03 | - | - | 122.94 | 108.42 | 20.64 |
| 1987 | 1.88 | 3.40 | 43.32 | 10.15 | 1.03 | .85 | .06 | .01 | - | - | 60.70 | 58.82 | 55.42 |
| 1988 | 39.59 | 4.06 | 6.30 | 18.26 | 1.40 | .14 | - | - | - | - | 69.75 | 30.16 | 26.10 |
| 1989 | | | | | | | | | | | 105.60 | | |

concluded that no definitive inferences on current resource status could be made based on survey data.

As for the northern stock several attempts were made to tune VPAs using the ADAPT and Laurec-Shepherd methods; procedures used in applying each were similar to those employed for the Northern stock. Here, F_{1988} values obtained for ages 2 and 3 proved to be similar. Again, however, problems were observed with the catch at age matrix (Table 7; weight at age, Table 8), patterns in residuals, and trends in q , resulting in the conclusion that VPA results could not be accepted with confidence.

Discussion of Assessment of Silver Hake, Southern Georges Bank-Mid-Atlantic Stock

Since results of both analyses were inconclusive, the concern was raised as to what should now be accepted as the "best scientific information" available. The immediate need was for a review of percent maximum spawning potential (MSP) analyses requested earlier by the New England Fishery Management Council (NEFMC). The Center had deferred this request until VPAs were completed and accepted at the current SAW. The question was therefore whether

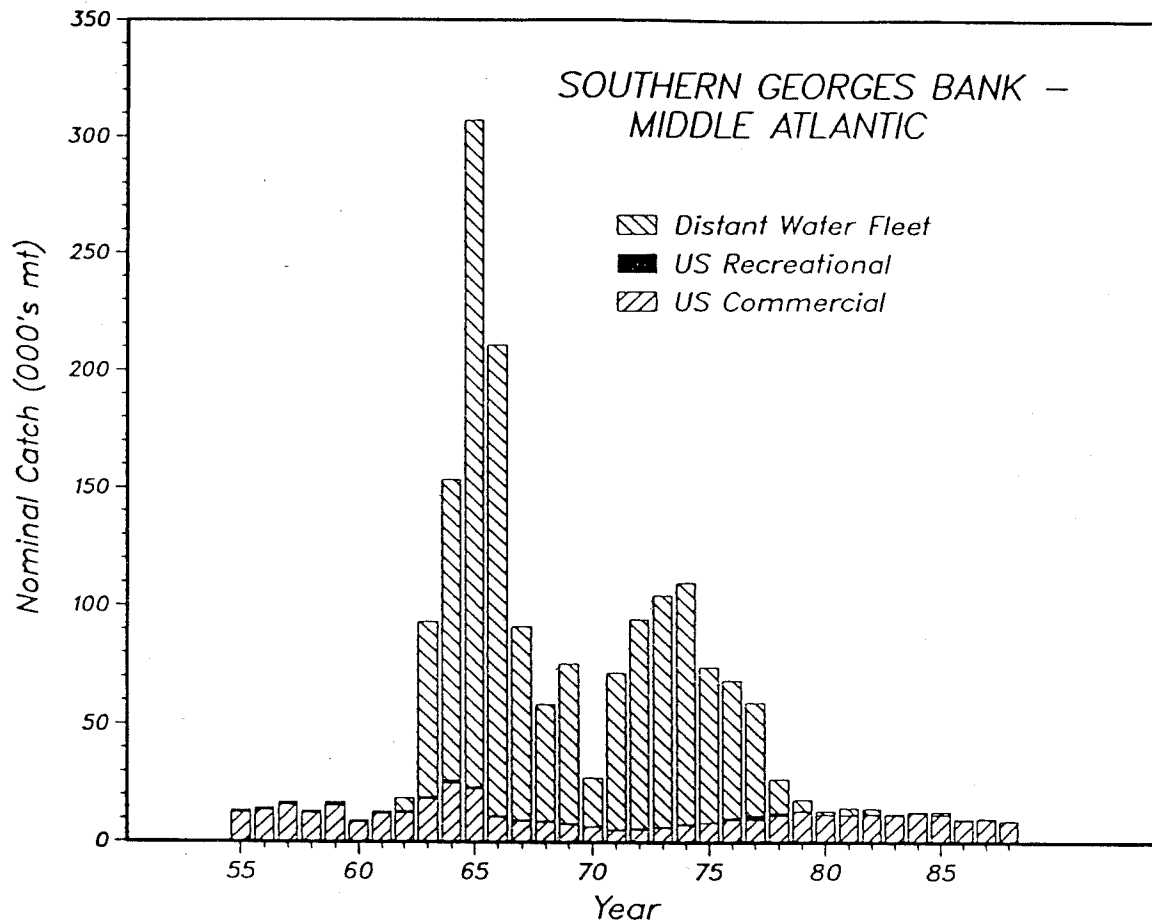


Figure 5. U.S. commercial and distant-water fleet components of the total catch from the Southern Georges Bank-Middle Atlantic silver hake stock.

to defer the request further or whether the VPA developed in the preceding (1987) assessment could be used. The former proved unacceptable because several additional months could be required given other commitments as well as the aforementioned problems with the catch at age matrix and tuning work. It was pointed out, however, that even if the earlier VPA could be used in some way, additional work was also needed to refine biological parameter estimates if percent MSP calculations were to be truly meaningful; much work could be given high priority, but again would take time. Use of alternative approaches, *e.g.*, $F_{0.1}$ rather than percent MSP as a biological reference point was also proposed although the consensus appeared to be that the latter would be preferable.

Discussion then turned to consideration of whether the earlier VPA could be used in some way with ancillary information to meet NEFMC needs. It was noted that results of the current analysis suggest that recent F values would not be lower (and would likely be higher, given observed declines of older fish in the catches and increasing effort in the southern New

England trawl fishery). It was, therefore, felt that some extrapolations could be made based on the earlier assessment and that it could be used until the aforementioned problems with catch at age and tuning analyses could be resolved. It was further agreed to review NEFMC percent MSP work during a subsequent session at the current SAW.

Review of Previous Spawning Stock-Biomass-per-Recruit Analyses for Silver Hake Stocks

In the process of developing definitions of overfishing for groundfish species managed or to be managed under the New England Multispecies Fishery Management Plan, New England Fishery Management Council staff undertook analyses of spawning stock biomass per recruit (SSB/R) to calculate percent MSP and F_{med} (or F_{rep}) for northern and southern stocks of silver hake (NEFMC 1990 MS).

Input values (NEFMC 1990 MS) derived primarily from the Almeida (1987) assessment were as-

Table 5. Silver hake catches (mt) from the Southern Georges Bank - Middle Atlantic stock

| Year | Bulgaria | Cuba | GDR | Italy | Japan | Mexico | Poland | Romania | Spain | USSR | Other ¹ | USA Comm. | USA Rec. | Total | USA catch/day |
|------|----------|-------|-----|-------|-------|--------|--------|---------|-------|---------|--------------------|--------------|--------------------|---------|------------------|
| 1955 | - | - | - | - | - | - | - | - | - | - | - | 12,489 | 1,353 | 15,717 | - |
| 1956 | - | - | - | - | - | - | - | - | - | - | - | 13,417 | 1,454 | 16,564 | - |
| 1957 | - | - | - | - | - | - | - | - | - | - | - | 15,476 | 1,677 | 17,153 | - |
| 1958 | - | - | - | - | - | - | - | - | - | - | - | 12,156 | 1,317 | 13,473 | - |
| 1959 | - | - | - | - | - | - | - | - | - | - | - | 15,439 | 1,673 | 17,112 | - |
| 1960 | - | - | - | - | - | - | - | - | - | - | - | 8,306 | 900 ² | 9,206 | - |
| 1961 | - | - | - | - | - | - | - | - | - | - | - | 11,918 | 1,291 | 13,209 | - |
| 1962 | - | - | - | - | - | - | - | - | - | 5,325 | - | 12,097 | 1,311 | 18,733 | - |
| 1963 | - | - | - | - | - | - | - | - | - | 74,023 | - | 18,252 | 1,107 | 93,382 | - |
| 1964 | - | - | - | - | - | - | - | - | - | 127,036 | - | 25,030 | 1,518 | 153,584 | 8.92 |
| 1965 | - | - | - | - | - | - | - | - | - | 283,366 | - | 22,406 | 1,359 ² | 307,131 | 13.26 |
| 1966 | - | - | - | - | - | - | - | - | - | 200,058 | - | 10,571 | 641 | 211,270 | 13.31 |
| 1967 | - | - | - | - | 38 | - | - | - | - | 81,711 | - | 8,957 | 543 | 91,249 | 4.56 |
| 1968 | - | - | - | - | 82 | - | 948 | - | - | 48,392 | - | 8,447 | 627 | 58,496 | 4.37 |
| 1969 | 746 | - | 6 | - | 252 | - | 235 | 6 | - | 66,151 | - | 7,601 | 564 | 75,561 | 4.10 |
| 1970 | 439 | - | - | - | 325 | - | 4 | 103 | - | 19,762 | - | 6,404 | 475 ² | 27,512 | 6.20 |
| 1971 | 721 | 146 | - | - | 107 | - | 36 | 432 | - | 64,902 | - | 5,163 | 383 | 71,890 | 2.53 |
| 1972 | 1,806 | 828 | 42 | - | 204 | - | - | 127 | - | 85,416 | - | 5,561 | 412 | 94,396 | 5.56 |
| 1973 | 1,502 | - | 50 | - | 438 | - | 343 | 49 | - | 95,606 | 1 | 6,146 | 458 | 104,593 | 3.86 |
| 1974 | 2,471 | - | 11 | - | 107 | - | 113 | 194 | - | 99,215 | 1 | 7,213 | 538 ² | 109,863 | 4.39 |
| 1975 | 1,917 | 212 | 8 | - | 1 | - | 26 | - | 22 | 63,425 | 201 | 8,342 | 99 ² | 74,253 | 5.08 |
| 1976 | 33 | 3,750 | 1 | - | 14 | - | 211 | 586 | 5 | 53,707 | - | 9,581 | 853 ² | 68,741 | 6.40 |
| 1977 | 1,052 | 269 | - | 60 | 59 | - | 2 | - | 103 | 46,305 | - | 9,484 | 1,974 ² | 59,308 | 7.37 |
| 1978 | - | - | - | 612 | 274 | 4 | - | - | 73 | 13,390 | - | 11,410 | 1,369 | 27,132 | 9.77 |
| 1979 | - | - | - | 600 | 696 | 110 | - | 16 | 380 | 3,075 | - | 13,087 | 411 ² | 18,375 | 7.85 |
| 1980 | - | 73 | - | 502 | 607 | 39 | 1 | - | 476 | - | - | 11,731 | 117 ² | 13,546 | 7.19 |
| 1981 | - | - | - | 1,705 | 641 | - | 48 | - | 649 | - | - | 11,718 | 65 ² | 14,826 | 10.27 |
| 1982 | - | - | - | 1,128 | 480 | - | - | - | 789 | - | - | 11,908 | 256 ² | 14,561 | 13.07 |
| 1983 | - | - | - | 334 | 116 | - | - | - | 170 | - | - | 11,520 | + ² | 12,140 | 10.03 |
| 1984 | - | - | - | 208 | 47 | - | - | - | 157 | - | - | 12,731 | + ² | 13,143 | 11.55 |
| 1985 | - | - | 16 | 938 | 42 | - | 15 | - | 310 | - | - | 11,820 | 23 ² | 13,164 | 6.80 |
| 1986 | - | - | 13 | 333 | 3 | - | - | - | 201 | - | - | 9,479 | 94 ² | 10,123 | 7.21 |
| 1987 | - | - | 2 | - | - | - | - | - | - | - | - | 10,053 | 68 | 10,121 | 6.84 |
| 1988 | - | - | 4 | - | - | - | - | - | - | - | - | 9,187 | 8 | 9,194 | 9.13 |
| 1989 | - | - | - | - | - | - | - | - | - | - | - | 13,169 | - | - | 11.74 |

¹Includes FRG (1973-1974) and Ireland (1975).

²From marine angler surveys, Type A catch only (+ denotes less than 30,000 fish); remaining years are estimated (see text).

sumed to be the best available information for percent MSP calculations. The SAW recommended that stock and recruitment data from 1973-1983 serve as the basis for calculating median observed SSB/R. Alternatively, the most recent points from the virtual population analysis could be downweighted. The sensitivity of target percent MSP estimates should be examined to evaluate the effects of a time series of somewhat more than 10 observed SSB/R values. Regardless of the outcome of that revision, the SAW reiterated that 20 percent MSP targets chosen "by analogy" are not appropriate.

If the analysis is carried beyond estimation of target percent MSP levels, *i.e.*, to estimation of F_{med} , definition of the partial recruitment vector becomes critical. The SAW indicated that the partial recruitment vector extending back to 1973 from the Almeida assessment would be consistent with the existing analysis, but the partial recruitment vector from separable virtual population analysis from an updated

catch at age matrix would provide more up-to-date information.

ASSESSMENT UPDATE FOR ATLANTIC MACKEREL

Landings

Landings of Atlantic mackerel peaked at 430,000 mt in 1973 and declined thereafter to 34,000 mt in 1978 (Table 9). During 1979-1984 landings averaged only 32,000 mt, but increased in the late 1980s to a peak of 82,000 mt in 1988 because of increased foreign and domestic catch. Since 1988, total landings have dropped because foreign nations have received smaller allocations.

SOUTHERN GEORGES BANK –
MIDDLE ATLANTIC

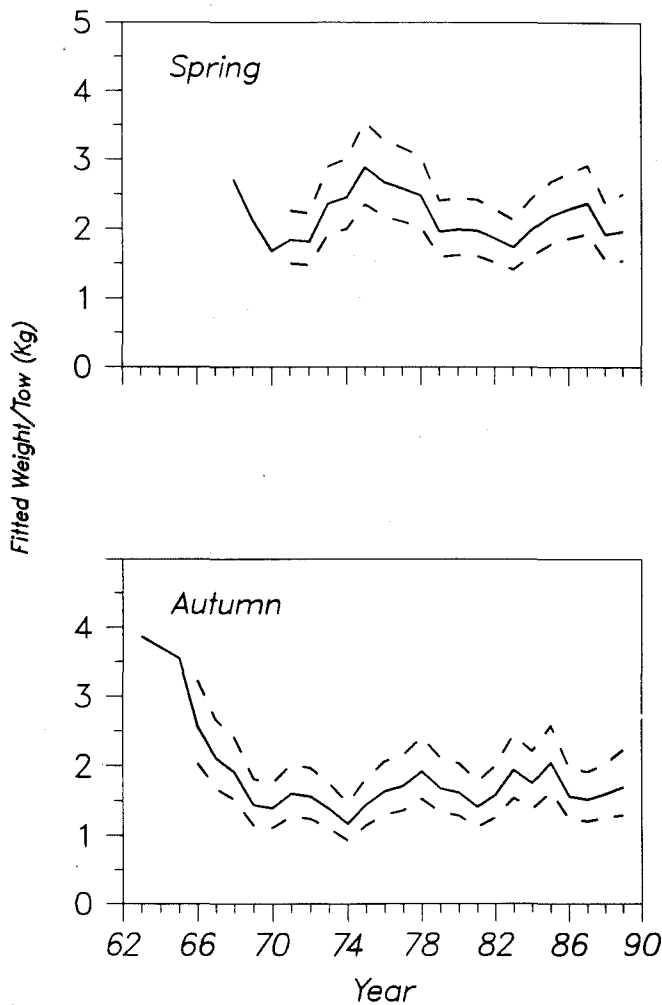


Figure 6. Fitted weight-per-tow indices from spring (upper) and autumn (lower) NEFC bottom trawl surveys during 1963-1989 with 80 percent confidence intervals.

Until 1987, the proportion of landings accounted for by USA domestic and JV operations was relatively small, but since that time has increased to become a major part of the total in 1990 (Table 9). Foreign catch by countries other than Canada declined from a recent high of 43,000 mt in 1988 to only 9,000 mt in 1990.

Research Vessel Trends

Stratified research vessel survey indices for the spring time-series from 1968-1990 indicate that the Atlantic mackerel stock increased greatly in the 1980s after a major decline in biomass and numbers in the mid to late 1970s (Table 10). Catch per tow in weight,

SOUTHERN GEORGES BANK –
MIDDLE ATLANTIC

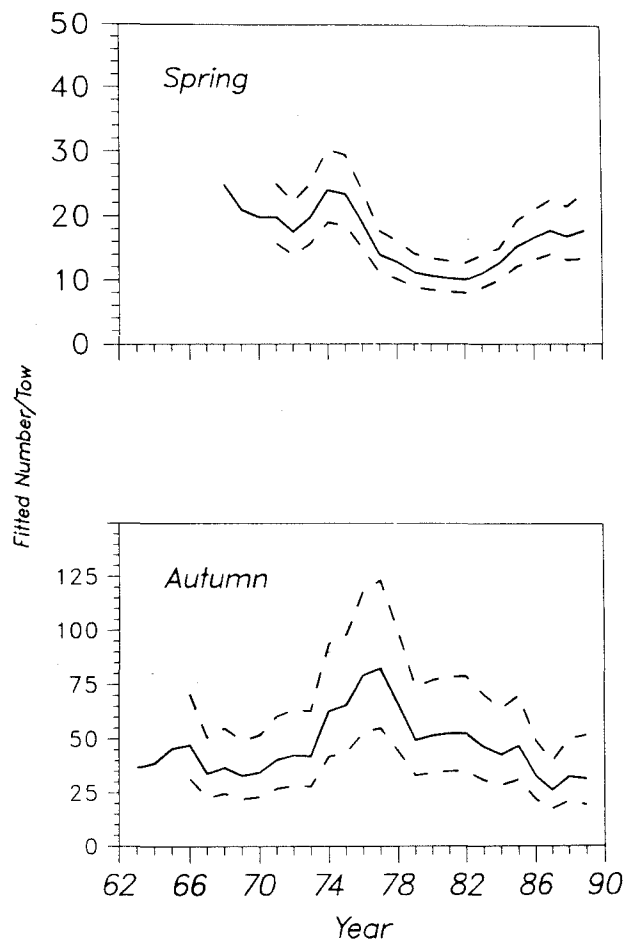


Figure 7. Fitted number-per-tow indices from spring (upper) and autumn (lower) NEFC bottom trawl surveys during 1963-1989 with 80 percent confidence intervals.

although highly variable in the 1980s, increased over values from the mid-late 1970s (Figure 8). The index as number per tow likewise showed a dramatic increase in the 1980s (Figure 8). The standard index for weight appears to have declined in 1988-1989, and increased in 1990, while the index for number has declined since 1987.

Atlantic mackerel are highly mobile and patchy, and the survey is inefficient in sampling this species. This leads to a high degree of variability in the survey time-series. To address this problem, transformations and smoothing methods were applied to the survey data. Log transformed survey indices in weight suggest that the biomass in 1987 may have been more similar to that in 1988 (Table 10).

Table 6. Stratified mean number per tow (linear) at age for silver hake from the Southern Georges Bank - Middle Atlantic stock (offshore strata 1-19,61-76, inshore strata 1-46, 52, 55) from NEFC bottom trawl surveys in the spring and autumn

| Year | Age | | | | | | | | | | Total | | |
|-------------------|--------|-------|-------|------|------|------|-----|-----|-----|-----|--------|-------|-------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | 0+ | 1+ | 2+ |
| Spring | | | | | | | | | | | | | |
| 1973 ¹ | - | 5.65 | 6.96 | 3.33 | 1.07 | .11 | .06 | .04 | - | .01 | 17.23 | 17.23 | 11.58 |
| 1974 ¹ | - | 28.40 | 2.19 | 3.55 | 2.06 | .69 | .24 | .07 | - | .01 | 37.22 | 37.22 | 8.82 |
| 1975 ¹ | - | 17.38 | 4.57 | 8.64 | 2.38 | .66 | .06 | .01 | - | - | 33.70 | 33.70 | 16.32 |
| 1976 ² | - | 12.08 | 5.15 | 3.40 | 1.70 | .37 | .10 | .02 | - | - | 22.82 | 22.82 | 10.74 |
| 1977 ² | - | 1.42 | 1.24 | 3.69 | 2.05 | .42 | .17 | .12 | .02 | - | 9.12 | 9.12 | 7.70 |
| 1978 ² | - | 6.24 | 2.84 | 1.53 | 2.22 | 1.05 | .32 | .03 | .01 | - | 14.24 | 14.24 | 8.00 |
| 1979 ² | - | 5.18 | 1.44 | 1.00 | .47 | .72 | .48 | .05 | - | - | 9.33 | 9.33 | 4.15 |
| 1980 ² | - | 3.60 | 3.07 | 2.10 | .79 | .25 | .27 | .21 | .07 | .02 | 10.38 | 10.38 | 6.78 |
| 1981 ² | - | 3.69 | 1.84 | 2.01 | 1.37 | .64 | .25 | .14 | .09 | .09 | 10.12 | 10.12 | 6.43 |
| 1982 | - | 1.31 | 3.11 | 1.02 | 1.03 | .86 | .30 | .18 | .06 | .10 | 7.96 | 7.96 | 6.65 |
| 1983 | - | 4.12 | 3.83 | 1.08 | .58 | .24 | .19 | .11 | .01 | .02 | 10.18 | 10.18 | 6.06 |
| 1984 | - | 2.47 | 5.74 | 2.39 | .59 | .13 | .11 | .05 | .02 | .01 | 11.50 | 11.50 | 9.03 |
| 1985 | - | 8.91 | 3.98 | 3.99 | 1.41 | .35 | .08 | .07 | .03 | .01 | 18.82 | 18.82 | 9.91 |
| 1986 | - | 3.35 | 9.57 | 2.19 | 1.74 | .27 | .04 | - | - | - | 17.20 | 17.20 | 13.81 |
| 1987 | - | 3.53 | 13.09 | 5.17 | 1.28 | .64 | .03 | - | - | - | 23.80 | 23.80 | 20.21 |
| 1988 | - | 4.58 | 2.42 | 5.57 | .84 | .06 | - | - | - | - | 13.47 | 13.47 | 8.89 |
| 1989 | | | | | | | | | | | 19.03 | | |
| Autumn | | | | | | | | | | | | | |
| 1973 ³ | 10.51 | 2.89 | 3.09 | 1.32 | .37 | .19 | .01 | - | - | - | 18.37 | 7.86 | 4.97 |
| 1974 | 121.59 | 4.19 | 1.58 | .45 | .10 | .04 | - | - | - | - | 127.95 | 6.36 | 2.17 |
| 1975 | 40.81 | 3.78 | 2.16 | 1.32 | .54 | .18 | .07 | .02 | .01 | .01 | 48.91 | 8.10 | 4.32 |
| 1976 | 95.46 | 2.49 | 4.92 | 2.62 | .91 | .24 | .13 | .12 | .01 | - | 106.91 | 11.45 | 8.96 |
| 1977 | 128.39 | 3.63 | 1.44 | 2.82 | .96 | .21 | .03 | .06 | .05 | - | 137.60 | 9.21 | 5.58 |
| 1978 | 57.05 | 9.46 | 4.20 | 2.76 | 2.50 | 1.13 | .16 | .05 | - | - | 77.32 | 20.27 | 10.81 |
| 1979 | 18.72 | 2.01 | 1.75 | 1.27 | .62 | .45 | .36 | .07 | .01 | - | 25.25 | 6.53 | 4.52 |
| 1980 | 42.85 | 3.74 | 1.39 | 3.34 | 1.04 | .50 | .20 | .38 | .03 | .02 | 53.48 | 10.63 | 6.89 |
| 1981 | 49.19 | 2.42 | .77 | 1.16 | .83 | .19 | .04 | - | .05 | - | 54.65 | 5.46 | 3.05 |
| 1982 | 60.74 | 2.85 | 2.28 | .91 | .39 | .17 | .07 | - | .02 | .01 | 67.45 | 6.71 | 3.86 |
| 1983 | 27.48 | 8.68 | 3.91 | 1.93 | .38 | .18 | .07 | .05 | - | - | 42.68 | 15.20 | 6.52 |
| 1984 | 22.23 | 4.79 | 2.29 | .92 | .24 | .03 | - | - | - | - | 30.51 | 8.28 | 3.49 |
| 1985 | 89.94 | 16.30 | 3.53 | 3.13 | .88 | .07 | .05 | - | - | - | 113.90 | 23.96 | 7.66 |
| 1986 | 19.96 | 4.95 | 2.21 | .50 | .16 | .06 | - | - | - | - | 28.15 | 7.88 | 2.93 |
| 1987 | .72 | 4.62 | 6.42 | .49 | .15 | .05 | - | - | - | - | 12.44 | 11.73 | 7.11 |
| 1988 | 36.94 | 3.29 | 7.56 | .82 | .07 | - | - | - | - | - | 49.04 | 11.74 | 8.45 |
| 1989 | | | | | | | | | | | 28.17 | | |

¹ Adjusted from offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .320:1 ratio.

² Adjusted from inshore-offshore #41 trawl catches to equivalent inshore-offshore #36 trawl catches using a .334:1 ratio.

³ Adjusted from offshore #36 trawl catches to equivalent inshore-offshore #36 trawl catches using a .890:1 ratio.

Both series were fitted using a time-series model (IMA) to reduce the variability between years. Results from this analysis suggest that although 95 percent confidence intervals are large, catch per tow in weight and number may have peaked in 1988 and declined somewhat since then (Table 10, Figure 9).

Age specific indices of abundance were computed for the 1968-1989 spring time-series. The catch per tow index at age two suggests that the 1982, 1985, and 1987 year classes were the strongest in the 1980s (Table 11). The 1982 cohort may have been the strong-

est on record. The 1984 and 1986 year classes may also be fairly large, perhaps equal in magnitude to the 1981 cohort.

ADAPT Results

Catch at age data for 1962-1987 were used in preliminary runs of ADAPT, a VPA tuning procedure, to ascertain if several problems with the current Atlantic mackerel VPA could be addressed. The prob-

Table 7. Commercial catch at age (millions of fish) of silver hake from the Southern Georges Bank - Middle Atlantic stock.

| Year | Age | | | | | | | | | Total |
|------|-------|-------|-------|-------|------|------|------|------|-----|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ | |
| 1955 | 17.4 | 9.6 | 20.0 | 21.7 | 8.7 | 1.9 | .7 | .3 | .1 | 80.3 |
| 1956 | 61.9 | 46.6 | 20.4 | 15.2 | 5.4 | 1.3 | .7 | .2 | .1 | 151.7 |
| 1957 | 2.4 | 22.2 | 31.3 | 22.6 | 9.6 | 2.6 | 1.0 | .3 | .1 | 92.0 |
| 1958 | 20.6 | 27.8 | 24.8 | 15.5 | 5.4 | 1.4 | .7 | .2 | .01 | 96.3 |
| 1959 | 11.8 | 11.4 | 36.6 | 24.7 | 8.7 | 2.0 | .7 | .2 | .01 | 96.0 |
| 1960 | 12.0 | 17.0 | 12.7 | 10.6 | 4.9 | 1.6 | .9 | .4 | .1 | 60.2 |
| 1961 | .4 | 6.2 | 26.2 | 21.5 | 5.5 | 1.5 | 1.0 | .3 | .2 | 62.7 |
| 1962 | .5 | 6.6 | 31.7 | 34.6 | 10.1 | 2.0 | 1.4 | .6 | .3 | 87.8 |
| 1963 | 6.5 | 33.8 | 171.7 | 196.2 | 53.5 | 8.2 | 2.5 | 1.2 | .5 | 474.1 |
| 1964 | 18.4 | 65.3 | 286.8 | 271.5 | 85.1 | 19.5 | 9.5 | 4.6 | 1.9 | 762.6 |
| 1965 | 46.9 | 203.7 | 901.7 | 553.0 | 75.1 | 16.1 | 7.3 | 2.4 | .8 | 1806.9 |
| 1966 | 18.7 | 359.8 | 507.6 | 289.7 | 77.8 | 25.1 | 10.9 | 5.0 | 1.2 | 1295.7 |
| 1967 | 15.7 | 121.5 | 216.3 | 154.9 | 30.8 | 7.3 | 3.0 | 1.5 | .3 | 551.5 |
| 1968 | 9.7 | 24.5 | 143.4 | 90.8 | 29.0 | 11.1 | 4.4 | 1.4 | .8 | 315.1 |
| 1969 | 1.8 | 20.0 | 111.0 | 100.6 | 40.7 | 11.4 | 10.3 | 4.2 | 2.6 | 302.6 |
| 1970 | 41.8 | 25.1 | 17.3 | 32.6 | 23.1 | 6.5 | 5.0 | 2.8 | 1.3 | 155.4 |
| 1971 | 8.0 | 41.3 | 92.3 | 79.0 | 44.4 | 18.7 | 12.3 | 11.1 | 8.0 | 315.1 |
| 1972 | 134.0 | 174.1 | 111.9 | 33.0 | 5.0 | 2.1 | .5 | .1 | .1 | 460.8 |
| 1973 | 72.8 | 325.0 | 112.9 | 29.3 | 4.9 | 1.1 | .5 | .1 | .01 | 546.4 |
| 1974 | 73.7 | 223.3 | 141.2 | 74.1 | 17.2 | 6.0 | 3.5 | 1.7 | .5 | 541.2 |
| 1975 | 5.5 | 106.6 | 149.3 | 51.0 | 19.8 | 2.7 | .2 | .1 | 1.0 | 336.1 |
| 1976 | 7.6 | 86.6 | 142.8 | 95.2 | 10.4 | 1.3 | .2 | .01 | .01 | 344.1 |
| 1977 | 2.6 | 34.0 | 132.6 | 68.8 | 11.2 | 3.1 | 2.2 | .3 | .01 | 254.8 |
| 1978 | 2.2 | 26.7 | 20.4 | 28.0 | 12.5 | 2.5 | .8 | .01 | .01 | 93.1 |
| 1979 | 8.1 | 22.0 | 17.3 | 8.0 | 10.4 | 6.8 | 1.1 | .2 | .01 | 73.9 |
| 1980 | 3.6 | 17.4 | 19.4 | 9.5 | 4.4 | 2.5 | 2.8 | .5 | .3 | 60.6 |
| 1981 | 17.6 | 24.0 | 28.4 | 16.1 | 5.0 | 1.6 | .8 | .7 | .4 | 94.7 |
| 1982 | 12.4 | 32.0 | 12.2 | 9.3 | 8.1 | 2.3 | .9 | .5 | .5 | 78.0 |
| 1983 | 8.4 | 23.0 | 16.7 | 6.0 | 4.3 | 2.3 | .9 | .1 | .2 | 61.8 |
| 1984 | 7.2 | 45.5 | 23.0 | 5.7 | .9 | .4 | .3 | .1 | .01 | 83.1 |
| 1985 | 7.6 | 26.1 | 23.1 | 7.6 | 1.5 | .2 | .2 | .01 | .01 | 66.5 |
| 1986 | 11.3 | 28.2 | 18.3 | 5.3 | 1.0 | .2 | .1 | .01 | .01 | 64.4 |
| 1987 | 5.6 | 25.1 | 17.8 | 5.9 | 4.5 | .2 | .01 | .01 | .01 | 59.2 |
| 1988 | 3.4 | 23.5 | 20.1 | 5.8 | .5 | .01 | .01 | .01 | .01 | 53.3 |

lem of non-convergence of the VPA at low fishing mortality rates, lack of measures of variability on the stock size estimates from VPA, and difficulty in tuning the mackerel VPA with ad-hoc methods were some of the issues of concern.

Preliminary results from this study suggest that the ADAPT procedure may be useful for solving some of the problems in the current mackerel VPA. Coefficients of variation for stock sizes from ages 5-9 were on the order of 60-70 percent, and higher for age groups 3 and 4. The estimate for the very large 1982 year class at age 6 in 1988 was somewhat lower than recent assessments had indicated. Fishing mortality (4+) was similar to recent estimates at $F=0.05$.

It was concluded that before significant new progress can be made with the mackerel VPA, recent catch at age data (1988-1990) need to be made available so that the contribution and sizes of incoming year classes can be assessed.

1991-1995 Prospectus

During the 9th SAW, a projection was provided based on stock size numbers in 1988 and estimated recruitment at age 1 for the 1987, 1988, and 1989 year classes in following years. Since the same procedure applied in the current year would only add another uncertain and untractable data point to the analysis, another procedure was applied to assess the current status of the stock. A stochastic simulation based on 1986 (the last tuned VPA year) starting numbers and a lognormal Shepherd (1982) S per R function (Sissenwine *et al.* 1988; Overholtz *et al.* 1990) was used to provide a risk analysis of harvests obtained by removing arbitrary constant catches from the mackerel stock in 1991-1995. The procedure was applied for catches ranging from 100,000 - 400,000 mt over the 1991-1995 period and 1,000 simulation runs were summarized for each year.

Table 8. Mean weight (kg) at age of silver hake from the Southern Georges Bank - Middle Atlantic stock

| Year | Age | | | | | | | | |
|------|------|------|------|------|------|------|------|-------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9+ |
| 1955 | .044 | .101 | .162 | .222 | .307 | .422 | .508 | .662 | .762 |
| 1956 | .034 | .074 | .154 | .223 | .316 | .438 | .496 | .664 | .777 |
| 1957 | .062 | .085 | .157 | .224 | .326 | .465 | .512 | .683 | .782 |
| 1958 | .060 | .088 | .152 | .215 | .310 | .409 | .490 | .682 | .878 |
| 1959 | .035 | .105 | .156 | .227 | .333 | .439 | .485 | .629 | .973 |
| 1960 | .047 | .074 | .159 | .216 | .317 | .445 | .547 | .702 | .904 |
| 1961 | .077 | .105 | .164 | .217 | .331 | .498 | .591 | .832 | .920 |
| 1962 | .067 | .106 | .157 | .215 | .300 | .441 | .646 | .778 | 1.007 |
| 1963 | .076 | .103 | .161 | .209 | .286 | .394 | .468 | .788 | .906 |
| 1964 | .057 | .107 | .154 | .210 | .301 | .456 | .545 | .651 | .929 |
| 1965 | .063 | .102 | .153 | .199 | .300 | .427 | .512 | .621 | 1.040 |
| 1966 | .058 | .089 | .143 | .207 | .311 | .453 | .534 | .654 | .944 |
| 1967 | .045 | .092 | .149 | .204 | .300 | .451 | .550 | .701 | .813 |
| 1968 | .046 | .096 | .138 | .194 | .311 | .454 | .554 | .767 | .955 |
| 1969 | .064 | .111 | .189 | .243 | .308 | .399 | .517 | .698 | 1.135 |
| 1970 | .049 | .093 | .163 | .209 | .270 | .347 | .445 | .597 | 1.009 |
| 1971 | .057 | .096 | .152 | .204 | .280 | .343 | .436 | .580 | .961 |
| 1972 | .092 | .201 | .274 | .370 | .372 | .451 | .734 | .752 | 1.151 |
| 1973 | .096 | .167 | .251 | .300 | .393 | .539 | .485 | .858 | 1.067 |
| 1974 | .057 | .178 | .225 | .302 | .325 | .415 | .577 | .680 | .982 |
| 1975 | .111 | .141 | .199 | .332 | .468 | .585 | .601 | .775 | 1.062 |
| 1976 | .064 | .168 | .195 | .228 | .453 | .507 | .927 | 1.132 | .973 |
| 1977 | .066 | .168 | .213 | .257 | .376 | .573 | .545 | 1.096 | .973 |
| 1978 | .081 | .192 | .286 | .344 | .333 | .424 | .606 | .758 | 1.299 |
| 1979 | .081 | .183 | .243 | .287 | .396 | .358 | .472 | .638 | 1.625 |
| 1980 | .103 | .194 | .212 | .263 | .315 | .416 | .509 | .723 | .731 |
| 1981 | .060 | .144 | .220 | .255 | .265 | .343 | .431 | .659 | .973 |
| 1982 | .106 | .158 | .210 | .246 | .298 | .355 | .435 | .446 | .673 |
| 1983 | .113 | .167 | .207 | .251 | .285 | .347 | .512 | .578 | .522 |
| 1984 | .044 | .138 | .183 | .304 | .324 | .418 | .512 | .659 | .720 |
| 1985 | .089 | .147 | .214 | .354 | .520 | .502 | .512 | .659 | .973 |
| 1986 | .078 | .133 | .193 | .268 | .385 | .613 | .512 | .659 | .973 |
| 1987 | .119 | .135 | .187 | .214 | .466 | .416 | .706 | .659 | .973 |
| 1988 | .061 | .153 | .176 | .275 | .367 | .664 | .512 | .659 | .973 |

Mean stock sizes in 1992 will remain relatively high over the entire range of possible catches, but will begin to decline significantly in 1993-1995 as catch increases (Table 12, Figure 10). CV's of stock biomass rise with an increase in catch indicating the increased probability of much lower stock sizes.

A summary of relative frequencies of stock sizes (1+ biomass) indicates that there is very little chance of the stock dropping below 1,000,000 mt at the beginning of 1992 under any of the catch options (Table 13). The probable size of the mackerel stock will be between 1,000,000 and 2,000,000 mt (Table 13; Figure 11).

One of the FMP benchmarks for the Atlantic mackerel stock is the maintenance of the spawning stock at a biomass of 600,000 mt or greater. To assess the chances of the SSB dropping below this level (another arbitrary level, 1,000,000 mt is also included)

a probability analysis was completed. Results of this analysis suggest that the SSB will not drop below 600,000 mt in 1992 for any of the catch levels studied, and will probably not go below the benchmark for catches from 100,000 - 250,000 mt for all years (Table 14). As catches increase beyond 250,000 mt the probability of a major decline in SSB increases. If the arbitrary 1,000,000 mt level were desired, a significant shift upward in the probability of failure would occur at smaller catches (Table 14; Figure 12). Distributions statistics for simulated catches and stock sizes, relative frequency of stock sizes and probability of spawning stock biomass falling below 600,000 mt and 1,000,000 mt for an $F_{0.1}$ harvest strategy are summarized in Table 15.

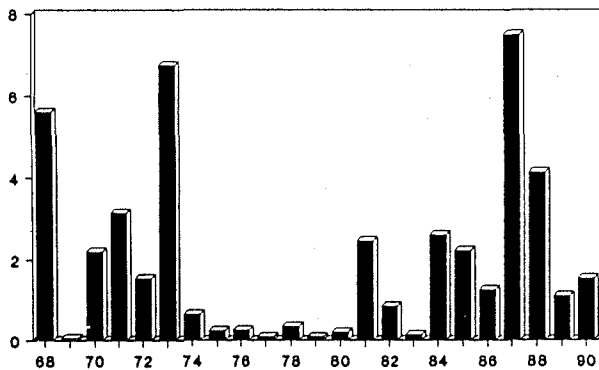
The VPA time series of stock size (1+ biomass; mean \pm 1 standard deviation for 1988-1995) for two arbitrary catch levels shows that the level of stock size

Table 9. Mackerel catches and landings (mt) from NAFO SA 2-6 during 1960-1990

| Year | USA | | Canada | Other Countries | Commercial Total | Grand Total |
|------|---------------------|------------------|---------------------|--------------------|------------------|-------------|
| | Commercial | Recreational | | | | |
| 1960 | 1,396 | 2,478 | 5,957 | — | 7,353 | 9,831 |
| 1961 | 1,361 | 3,022 | 5,459 | 11 | 6,831 | 9,853 |
| 1962 | 938 | 3,565 | 6,801 | 175 | 7,914 | 11,479 |
| 1963 | 1,320 | 3,981 | 6,363 | 1,299 | 8,982 | 12,963 |
| 1964 | 1,644 | 4,343 | 10,786 | 801 | 13,231 | 17,574 |
| 1965 | 1,998 | 4,292 | 11,185 | 2,945 | 16,128 | 20,420 |
| 1966 | 2,724 | 4,535 | 11,577 | 7,951 | 22,252 | 26,787 |
| 1967 | 3,891 | 4,498 | 11,181 | 19,047 | 34,119 | 38,617 |
| 1968 | 3,929 | 7,781 | 11,134 | 65,747 | 80,810 | 88,591 |
| 1969 | 4,364 | 13,050 | 13,257 | 114,189 | 131,810 | 144,860 |
| 1970 | 4,049 | 16,039 | 15,710 | 210,864 | 230,623 | 246,662 |
| 1971 | 2,406 | 16,426 | 14,942 | 355,892 | 373,240 | 389,666 |
| 1972 | 2,006 | 15,588 | 16,254 | 391,464 | 409,724 | 425,312 |
| 1973 | 1,336 | 10,723 | 21,619 | 396,759 | 419,714 | 430,437 |
| 1974 | 1,042 | 7,640 | 16,701 | 321,837 | 339,580 | 347,220 |
| 1975 | 1,974 | 5,190 | 13,544 | 271,719 | 287,237 | 292,427 |
| 1976 | 2,712 | 4,202 | 15,746 | 223,275 | 241,733 | 245,935 |
| 1977 | 1,377 | 522 | 20,362 | 56,067 | 77,806 | 78,328 |
| 1978 | 1,605 | 6,571 | 25,429 | 841 | 27,875 | 34,446 |
| 1979 | 1,990 | 3,588 | 30,244 | 440 | 32,674 | 36,262 |
| 1980 | 2,683 | 2,364 | 22,136 | 566 | 25,385 | 27,749 |
| 1981 | 2,941 | 8,505 | 19,294 | 5,361 | 27,596 | 32,101 |
| 1982 | 3,330 | 1,162 | 16,379 | 6,647 | 26,356 | 27,518 |
| 1983 | 3,805 | 3,280 | 19,785 | 5,955 | 29,545 | 32,825 |
| 1984 | 5,954 | 2,618 | 16,995 | 15,045 | 37,994 | 40,612 |
| 1985 | 6,632 | 3,287 | 27,948 | 32,409 | 67,840 | 70,276 |
| 1986 | 9,637 | 3,943 | 23,700 | 25,355 | 58,692 | 62,635 |
| 1987 | 12,310 | 5,567 | 22,118 | 35,094 | 69,522 | 75,089 |
| 1988 | 12,309 | 3,853 | 23,000 | 42,858 | 78,167 | 82,020 |
| 1989 | 14,634 | 947 ¹ | 22,000 | 36,823 | 73,457 | 74,404 |
| 1990 | 28,265 ¹ | — | 25,000 ² | 9,126 ¹ | 62,391 | 62,391 |

¹ Preliminary
² Estimated

MACKEREL CATCH/TOW WT
1968-1990



MACKEREL CATCH/TOW #
1968-1990

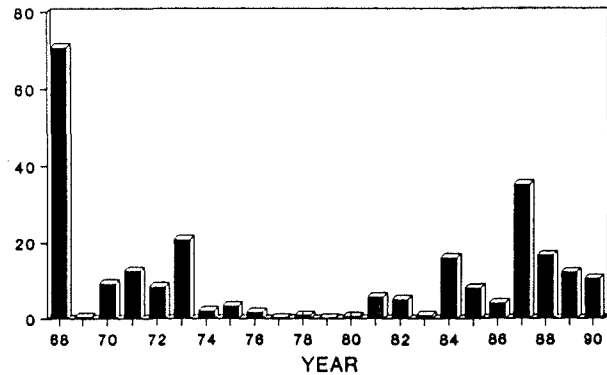


Figure 8. Mackerel stratified mean weight- and number-per-tow from NEFC spring research surveys for strata 1-25 and 61-76 for 1968-1990, untransformed, unfitted (standard) data.

Table 10. Mackerel stratified mean weight and number per tow from NEFC spring research surveys for strata 1-25 and 61-76 for 1968-1990 for standard and log transformed data. Fitted values were obtained from a IMA model

| Year | Standard | | Fitted | | Log | | Fitted | |
|-----------------|----------|--------|--------|--------|--------|--------|--------|--------|
| | Weight | Number | Weight | Number | Weight | Number | Weight | Number |
| 68 | 5.609 | 70.869 | 1.147 | 10.016 | 1.669 | 15.253 | 0.413 | 2.289 |
| 69 | 0.055 | 0.484 | 0.935 | 5.944 | 0.031 | 0.178 | 0.345 | 1.601 |
| 70 | 2.200 | 9.356 | 1.098 | 6.886 | 0.871 | 2.528 | 0.393 | 1.694 |
| 71 | 3.145 | 12.668 | 1.179 | 7.350 | 0.887 | 2.773 | 0.404 | 1.662 |
| 72 | 1.542 | 8.490 | 1.116 | 6.786 | 0.603 | 2.260 | 0.375 | 1.480 |
| 73 | 6.746 | 20.973 | 1.013 | 5.902 | 0.382 | 1.199 | 0.328 | 1.218 |
| 74 | 0.656 | 2.241 | 0.720 | 3.661 | 0.335 | 1.129 | 0.281 | 1.004 |
| 75 | 0.242 | 3.540 | 0.519 | 2.588 | 0.167 | 0.986 | 0.235 | 0.811 |
| 76 | 0.254 | 1.800 | 0.412 | 1.683 | 0.141 | 0.541 | 0.206 | 0.630 |
| 77 | 0.081 | 0.287 | 0.348 | 1.075 | 0.071 | 0.195 | 0.189 | 0.505 |
| 78 | 0.345 | 0.970 | 0.354 | 0.976 | 0.193 | 0.429 | 0.197 | 0.483 |
| 79 | 0.089 | 0.172 | 0.362 | 0.888 | 0.080 | 0.146 | 0.205 | 0.473 |
| 80 | 0.202 | 0.559 | 0.444 | 1.251 | 0.140 | 0.310 | 0.242 | 0.578 |
| 81 | 2.470 | 5.872 | 0.602 | 2.187 | 0.744 | 1.565 | 0.306 | 0.794 |
| 82 | 0.854 | 5.167 | 0.678 | 2.936 | 0.359 | 0.998 | 0.345 | 0.960 |
| 83 | 0.135 | 0.884 | 0.743 | 3.386 | 0.112 | 0.551 | 0.387 | 1.153 |
| 84 | 2.611 | 16.228 | 1.015 | 5.588 | 0.883 | 2.463 | 0.510 | 1.591 |
| 85 | 2.232 | 8.242 | 1.227 | 6.939 | 0.924 | 2.685 | 0.626 | 2.021 |
| 86 | 1.264 | 4.178 | 1.482 | 8.231 | 0.443 | 1.196 | 0.730 | 2.434 |
| 87 | 7.492 | 35.231 | 1.828 | 11.699 | 3.208 | 11.531 | 0.909 | 3.351 |
| 88 | 4.133 | 16.792 | 1.881 | 12.392 | 2.056 | 5.560 | 0.961 | 3.655 |
| 89 | 1.100 | 12.273 | 1.749 | 12.104 | 0.668 | 3.841 | 0.922 | 3.684 |
| 90 ¹ | 1.540 | 10.639 | 1.723 | 11.780 | | | | |

¹ Preliminary

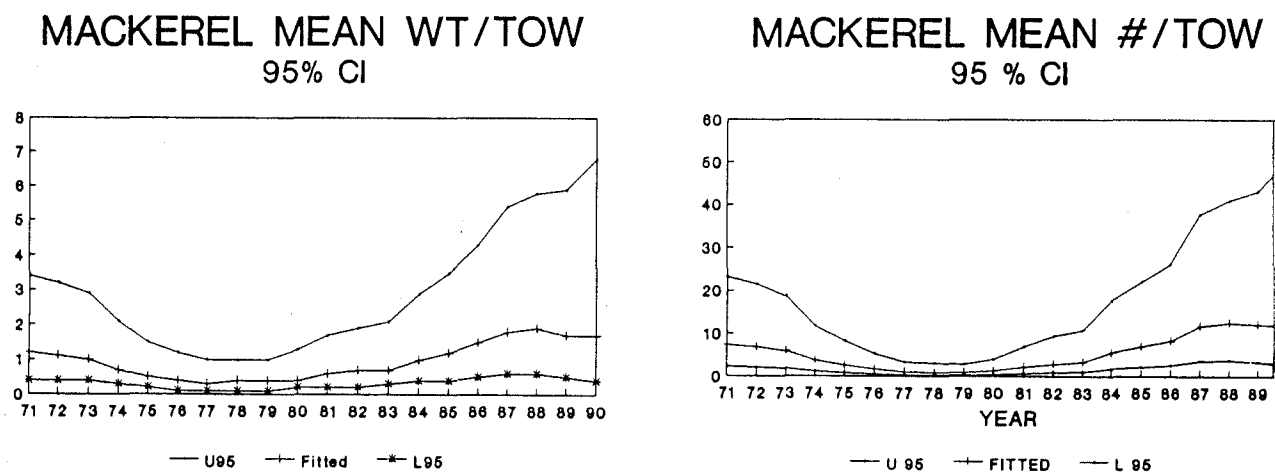


Figure 9. Mackerel stratified mean weight and and number-per-tow and 95 percent confidence intervals from NEFC spring research surveys for strata 1-25 and 61-76 for 1968-1990, log-transformed fitted data.

Table 11. Catch per tow at age (numbers) for Atlantic mackerel from spring groundfish surveys for strata 1-25, 61-76 for 1968-1989. Values are log-retransformed.

| Year | Age | | | | | | | | | | | | | |
|------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 68 | 12.9400 | 0.4150 | 0.1894 | 0.0523 | 0.0164 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 69 | 0.0297 | 0.1418 | 0.0167 | 0.0058 | 0.0003 | 0.0007 | 0.0005 | 0.0009 | 0.0004 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 70 | 0.2795 | 0.1845 | 1.3910 | 0.6115 | 0.1812 | 0.0617 | 0.0549 | 0.0877 | 0.0827 | 0.0447 | 0.0026 | 0.0000 | 0.0000 | 0.0000 |
| 71 | 0.3282 | 0.9409 | 0.4383 | 1.1250 | 0.3929 | 0.0621 | 0.0141 | 0.0073 | 0.0062 | 0.0048 | 0.0035 | 0.0000 | 0.0000 | 0.0000 |
| 72 | 0.8719 | 0.3077 | 0.5929 | 0.2261 | 0.3254 | 0.0583 | 0.0112 | 0.0011 | 0.0018 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 73 | 0.3514 | 0.3398 | 0.1758 | 0.2338 | 0.1262 | 0.2846 | 0.1821 | 0.1524 | 0.0460 | 0.0367 | 0.0033 | 0.0291 | 0.0181 | 0.0150 |
| 74 | 0.3478 | 0.1796 | 0.2358 | 0.0478 | 0.0985 | 0.0599 | 0.2084 | 0.0912 | 0.0590 | 0.0117 | 0.0115 | 0.0000 | 0.0000 | 0.0000 |
| 75 | 0.6544 | 0.2298 | 0.0409 | 0.0226 | 0.0064 | 0.0073 | 0.0043 | 0.0039 | 0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 76 | 0.0959 | 0.3871 | 0.0710 | 0.0135 | 0.0024 | 0.0006 | 0.0028 | 0.0004 | 0.0019 | 0.0003 | 0.0003 | 0.0000 | 0.0000 | 0.0000 |
| 77 | 0.0095 | 0.0472 | 0.0850 | 0.0453 | 0.0154 | 0.0052 | 0.0028 | 0.0070 | 0.0038 | 0.0054 | 0.0010 | 0.0075 | 0.0000 | 0.0000 |
| 78 | 0.0502 | 0.1097 | 0.1032 | 0.1943 | 0.0958 | 0.0284 | 0.0110 | 0.0027 | 0.0148 | 0.0000 | 0.0164 | 0.0000 | 0.0013 | 0.0000 |
| 79 | 0.0105 | 0.0037 | 0.0072 | 0.0126 | 0.0495 | 0.0144 | 0.0103 | 0.0057 | 0.0057 | 0.0190 | 0.0042 | 0.0156 | 0.0030 | 0.0064 |
| 80 | 0.0234 | 0.1877 | 0.0066 | 0.0048 | 0.0233 | 0.0489 | 0.0110 | 0.0107 | 0.0070 | 0.0017 | 0.0096 | 0.0000 | 0.0107 | 0.0064 |
| 81 | 0.3355 | 0.1371 | 0.4294 | 0.0476 | 0.0463 | 0.1613 | 0.4041 | 0.2302 | 0.1385 | 0.0704 | 0.0673 | 0.0844 | 0.0769 | 0.1031 |
| 82 | 0.4323 | 0.1950 | 0.0215 | 0.0979 | 0.0182 | 0.0102 | 0.0245 | 0.0965 | 0.0440 | 0.0266 | 0.0156 | 0.0122 | 0.0200 | 0.0092 |
| 83 | 0.2357 | 0.2873 | 0.0222 | 0.0016 | 0.0036 | 0.0006 | 0.0002 | 0.0014 | 0.0022 | 0.0004 | 0.0008 | 0.0006 | 0.0002 | 0.0000 |
| 84 | 0.2598 | 1.8014 | 0.6055 | 0.0415 | 0.0050 | 0.0432 | 0.0036 | 0.0025 | 0.0161 | 0.0470 | 0.0153 | 0.0075 | 0.0041 | 0.0098 |
| 85 | 0.3382 | 0.0846 | 1.8513 | 0.2348 | 0.0277 | 0.0107 | 0.0469 | 0.0032 | 0.0097 | 0.0416 | 0.0666 | 0.0405 | 0.0119 | 0.0258 |
| 86 | 0.1301 | 0.4497 | 0.0778 | 0.5908 | 0.1177 | 0.0080 | 0.0014 | 0.0196 | 0.0004 | 0.0019 | 0.0184 | 0.0101 | 0.0054 | 0.0116 |
| 87 | 1.4842 | 1.7945 | 0.8742 | 0.3719 | 2.9450 | 0.4967 | 0.1427 | 0.0156 | 0.1383 | 0.0058 | 0.0406 | 0.0412 | 0.1202 | 0.0482 |
| 88 | 0.6336 | 0.4577 | 0.3666 | 0.3357 | 0.3748 | 1.7688 | 0.4428 | 0.0513 | 0.0478 | 0.0405 | 0.0426 | 0.0764 | 0.0519 | 0.0118 |
| 89 | 1.5826 | 1.6407 | 0.0707 | 0.2841 | 0.0087 | 0.0108 | 0.0666 | 0.0086 | 0.0050 | 0.0044 | 0.0060 | 0.0020 | 0.0029 | 0.0029 |

is uncertain under any level of catch for the 1991-1995 period (Figure 13). The results of this entire analysis suggest, however, that there is probably a large amount of mackerel biomass at this time and a considerable number of reasonable options available for harvesting this resource.

Discussion of Atlantic Mackerel Assessment

Discussion centered around variation in input parameters for the Monte Carlo simulation model. It was pointed out that only recruitment inputs were varied, therefore, results from the analysis probably underestimated overall variability. Despite the possible conservative nature of the estimates, it was felt that the stock biomass is high enough to maintain the spawning stock at >600,000 mt for several years even with poor recruitment.

SAW participants concluded that the risk analysis approach was useful to provide management advice for the near future, particularly given the current stock level. In the long term, this approach may create problems if catches increase and no catch at age data are available for analysis. If help at the technical level were available to process a backlog of length samples, an updated VPA could be run and a new risk assessment made with greater precision. It was suggested that in future analyses, uncertainty in stock size at the beginning of the projection (*e.g.*, based on C.V. estimates from the ADAPT output) be incorporated.

The generic problem of assessing pelagic species was addressed. The distribution of pelagic species is often dependent on environmental conditions, resulting in low efficiency using CPUE estimates. It was suggested that given adequate funds, it would be worth pursuing alternative survey methods such as hydroacoustic approaches.

ASSESSMENT UPDATE FOR BUTTERFISH IN THE GULF OF MAINE - MID-ATLANTIC AREA

Commercial Fishery

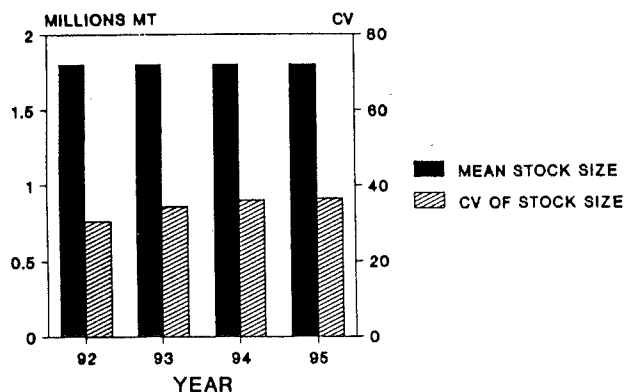
The USA catch of butterfish increased 56 percent, from 2,083 mt in 1988 to 3,121 mt in 1989. However, the 1989 catch is 41 percent below the 1978-1988 average (5,309 mt), a period when domestic butterfish catches were high (Table 16). Since 1987, the distant water fleet (DWF) catches have been negligible because most of the DWF butterfish Total Allowable Level of Foreign Fishing (TALFF) is directly tied to foreign squid allocations which have been non-existent.

Total landings (L), and landings per unit effort (LPUE) declined 5 percent and 9 percent, respectively, whereas effort (f) increased 5 percent from 1988 levels during the January-June period. In the July-December period total landings and effort increased 148 percent and 190 percent, while LPUE declined 15 percent from the corresponding July-

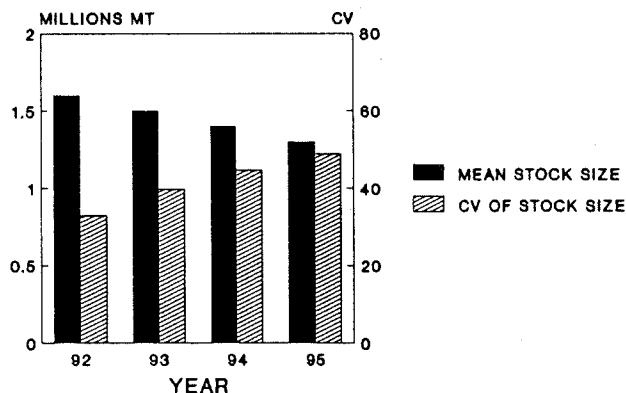
Table 12. Stock size (1+ biomass, millions mt) for 1992-1995 if a constant catch equal to 100,000 - 400,000 mt (column 1) is removed from the Atlantic mackerel stock in 1991-1995

| Catch | Year | Mean | Upper Range | Lower Range | SD | CV |
|---------|------|------|-------------|-------------|------|------|
| 100,000 | 92 | 1.8 | 5.2 | 1.0 | 0.54 | 30.5 |
| | 93 | 1.8 | 5.4 | 0.9 | 0.61 | 34.3 |
| | 94 | 1.8 | 6.1 | 0.8 | 0.65 | 36.0 |
| | 95 | 1.8 | 6.7 | 0.7 | 0.66 | 36.5 |
| 150,000 | 92 | 1.7 | 5.1 | 1.0 | 0.54 | 31.2 |
| | 93 | 1.7 | 5.3 | 0.8 | 0.61 | 35.9 |
| | 94 | 1.7 | 6.0 | 0.7 | 0.65 | 38.5 |
| | 95 | 1.7 | 6.7 | 0.5 | 0.66 | 39.8 |
| 200,000 | 92 | 1.7 | 5.1 | 0.9 | 0.54 | 32.1 |
| | 93 | 1.6 | 5.2 | 0.7 | 0.61 | 37.7 |
| | 94 | 1.6 | 5.9 | 0.5 | 0.65 | 41.3 |
| | 95 | 1.6 | 6.6 | 0.4 | 0.66 | 43.9 |
| 250,000 | 92 | 1.6 | 5.0 | 0.9 | 0.54 | 32.9 |
| | 93 | 1.5 | 5.1 | 0.6 | 0.61 | 39.7 |
| | 94 | 1.4 | 5.7 | 0.4 | 0.65 | 44.7 |
| | 95 | 1.3 | 6.5 | 0.2 | 0.66 | 48.9 |
| 300,000 | 92 | 1.6 | 5.0 | 0.8 | 0.54 | 33.8 |
| | 93 | 1.4 | 5.0 | 0.6 | 0.61 | 41.9 |
| | 94 | 1.3 | 5.6 | 0.3 | 0.64 | 48.8 |
| | 95 | 1.2 | 6.4 | 0.1 | 0.66 | 55.5 |
| 350,000 | 92 | 1.5 | 4.9 | 0.8 | 0.54 | 34.8 |
| | 93 | 1.4 | 4.9 | 0.5 | 0.60 | 44.4 |
| | 94 | 1.2 | 5.4 | 0.2 | 0.64 | 53.7 |
| | 95 | 1.0 | 6.4 | 0.0 | 0.66 | 64.5 |
| 400,000 | 92 | 1.5 | 4.9 | 0.7 | 0.53 | 35.8 |
| | 93 | 1.3 | 4.8 | 0.4 | 0.60 | 47.3 |
| | 94 | 1.1 | 5.3 | 0.1 | 0.64 | 59.9 |
| | 95 | 0.9 | 6.3 | 0.0 | 0.67 | 77.1 |

STOCK SIZE VARIATION CATCH = 100,000 MT



STOCK SIZE VARIATION CATCH = 250,000 MT



STOCK SIZE VARIATION CATCH = 400,000 MT

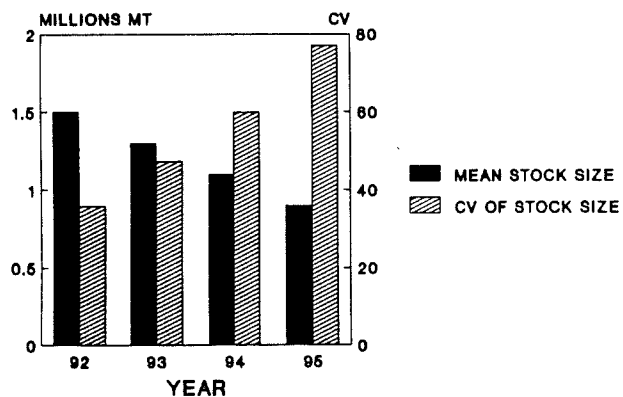
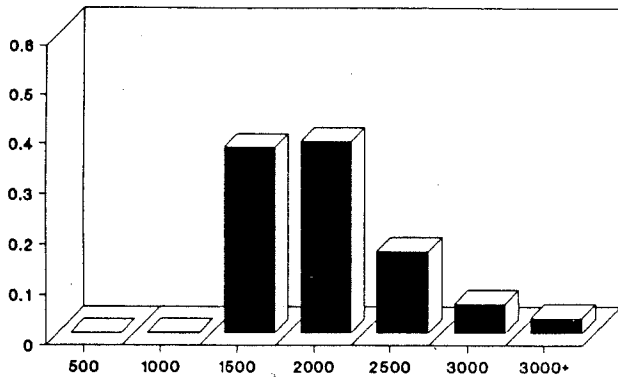
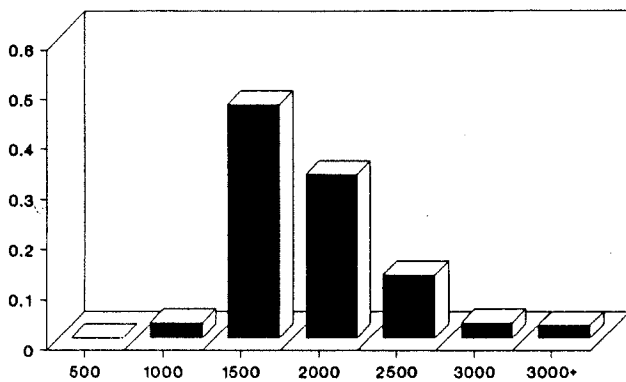


Figure 10. Means and coefficients of variation of projected stock sizes (1+ biomass, millions mt) for 1992-1995 if a constant catch equal to 100,000; 250,000; or 400,000 mt is removed from the Atlantic mackerel stock in 1991-1995.

STOCK SIZE 000'S MT
CATCH = 100,000 MT



STOCK SIZE 000'S MT
CATCH = 250,000 MT



STOCK SIZE 000'S MT
CATCH = 400,000 MT

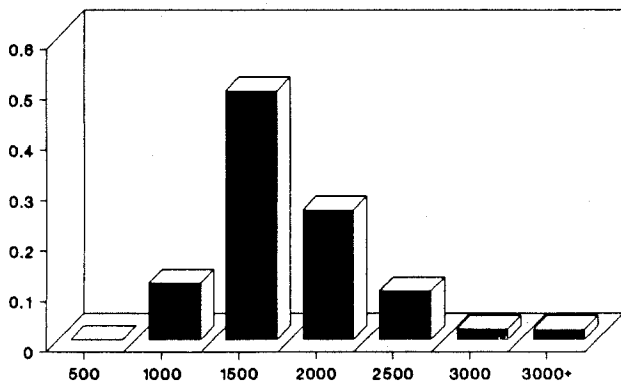


Figure 11. Relative frequencies of various stock sizes (thousands of mt) for 1992 catches of 100,000; 250,000; or 400,000 mt in 1991.

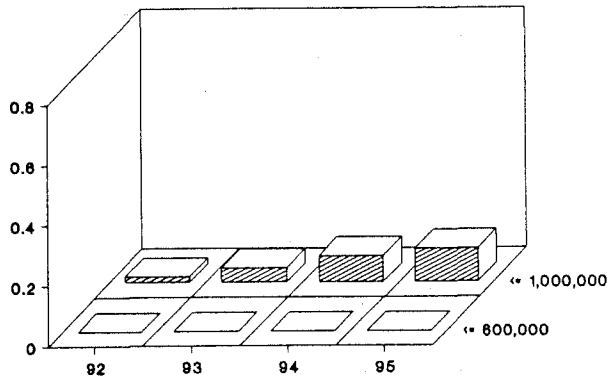
Table 13. Relative frequencies of various stock sizes (thousands of mt) for 1992 for catches of 100,000 - 400,000 mt in 1991. Categories are 0 - ≤500,000 mt, > 500,000 - ≤ 1,000,000 mt etc.

| Catch | Stock Size | | | | | | |
|---------|------------|-------|-------|-------|-------|-------|-------|
| | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3000+ |
| 100,000 | 0.000 | 0.001 | 0.368 | 0.381 | 0.162 | 0.058 | 0.030 |
| 150,000 | 0.000 | 0.006 | 0.399 | 0.369 | 0.147 | 0.050 | 0.029 |
| 200,000 | 0.000 | 0.017 | 0.443 | 0.344 | 0.130 | 0.040 | 0.026 |
| 250,000 | 0.000 | 0.030 | 0.465 | 0.325 | 0.125 | 0.030 | 0.025 |
| 300,000 | 0.000 | 0.047 | 0.490 | 0.297 | 0.116 | 0.027 | 0.023 |
| 350,000 | 0.000 | 0.066 | 0.515 | 0.267 | 0.107 | 0.023 | 0.022 |
| 400,000 | 0.000 | 0.112 | 0.493 | 0.257 | 0.097 | 0.021 | 0.020 |

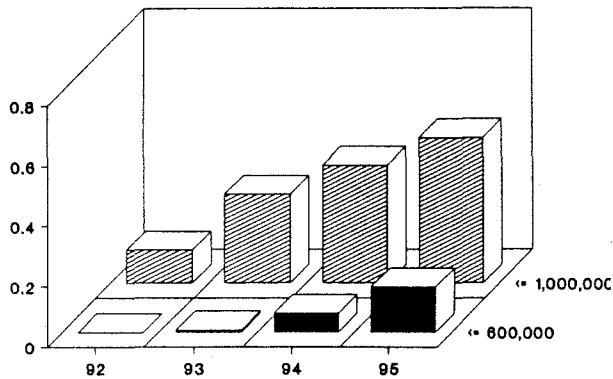
Table 14. Probability of the Atlantic mackerel spawning stock dropping below 600,000 mt and 1,000,000 mt in 1992-1995 if a constant catch equal to 100,000 - 400,000 mt (column 1) is harvested from the stock in 1991-1995

| Catch | Year | P of SSB | P of SSB |
|---------|------|----------|------------|
| | | ≤600,000 | ≤1,000,000 |
| 100,000 | 1992 | 0.000 | 0.019 |
| | 1993 | 0.000 | 0.047 |
| | 1994 | 0.000 | 0.086 |
| | 1995 | 0.000 | 0.110 |
| | 1992 | 0.000 | 0.038 |
| 150,000 | 1993 | 0.000 | 0.120 |
| | 1994 | 0.000 | 0.181 |
| | 1995 | 0.000 | 0.218 |
| | 1992 | 0.000 | 0.074 |
| 200,000 | 1993 | 0.000 | 0.206 |
| | 1994 | 0.018 | 0.271 |
| | 1995 | 0.056 | 0.356 |
| | 1992 | 0.000 | 0.109 |
| 250,000 | 1993 | 0.007 | 0.296 |
| | 1994 | 0.062 | 0.392 |
| | 1995 | 0.149 | 0.482 |
| | 1992 | 0.000 | 0.172 |
| 300,000 | 1993 | 0.028 | 0.391 |
| | 1994 | 0.148 | 0.496 |
| | 1995 | 0.267 | 0.584 |
| | 1992 | 0.000 | 0.222 |
| 350,000 | 1993 | 0.064 | 0.473 |
| | 1994 | 0.243 | 0.598 |
| | 1995 | 0.410 | 0.685 |
| | 1992 | 0.000 | 0.280 |
| 400,000 | 1993 | 0.137 | 0.557 |
| | 1994 | 0.369 | 0.685 |
| | 1995 | 0.539 | 0.771 |
| | 1992 | 0.000 | 0.280 |

SSB PROBABILITY
CATCH = 100,00 MT



SSB PROBABILITY
CATCH = 250,000 MT



SSB PROBABILITY
CATCH = 400,000 MT

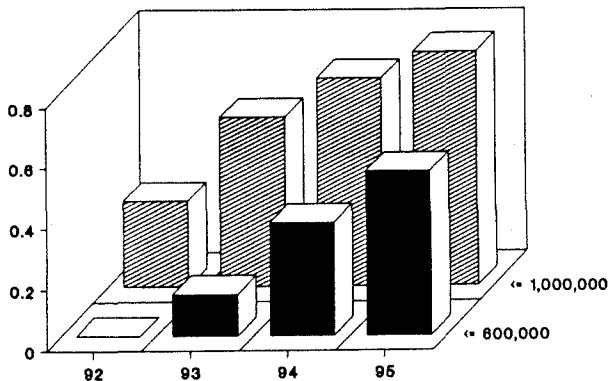
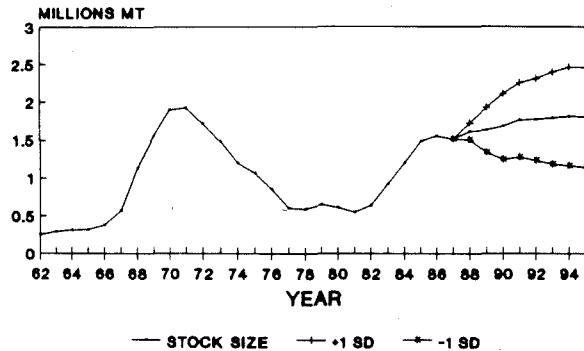


Table 15. Vital statistics for the Atlantic mackerel stock for an $F_{0.1}$ harvest strategy. The sections in this table are comparable to Tables 4-6, except that mean catches for 1991-1995 are included. $F_{0.1} = 0.29$.

| F | Year | Mean | Upper Range | Lower Range | SD | CV | |
|---|-------|-------------------|------------------|-------------|-------|-------|-------|
| Catch (thousand mt) | | | | | | | |
| 0.29 | 91 | 380 | 954 | 10 | 99.2 | 25.9 | |
| | 92 | 320 | 990 | 190 | 99.3 | 30.4 | |
| | 93 | 280 | 1000 | 142 | 101.5 | 36.3 | |
| | 94 | 250 | 890 | 110 | 98.5 | 38.7 | |
| | 95 | 240 | 890 | 97 | 96.8 | 40.7 | |
| Stock Size (million mt) | | | | | | | |
| 0.29 | 92 | 1.5 | 4.3 | 0.8 | 0.46 | 30.6 | |
| | 93 | 1.4 | 5.0 | 0.6 | 0.48 | 35.5 | |
| | 94 | 1.3 | 5.3 | 0.5 | 0.48 | 38.6 | |
| | 95 | 1.2 | 6.5 | 0.5 | 0.48 | 40.8 | |
| Relative Frequency of Stock Size (thousand mt) | | | | | | | |
| 0.29 | 500 | 1000 | 1500 | 2000 | 2500 | 3000 | 3000+ |
| | 0.000 | 0.042 | 0.549 | 0.289 | 0.088 | 0.018 | 0.014 |
| Probability of SSB | | | | | | | |
| 0.29 | | $\leq 600,000$ mt | $\leq 1,000,000$ | | | | |
| | 92 | 0.001 | 0.194 | | | | |
| | 93 | 0.001 | 0.435 | | | | |
| | 94 | 0.045 | 0.526 | | | | |
| | 95 | 0.110 | 0.621 | | | | |

Figure 12. Probability of the Atlantic mackerel spawning stock dropping below 600,000 mt or 1 million in 1992-1995 if a constant catch equal to 100,000; 250,000; or 400,000 mt is harvested from the stock in 1991-1995.

RANGE OF STOCK SIZE
CATCH = 100,000 MT



RANGE OF STOCK SIZE
CATCH = 400,000 MT

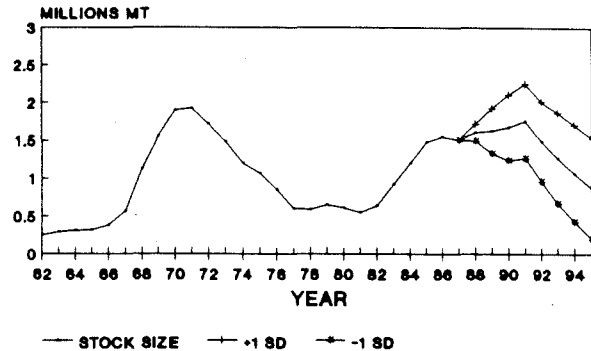


Figure 13. Projected stock sizes (and standard deviations) simulated under constant catch conditions of either 100,000 or 400,000 mt, 1988-1995. Observations for 1962-1987 are based on previous virtual population analysis.

Table 16. Nominal catch (mt) of butterfish from Northwest Atlantic Fisheries Organization (NAFO) Subareas 5 and 6, 1965-1989

| Year | US | Foreign | Nominal Catch | Adjusted Nominal Catch ¹ |
|-------------------|--------|---------|---------------|-------------------------------------|
| 1965 | 3,340 | 749 | 4,089 | 4,089 |
| 1966 | 2,615 | 3,865 | 6,480 | 6,480 |
| 1967 | 2,452 | 2,316 | 4,768 | 4,768 |
| 1968 | 1,804 | 5,437 | 7,241 | 7,241 |
| 1969 | 2,438 | 15,073 | 17,511 | 17,816 |
| 1970 | 1,869 | 9,028 | 10,897 | 14,319 |
| 1971 | 1,570 | 6,238 | 7,853 | 10,483 |
| 1972 | 819 | 5,671 | 6,490 | 13,040 |
| 1973 | 1,557 | 17,847 | 19,454 | 33,236 |
| 1974 | 2,528 | 10,337 | 12,865 | 17,993 |
| 1975 | 2,088 | 9,077 | 11,165 | 14,852 |
| 1976 | 1,528 | 10,353 | 11,881 | 16,249 |
| 1977 | 1,448 | 3,205 | 4,653 | 4,760 |
| 1978 | 3,676 | 1,326 | 5,002 | 5,375 |
| 1979 | 2,831 | 840 | 3,671 | 3,938 |
| 1980 | 5,356 | 879 | 6,235 | 6,748 |
| 1981 | 4,855 | 936 | 5,791 | 6,255 |
| 1982 | 9,060 | 631 | 9,691 | 10,483 |
| 1983 | 4,905 | 630 | 5,535 | 6,816 |
| 1984 | 11,972 | 429 | 12,401 | 16,854 |
| 1985 | 4,739 | 804 | 5,543 | 7,969 |
| 1986 | 4,418 | 164 | 4,582 | 6,166 |
| 1987 | 4,508 | - | 4,508 | 4,508 |
| 1988 | 2,083 | - | 2,083 | 2,083 |
| 1989 ² | 3,121 | - | 3,121 | 3,121 |

¹ Adjusted to account for non-reported discards of countries not reporting butterfish from directed *Loligo* fishing operations (Murawski and Waring, 1979). The 1976-1986 adjusted catch incorporate estimated discards in US fishery.

² Provisional

Table 17. International landings (L), USA LPUE (mt/day), and international effort (f) expressed as equivalent USA days fished

| Year | January-June | | | July-December | | |
|-------------------|--------------|-------|--------|---------------|-------|-------|
| | L | LPUE | f | L | LPUE | f |
| 1976 | 10164.7 | 2.20 | 4620.3 | 1716.3 | 3.69 | 465.1 |
| 1977 | 3182.4 | 7.66 | 415.5 | 1470.6 | 5.05 | 291.2 |
| 1978 | 1549.5 | 8.83 | 175.5 | 3452.5 | 8.64 | 399.6 |
| 1979 | 1562.4 | 7.64 | 204.5 | 2108.6 | 6.12 | 344.5 |
| 1980 | 1491.4 | 6.79 | 219.6 | 4743.6 | 13.05 | 363.5 |
| 1981 | 2090.2 | 14.16 | 147.6 | 3700.8 | 11.85 | 321.3 |
| 1982 | 2199.9 | 13.12 | 167.7 | 7490.8 | 22.59 | 331.6 |
| 1983 | 1467.6 | 12.79 | 115.5 | 4067.7 | 13.39 | 303.7 |
| 1984 | 6763.6 | 40.33 | 167.7 | 5637.4 | 20.91 | 269.6 |
| 1985 | 3523.5 | 16.07 | 219.3 | 2019.0 | 11.51 | 175.4 |
| 1986 | 1685.2 | 17.40 | 96.9 | 2896.8 | 17.06 | 169.8 |
| 1987 | 3113.4 | 20.41 | 152.5 | 1394.5 | 12.37 | 112.7 |
| 1988 ¹ | 1202.7 | 9.03 | 133.2 | 798.1 | 9.00 | 88.7 |
| 1989 ¹ | 1144.0 | 8.18 | 139.9 | 1975.4 | 7.67 | 257.5 |

¹ Provisional

Table 18. Indices of relative abundance (stratified mean number per tow) for butterfish by age group, and mean weight per tow (kg) derived from NEFC autumn bottom trawl survey data, 1968-1989

| Year | Age | | | | | Total | Age 1 and Older | Weight (kg) |
|------|--------|-------|-------|------|------|--------|--------------------|----------------|
| | 0 | 1 | 2 | 3 | 4 | | | |
| 1968 | 41.28 | 50.59 | 1.64 | 0.10 | 0. | 93.61 | 52.3 | 7.7 |
| 1969 | 39.48 | 18.82 | 2.12 | 0.16 | 0. | 60.58 | 21.1 | 3.9 |
| 1970 | 26.43 | 11.24 | 0.86 | 0.10 | 0. | 38.63 | 12.2 | 2.3 |
| 1971 | 208.85 | 8.76 | 0.70 | 0.24 | 0. | 218.55 | 9.6 | 4.3 |
| 1972 | 73.20 | 8.34 | 0.31 | 0.05 | 0. | 81.90 | 8.7 | 2.7 |
| 1973 | 119.10 | 27.73 | 1.50 | 0.07 | 0. | 148.40 | 29.3 | 6.1 |
| 1974 | 82.13 | 15.96 | 1.74 | 0.37 | 0. | 100.20 | 18.0 | 3.8 |
| 1975 | 26.34 | 17.54 | 1.71 | 0.15 | 0. | 45.74 | 19.4 | 2.3 |
| 1976 | 110.63 | 26.50 | 2.12 | 0.33 | 0. | 139.58 | 29.0 | 5.8 |
| 1977 | 47.73 | 32.78 | 6.22 | 0.24 | 0. | 86.97 | 39.3 | 5.2 |
| 1978 | 134.96 | 7.96 | 10.18 | 1.05 | 0. | 154.15 | 19.2 | 4.3 |
| 1979 | 231.51 | 73.01 | 4.85 | 0.18 | 0. | 309.55 | 78.1 | 12.1 |
| 1980 | 233.19 | 80.42 | 18.82 | 0.73 | 0.04 | 333.20 | 100.0 | 15.2 |
| 1981 | 234.55 | 47.14 | 12.88 | 0.29 | 0.01 | 294.87 | 60.3 | 7.0 |
| 1982 | 80.31 | 26.12 | 4.73 | 0.14 | 0.14 | 111.44 | 30.7 | 4.7 |
| 1983 | 358.77 | 78.49 | 10.70 | 3.25 | 0.07 | 451.28 | 92.5 | 12.8 |
| 1984 | 268.60 | 79.55 | 11.07 | 2.79 | 0. | 362.01 | 93.4 | 11.4 |
| 1985 | 286.26 | 85.69 | 12.40 | 2.27 | 0.09 | 386.71 | 100.4 | 15.2 |
| 1986 | 140.16 | 29.75 | 12.19 | 1.96 | 0.33 | 184.39 | 44.3 | 6.8 |
| 1987 | 78.59 | 31.55 | 7.17 | 0.25 | 0. | 117.56 | 39.0 | 4.7 |
| 1988 | 282.28 | 21.59 | 13.29 | 0.20 | 0. | 317.36 | 35.1 | 7.3 |
| 1989 | 332.31 | 49.95 | 15.05 | 1.03 | 0. | 398.34 | 66.0 | 12.2 |

December levels (Table 17). In addition, the 1989 LPUE indices are the lowest observed since 1981. The LPUE index has been declining for the past several years in both time periods. Fishing effort (f) during the July-December period, the traditional domestic butterfish season, has increased following six consecutive years of decline (Table 17).

Survey Abundance Indices

Indices of relative abundance and biomass (number and weight) from the NMFS, NEFC 1989 autumn bottom trawl survey increased 26 percent and 67 percent, respectively from 1988 values (Table 18). Likewise, the recruitment index (number per tow at age 0) increased 18 percent (Table 18). Additionally, the age 1+ index increased 88 percent, following three consecutive declines, and is the sixth highest observed in the 22 year (1968-1989) time series (Table 18). Also, the 1989 recruitment (332.3 age 0 fish per tow), age 1+ (66.0 fish per tow), and biomass (12.3 kg per tow) indices are 44 percent, 49 percent, and 77 percent, respectively, above the 21-year averages (147.7 fish per tow, 44.4 fish per tow, and 6.9 kg per tow). The nearly 50 percent increase in age 1+ abundance is largely attributed to age 1 fish, although the abun-

dance of age 2 and 3 fish also increased (Table 18). Age 2 (15.5 fish per tow) and age 3 (1.0 fish per tow) abundance indices are the second and sixth highest observed in the 21-year time series; and for the third consecutive year, no age 4 fish were caught.

Indices of relative abundance (number and weight) for all regions combined from the Massachusetts 1989 inshore autumn bottom trawl survey declined nearly 80 percent from record-high 1988 values (Table 19). Furthermore, the 1989 abundance (103.6 fish per tow) and biomass (1.49 kg per tow) indices are nearly 50 percent below the 11-year (1978-1988) average. Overall, however, Massachusetts 1978-1989 indices do not exhibit the same yearly trends as seen in NEFC data (Figure 14). Indices of relative abundance from Connecticut surveys (Figure 14) follow yearly trends seen in the NEFC 1984-1989 data. However, since age data are not available for the Long Island Sound surveys, more detailed comparisons with the NEFC survey data cannot be made.

Indices of relative abundance (number) for three NEFC offshore (>27 m depth) strata sets from 1968 to 1988 were calculated to examine long-term trends by geographic region (Figure 15a). Abundance indices in each of the three regions prior to 1979, when foreign landings were relatively high, were generally lower than values observed in corresponding areas during

BUTTERFISH

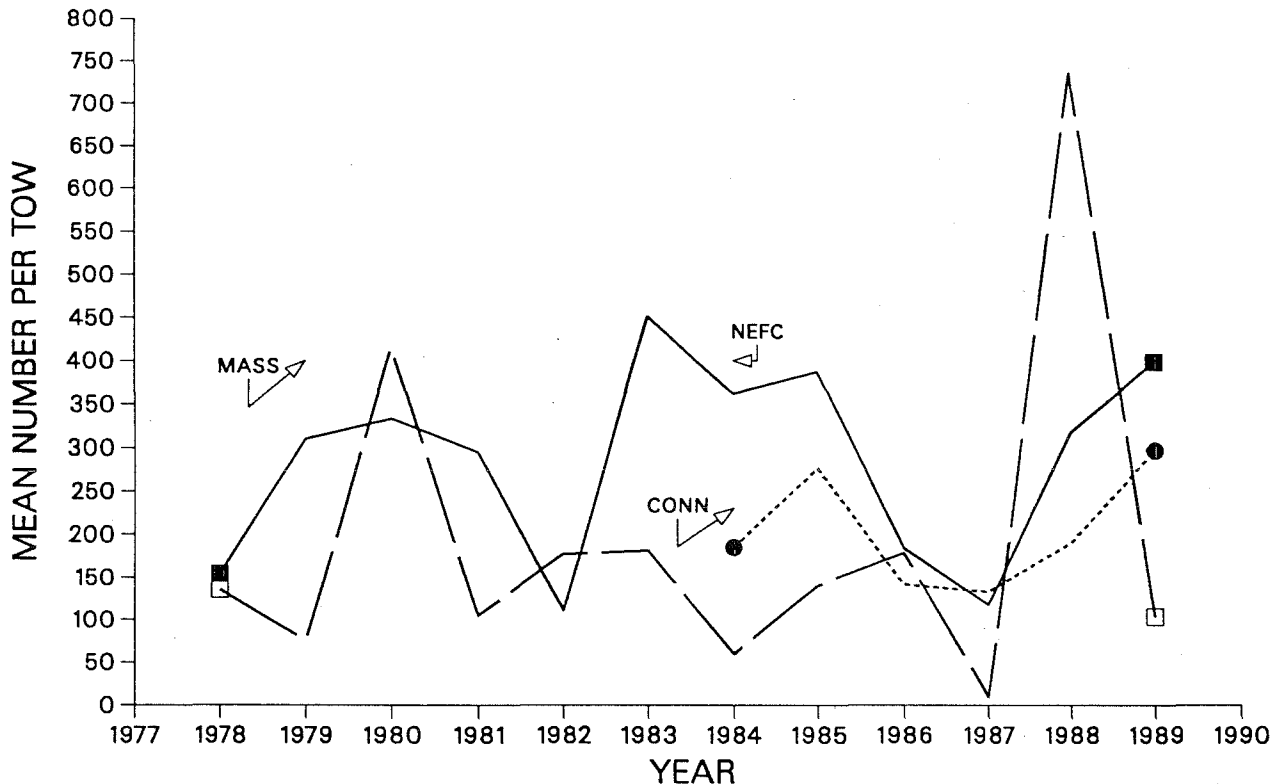


Figure 14. Butterfish abundance indices from NEFC (1978-1989), Massachusetts Division of Marine Fisheries (1978-1989), and Connecticut Department of Environmental Protection (1984-1989) autumn bottom trawl surveys.

1979-1989. Furthermore, during the latter time period, southern New England (SNE) indices were always greater than those for Georges Bank; between 1968 and 1978, however, Georges Bank indices were greater than those for SNE about 50 percent of the time. Average bottom temperature for the three regions were similar in each of the two periods (Figure 15b). Bottom temperatures in all three regions have generally been declining since the mid-1980s. The 1989 mean bottom temperatures for the Georges Bank (10.9°), SNE (10.1°), and mid-Atlantic (10.5°) regions were, respectively, 1.0°, 1.2°, and 2.5° below the 1968-1988 average.

Total Mortality

Total instantaneous mortality (Z) rates between ages 0/1 increased 34 percent from 1987/88 to 1988/89 levels; whereas, total mortality rates between ages 1/2 and 2/3 declined 58 percent and 29 percent, respectively (Table 20). The mean Z s between ages 0/1

and 1/2 in recent years (1978/89) are below the corresponding values for the previous ten years (1968/77) (Table 20). The Z between ages 2/3, however, is about one-third higher in the recent time period.

Summary

The 1989 NEFC recruitment index is comparable to the high indices observed during the 1979-1981 and 1983-1985, and 1988 periods, and is more than double (excluding 1971) recruitment indices observed during the 1968-1978 time period. This implies that since 1979, survival of pre-recruit sizes has increased. The 1989 age 1+ index is approximately 40 percent below the high indices observed between 1979-1985, but is more than double most indices prior to 1977. Overall, this suggests that stock abundance is sufficient to support catches at the MSY level (16,000 mt), although recent domestic catches have only been about one-sixth of this level.

The general inverse relationship between the Massachusetts and NEFC butterfish indices may be attrib-

Table 19. Butterfish autumn abundance indices, weight (kg/tow) and numbers per tow from 1978-1989 Massachusetts inshore bottom trawl surveys

| Year | Region 1 ¹ | Region 2 ² | Region 3 ³ | Region 4 ⁴ | Region 5 ⁵ | All Regions |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|-------------|
| Kg/Tow | | | | | | |
| 1978 | 3.54 | 1.99 | 1.22 | 0.44 | 0.09 | 1.42 |
| 1979 | 2.63 | 0.68 | 0.56 | 0.62 | 0.07 | 0.91 |
| 1980 | 6.14 | 7.91 | 0.99 | 5.22 | 1.49 | 4.61 |
| 1981 | 2.33 | 2.37 | 0.38 | 5.76 | 0.02 | 2.43 |
| 1982 | 7.14 | 0.59 | 0.27 | 0.33 | 0.21 | 1.68 |
| 1983 | 5.28 | 1.13 | 1.90 | 1.60 | 0.57 | 2.06 |
| 1984 | 2.93 | 1.72 | 0.36 | 0.30 | 0.40 | 1.15 |
| 1985 | 2.02 | 1.42 | 0.60 | 2.03 | 7.48 | 2.77 |
| 1986 | 9.48 | 1.67 | 1.69 | 1.66 | 1.67 | 3.20 |
| 1987 | 1.15 | 0.73 | 0.01 | 0.01 | 0.01 | 0.39 |
| 1988 | 21.43 | 16.40 | 1.38 | 0.17 | 0.31 | 8.01 |
| 1989 | 5.42 | 0.84 | 1.13 | 0.07 | 0.11 | 1.49 |
| Numbers/Tow | | | | | | |
| 1978 | 240.37 | 200.31 | 276.90 | 14.46 | 4.09 | 135.10 |
| 1979 | 204.04 | 62.91 | 132.60 | 11.93 | 1.46 | 76.11 |
| 1980 | 452.81 | 798.77 | 274.18 | 367.89 | 125.61 | 414.91 |
| 1981 | 160.99 | 143.85 | 92.37 | 114.51 | 5.20 | 104.86 |
| 1982 | 777.33 | 81.09 | 31.31 | 12.57 | 3.56 | 177.68 |
| 1983 | 499.39 | 162.42 | 206.89 | 52.59 | 27.06 | 181.12 |
| 1984 | 148.05 | 58.73 | 78.65 | 9.25 | 19.84 | 59.33 |
| 1985 | 217.68 | 116.74 | 153.23 | 72.88 | 163.24 | 140.42 |
| 1986 | 517.66 | 194.54 | 107.39 | 56.64 | 29.72 | 178.44 |
| 1987 | 25.56 | 17.58 | 4.12 | 0.47 | 0.07 | 9.50 |
| 1988 | 2275.76 | 1048.00 | 419.95 | 15.18 | 4.82 | 736.17 |
| 1989 | 215.65 | 67.69 | 290.03 | 1.03 | 4.58 | 103.55 |

¹ Buzzards Bay
² Nantucket Sound
³ East of Cape Cod
⁴ Cape Cod Bay
⁵ Massachusetts Bay

uted to differences in environmental conditions between the two survey regions. Since Massachusetts coastal waters are within the northern-most range of this species, it seems likely that butterfish would be more sensitive to water temperatures within this region. A strong relationship between autumn temperature data and survey abundance indices has not been demonstrated, however.

The decline in fishing effort during the past several years suggests that southern New England butterfish vessels may have switched to other species (*i.e.*, *Illex*) because of low availability of marketable size butterfish on the traditional fishing grounds in recent years.

The decline in the mean Z between ages 1/2 fish since 1978 probably reflects the decline in total DWF fishing mortality. The DWF fishery on butterfish was

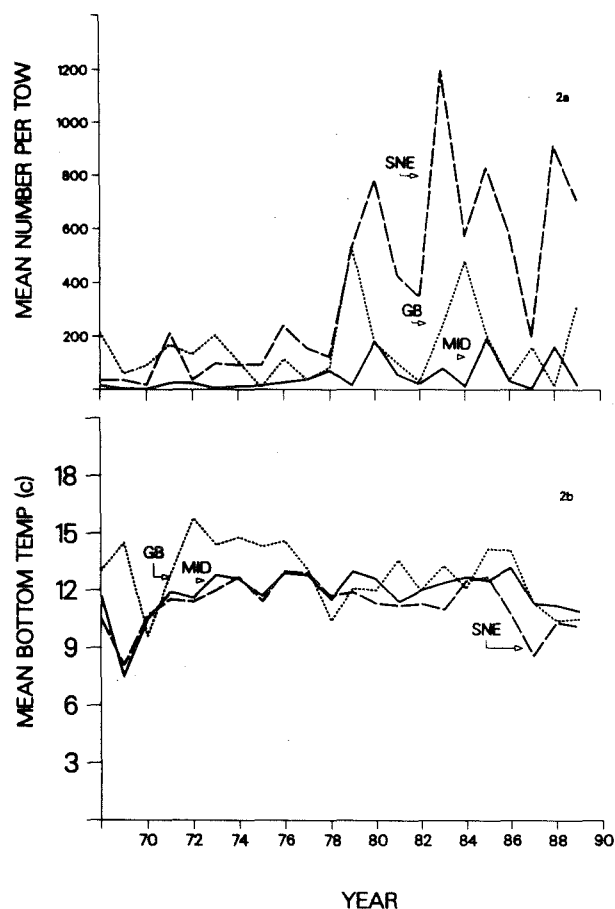


Figure 15. Butterfish abundance indices (15a) and mean bottom temperature (°C), (15b) for selected NEFC autumn bottom trawl surveys, 1968-1989.

conducted principally in winter, thus impacting recruiting age 1 fish. The mean Zs between ages 0/1 for the two time periods are nearly identical which implies that current domestic fishing mortality rates are equivalent to historical DWF levels, assuming natural mortality, ($M=0.8$) has remained constant over time. Although the component of natural mortality that is due to predation by pelagic fish species and large whales has not been estimated, it is probably the most important segment. The decline in Zs between ages 1/2 and 2/3 from 1988/89 may be attributable to declines in fishing effort by the domestic fleet.

Discussion of Butterfish Assessment

SAW participants accepted the conclusions of the butterfish assessment update without reservation.

Table 20. Total mortality rates (Z) for butterfish derived from NEFC autumn abundance indices (Table 19), 1968-1989

| Year | Age | | | |
|------------|------|------|------|------|
| | 0/1 | 1/2 | 2/3 | 3/4 |
| 1968/69 | .78 | 3.17 | 2.33 | - |
| 1969/70 | 1.26 | 3.09 | 3.05 | - |
| 1970/71 | 1.10 | 2.78 | 1.28 | - |
| 1971/72 | 3.22 | 3.34 | 2.64 | - |
| 1972/73 | .97 | 1.72 | 1.49 | - |
| 1973/74 | 2.01 | 2.77 | 1.40 | - |
| 1974/75 | 1.54 | 2.23 | 2.45 | - |
| 1975/76 | .01 | 2.11 | 1.65 | - |
| 1976/77 | 1.22 | 1.45 | 2.18 | - |
| 1977/78 | 1.79 | 1.17 | 1.78 | - |
| 1978/79 | .61 | .50 | 4.03 | - |
| 1979/80 | 1.06 | 1.36 | 1.88 | 1.50 |
| 1980/81 | 1.60 | 1.83 | 4.17 | 4.29 |
| 1981/82 | 2.20 | 2.30 | 4.52 | .73 |
| 1982/83 | .02 | .89 | .38 | .69 |
| 1983/84 | 1.51 | 1.96 | 1.34 | - |
| 1984/85 | 1.14 | 1.86 | 1.58 | 3.43 |
| 1985/86 | 2.26 | 1.95 | 1.84 | 1.93 |
| 1986/87 | 1.49 | 1.42 | 3.89 | - |
| 1987/88 | 1.29 | 0.86 | 3.57 | - |
| 1988/89 | 1.73 | 0.36 | 2.55 | - |
| 68/77 MEAN | 1.39 | 2.38 | 2.03 | - |
| 78/89 MEAN | 1.36 | 1.39 | 2.70 | - |

ASSESSMENT UPDATE FOR LONG-FINNED SQUID (*Loligo pealei*)

The Fishery

The USA *Loligo* catch of 23,402 mt, in 1989, was the highest on record, 22.7 percent greater than the previous high level seen during 1988. Subarea 5 landings (10,929 mt) represented about 47 percent of the total, while landings from Subarea 6 (12,473 mt) accounted for the remaining 53 percent of the USA total (Table 21). Landings were distributed throughout the year, with catch peaking in Subarea 5 during May (3,271 mt), and during February in Subarea 6 (2,243 mt) (Figure 16). Lowest monthly catches were during July-September. Otter trawl vessels accounted for all but about 5 percent of the landings, in 1989, with pound nets taking most of the remainder. While the fishery had been dominated by medium sized vessels (51-150 GRT) since 1978, medium and large (151-500 GRT) vessels account for comparable proportions of the 1989 landings (48 percent and 47 percent). Small vessels (5-50 GRT) accounted for 6 percent of the total 1989 landings. While catches in the traditionally important inshore Vineyard and Nantucket Sound (Figure 17, SA 538) spring-summer fishery remained important (14 percent of USA total and 21 percent of the directed total), the fishery for *Loligo* in the offshore areas continued to increase in importance during 1989. Landings south of Cape Cod and the Islands (SA 537) and on southwestern Georges Bank (SA 526) accounted for 29 percent of the USA total, and landings from the mid-Atlantic area (SA 611-636) represented 50 percent of 1989 total (Table 21). The participation of large USA freezer/processors, transferring catches from smaller catcher vessels also increased during 1989.

In recent years the foreign fleet fishery for *Loligo* has been reduced to low by-catch levels, and in 1989 it took only about 5 mt of *Loligo* in conjunction with its directed mackerel fishery (Table 22).

Commercial Length Frequencies

Length frequency data from the 1988 USA fishery in the Southern New-England and mid-Atlantic areas indicate that *Loligo* taken in the 1989 fishery generally ranged in size from about 8 to 28 cm, with individuals over 30 cm taken in some months. A single mode, generally between 14 and 18 cm, dominated the catches in each month (Figure 18). This is similar to the size distribution seen in past years.

Commercial Catch-Per-Effort

Catch-per-unit-effort (CPUE, metric tons per day

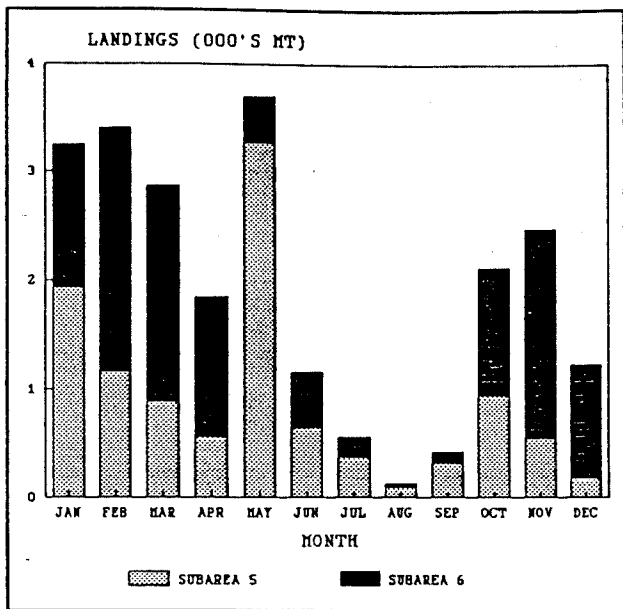


Figure 16. Landings of *Loligo* squid, by month, during 1989.

Table 21. Total monthly *Loligo* squid landings, by statistical area (SAR), 1989

| SAR | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|-----|--------|--------|--------|--------|--------|--------|-------|-------|-------|--------|--------|--------|---------|
| 514 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 8.5 | 0.4 | 10.6 |
| 521 | 0.0 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 5.5 | 0.0 | 0.0 | 0.1 | 0.8 | 0.4 | 7.4 |
| 522 | 0.0 | 0.0 | 0.0 | 0.0 | 1.9 | 0.0 | 0.9 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 3.0 |
| 525 | 0.0 | 0.2 | 1.6 | 4.0 | 4.9 | 0.7 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12.7 |
| 526 | 1016.4 | 542.0 | 689.4 | 110.0 | 1.6 | 0.6 | 3.5 | 0.6 | 18.1 | 0.0 | 5.8 | 0.3 | 2388.3 |
| 537 | 918.2 | 623.0 | 198.1 | 211.7 | 131.1 | 296.9 | 344.2 | 77.6 | 277.6 | 778.3 | 387.4 | 162.0 | 4406.1 |
| 538 | 0.0 | 0.0 | 0.0 | 225.7 | 2650.3 | 326.1 | 7.3 | 1.6 | 2.5 | 9.5 | 6.3 | 0.0 | 3229.3 |
| 539 | 2.3 | 0.3 | 0.1 | 10.4 | 480.7 | 22.0 | 8.7 | 16.0 | 22.7 | 153.0 | 138.6 | 16.8 | 871.5 |
| 562 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| SA5 | 1936.9 | 1165.5 | 889.2 | 561.8 | 3271.2 | 646.5 | 371.5 | 95.9 | 320.9 | 942.6 | 547.4 | 179.9 | 10929.0 |
| 611 | 0.0 | 0.0 | 0.0 | 0.7 | 12.7 | 10.6 | 23.1 | 1.1 | 3.3 | 9.8 | 22.5 | 0.9 | 84.6 |
| 612 | 4.3 | 24.6 | 2.3 | 9.7 | 75.4 | 134.0 | 73.7 | 23.5 | 11.7 | 223.1 | 203.2 | 38.1 | 823.6 |
| 613 | 104.1 | 24.2 | 37.7 | 161.4 | 57.2 | 255.3 | 73.6 | 12.9 | 31.1 | 530.5 | 229.5 | 186.8 | 1704.2 |
| 614 | 0.0 | 0.0 | 0.0 | 0.0 | 178.6 | 11.5 | 0.0 | 0.7 | 0.0 | 0.0 | 428.9 | 33.3 | 653.0 |
| 615 | 0.0 | 0.4 | 0.2 | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 169.8 | 0.0 | 173.0 |
| 616 | 674.1 | 1618.2 | 967.7 | 411.2 | 79.0 | 4.6 | 0.0 | 0.0 | 0.6 | 161.8 | 227.1 | 139.3 | 4283.6 |
| 621 | 1.8 | 2.1 | 0.0 | 1.0 | 0.1 | 10.4 | 2.4 | 0.1 | 0.6 | 1.5 | 78.1 | 216.9 | 315.1 |
| 622 | 414.9 | 324.2 | 606.3 | 444.0 | 20.2 | 85.2 | 16.1 | 0.0 | 3.4 | 33.5 | 409.7 | 200.7 | 2558.2 |
| 623 | 0.0 | 215.7 | 225.0 | 147.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.0 | 37.6 | 0.0 | 626.3 |
| 625 | 0.4 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.4 | 0.3 | 2.8 |
| 626 | 88.0 | 20.9 | 65.3 | 92.1 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 60.5 | 40.0 | 21.7 | 389.1 |
| 631 | 0.0 | 1.8 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 4.7 | 3.9 | 12.4 |
| 632 | 28.3 | 10.4 | 77.3 | 19.5 | 0.0 | 0.0 | 0.0 | 0.0 | 52.6 | 151.5 | 73.6 | 27.3 | 440.5 |
| 635 | 0.9 | 0.7 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 2.5 |
| SA6 | 1316.8 | 2243.2 | 1981.8 | 1286.6 | 425.3 | 511.6 | 188.9 | 38.3 | 104.3 | 1176.1 | 1926.1 | 869.7 | 12069.0 |
| 5&6 | 3253.7 | 3408.7 | 2871.0 | 1848.4 | 3696.5 | 1158.1 | 560.4 | 134.2 | 425.2 | 2118.7 | 2473.5 | 1049.6 | 22998.0 |

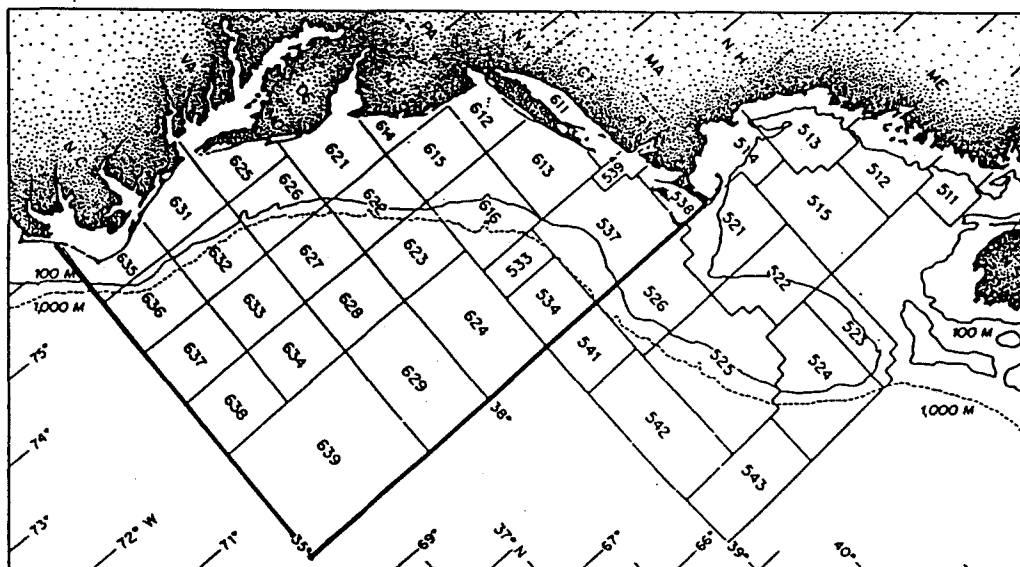


Figure 17. U.S.A. statistical areas (SA) used for reporting landings statistics.

Table 22. Annual *Loligo* squid catches (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by the USA¹ and foreign fleets, 1963-89

| 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 | 23,402 | 5 | 23,407 |

¹ Includes joint venture catches made by USA catcher vessels.

fished) indices from the directed otter trawl fishery (those otter trawl trips where squid accounted for over 75 percent of the total) in SAs 537-636, are given in Table 23 (Figure 19), for 1976-89. This index reflects the relative availability of *Loligo* to the directed fishery. The 1989 index was comparable to that seen in 1988 and was the third highest since 1976, 58 percent greater than the 1976-88 mean value.

Research Vessel Surveys

Minimum biomass and abundance (numbers) estimates based on areal expansion of stratified mean weights and numbers per tow from the autumn NEFC bottom trawl surveys are provided in Table 24. These estimates assume 100 percent catchability of *Loligo* during daytime, and account for off-bottom movements during the night. The 1989 biomass estimate represents the highest of the time series, about 2

percent greater than the previous high seen in 1984. The abundance estimate was the third highest of the series, and 53 percent greater than the previous 21 year (1968-88) mean.

The 1989 NEFC autumn bottom trawl total abundance index (stratified mean number per tow) for the mid-Atlantic through Georges Bank strata was the fourth highest of the 1967-89 series, 45 percent above the mean (Table 25). The pre-recruit index (individuals ≤ 8 cm dorsal mantle length) was about 15 percent above the series mean, but 15 percent below the 1988 level. It is these pre-recruits that will make up the bulk of the catch during the summer and autumn of 1990.

The proportion of zero tows (PZ), an alternative survey index derived from the autumn survey data was found to be significantly (negatively) correlated to the subsequent availability of *Loligo* to the inshore fishery (Lange, 1987). The 1989 index (PZ=0.20) was the highest since 1981, comparable to the mean for the 1976-88 period, but 85 percent above the recent (1982-88) mean. If the relationship holds for the 1989 index, availability to the domestic fishery in 1990 should be about average for the long-term, but below that seen during most of the 1980s. This decrease in availability should be evidenced in lower CPUE in the 1990 directed fishery.

The State of Massachusetts research survey stratified mean number per tow index for *Loligo* for autumn 1989 was about 35 percent below the 1980-88 average (258.2 vs 398.3 squid per tow, Table 26). Catch rates in all areas except Massachusetts Bay were well below previous levels.

Prospects for 1990

Total abundance during the NEFC autumn 1989 survey, based on daytime tows only, was 3.6 billion. Pre-recruits accounted for 64.6 percent of the total (2.3 billion). If 55 percent of the pre-recruits are from the spring cohort, and catchability is 45 percent (Lange 1984), 2.8 billion recruits [$2.3(0.55/0.45)$] are estimated from that cohort. The autumn cohort is assumed to contribute, on average, an additional 18 percent of those from the spring cohort (0.51 billion). Total recruitment from the 1989 year class is therefore estimated to be 3.32 billion.

Table 27 provides estimates of potential yield of *Loligo* squid from the 1989 year class, assuming 3.32 billion recruits, for an offshore/inshore and an inshore fishery and a range of mortality rates. The nature of the current fishery probably falls somewhere between these two models, as the USA offshore fishery continues to expand. Lange *et al.* (1984), assuming a moderate stock-recruitment relationship, found the highest equilibrium yield associated with an F of 0.70, while actual F levels had probably been

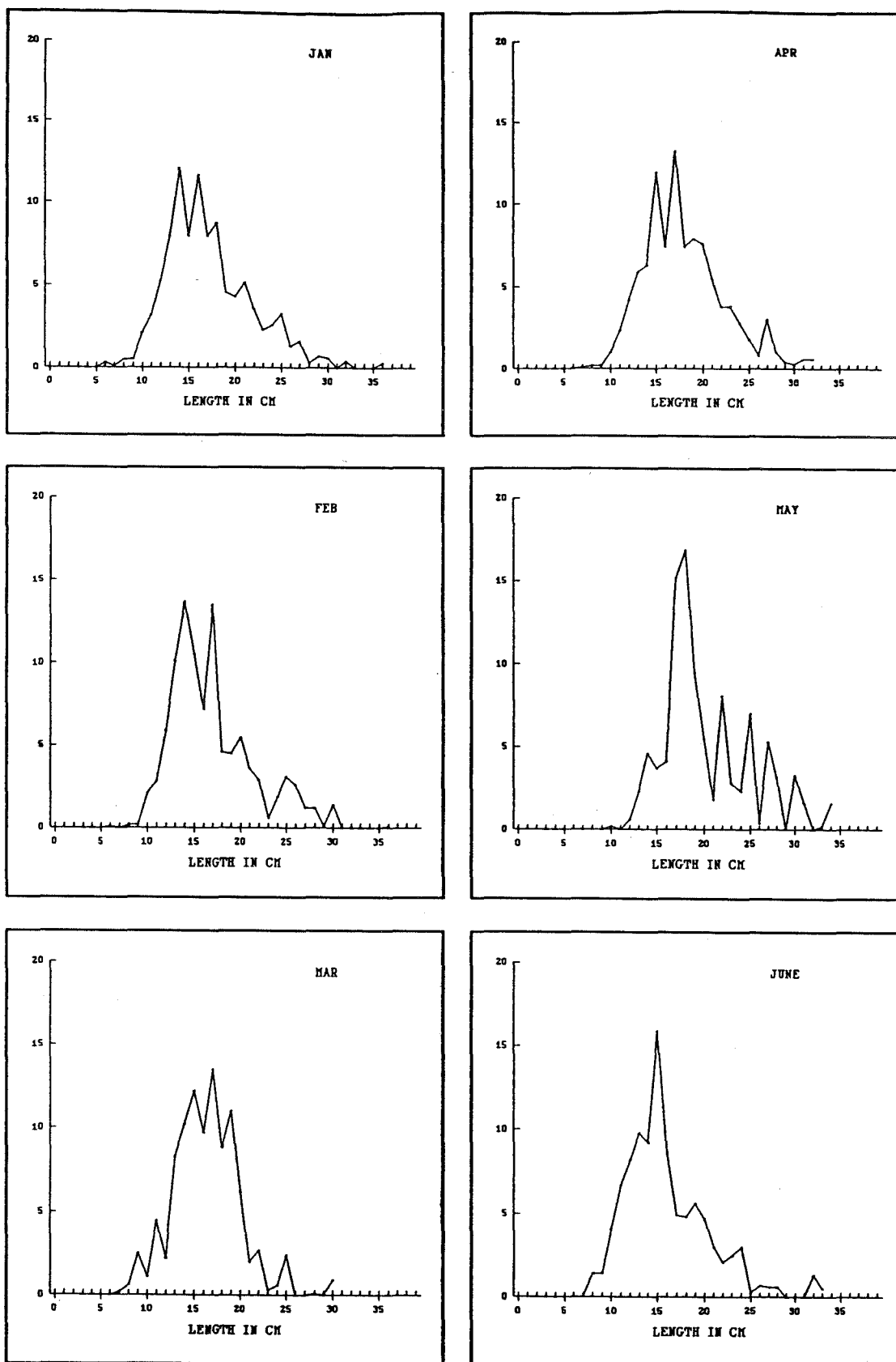


Figure 18. U.S.A. 1989 monthly commercial length frequencies for *Loligo* squid, in percent.

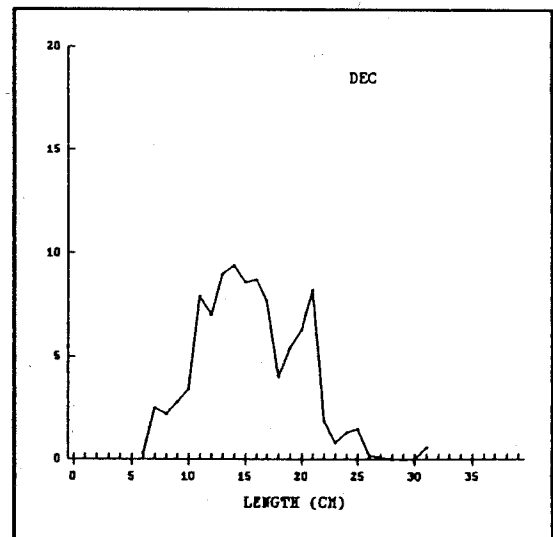
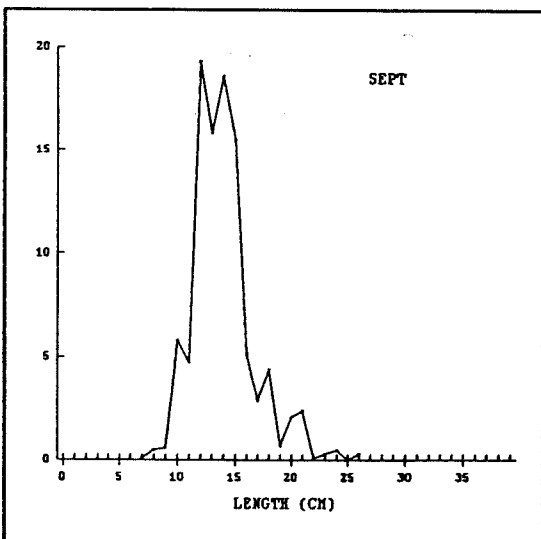
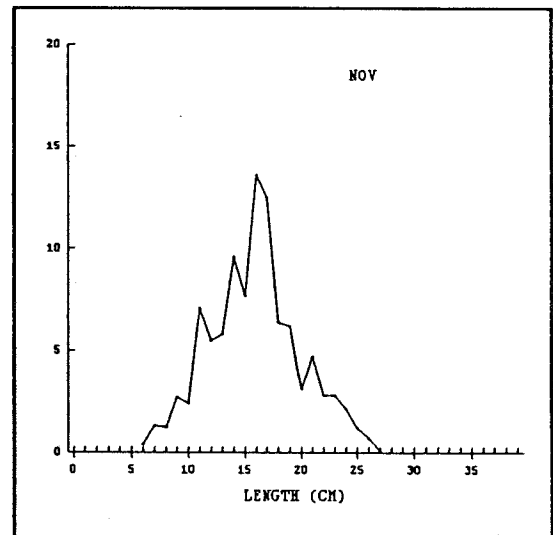
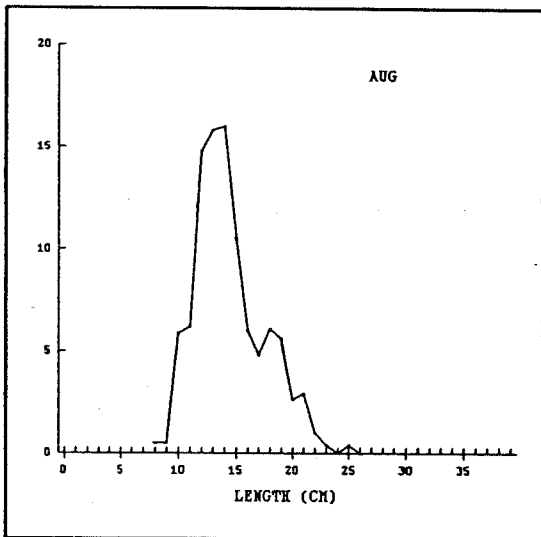
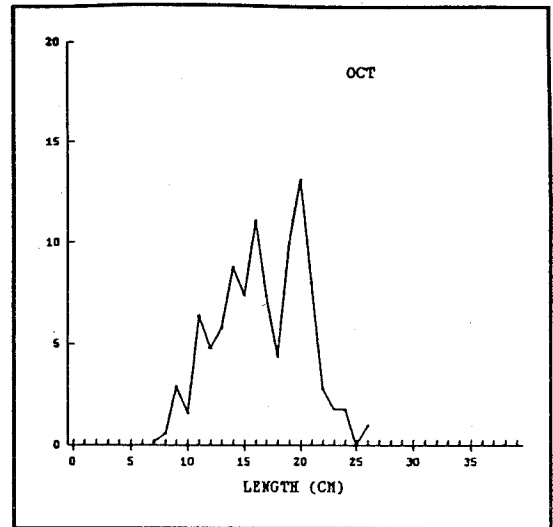
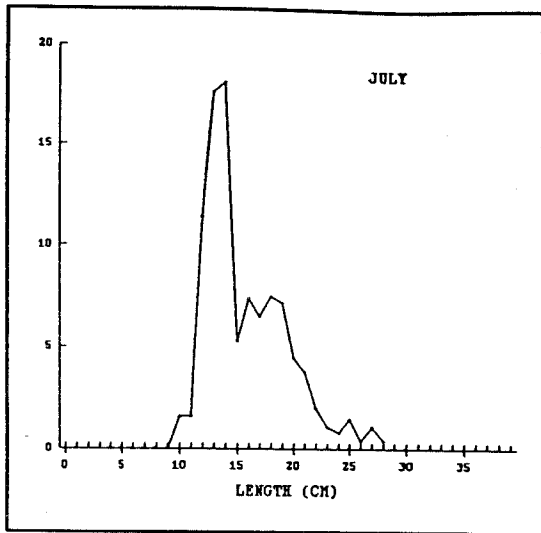


Figure 18. Continued.

Table 23. Catch-per-unit-effort (CPUE) in metric tons per day fished, from the directed¹ *Loligo* fishery, 1976-89

| Year | CPUE |
|------|-------|
| 1976 | 7.63 |
| 1977 | 4.91 |
| 1978 | 2.51 |
| 1979 | 5.18 |
| 1980 | 5.18 |
| 1981 | 3.76 |
| 1982 | 5.27 |
| 1983 | 11.27 |
| 1984 | 8.96 |
| 1985 | 7.98 |
| 1986 | 8.42 |
| 1987 | 10.48 |
| 1988 | 11.20 |
| 1989 | 10.71 |

¹ Directed effort is defined as otter trawl trips from SAs 537-636 where over 75% of the landings were *Loligo*.

Table 24. *Loligo* squid minimum biomass (metric tons) and abundance (numbers, in millions) estimates¹ for the Mid-Atlantic to Gulf of Maine, from autumn NEFC bottom trawl surveys, 1968-89

| Year | Biomass | Abundance |
|------|---------|-----------|
| 1968 | 29,111 | 1,212 |
| 1969 | 48,055 | 2,393 |
| 1970 | 19,640 | 1,946 |
| 1971 | 14,050 | 1,106 |
| 1972 | 21,039 | 1,533 |
| 1973 | 44,252 | 3,092 |
| 1974 | 46,442 | 4,757 |
| 1975 | 48,636 | 7,789 |
| 1976 | 51,436 | 4,372 |
| 1977 | 27,421 | 3,157 |
| 1978 | 18,800 | 1,251 |
| 1979 | 19,333 | 2,114 |
| 1980 | 34,275 | 9,314 |
| 1981 | 24,345 | 3,411 |
| 1982 | 26,527 | 2,303 |
| 1983 | 62,363 | 4,460 |
| 1984 | 66,122 | 4,670 |
| 1985 | 55,612 | 4,865 |
| 1986 | 47,029 | 3,139 |
| 1987 | 8,363 | 689 |
| 1988 | 31,895 | 4,260 |
| 1989 | 67,619 | 5,243 |

¹ From areal expansion of stratified mean weights (kg) and numbers per tow assuming 100% catchability during daytime. Nighttime catch data were expanded to account for diel differences in catch.

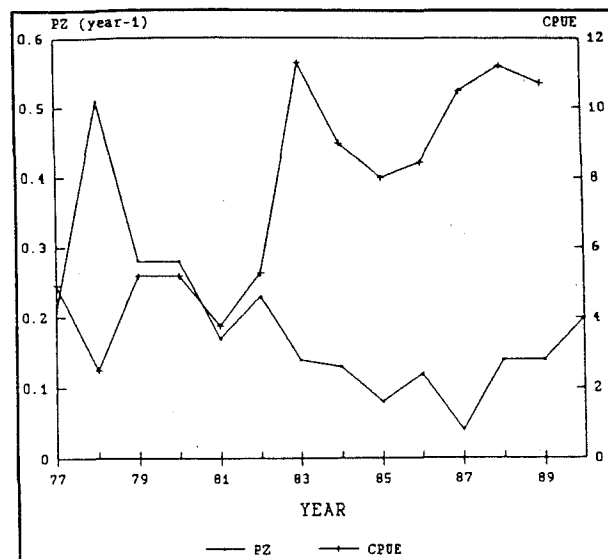


Figure 19. Catch-per-unit-effort (CPUE) of *Loligo* squid in the directed U.S.A. fishery (directed fishery defined as all those trips where *Loligo* squid accounted for more than 75 percent of the total trip catch), and proportion of zero tows (PZ) from the preceding NEFC autumn survey.

Table 25. Total and pre-recruit (≤ 8 cm) stratified mean numbers per tow¹ of *Loligo* squid from the NEFC autumn bottom trawl surveys (mid-Atlantic to Georges Bank), 1967-89

| Year | All sizes | Pre-recruits |
|------|-----------|--------------|
| 1967 | 134.5 | 126.9 |
| 1968 | 176.5 | 159.9 |
| 1969 | 237.3 | 217.4 |
| 1970 | 85.6 | 79.3 |
| 1971 | 163.3 | 161.5 |
| 1972 | 271.4 | 258.5 |
| 1973 | 372.0 | 353.9 |
| 1974 | 251.7 | 233.3 |
| 1975 | 614.4 | 593.3 |
| 1976 | 410.9 | 302.5 |
| 1977 | 388.5 | 297.7 |
| 1978 | 144.2 | 93.4 |
| 1979 | 193.7 | 156.5 |
| 1980 | 364.1 | 279.8 |
| 1981 | 226.2 | 161.8 |
| 1982 | 310.4 | 256.6 |
| 1983 | 373.4 | 251.1 |
| 1984 | 299.8 | 152.2 |
| 1985 | 442.2 | 310.8 |
| 1986 | 453.0 | 360.4 |
| 1987 | 56.7 | 32.0 |
| 1988 | 413.7 | 320.0 |
| 1989 | 420.6 | 271.9 |

¹ Stratified mean number per tow of all sizes and of individuals ≤ 8 cm dorsal mantle length.

Table 26. Massachusetts State research vessel survey catch-per-tow indices for *Loligo* by area, in numbers, 1980-89

| Year | Region 1 ¹ | Region 2 ² | Region 3 ³ | Region 4 ⁴ | Region 5 ⁵ |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1980 | 402.1 | 580.0 | 140.9 | 150.4 | 19.2 |
| 1981 | 379.9 | 365.6 | 301.3 | 216.5 | 186.3 |
| 1982 | 868.4 | 851.4 | 477.3 | 988.8 | 6.0 |
| 1983 | 476.9 | 438.5 | 90.9 | 695.8 | 244.4 |
| 1984 | 209.2 | 147.8 | 194.9 | 128.3 | 11.9 |
| 1985 | 445.5 | 1010.7 | 684.2 | 747.6 | 274.4 |
| 1986 | 919.5 | 359.8 | 610.7 | 103.7 | 29.3 |
| 1987 | 546.6 | 584.9 | 138.3 | 232.4 | 0.4 |
| 1988 | 1,229.4 | 349.9 | 642.3 | 596.7 | 19.7 |
| 1989 | 433.5 | 144.0 | 261.4 | 36.0 | 407.4 |
| Mean (1980-88) | 608.6 | 521.0 | 364.5 | 428.9 | 88.0 |

¹ Buzzards Bay² Nantucket Sound³ East of Cape Cod⁴ Cape Cod Bay⁵ Massachusetts BayTable 27. Estimated yield (in metric tons) of *Loligo* squid associated with various levels of fishing mortality and the 1989 recruitment level of 3.32 billion individuals for the offshore/inshore and inshore fisheries (assuming a moderate stock-recruitment relationship)

| F | Offshore-Inshore | Inshore |
|------|------------------|---------|
| 0.27 | 29,490 | 32,729 |
| 0.41 | 38,588 | 43,709 |
| 0.55 | 44,352 | 50,598 |
| 0.70 | 46,289 | 54,564 |
| 0.93 | 42,728 | 61,203 |

around 0.4 or less. Yields, during 1990, from the 1989 year class at an F level of 0.70 would be expected to range between 46,000 and 54,000 mt (between 38,000 and 44,000 at an F level of 0.4). However, these estimates do not take into consideration problems of availability to the fishery associated with environmental and fishery effects.

Environmental Considerations

Loligo squid are highly migratory, moving inshore in spring and summer and offshore to deep waters during autumn and winter. The timing and extent of these seasonal migrations are assumed to be related, at least in part, to temperature preferences of this species. While offshore temperatures observed during the NEFC 1990 spring survey were generally at or above normal (pers. comm. T. Holzworth, NEFC),

indications are that lower than normal temperatures in the inshore areas of southern-New England during April-May 1990 may have effected inshore movements of *Loligo*.

Conclusions

Above average apparent abundance of both adults and pre-recruits during the autumn offshore 1989 NEFC research vessel survey suggests that current abundance of *Loligo* is adequate to provide catches, during 1990, of between 38,000 and 44,000 mt, even at F levels below those expected to produce the highest equilibrium yield. However, availability to the USA fishery in 1990, as indicated by the proportion of zero tows during the autumn 1989 survey, may be below that seen in recent years, resulting in lower CPUE. Also, the Massachusetts State inshore autumn 1989 survey results suggest that the cohorts that would contribute to the fishery in its waters would not be abundant enough to sustain landings at recent annual levels. In fact, total USA catches through the first three months of 1990 were about 53 percent below those for the same period of 1989, though still above the long-term mean.

Discussion of Long-finned Squid (*Loligo pealei*) Assessment

The question was raised as to the need for NEFC Domestic Sea Sampling coverage of freezer trawler operations during the offshore phase of the fishery. It is recommended that a Working Group evaluate these needs, and develop potential solutions. It was also noted that Massachusetts Division of Marine Fisheries sampling was confined to the catcher boats only during the past season in Vineyard/Nantucket Sound, and that, in general, freezer trawler operations, because of differing priorities, are probably not adequately sampled.

It is also proposed that analyses of environmental conditions, such as wind patterns and water temperatures, from existing oceanographic data bases may provide insights as to factors relating to distribution and availability of *Loligo*.

Discussion focused on the applicability of a DeLury method to estimate the initial biomass of a cohort similar to an approach developed for the Falkland Islands *Illex* fishery. Such an approach would necessitate daily catch information from a key segment of the fleet, and weekly or monthly catch data from the remainder of the fleet. It is proposed that the local spring fishery in the Vineyard/Nantucket Sound region may provide an appropriate vehicle for such a study, and it is suggested that the SAW working group (mentioned above) be formed to explore this topic.

ASSESSMENT UPDATE FOR SHORT-FINNED SQUID (*Illex illecebrosus*)

The Fishery

Total USA catch of short-finned squid (*Illex illecebrosus*) during 1989 was 6,802 mt (Table 28). The USA fishery directed at *Illex* was conducted entirely in Subarea 6 (Mid-Atlantic area, primarily Statistical Areas (SA) 622 and 623, Figure 17) during 1989, with only 96 mt reported from Subarea 5 (primarily SA 537). The 1989 catch increased to over three times the 1988 level (1,966 mt), and total USA catch was the fourth highest on record, at about the mean level since a significant directed USA fishery began, in 1982. Negligible catch (≤ 0.5 mt) was taken as bycatch in the joint venture mackerel fishery. Virtually all (99 percent) of the directed fishery landings were made during June-September (Figure 20), with 98.6 percent from the area south of Delaware Bay (SA 622-636). The fishery was again dominated by ton class 3 and 4 vessels (51-150 GRT and 151-500 GRT), as seen since 1982.

Length frequency data from the 1989 USA fishery in SAs 622-632 indicate presence of a single age class, with a single mode each month approximating the monthly mean. This mode ranged from about 15 cm during June, increasing to about 18 cm by August.

Catch (metric tons) per unit effort (days fished) (CPUE) indices from the USA *Illex* fishery have been recalculated for the 1982-1989 period. The shift of the fishery from a by-catch fishery primarily in the New England area (SAs 511-537), to a directed fishery in the southern mid-Atlantic area (SAs 622-636) is evident when the total numbers of trips are compared with directed trips, Figure 21(a and b). Total number of trips landing *Illex*, from all areas, dropped from over 900 in 1982 to an average of 183 over all subsequent years; catch rates, overall, have increased (Figure 21a). The number of trips in the directed fishery (now defined as otter trawl trips from SAs 622-636 where *Illex* accounted for over 95 percent of the landings, Figure 21b), has generally declined since 1982, though there was a 59 percent increase from 1988 to 1989. This effort is assumed to reflect market conditions, which have been poor in recent years. Catch rates, however, have continued to increase. Directed CPUE in 1989 was about 48 percent above the 1982-88 mean, and about 5 percent above the 1988 level. This indicates that the reduced catch from recent levels is probably not due to reduced availability, and as noted is probably associated with poor market conditions.

Table 28. Annual short-finned squid landings (in metric tons) from the Northwest Atlantic (Cape Hatteras to Gulf of Maine) by USA and the distant-water-fleet (DWF), 1963-89

| Year | USA | DWF | Total |
|------|--------|--------|--------|
| 1963 | 810 | 0 | 810 |
| 1964 | 358 | 2 | 360 |
| 1965 | 444 | 78 | 522 |
| 1966 | 452 | 118 | 570 |
| 1967 | 707 | 285 | 992 |
| 1968 | 678 | 2,593 | 3,271 |
| 1969 | 562 | 975 | 1,537 |
| 1970 | 408 | 2,418 | 2,826 |
| 1971 | 455 | 159 | 614 |
| 1972 | 472 | 17,169 | 17,641 |
| 1973 | 530 | 18,625 | 19,155 |
| 1974 | 148 | 20,480 | 20,628 |
| 1975 | 107 | 17,819 | 17,926 |
| 1976 | 229 | 24,707 | 24,936 |
| 1977 | 1,024 | 23,771 | 24,795 |
| 1978 | 385 | 17,310 | 17,695 |
| 1979 | 1,780 | 15,742 | 17,522 |
| 1980 | 349 | 17,529 | 17,878 |
| 1981 | 631 | 14,723 | 15,354 |
| 1982 | 5,902 | 12,350 | 18,252 |
| 1983 | 9,944 | 1,776 | 11,720 |
| 1984 | 9,547 | 676 | 10,223 |
| 1985 | 4,997 | 1,053 | 6,050 |
| 1986 | 5,176 | 250 | 5,422 |
| 1987 | 10,260 | 0 | 10,260 |
| 1988 | 1,966 | 1 | 1,967 |
| 1989 | 6,802 | * | 6,802 |

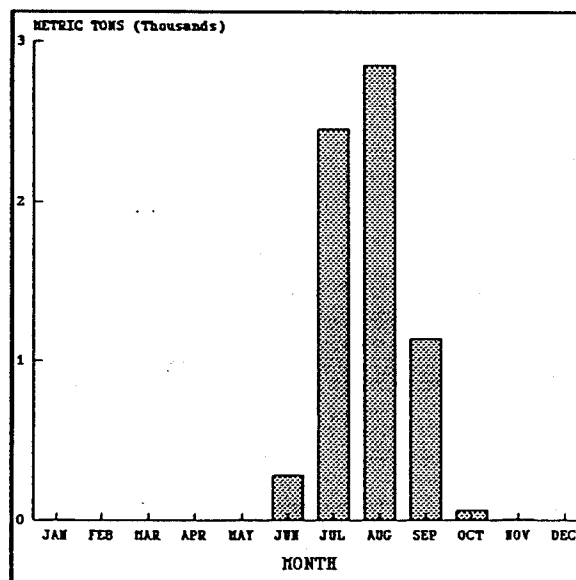


Figure 20. Monthly catches of short-finned squid in the U.S.A. domestic fishery during 1989.

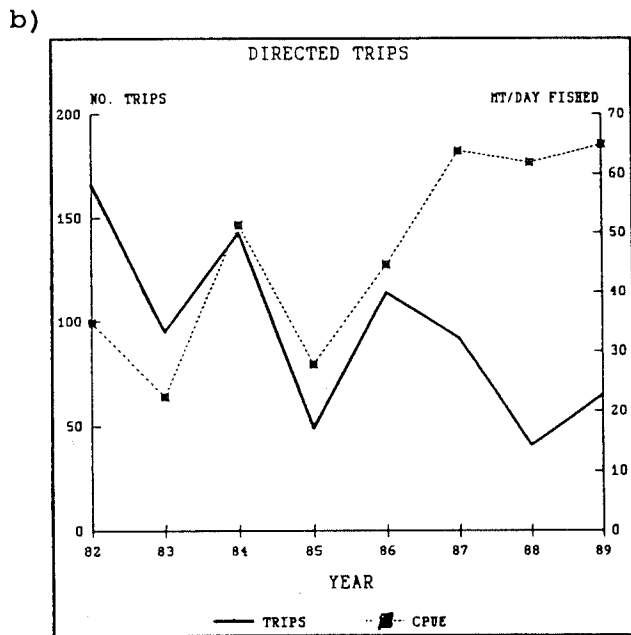
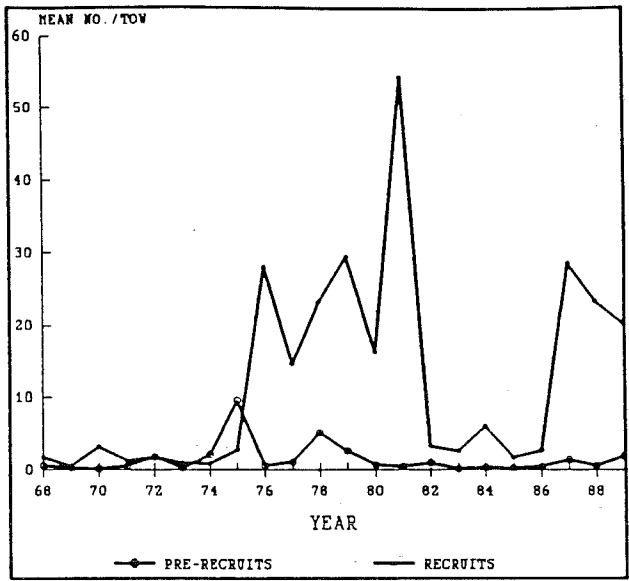
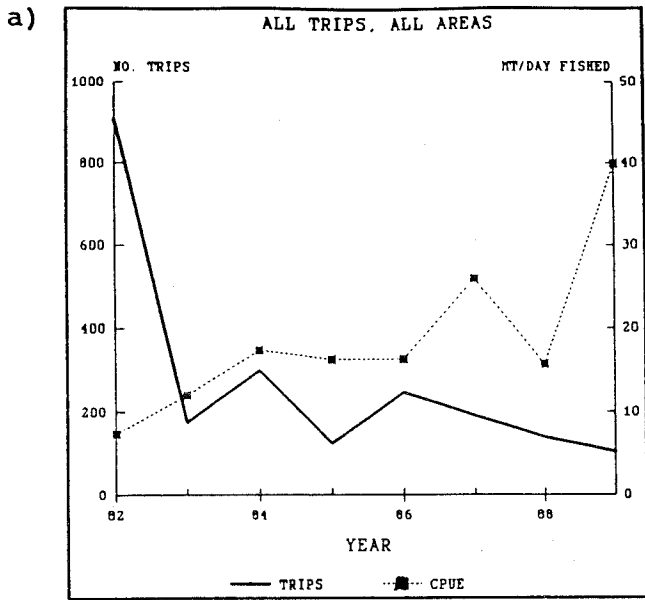


Figure 21. Number of trips landing *Illex* squid and catch-per-unit-effort (CPUE) in the U.S.A. fishery for a) all areas and trips, and b) the directed fishery (where the directed fishery is defined as all those trips in SAs 622-636 where squid accounted for more than 95 percent of the total trip catch).

Research Vessel Surveys

The 1989 NEFC autumn bottom trawl survey abundance index (stratified mean number per tow) for *Illex* squid in the mid-Atlantic through Georges Bank strata was 8 percent below that for 1988 but was

Figure 22. Recruit and pre-recruit (≤ 10 cm dorsal mantle length) indices (mean catch in number, per tow) for the short-finned squid, from the autumn NEFC bottom trawl survey.

Table 29. Short-finned squid abundance and pre-recruit indices from NEFC autumn surveys, 1968-89

| Year | Mean Number Per Tow ¹ | | Pre-Recruit Ratio ² |
|--------------|----------------------------------|-------------|--------------------------------|
| | Total | Pre-Recruit | |
| 1968 | 2.3 | 0.6 | 0.26 |
| 1969 | 0.8 | 0.3 | 0.38 |
| 1970 | 3.4 | 0.2 | 0.06 |
| 1971 | 1.9 | 0.6 | 0.32 |
| 1972 | 3.5 | 1.8 | 0.51 |
| 1973 | 1.3 | 0.3 | 0.23 |
| 1974 | 3.0 | 2.1 | 0.70 |
| 1975 | 12.4 | 9.6 | 0.77 |
| 1976 | 28.7 | 0.6 | 0.02 |
| 1977 | 15.8 | 1.1 | 0.07 |
| 1978 | 28.4 | 5.1 | 0.18 |
| 1979 | 32.1 | 2.6 | 0.08 |
| 1980 | 17.0 | 0.7 | 0.04 |
| 1981 | 54.8 | 0.5 | 0.01 |
| 1982 | 4.3 | 1.0 | 0.23 |
| 1983 | 2.8 | 0.2 | 0.07 |
| 1984 | 6.4 | 0.4 | 0.06 |
| 1985 | 2.0 | 0.3 | 0.15 |
| 1986 | 3.2 | 0.5 | 0.16 |
| 1987 | 30.0 | 1.4 | 0.05 |
| 1988 | 24.0 | 0.6 | 0.03 |
| 1989 | 22.2 | 1.9 | 0.09 |
| 1968-88 mean | 13.2 | 1.5 | 0.11 |

¹Stratified mean number per tow of all size individuals (total) and of pre-recruits (≤ 10 cm), Mid-Atlantic to Georges Bank.
²Ratio of pre-recruits to total mean numbers per tow.

68 percent greater than the 1968-88 mean (Figure 22, Table 29). However, the pre-recruit (≤ 10 cm dorsal mantle length individuals) index was three times the 1988 index and 27 percent above the 1968-88 mean. Catch-per-tow indices for each of the three major strata sets were also examined separately (Figure 23). While the SNE-MA area index was still significantly below the high 1987 value, it was twice that seen in 1988, and nearly twice the 1968-88 mean. The value from Georges Bank was less than half the 1988 level, but 27 percent greater than the series mean and well above that seen during most of the 1980s. The Gulf of Maine value was comparable to that from 1988, which was the highest since 1980. Larger individuals are generally found in the more northern areas with smaller *Illex* seen further south. The higher value in the southern New England-mid-Atlantic area may be associated with higher abundance of pre-recruits.

No significant relationship has been found between research vessel catch-per-tow data for *Illex* and availability to the subsequent *Illex* fishery when data for all years are examined. However, highly significant results ($p < 0.01$) were found for the relationship between SNE-MA mean numbers per tow for years with above average indices, and USA catches in the following year (although this relationship was strongly influenced by the 1981 index). Also, *Illex* abundance indices have generally held at either high or low levels for several years before exhibiting dramatic changes. Low abundance indices were seen during 1968-74, followed by high indices for 1975-81, and low indices from 1982 to 1986. It may be expected that above average indices as seen in 1987-89 will continue for the next few years.

Research survey and commercial fishery data have been used to evaluate the effects of environmental variability on the *Illex* population. However, results have been inconclusive. Stepwise regression analyses of mean catches-per-tow in weight (or number) for the autumn surveys (by area and overall) and average bottom temperatures from the autumn (mid-Atlantic through Georges Bank strata) and spring (mid-Atlantic strata) surveys, on USA annual catch and catch-per-unit-effort data were not significant.

Conclusions

Above-average apparent abundance of adult *Illex* during the autumn 1989 NEFC research vessel survey suggests that current abundance would be adequate to provide catches during 1990 at the domestic annual harvest level (DAH) of 15,000 mt. This level is comparable to the average total landings from the fishery since the directed fishery began (1972-1988). In fact, the current stock size should support catches at a level similar to that seen during the previous period of high

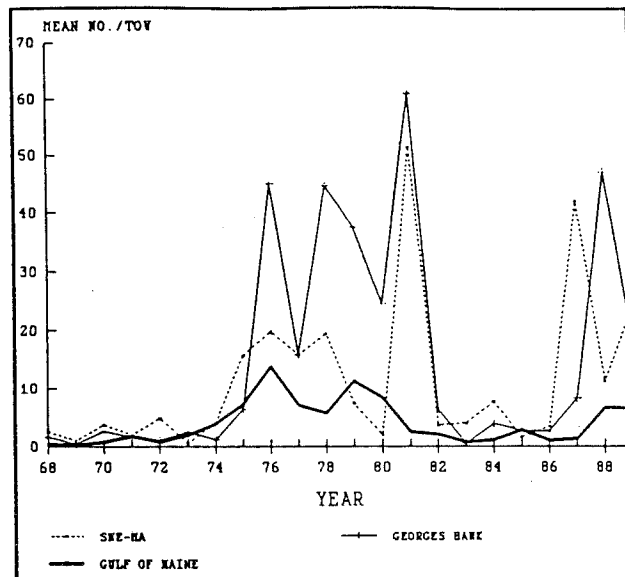


Figure 23. Stratified mean number-per-tow of short-finned squid from the NEFC bottom trawl surveys, by area (southern New England-Mid-Atlantic, Georges Bank, and Gulf of Maine.)

abundance (19,500 mt average during 1976-82). However, the ability of the fishery to take this level of catch is dependent on the availability of squid within the area of the fishery. This availability is associated with environmental and behavioral factors which are not yet fully understood. Also, *Illex* abundance indices have generally held at either high or low levels for several years before exhibiting dramatic changes. It may be expected that above average indices as seen in 1987-89 will continue for the next few years.

Discussion of Short-finned Squid (*Illex illecebrosus*) Assessment

The *Illex* fishery was characterized as a directed fishery, consisting primarily of day trips, with negligible by-catch, and driven by world market conditions. The question was posed as to the introduction of a Japanese jig fishery in the northwest Atlantic in light of their diminished role in the Falkland Islands fishery. It was noted that the jig gear is highly efficient for *Illex* in that fishery, particularly at night using lights; however, two studies (a study involving a Japanese vessel with jig gear fishing for *Illex*, and a cooperative Mass. DMF - URI study for *Loligo*) showed that the jig gear is not successful for squid in this region. There may be international interest in an *Illex* fishery in the Northwest Atlantic, e.g., a potential jig fishery in Canadian waters.

Table 30. Landings of ocean quahog (thousands of metric tons of meats) from state waters and the Exclusive Economic Zone, 1967-1990

| Year | State Waters | EEZ | Total | Percent EEZ |
|------|--------------|--------|--------|-----------------|
| 1967 | 20 | - | 20 | 0 |
| 1968 | 102 | - | 102 | 0 |
| 1969 | 290 | - | 290 | 0 |
| 1970 | 792 | - | 792 | 0 |
| 1971 | 921 | - | 921 | 0 |
| 1972 | 634 | - | 634 | 0 |
| 1973 | 661 | - | 661 | 0 |
| 1974 | 365 | - | 365 | 0 |
| 1975 | 569 | - | 569 | 0 |
| 1976 | 656 | 1,854 | 2,510 | 74 |
| 1977 | 1,118 | 7,293 | 8,411 | 87 |
| 1978 | 1,218 | 9,197 | 10,415 | 88 |
| 1979 | 1,404 | 14,344 | 15,748 | 91 |
| 1980 | 1,458 | 13,885 | 15,343 | 90 |
| 1981 | 410 | 15,966 | 16,375 | 97 |
| 1982 | 207 | 15,572 | 15,779 | 99 |
| 1983 | 701 | 15,228 | 15,978 | 96 |
| 1984 | 1,200 | 16,401 | 17,602 | 93 |
| 1985 | - | 23,566 | 23,566 | 99 ¹ |
| 1986 | 814 | 19,771 | 20,585 | 96 |
| 1987 | 569 | 22,226 | 22,795 | 98 |
| 1988 | 412 | 20,594 | 21,006 | 98 |
| 1989 | 184 | 22,956 | 23,141 | 99 |
| 1990 | | | | |

¹ Some inshore landings were from Maine coastal waters, but the magnitude of the fishery was small, and catch statistics are not available.

REVISED ASSESSMENT OF OCEAN QUAHOG

Landings of ocean quahog, *Arctica islandica*, in the middle Atlantic Bight Exclusive Economic Zone (EEZ) have totaled about 220,000 mt of shucked meats, since the inception of the fishery in 1976. Current annual landings are about 23,000 mt per year, approximately 85 percent of the EEZ-wide annual quota of 27,211 mt (Table 30; Figure 24). The fishery is currently regulated under the Surf Clam - Ocean Quahog FMP of the Mid Atlantic Council. Regulatory measures to date have included an annual quota, as well as record keeping requirements. Effort regulation was required for a brief period, before the annual quota was increased to meet industry requirements for increased access to the resource. Recent biological assessments of the stock (Murawski and Serchuk 1983; Murawski 1986) have documented the extreme stability in the middle Atlantic ocean quahog resource, attributable to very low natural mortality rates ($M=0.01-0.03$; Murawski and Serchuk, 1989a) and very poor recruitment since surveying was initiated (1965-1989). This

OCEAN QUAHOG LANDINGS MIDDLE ATLANTIC BIGHT

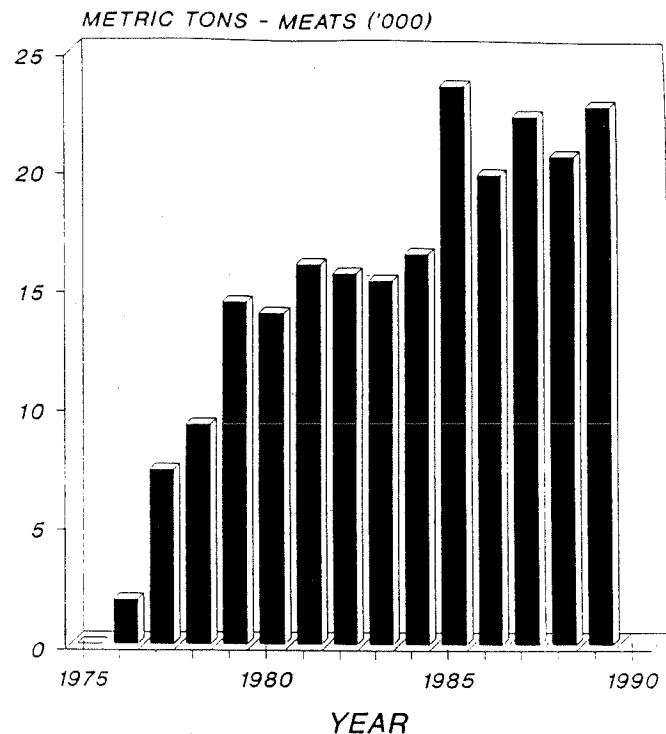


Figure 24. Landings of ocean quahog from the Middle Atlantic Bight, 1975-1990. Data are given in thousands of metric tons of shucked meats.

assessment updates survey and commercial catch and performance data, and proposes an extension of the DeLury population estimation method (Ricker 1975) to calibrate survey swept-area biomass estimates for the region-wide ocean quahog population. Also, growth equations for the stock are re-evaluated, based on additional mark-recapture information from a long-term study being undertaken off Long Island, New York (Murawski *et al.* 1982; Ropes *et al.* 1984).

The majority of ocean quahog landings in the Middle Atlantic Bight are derived from the area off the Delmarva Peninsula and off New Jersey (Figure 25). These areas contain only about 29 percent of the region-wide resource, but are the nearest available resources to shore-based shucking facilities. Catch per unit of effort (CPUE, measured in bushels per hour fished by class 3 vessels [101+ GRT]) has declined steadily in the Delmarva assessment area, from 158 bushels per hour in 1983 to 116 bushels per hour in 1990 (-27 percent; Figure 26). CPUE off New Jersey has declined more modestly, from 150 bushels per hour in 1987 to 135 bushels per hour in 1990 (-10 percent; Figure 26).

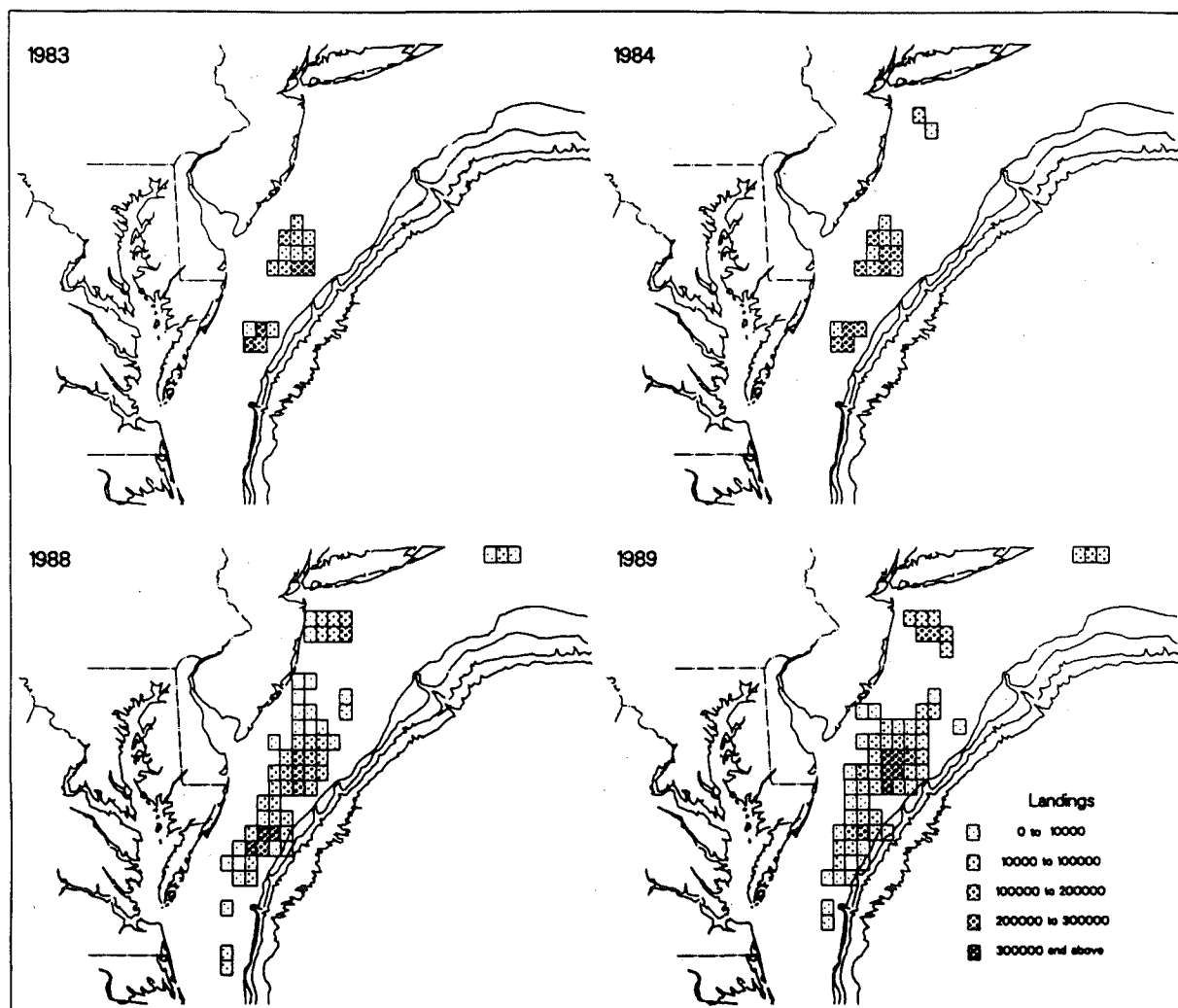


Figure 25. Geographic distribution of ocean quahog landings from the Middle Atlantic Bight, 1983, 1984, 1988, and 1989. Data were derived from mandatory logbook submissions, and are expressed in bushels of quahogs landed, by ten minute square.

Regression of the cumulative catch for the Delmarva region (that region subject to the most intense harvesting since the inception of the fishery) on class 3 CPUE (Figure 27) results in a significant negative relationship. This relationship implies that in the absence of new recruitment and assuming a very low rate of natural mortality, that change in CPUE is indicative of decline in the Delmarva-wide ocean quahog population (by 27 percent over the time period). The relationship allows extrapolation of the size of the initial stock (in 1982), based on the point at which CPUE would be zero (entire cumulative stock caught). The preliminary estimate for the Delmarva region is 369,900 mt of shucked meats in 1982. Similar methods were applied to ocean quahog data at a finer scale of spatial resolution, to examine the variability in this relationship under differing initial densities and

catch rates. Six ten-minute squares were selected, representing several of the areas that have in the past or are currently supporting the bulk of the landings (Figures 28 and 29). In all cases there were statistically significant negative relationships between cumulative catch and CPUE, with the slopes, elevations, and variability about the lines probably related to the underlying initial densities, heterogeneities of quahog distributions within each square, and the time trajectories of exploitation. Extensions of this approach should in the future focus on the factors influencing fleet CPUE as a measure of stock abundance, the appropriate fleet aggregation level (individual vessels --> complete aggregation), and the most representative spatial scales for aggregation.

Research vessel surveys in the Delmarva and New Jersey areas do not indicate significant popula-

OCEAN QUAHOG CPUE MIDDLE ATLANTIC BIGHT

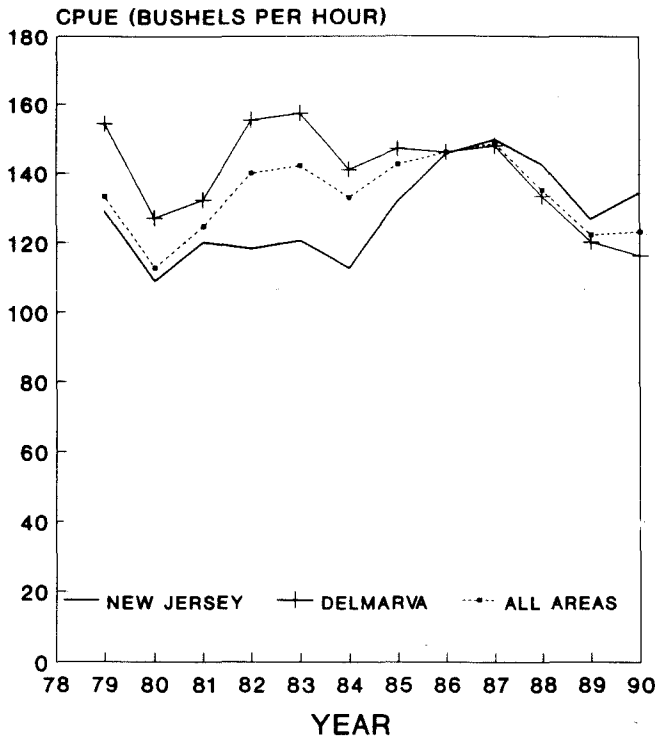


Figure 26. Catch-per-unit-effort (CPUE, bushels per hour fished) for class 3 vessels (101+ GRT), fishing in two areas of the Middle Atlantic Bight, 1979-1990. Data were derived from mandatory logbook submission data.

tion reductions in the areas that have been exploited (Tables 31-33), but this may be reflective of the underlying precision of these surveys. Although stratified mean number per tow indices have CVs on the order of 0.2 for the various assessment areas (Delmarva-Georges Bank), precision is much lower for individual survey strata, especially those that have yielded catches to date (Table 33; Figure 30). This is due to the relatively low number of tows allocated to these strata, and the heterogeneity in quahog densities within these areas.

Size composition data from research vessel surveys (Tables 31 and 32; Figures 31-33) confirm the region-wide lack of significant new recruitment over the past several decades, and the stability in size composition, indicative of very slow growth rates. Research vessel swept area estimates of numbers and biomass are presented in Table 34. Several surveys are combined for these calculations, due to factors noted above. Total swept area biomass is estimated to be 1.1 million mt of meats, with the majority of the resource occurring off southern New England, Georges

LESLIE-DeLURY ESTIMATE OCEAN QUAHOG - DELMARVA

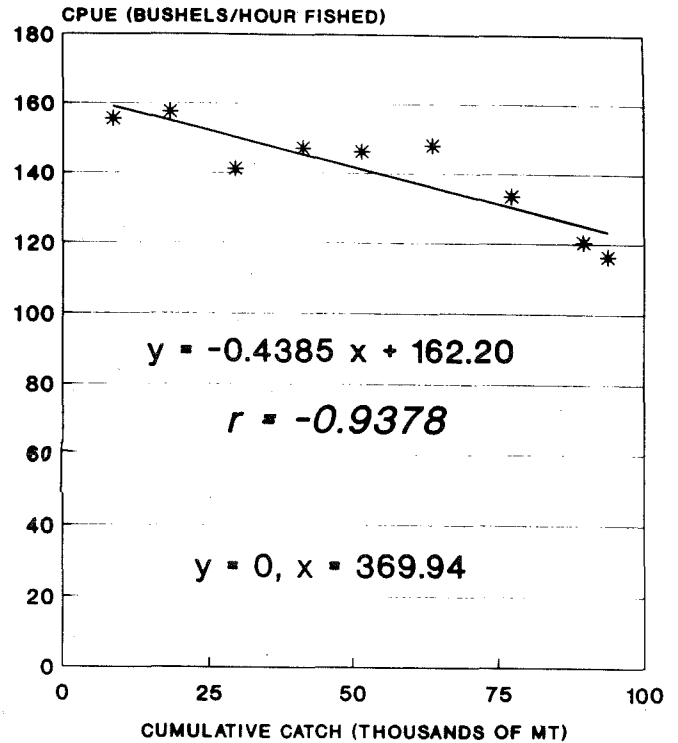


Figure 27. Relationship between CPUE (bushels per hour fishing by class 3 vessels) and cumulative ocean quahog catch in the Delmarva assessment area, 1982-1990. Regression statistics indicate the theoretical cumulative population extant at the beginning of the series to be 370,000 mt of meats.

Bank, New Jersey, and Long Island. Average densities are highest off Long Island and Southern New England.

A preliminary DeLury population estimates for the Delmarva assessment area was 370,000 mt of shucked meats in 1982. Swept-area biomass estimates, based on research vessel surveys conducted in 1980-1982 were 90,000 mt of meats, thus, a crude estimate of the survey efficiency is $90/370 = 0.2432$. Results of research submersible studies confirm the general conclusion that research vessel efficiency is less than 100 percent (Murawski and Serchuk 1989b), but there are several potential biases inherent in the DeLury method that may produce inflated population size estimates. Thus, the swept area biomass estimates are likely lower than the extant stock, but the magnitude may not be as great as that suggested by the DeLury method. Actual ocean quahog biomass is probably about double the minimum swept area population estimate given in Table 34.

Revised growth equations for the middle Atlantic ocean quahog resource are given, based on a compre-

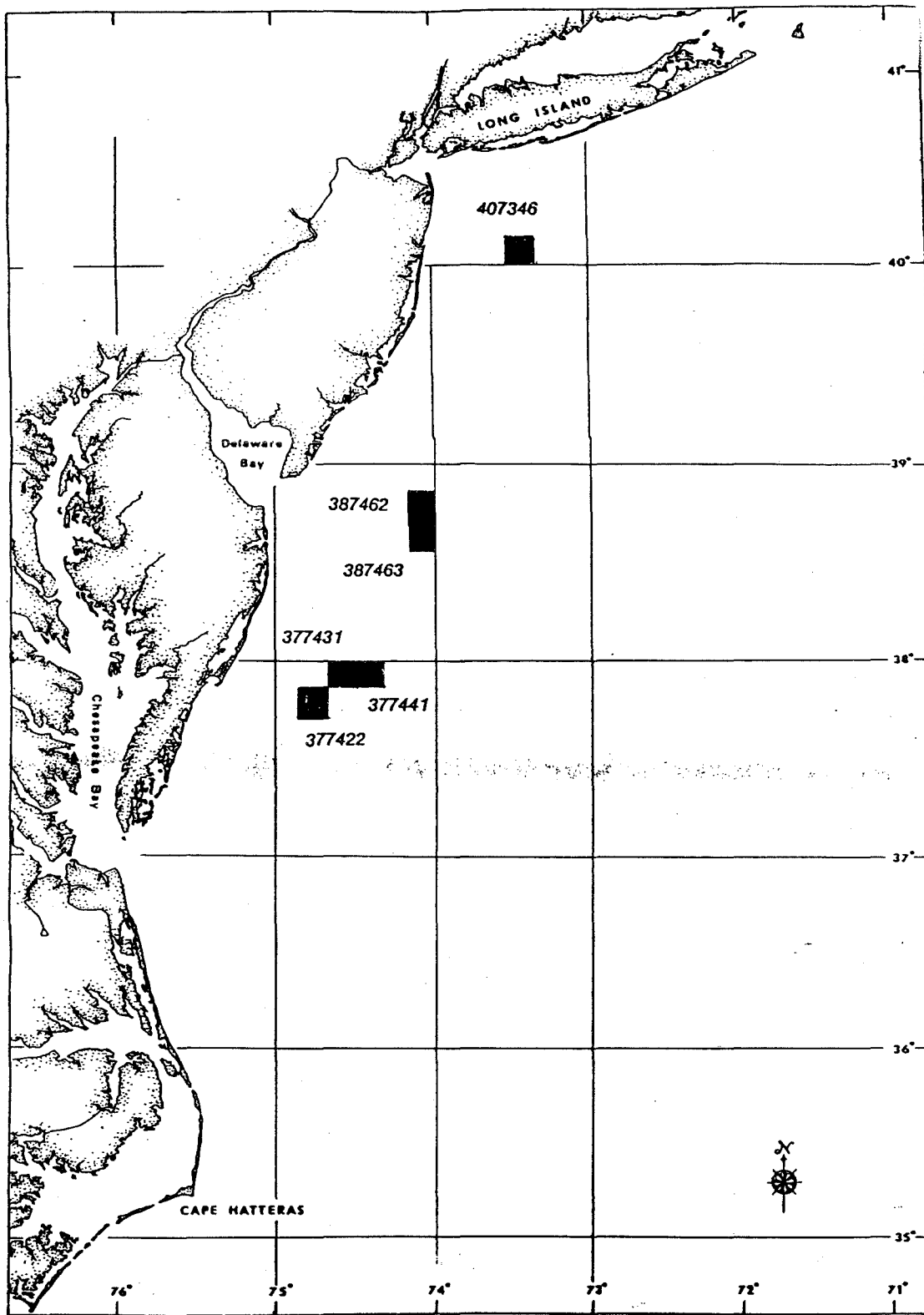
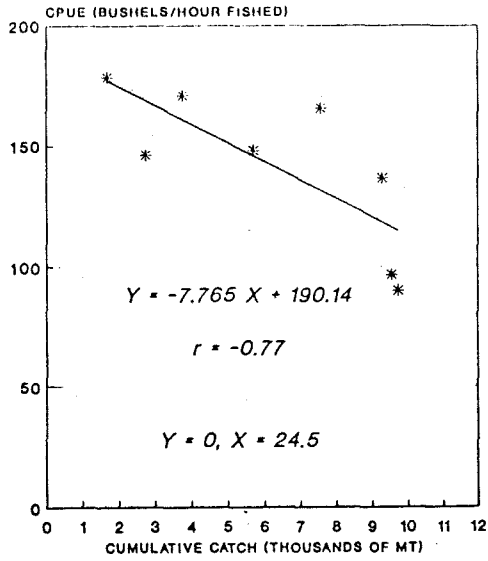
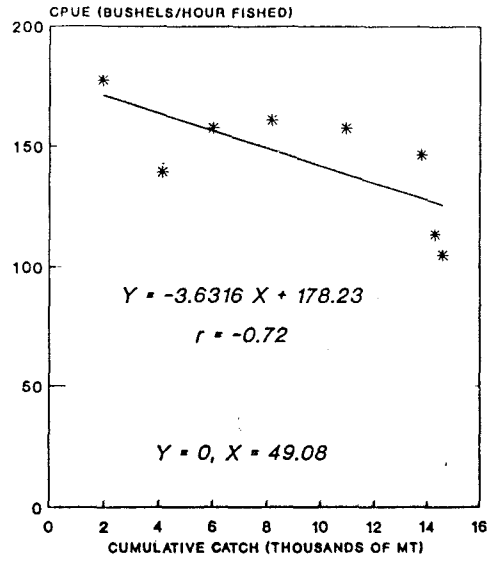


Figure 28. Locations of six ten-minute squares selected for fine-scale analysis of the relationship between cumulative ocean quahog catch and CPUE (Figure 29). These squares represent locations of previous or current intensive ocean quahog harvesting.

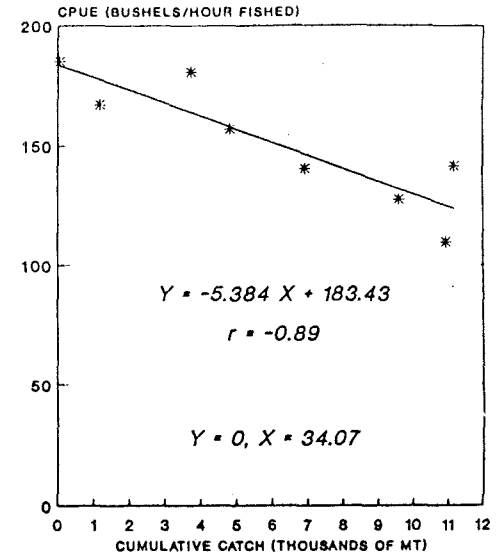
LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 377422



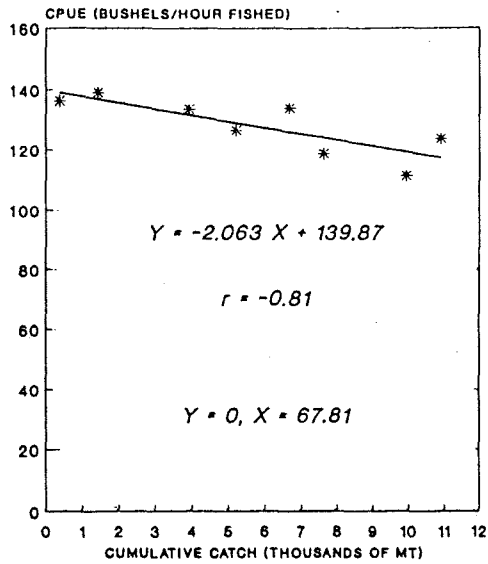
LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 377431



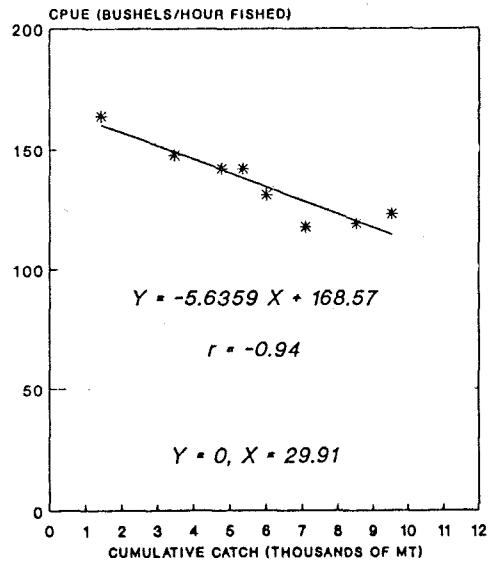
LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 377441



LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 387462



LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 387463



LESLIE-DeLURY ESTIMATE
OCEAN QUAHOG - TNMS = 407346

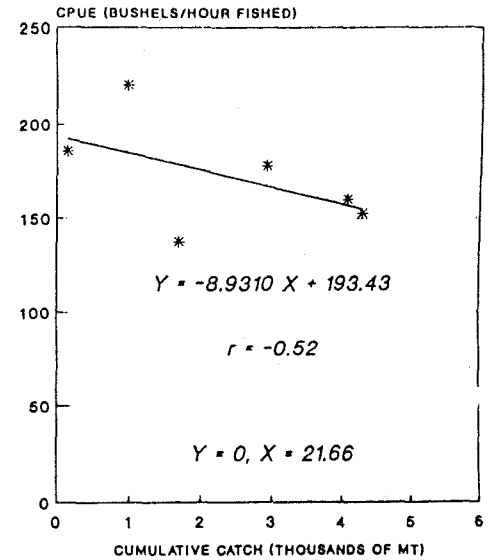


Figure 29. Relationship between cumulative ocean quahog catch (thousands of mt of meats) and class 3 CPUE (bushels per hour fished) for six ten-minute squares given in Figure 28.

Table 31. Research vessel survey indices for ocean quahog in the Delmarva assessment area, 1980-1989. Data are stratified mean numbers and weights per standardized survey tow.

| Length Interval (mm) | Year of Survey Data | | | |
|-------------------------------|------------------------|--------|--------|-------------|
| | 1980-1982 ¹ | 1986 | 1989 | All Data |
| 20-29 | | | | |
| 30-39 | | | 0.03 | 0.01 |
| 40-49 | | | 0.05 | 0.02 |
| 50-59 | 0.07 | 0.09 | 0.04 | 0.07 |
| 60-69 | 0.78 | 0.25 | 0.55 | 0.63 |
| 70-79 | 7.77 | 5.82 | 19.14 | 8.17 |
| 80-89 | 15.39 | 13.87 | 11.38 | 13.85 |
| 90-99 | 15.80 | 14.81 | 8.55 | 14.61 |
| 100-109 | 7.03 | 6.44 | 4.67 | 7.19 |
| 110-119 | 0.72 | 2.12 | 0.60 | 1.04 |
| 120-129 | 0.04 | 0.16 | | 0.05 |
| 130-139 | 0.01 | | | 0.01 |
| Total | 47.63 | 43.57 | 45.01 | 45.66 |
| SD | 9.99 | 10.54 | 27.67 | 8.05 |
| CV | 0.21 | 0.24 | 0.61 | 0.18 |
| n | 250 | 76 | 88 | 414 |
| Area of Surveyed strata | 5,926 | 5,715 | 5,715 | 5,926 |
| Mean weight per tow (kg) | 1.6233 | 1.5667 | 1.3207 | 1.5701 |

¹ Four surveys: two in 1980; one in 1981; one in 1982.

hensive re-analysis of mark-recapture data from an experiment conducted off Long Island, New York, during 1978-present (Table 35; Figure 34). Revised growth equations are essentially similar to those computed from only a single year of mark-recapture data, and confirm the slow growth rate and extreme longevity of the ocean quahog resource in the middle Atlantic region. Size distribution data from the vicinity of the marking site, taken in 1978 and again in 1989 show progression of size modes consistent with growth rates computed from the calculated growth equations (Figure 35).

Discussion of Ocean Quahog Assessment

During discussion it was noted that recent NEFC work on estimating age and growth of ocean quahogs was reviewed at the 1990 meeting of the National Shellfish Association. There was general agreement at that meeting confirming the slow growth and extreme longevity of this species.

A further examination of the variance of the CPUE estimates employed in the Leslie-DeLury estimates of

Table 32. Research vessel survey indices for ocean quahog in the New Jersey assessment area, 1980-1989. Data are stratified mean numbers and weights (meats, kg) per standardized survey tow.

| Length Interval (mm) | Year of Survey Data | | | |
|-------------------------------|------------------------|--------|--------|-------------|
| | 1981-1981 ¹ | 1986 | 1989 | All Data |
| 20-29 | | | 0.09 | 0.02 |
| 30-39 | 0.01 | 0.02 | 0.02 | 0.01 |
| 40-49 | 0.06 | 0.08 | 0.11 | 0.07 |
| 50-59 | 0.22 | 0.01 | 0.34 | 0.22 |
| 60-69 | 2.21 | 1.21 | 2.93 | 2.18 |
| 70-79 | 9.56 | 5.86 | 8.79 | 9.05 |
| 80-89 | 32.82 | 27.82 | 19.81 | 30.08 |
| 90-99 | 37.15 | 53.13 | 21.64 | 35.71 |
| 100-109 | 14.46 | 23.79 | 7.49 | 14.15 |
| 110-119 | 2.42 | 4.66 | 1.66 | 2.48 |
| 120-129 | 0.22 | 0.38 | 0.21 | 0.23 |
| 130-139 | 0.11 | 0.08 | | 0.01 |
| Total | 99.16 | 117.05 | 63.06 | 94.21 |
| SD | 11.81 | 26.48 | 14.24 | 8.79 |
| CV | 0.12 | 0.23 | 0.23 | 0.09 |
| n | 360 | 105 | 111 | 576 |
| Area of Surveyed Strata | 7,601 | 6,856 | 7,332 | 7,601 |
| Mean weight per tow (kg) | 3.2628 | 4.2435 | 1.9732 | 3.1195 |

¹ Four surveys: two in 1980; one in 1981; one in 1982.

quahog biomass was suggested. An investigation of the precision of these data might help clarify preliminary conclusions about variation in the density of the quahog resources suggested by the relationship between CPUE and cumulative catch within 10-minute squares (*i.e.*, lower slope of the relationship suggesting higher densities and/or more homogenous distribution).

It was noted that a limited fishery for ocean quahogs exists off the coast of eastern Maine. Most of the fishery is carried out in state waters, although some activity has been recently noted in the EEZ. The Maine fishery generally harvests smaller quahogs than the fishery in the Mid-Atlantic. The Maine quahog fishing areas are not included in current NEFC survey coverage, nor are required logbooks currently submitted in this fishery.

ASSESSMENT UPDATE FOR POLLOCK: FUTURE DIRECTIONS AND ISSUES

The stock assessment for pollock in the northwest Atlantic undertaken during the Pollock Working Ses-

Table 33. Research vessel survey abundance indices for ocean quahog, by individual survey strata, 1980-1989. Data are mean numbers per standardized survey tow

| Survey Stratum | Year of Survey Data | | | All Data |
|-------------------|--------------------------|--------------------|--------------------|--------------------|
| | 1980-1982 ^{1,2} | 1986 | 1989 | |
| Delmarva | | | | |
| 9 | 15.72(4.68) 103 | 3.45(4.45) 29 | 4.41(3.69) 37 | 11.14(5.25) 169 |
| 10 | 77.00(1.33) 8 | 9.67(0.99) 3 | 28.33(1.67) 3 | 52.14(1.60) 14 |
| 11 | 27.25(0.62) 4 | 16.50(0.81) 2 | 9.00(0.94) 2 | 20.00(0.75) 8 |
| 13 | 66.45(2.82) 60 | 81.25(2.61) 20 | 40.85(1.74) 20 | 64.29(2.73) 100 |
| 14 | 501.50(1.11) 8 | 449.67(0.23) 3 | 176.00(0.86) 3 | 420.64(1.04) 14 |
| 15 | 106.17(1.59) 12 | 117.25(0.78) 4 | 397.75(1.92) 4 | 166.70(2.11) 20 |
| New Jersey | | | | |
| 17 | 193.16(1.51) 44 | 126.42(1.26) 12 | 190.42(1.64) 12 | 180.90(1.52) 68 |
| 18 | 333.91(1.55) 11 | 250.67(1.25) 3 | 87.00(1.51) 3 | 275.65(1.59) 17 |
| 19 | 115.22(1.43) 9 | 79.67(0.44) 3 | 35.00(1.54) 3 | 92.07(1.42) 15 |

¹ Mean (CV)
n

² Four surveys: two in 1980; one in 1981; one in 1982.

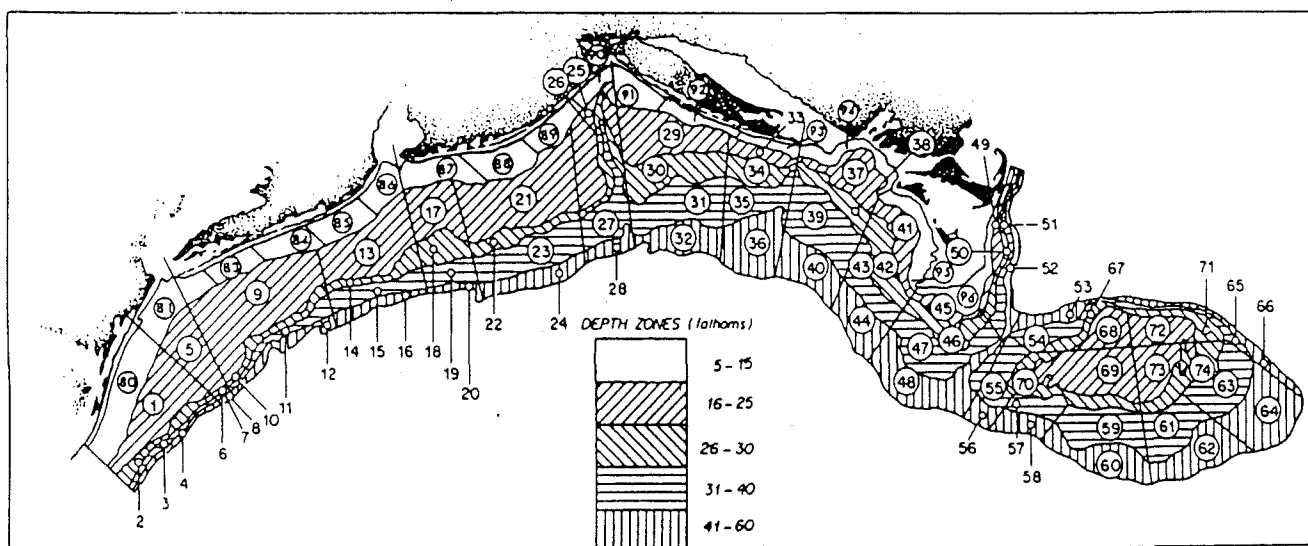


Figure 30. Ocean shellfish survey strata off the northeast U.S.A. Stratification plan is used both for hydraulic dredge surveys and for sea scallop dredge surveys.

**OCEAN QUAHOG LENGTH FREQUENCY
DELMARVA ASSESSMENT AREA**

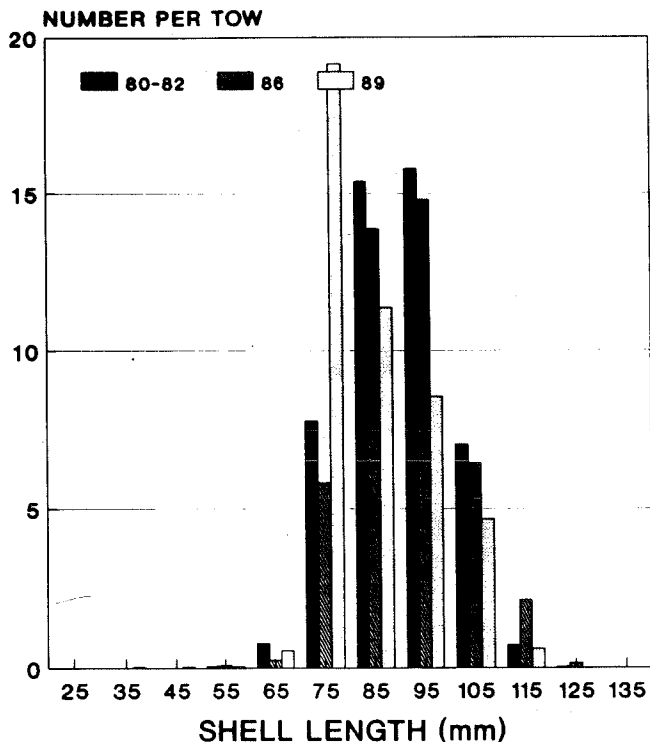


Figure 31. Survey length composition of ocean quahogs from the Delmarva assessment area, during three time periods: 1980-1982, 1986, and 1989. Data are expressed as the stratified mean number-per-tow taken in each 1-cm size interval.

**OCEAN QUAHOG LENGTH FREQUENCY
NEW JERSEY ASSESSMENT AREA**

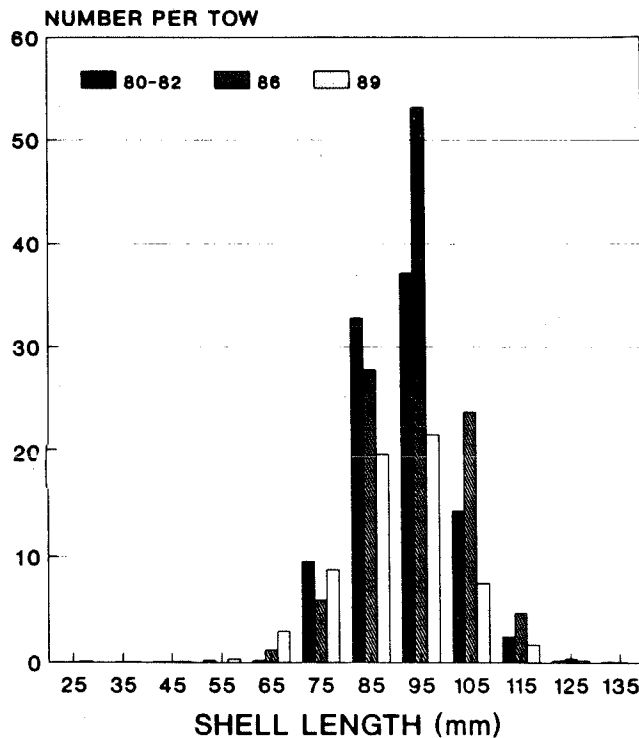


Figure 32. Survey length composition of ocean quahogs from the New Jersey assessment area, during three time periods: 1980-1982, 1986, and 1989. Data are expressed as the stratified mean number-per-tow taken in each 1-cm size interval.

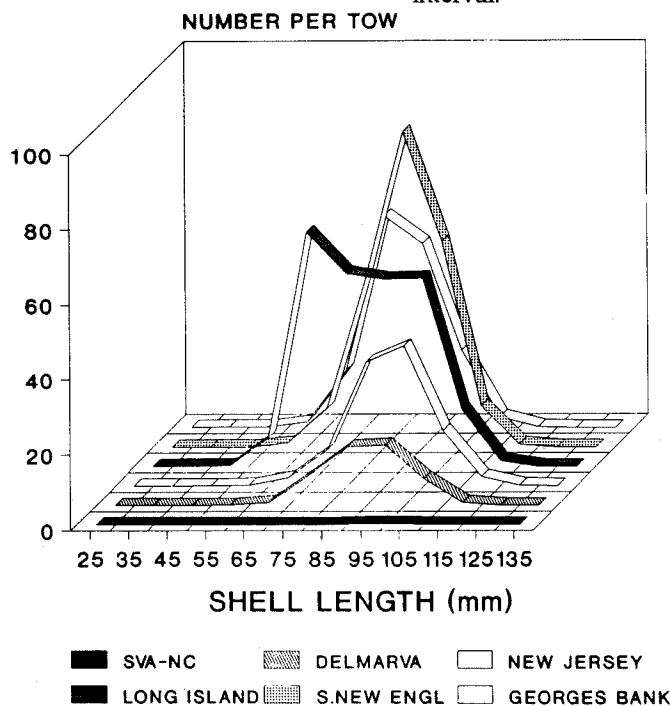


Figure 33. Average long-term size composition of ocean quahogs taken in research vessel surveys in six assessment areas off the northeastern U.S.A. Time periods for each set of data are those given in Table 34.

Table 34. Minimum population size estimates (metric tons of meats) for ocean quahog, based on swept-area estimates from NMFS hydraulic clam surveys, 1980-1989

| Area | Years ¹ | Number of Tows | Strata ² Area | \bar{N} | CV | \bar{W}^3 | Minimum Biomass ⁴ | % |
|-----------------------|--------------------|----------------|--------------------------|-----------|------|-------------|------------------------------|---------------|
| S. VA-NC | | | | | | | | |
| | 1980-1989(6) | 86 | 3,152 | 0.49 | 0.41 | 0.0214 | 630.0 | 0.06 |
| Delmarva | | | | | | | | |
| | 1980-1982(4) | 250 | 5,926 | 47.63 | 0.21 | 1.6233 | 89,988.6 | 8.23 |
| New Jersey | | | | | | | | |
| | 1980-1982(4) | 360 | 7,601 | 99.16 | 0.12 | 3.2628 | 231,997.6 | 21.22 |
| Long Island | | | | | | | | |
| | 1980-1989(6) | 229 | 4,478 | 238.59 | 0.11 | 5.3517 | 224,180.7 | 20.51 |
| S. New England | | | | | | | | |
| | 1980-1989(6) | 152 | 6,145 | 206.94 | 0.13 | 5.3464 | 307,330.5 | 28.11 |
| Georges Bank | | | | | | | | |
| | 1982-1989(3) | 163 | 7,937 | 146.89 | 0.23 | 3.2209 | 239,142.0 | 21.87 |
| | Sum | 1,240 | 35,239 | | | | 1,093,269 | 100.00 |

¹ Number of separate R/V surveys used is given in parentheses

² Square nautical miles

³ W is the mean meat weight per standardized tow

⁴ Minimum biomass estimated, based on a standardized tow sweeping 0.0001069 square nautical miles, unit is metric tons - meat weight

sion of the Ninth SAW was briefly reviewed. Several virtual population analyses were completed, but, because of time constraints at that time, a final definition of terminal F for 1988 was not determined. Preliminary results suggested values in the range of 0.4-0.6. These are somewhat higher than the estimates derived in the most recent Canadian assessments of about 0.3-0.4. The U.S. assessment considers Gulf of Maine-Georges Bank-Scotian Shelf pollock to be a unit stock, while the Canadian assessment is based only upon data from NAFO Divisions 4VWX and the Canadian portion of Division 5Z. U.S. pollock landings peaked at 24,000 mt in 1986 and declined to 10,000 mt in 1989; Canadian landings, however, have remained in excess of 40,000 mt since 1985 (Figure 36). Commercial catch rates have declined 60 percent in the U.S. fishery since 1983 while Canadian catch rates

have remained stable at high levels since the late 1970s (Figure 37). Indices derived from the autumn U.S. bottom trawl surveys in the Gulf of Maine and Georges Bank show a continued decline in biomass since 1976. The Canadian bottom trawl surveys conducted on the Scotian Shelf indicate increasing biomass since the early 1970s although the 1989 value is relatively low compared to recent indices. The 1989 U.S. value is near or at the historic low (Figure 38). U.S. analyses identify record levels of exploitation and a precipitous decline in spawning stock biomass since 1984 (Figure 39). There is some indication of a good 1985 year class in the Canadian assessment and in first-quarter 1989 U.S. landings. The U.S. assessment will update the VPA when 1989 commercial age data become available.

The disparity in trends between U.S. and Cana-

Table 35. Summary of ocean quahog growth equations fitted from mark-recapture data from a study conducted off Long Island, NY, 1978-1983. Von Bertalanffy growth parameters L-infinity and K were fitted to growth increment data. Standard deviations are in parentheses

| Year | n | Length at Recapture (mm) | Growth Increment (mm) | Estimated Parameters ¹ | | |
|------|-----|--------------------------|-----------------------|-----------------------------------|-----------------|----------------|
| | | | | L-infinity (mm) | R | K ² |
| 1979 | 67 | 73.31 (14.67) | 0.56 (0.38) | 104.92 (3.23) | 0.98 (0.002) | 0.0200 |
| 1980 | 200 | 79.01 (13.91) | 1.17 (1.04) | 97.95 (1.22) | 0.97 (0.001) | 0.0287 |
| 1981 | 75 | 76.12 (12.23) | 2.00 (1.41) | 97.79 (2.40) | 0.97 (0.003) | 0.0295 |
| 1982 | 51 | 74.29 (11.52) | 3.17 (2.08) | 94.77 (2.38) | 0.96 (0.003) | 0.0359 |
| 1983 | 52 | 82.06 (12.36) | 2.68 (2.62) | 97.37 (2.29) | 0.97 (0.003) | 0.0317 |
| All | 445 | 78.08 (13.44) | 1.62 (1.68) | 97.28 (0.82) | 0.97 (0.001) | 0.0311 |

¹ $L_{\text{recapture}} = L_{\text{marking}} * R^t + L_{\text{infinity}} * (1-R)^t$; t = elapsed time

² $K = -\ln(R)$

dian data sets may be related to an apparent net migration of pollock from the Gulf of Maine-Georges Bank region to the Scotian Shelf. Whether this movement is a short term phenomenon associated with environmental events or represents a systematic migration of older fish is uncertain; it was noted that a northward shift in the Scotian Shelf fishery from Division 4WX to Division 4V and Subarea 3 has also occurred. This movement may explain the earlier appearance of dominant year classes in the U.S fishery and the higher levels of fishing mortality on the smaller fish in U.S. waters. To address the migration issue, a joint U.S.-Canadian tagging study, delayed from last year due to vessel problems, will be conducted this winter on spawning adults in the Jeffreys Ledge area. Results of this study may help to define stock structure for pollock and delineate appropriate assessment strategies.

During ensuing discussion, it was suggested that, if indeed there was net migration of pollock occurring, then tagging efforts should also include young pollock from inshore areas. In response to a question regarding stock ID studies, it was stated that meristic, morphometric, and electrophoretic studies have been generally inconclusive, although some separation of Division 4V pollock from Division 4X and Subarea 5 fish is possible.

ASSESSMENT UPDATE FOR OFF-SHORE LOBSTER: FUTURE DIRECTIONS AND ISSUES

The major issue discussed was whether or how lobster assessments should be combined for inshore and offshore areas. The answer may depend on the degree of migration between the two areas. It was suggested that tagging data may provide some information on migration rate to use in model simulations. Size structure differences should also be taken into account if areas were combined. It is recommended that a working group be developed to consider, among other items, future directions of lobster assessments.

Results of correlation between proportion of pre-recruits in survey data and commercial landings (Figures 40-42) track the size structure of the stock, not abundance. Also, the lack of a relationship between survey mean weight per tow and landings (Figure 43) may be the result of not including effort changes, which could be driving the increase in landings. The lack of commercial effort data was discussed in an attempt to resolve the problem. It was concluded that the problem should also be considered by the lobster working group.

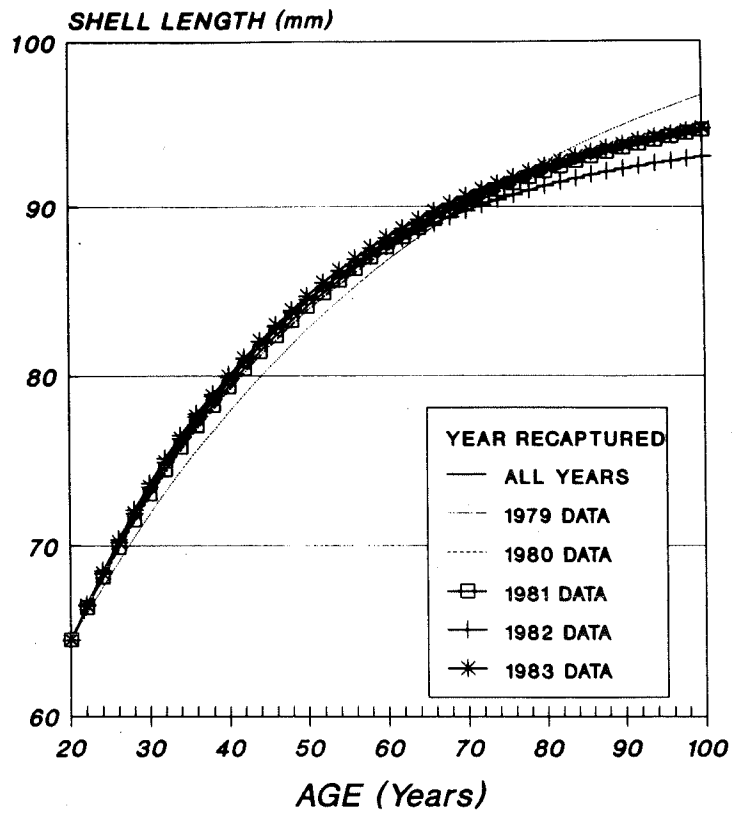


Figure 34. Von Bertalanffy growth equations for ocean quahog, based on data obtained from mark-recapture studies conducted off Long Island, NY, 1978-1983. Equations are computed for each year's recapture data separately, and for all data combined.

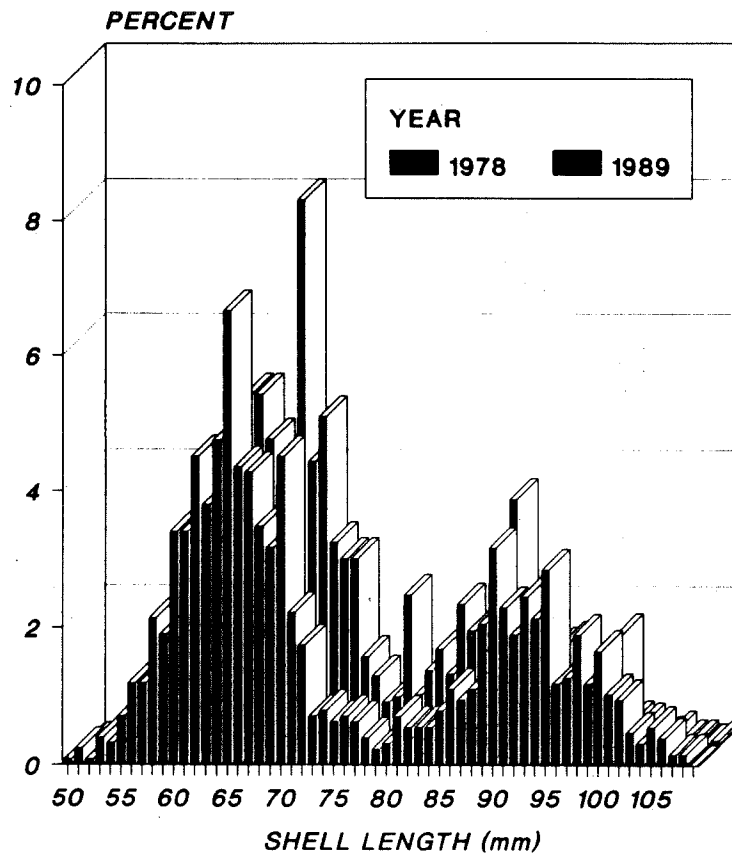


Figure 35. Size composition of research vessel catches in the vicinity of the area where mark-recapture studies of ocean quahog were undertaken, 1978 and 1989. Data show some progression of the smaller size mode over the 11-year period, but little growth of larger animals. These results are in general agreement with the results of mark-recapture studies.

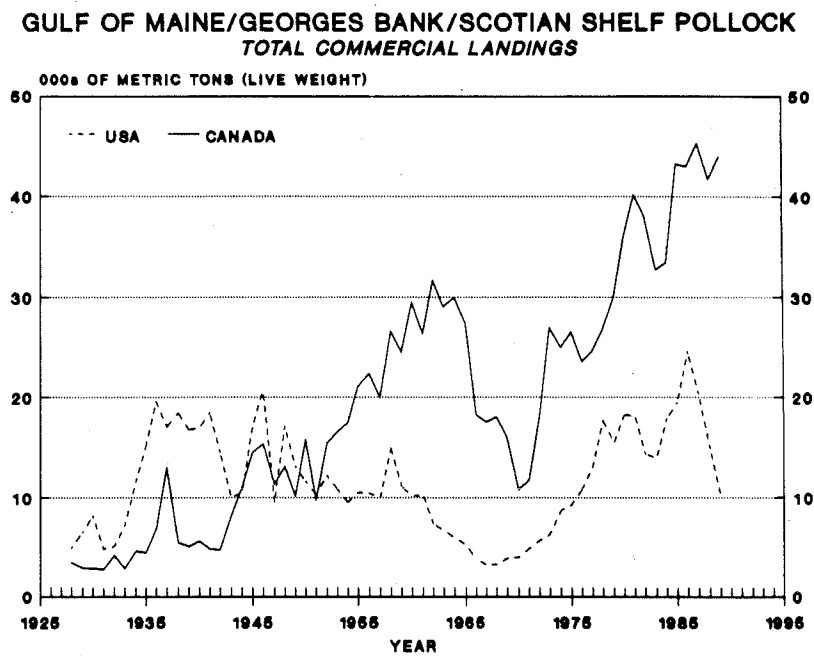


Figure 36. U.S. and Canadian commercial landings of pollock (mt, live) from NAFO Divisions 4VWX and Subareas 5 and 6, Gulf of Maine-Georges Bank-Scotian shelf, 1928-1989.

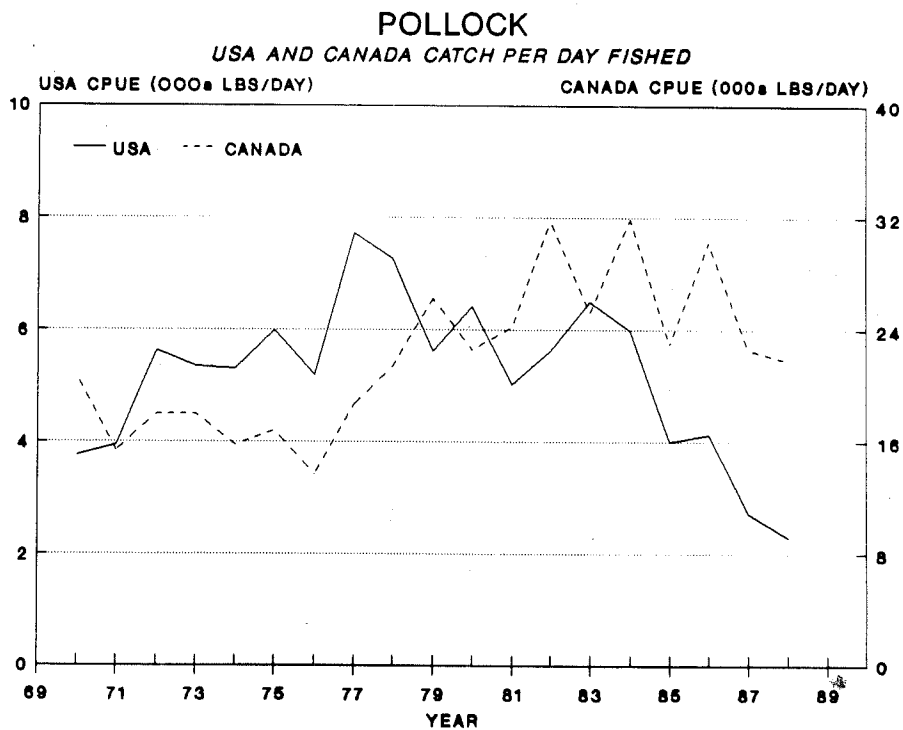


Figure 37. Trends in U.S. and Canadian commercial catch-per-unit-effort for Gulf of Maine-Georges Bank-Scotian Shelf pollock, 1970-1988.

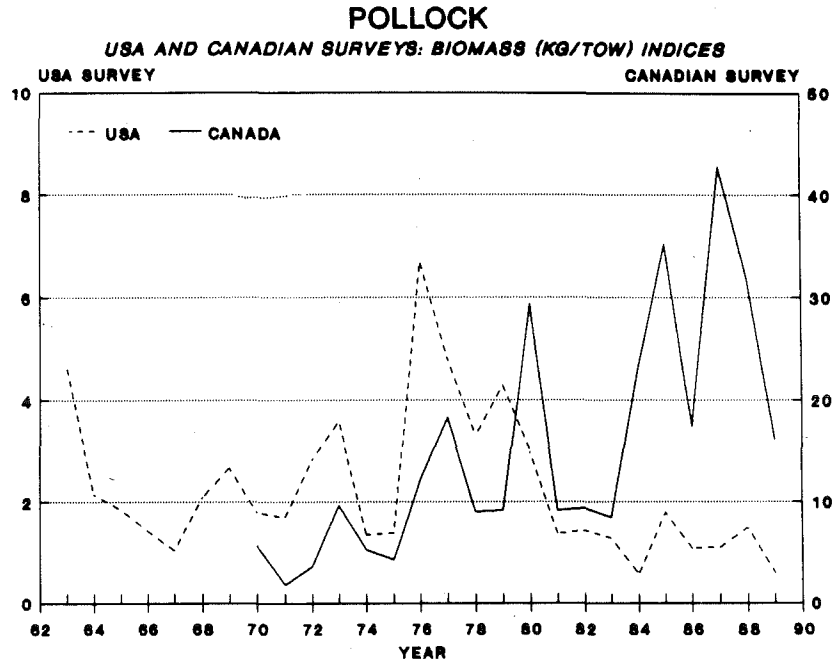


Figure 38. Stratified mean weight-per-tow (kg) of Gulf of Maine-Georges Bank-Scotian Shelf pollock in U.S. and Canadian research vessel surveys, 1963-1989.

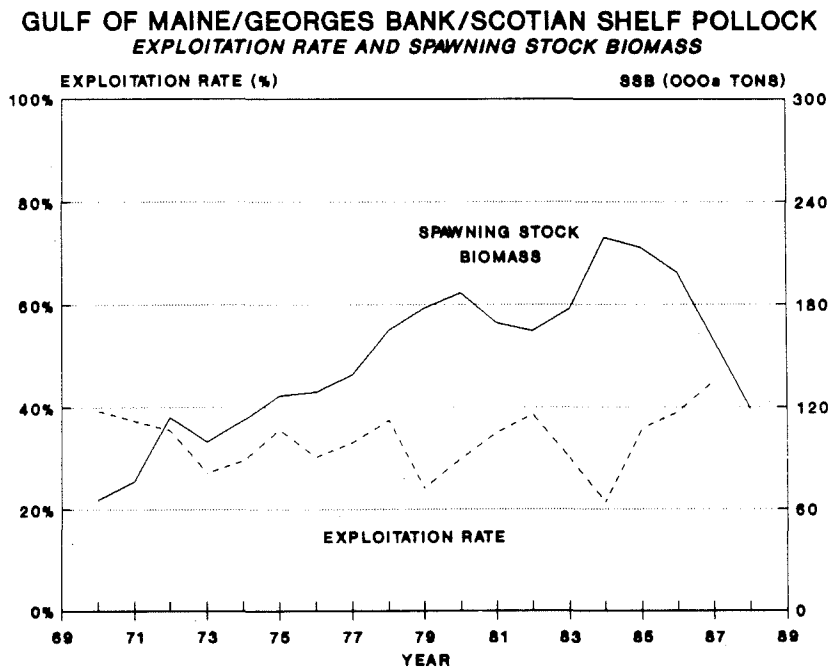


Figure 39. Trends in spawning stock biomass and exploitation rate of Gulf of Maine-Georges Bank-Scotian Shelf pollock from previous U.S. analyses (Mayo *et al.* 1989.)

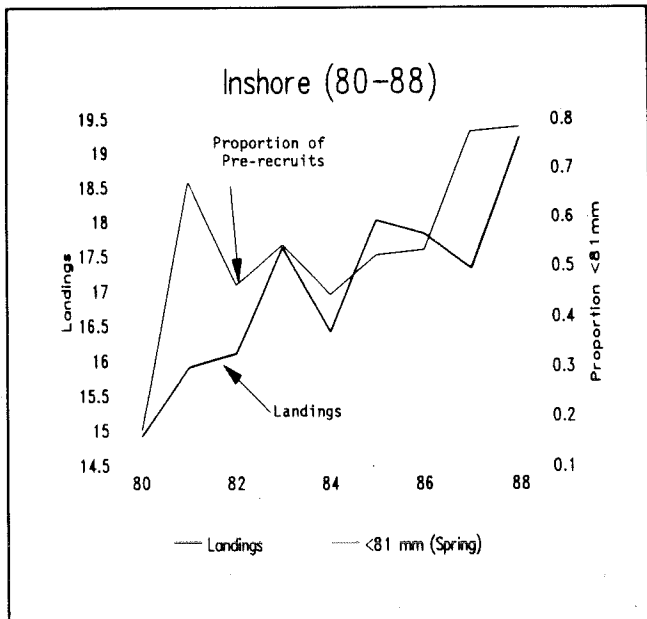


Figure 40. Proportion of pre-recruit (<81 mm) American lobsters from NEFC spring groundfish surveys and total U.S. inshore landings from the same calendar year (1980-1988).

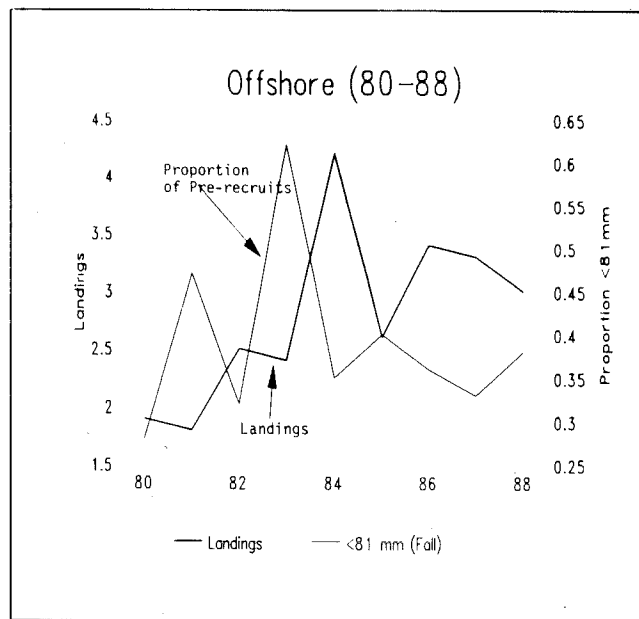


Figure 41. Proportion of pre-recruit (<81 mm) American lobsters from NEFC autumn groundfish surveys and total U.S. offshore landings from the same calendar year (1980-1988).

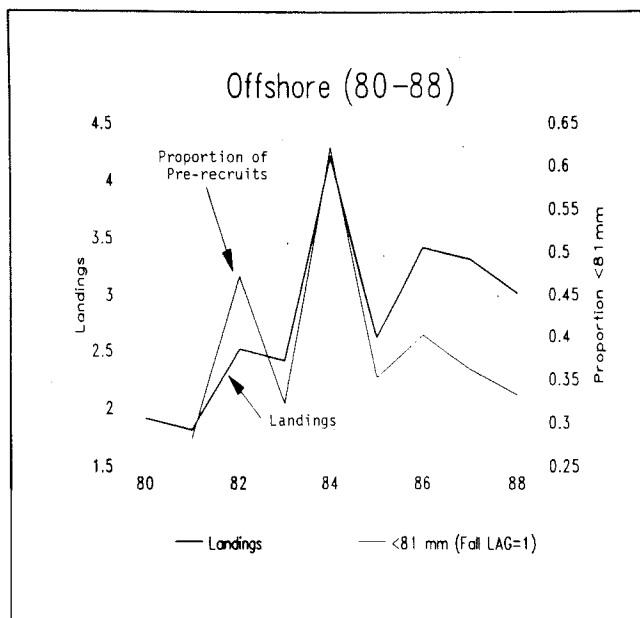


Figure 42. Proportion of pre-recruit (<81 mm) American lobsters from NEFC autumn groundfish surveys and total U.S. offshore landings from the following calendar year (1980-1988).

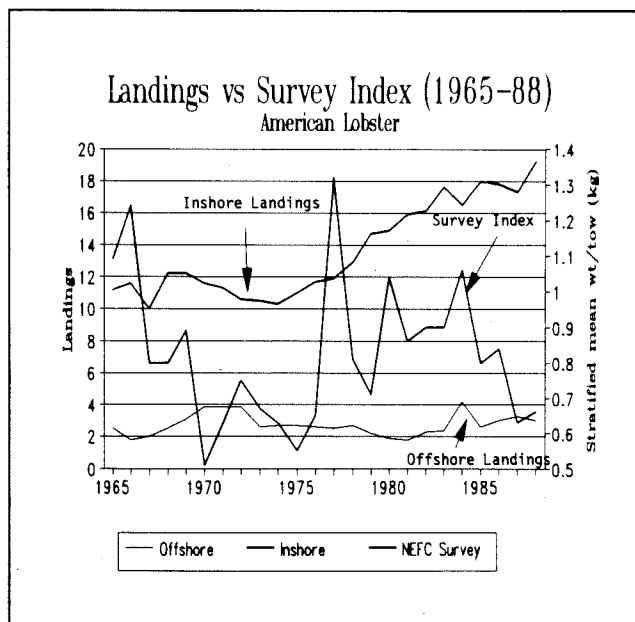


Figure 43. Inshore and offshore landings of American lobsters and stratified mean weight-per-tow from NEFC autumn groundfish surveys, 1965-1988.

WORKING GROUP REPORTS

METHODS (WG #9)

Members: Brian Rothschild (Chair, CBL), Vaughn Anthony (NEFC), Peter Colosi (NERO), Ray Conser (NEFC), Mike Fogarty (NEFC), Tom Hoff (MAFMC), Pamela Mace (NEFMC), Howard Russell (NEFMC).

Terms of Reference (Revised)

1. Review the classic definition of maximum sustainable yield (MSY) as well as the qualifications associated with the definition.
2. Consider alternatives to that definition and specify how these alternatives provide advice on either maximum yield, sustainable yield, or the desired combination of the two.
3. Review existing FMPs to determine how this problem has been handled under the FCMA.
4. Make recommendations on future research, noting any constraints in implementation.
5. Identify potential methods for evaluating stock-status, relative to over-fishing definitions.
6. Consider the utility and reliability of the various methods identified in 5.

Discussion of Report of Methods Working Group

The presentation of the Methods Working Group (formerly the Long Term Potential Catch Working Group) involved both consideration of the report of the meeting (17-18 April) and an additional working paper on "conditional" MSY and the overfishing problem. The discussion of these documents focused on: (1) evaluation and interpretation of the various methods currently in use to compute potential yields and biological reference points, (2) the utility of various reference points in guiding the Councils in their formulation of overfishing definitions, and (3) some operational "rules to live by" with regards to common pitfalls associated with some of the proposed biological reference points.

Considerable debate was generated concerning two specific points: (1) the classification of dynamic pool methods as "equilibrium" approaches, and (2) the distinction between stocks being in an overfished

condition, and overfishing currently occurring on the stock. The debate concerning the "equilibrium" classification of yield per recruit methods is essentially semantic when the stock approaches very long-term conditions of average recruitment, age structure, etc. As the long-term expectations of catch, stock size, and age structure approach constant values, the stock can essentially be classified as being in an equilibrium state. Since long-term averages rather than constant rates are implied, it may be appropriate to consider results in terms of stationarity rather than equilibrium.

The debate on overfishing vs overfished status relates to the use of long-term biological reference points, such as percent MSP, as compared to "real-time" measures of stock abundance and fishery yield. If significant recruitment overfishing occurs for an extended period, the stock can be driven to very low levels, from which recovery may be problematic for an extended period, even if F levels are reduced below target reference points, such as percent MSP. A good example of this conundrum is Gulf of Maine redfish. The stock is currently in a very drastic state of overfishing - induced decline, but Fs have declined in recent years. Under the Multispecies FMP, the stock may not technically be classified as "overfished" based on a long-term reference point, even though the stock is unquestionably suffering from chronic overfishing, and is in need of significant protection. The ensuing discussion evaluated the pros and cons of a number of equilibrium biological reference points, and their adequacy with respect to the overfishing vs overfished debate. The Working Group stressed that it was not trying to pass judgement on overfishing definitions proposed by the Councils, but rather was trying to point out where some definitions may be inconsistent.

Because there were divergent opinions among Working Group and SAW members with respect to the report, the SAW requested that the summary of this meeting of the Working Group be incorporated into the final report of the Working Group, as appropriate. At some later point, after further consideration by the Working Group, this report may be a future agenda item for the proposed Stock Assessment Review Team. In light of recent shifts in the Working Group's terms of reference, the SAW recommends referral of these terms of reference to the proposed Steering Committee for review.

SCALLOP FISHERY ANALYSIS WORKING GROUP (WG #23)

Members: Louis Goodreau (Chair, NEFMC), William DePaul (VIMS), Steven Edwards (NEFC), James

Kirkley (VIMS), Chris Rogers (MAFMC), Howard Russell (NEFMC), Fred Serchuk (NEFC), Stan Wang (NERO)

Terms of Reference

1. To compile a list of current sea scallop research and existing or developing biological and economic databases.
2. To describe and evaluate methods of estimating fishing mortality and partial recruitment from existing sea scallop data.
3. (If existing data are judged to be inadequate for #2,) to evaluate the costs and benefits of alternative approaches to collecting the necessary data.
4. To formulate a research strategy for the development of bio-economic models to aid in evaluating the effects of alternative management actions on individual vessels (micro-economic model), and evaluating the overall benefits of management (macro-economic model). The strategy should emphasize the inter-relationship between the models, be explicit about the type and utility of products that will be produced, and use the models to optimize data collection.

This report of the SAW Sea Scallop Working Group is the result of discussions at one full-day meeting May 8, 1990. David Ham (NERO) and Phil Logan (NEFC) also attended the meeting.

Current Sea Scallop Research and Databases

Most of the participants had presented their current research at the Ninth SAW in November 1989. Goodreau, Russell, and Wang attempted to present their generalized model of the sea scallop fishery at the May 8 meeting. The general model is used to describe a research strategy below (see #4). The biological submodel is also described below (see #2 and attached [WP #13 addendum]). Drs. Kirkley and DePaul presented their "Short-Run Situation Outlook: Mid-Atlantic Sea Scallops" (also attached [WP #16]).

There were no other presentations of research currently underway at the May 8 meeting.

Estimating Fishing Mortality and Partial Recruitment

Mr. Russell will make a formal presentation of the

"Biological Submodel under Development at NEFMC". The submodel was discussed at the May 9 meeting vis-a-vis the evaluation of methods for estimating fishing mortality and partial recruitment from existing sea scallop data.

Consistent with the Sea Scallop Session at the November 1989 SAW, all agreed with the submodel use of existing data to estimate fishing mortality rates.

The discussion was more divergent on the partial recruitment of the commercial catch. The submodel postulates stochastic, knife-edge recruitment. Three issues arose:

1. Using the annual survey to estimate the pre-recruit biomass, rather than assuming stochastic recruitment, is a possibility. It was agreed that such measurements are feasible from past surveys of the Georges Bank area, but that further study is required on the mid-Atlantic area data.
2. It was also agreed that the assumption of knife-edge recruitment is untenable; however, there was disagreement on the measurement of partial recruitment: some argued that current (survey) data are sufficient, while others thought that the size and age composition of the commercial catch is necessary.
3. Measuring the size and age composition of the commercial catch requires more than the current practice of collecting shells from the last tow of some (select) trips, which is assumed to be biased. There is disagreement whether a new data collection system, specific to sea scallops, to measure landings by size would also be biased.

Mr. Russell's presentation at the Tenth SAW should produce more input to resolve these issues.

Costs and Benefits of Alternative Data Collection

The Economic Investigation at Woods Hole is [sic] currently procuring costs data in the New Bedford [sic] as input to its Financial Simulator. No cost estimates for this program were available.

A study by Goodreau and Zhanguo Li, "Sea Scallop Enforcement and Monitoring Project", was handed out at the May 8 meeting. The study proposed a database solution and provided a cost estimate of just under \$50,000 (\$40,000 startup cost plus \$7200 annual maintenance). Cost estimates were based on a Nomad implementation on an IBM mainframe, and would have to be adjusted for a database, such as, Sybase on the VAX at Woods Hole.

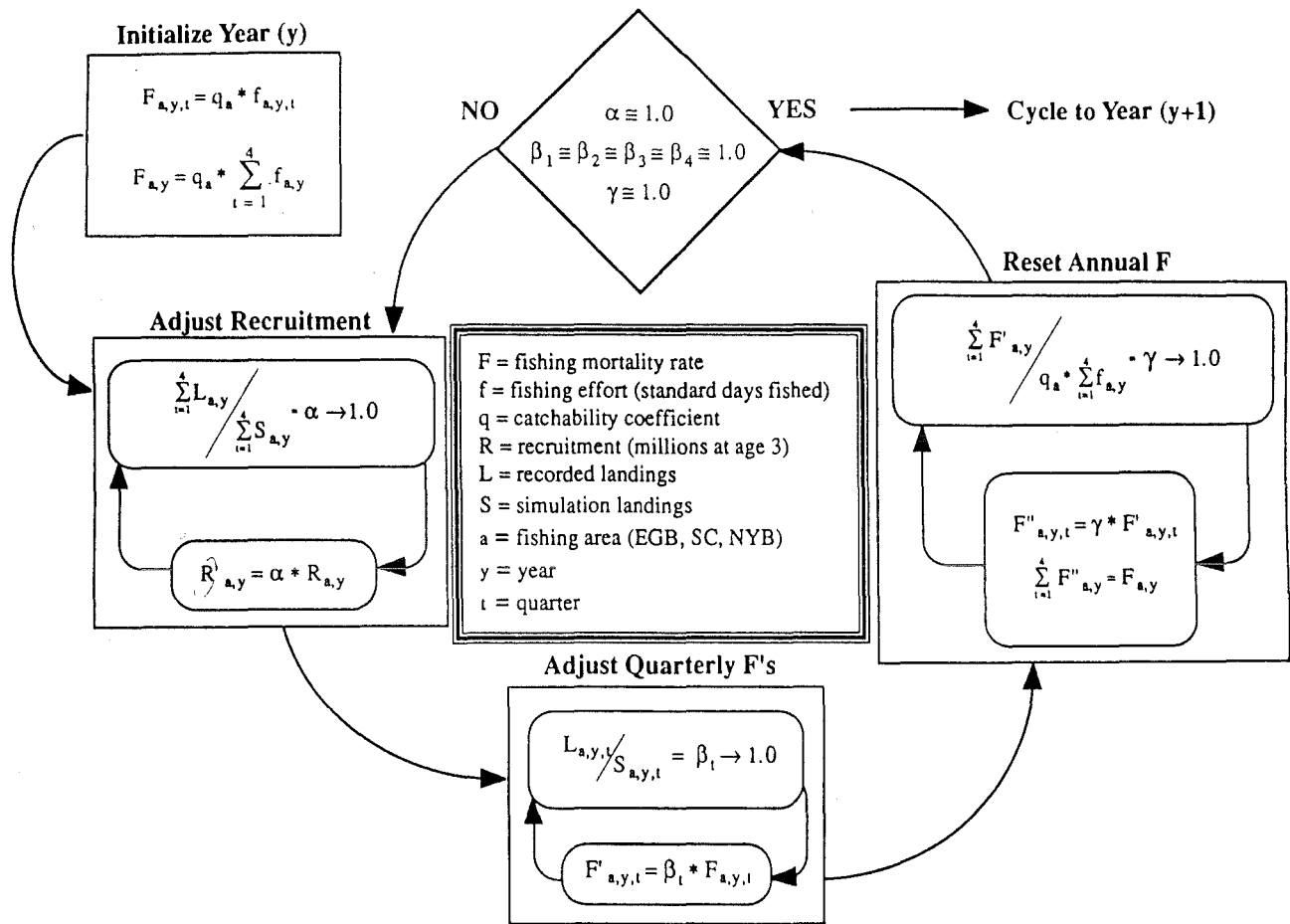


Figure 44. Scheme of bio-economic model for sea scallop fishery developed by staffs of New England Fishery Management Council and Northeast Regional Office.

One item which is continually requested by economists, the number of crew on the vessel on each fishing trip (see below), can be readily collected through the existing weigh-out system at zero incremental cost.

No other cost estimates for data collection were available at the May 8 meeting.

Research Strategy for Bio-Economic Models

An economic model used for analysis of the original Scallop FMP is being updated, and expanded to include estimates of stock biomass and catch at age from a biological model (see section on Estimating Fishing Mortality, page 49).

Figure 44 shows both the original model, with commercial landings based partly on standardized commercial CPUE, and the proposed model, with catch by age class based on a biological production submodel. The submodel has been discussed above

in the section on Estimating Fishing Mortality. The economic portions, both price and fishing effort sectors, will be discussed next.

The price sector contains all the factors expected in a general demand equation, including scallop price and quantity, the price of substitutes, the price of imports, and general economic variables (e.g., consumers' income), etc. The market levels have been reduced to two; retail price data are no longer collected by NMFS. The original substitute was the price for king crab; this must change as these prices are also no longer collected by NMFS. The specification of imports was rather simple in the original model, because Canadian imports of sea scallops, mostly caught from the same Georges Bank resource, accounted for all scallop imports [for practical purposes]. Since 1984, however, sea scallop imports have increased dramatically and have arrived from nations such as Peru, Iceland, and Japan.

Nevertheless, the fishing effort sector generated more heated discussion at the May 8 meeting. It was argued that the effort (days fished) equations do not

account for changes in vessel composition and behavior. This is absolutely correct; the model, as currently specified, is a "macro-model" in the sense that we are concerned with the overall level of fishing effort resulting from various stock levels and prices. There is an immediate need for a scallop vessel sector, or "micro-model", to be derived from the general specification. For instance, it is argued that there must exist a labor-for-days substitution which maintains vessel productivity with fewer days at sea by adding more crew. There are currently no such models being proposed.

Recent management discussions at the NEFMC are entering this arena. Under proposed "effort control" scenarios, including a moratorium on the number of fishing vessels, formulae for vessel transfer (to/from other fisheries), replacement, and upgrade are necessary. The current formulation would require that all scallop vessels be replaced only with a vessel of the same horsepower, albeit with additional caps on overall dredge size (30 ft) and crewsize (9). Such attempts show that the concern for vessel power or catchability is real, despite the lack of economic models to show the same. This neglects the fact, however, that the change in ownership of a scallop vessel may have profound effects on its catchability (*i.e.*, its productivity, all other things constant, for a given number of days-at-sea or fished may change drastically). The only surefire way to hold vessel productivity constant is to prevent change of ownership of scallop vessels as well. Only then can the current specification of fishing effort in the general bio-economic model above be expected to be reliable.

Addendum Summary: Biological Submodel Under Development at New England Fishery Management Council Office

The objective of the submodel is to develop an age-structured simulation of the historic scallop fishery since 1975. Input includes quarterly commercial scallop catch and effort data for three areas (eastern Georges Bank, South Channel and the mid-Atlantic) and eight vessel tonnage classes. Effort is standardized by tonnage class by relating average CPUE to CPUE for a tonnage class. Total biomass is based on swept-area estimates from NEFC scallop surveys, assuming 75 percent survey dredge efficiency. Exploitation ratios are then estimated from August commercial catches and August estimates of survey biomass. An annual catchability coefficient is then estimated for the total survey area and component areas. Different selection ogives are assumed for Georges Bank and mid-Atlantic fisheries. Quarterly

weights at age are estimated from growth equations, and are constant over time. Recruitment and quarterly estimates of fishing mortality are generated by area and year by iterating until simulated annual and quarterly landings match observed annual and quarterly landings (Figure 45).

Discussion of Report of Scallop Fishery Analysis Working Group

Three major issues were discussed concerning collection of biological and economic data for sea scallops. These were (1) collection of size composition data, (2) collection of data on crew size, and (3) collection of cost data. Currently, size composition data are obtained from survey data and from shells taken from the last tow of commercial trips (the latter are probably biased samples). The proposed alternative of collecting meat counts by size was not considered adequate by SAW participants because of logistical problems with data collection (handling of meats affecting size, mixing of bags from different areas to obtain the regulated meat count, etc.) and the potentially poor accuracy in translating meat size to scallop size/age. The possibility of doing sea sampling to get this information was raised. If so, the sampling would need to be very intensive because of the large variation among trips. The sea sampling design would need to take this variability into account. In summary, there appear to be 3 options for obtaining this information: (1) collecting shells, (2) sea sampling, and (3) collecting meat counts by size. The first two options are preferred over the last.

The Working Group's proposal for collecting crew size data was to add a question to the interviews conducted by NMFS port agents. The discussion that followed this proposal made it clear this is not as simple a solution as it seems. Such data could only be obtained from interviewed trips; weigh-out slips are obtained from dealers, not from the source, and thus would not include this type of information. The software systems developed for use in the ports would have to be re-written if more questions were added, and this would incur some costs. The WG pointed out that at present there is no reliable information at all. Since most scallop trips are interviewed (except in the mid-Atlantic), some information might be obtained this way. It was suggested that occasional sampling might be done to collect this information.

Discussion of a bioeconomic model brought several issues to light. The method used to standardize effort was questioned, and suggestions were made to employ a log-linear model approach rather than obtaining fishing power coefficients as ratios of average CPUE by vessel class. Potential interactions among variables should be examined using analysis of vari-

SEA SCALLOP MODEL

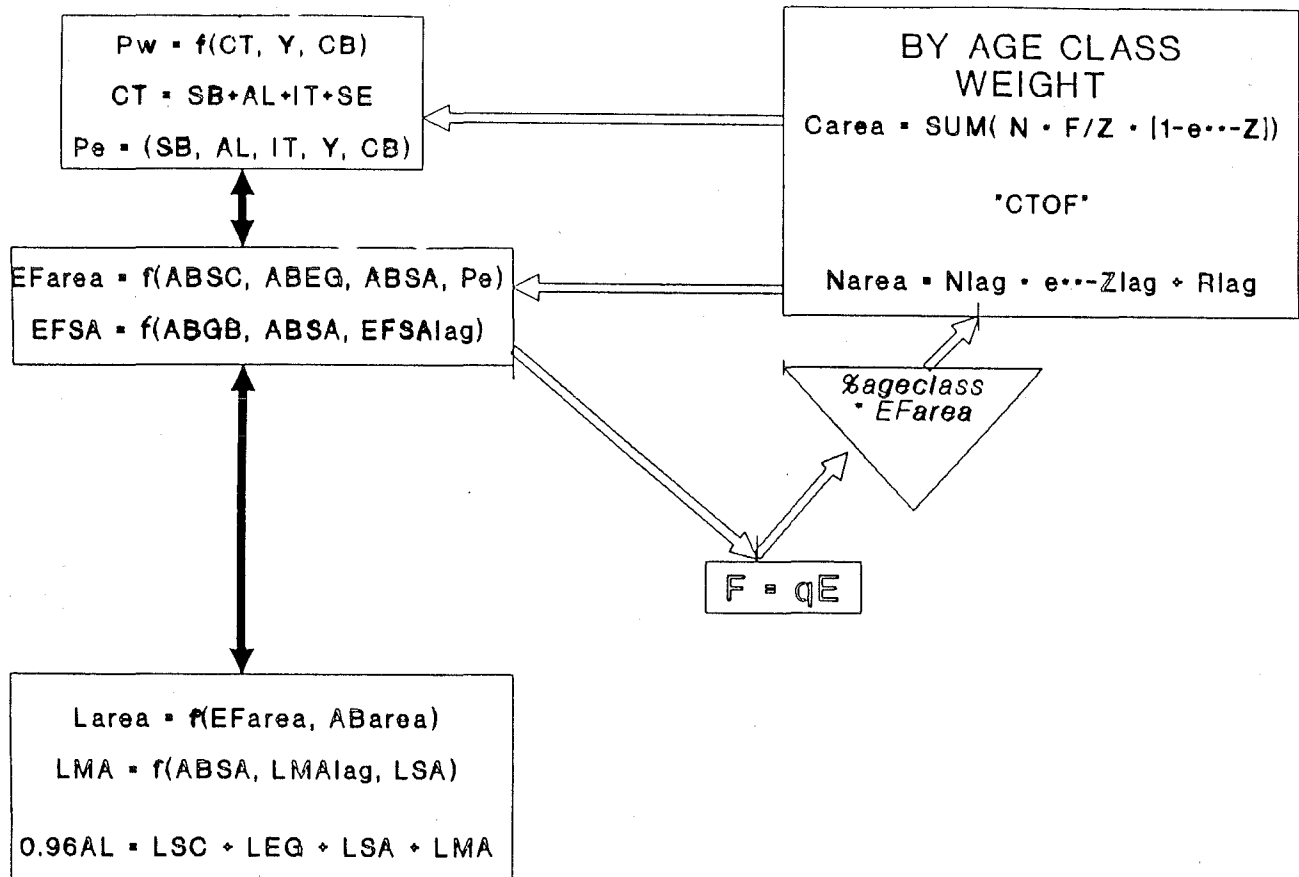


Figure 45. Simplified flow diagram of computer program used to simulate historic sea scallop fishery, biological submodel.

ance. Average CPUE was used in the analysis rather than individual trip CPUEs. Use of individual trip CPUE is preferable because averaging masks variability between trips and effectively weights all gear types equally. All trips, whether interviewed or not, were included in the analysis. Because the data from non-interviewed trips may be unreliable, a comparison should be made of interviewed vs. non-interviewed trips to determine whether significant differences exist. If so, only interviewed trips should be used.

The model assumes that effort is static, *i.e.* that the behavior of the fleet does not change over time due to learning, changing crews, *etc.* The need for vessel behavior modeling was raised several times. NEFC is currently working on this problem.

Other technical issues that need to be addressed include the arbitrary assumption that had to be made regarding efficiency of the scallop sampling gear (75 percent in this iteration), the seasonal cycle of meat

weights (not presently accounted for in the model), and examination of area effects (area-specific input parameters needed, Northeast Regional Office and New England Fishery Management Council modelers plan to incorporate in the future).

Any model requires cost information, which is not presently available. The group felt it was important that a data collection system for cost data be designed and implemented, and costs be incorporated in the model.

The outstanding issues that need to be addressed by the working group include (1) developing a sampling scheme for size composition, (2) developing a cost data collection system and incorporating such information in the model, (3) incorporating dynamic vessel behavior in models, and (4) separating the mid-Atlantic and Georges Bank in the data collection and modeling efforts. The Working Group should report on further progress in these areas in the future.

SEA SAMPLING PRIORITIES WORKING GROUP (WG #24)

Members: Darryl Christensen (Chair, NEFC), Steve Clark (NEFC), Dave Pierce (MDMF), Chris Kellog (NEFMC), Tom Hoff (MAFMC), Greg Power (NEFC), representatives from NERO, ASMFC

Terms of Reference

1. Develop FY91 sampling priorities and procedures relative to data needs for stock assessment and FMP and MMPA compliance monitoring.

The current domestic sea sampling contract with the Manomet Bird Observatory (MBO) is due to expire at the end of September, 1990. A new contract, currently being prepared for FY '91, includes the following features:

- greater flexibility in scheduling sampling priorities among fisheries,
- ability to increase sampling coverage as new funds become available, and
- coverage to be based on sea days rather than a fixed list of trips.

The final schedule will not be set until a contractor is selected and it is anticipated that marine mammal funds will account for a major source of the funding. A preliminary schedule of proposed sea sampling coverage based on an estimate of 1,000 sea days was presented (Table 36). Of this total, 410 sea days were allocated to the Gulf of Maine gillnet fishery to monitor marine mammal-gillnet interactions. Allocations for each of the remaining fisheries ranged from 15 to 135 sea days annually, with one to 15 sea days allocated on a monthly basis. This level of coverage would allow, for example, one trip per month to be sampled in each of the major trawl fisheries in the four geographic regions.

Discussion of the Report of the Sea Sampling Priorities Working Group

It was generally agreed that, except for the Gulf of Maine gillnet fishery, current and proposed levels of coverage in the sea sampling program may be insufficient to allow generalization to an entire fleet. For example, the proposed sampling level of one trip per month in the Georges Bank fishery will not allow statistically reliable estimates of discard rates to be applied to the overall fishery. Given the expected temporal and spatial variation in discard rates, such estimates are likely to be imprecise and biased. The original intent of the domestic sea sampling program, to provide estimates of discard rates in the New

England multi-species trawl fishery, has been severely compromised by dilution of coverage in order to satisfy compliance requirements in other fisheries.

Coverage could be increased by including sea sampling activities as a mandatory requirement in the federal permit process, or by alternate arrangements with other contractors such as on-going programs conducted by academic institutions. Neither solution is a satisfactory means of increasing coverage in the near term.

The degree of variability in the sea sampling database cannot be determined until the existing data are analyzed in a systematic manner. Although some analyses of a subset of the data are underway, a comprehensive examination of the entire database is required before complete guidelines on the level of desired coverage can be issued. In order to accomplish this task, all existing data must be readily accessible for extraction and analysis. To this end, it was noted that the first nine months of sea sampling data have been entered and audited, and are now available on the Woods Hole VAX.

Collection of commercial length and age samples through the sea sampling program is necessary to offset reductions in coverage in the ports. The sea sampling program also provides a means of obtaining biological samples *e.g.*, for examining seasonal variation in the maturation cycles, and for collection of seasonal sea scallop age samples.

Recommendations

Noting that the level of coverage in the sea sampling program is unlikely to provide parameter estimates such as discard rates, the SAW *recommends* that resources be made available so that all data from the Gulf of Maine shrimp fishery and the Georges Bank trawl fishery can be analyzed on a statistical basis to provide guidance for future sea sampling program requirements.

In view of the reduced ability of the Statistics Investigation to obtain commercial length and age samples in the ports, the SAW *recommends* that additional resources be allocated to monitor and coordinate biological sampling at sea and dockside, to evaluate sampling adequacy, and to adjust sampling priorities on a real time basis.

SAW DOCUMENTATION (WG #25)

Members: Pamela Mace (Chair, NEFMC), Peter Colosi (NERO), Bruce Higgins (NEFC), Tom Hoff (MAFMC), Paul Perra (ASMFC), Fred Serchuk (NEFC)

Table 36. Preliminary list for 1,000 sea days of observer coverage

| Fishery and Area | Month (Fiscal Year 1991) | | | | | | | | | | | | Total | |
|-------------------------------|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------|-----|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | | |
| | Gillnet | | | | | | | | | | | | | |
| Gulf of Maine | 40 | 40 | 30 | 15 | 15 | 30 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 410 |
| | Driftnet | | | | | | | | | | | | | |
| Southern New England | 10 | 10 | | | | | | | 10 | 10 | 10 | 10 | 60 | |
| | Trawl | | | | | | | | | | | | | |
| Gulf of Maine | 5 | 5 | 10 | 10 | 10 | 10 | 5 | 5 | 5 | 5 | 5 | 5 | 80 | |
| Georges Bank | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 15 | 15 | 15 | 135 | |
| Southern New England | 5 | 5 | 10 | 10 | 10 | 10 | 5 | 5 | 5 | 5 | 5 | 5 | 80 | |
| Mid-Atlantic | 5 | 5 | 10 | 10 | 10 | 10 | 10 | 5 | 5 | 5 | 5 | 5 | 85 | |
| | Fish Pot | | | | | | | | | | | | | |
| Mid-Atlantic | 2 | 2 | 1 | | | | | 2 | 2 | 2 | 2 | 2 | 15 | |
| | Longline | | | | | | | | | | | | | |
| Mid-Atlantic | 10 | | | | | | | | 5 | 10 | 5 | 10 | 40 | |
| Southern New England | 5 | | | | | | | | 10 | 5 | 10 | 5 | 35 | |
| | Scallop | | | | | | | | | | | | | |
| New England & Mid-Atlantic | 12 | | | 12 | | 12 | | | 12 | | | 12 | 60 | |
| Total | | | | | | | | | | | | | 1000 | |

Other Requests

MAFMC

Fish traps (scup) RI & CT
 Additional longline trips including directed shark fisheries
 Tilefish longline
 Additional squid (*Loligo*)
 Directed *Illex* fisheries
 Weakfish & bluefish coverage

NEFMC

FAAS coverage continued
 Continued general coverage of small mesh trawl fisheries
 "Some scallop coverage"
 Additional offshore lobster

NEFC - CUD

Increase scallop dredge coverage to 120 days

SEFC

Additional longline and swordfish driftnet coverage

Terms of Reference

1. Review effectiveness of the SAW report as prepared for the nine SAWs in regard to meeting informational needs in the New England and Mid-Atlantic regions.
2. Develop proposals for other methods of reporting results of future SAWs that would meet better the informational needs of the principal users of the SAW results.
3. Evaluate formats used by ACFM and other groups for presentation of assessment results.

Report

This report of the SAW Documentation Working Group is the result of discussions at one full-day meeting (on May 4) and several follow-up faxes and telephone conversations. Tom Hoff and Paul Perra were unable to attend the May 4 meeting, but did provide prior comments for the rest of the group to consider. Wendy Gabriel also attended most of the May 4 meeting, and Vaughn Anthony contributed to some of the final discussions.

The terms of reference are each discussed below. The order of presentation of the second and third items has been reversed.

The Effectiveness of the SAW Process to Date

The Working Group discussed at length the pros and cons of the current SAW process. Positive aspects identified by the group included:

- (i) The SAW represents the primary formal mechanism for the peer review of any unpublished science that is used in Fishery Management Plans (FMPs) and FMP Amendments.
- (ii) The SAW process has evolved to include a broader participation of people.
- (iii) The process has evolved from one of stock assessment reviews only, to a mix of assessments and research coordination. The group believes that it is important for a broad range of scientists to play an active role in coordinating assessment-related research.
- (iv) The SAW process has resulted in some sharing of assessment responsibilities.

- (v) SAWs have been receptive to requests for the science needed to meet management requirements (as long as these requirements can be predicted up to six months ahead of time).

The Working Group also identified numerous problems that undermine the utility of the SAWs:

- (i) Much of the science used to formulate FMPs is not vetted through the SAWs. One reason this occurs is that there is often a mistiming between SAWs and requirements for analyses to support Plan development. No matter how frequently SAWs occur, there will always be events happening between SAWs that require scientific analysis. (The group agreed that this problem could probably only be resolved in the context of a Plan Development Team or similar structure involving participation by scientists, managers and administrators throughout the Plan formulation process).
- (ii) Other than producing a record of the meeting, the SAWs are not really goal- or product-oriented, and therefore there is little pressure to complete assessments to the point where it can be said that there is a consensus on the status of the stocks. Pollock and Gulf of Maine herring are two such examples from the most recent SAW. Reasons for the lack of completeness include lack of time and, in some cases, a lack of incentive or perceived need for definitive results. The group strongly believes that the SAW should be modified so that peer-review and consensus agreement on assessment results become the primary focus.
- (iii) Although the group feels that the SAWs should discuss research coordination as well as stock assessments, the role of stock assessments has been considerably de-emphasized in favor of "show and tell" seminars on non-assessment Working Group reports and special topics. The number of stock assessments (particularly full analytical assessments) conducted at each SAW is currently far too small to satisfy management requirements in a timely fashion. (It should be noted that the NEFMC and ASMFC perceive this to be more of a problem than does the MAFMC, primarily because assessment updates are provided for most of the Mid-Atlantic species at each spring SAW, whereas the approach is ad hoc for species of concern to the other two organizations).
- (iv) There is a lack of commitment by some client groups to participate fully in the SAW process. The one-week time constraint limits the breadth and depth to which activities can be reviewed and discussed, yet a week is too long for some people to

stay. Cost and location may be factors limiting participation by individuals who do not reside within commuting distance of Woods Hole.

- (v) The SAW documentation needs to be handled differently. In general, draft Working Group reports and other background materials (which have no status and may even contain serious flaws) are probably referred to more often than the meticulously-reviewed SAW Report itself. This is because the SAW Report does not go far enough in its conclusions or assessment analyses, and the scientific staff of fisheries management organizations need the more detailed information provided in working papers in order to complete or expand on the assessment results. It is necessary to either refine the assessment analyses in the SAW Report, or correct and upgrade the working papers to a form suitable for distribution, or both.
- (vi) There is far too much time spent reviewing the rapporteur's reports of the discussions following each SAW presentation. Often, much of the discussion is not particularly relevant to managers or other client groups. The main problem, however, is that since a report of proceedings (but not necessarily analytical results) is the SAW product, stock assessment reviews are often terminated in the initial stages of discussion (e.g. Gulf of Maine herring at the ninth SAW).

Formats Used by Other Stock Assessment Organizations

The Working Group reviewed the structure and reporting formats of the following organizations that conduct stock assessments: International Council for the Exploration of the Sea (ICES), Northwest Atlantic Fisheries Organization (NAFO), Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) and New Zealand Fisheries Assessment Meetings (NZFAM). The main output from each of these groups is a consensus Advisory Document that transmits to fisheries managers all of the most pertinent information they need to manage the fish stocks under their jurisdiction. It was agreed that a similar type of document should also be the principal output from future SAWs. Other group deliberations are reflected in the following proposal for an alternative SAW model.

Proposed Alternative Model

The proposed alternative model (Figure 46) represents a synthesis of the positive aspects of the current SAW process with the most relevant and work-

able parts of the models used by the above-mentioned stock assessment agencies. The Working Group hopes that this proposal will be fully discussed and refined during the tenth SAW.

The most substantive part of the proposal (Figure 46) is that the SAW should be split into two parts: an Assessment Review process and a SAW Plenary. The Assessment Review Team (ART) would comprise a relatively small group of technical experts who would meet for about a week immediately prior to the SAW Plenary. Materials available to the ART would include working papers (probably consisting mostly of tables and graphs with relatively little text) from Assessment Working Groups and individual assessment scientists, the Status of the Fishery Resources document produced by the Population Dynamics Branch at NEFC, and other relevant materials. The ART would be restricted to reviewing stock status and stock assessments, not related research, nor the need for research coordination (although the ART could make general recommendations about the research required to support assessments).

The ART should review the status of all managed fish stocks within the Northeast Region at least once per year. In some cases (hopefully an increasing number of cases), it may be necessary to review a full analytical assessment (e.g. VPA), and to re-run parts of the analysis during the ART Meetings. In other cases, the "review" may be very brief, quickly reaching a conclusion such as: "the few new data that exist suggest that there has been no significant change in the status of the stock since the last review". To encourage participation by State scientists, each ART Meeting/SAW Plenary should include at least one coastal species.

The principal output from the Assessment Review Meetings would be a consensus summary of stock status and stock assessment results. This summary should follow a standard format, possibly some combination of the formats currently used by ICES, CAFSAC and the Status of the Fishery Resources document (i.e. one-half page to two pages of explanatory text, along with tables and figures that give landings statistics, survey results, other indicators of trends in stock size, fishing mortality estimates, biological reference points, etc.). Once Regional Fishery Management Council definitions of "overfishing" are finalized, the summary should also include an assessment of whether there is overfishing according to the adopted criteria.

Other proposed outputs from the Assessment Review Meetings include a rapporteur's report and a list of working papers that merit upgrading to SAW Research Documents. The rapporteur's report would consist of brief evaluations of each reviewed assessment (e.g. validity of techniques, recommendations for future analysis). Clients for the report would be

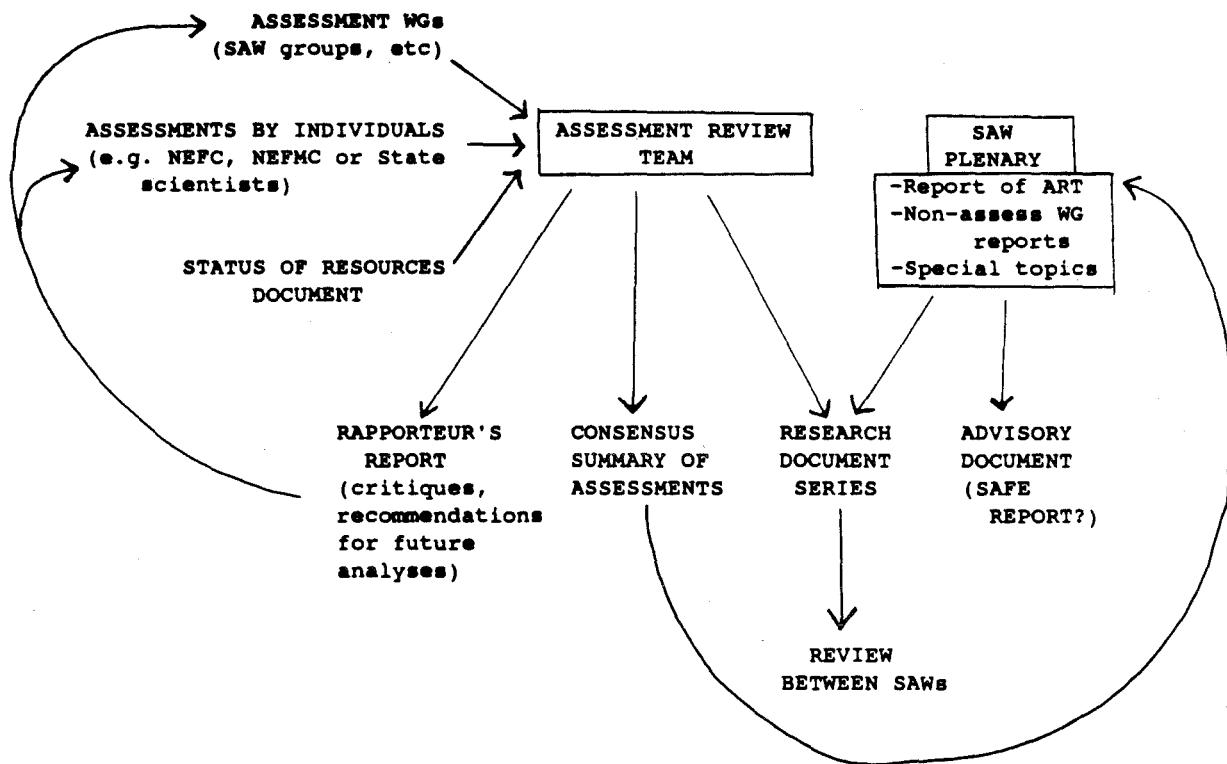


Figure 46. Proposed alternative model for future Stock Assessment Workshops, Report of SAW Documentation Working Group.

the Assessment Working Groups and individual assessment scientists, not the SAW Plenary, nor fisheries managers. As such, the report would not need to receive meticulous attention to detail.

The SAW Plenary would be scheduled for the week following the Assessment Review Meetings. Suggested responsibilities of the Plenary are to review the report of the ART, review and discuss the activities of non-assessment Working Groups (*i.e.* WGs involved in assessment-related activities, but not producing individual stock assessments), and review and suggest Special Topics of direct relevance to SAW participants. The primary output from the SAW Plenary would be an Advisory Document for use by fisheries managers and other interested parties. This document would probably consist of two parts: assessment advice and a brief summary of assessment-related research activities. The assessment advice would be based on the reviewed and adopted ART report. The SAW Plenary may wish to add additional relevant information to the report (*e.g.* economic analyses, subsidiary research results, a section on the implications of the assessment results, *etc.*). It is possible that the output from the SAW Plenary could fulfill the new requirement to produce Stock Assessment and Fishery Evaluations (SAFEs).

At the end of its meeting, the SAW Plenary would also decide which, if any, working papers on assess-

ment-related research should be upgraded to SAW Research Documents for distribution to users who need more detailed assessment information. It is proposed that the SAW Research Documents be part of a new series of publications put out by the SAW (not just NEFC) via a speedy (truncated) review process. Research Documents should appear in final form within 60 days of each SAW Plenary.

The Working Group also discussed a suggestion that the ART/SAW process be coordinated by a SAW Steering Committee. The main roles of the Steering Committee would be to formulate general terms of reference and ensure that appropriate resources are made available to fulfil the terms of reference. Membership of the Steering Committee has yet to be determined.

Potential of the Proposed Model for Resolving Current SAW Failings

The requirements for a consensus summary of assessments from the ART Meetings and an Advisory Document or SAFE Report* from the SAW Plenary should ensure that the SAWs become more product-oriented. The proposed increase in the intensity of the Assessment Review process (*i.e.* the creation of an Assessment Review Team) will also ensure that the status of fish stocks is revised more frequently, and

that a larger fraction of the science used to formulate FMPs receives appropriate peer review. However, it is likely that there will always be ad hoc analyses that are needed within days or weeks, rather than months.

The proposed model may also resolve some of the problems of participation in SAWs. For example, there need not be much duplication in participation in the ART Meetings and the SAW Plenary. As mentioned above, the Assessment Review Team would consist of a relatively small group of technical experts (although the meetings would be open to any fisheries scientists or fisheries managers who wished to attend). It would be expected that a much larger group would attend the SAW Plenary--probably most of the people who currently attend the SAW. The ART Meetings would almost certainly take longer than the SAW Plenary, because the former would be operating at a much finer level of analytical detail than the latter. It is anticipated that the ART Meetings would require a full week, whereas the SAW Plenary should be able to fulfill its responsibilities within three to four days.

The agenda for the ART Meetings would need to be flexible so that each assessment could receive as much attention as necessary. Although this flexibility may create difficulties for individuals who wish to participate in selected parts of the meetings, it is essential that sufficient analysis is completed to enable consensus agreement on stock status. Conversely, the agenda for the SAW Plenary could be structured to accommodate individual time schedules, with little scope for flexibility once the meetings begin. However, because of large number of managed fish stocks, it may still be necessary to have two ART/SAW Plenary Meetings per year.

The proposed outputs from the ART Meetings and the SAW Plenary would mitigate the problem of unrefereed working papers being used as a basis for subsequent scientific analysis. They would also ensure that most of the available time is devoted to the important task of reaching consensus on the implications of assessment results, rather than debating the wording of rapporteur's reports of the discussions following each presentation.

Discussion of SAW Documentation Working Group Report: Proposed Model for Stock Assessment Review and Fisheries Advice

Stock Assessment Workshop Structures

The Stock Assessment Workshop is to be composed of four basic components: 1.) a Steering Committee, 2.) Assessment Working Groups (WGs) and individuals, 3.) a Stock Assessment Review Commit-

tee, and 4.) a Plenary to provide Scientific Advice on Regulated Fisheries (Figure 47).

Structure of Steering Committee: Membership to include Directors from Regional Office, NEFC, NEFMC, MAFMC, and ASMFC, or their designated representatives.

Structure of Assessment WGs: Membership dependent on the complexity and scope of the problem; some assessments and auxiliary analyses could be conducted by individual NEFC, Council, State or other scientists.

Structure of Stock Assessment Review Committee: Membership of the Stock Assessment Review Committee would consist of five to ten scientists with technical expertise in assessment methodology. Participation by at least one external assessment scientist from outside the Northeast region would be highly desirable. Meetings would be open to observers as well. Membership of the Stock Assessment Review Committee should rotate regularly, with some carry-over of members to maintain continuity.

Structure of Plenary for Scientific Advice: Core group would consist of representatives of each client group (e.g., Regional Office, Councils, Atlantic States Marine Fisheries Commission, Northeast Fisheries Center); participation by a wide variety of experts (i.e., the current SAW participants) would be encouraged.

Stock Assessment Workshop Functions

The primary functions of the proposed system are to produce peer-reviewed, consensus stock assessments, and related analyses; and peer-reviewed, consensus advisory documents on regulated fisheries.

Functions of Steering Committee: The main role of the Steering Committee is to oversee the Assessment-Review-Advisory process, (including approval of time and place of meetings, selection of chairpersons and monitoring participation). The Steering Committee will evaluate recommendations on assessment needs made by the Stock Assessment Review Committee and the Plenary for Scientific Advice, set priorities, and ensure that available resources match assessment requirements. Technical terms of reference for WGs and other assessment needs will probably be formulated by the Stock Assessment Review Committee and the Plenary for Scientific Advice, but it will be up to the Steering Committee to approve or modify them and determine priorities.

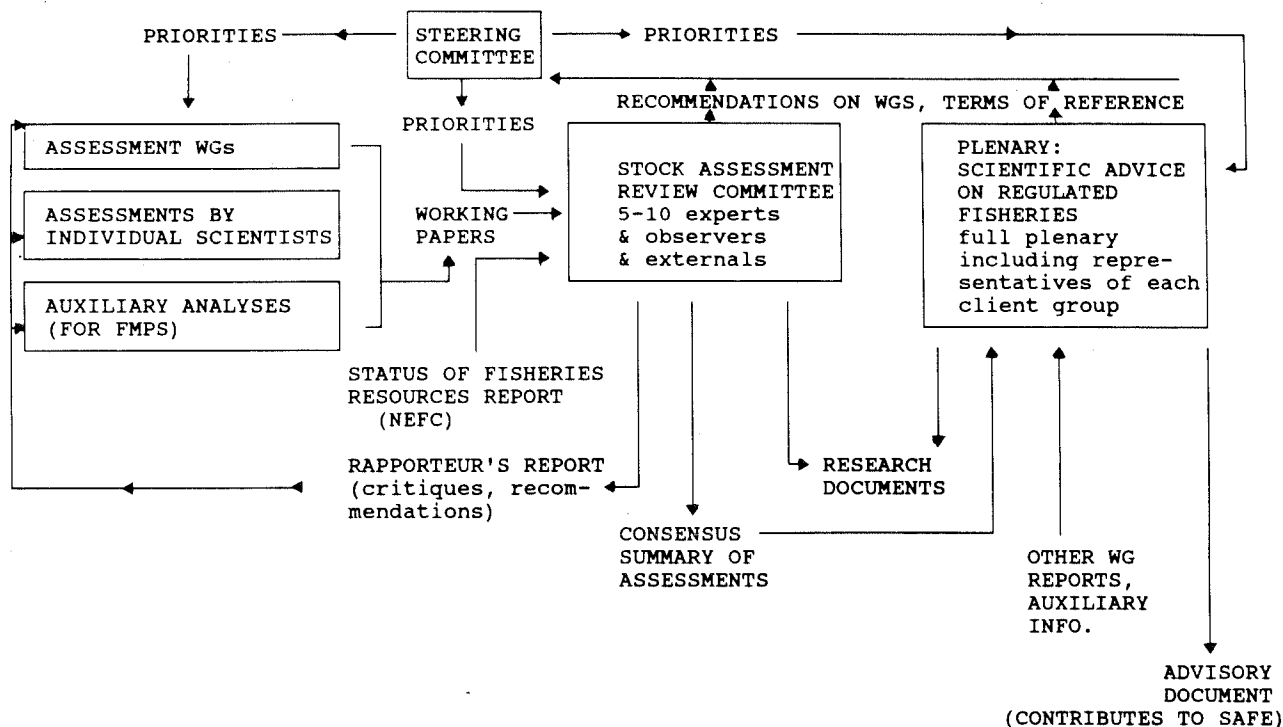


Figure 47. Revised alternative model for future Stock Assessment Workshops, Tenth SAW.

Functions of Assessment WGs: Assessment WGs and individual scientists will produce assessment analyses (evaluation of trends in landings or survey indices, yield per recruit, VPA, *etc.*) appropriate to individual FMP requirements and data availability. Assessment results will be outlined in draft form in Working Papers. Assessment WGs will receive critiques of their analyses from the Stock Assessment Review Committee rapporteurs' reports, which they should take into account in future analyses.

Functions of Stock Assessment Review Committee: The Stock Assessment Review Committee will review assessments produced by WGs and individual scientists (Working Papers), assessment information provided in the NEFC Status of the Fisheries Resources report, and other relevant documentation to produce a Consensus Summary of stock status and stock assessment results. The Stock Assessment Review Committee should review the status of all exploited fishery resources within the Northeast Region at least once per year. (Reviews for stocks with few data or analyses will be brief.) The Stock Assessment Review Committee will also produce rapporteurs' reports that provide assessment critiques and recommendations for future analyses to the Assessment WGs and

individuals. They will also make recommendations to the Steering Committee on the need for new assessments or Assessment WGs, together with appropriate Terms of Reference. Finally, they will recommend which research results and assessment analyses (*e.g.*, working papers) should be upgraded as Stock Assessment Review Committee Research Documents (see following section). (Upgrades would then be completed by the Assessment WGs or individuals who produced the Working Papers.)

Functions of Plenary for Scientific Advice: The Plenary will review the Consensus Summary of Assessments from the Stock Assessment Review Committee, as well as other relevant information including input from non-assessment WGs, to produce an Advisory Document in a format that contributes to SAFE reporting requirements. Thus, while the Stock Assessment Review Committee will produce a summary of assessment results, the Plenary for Scientific Advice will focus on the implications of those (and other) results. The Plenary for Scientific Advice may also recommend the formation of new WGs and Terms of Reference, and will determine which of the non-assessment WG Working Papers should be upgraded to Research Documents.

Stock Assessment Workshop Operations

Secretariat: Dedicated personnel and other resources are required for the operation of this system. The secretariat would be responsible for organizational and administrative aspects, including report production, of the review and advisory meetings.

Frequency and timing of meetings: The Steering Committee and the Assessment WGs would meet as necessary throughout the year. The Stock Assessment Review Committee and the Plenary for Scientific Advice would each meet twice per year, probably once in the spring and once in the fall. The species or issues to be considered at each meeting will depend on the timing of the need for management information. Stock Assessment Review Committee meetings will probably take a full week each time, while Plenary meetings are expected to last about three days. Stock Assessment Review Committee meetings should occur about two weeks prior to Plenary meetings. Assessment requests may be submitted to the Steering Committee at any time during the year. However, special meetings of the Stock Assessment Review Committee (or the Plenary for Scientific Advice) would only be set up in unusual circumstances where the Steering Committee determined that the problem warranted immediate attention.

Research Documents: The forerunners of Research Documents are Working Papers that have received preliminary approval for upgrade by either the Stock Assessment Review Committee or the Plenary for Scientific Advice. Once WGs or individuals have completed the upgrades, the Research Documents will be submitted to a speedy review process, to be determined by the Steering Committee. Research Documents should appear in final form within 60 days of the Stock Assessment Review Committee or Plenary for Scientific Advice meetings.

NEW WORKING GROUPS

LOBSTER ASSESSMENT WORKING GROUP (WG #26)

Members: J. Idoine (Chair, NEFC), M. Fogarty (NEFC), NERO Staff representative, ASMFC representative(s).

Terms of Reference

1. Investigate feasibility of combined inshore/off-shore lobster assessment.

2. Develop list of data requirements and collection techniques for lobster assessments.
3. Evaluate available information on migration patterns of lobster (relative to item 1 above).

RESEARCH EVALUATION OF REPORTING REQUIREMENTS FOR VARIOUS FLEET COMPONENTS OF SQUID FISHERIES (WG #27)

Members: Tom Hoff (Chair, MAFMC), Steve Murawski (NEFC), Andy Rosenberg (NEFC), Anne Lange (NEFC/MD DNR), NEFMC Representative, NERO Representative, Arnie Howe (MA DMF)

Terms of Reference

1. Evaluate Falklands experience with squid relative to daily reporting requirements of fleets and usefulness of data in population estimates.
2. Look at historical CPUE data and then propose appropriate comparisons of population estimates derived from fishing fleet data with NEFC survey abundance indices.
3. Select components of fleets (*i.e.* inshore Mass fishery or freezer trawlers segments of fleet) for data reporting.
4. Suggest to MAFMC and RO that changes in reporting accompany quota setting process.

SPECIAL TOPICS

SAFE REQUIREMENTS AND THE STATUS OF FISHERY RESOURCES REPORT

The discussion on SAFE (Stock Assessment and Fishery Evaluations, as dictated by 602 regulations) requirements and their relevance to the current Status of Fishery Resources Report ("Status of Stocks") produced by NEFC occurred at two separate sessions during the SAW, reflecting the considerable debate and lack of complete consensus on all associated issues. During these discussions the intent of the SAFE procedures, the required content of SAFE reports, and the responsibilities and procedures for preparing SAFE reports were discussed. Alternative proce-

dures for preparing SAFE reports based on various products already generated within the Council and NMFS systems were evaluated.

With respect to the content of SAFE reports, it was stressed that such contents will and can vary with the condition of the resources and requirements of the FMPs. However, it is apparent that the SAFE reports are intended to represent a current evaluation of the biological condition of the resources, relative to overfishing definitions.¹ The content of the SAFE documents should reflect the specifics of particular FMPs. The detailed economic analyses to be included in the SAFEs are unclear. If there are specific economic reference points or economic performance objectives in an FMP, then the SAFE report should include sufficient economic information to address the determination of those reference points.

Considerable debate focused on the adequacy of the current NEFC Status of Stocks document as the basis for the SAFE reports, and which additional information would be required to fulfill the SAFE report requirements. Generally, it was noted that a combination of information currently contained in the Status of Stocks document, combined with Stock Assessment Workshop (SAW) reports, and various other documents specific to particular FMPs would suffice the purpose of SAFE report preparation. In particular, bioeconomic and fishery performance data contained in annual quota determination papers for several Mid-Atlantic Council FMPs were judged to be essential items for the SAFE reports.

The group considered for each FMP the adequacy of the Status of Stocks and SAW documents, and which additional items would be necessary in SAFE report preparation:

New England Council

1. Lobster FMP

Although an overfishing definition has yet to be proposed for this stock, information in the current Status of Stocks document, supplemented with data relevant to the overfishing definition (e.g. current F levels, etc.) would probably fulfill the SAFE requirements for this FMP.

2. Multispecies FMP

It was suggested that the Status of Stocks document could in theory serve as the SAFE report, but that certain additional data would be required, including estimates of "current" fishing mortality rates, along with values of F_{REP} , F_{MED} current percentMSP,

and short-term (2-3 year) projections of fishery performance and stock sizes under both "current" fishing mortality and exploitation patterns, and those associated with the management targets.

3. Sea Scallop

With respect to the Sea Scallop FMP, although no overfishing definitions have been agreed upon by the Council, they are likely to be related to fishing mortality, percentMSP, and/or minimum biomass goals. Thus, if the Status of Stocks document is to serve as the SAFE report, current evaluations of these types of exploitation measures would be required. With respect to the Sea Scallop FMP some measures of the economic performance of the fishery will perhaps be required to be included in the SAFE report.

Mid-Atlantic Council

4. Squid, Mackerel, Butterfish FMP

Annual quota determinations consistent with biological reference points, as modified by several economic factors are required for this FMP. The quota setting process is highly time-bound, with the annual updates of stock status required by June. The Status of Stocks document is currently not produced in a timely enough fashion, but the spring SAW document (including assessments of squids and butterfish) meets the needs of the Council. Mackerel stock status has in the past been evaluated during the summer (with the availability of winter catch at age data, and catch information from Canada). The results of the summer evaluation of mackerel stock status were then transmitted from the NEFC to the Council. Although this system currently meets the Council's needs, it doesn't allow for peer-review of the assessment advice for mackerel, except after the fact. The current Status of Stocks document information, along with the SAW reports and quota papers produced by the Mid-Atlantic Council for this FMP will be sufficient for the SAFE report.

5. Surf Clam - Ocean Quahog FMP

As with the Squid-Mackerel-Butterfish FMP, the Surf Clam-Ocean Quahog FMP requires certain timely bioeconomic information not currently included in the Status of Stocks document. In particular, the quota paper produced by the Council includes information on fishery performance, economic conditions and marketing, that are not included in the Status of Stocks or SAW reports on the population status of surf clam or ocean quahog. It was suggested that Mid-

¹ 602.12 (e) (1): "The SAFE report is a document or set of documents that provides Councils with a summary of the most recent biological condition of species in the fishery management unit (FMU), and the social and economic condition of the recreational and commercial fishing interests and the fish processing industries." -- [Ed. note.]

Atlantic Council quota papers could be reviewed as SAW quota reports, and vetted at the proper level of the revised SAW process.

6. Summer Flounder, Scup, Sea Bass

The current Status of Stocks document could in principle be used for SAFE report preparation, however, there are critical data on the status of exploitation of these stocks that are currently incomplete or lacking in the Status of Stock document, including current fishing mortality rates, stock sizes, *etc.* Based on anticipated provisions in the FMP, if these three stocks were considered at the spring SAW, the SAW report would likely be a critical piece of the SAFE report.

Other FMPs

7. Bluefish, Striped Bass, Northern Shrimp

These stocks are currently regulated within inter-jurisdictional formats (*e.g.* with ASMFC). With respect to bluefish, an annual assessment update is required by August 15, thus material presented at the spring SAW would be timely enough for inclusion in the evaluation process. For the other two species, consultation with ASMFC and other state representatives would be required to evaluate the content and timeliness of data necessary for SAFE determination.

8. Red/Silver Hakes

Current plans call for these stocks (4) to be included in the Multispecies FMP of the New England Council. Thus, in this event, data requirements specified for that FMP (see 2.) would apply.

A further complication discussed was the timeliness of the Status of Stocks document, and if the current production schedule for that document was timely enough for the SAFE report. It was concluded that if the Status of Stocks document was to serve as the essence of the SAFE report, that additional resources would be required in its production, to meet the time requirements dictated by the 602 regulations.

Finally, the SAW considered a working paper prepared by NEFC staff, outlining the current (1989) determinations of exploitation levels appearing in the 1989 Status of Stocks document. The definitions appearing in the Status of Stocks (underfished, fully exploited, overfished) are not currently based on explicit overfishing definitions proposed by the Councils, but rather are a synthesis of available population and fishery data, relative to a series of quantitative and qualitative criteria commonly used when determining the status of fisheries. For each stock evaluated in the Status of Stocks document, current trends in abun-

dance, catch (and Fs where available) are reviewed as potential criteria for a summary exploitation determination. The SAW, however, was unwilling to come to a consensus as to each of these summary evaluations because of the potential conflicts that may arise between determinations based on the Council's explicit overfishing definitions, and the summary evaluations appearing in previous Status of Stocks documents. Thus, the SAW was unable to offer guidance on such determinations to appear in the next edition of the Status of Stocks document.

STATUS OF GEORGES BANK SEA HERRING

Introduction

The fishery for herring on Georges Bank (5Z) began in 1961 and grew rapidly. Landings by a multinational fleet using a variety of gear types increased to 374,000 t in 1968 and yielded approximately 2.7 million t before crashing in 1977 (Anthony and Waring 1980).

For several years, there was virtually no sign of either adults (Azarovitz and Grosslein 1987) or larvae (Smith and Johnson 1986) from what had once been estimated to be the largest herring population in the northwest Atlantic. In recent years (since 1984), however, there has been increasing indication of reappearance of Georges Bank herring, including evidence of spawning and substantial number of larvae.

Two working papers dealing with recent Canadian and U.S. research were presented to the SAW. In this report, we summarize the status of Georges Bank herring with particular reference to population recovery and the source of the apparent resurgence of this stock.

Stephenson and Kornfield (1990) demonstrated that herring collected on Georges Bank were genetically distinct from individuals collected on the Scotian Shelf and elsewhere in the Gulf of Maine. Here, we infer an important linkage between the apparent resurgence of the Georges Bank stock and herring from the Nantucket Shoals region. These results have important implications for inferences regarding the stock structure of herring in this area and the mechanisms involved in stock separation (Iles and Sinclair 1982; Sinclair and Iles 1985; Sinclair, 1989).

Chronology of the Reappearance of Herring on Georges Bank

The absence of Georges Bank herring after the collapse of the fishery in 1977 was indicated by

MARMAP (1977-1987) larval surveys (e.g., Smith and Johnson 1986) and NEFC groundfish surveys (e.g., Azarovitz and Grosslein 1987).

Evidence for reappearance has been compiled primarily from US and Canadian surveys for larvae (oblique bongo tows) and from the appearance of adult herring in research bottom trawl surveys, with additional observations from occasional cruises for other species and the commercial fishery.

The first indication of reappearance was postlarval herring taken by International Young Gadoid Pelagic Trawl (IGYPT) in the spring of 1984 (1983 year-class). Research bottom trawl surveys began picking up prespawning adult herring in the spring of 1986 and the first spawning adults in the fall of 1986; these were almost exclusively of the 1983 year-class. Key information came in the fall of 1986 with the verification of ripe herring in both Department of Fisheries and Oceans, Canada (DFO) and NEFC groundfish trawl surveys of Georges Bank.

Since 1987 DFO (Canada) has documented larvae and spawning adults in annual (November) surveys of Georges Bank. Since 1988, NEFC has documented the spatial and temporal distribution of larvae in a series of four larval surveys of Georges Bank and Nantucket Shoals. Adult herring have been recorded in increasing numbers in the bottom trawl surveys of both countries.

Larval Distribution

Summaries of ICNAF larval herring surveys during 1971-76 indicated two distinct loci of recently hatched (4 to 7mm) larvae in the northeast peak of Georges Bank and in the Nantucket Shoals region (Smith and Morse, in prep. Figure 48). Abundance levels of recently hatched larvae were sharply reduced on Georges Bank in MARMAP surveys conducted from 1977-82 (Figure 49). No recently hatched larvae were obtained on Georges Bank proper during 1983-1987 and the occurrence of early stage larvae was confined to the Nantucket Shoals region and the Cape Cod region (Figure 50). In 1988, the dominant production regions remained Nantucket Shoals and the Cape Cod area although some early stage larvae were obtained on the central plateau of Georges Bank (Figure 51). The distribution of latter stage larvae (>7mm) in all years was consistent with diffusion and some advection from the apparent production centers (Figures 48-51).

Canadian surveys of the outer part of Georges Bank since 1987 have documented the occurrence of larvae along the northwestern edge of the bank (Figures 52a-52c). The finer spatial resolution of the Canadian survey indicated the occurrence of early stage larvae in 1987, which was not shown in the

corresponding MARMAP survey (Figure 53).

Trends in production of larvae on Georges Bank and Nantucket Shoals for the period 1971-88 are provided in Figure 54. By 1977, larval herring on Georges Bank were no longer detected in larval surveys. In contrast, some residual production was evident on Nantucket Shoals during 1977-83. Evidence of increased larval production during 1985-88 was first centered on Nantucket Shoals and substantial levels of larval production were not observed on Georges Bank until 1988.

Bottom Trawl Surveys

Shifts in the abundance and distribution of herring during the spawning season are evident in autumn bottom trawl surveys conducted by NEFC since 1963. During 1963-70 herring on Georges Bank were concentrated along the northern edge and on the southern flank of the bank (Figure 55). Catches during 1971-76 and 1977-81 declined markedly relative to 1963-70, but occurred primarily on the northern edge of Georges Bank and in the Nantucket Shoals region. Large scale increases in abundance were evident during 1982-89 with the dominant catches occurring on the northern edge of the bank (notably, the northwest corner) and Nantucket Shoals.

Trends in stratified mean catch per tow indicate a sharp increase in abundance on Georges Bank since 1986. Abundance levels for strata 13-23 increased dramatically in 1988, largely the result of two large catches in stratum 23. Abundance estimates excluding stratum 23 show a general increase since 1986, but of far lower magnitude than for strata 13-23. The dominant influence of stratum 23 is consistent with the pivotal role of increases in abundance in the northwest corner of Georges Bank and on Nantucket shoals.

Examination of the relative age composition of herring collected in US surveys during 1987-89 (Figure 56) show a dominance of three year old fish (with the exception of 1987, which was dominated by ages 3 and 4). This may suggest that the fish are being recruited from other areas (although differential vulnerability of capture on the spawning grounds cannot be discounted). Age distributions from the Canadian herring surveys (Figure 56) are similar, but show dominance by 1984 and 1986 year classes.

Stock Identification

Ongoing studies of stock identification based on meristic, morphometric, parasites and genetics have revealed a few interesting differences in Georges Bank

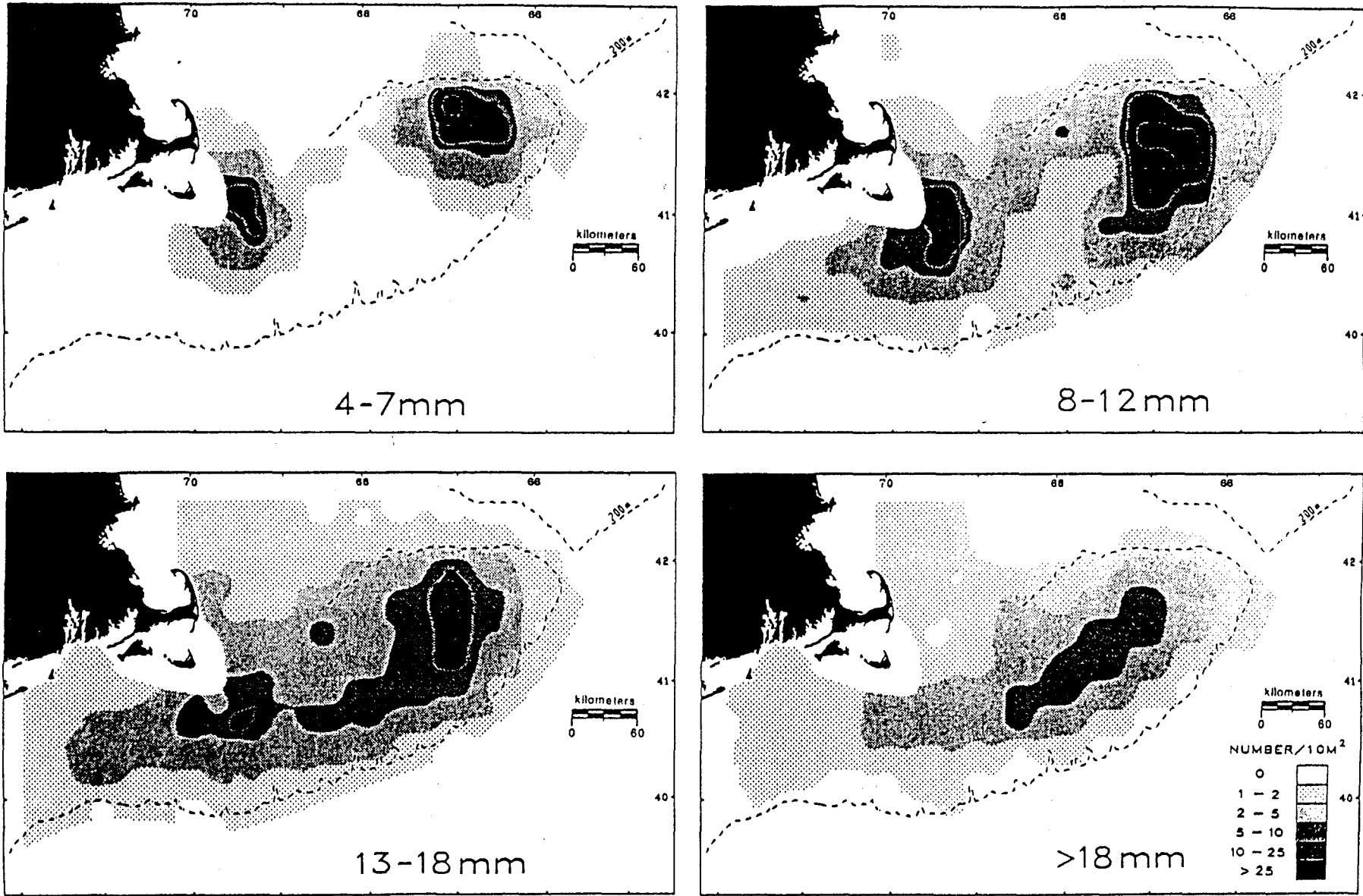


Figure 48. Composite representation of the distribution of herring larvae in ICNAF ichthyoplankton surveys during 1971-1976.

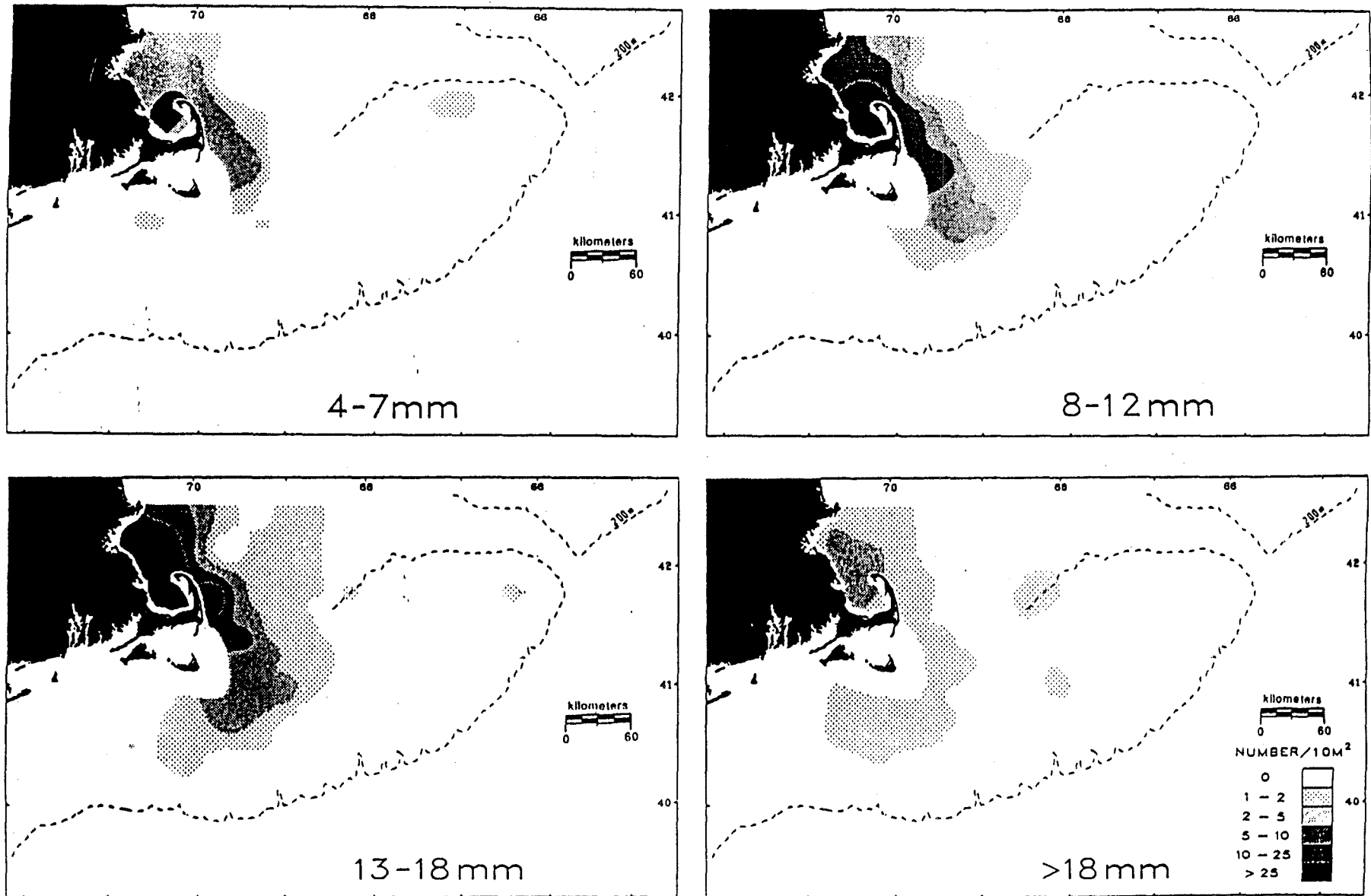


Figure 49. Composite representation of the distribution of herring larvae in ICNAF ichthyoplankton surveys during 1977-1982.

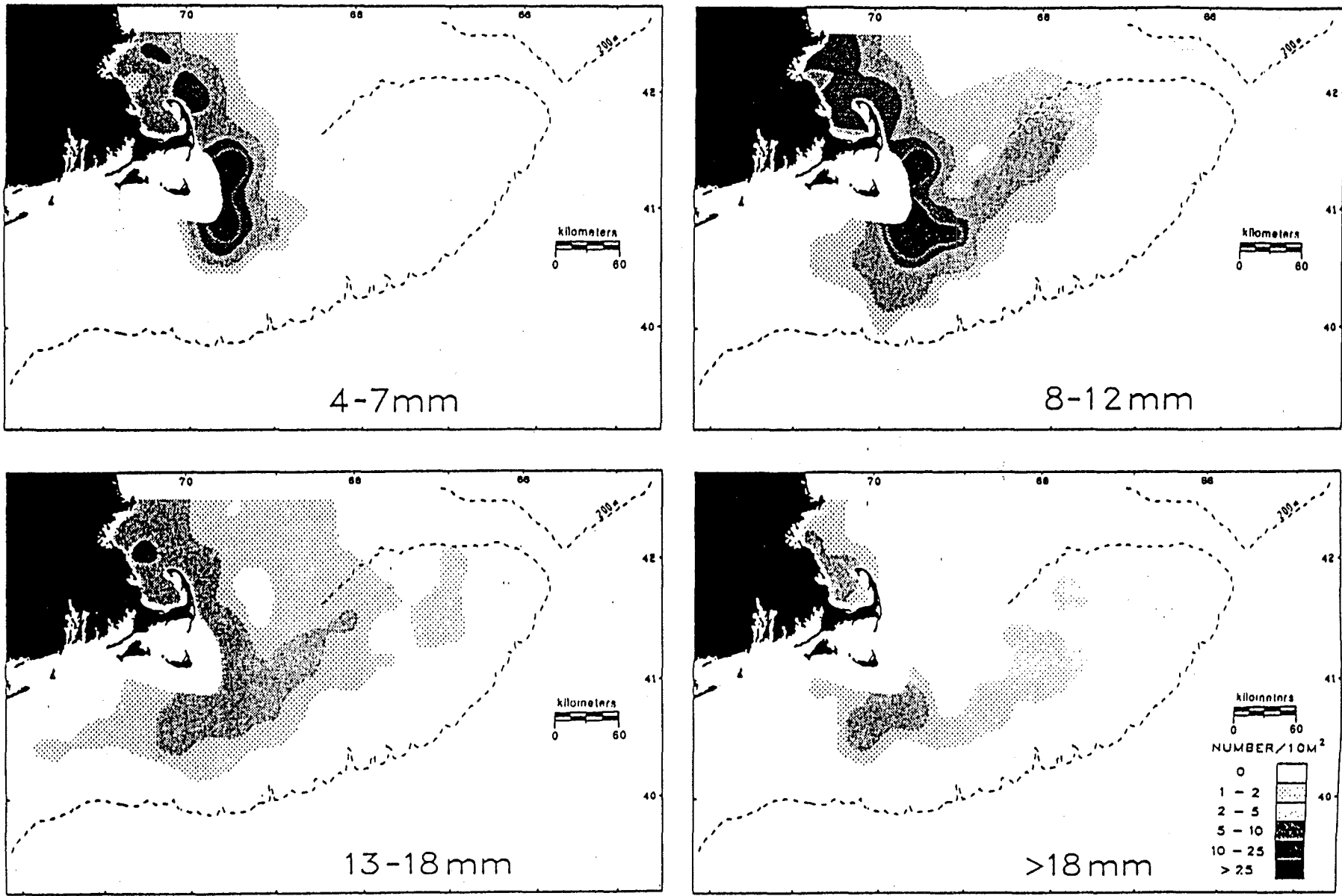


Figure 50. Composite representation of the distribution of herring larvae in ICNAF ichthyoplankton surveys during 1983-1987.

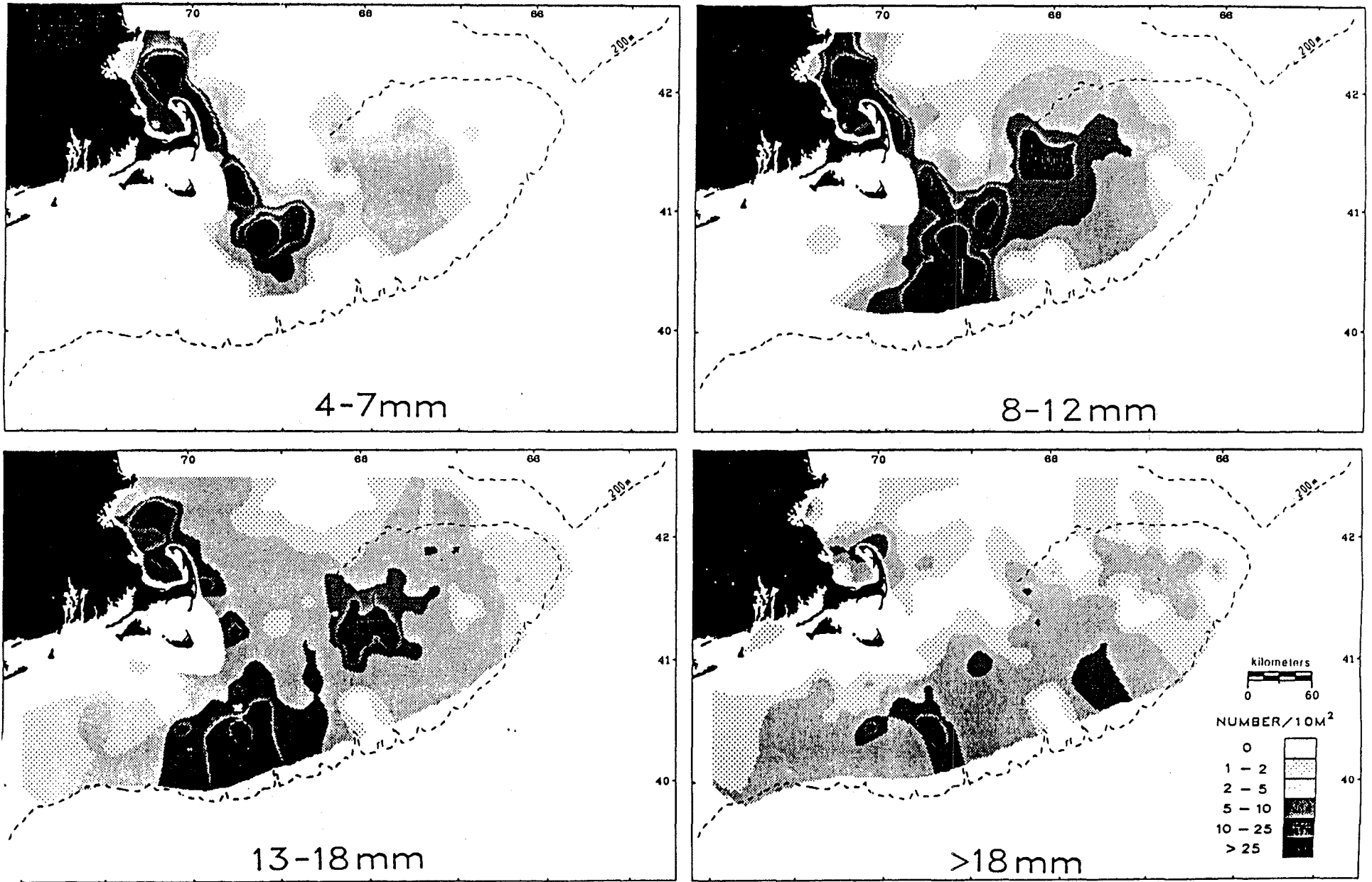
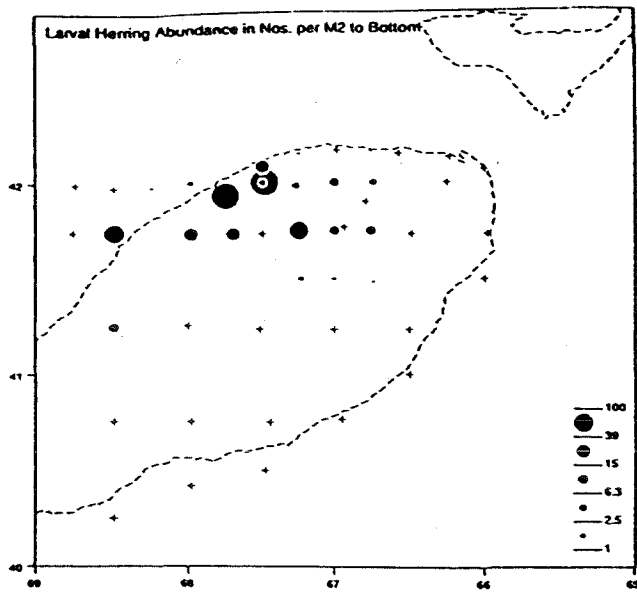
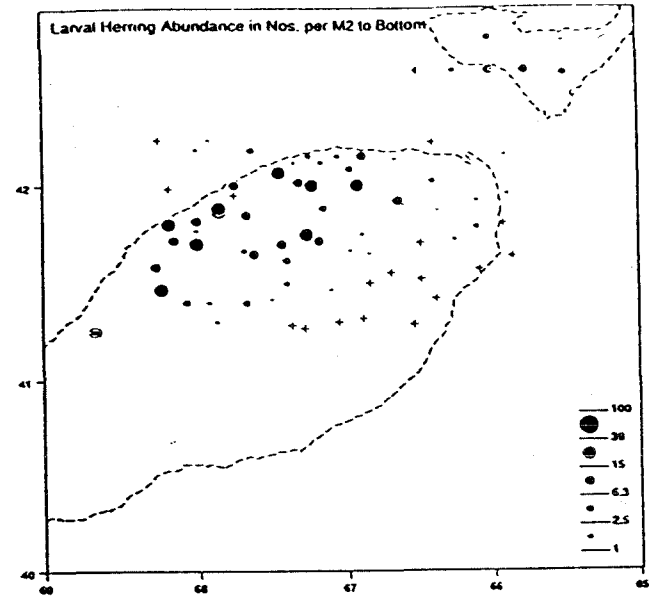


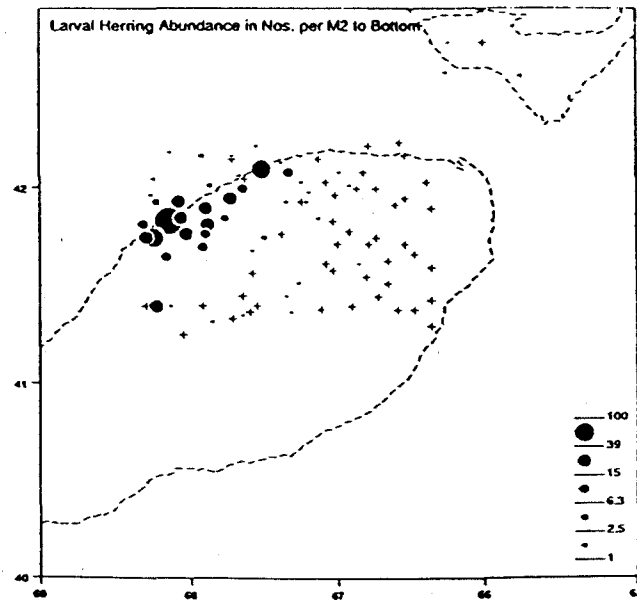
Figure 51. Distribution of herring larvae in directed larval herring surveys during 1988.



H181 (NOV. 1987) Georges Bank Survey - Port Bongo



H195 (NOV. 1988) Georges Bank Survey - Port Bongo



H207 (NOV. 1989) Georges Bank Survey - Port Bongo

Figure 52. Larval herring abundance (no. m⁻²) from Canadian autumn Georges Bank herring surveys: A: 1987 (H 181); B: 1988 (H 195); C: 1989 (H 207).

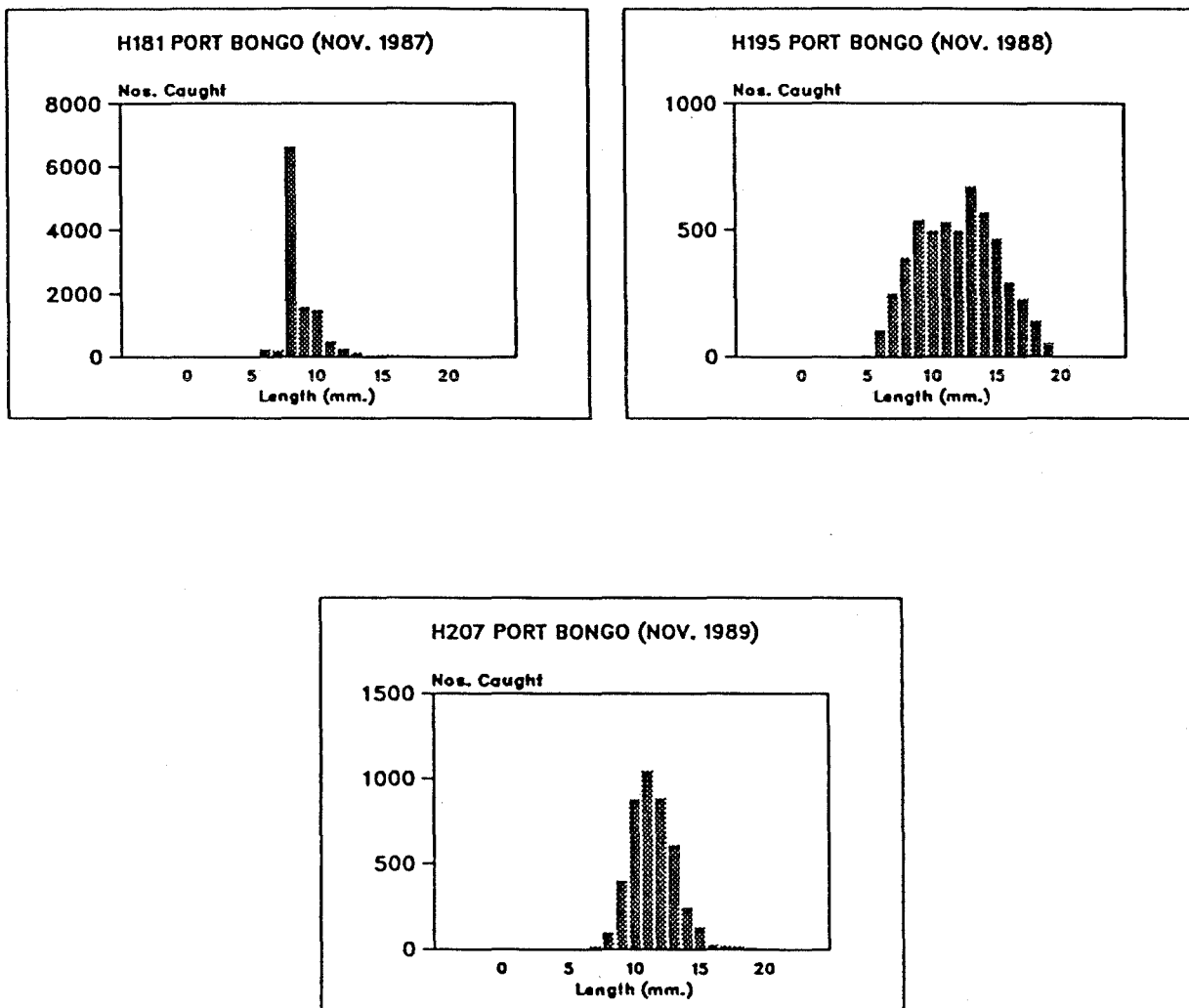


Figure 53. Length frequency distribution of larval herring from Canadian surveys of Georges Bank in November 1988 (H 195) and 1989 (H 207).

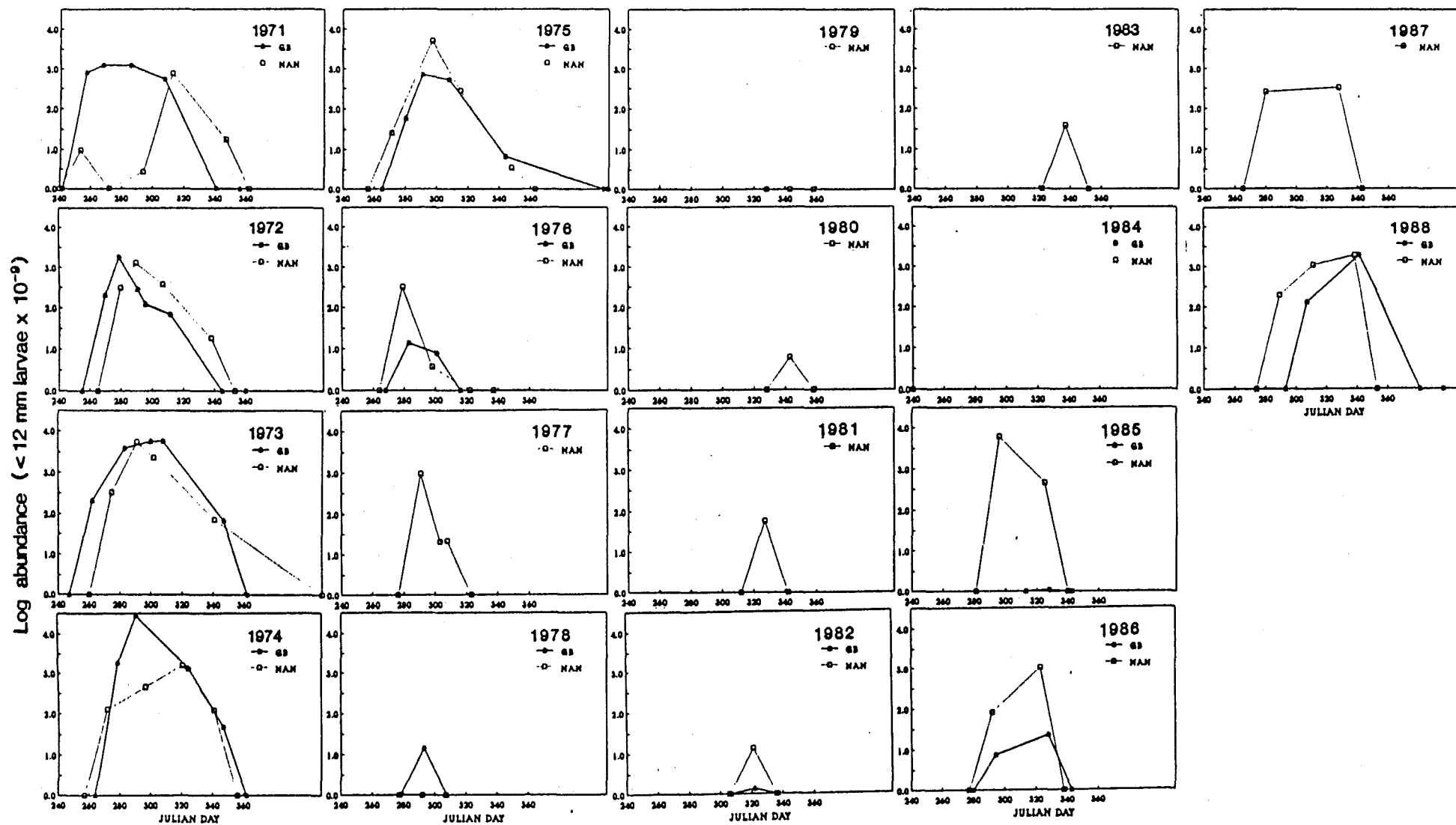


Figure 54. Abundance trends of larval herring (<12 mm) for Georges Bank and Nantucket Shoals, 1971-1988.

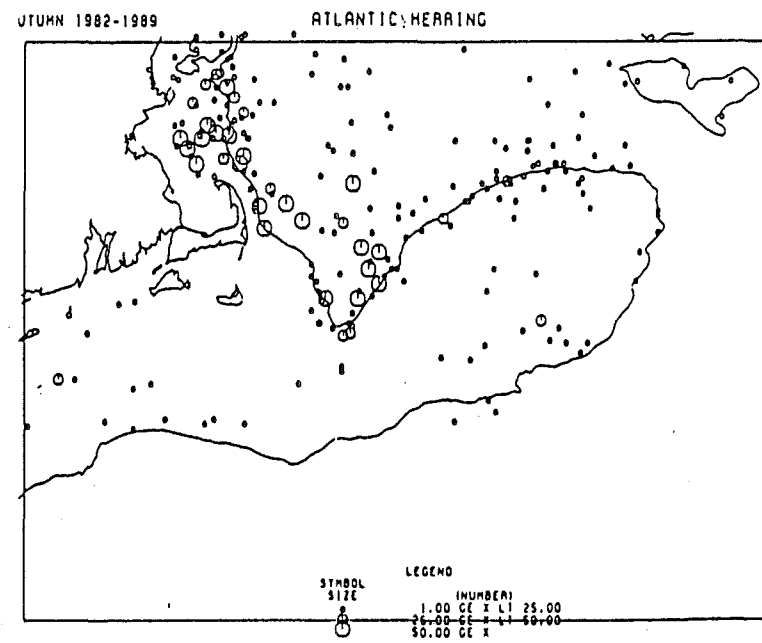
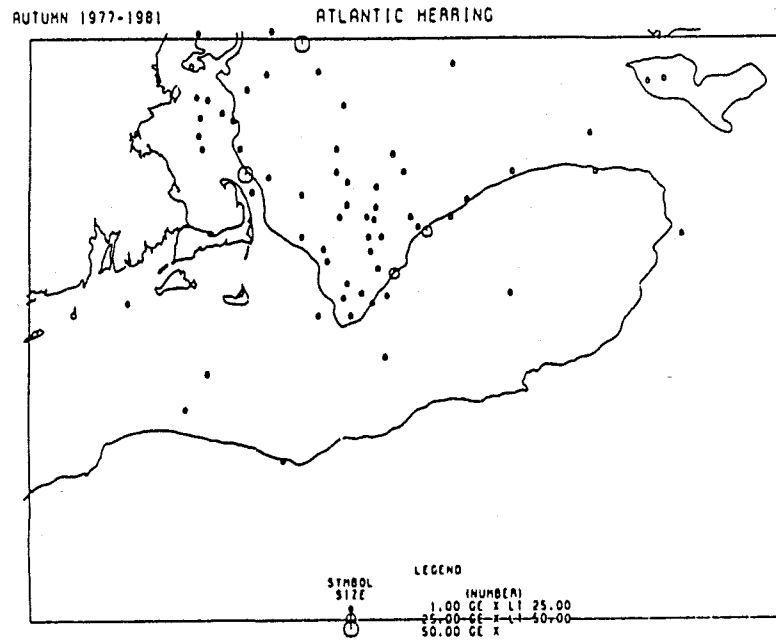
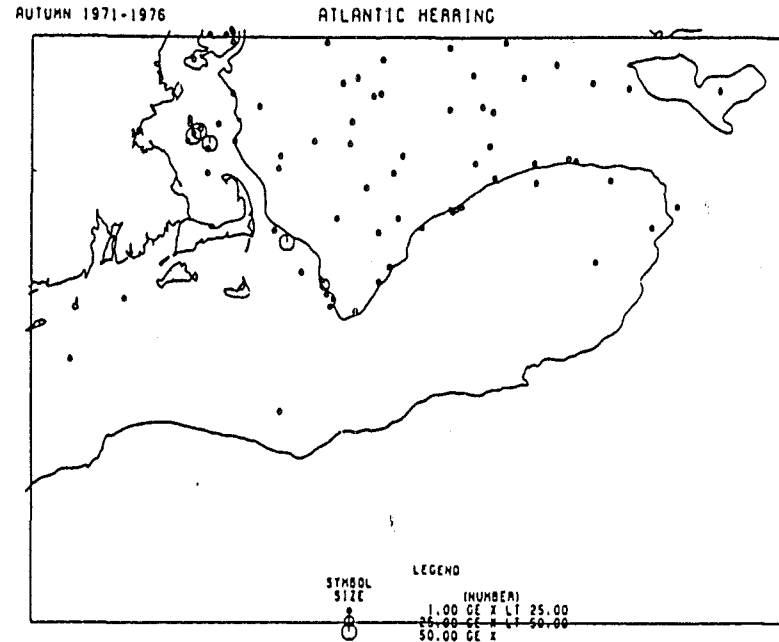
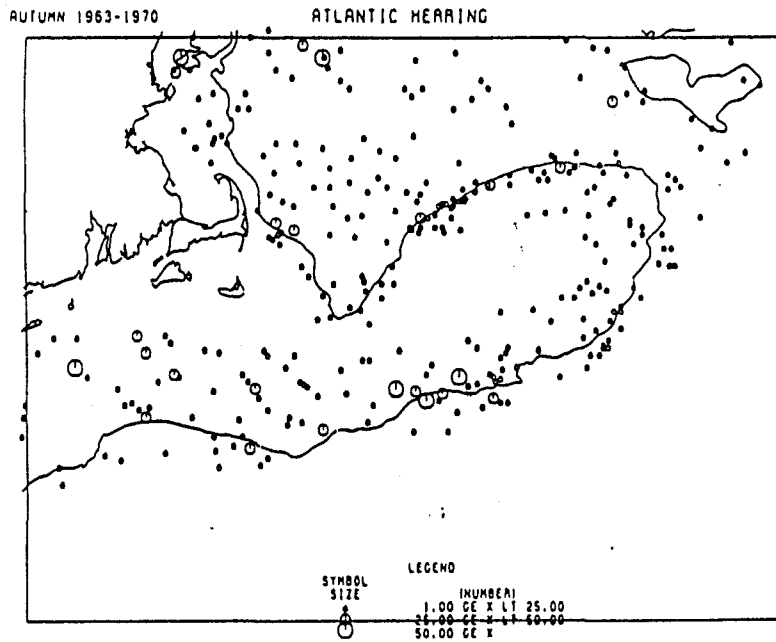


Figure 55. Composite representation of the distribution of herring in NEFC autumn bottom trawl surveys during 1963-1970, 1971-1976, 1977-1981, and 1982-1989.

samples relative to other assessment units in the Gulf of Maine including differences in the isozyme PGI-2 (Stephenson and Kornfield 1990) and in prevalence of the parasites of the *Scolex pleuronectes* group.

Prognosis

Recovery of the Georges Bank stock continues, but there is insufficient information at present to provide a definitive estimate of population size. Larval surveys have documented successful spawning in recent years, but spawning on the outer portion of Georges Bank still appears to be much less than pre-collapse levels. These results suggest that the apparent recovery of herring populations in Nantucket Shoals-Georges Bank region since the mid 1980s may have been initiated by increased larval production in the Nantucket Shoals area and is progressing in an easterly direction. Larval herring surveys in 1988 provide some indication of spawning on the historically important grounds in the northwest corner of Georges Bank, but that all of the traditionally important spawning grounds on Georges Bank (e.g., the Northeast Peak) had not been reoccupied by 1988.

Research survey ground trawl catches of herring show recruitment of additional year classes, but the population is still relatively young (since 1983 year class) and dominated by ages 3 and 4. The Georges Bank stock appears to be in the early stages of recovery and it is premature to consider a directed fishery.

Discussion of Status of Georges Bank Sea Herring

Several recent surveys (e.g., by Maine Department of Natural Resources, Bigelow Laboratory) may also provide valuable information.

It was suggested that analysis of the cod and dogfish stomach contents data may be useful for developing a qualitative index of abundance for herring. However, these data will be most useful for developing a quantitative index if prey preference can be estimated annually.

Relative age composition data from the NEFC Autumn bottom trawl surveys, 1987-89, do not track recent herring year-classes in a consistent manner (Figure 56). It was suggested that this may be evidence of fish moving onto Georges Bank from other areas. However, it was noted that the number of herring taken in the survey is small and that the age frequency distributions may be affected greatly by availability and sampling error.

Recent work has established two unique genetic markers in herring taken on Georges Bank. It was

noted, however, that the data used in this study did not include samples from the Nantucket Shoals area. Although there is a clear oceanographic demarcation between Nantucket Shoals and Georges Bank (e.g. thermal fronts), there may be some transport of larvae from Nantucket Shoals to Georges Bank. Considerable discussion ensued on this point. Collectively the available data do not provide a clear resolution to the question of the role of Cape Cod area/Nantucket spawning. In summary, it was noted that the question was not whether spawning is occurring on the Northeast Peak of Georges Bank (supporting resurgence), but whether the recent spawning observed on the Northeast Peak is sufficient to fully explain the observed recovery without possible reestablishment from other areas (e.g. Nantucket Shoals).

A general question was raised concerning the discreteness of herring stocks in the northwest Atlantic. Tagging studies have generally demonstrated discreteness at time of spawning. Age structure also appears to be consistent from year to year on the spawning grounds. However, it is clear that the fish from various stocks mix at other times of the year. However this is appraised, it is apparent that continued analysis on stock identification and discreteness, including genetics, is desirable.

The Stock Assessment Workshop encourages continuation of USA and Canadian evaluation of the recovery of this stock including further investigation of the empirical relationship between bottom trawl surveys indices and the precollapse VPA. It also encourages further work, including larval surveys, to resolve the relationship between spawning on Nantucket Shoals and Georges Bank.

It is suggested that the recovery of the Georges Bank stock be monitored using larval surveys at least until there is evidence of occupation of the historically important spawning grounds. The apparent discrepancy between historical distribution patterns of spawning activity and recent larval distribution indicates that caution should be exercised for this resource until the full dimensions of the recovery can be evaluated.

THE 1989 EXPERIMENTAL WHITING FISHERY ON GEORGES BANK

Introduction

The 1989 Experimental Whiting Fishery was conducted during 15 June - 31 October. During the fishery, 161 trips were completed by 20 vessels from Pt. Judith, Gloucester, Newport, and Portland. This was a 35 percent increase in the number of trips landed from the 1988 fishery. These vessels fished 1,299 tows, an increase of 28 percent over last years

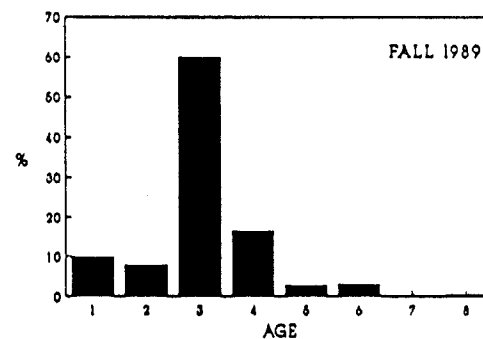
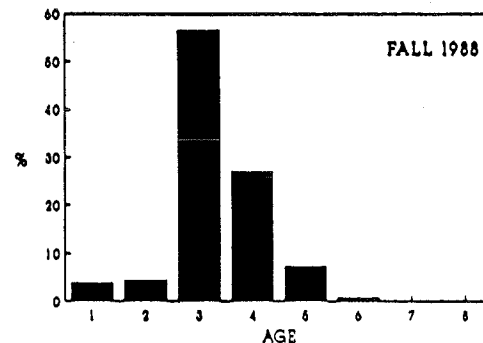
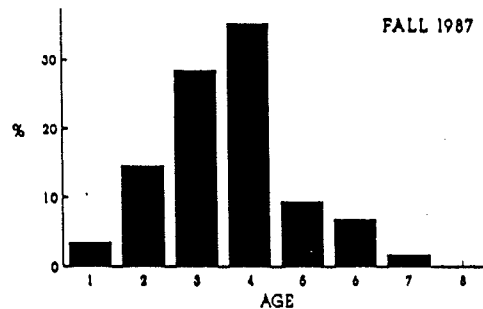
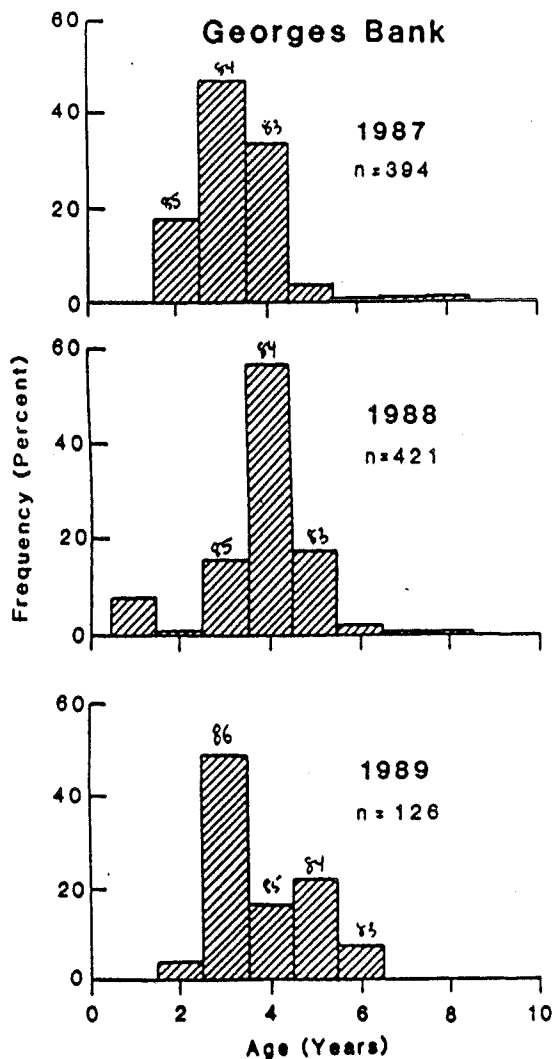


Figure 56. Relative age composition of Georges Bank herring. A: Derived from groundfish trawl data collected on Canadian autumn Georges Bank herring surveys, 1987-1989. B: Derived from herring collected in NEFC autumn bottom trawl surveys, 1987-1989.

1,014 tows. Hours fished were up 15 percent from 1,669 in 1988 to 1,918 in 1989.

Figure 57 indicates the location of each trip made in the fishery. Pt. Judith and Gloucester vessels made 157 of the total 161 trips. The window in which the fishery was allowed to be prosecuted was determined based on a plot of the 1988 catch data indicating the areas (ten minute latitude by ten minute longitude squares) where the heaviest catches of whiting occurred. From this chart an area was outlined in which fishing could take place in 1989. In addition, a 2.5 inch minimum mesh size requirement was set for the cod end of the net.

In 1989, permits were issued by NEFC port agents allowing vessels to fish in the regulated area for up to 2 weeks. A new permit was issued for the next two week period in which a vessel wished to participate in the fishery. Each time a new permit was issued, the vessel was required to turn in logs for the previous two week fishing period. These logs contained effort information and catch in pounds for all species landed or discarded during the previous trip.

Manomet Bird Observatory sea samplers completed tow by tow logs during the fishery under contract with NOAA Fisheries. Ten trips were sampled by these observers in 1989.

ALL TRIPS (JUNE - OCTOBER 1989)

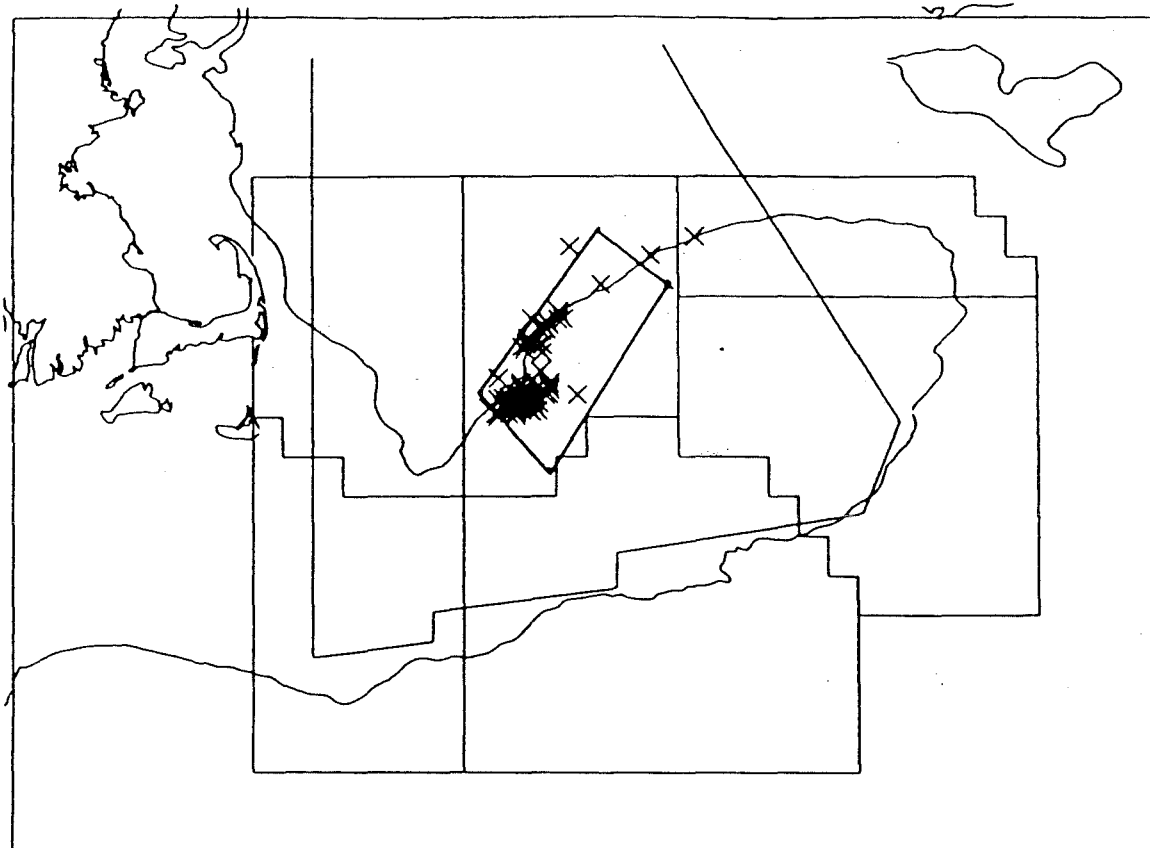


Figure 57. Location of area fished by boats participating in 1989 Experimental Whiting Fishery marked by "x".

Results

Total catch during the fishery was 7,957,112 lbs (3,609 mt) of which 6,526,381 lbs (2,960 mt) were landed (Table 37). Whiting contributed 85 percent of the catch (6,777,719 lbs, 3.074 mt) and 95 percent of the landings (6,205,578 lbs, 2,815 mt). Regulated species catch was only 45,587 lbs (21 mt), or 0.6 percent of the total. Landings of regulated species were correspondingly low with 33,122 lbs (15 mt), or 0.5 percent of total landings. Regulated species catch was composed primarily of cod, white hake, yellowtail flounder, and American plaice (Table 38). Cod at 22,225 lbs (10 mt) made up approximately one-half of regulated species catch and one-half of the regulated species landings (18,422 lbs, 8 mt).

Discarded catch totaled 1,430,731 lbs (649 mt) or 18 percent of total catch, and was composed mostly of whiting, red hake, dogfish, skates, Atlantic herring, and squid.

During the open season, the highest number of trips completed, largest overall total catch and highest catch per unit effort (CPUE) of whiting was ob-

served in August (Table 39, Figure 58, and below). Listed below are the number of trips, catch of whiting, and CPUE by month. CPUE was calculated as the average number of pounds of whiting caught per hour fishing.

| Month | Number of Trips | Total Whiting (lbs) | Average Whiting (lbs) | Whiting CPUE |
|--------------|-----------------|---------------------|-----------------------|---------------|
| June | 6 | 207,700 | 34,600 | 2639.1 |
| July | 34 | 1,314,830 | 38,700 | 3292.8 |
| August | 69 | 3,751,912 | 54,400 | 5195.6 |
| Sept | 31 | 1,028,862 | 33,200 | 2214.0 |
| Oct | 21 | 474,415 | 22,600 | 1839.5 |
| Total | 161 | 6,777,719 | 42,100 | 3533.4 |

About 97 percent of the total August catch came from two 10 minute squares (4,080,958 lbs (1,851 mt) out of 4,190,188 lbs (1,901 mt)), as did 97 percent of the August whiting catch.

Table 37. Summary of 1989 Experimental Whiting Fishery

| | Gloucester | Pt. Judith | Newport | Portland | Total |
|-------------------|------------|------------|---------|----------|-----------|
| No. of Trips | 90 | 67 | 3 | 1 | 161 |
| No. of Tows | 408 | 778 | 39 | 74 | 1299 |
| Hrs Fished | 784.9 | 941.5 | 58.5 | 133.2 | 1918.1 |
| Ave. Tow Duration | 1.9 | 1.2 | 1.5 | 1.8 | 1.5 |
| Total Catch | 2,342,559 | 4,827,451 | 278,030 | 509,072 | 7,957,112 |
| Whiting | 2,114,503 | 4,073,716 | 199,500 | 390,000 | 6,777,719 |
| Reg. Species | 10,793 | 30,092 | 630 | 4,072 | 45,587 |
| Others | 217,263 | 723,643 | 77,900 | 115,000 | 1,133,806 |
| Total Landings | 2,113,356 | 3,882,908 | 189,955 | 340,162 | 6,526,381 |
| Whiting | 2,023,558 | 3,657,020 | 185,000 | 340,000 | 6,205,578 |
| Reg. Species | 8,905 | 22,600 | 455 | 162 | 32,122 |
| Others | 80,893 | 203,288 | 4,500 | 0 | 288,681 |
| Total Discard | 229,203 | 944,543 | 88,075 | 168,910 | 1,430,731 |
| Percent | 9.8 | 19.6 | 31.7 | 33.2 | 18.0 |

Table 38. Summary of species caught in 1989 Experimental Whiting Fishery

| Species | Landed | Discard | Total | Percent of Catch |
|---------------------|------------------|------------------|------------------|------------------|
| Silver hake | 6,205,578 | 572,141 | 6,777,719 | 85.18 |
| Red hake | 254,010 | 440,958 | 694,968 | 8.73 |
| Dogfish | 0 | 178,519 | 178,519 | 2.24 |
| Squid | 10,300 | 98,456 | 108,756 | 1.37 |
| Atlantic herring | 15,129 | 44,264 | 59,393 | 0.75 |
| Skates | 320 | 43,000 | 43,320 | 0.54 |
| Cod | 18,422 | 3,833 | 22,255 | 0.28 |
| Sculpin | 0 | 22,142 | 22,142 | 0.28 |
| Yellowtail flounder | 5,078 | 3,071 | 8,149 | 0.10 |
| Blueback herring | 0 | 6,411 | 6,411 | 0.08 |
| White hake | 1,914 | 4,077 | 5,991 | 0.08 |
| Other fish | 0 | 5,388 | 5,388 | 0.07 |
| American plaice | 3,833 | 1,231 | 5,064 | 0.06 |
| Monkfish | 3,545 | 971 | 4,516 | 0.06 |
| Butterfish | 3,588 | 490 | 4,078 | 0.05 |
| Ocean pout | 0 | 1,730 | 1,730 | 0.02 |
| Haddock | 946 | 502 | 1,448 | 0.02 |
| Scallop | 145 | 1,103 | 1,248 | 0.02 |
| Pollock | 695 | 542 | 1,237 | 0.02 |
| Cusk | 0 | 794 | 794 | 0.01 |
| Jonah crab | 0 | 760 | 760 | 0.01 |
| Mackerel | 723 | 0 | 723 | 0.01 |
| Witch flounder | 618 | 88 | 706 | 0.01 |
| Winter flounder | 614 | 70 | 684 | 0.01 |
| Bluefish | 567 | 0 | 567 | 0.01 |
| Porbeagle | 275 | 0 | 275 | <0.01 |
| Fourspot flounder | 0 | 116 | 116 | <0.01 |
| Redfish | 2 | 51 | 53 | <0.01 |
| Lobster | 30 | 20 | 50 | <0.01 |
| Swordfish | 35 | 0 | 35 | <0.01 |
| Halibut | 6 | 3 | 9 | <0.01 |
| Wolfish | 8 | 0 | 8 | <0.01 |
| Total | 6,526,381 | 1,430,731 | 7,957,112 | 100.00 |

Table 39. Weekly catch and effort summary of 1989 Experimental Whiting Fishery

| Week | Trips | Hours Fished | Total Catch | Whiting Catch | Percentage of Catch | Regulated Catch | Percentage of Catch |
|--------------|------------|-----------------|------------------|------------------|------------------------|--------------------|------------------------|
| 1 | 0 | 0 | 0 | 0 | | 0 | |
| 2 | 3 | 37.7 | 90,933 | 65,200 | 72 | 1,049 | 1.15 |
| 3 | 3 | 41.0 | 180,673 | 142,500 | 79 | 1,943 | 1.08 |
| 4 | 2 | 34.0 | 94,080 | 35,000 | 37 | 1,230 | 1.31 |
| 5 | 10 | 185.2 | 635,918 | 549,556 | 86 | 12,952 | 2.04 |
| 6 | 6 | 53.1 | 175,336 | 156,000 | 89 | 791 | 0.45 |
| 7 | 8 | 59.0 | 321,615 | 265,500 | 83 | 975 | 0.30 |
| 8 | 22 | 122.7 | 924,964 | 829,836 | 90 | 5,283 | 0.57 |
| 9 | 15 | 136.0 | 782,911 | 701,325 | 90 | 2,175 | 0.28 |
| 10 | 19 | 154.2 | 1,060,454 | 994,500 | 94 | 1,200 | 0.11 |
| 11 | 14 | 272.6 | 1,356,319 | 1,175,625 | 87 | 6,882 | 0.51 |
| 12 | 6 | 90.5 | 437,564 | 359,400 | 82 | 1,719 | 0.39 |
| 13 | 10 | 181.9 | 434,855 | 366,600 | 84 | 2,280 | 0.52 |
| 14 | 6 | 97.0 | 342,564 | 293,630 | 86 | 1,873 | 0.55 |
| 15 | 7 | 109.8 | 293,558 | 199,457 | 68 | 1,067 | 0.36 |
| 16 | 8 | 76.0 | 231,800 | 169,175 | 73 | 1,095 | 0.47 |
| 17 | 8 | 125.4 | 273,246 | 180,615 | 66 | 1,616 | 0.59 |
| 18 | 5 | 52.0 | 79,135 | 72,800 | 92 | 295 | 0.37 |
| 19 | 2 | 22.0 | 26,360 | 24,400 | 93 | 60 | 0.23 |
| 20 | 7 | 68.0 | 214,827 | 196,600 | 92 | 1,102 | 0.51 |
| Total | 161 | 1333.1 | 7,957,112 | 6,777,719 | 85 | 45,587 | 0.57 |

A few of the logbooks received from fishermen included LORAN bearings outside the allowable area for small mesh fishing. Based on data available there was no apparent benefit for them to do this so it is possible incorrect LORAN bearings were listed on the logbooks. It was also possible that these fishing locations were real. An additional possibility of error in these locations may have stemmed from the initial use of Canadian LORAN chains in designating the window. When completing logbooks, no fishermen listed Canadian LORAN bearings.

Size Composition of the Whiting Catch

A review of length frequencies completed by sea samplers showed the most frequent size range of landed whiting was 11-12 inches (27.9-30.5 cm) (Figure 59). The smallest measured landed whiting was 6 inches (15.2 cm) and the longest 20 inches (50.8 cm). A total of 2,551 landed whiting were measured. Of those landed, 86 percent were 11 inches or bigger.

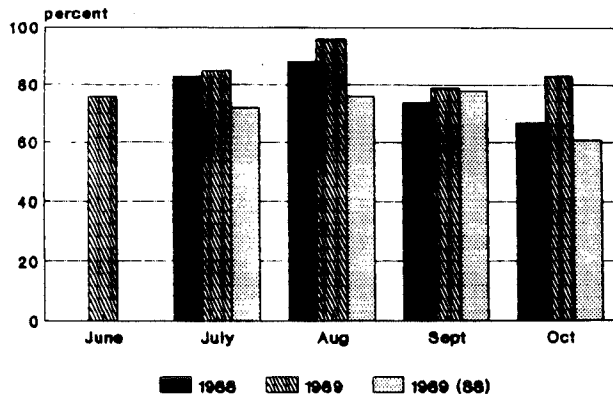
Length frequencies taken of discards showed these were smaller fish. Almost 40 percent of the 3,707 measured whiting discard were 9 inches and 90 percent of all discards were 10 inches or smaller. Based on these data discards were too small to retain for market.

Based on these length frequencies, most of the landed silver hake were 3 years or older and those discarded 2 years or younger. Figures showing the size ranges for red hake, white hake, cod, and American plaice landings and discard are also presented in Figures 60-63. The data indicate that small individuals of each of these species were taken in the fishery.

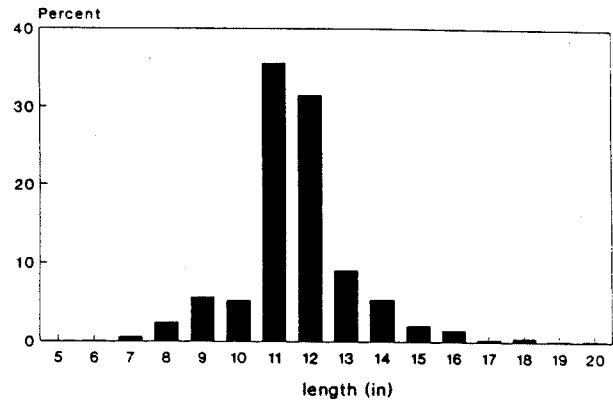
Sea-Sampled vs Non-Sea-Sampled Trips

Ten trips were sampled by onboard observers during the fishery. In sampled trips, whiting accounted for 74 percent of the catch or 13 percent less than reported in non-sea-sampled trips (87 percent). Sampled trips caught more red hake, squid, skates, dogfish and sculpin compared to trips overall. The reported catch of regulated species was higher in sea-sampled trips than in non-sea-sampled trips. However, this percentage was very low (1.34 percent). Cod, white hake, yellowtail flounder, and American plaice were the most prevalent regulated species caught in sea-sampled trips, confirming logbook data from non-sea-sampled trips. These four species accounted for 93 percent of all regulated species caught in sea-sampled trips. In non-sampled trips they represented 91 percent of all regulated species catches. Figure 64

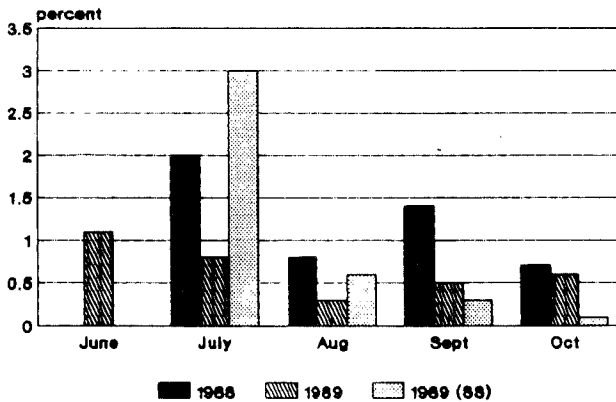
Whiting % of Catch



Whiting Landings Size Composition (2551 fish measured)



Regulated Species % of Catch



Whiting Discard Size Composition (3707 fish measured)

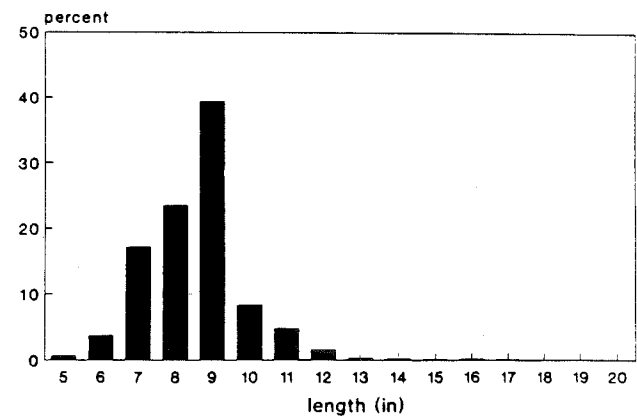


Figure 58. Percentage of catch composed of whiting and regulated species by month, 1988-1989 Experimental Whiting Fishery. SS refers to sea-sampled trips.

Figure 59. Length frequency distribution of whiting landings and discard, 1989 Experimental Whiting Fishery.

gives a monthly comparison of whiting and regulated species catches.

Logbooks vs Weighouts

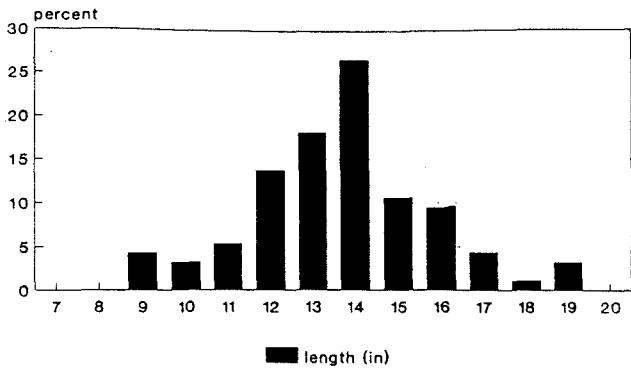
During the Experimental Fishery, fishermen were required to complete a log for each trip. The data from these logbooks were compared with landings data available through the standard NEFC weighout system. Table 40 provides a comparison of species landings based on logbook vs weighout information.

The percentage of total landings contributed by whiting was consistent between logbooks and weighouts. The percentage of total landings consisting of whiting was lowest in June, at 87 percent based on weighout data, compared to 90 percent based on logbook data. The percentage of total landings consisting of whiting was highest in August, at 96 percent

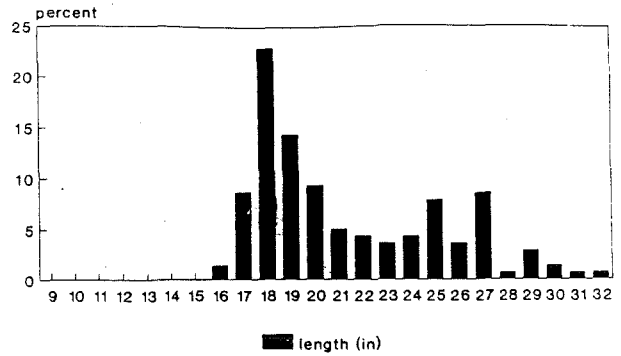
based on both weighout and logbook data. Overall, whiting represented 95 percent of the landings based on logbook data and 94 percent of landings based on weighout data.

Regulated species landings reported in the weighouts differed considerably from those reported in the logbooks. The actual differences however, represented a very small percentage of the total. The largest percentage differences between the two data sources were observed in August and September, when the percentage of total landings consisting of regulated species based on weighout data was twice that observed from logbook data. Based on weighout data, in August, 0.4 percent of the total landings were estimated to consist of regulated species, compared to estimates of 0.2 percent based on logbook data. In September, comparable percentages were 1.2 percent and 0.6 percent, based on weighout and logbook data, respectively. The highest percentages of regulated

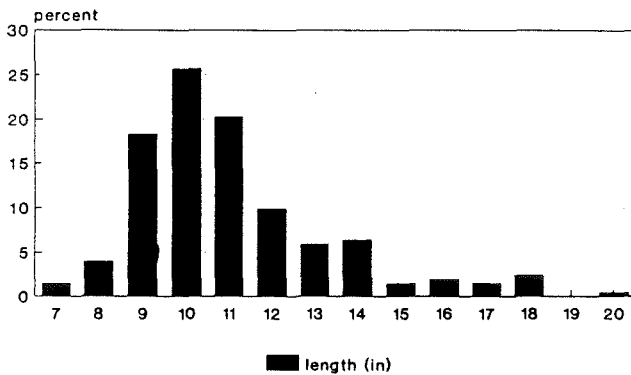
Red Hake Landings Size Composition (94 fish measured)



White Hake Landings Size Composition (140 fish measured)



Red Hake Discard Size Composition (202 fish measured)



White Hake Discard Size Composition (307 fish measured)

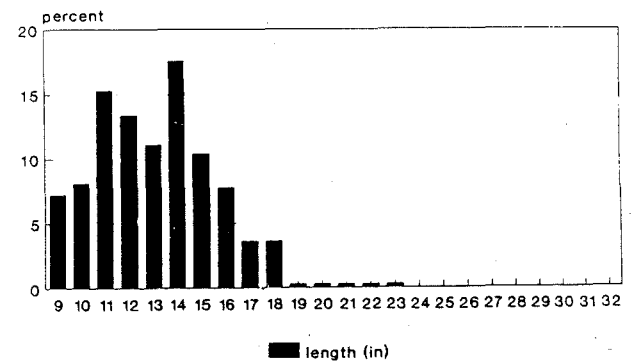
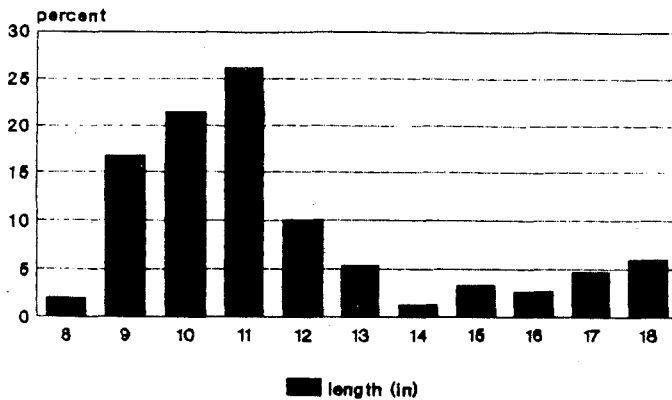


Figure 60. Length frequency composition of red hake landings and discard, 1989 Experimental Whiting Fishery.

Figure 61. Length frequency composition of white hake landings and discard, 1989 Experimental Whiting Fishery.

Cod Discard Size Composition (149 fish measured)



American Plaice Discard Size Composition (388 fish measured)

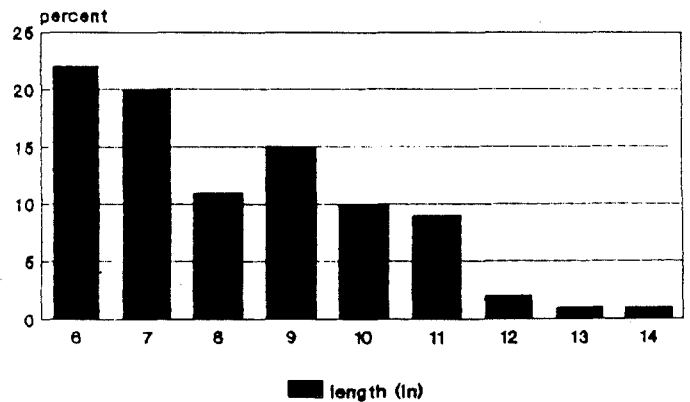


Figure 62. Length frequency composition of Atlantic cod discard, 1989 Experimental Whiting Fishery. No landed cod were measured.

Figure 63. Length frequency composition of American plaice discard, 1989 Experimental Whiting Fishery. No landed American Plaice were measured.

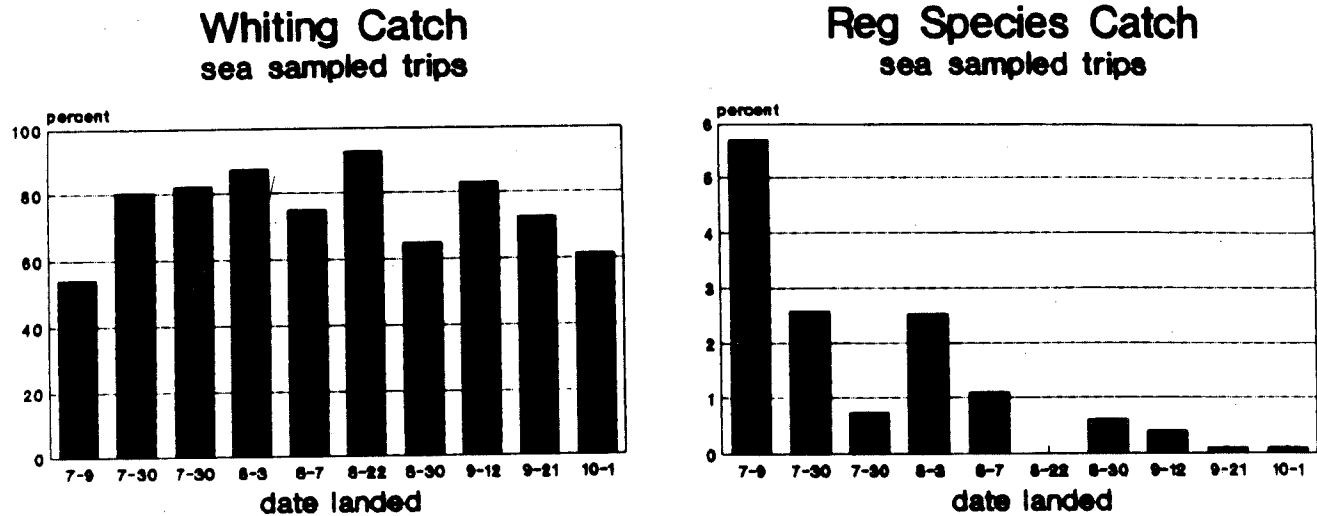


Figure 64. Percentage of catch composed of whiting and regulated species, based on sea sampled trips throughout the 1989 Experimental Whiting Fishery.

species in landings (based on weighout data) were observed in June (1.7 percent) and July (1.5 percent). Total regulated species landings equalled 32,122 lbs (15 mt) based on logbook data vs 42,804 lbs (19 mt) when based on weighout data (33 percent higher).

Landings for Pt. Judith from logbooks totaled 3,657,020 lbs (1,659 mt) of whiting while landing based on weighouts totalled 3,216,979 lbs (1,459 mt). The difference between the logbook and weighout estimates was due to poor quality fish which were discarded dockside. This was not true for regulated species. Weighouts listed 30,765 lbs (14 mt) compared to 22,600 lbs (10 mt) from logbooks, or 36 percent more from dealers' records than indicated by fishermen. Even though there was considerable difference between logbook and weighout data for regulated species, landings were still very low. In logbooks regulated species were 0.6 percent vs 0.9 percent in weighouts. Figure 65 compares Pt. Judith weighout and logbook data.

The differences between sea sampled, logbook, and weighout data are similar. The fishermen tended to underestimate discard of unwanted fish as well as other species retained for market. The differences are small but consistent.

Mesh Size

All the gear used in this year's fishery were otter trawls with a mesh size ranging from 2.5 to 3.5 inches. Below is a breakdown of the whiting and regulated species catch by mesh size, described in Table 41.

Conclusions

Results of the 1989 fishery were about the same as for 1988. The data again showed that a small mesh fishery could take place in the large mesh area without significant catches of regulated species.

Discussion of 1989 Experimental Whiting Fishery on Georges Bank

The brief discussion following the presentation of the results of the Experimental Fishery revolved primarily around the potential effects a small mesh fishery such as this may have on the Gulf of Maine - Northern Georges Bank whiting stock in light of previous SAW discussions. The NEFMC staff report on percent MSP indicated that this stock may in fact be overfished based on current stock biomass estimates, F levels, and SSB/R analyses. However, it was pointed out that one of the original objectives of this "experimental" fishery was to relieve some pressure from seriously depleted groundfish stocks. Both the 1988 and 1989 experiments have demonstrated that this fishery is one of the 'cleanest' fisheries in New England with very low levels of regulated species bycatch.

The concern was raised that with increasing stock sizes on Georges Bank of other species such as Atlantic herring, the fishery will have to continue to be closely monitored to determine the impact on these stocks. In response, it was also pointed out that the impact on NEFC port agents' and Statistics Investigation staff time of the experimental fishery was very

Table 40. Comparison of landings data from logbooks and weighouts, 1989 Experimental Whiting Fishery

| Species | Logbooks | Weighouts | Percent Difference |
|---------------------------|------------------|------------------|--------------------|
| Silver hake | 6,205,578 | 5,699,129 | -8.2 |
| Red hake | 254,010 | 235,290 | -7.4 |
| Atlantic herring | 15,129 | 32,460 | 114.6 |
| Cod | 18,422 | 20,421 | 10.9 |
| Squid | 10,300 | 12,200 | 18.4 |
| Monkfish | 3,545 | 9,582 | 170.3 |
| Butterfish | 3,588 | 6,210 | 73.1 |
| Yellowtail flounder | 5,078 | 5,452 | 7.4 |
| White hake | 1,914 | 5,402 | 182.2 |
| American plaice | 3,833 | 4,953 | 29.2 |
| Witch flounder | 618 | 3,395 | 449.4 |
| Cusk | 0 | 159 | |
| Redfish | 2 | 80 | 3,900.0 |
| Skates | 320 | 1,780 | 456.3 |
| Winter flounder | 614 | 1,329 | 116.4 |
| Bluefish | 567 | 963 | 69.8 |
| Pollock | 695 | 885 | 27.3 |
| Haddock | 946 | 803 | -15.1 |
| Mackerel | 723 | 723 | 0.0 |
| Wolfish | 8 | 693 | 8,562.5 |
| Porbeagle | 275 | 245 | -10.9 |
| Windowpane flounder | 0 | 84 | |
| Summer flounder | 0 | 78 | |
| Scup | 0 | 76 | |
| Shark unclass. | 0 | 43 | |
| Halibut | 6 | 27 | 350.0 |
| Shad | 0 | 20 | |
| Scallop | 145 | 0 | -100.0 |
| Swordfish | 35 | 0 | -100.0 |
| Lobster | 30 | 0 | -100.0 |
| Total | 6,526,381 | 6,042,482 | -7.4 |
| Total (no whiting) | 320,803 | 343,353 | 7.0 |
| Regulated species | 32,122 | 42,804 | 33.3 |

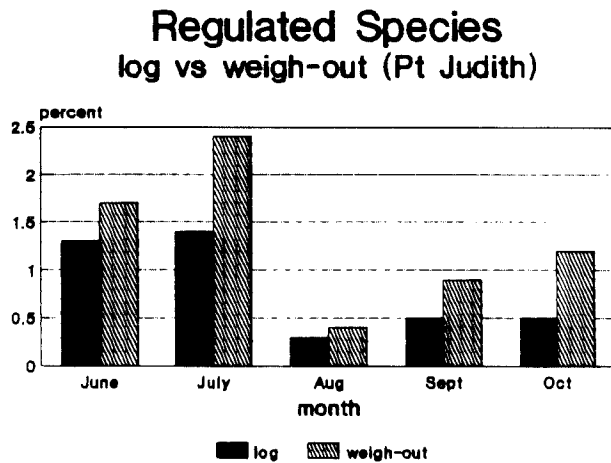
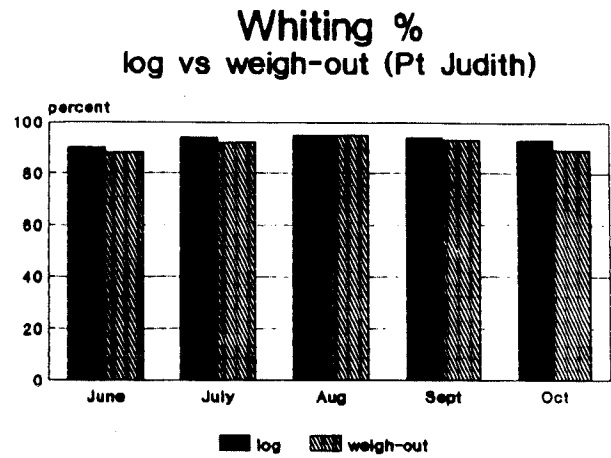


Figure 65. Comparison of landings based on logbook vs sea-sampling data, Pt. Judith, for whiting and regulated species as percentage of total landings, 1989 Experimental Whiting Fishery.

Table 41. Breakdown of whiting and regulated species catch by mesh size

| Mesh (in.) | Tows | Landed (lbs) | Discarded (lbs) | Total | Percentage of Total |
|--------------------------|--------------|------------------|-----------------|------------------|---------------------|
| Whiting | | | | | |
| 2.5 | 623 | 3,240,558 | 235,095 | 3,475,653 | 52 |
| 3.0 | 516 | 2,034,020 | 230,446 | 2,264,466 | 33 |
| 3.5 | 120 | 931,000 | 106,600 | 1,036,600 | 15 |
| Total | 1,299 | 6,205,578 | 572,141 | 6,777,719 | |
| Regulated species | | | | | |
| 2.5 | 623 | 11,766 | 6,332 | 18,108 | 40 |
| 3.0 | 516 | 18,750 | 6,714 | 25,464 | 56 |
| 3.5 | 120 | 1,596 | 419 | 2,015 | 4 |
| Total | 1,299 | 32,122 | 13,465 | 45,587 | |

great and that the 1990 fishery will be far less closely monitored by NEFC staff.

INFORMATION RELATIVE TO THE AUTUMN 1990 SAW AGENDA

A major revision of the structure of the SAW was recommended during this Workshop. Under the proposed new structure, two sets of meetings will be held in the Autumn for the 11th SAW: a week-long meeting of the Stock Assessment Review Committee (SARC) and a 2-3 day meeting of the SAW Plenary. This structure has not yet been approved, which will be problematic for developing agenda topics for the 11th SAW. Accordingly, topics were agreed upon which could fit the new two-meeting structure, but which could also be applied to a single, larger meeting under the current structure if the revision is not approved.

STOCK ASSESSMENT REVIEWS

For the Assessment Review (SARC) portion of the 11th SAW, the suggested topics are:

- (1) Review and resolve the silver hake assessments by further examination of potential errors in the catch-at-age matrix and in the underlying assumptions of the analyses.
- (2) Review MSP calculations for silver hake and other stocks in the multispecies fishery for which sufficient assessment information is available.

- (3) Investigate short-cut methods for updating estimates of the current fishing mortality rate.
- (4) Review assessments for species of particular interest to the ASMFC.
- (5) Compile and review information on the tilefish fishery in preparation for any initiative to develop a management plan.

OTHER SPECIAL TOPICS AND WORKING GROUPS REPORTS

The 11th SAW Plenary is recommended to consider the following issues:

- (1) Review the sea sampling program and preliminary analysis of the samples.
- (2) Review the Atlantic Salmon Assessment Program.
- (3) Discuss results of the Lobster Assessment Working Group (WG #26)
- (4) Discuss the results of the Working Group for Research Evaluation of Reporting Requirements for Various Fleet Components of Squid Fisheries (WG #27).

TIMING

If the new structure is adopted, the SARC meeting will be held the week of October 15, 1990, and the Plenary on November 5-7, 1990. If only one session is held, it should be the week of November 5, 1990.

REFERENCES

- Almeida, F. P. 1987. Status of the silver hake resource off the northeast coast of the United States - 1987. NMFS/NEFC: Woods Hole. Laboratory Reference Document No. 87-03. Available from NEFC, Woods Hole, MA; 02543.
- Anthony, V.C., and G. Waring. 1980. The assessment and management of the Georges Bank herring fishery. *Rapp. P. -v. Reun. Cons. Int. Explor. Mer.* 177:72-111.
- Azarovitz, T.R., and M.D. Grosslein. 1987. Fishes and squids. In Backus, R.H. (ed.). *Georges Bank*. Cambridge, MA: MIT Press, p.315-346.
- Iles, T.D. and M. Sinclair. 1982. Atlantic herring: stock discreteness and abundance. *Science* 215:627-633.
- Lange, A.M.T. 1984. An assessment of the long-finned squid resource off the Northeastern United States- Autumn 1984. NMFS/NEFC: Woods Hole. Laboratory Reference Document No. 84-37. Available from NEFC, Woods Hole, MA; 02543.
- Lange, A.M. 1987. Survey statistics to predict relative availability of the long-finned squid (*Loligo pealei*) to the USA fishery. NMFS/NEFC: Woods Hole, MA. Working Paper# 10, 5th Stock Assessment Workshop. 18p.
- Lange, A.M. and G.T. Waring. (in review). Basis of fishery interactions between long-finned squid (*Loligo pealei*) and butterfish (*Peprilus triacanthus*). *J. NW Atl. Fish. Sci.* (in review).
- Lange, A.M., M.P. Sissenwine, and E.D. Anderson. 1984. Yield analysis for the long-finned squid, *Loligo pealei* (LeSueur). International Council for Exploration of the Sea. C.M. 1984/K:25. 40p.
- Mayo, R., J. McGlade, and S. Clark. 1989. Patterns of exploitation and biological status of pollock (*Pollachius virens* L.) in the Scotian Shelf, Georges Bank, and Gulf of Maine area. *J. Northw. Atl. Fish. Sci.* 9:13-26.
- Mid-Atlantic Fishery Management Council. 1985. Amendment #2 to the Fishery Management Plan for the Atlantic Mackerel, Squid, and Butterfish Fisheries. Dover, DE: MAFMC. 96p.
- Murawski, S. A., and G. T. Waring. 1979. A population assessment of butterfish, *Peprilus triacanthus*, in the northwestern Atlantic Ocean. *Trans. Am. Fish. Soc.* 108:427-439.
- Murawski, S.A. 1986. Assessment update for the ocean quahog, *Arctica islandica*, resource and fishery in FCZ waters off the northeastern USA -- summer 1986. NMFS/NEFC; Woods Hole, MA. Working Paper #I.2, 5th Stock Assessment Workshop. 14 pp.
- Murawski, S.A., J.W. Ropes, and F.M. Serchuk. 1982. Growth of the ocean quahog, *Arctica islandica*, in the Middle Atlantic Bight. *Fishery Bulletin (U.S.)* 80(1):21-34.
- Murawski, S.A., and F.M. Serchuk. 1983. An assessment of the ocean quahog, *Arctica islandica*, resource and fishery in FCZ waters off the northeastern USA - Autumn 1983. NMFS/NEFC: Woods Hole, MA. Woods Hole Laboratory Reference Number 83-25. 32 pp. Available from NEFC, Woods Hole, MA; 02543.
- Murawski, S.A., and F.M. Serchuk. 1989a. Mechanized shellfish harvesting and its management: the offshore clam fishery of the eastern United States. In: J. Caddy, (ed.), *Marine invertebrate fisheries, their assessment and management*. New York: John Wiley and Sons, p.479-506. 752 pp.
- Murawski, S.A., and F.M. Serchuk. 1989b. Environmental effects of offshore dredge fisheries for bivalves. International Council for the Exploration of the Sea. C.M. 1989/K:27.
- New England Fishery Management Council (NEFMC), 1990 MS. Are silver hake overfished? Mimeo. Available from NEFMC, Saugus, MA, 01906.
- Overholtz, W. J., S. A. Murawski and K. L. Foster. (In press). Impact of predatory fish, marine mammals, and seabirds on the pelagic fish ecosystem of the northeastern USA. *Rapp. P.-v. Reun. Cons. int. Explor. Mer.*
- Report of the Eighth Stock Assessment Workshop. 1989. NMFS/NEFC: Woods Hole, MA. Woods Hole Laboratory Reference Number 89-08. Available from NEFC, Woods Hole, MA; 02543.122p.
- Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bulletin of the Fisheries Research Board of Canada* 191. 382 pp.
- Ropes, J.W., D.S. Jones, S.A. Murawski, F.M. Serchuk, and A. Jearld, Jr. 1984. Documentation of annual growth lines in ocean quahogs, *Arctica islandica*. *Fishery Bulletin (U.S.)* 82(1):1-19.
- Shepherd, J. G. 1982. A versatile new stock-recruitment relationship for fisheries, and the construction of sustainable yield curves. *J. Cons. int. Explor. Mer.* 40:65-75.
- Sinclair, M. and T.D. Iles. 1985. Atlantic herring (*Clupea harengus harengus*) distributions in the Gulf of Maine-Scotian shelf area in relation to oceanographic features. *Can. J. Fish. Aquat. Sci.* 42:880-887.
- Sinclair, M. 1989. *Marine Populations: An essay on population regulation and speciation*. Seattle, WA: University of Washington Press.
- Sissenwine, M. P., M. J. Fogarty and W. J. Overholtz. 1988. Some fisheries management implications of recruitment variability. In: J. A. Gulland, (ed.), *Fish Population Dynamics (Second Edition)*. New York: John Wiley and Sons, Ltd., p. 129-153.
- Smith, W.G., and E. Johnson. 1986. Contrasts in distribution patterns of larval Atlantic herring in

- the Georges Bank area, early 1970s vs early 1980s. North Atlantic Fishery Organization. SCR Doc. 86/93.
- Smith, W.G. and W. W. Morse. Recolonization of the Nantucket Shoals/Georges Bank area by Atlantic herring (*Clupea harengus harengus*). Manuscript in preparation.
- Stephenson, R.L. and I. Kornfield. 1990. Reappearance of spawning Atlantic herring (*Clupea harengus harengus*) on Georges Bank: Population resurgence not recolonization. *Can. J. Fish. Aquat. Sci.* 47: 1060-1064.
- Waring, G. T. 1986. An analysis of spatial differences in size composition and abundance of butterfish, *Peprilus triacanthus*, off the northeast United States. NMFS/NEFC: Woods Hole, MA. Woods Hole Laboratory Reference Number 86-04. 23 pp. Available from NEFC, Woods Hole, MA; 02543.

APPENDICES

APPENDIX 1: LIST OF WORKING PAPERS

- WP #1 Assessment Update for Long-finned Squid (*Loligo pealei*), spring 1990 - A. M. Lange.
- WP #2 Report of the SAW Documentation Working Group (SAW WG #25).
- WP #3 Assessment Update for Short-finned Squid (*Illex illecebrosus*) - A. M. Lange.
- WP #4 Report of the Meeting of the Methods Working Group (SAW WG #9).
- WP #5 Status of Butterfish in the Gulf of Maine-Mid-Atlantic Area, June 1990 - G. Waring.
- WP #6 Atlantic mackerel prospectus for 1991-1995 - W. J. Overholtz
- WP #7 Silver Hake Assessment Update, Gulf of Maine-Northern Georges Bank Stock - M. McBride.
- WP #7 Addendum Silver Hake - Northern Stock VPA Calibration with Laurec-Shepherd (L-S) Method - R. Mayo.
- WP #8 Silver Hake Assessment Update, Southern Georges Bank - Middle Atlantic Stock - M. McBride.
- WP #8 Addendum Silver Hake - Southern Stock VPA Calibration with Laurec-Shepherd (L-S) and Hybrid (HY) Methods - R. Mayo.
- WP #9 Status of Stocks at 1989 and Rationale - Conservation and Utilization Division.
- WP #10 Population and Fishery Dynamics of Ocean Quahog, *Arctica islandica*, in the Middle Atlantic Bight - S. A. Murawski, F. M. Serchuk, J. S. Idoine, and J. W. Ropes.
- WP #11 Current and Proposed Sea Sampling Schedules for Discussion - D. Christensen.
- WP #12 Comments on "Conditional" MSY and the Overfishing Definition Problem - V. Anthony.
- WP #13 Status of Georges Bank Herring - Fisheries Ecology Division and Conservation and Utilization Division
- WP #14 Report of the SAW Sea Scallop Working Group (SAW WG #23).
- WP #14 Addendum Biological Submodel Under Development at NEFMC - New England Fishery Management Council Staff.
- WP #15 Reappearance of Georges Bank (5Z) herring: a biological update - R. L. Stephenson, M.J. Power and D. J. Gordon. (Revision of CAFSAC WP 90/129, May 1990.)
- WP #16 Kirkely, J. and W. DuPaul. 1990. Short-run situation outlook: Mid-Atlantic sea scallops. Marine Resources Advisory No. 36 April 1990. Virginia Sea Grant Marine Advisory Services at VIMS/William and Mary.
- WP #17 Are Silver Hake Overfished? and related correspondence - New England Fishery Management Council Staff.
- WP #18 The 1989 Experimental Whiting Fishery on Georges Bank - John Mahoney.

APPENDIX 2: AGENDA

Tenth Stock Assessment Workshop

AGENDA (6/4/90)

4 - 8 June, 1990
 Northeast Fisheries Center
 Aquarium Conference Room
 Woods Hole, MA 02543

Monday, 4 June

| | | |
|-------|---|--|
| 9:30 | Opening remarks Adoption of agenda | A. Peterson, Jr. W. Gabriel, Moderator |
| 9:45 | Report of the SAW Documentation Working Group; Implications for Revisions to SAW Process | P. Mace |
| 11:45 | Lunch | |
| 1:00 | Report of Methods Working Group | V. Anthony |
| 3:00 | SAFE Requirements and the Status of Fishery Resources Report | V. Anthony |

Tuesday, 5 June

| | | |
|-------|---|--------------|
| 9:00 | Assessments of Silver Hake Stocks | M. McBride |
| 11:45 | Lunch | |
| 1:00 | Mackerel Assessment Update | W. Overholtz |
| 1:30 | Butterfish Assessment Update | G. Waring |
| 2:00 | <i>Loligo</i> Assessment Update | A. Lange |
| 2:30 | <i>Illex</i> Assessment Update | A. Lange |
| 3:00 | Ocean Quahog Assessment | S. Murawski |
| 4:00 | Working Session: Specific assessment issues arising from presentations | |

Wednesday, 6 June

| | | |
|-------|---|-------------|
| 8:00 | Working session, continued | |
| 9:30 | Review of available reports (Monday, Tuesday presentations) | |
| 11:15 | Pollock Assessment Update: future directions and issues | R. Mayo |
| 11:45 | Lunch | |
| 1:00 | Report of Sea Scallop Working Group | L. Goodreau |
| 4:00 | Review of available reports (Tuesday presentations) | |

Thursday, 7 June

| | | |
|-------|---|--------------|
| 9:00 | Review of available reports (Wednesday presentations) | |
| 10:00 | Special topic: Georges Bank Sea Herring Recovery | M. Grosslein |
| 11:00 | Results of Working Session(s) | |

| | | |
|-------|---|----------------|
| 11:45 | Lunch | |
| 1:00 | Offshore Lobster Assessment Update: future directions and issues | J. Idoine |
| 2:00 | Report of Sea Sampling Priorities Working Group | D. Christensen |
| 3:00 | Experimental Whiting Fishery, 1989 | J. Mahoney |
| 4:00 | Review of available reports (Wednesday presentations) | |

Friday, 8 June

| | |
|-------|---|
| 9:00 | Finalization of Report (remaining sections) |
| 10:30 | Eleventh SAW: Terms of reference, timing |
| 11:45 | End of session |

APPENDIX 3: LIST OF PARTICIPANTS

NMFS, NEFC, WOODS HOLE

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 Michael Fogarty
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