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The timely need for such information by decision makers often precludes publication in formal journals. The NOAA Technical Memorandum NMFS-F/NEC series provides a relatively quick and highly visible outlet for documents prepared by NEFC authors, or similar material prepared by others for NEFC purposes, where formal review and editorial processing are not appropriate or feasible. However, documents within this series reflect sound professional work and can be referenced in formal journals. Any use of trade names within this series does not imply endorsement.

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(continued on inside back cover)

Wallace W. Morse, Michael P. Fahay, and Wallace G. Smith

Sandy Hook Lab., National Marine Fisheries Serv., Highlands, NJ 07732
MARMAP ATLAS SERIES

This is the second in a series of atlases containing data on the phytoplankton, zooplankton, ichthyoplankton, hydrography, nutrients, or productivity of the Northeast Continental Shelf ecosystem. The sampling was conducted as part of the Marine Resources Monitoring, Assessment and Prediction (MARMAP) Program of the Northeast Fisheries Center. The cooperating institutions in the program are:

AtlantNIRO, Kaliningrad, USSR
College of the Atlantic, Bar Harbor, ME
Institut fur Hochseefischerei, Rostock, GDR
Manomet Bird Observatory, Manomet, MA
Morski Instytut Rybacki (MIR), Gdynia, POL
School of Oceanography, University of Rhode Island, Narragansett, RI

MARMAP atlases are issued as individual NOAA Technical Memorandums as they become available. They provide processed measurements of variability in key components of the Northeast Continental Shelf Ecosystem. A general description of the MARMAP Program is given in Sherman (1980).

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INTRODUCTION

This is the second in a set of publications dealing with a time series of mesoscale plankton surveys and attendant information from a comprehensive fishery ecosystem monitoring program known as MARMAP\(^1\) (Sherman 1980; 1986). It is intended to summarize survey results pertaining to the principal fish larvae found in coastal waters off northeastern United States by providing pictorial descriptions of the distribution patterns of numerically dominant larvae representing 26 taxa. The time period covered in this report includes the first 7 years of the surveys and extends from the winter of 1977 through spring 1984.

Fishery ecology research at the Northeast Fisheries Center integrates MARMAP survey information with fine scale, process oriented research to determine seasonal and annual variability in biological and environmental components of the ecosystem that influence recruitment. Surveys are conducted at monthly to bimonthly intervals and cover the continental shelf from Cape Hatteras, North Carolina to Cape Sable, Nova Scotia, an area of 260,000 km\(^2\). They provide a description of the interannual variability in temporal and spatial patterns of distribution, abundance, production and mortality of fish eggs and larvae, along with measurements and/or collections of neuston, zooplankton, phytoplankton, chlorophyll \(\text{a}\), temperature and salinity. In addition to their contribution to NEFC's recruitment initiative, ichthyoplankton data are used to derive fishery-independent estimates of adult spawning biomass (Berrien et al. 1984). During the period covered in this report, we completed 50 surveys, collected 15,450 plankton samples for ichthyoplankton/zooplankton analysis and made more than 150,000 ancillary measurements and/or observations.

\(^1\)Marine Resources Monitoring, Assessment and Prediction
METHODS

Fish larvae are collected on two types of cruises: those dedicated to broadscale plankton surveys; and those with a primary mission of assessing the distribution and abundance of fish and mollusk populations using trawls or dredges. Station plans on plankton surveys remain largely unchanged between cruises. Sampling sites are spaced at 8 to 18-km intervals along 7 transects. Others are uniformly distributed over the shelf at 25 to 35-km intervals. The survey area is sectioned into four subareas for analytical purposes. (Figure 1). The location of ichthyoplankton stations on trawl and dredge surveys are selected from stratified random station plans and change with each survey (Grosslein 1969). Sampling frequency on trawl and dredge cruises is similar to that on broadscale plankton surveys.

Survey methods and collections through 1983 are described by Sibunka and Silverman (1984). Double oblique tows are made with a 61-cm bongo which is lowered to within a few meters of bottom or to a maximum depth of 200 m at 50 m min\(^{-1}\) and retrieved at 20 m min\(^{-1}\). Ship speed varies between 1 and 2 kts to maintain a 45° wire angle during the tow. One side of the sampler is fitted with a 0.505-mm mesh net for ichthyoplankton studies, the other with a 0.333-

mm mesh net for zooplankton monitoring. Initial processing of the 61-cm samples is completed at the Morski Instytut Rybacki, Szczecin, Poland. Larvae are identified and measured at the institute, then returned to NEFC's Sandy Hook Laboratory, along with appropriate log sheets. Quality control procedures are completed at Sandy Hook and the data are computer encoded. Larval abundance is standardized to the number of larvae per 10 m\(^2\) using methods described by Smith and Richardson (1977).
OVERVIEW OF LARVAL DISTRIBUTION PATTERNS

Surveys conducted from 1977 to spring 1984 have collected over 200 taxa of fish larvae in all areas and seasons of the year. However, the ichthyoplankton on the shelf is dominated by relatively few taxa during each season or within a subarea. Approximately 91% by number of all the fish larvae collected are contained within the 26 taxa in this report. Both sand lance and hakes have each accounted for over 90% of the total collections of larvae during times of peak larval abundance. The annual spawning cycles of all 26 species combined reveal a peak in larval abundance during the warm water months (June - October) and a decrease in both abundance and species diversity during the winter. Table 2 lists the occurrence of each taxa within a subarea and ranks them by average abundance during the spawning season of each taxa. It is clear from Table 2 that the species composition and relative rankings change dramatically from south to north. Over 30% of the taxa in the Mid-Atlantic subarea do not occur at all in the Gulf of Maine subarea. An additional 20% of the taxa in the Gulf of Maine occur in very low numbers there yet are quite abundant in the Mid-Atlantic subarea. Summer migrants into the survey area from southern waters account for much of this difference. Southern New England and Georges Bank may be considered transitional areas where both northern and southern taxa spawn. All 26 taxa occur in Southern New England. Georges Bank closely resembles the Gulf of Maine in species composition except for the occurrence of summer flounder on Georges Bank.

Sand lance larvae dominate the winter collections in three of the four subareas and account for over 90% of the larval fish community during the winter months. Their relatively long hatching period (Nov. - May) and the
persistence of the larval stage within the water column (Reay, 1970) as well as a large spawning biomass have sustained these large collections throughout the 1977-1984 sampling interval. It is the only taxa which maintains a dominant presence in all subareas.

The spring spawning migration of Atlantic mackerel through the survey area produces larval concentrations in all four subareas. They are ranked second in Southern New England after sand lance and remain in the top five in both Mid-Atlantic and Gulf of Maine subareas. In contrast to sand lance, Atlantic mackerel have a relatively short spawning season within each subarea and the larvae do not persist in the plankton community. However, their high spawning biomass and high egg production from large shoals of spawning fish produce significant larval concentrations each spring.

The Mid-Atlantic subarea is a principal spawning area for many taxa which migrate from both southern and northern waters during the spring or fall of the year. Spring migrants from the south include bluefish, searobins, Atlantic croaker, and Atlantic menhaden. Northern fishes which migrate south include silver hake, Atlantic cod, pollock, and Atlantic herring. The remaining taxa are resident within the subarea, though some seasonal migrations are made to offshore areas during the winter.

The Southern New England subarea is host to all 26 taxa and contains the highest concentration of fish larvae within the survey area. Spring and summer spawning taxa dominate in this area with a well mixed fauna of both northern and southern migrants. Five species (Atlantic croaker, smallmouth flounder, bluefish, anchovies, and searobins) are at their northern limits of spawning here.

The Georges Bank larval community is dominated by members of the family Gadidae. Georges Bank waters contain significant numbers of silver hake,
hakes, haddock, offshore hake, and Atlantic cod larvae as well as small numbers of pollock larvae. The southern migrants have all but disappeared to be replaced by higher concentrations of gadid and yellowtail flounder larvae.

The Gulf of Maine contains the fewest larvae both in number of taxa and relative abundance. Few larvae are caught within the central basin of the Gulf except for redfishes. Only in this subarea does Atlantic herring produce larvae in any numbers with occurrences mostly along the coasts of Massachusetts and Maine and on the Nova Scotian shelf.

MARMAP Contribution No. FED/NEFC 86-16
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<td>83-07</td>
<td>Aug 16-Sep 4</td>
<td>62</td>
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<td>Sep 14-Nov 9</td>
<td>165</td>
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<td>47</td>
<td><em>Delaware II</em></td>
<td>83-09</td>
<td>Nov 16-Dec 20</td>
<td>151</td>
</tr>
<tr>
<td></td>
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<td>1984</td>
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<td>48</td>
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<td>84-01</td>
<td>Jan 10-Feb 8</td>
<td>160</td>
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<td>49</td>
<td><em>Albatross IV</em></td>
<td>84-02</td>
<td>Mar 2-Apr 15</td>
<td>156</td>
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<td>50</td>
<td><em>Albatross IV</em></td>
<td>84-03</td>
<td>May 9-Jun 2</td>
<td>178</td>
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</table>
Table 2. Rankings in order of abundance for numerically dominant fish larvae in four coastal subareas off northeastern United States as determined from MARMAP surveys, 1977-84.

<table>
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<tr>
<th>MID-ATLANTIC Taxa</th>
<th>SOUTHERN NEW ENGLAND Taxa</th>
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<tr>
<td>Sand lances</td>
<td>Sand lances</td>
</tr>
<tr>
<td>Bluefish</td>
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<tr>
<td>Anchovies</td>
<td>Hakes (Urophycis spp.)</td>
</tr>
<tr>
<td>Gulfstream flounder</td>
<td>Silver hake</td>
</tr>
<tr>
<td>Atlantic mackerel</td>
<td>Cunner</td>
</tr>
<tr>
<td>Searobins</td>
<td>Gulfstream flounder</td>
</tr>
<tr>
<td>Smallmouth flounder</td>
<td>Butterfish</td>
</tr>
<tr>
<td>Hakes (Urophycis spp.)</td>
<td>Yellowtail flounder</td>
</tr>
<tr>
<td>Butterfish</td>
<td>Bluefish</td>
</tr>
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<td>Atlantic croaker</td>
<td>Ceratoecopelus maderensis</td>
</tr>
<tr>
<td>Yellowtail flounder</td>
<td>Summer flounder</td>
</tr>
<tr>
<td>Benthosema glaciale</td>
<td>Anchovies</td>
</tr>
<tr>
<td>Windowpane</td>
<td>Offshore hake</td>
</tr>
<tr>
<td>Ceratoecopelus maderensis</td>
<td>Windowpane</td>
</tr>
<tr>
<td>Silver hake</td>
<td>Benthosema glaciale</td>
</tr>
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<td>Atlantic menhaden</td>
<td>Smallmouth flounder</td>
</tr>
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<td>Summer flounder</td>
<td>Atlantic cod</td>
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<td>Witch flounder</td>
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<td>Haddock</td>
</tr>
<tr>
<td>Atlantic cod</td>
<td>Atlantic menhaden</td>
</tr>
<tr>
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<td>Atlantic herring</td>
</tr>
<tr>
<td>Atlantic herring</td>
<td>American plaice</td>
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<td>Pollock</td>
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<td>Searobins</td>
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<td>Atlantic croaker</td>
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<tr>
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<tr>
<td>Cunner</td>
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<td>Benthosema glaciale</td>
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<td>Pollock</td>
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<td>Redfishes</td>
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<td>American plaice</td>
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<td>Offshore hake</td>
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<tr>
<td>Yellowtail flounder</td>
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<tr>
<td>Atlantic cod</td>
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<tr>
<td>Benthosema glaciale</td>
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<td>Gulfstream flounder</td>
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<td>Windowpane</td>
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<td>Ceratoecopelus maderensis</td>
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<th>GULF OF MAINE Taxa</th>
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<td>Atlantic cod</td>
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<td>Benthosema glaciale</td>
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<td>Gulfstream flounder</td>
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<td>Windowpane</td>
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<td>Ceratoecopelus maderensis</td>
</tr>
</tbody>
</table>
Figure 1. Standard station plan and four subareas for MARMAP, NEFC ichthyoplankton surveys.
Figure 2. Distribution and abundance of menhaden, _Brevortia tyrannus_, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 2. continued.
Figure 2. continued.
Figure 2. continued.
Figure 2. continued
Figure 2. continued.
Figure 3. Distribution and abundance of herring, *Clupea harengus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 3. continued.
Figure 3. continued.
Figure 3. continued.
Figure 3. continued.
Figure 3. continued.
Figure 3. continued.
Figure 3. continued.
Figure 4: Distribution and abundance of larval anchovies, Engraulidae, off northeastern United States, winter 1977 through spring 1984.
LARVAL ANCHOVIES SURVEY 10 
JUN 24 - JUL 16, 1978

LARVAL ANCHOVIES SURVEY 11 
AUG 12 - SEP 4, 1978

LARVAL ANCHOVIES SURVEY 12 
OCT 6 - NOV 11, 1978

LARVAL ANCHOVIES SURVEY 16 
MAY 6 - MAY 29, 1979

NUMBER/10m²

0
1-10
11-100
101-1000
1001-10,000

Figure 4. continued.
Figure 4. continued.
Figure 4. continued.
Figure 4. continued.
Figure 4. continued.
Figure 4. continued.
Figure 5. Distribution and abundance of *Ceratoscopelus maderensis* off northeastern United States, winter 1977 through spring 1984.
Ceratoscopelus maderensis
SURVEY 6
OCT 18 - NOV 9, 1977

Ceratoscopelus maderensis
SURVEY 7
NOV 13 - DEC 13, 1977

Ceratoscopelus maderensis
SURVEY 8
FEB 16 - MAR 17, 1978

Ceratoscopelus maderensis
SURVEY 9
APR 18 - MAY 23, 1978

Figure 5. continued.
Figure 5. continued.
Figure 5. continued.
Figure 5. continued.
Figure 5. continued.
Figure 5. continued.
Figure 5. continued.
Figure 6. Distribution and abundance of *Benthosema glaciale* off northeastern United States, winter 1977 through spring 1984.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 6. continued.
Figure 7. Distribution and abundance of larval hakes, *Urophycis* spp., off northeastern United States, winter 1977 through spring 1984.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 7. continued.
Figure 8. Distribution and abundance of cod, Gadus morhua, larvae off northeastern United States, winter 1977 through spring 1984.
COD LARVAE
SURVEY 5
JUL 30 - AUG 30, 1977

COD LARVAE
SURVEY 6
OCT 18 - NOV 9, 1977

COD LARVAE
SURVEY 7
NOV 13 - DEC 13, 1977

COD LARVAE
SURVEY 8
FEB 16 - MAR 17, 1978

Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 8. continued.
Figure 9. Distribution and abundance of haddock, *Melanogrammus aeglefinus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 9. continued.
HADDOCK LARVAE SURVEY 14  
FEB 25 - MAR 14, 1979

74° 76° 74°
HADDOCK LARVAE SURVEY 21  
FEB 20 - APR 4, 1980

74° 76° 74°

NUMBER/10m²

0
1-10
11-100
101-1000
1001-10,000

Figure 9. continued.
Figure 9. continued.
Figure 9. continued.
Figure 9. continued.
Figure 9. continued.
Figure 10. Distribution and abundance of pollock, *Pollachius virens*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 10. continued.
Figure 10. continued.
Figure 10. continued,
Figure 10. continued.
Figure 10. continued.
Figure 10. continued.
Figure 10. continued.
Figure 10. continued.
Figure 10. continued.
Figure 11. Distribution and abundance of offshore hake, *Merluccius albidus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 11. continued.
Figure 11. continued.
Figure 11. continued.
OFFSHORE HAKE LARVAE SURVEY 23
MAY 23 - JUN 29, 1980

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

OFFSHORE HAKE LARVAE SURVEY 24
JUL 16 - AUG 9, 1980

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

OFFSHORE HAKE LARVAE SURVEY 25
SEP 26 - OCT 29, 1980

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

OFFSHORE HAKE LARVAE SURVEY 26
NOV 19 - DEC 21, 1980

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

Figure 11. continued.
Figure 11. continued.
Figure 11. continued.
Figure 11. continued.
Figure 11. continued.
Figure 12. Distribution and abundance of silver hake, *Merluccius bilinearis*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 12. continued.
Figure 13. Distribution and abundance of bluefish, *Pomatomus saltatrix*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 13. continued.
Figure 13. continued.
Figure 13. continued.
BLUEFISH LARVAE SURVEY 50
MAY 9 - JUN 2, 1984

NUMBER/10m²

• 0
• 1-10
○ 11-100
□ 101-1000
□ 1001-10,000

Figure 13. continued.
Figure 14. Distribution and abundance of Atlantic croaker, *Micropogonias undulatus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 14. continued.
ATLANTIC CROAKER LARVAE SURVEY 12
OCT 6 - NOV 11, 1978

ATLANTIC CROAKER LARVAE SURVEY 16
MAY 6 - MAY 29, 1979

ATLANTIC CROAKER LARVAE SURVEY 17
JUN 17 - JUL 13, 1979

ATLANTIC CROAKER LARVAE SURVEY 18
AUG 11 - SEP 2, 1979

NUMBER/10m²

Figure 14. continued.
Figure 14. continued.
Figure 14. continued.
Figure 14. continued.
Figure 15. Distribution and abundance of cunner, Tautogolabrus adspersus, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 15. continued.
Figure 15. continued.
Figure 15. continued.
Figure 15. continued.
Figure 16. Distribution and abundance of Atlantic mackerel, *Scomber scombrus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 16. continued.
Figure 16. continued.
Figure 16. continued.
Figure 17. Distribution and abundance of butterfish, *Peprilus triacanthus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 17. continued.
Figure 18. Distribution and abundance of larval redfishes, *Sebastes* spp., off northeastern United States, winter 1977 through spring 1984.
Figure 18. continued.
Figure 18. continued.
Figure 18. continued.
Figure 18. continued.
Figure 18. continued.
Figure 18. continued.
Figure 18. continued.
Figure 19. Distribution and abundance of larval searobins, Prionotus spp., off northeastern United States, winter 1977 through spring 1984.
Figure 19. continued.
Figure 19. continued.
Figure 19. continued.
Figure 20. Distribution and abundance of larval sandlances, *Ammodytes* spp., off northeastern United States, winter 1977 through spring 1984.
Figure 20. continued.
Figure 20. continued.
Figure 20. continued.
Figure 20. continued.
Figure 20. continued.
Figure 20. continued.
Figure 20. continued.
Figure 20: continued.
Figure 21. Distribution and abundance of Gulf Stream flounder, Citharichthys arctifrons, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 21. continued.
GULF STREAM FLOUNDER LARVAE
SURVEY II
JUN 24 - JUL 16, 1978

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

GULF STREAM FLOUNDER LARVAE
SURVEY II
AUG 12 - SEP 4, 1978

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

GULF STREAM FLOUNDER LARVAE
SURVEY III
OCT 6 - NOV 10, 1978

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

GULF STREAM FLOUNDER LARVAE
SURVEY IV
MAY 6 - MAY 29, 1979

NUMBER/10m²
- 0
- 1-10
- 11-100
- 101-1000
- 1001-10,000

Figure 21. continued.
Figure 21. continued.
Figure 21. continued.
Figure 21. continued.
Figure 21. continued.
Figure 21. continued.
Figure 21. continued.
Figure 22. Distribution and abundance of smallmouth flounder, *E. microstomus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 22. continued.
Figure 22. continued.
Figure 22. continued.
Figure 22. continued.
Figure 22. continued.
Figure 22: continued.
Figure 22. continued.
Figure 22. continued.
Figure 22. continued.
Figure 23. Distribution and abundance of summer flounder, Paralichthys dentatus, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 23. continued.
Figure 23: continued.
Figure 23. continued.
SUMMER FLOUNDER LARVAE SURVEY 26
NOV 19 - DEC 21, 1980

SUMMER FLOUNDER LARVAE SURVEY 28
MAR 19 - APR 8, 1981

SUMMER FLOUNDER LARVAE SURVEY 33
SEP 17 - NOV 8, 1981

Figure 23. continued.
Figure 23: continued.
Figure 23. continued.
Figure 23. continued.
Figure 24. Distribution and abundance of windowpane, *Scopthalmus aquosus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 24. continued.
Figure 24. continued.
Figure 24. continued.
Figure 24. continued.
Figure 24. continued.
Figure 24. continued.
Figure 24: continued.
Figure 24. continued.
Figure 24. continued.
Figure 25. Distribution and abundance of American plaice, Hippoglossoides platessoides, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 25. continued.
Figure 25. continued.
Figure 25. continued.
Figure 26. Distribution and abundance of yellowtail flounder, *Limanda ferruginea*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 26. continued.
Figure 26. continued.
Figure 26. continued.
Figure 26. continued.
Figure 26. continued.
Figure 26. continued.
Figure 27. Distribution and abundance of witch flounder, *Glyptocephalus cynoglossus*, larvae off northeastern United States, winter 1977 through spring 1984.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
Figure 27. continued.
(continued from inside front cover)


39. **USA Historical Catch Data, 1904-82, for Major Georges Bank Fisheries.** By Anne M. T. Lange and Joan E. Palmer. May 1985. iii + 21 p., 12 figs., 2 tables. NTIS Access. No. PB85-233948/AS.


44. **NOAA's Northeast Monitoring Program (NEMP): A Report on Progress of the First Five Years (1979-84) and a Plan for the Future.** By Robert N. Reid, Merton C. Ingham, and John B. Pearce, eds., and Catherine E. Warsh (water quality), Robert N. Reid (sediments & bottom organisms), Adriana Y. Cantillo (trace contaminants in tissues), and Edith Gould (biological effects), topic coords. May 1987. xi + 138 p., 13 figs., 1 table, 9 app.


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