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APPROVED
BY Susan Olsen
DATE 4/28/97

UNITED STATES
DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
State, Federal & Constituent Programs Division

ANNUAL REPORT

Grantee: **MAINE DEPARTMENT OF MARINE RESOURCES**

Project No: **3-IJ-84-2**

Grant No: **NA46FI0105**

Project Title: **TRANSBOUNDARY HERRING PROJECT**

Period Covered: **03/01/95 - 02/29/96** 4

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Approved by: ______

Date: **NOVEMBER 15, 1996**

Statutory Funding Authority:
- ___Anadromous Fish Conservation Act (P.L. 89-304)
- ___Chesapeake Bay Studies
- ___Endangered Species Act
- **X** Interjurisdictional Fisheries Act (Title III of P.L. 99-659)
- ___Magnuson Act
- ___Oyster Disease Research
- ___Saltonstall-Kennedy
- ___Unallied Industry Projects
- ___Unallied Science Projects
- ___ACFCMA

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State: Maine
Project No. 3-IJ-84-2
Contract No. NA46FI0105

March 1 1995 - February 29 1996

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November 15 1996

OVERVIEW

The Transboundary Herring Project has been conducted within the Pelagic Fisheries Division (Bureau of Marine Sciences) of the Maine Department of Marine Resources since 1986. This project is funded by the Interjurisdictional Fisheries Act and administered by the National Marine Fisheries Service, State, Federal and Constituent Program Division, at the Northeast Regional Office in Gloucester, MA.

This annual report summarizes project activities during the period March 1 1994 to February 28 1995. It contains five separate research reports and five appendices. The six jobs that are reported on separately are: 1) herring catch statistics, 2) herring sample data, 3) resource assessment, 4) acoustic survey, 5) larval survival and recruitment.

RESEARCH REPORT #1: HERRING CATCH STATISTICS

Introduction

The Maine Department of Marine Resources has been compiling Maine commercial herring fishery statistics since 1990. These include detailed information on landings by gear type, month, and area of capture as well as supplementary information concerning imports and exports from Canada, the quantity of herring sold to the canneries and for bait, and the annual quantity and wholesale value of herring products canned in Maine. Statistics are also compiled for herring landed aboard foreign owned processing ships as part of Internal Waters Processing (IWP) operations approved by the State of Maine. All data are summarized in an annual report which is distributed to industry members. Landings data are also provided annually to the U.S. National Marine Fisheries Service (NMFS) in Portland and Woods Hole, MA. Data collection is a cooperative effort involving the Maine DMR, NMFS port agents, the Maine Sardine Council, employees in the packing plants, and fishermen.

Methods

Landings statistics are compiled for all herring landed in Maine which reach the packing plants and for herring which is utilized for other purposes (bait and processing aboard foreign vessels operating in state waters). Most of the primary information is provided by the Maine Sardine Council, which receives reports on each load of herring which arrives at the plants. Some additional information is provided directly by plant managers, fishermen, NMFS port agents in Rockland and Portland, and observers aboard foreign processing vessels.

Landings are compiled by gear type, area caught, and month. Gear types are identified using NMFS gear codes. The major gear types used in Maine are weirs, stop seines, purse seines, and (recently) mid-water trawls. (Herring landed by trawl in Maine are caught outside of state waters since it is illegal to use trawls in Maine state waters to catch herring). Weirs and stop seines are referred to as fixed gear while purse seines and trawls are grouped as mobile gear.

The Maine coast is divided into three major statistical areas which are subdivided into 15 smaller areas (see Fig. 1 in Appendix A). Additional fishing areas are identified in Canadian waters, off the New Hampshire and Massachusetts coast, and in offshore Maine waters.

The data are entered, coded, and processed on a PC at the DMR Laboratory in Boothbay Harbor using Dbase software. The confidentiality of unaggregated data is maintained by limiting access to the reporting slips and data files to DMR employees who have been approved by the NMFS to work with confidential information. An annual summary is sent to the NMFS Fisheries Statistics Office in Portland at the end of the year.

Results

A total of 48,279 mt of herring were landed in Maine in 1995, 39,503 mt (82%) by the domestic fishery and 8,776 mt (18%) for processing aboard three Russian processing ships that operated in Maine state waters under the provisions of the Internal Waters Processing (IWP) amendment to the Magnuson Act. Total landings increased by 10,306 mt (27%) over the previous year, due to growth in both IWP and domestic landings. Domestic landings in Maine increased by 4,379 mt over 1994 and by 24,000 mt since 1989 (15,629 mt). IWP landings increased three-fold over 1994, reaching a record high for the period of time that IWP operations have been conducted in Maine. The previous high was 6,647 mt in 1992. Domestic landings in 1995 were the highest recorded in the State of Maine since 1981.

The domestic fishery in 1995 was active from April through November with a peak in October (see Table 4, Appendix A). Substantial shoreside landings were also recorded between July and September. The IWP fishery took place between June and September, with 86% of the catch in July and August (Table 5, Appendix A).

Herring landed shoreside in Maine are being increasingly utilized for bait. Domestic landings were divided evenly between bait and herring destined for canning during 1992-1994 (Table 9, Appendix A), but in 1995, reported bait landings increased by over 6,000 mt compared to the previous year, reaching 23,662 mt. The total quantity of herring utilized by the six remaining Maine canneries (only four of which are important) was 29,788 mt, about 3,000 mt less than in 1993. Production in the canning industry has remained stable since 1990. Almost half of the fish utilized in the canneries was trucked into Maine from other states (11,204 mt) and from Canada (only 2,804 mt). The total wholesale value of herring packed by Maine canneries in 1995 was $43.6 million.

Along with the increased importance of herring as bait in the lobster fishery in recent years, there has been a shift towards increased use of mid-water trawls in the fishery. In 1995, trawl-caught herring accounted for almost 18,000 mt, a dramatic increase over 1993 and 1994 (4,000-4,500 mt). Purse seines still accounted for the majority (63%) of the landings. For the first time in the history of the fishery, there were no fixed gear landings in 1995. Seiners supplied only 113 mt to the IWP ships, whereas mid-waters trawlers provided only 23% of the domestic catch.

Herring landings in Maine in 1995 came from the central and western coastal areas (19% and 23%, respectively), offshore central Maine (20%) and Jeffreys Ledge and Massachusetts Bay (34%) (Table 3, Appendix A). As in other recent years, the quantity of herring caught in eastern Maine was negligible. There was considerable purse seine fishing in the Outer Falls area in 1995, a fishing ground located 40 miles offshore. Catches from this area totalled 9,529 mt in 1995 and were taken primarily between June and August when inshore central Maine catches were low (Table 6, Appendix A). The fishery in central Maine shifted to more inshore fishing grounds in September and October. Primary fishing grounds in this area are Mt. Desert Rock and the islands in outer Penobscot Bay. In western Maine, fishing was intense in July, August, and September: primary fishing grounds in this area are Monhegan Island and the Kettle Bottom. There was some fishing on Jeffreys Ledge in the spring, but the largest catches were taken before and after the spawning closure, in August (all trawl catches) and October (primarily purse seines).

RESEARCH REPORT #2: HERRING SAMPLE DATA

Introduction

The Maine Department of Marine Resources has maintained responsibility for processing samples from the commercial catch in Maine and Massachusetts since 1978. Commercial herring samples have been processed at the Fisheries Laboratory in Boothbay Harbor since 1965, either by the National Marine Fisheries Service, which had a facility there until 1973, or by the Maine DMR, either under contract to NMFS or on its own.

Methods

Herring samples are collected on a regular basis at the packing plants by plant personnel, by observers placed aboard IWP ships, and by NMFS port agents in Gloucester, MA, and Rockland, ME. Additional samples are collected during the winter south of Cape Cod from loads delivered to Maine canneries. Sample collection in the plants is done on a voluntary basis whereas NMFS port agents are given a quota (a certain number of samples per week or month). The objective is to collect at least two samples per week per gear type (mobile vs. fixed) for any sub-area where fishing is taking place. Typically, between 100 and 150 samples are collected each year.

The number of fish per sample varies depending on the size of the fish and whether a proportion of them are aged or not, but the usual sample size is 50. (Some samples are not processed for age data at all). The samples are frozen and transported to the Maine DMR lab in Boothbay Harbor where they are processed. For age samples, 15 (juveniles) to 30 (adults) are aged. At least one fish is selected for ageing from each 1 cm length interval (i.e., aged fish are not selected at random). Length, weight, sex, and gonad condition (for adults) are determined for all fish and age is estimated by determining the number of annual increments in otoliths. All data are recorded and entered into computer files using Dbase. A copy of the complete annual data set is sent to the NMFS in Woods Hole on computer disk at the end of the year. Estimation of total catch-at-age in the fishery is based on the use of monthly age-length keys for each gear type (mobile and fixed) and major fishing area.

Results

A total of 90 samples were processed during the project year from the 1994 and 1995 fishing years (Table 1). They included 34 1994 samples and 56 1995 samples. A total of 4509 fish were processed, 1335 of which were aged. A total of 141 samples were collected in 1995, 122 from the Gulf of Maine and 19 from southern New England (Table 2). Thirty-six of them were collected in Massachusetts (mostly in Gloucester), 70 from domestic landings in Maine, 10 from fish landed in southern New England and trucked to Maine, and 25 from IWP vessels. The 95 samples collected in Maine ports represented approximately 7% of the total number of landings in 1995. The sampling coverage was somewhat better for IWP landings (10%) than for domestic landings (6%). On average, one sample was collected for every 508 mt of fish landed in Maine.

Table 1. Number of herring samples processed, number of fish processed and number of fish aged by month, March 1995 - February 1996.

Month Processed	Fishing Year	No. Samples	Total No. Fish	No. Fish Aged
March '95	1994	5	247	65
April	1994	14	717	210
May	1994	15	747	180
June	1995	3	150	60
July-Aug	1995	18	901	405
Sept	1995	8	400	90
Oct	1995	4	200	30
Nov	1995	2	100	25
Dec	1995	6	300	70
Jan '96	1995	6	298	155
Feb	1995	9	449	45
Total		90	4509	1335

JOB #3: RESOURCE ASSESSMENT AND MANAGEMENT

Recommendations regarding allocations for Internal Waters Processing harvests in the Gulf of Maine, southern New England, and Georges Bank for the fishing year beginning July 1 1995 were made to the ASMFC Atlantic Herring Section in April 1995. Recommended IWP harvest levels were based on the results of the 1993 Atlantic assessment for the coastal stock complex.

The Pelagic Division leader (D. Stevenson) worked with other Atlantic Herring Plan Development Team members, National Marine Fisheries Service staff and industry members to prepare a Preliminary Management Plan that would permit the sale of Atlantic herring by U.S. fishermen to foreign owned processing ships operating in federal waters on Georges Bank and off southern New England and the mid-Atlantic states. This PMP was approved by the U.S. Secretary of Commerce in August 1995.

D. Stevenson also met twice with herring industry and government agency representatives from the U.S. and Canada to discuss assessment and management issues of mutual concern in the two countries. A primary subject of discussion was the U.S. decision to allow for joint venture processing operations on Georges Bank and on Nantucket Shoals beginning in 1995 and how much adult herring could be harvested in these two management areas without jeopardizing the recovery of the "offshore" spawning stock.

D. Stevenson participated for the third consecutive time in the International Council for the Seas (ICES) annual Herring Assessment Working Group meeting in Copenhagen, Denmark in March 1995 and assisted in the assessment of the North Sea stock, using a new computer program (ICA) that has recently been developed especially for performing virtual population analyses of pelagic stocks.

Final catch at age estimates (numbers of fish) were derived for the 1994 Atlantic coast herring fishery. 1993 and 1994 catch at age data were incorporated into a revised stock assessment that was completed and reviewed at the NMFS Stock Assessment Review Committee meeting in Woods Hole, MA in November 1995 (SARC 21). A working paper describing the methods used and the results of this assessment was prepared for review by the Pelagic Fishery Sub-Committee prior to the SARC meeting.

A workshop was convened at the DMR Laboratory in September with participants from Canada, the U.S. and Scotland to compare the performance of two alternative computer programs (ICA and ADAPT) that are being used to conduct virtual population analyses of various herring stocks in the North Atlantic.

RESEARCH REPORT #4: ACOUSTIC SURVEY

Introduction

A three week hydroacoustic survey for spawning herring on Jeffreys Ledge and adjacent waters in the southwestern Gulf of Maine was conducted in October 1995. The objectives of this project were to conduct further testing of acoustic survey methodology and echo integration techniques that were first used on Jeffreys Ledge in late September 1994 (USDC 1995) and, in the process, to estimate the distribution and abundance of adult herring in the survey area. The development of a direct, fishery-independent method for estimating the biomass of individual spawning populations of herring within the Atlantic coastal stock complex is critical since the only assessment information that is currently available for this species applies to the entire coastal stock complex, which includes separate spawning populations on Georges Bank, Nantucket Shoals and in the Gulf of Maine (NEFSC 1996). The absence of stock-specific assessment information greatly complicates the resource allocation process for this species (ASMFC 1993).

Methods

The survey was conducted during ten nights starting on October 3 and ending on October 20 aboard the R/V Gloria Michelle using a SIMRAD EY-500 70 kHz single beam scientific grade echosounder. Digitized echo signal data were collected along a series of randomly selected straight line transects that crossed in a general east-west direction across the ledge and varied in length from only 3-4 miles where the ledge is narrow and well-defined to 10-15 miles on the broader southern part of the ledge and further south in Massachusetts Bay. Each transect was assumed to provide an independent random sample of herring distribution and abundance within a designated sub-area (Figure 1). Three separate transects were covered in sub-areas 1-8 (Jeffreys Ledge), one each week. Six additional transects (numbers 9-14) located south of the ledge, three of which crossed over Stellwagen Bank, were traversed only once. One night's survey work was also devoted to a series of north-south transects on the top of the ledge in sub-area six. Results from the non-replicated transects south of the ledge and on top of the ledge are not presented in this report.

Echo signal data from each transect were analyzed using the SIMRAD EP-500 echo integration software. The sounder was calibrated prior to the start of the survey with reference to a copper sphere of known target strength. In order to depict distributional patterns in echo intensity across the ledge, area backscatter (S_A) measurements for each ping were averaged for all pings within each of five segments (equal number of pings per segment) for that portion of each transect that was less than 100 meters in depth. A single average S_A value was then calculated for each transect and for each segment during each week.

Results

Mean area backscatter estimates obtained across the ledge (Figure 2-4) indicated a shift in abundance and horizontal distribution during the survey. The intensity of the echo signal data collected during the first and third weeks was much higher (almost an order of magnitude) than during the second week (Table 1). Also, S_A values were much higher at the northern end of the ledge during the first week (transects 1-3) and were generally higher from the center of the ledge to its western edge, particularly on transect 3. The exception to the rule in week 1 was transect 5 which had its highest value on the eastern edge. Backscatter values were much more evenly distributed up and down the ledge during weeks 2 and 3, but the estimates obtained for transects 1, 2, 3 and 7 were still higher in the third week on the western side, whereas values for transects 4-6 were higher on the eastern side.

The most obvious difference in vertical distribution observed during the course of the survey was that all targets at the northern end of the ledge during the first week were right down on the bottom (Figure 5A and B) and in mid-water during the second week (Figures 6A and B). Although there was also a "lighter" scattering layer on the bottom on many other occasions, it was usually accompanied by a mid-water aggregation of fish. There is little doubt about the identity of the mid-water scattering layer (herring), but the "heavy" bottom layer observed at the northern end of the ledge during the first week was most likely herring mixed in with a variety of benthic finfish species.

Normally, estimates of echo signal intensity would be converted to fish density and biomass estimates based on continuous sampling of acoustic "targets" with appropriate fishing gear during the course of the survey. For pelagic species like herring, this sampling requires the use of bottom and mid-water trawls, or purse seines, to determine the species composition of mid-water and bottom aggregations of fish and to determine the size distribution and mean weights of herring and other species in the catches. In this case, however, the Gloria Michelle was only equipped with a small bottom trawl that proved inadequate for sampling aggregations of fish on or near the bottom. The survey area was closed for management purposes during the first two weeks of the survey, so no commercial samples of herring were available for analysis until the fishery opened on October 13. On that date, catches by several mid-water trawlers confirmed that the mid-water aggregations of herring observed during the entire survey were, in fact, large adult herring, most of which had spawned. However, the species composition of the bottom aggregations of fish could not be determined.

Since there was no way of determining what proportion of this bottom scattering layer could be attributed to herring, reliable herring density and biomass estimates could not be generated from the available echo intensity data. Once additional groundtruth information is obtained, particularly for bottom aggregations of fish, that will permit an allocation of the backscatter estimates collected during the 1995 survey among species, herring density and biomass estimates will be calculated. Such groundtruth information will be collected during the 1996 acoustic survey on Jeffreys Ledge by the Maine Department of Marine Resources.

Explanation of echogram features (Figures 5 and 6): Horizontal line at the top is the surface, primary bottom echo shows as irregular, dark red line with secondary bottom echo underneath. "Targets" appear on the bottom or in the water column, color coded according to vertical scale at right (red and pink strongest, blue and gray weakest). Number of pings (sound pulses) at top indicates distance travelled, at one ping per second: at a vessel speed of six knots, one nautical mile equals 10 minutes or 600 pings. Vertical scale at left is depth in meters. Panel at bottom is an expanded view of the bottom, shown as a flat bottom, with targets within three meters of the bottom.

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ASMFC 1993. Atlantic Herring Fishery Management Plan (draft). Atlantic States Marine Fisheries Committee, Washington, D.C., Nov. 12 1993.

NEFSC 1996. Stock Assessment Review Committee (SARC) Consensus Summary of Assessments. NOAA/NMFS Northeast Fisheries Science Center, Woods Hole, MA.

USDC 1995. Transboundary Herring Final Report, Project No. 3-IJ-84 from the Maine Dept. Marine Resources. U.S. Dept. Commerce, NOAA/NMFS, State, Federal and Constituent Program Division, Northeast Regional Office, Gloucester, MA.

Table 1. Area backscatter (echo intensity) estimates obtained from acoustic survey on Jeffreys Ledge during first three weeks of October 1995. Echo signal data were integrated from either 0.6 or 1 meter above the bottom to the upper depth indicated and averaged for each of five segments of equal distance from the west to the east side of the ledge for depth less than 100 meters.

			West				East	
Transect	Layer (m)		Seg 1	Seg 2	Seg 3	Seg 4	Seg 5	Mean
Week 1								
1a	1:0.60 to 30.60		75826	90831	99619	68303	46729	76262
2a	1:0.60 to 30.60		17799	39576	54496	38954	41242	38413
3a	1:0.60 to 30.60		139635	121059	44148	59347	18515	76541
4a	1:0.60 to 20.40		1525	3383	335	862	2096	1640
5a	1:0.60 to 15.60		1515	2004	1261	4344	12861	4397
6a	1:0.60 to 30.60		4392	2777	3872	1061	2444	2909
7a	1:0.60 to 22.20		5434	7409	959	3566	517	3577
8a	1:0.60 to 11.40		491	616	464	419	253	449
Mean			30827	33457	25644	22107	15582	25523
Week 2								
1b	1:0.60 to 31.20		9418	1887	8618	5791	1924	5528
2b	1:0.60 to 45.00		486	3994	8337	7969	7329	5623
3b	1:0.60 to 25.20		274	4065	2096	1218	4452	2421
4b	1:0.60 to 35.40		212	527	1277	9749	6669	3687
5b	1:0.60 to 25.20		2503	1409	3382	2305	3041	2528
6b	1:0.60 to 16.80		889	871	939	1834	3809	1669
7b	1:0.60 to 37.20		744	4836	2274	981	513	1869
8b	1:0.60 to 30.60		3323	5421	4816	5270	2912	4348
Mean			2231	2876	3967	4390	3831	3459
Week 3								
1c	1:1.00 to 21.00		21600	43320	23905	9749	2743	20263
2c	1:1.00 to 21.00		107406	84998	2448	30075	2799	45545
3c	1:1.00 to 21.00		12405	1828	5613	1069	1672	4517
4c	1:1.00 to 21.00		53438	44760	23077	60843	79249	52273
5c	1:0.60 to 21.60		13063	4618	12959	9531	53590	18752
6c	1:0.60 to 39.60		10121	5138	27727	10477	30075	16708
7c	1:0.60 to 21.60		39774	19686	10309	6114	2560	15689
8c	1:0.60 to 41.40		9441	4412	10390	9640	9661	8709
Mean			33406	26095	14553	17187	22794	22807

Figure 1. Eight sub-areas surveyed on Jeffreys Ledge during October 1995. Acoustic data were collected along randomly selected east-west transects through each area once during each of three consecutive weeks. The dashed line denotes the 100 meter depth contour which delineates the ledge from deeper water on either side.

Figure 2. Echo intensity estimates for Jeffreys Ledge (depth less than 100 meters) for the first week of October, 1995. For each of eight transects, average S_A values are shown for each of five segments across the ledge (equal number of pings per segment for any given transect).

Figure 3. Echo intensity estimates for Jeffreys Ledge (depth less than 100 meters) for the second week of October, 1995. For each of eight transects, average S_A values are shown for each of five segments across the ledge (equal number of pings per segment for any given transect).

Figure 4. Echo intensity estimates for Jeffreys Ledge (depth less than 100 meters) for the third week of October, 1995. For each of eight transects, average S_A values are shown for each of five segments across the ledge (equal number of pings per segment for any given transect).

Figure 5A. Echogram showing consistently strong bottom echo and total absence of mid-water echoes. Transect 1A, October 4 1995, 19:31 to 20:50 hrs, distance 7.5 n miles, direction east to west.

Figure 5B. Echogram showing consistently strong bottom echo and one large aggregation of fish on top of the ledge rising up from the bottom (50 m) to within 15 m of the surface. Transect 2A, October 4-5, 1995, 23:53 to 01:46 hrs, distance 11 n miles, direction west to east.

Figure 6A. Echogram showing interrupted bottom echo and fairly consistent aggregations of fish rising up as high as 30 m off the bottom, also a light scattering layer near the surface. Transect 1B, October 10 1995, 04:58 to 05:41 hrs, distance 4 n miles, direction west to east.

Figure 6B. Echogram showing very sparse bottom echo with mid-water aggregations of fish dispersed from depth of 15 m or so to within a few meters of the bottom. Transect 2B, October 10 1995, 02:33 to 03:32 hrs, distance 5.5 n miles, direction west to east.

Explanation of echogram features: Horizontal line at the top is the surface, primary bottom echo shows as irregular, dark red line with secondary bottom echo underneath. "Targets" appear on the bottom or in the water column, color coded according to vertical scale at right (red and pink strongest, blue and gray weakest). Number of pings (sound pulses) at top indicates distance travelled, at one ping per second: at a vessel speed of six knots, one nautical mile equals 10 minutes or 600 pings. Vertical scale at left is depth in meters. Panel at bottom is an expanded view of the bottom, shown as a flat bottom, with targets within three meters of the bottom.

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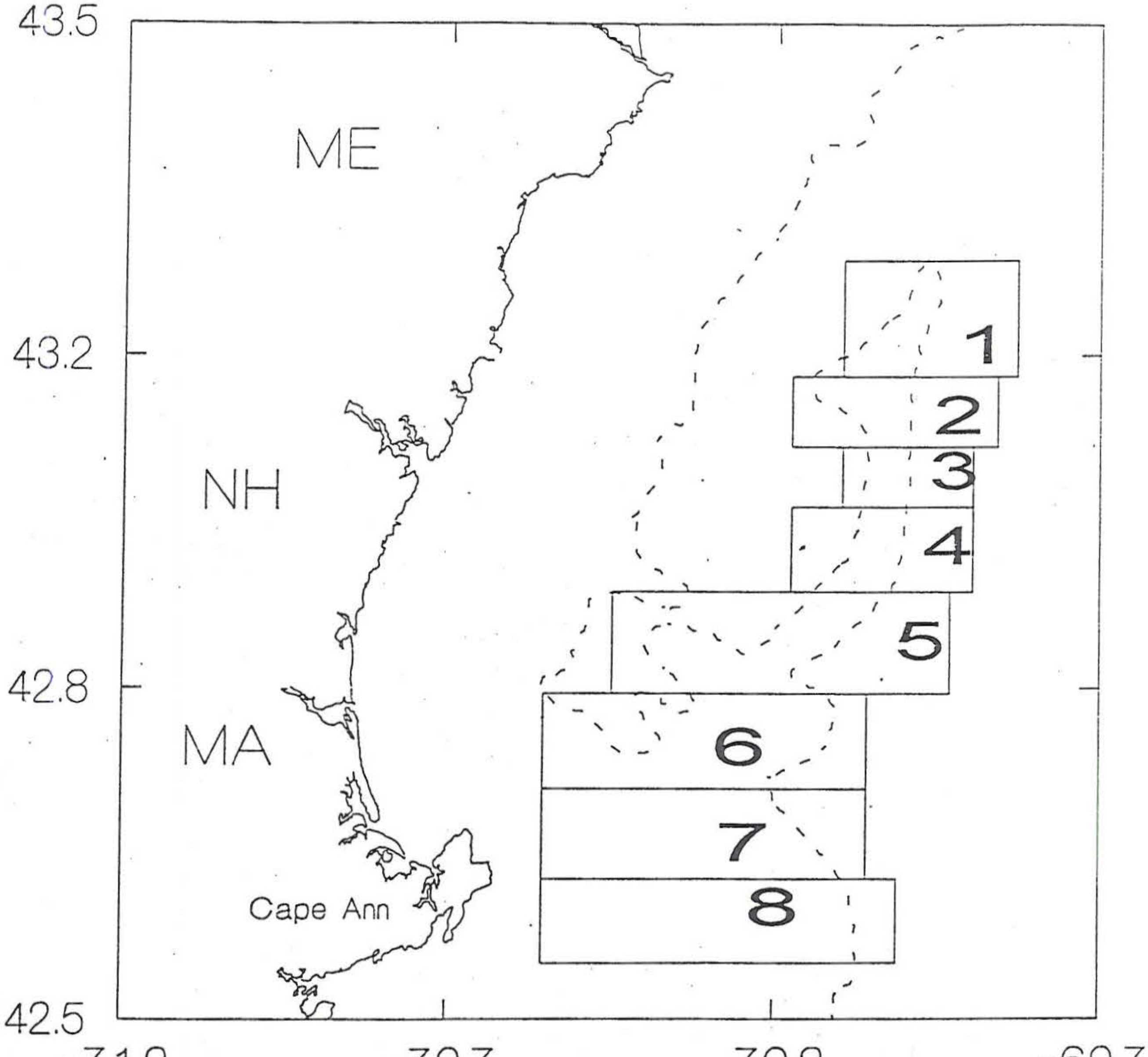

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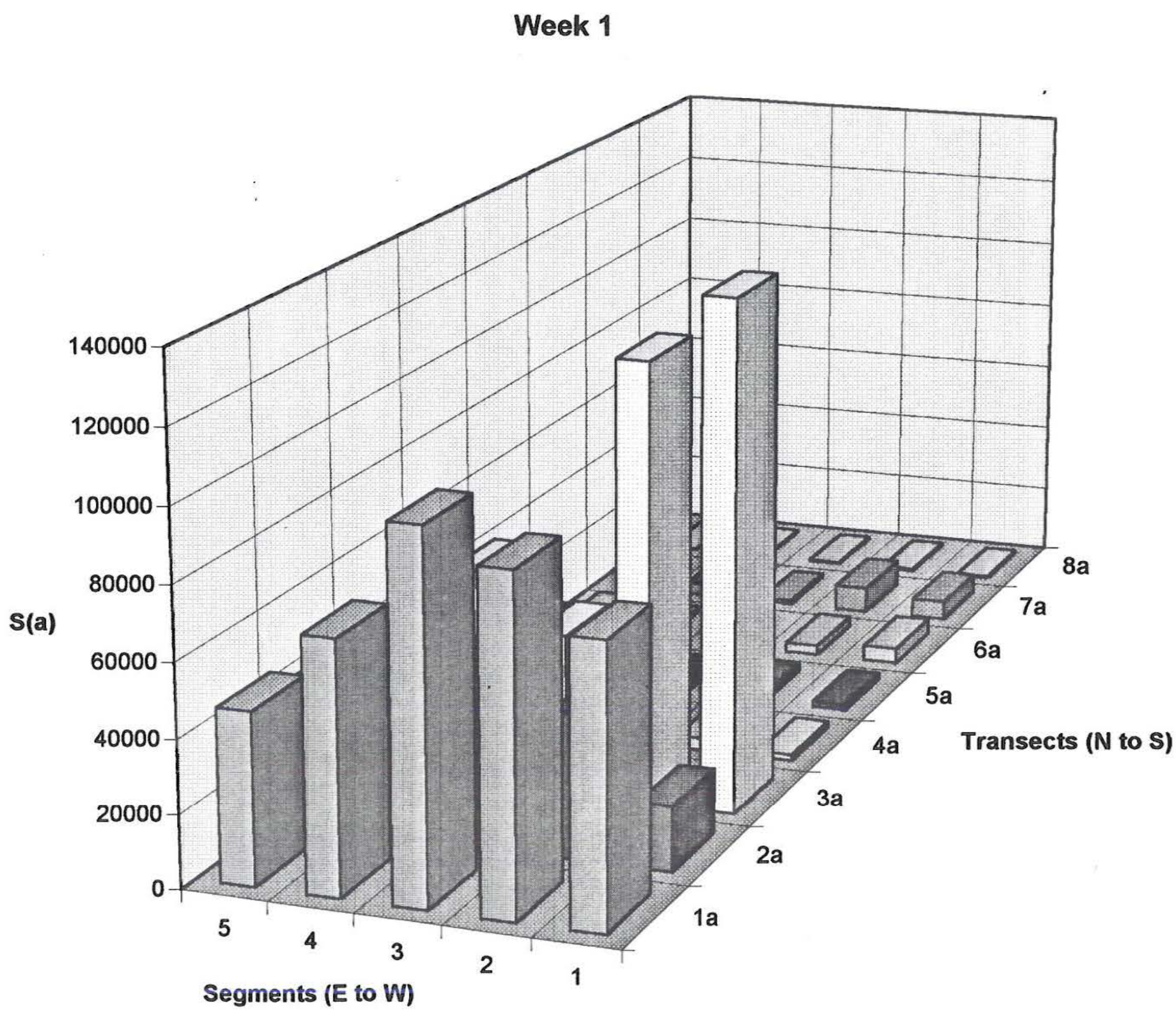

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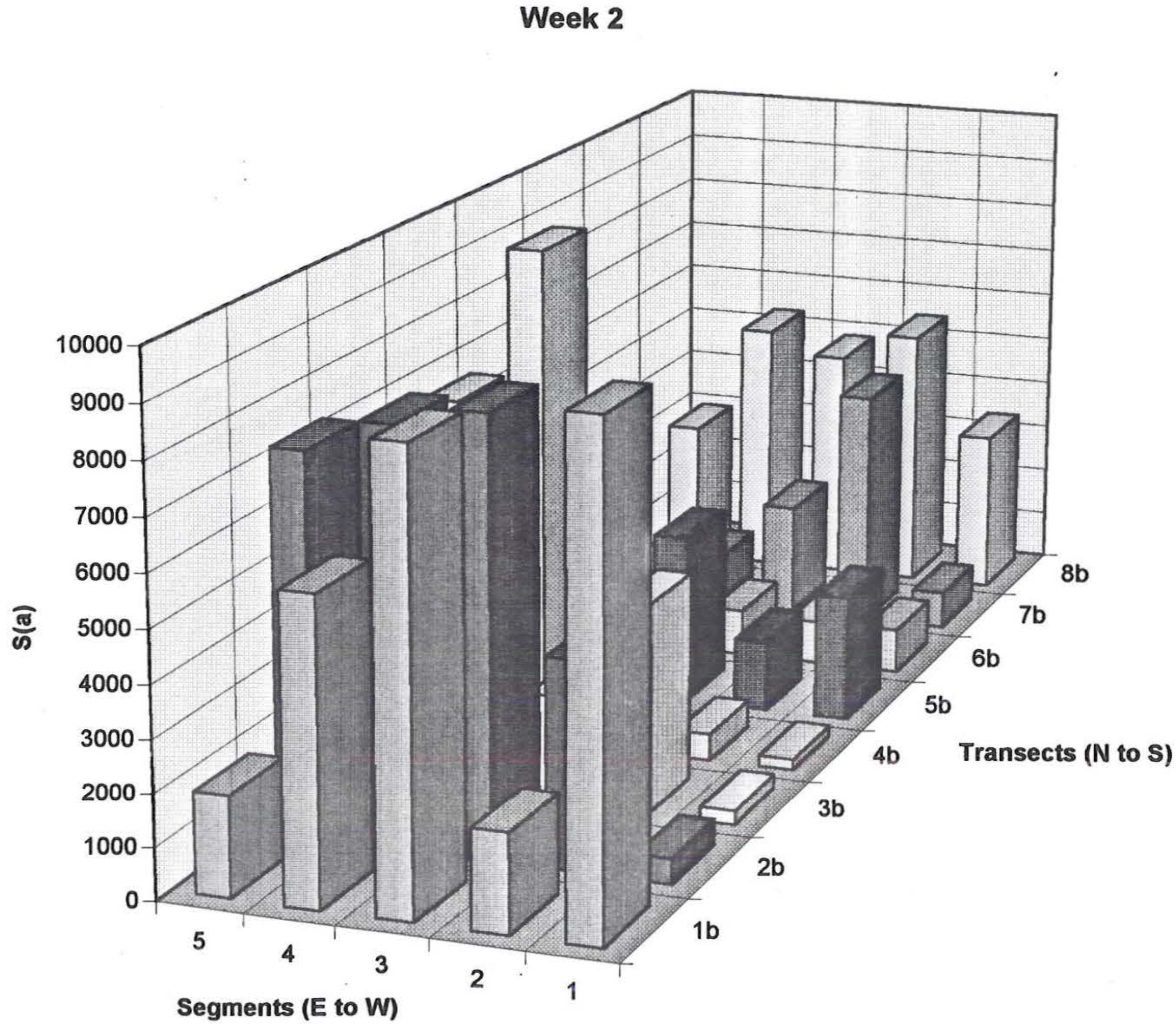


Figure 4. Echo intensity estimates for Jeffreys Ledge (depth less than 100 meters) for the third week of October, 1995. For each of eight transects, average S_A values are shown for each of five segments across the ledge (equal number of pings per segment for any given transect).

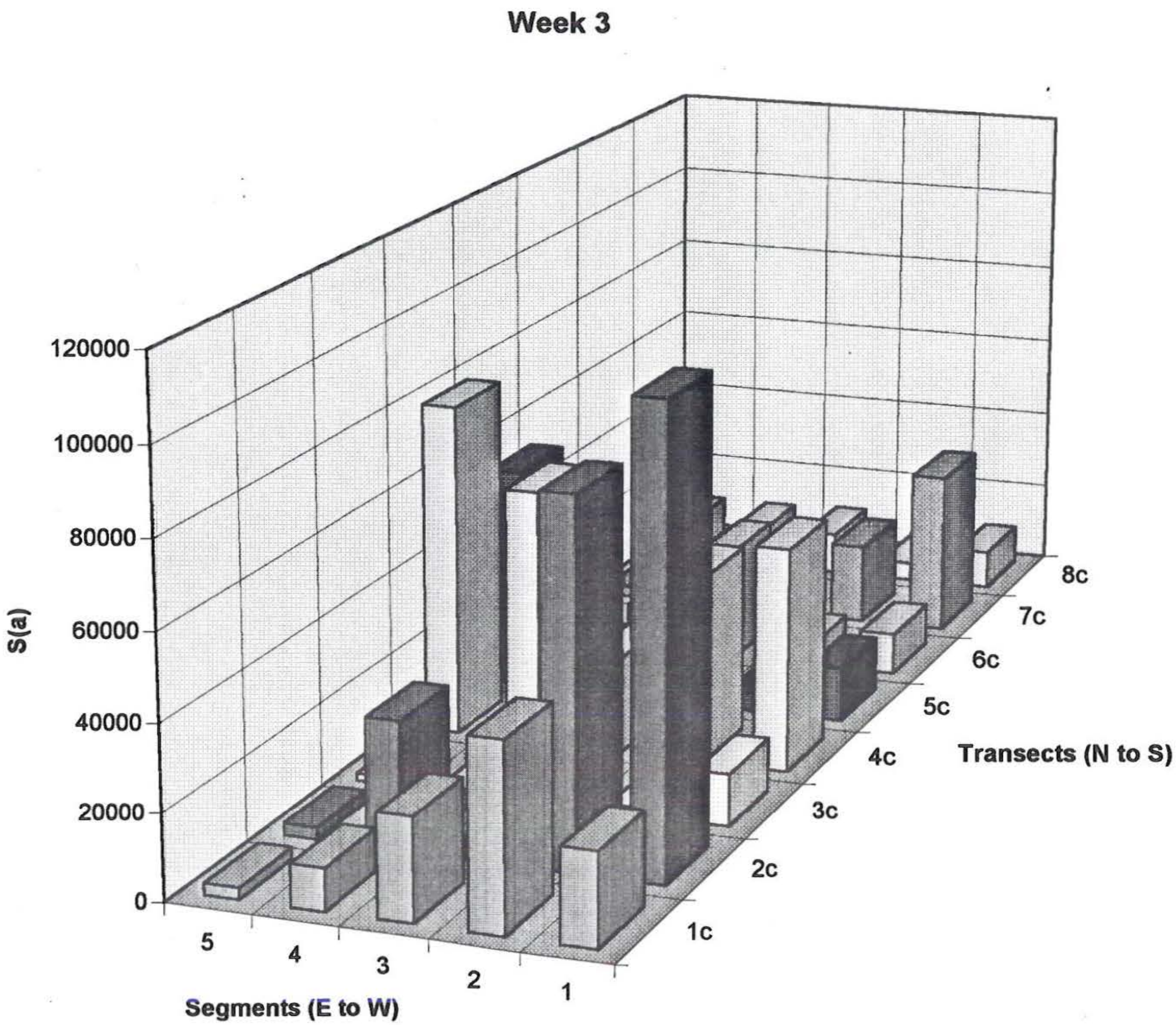


Figure 5A. Echogram showing consistently strong bottom echo and total absence of mid-water echoes. Transect 1A, October 4 1995, 19:31 to 20:50 hrs, distance 7.5 n miles, direction east to west.

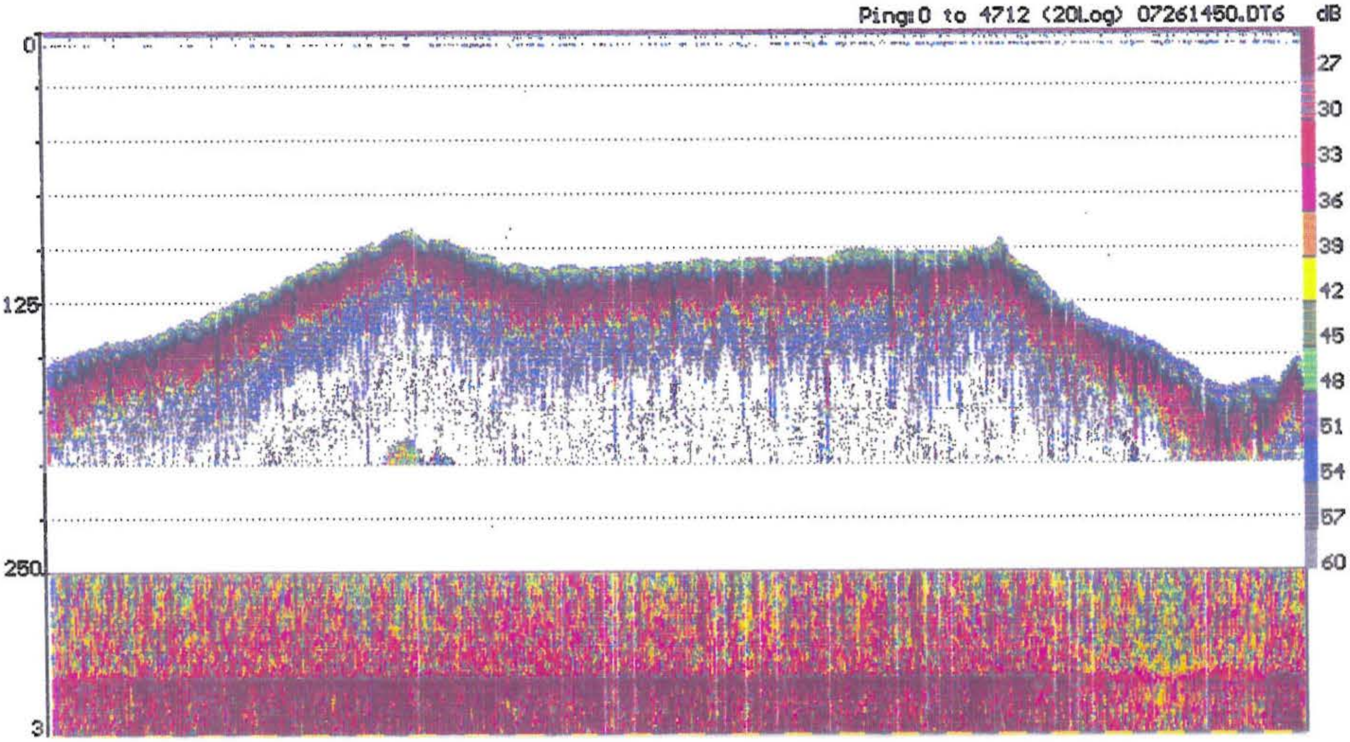


Figure 5B. Echogram showing consistently strong bottom echo and one large aggregation of fish on top of the ledge rising up from the bottom (50 m) to within 15 m of the surface. Transect 2A, October 4-5, 1995, 23:53 to 01:46 hrs, distance 11 n miles, direction west to east.

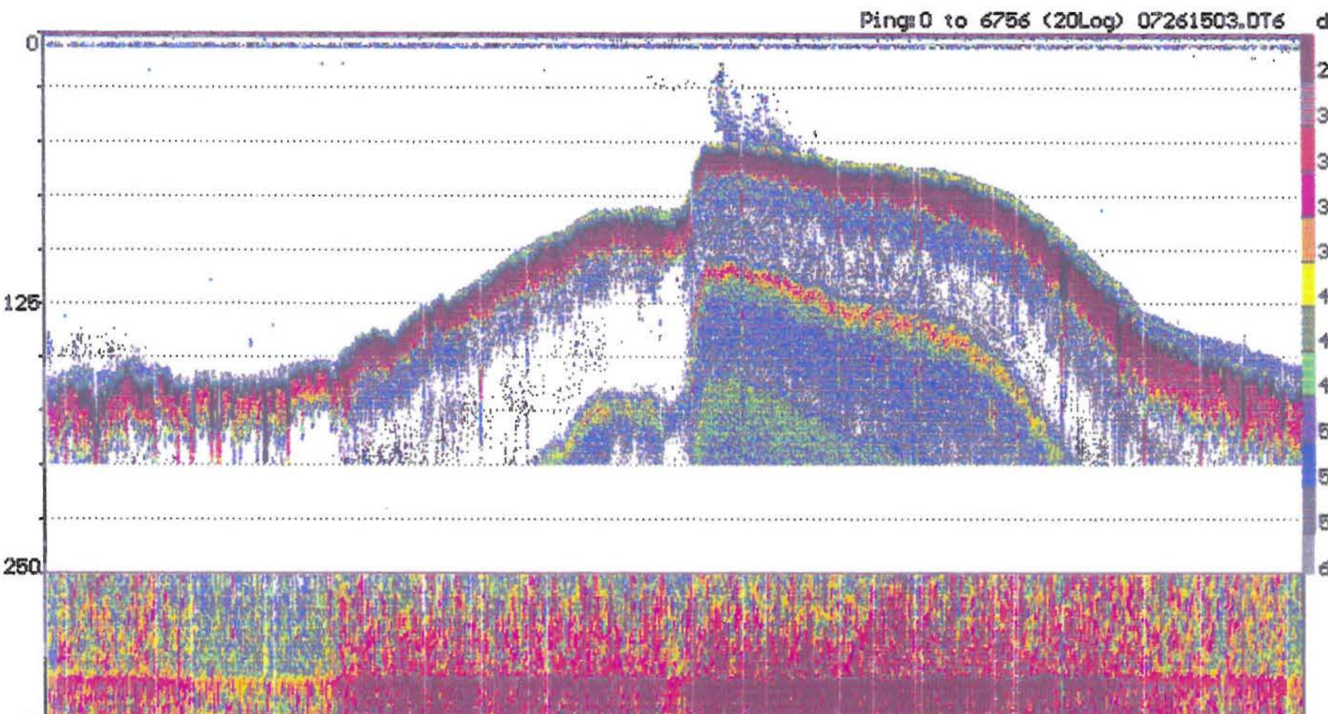


Figure 6A. Echogram showing interrupted bottom echo and fairly consistent aggregations of fish rising up as high as 30 m off the bottom, also a light scattering layer near the surface. Transect 1B, October 10 1995, 04:58 to 05:41 hrs, distance 4 n miles, direction west to east.

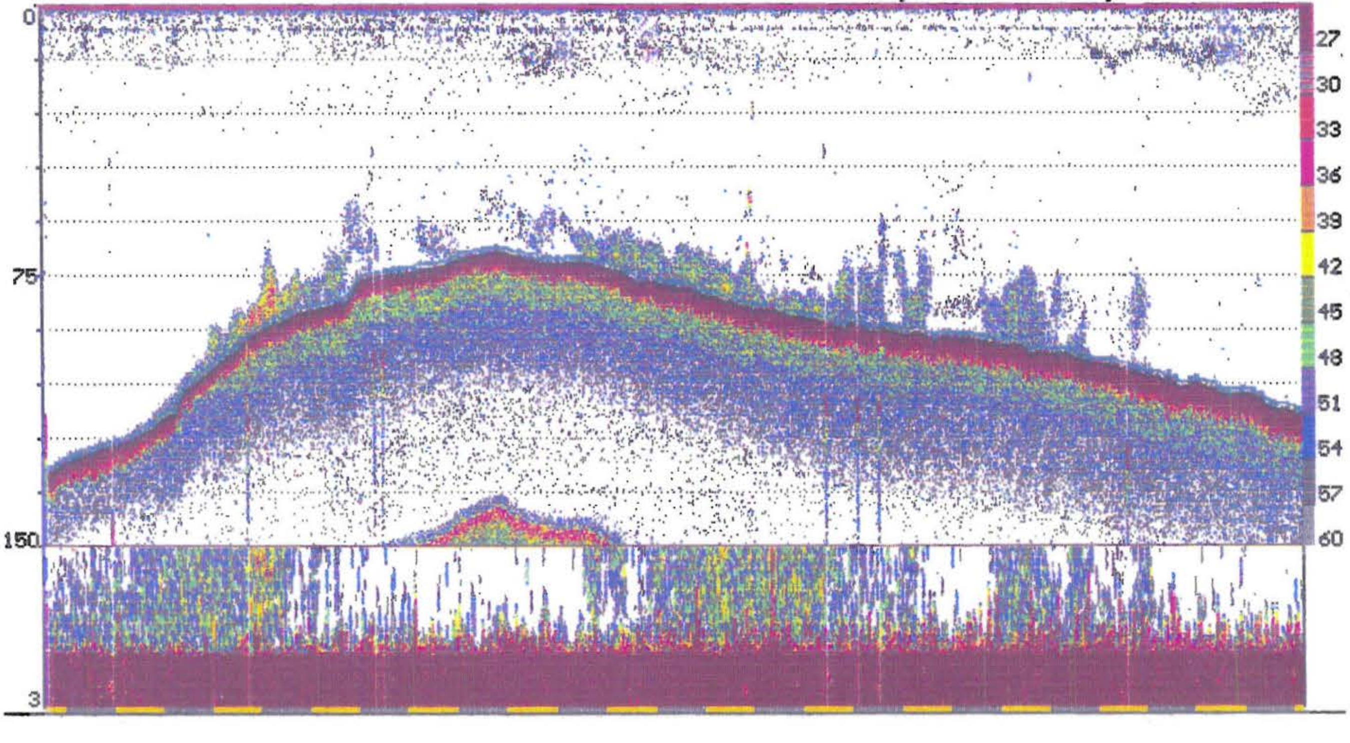
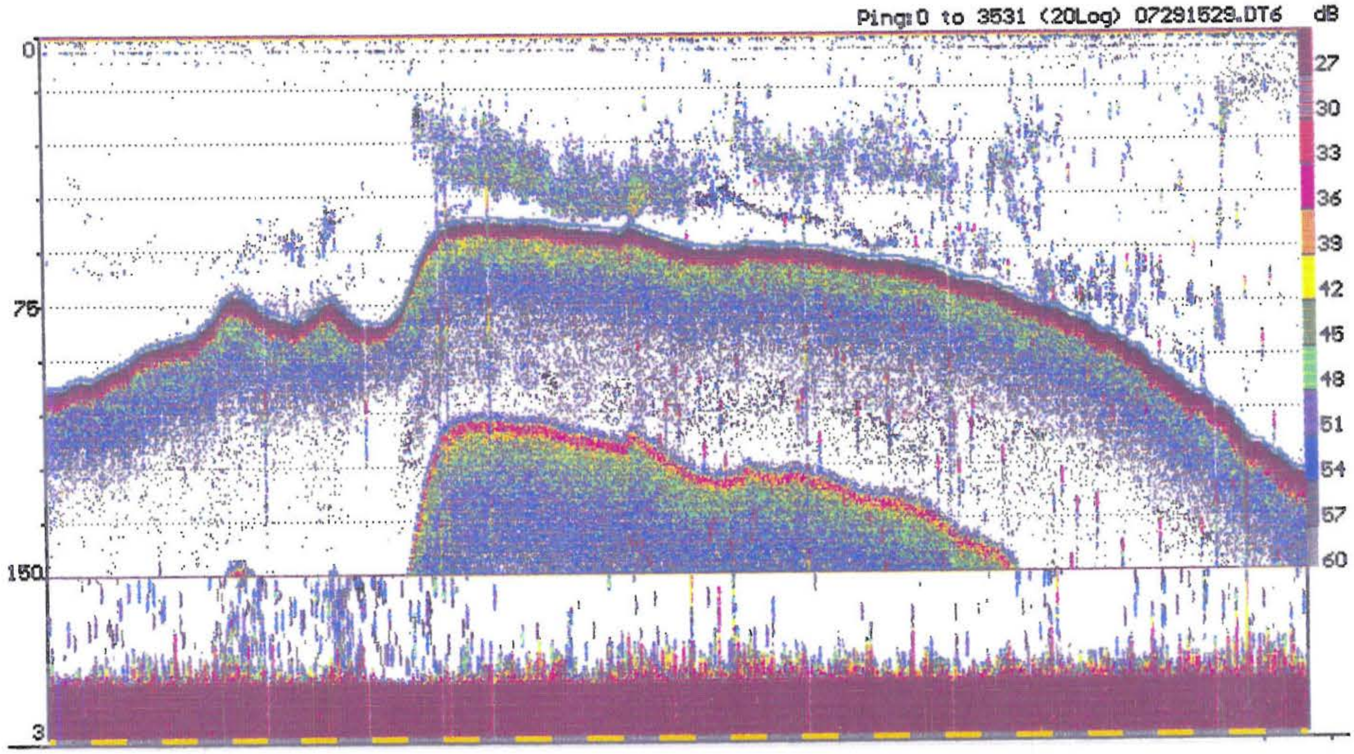


Figure 6B. Echogram showing very sparse bottom echo with mid-water aggregations of fish dispersed from depth of 15 m or so to within a few meters of the bottom. Transect 2B, October 10 1995, 02:33 to 03:32 hrs, distance 5.5 n miles, direction west to east.



RESEARCH REPORT #5: LARVAL HERRING RECRUITMENT

Introduction:

Larval Atlantic herring which hatch in coastal waters of Maine, New Hampshire and Massachusetts in the late summer and fall are transported by surface currents to inshore overwintering areas where they remain until the following spring when they metamorphose into juveniles (Graham 1982, Graham and Townsend 1985, Townsend at al. 1986, Chenoweth et al. 1989). For a number of consecutive years during the 1970's and 1980's, the Maine Department of Marine Resources monitored larval herring size and age frequencies and abundance at two inshore sampling locations for the purpose of forecasting recruitment of two year old juveniles herring to the coastal fishery. This forecasting program was abandoned in 1990, but there is still interest in processing the samples that were collected in the late 1980's for the purpose of understanding the physical processes that affect the survival of individual age groups (cohorts) of larval herring that enter the Sheepscot River, the inshore monitoring location that has produced the longest continuous series of data. Of particular interest are the spawning origin and fate of each cohort (i.e., changes in the abundance of each age group once it enters the estuary) and understanding what effect physical factors such as winter water temperatures and river runoff may have on the survival or retention of each cohort once it enters the estuary.

A great deal of work has already been done in the Sheepscot River to address these issues (Graham 1972, Townsend and Graham 1981, Townsend et al. 1989, Graham and Stevenson 1990, Lazzari and Stevenson 1992, Lazzari et al. 1993), but with one exception (Stevenson et al. 1989), no analysis has been completed using data derived from larval year classes sampled in the estuary since 1985. The purpose of work performed during the past three years as part of the Department's Transboundary Herring Project has been to finish ageing larvae collected in the Sheepscot River during 1988-89 and to complete the analysis of catch rate and age frequency data for the 1985-1988 year classes from this location. The addition of these more recent years will allow a more complete analysis of larval recruitment dynamics in the estuary over a longer time period. This report summarizes the results of age frequency analysis for the 1988 larval year class.

Methods

Herring larvae were collected in buoyed and anchored nets at several different depths and sampling locations in the Sheepscot River (Graham and Venno 1968) on thirteen different sampling dates from October 1988 to February 1989 and preserved in 95% ethanol. A sub-sample of larvae were randomly removed from each sample and measured to the nearest millimeter. Sagittal otoliths were removed from approximately 50 larvae from each sampling date and prepared for microscopic examination and image analysis using a video camera and OPTIMAS software routines. The number of daily growth increments in each otolith were counted and the data were exported to a spread sheet for analysis. Ring counts were then converted to age estimates using previously published estimates of the time delay between spawning and formation of the first daily ring (23 days according to Stevenson et al. 1989). Daily ring formation has been verified in a previous study (Townsend and Graham 1981).

Age frequencies were estimated for each date using an age-length key that represented the full range of sizes present, with lengths grouped into 3 mm intervals and ages grouped into 5 day intervals. The results were presented for individual sampling dates and by month. The monthly data were compiled as representing the middle of each month, regardless of the actual dates when larvae were sampled. For this reason, the daily age frequency data are more accurate than the monthly summaries. Abundance (frequency) was expressed as a catch rate, i.e., the estimated number of larvae caught per 100 m^3 for each 5 day age interval, with age defined in terms of spawning date.

Results

A few herring larvae were present in the river in October and November (Figure 1). Larvae that entered the river in October were derived primarily from eggs that were spawned in July, August, and September (Fig. 2). The older larvae presumably hatched in eastern Maine coastal waters, since herring are known to spawn in July and August only in eastern Maine, and were transported westward by the coastal current, reaching the Sheepscot River two to three months after hatching. This same behavior has been noted for previous larval year classes in the Gulf of Maine (Graham 1982, Graham and Townsend 1985). Larvae spawned in September could have come from eastern Maine or from spawning grounds further west along the coast. As noted in both the size and age frequency data (Figs. 3-5) a single cohort of larvae was present on October 6 (Fig. 3A) that hatched from eggs that were spawned in August. This same cohort was present in equal densities two weeks later (Fig. 3B), but was dominated by younger larvae derived from spawning in September.

In November, the majority of the larvae in the river were one to two months old, having hatched from eggs spawned in September and October (Fig. 2). The cohort which entered the river on October 2 was no longer present. Catch rates for the month were still low (Fig. 1), but were higher on November 2 than on November 17. Larvae which entered the river on November 2 were divided into two distinct age groups (Fig. 3C). Herring spawn at a number of locations along the coast in September and October, so the larvae sampled in November could have come from just about anywhere. Their low densities suggest that either they came from some distance or that spawning at that time of year in the mid-coast region was light.

Larvae present in the river in December belonged almost entirely to a single cohort that was derived from spawning in late October and November (Fig. 2) and they were more abundant than in the previous two months, especially on December 8 (Fig. 1). Most of them were spawned in November. All the larvae that were in the river in October and November had disappeared, either as a result of mortality or because they were discharged from the river by runoff which typically peaks in December (Lazzari et al. 1993). Herring are known to spawn on Jeffreys Ledge, a very productive spawning ground located about 100 km south of the Sheepscot, in October. Some of the larvae from Jeffreys Ledge presumably make it as far north as the Sheepscot despite the prevailing southwestward coastal current (Lazzari and Stevenson 1992).

Two cohorts were present on January 5, a large one derived from late November - early December spawning and a small one from late October - early November spawning (Fig. 3H). Note that the peak catch rate for the whole sampling period was recorded on this date (Fig. 1), so even the smaller cohort was present at higher densities than were recorded on some other sampling dates. The large cohort present on January 5 was composed of larvae a month old. Their place of origin is a mystery, since the only known areas where herring spawn this late in the year are Georges Bank and Nantucket Shoals. The abundance of this cohort suggests, however, that the larvae came from an area much closer to the river. For the month of January as a whole, a wide range of spawning dates was represented, from August to early December (Fig. 2).

By February, larval densities had returned to the same low levels as in October and November (Fig. 1). A few larvae from September and October were in the river in February, but most were derived from spawning in November and December (Fig. 2). Since the December and early January samples included no larvae spawned this early in the year (Figs. 3E through H), the most plausible explanation is that they spent December and early January in coastal waters and entered the river in late January and February. Temperature histories derived from estimates of strontium-calcium ratios in otoliths of herring larvae collected in the Sheepscot River in February 1986 and between October 1986 and April 1987 indicated that the larvae were, in fact, exposed to colder water temperatures than prevail in the river at that time of year and therefore must have spent the fall and winter in warmer coastal waters (Townsend et al. 1989). By contrast, larvae collected in the river in the spring had temperature histories that resembled spring water temperatures in the river and therefore must have entered the river in the spring after overwintering offshore. The range of spawning dates represented in February was similar to January (Fig. 2), suggesting that larvae present in the river in mid-winter remained there.

The absence of large larvae (> 27 mm) from October through early January (Fig. 4) was indicative of the loss of large larvae from the river during this period. The continual presence of small larvae in the fall and early winter is to be expected, given the continuous recruitment of new cohorts into the river over this time period. By late January, most of the larvae in the river ranged from 19 mm to 39 mm (Figs. 4 & 5).

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Figure 1. Catch rates for larval Atlantic herring in the Sheepscot River, October 1988 - February 1989.

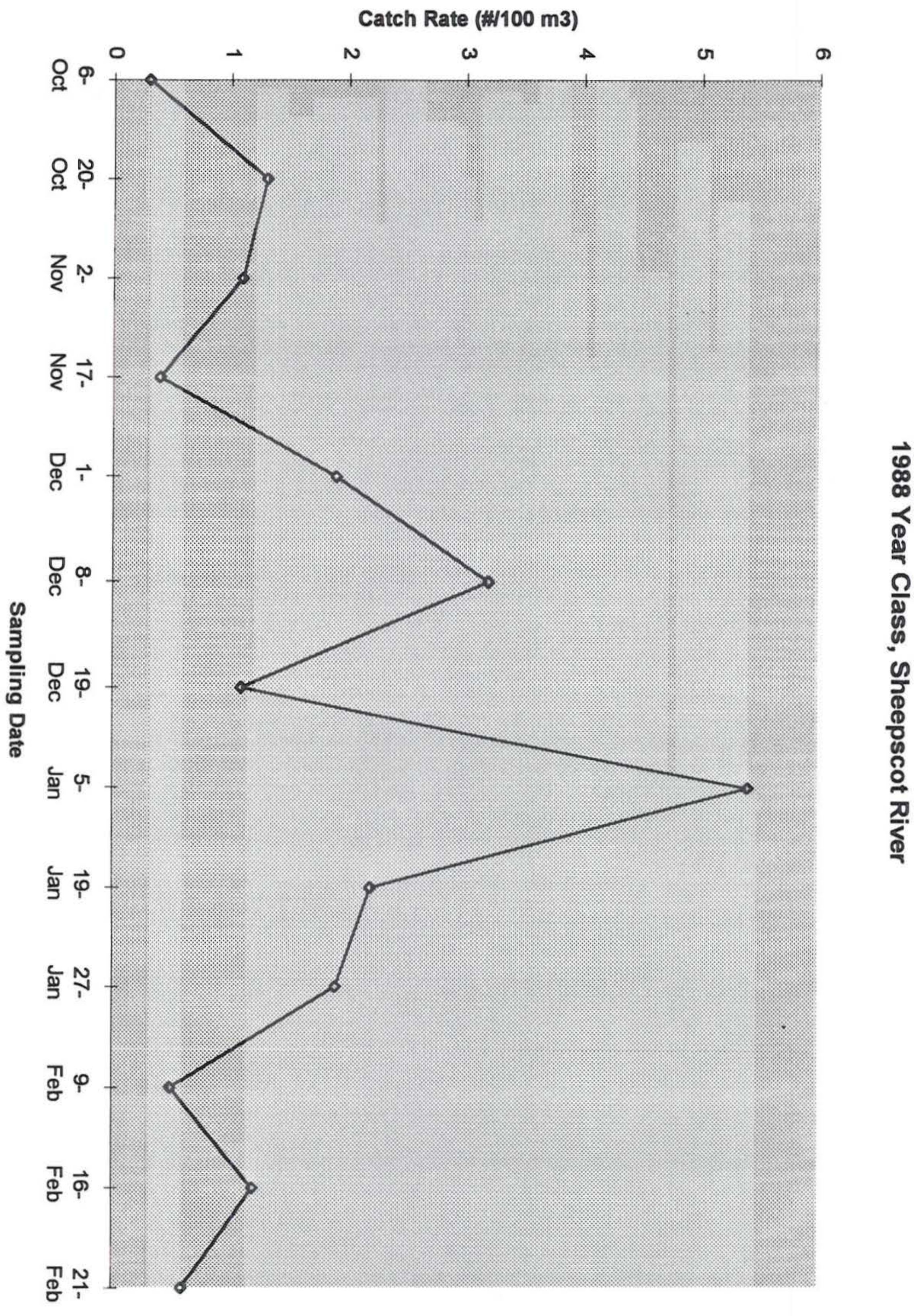


Figure 2. Estimated monthly age frequencies by spawning date for larval Atlantic herring larvae sampled in the Sheepscot River, October 1988 - February 1989, expressed in terms of catch rate. Data were compiled on a mid-month basis.

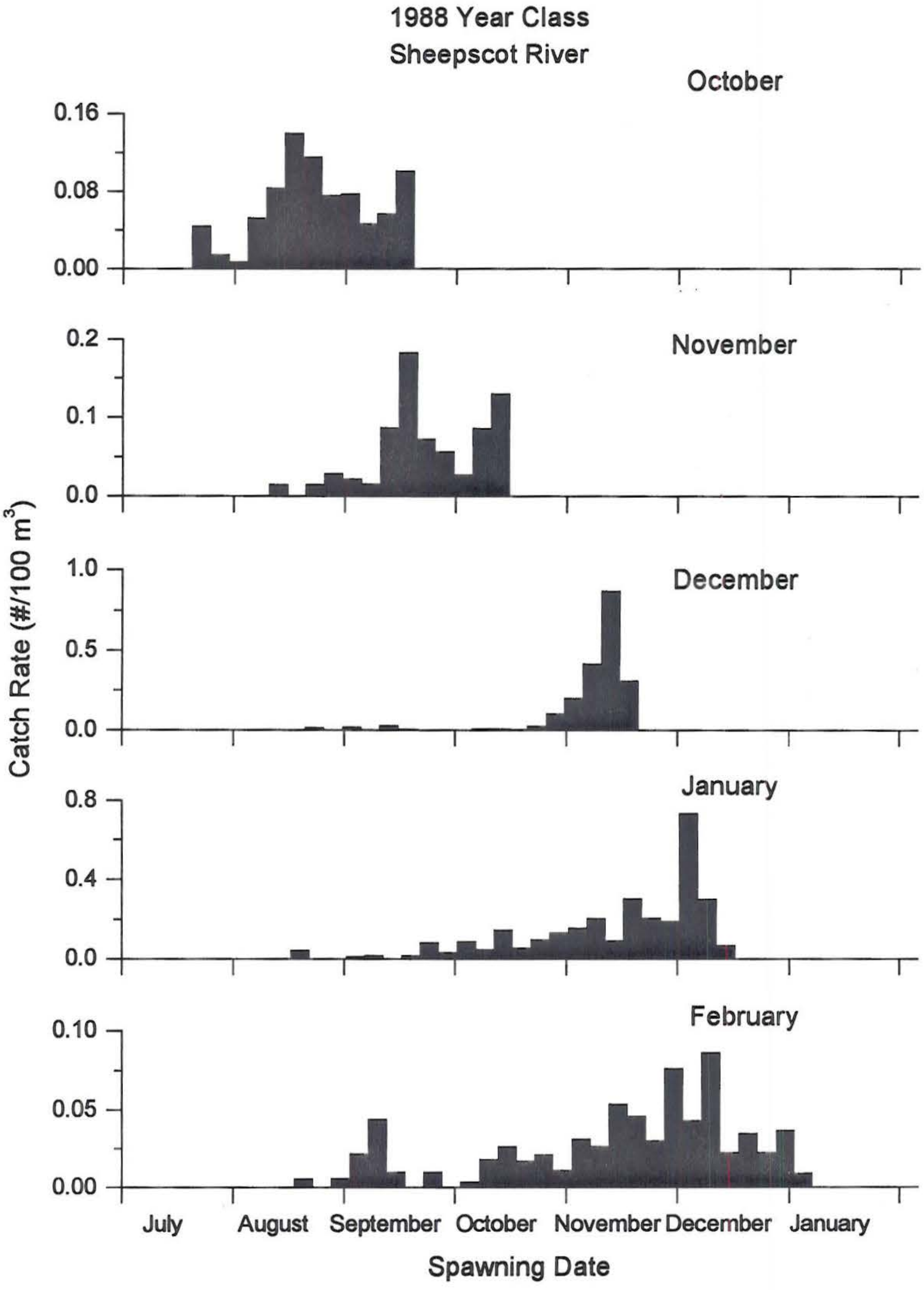


Figure 3. Estimated age frequencies by spawning date for larval Atlantic herring sampled in the Sheepscot River on thirteen dates, October 1988 - February 1989, expressed in terms of catch rate.

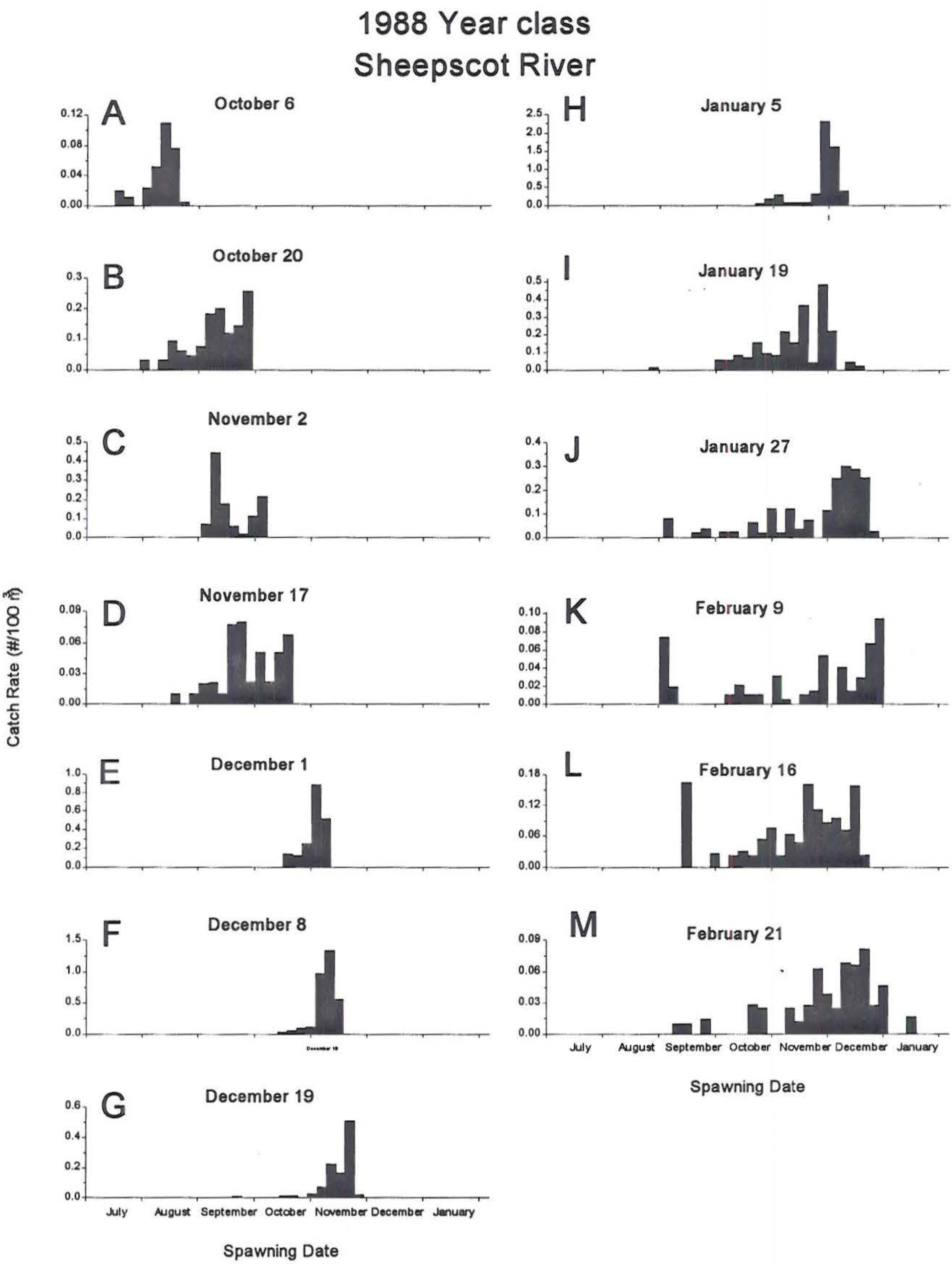


Figure 4. Length frequencies of larval Atlantic herring sampled in the Sheepscot River during October 1988 - February 1989.

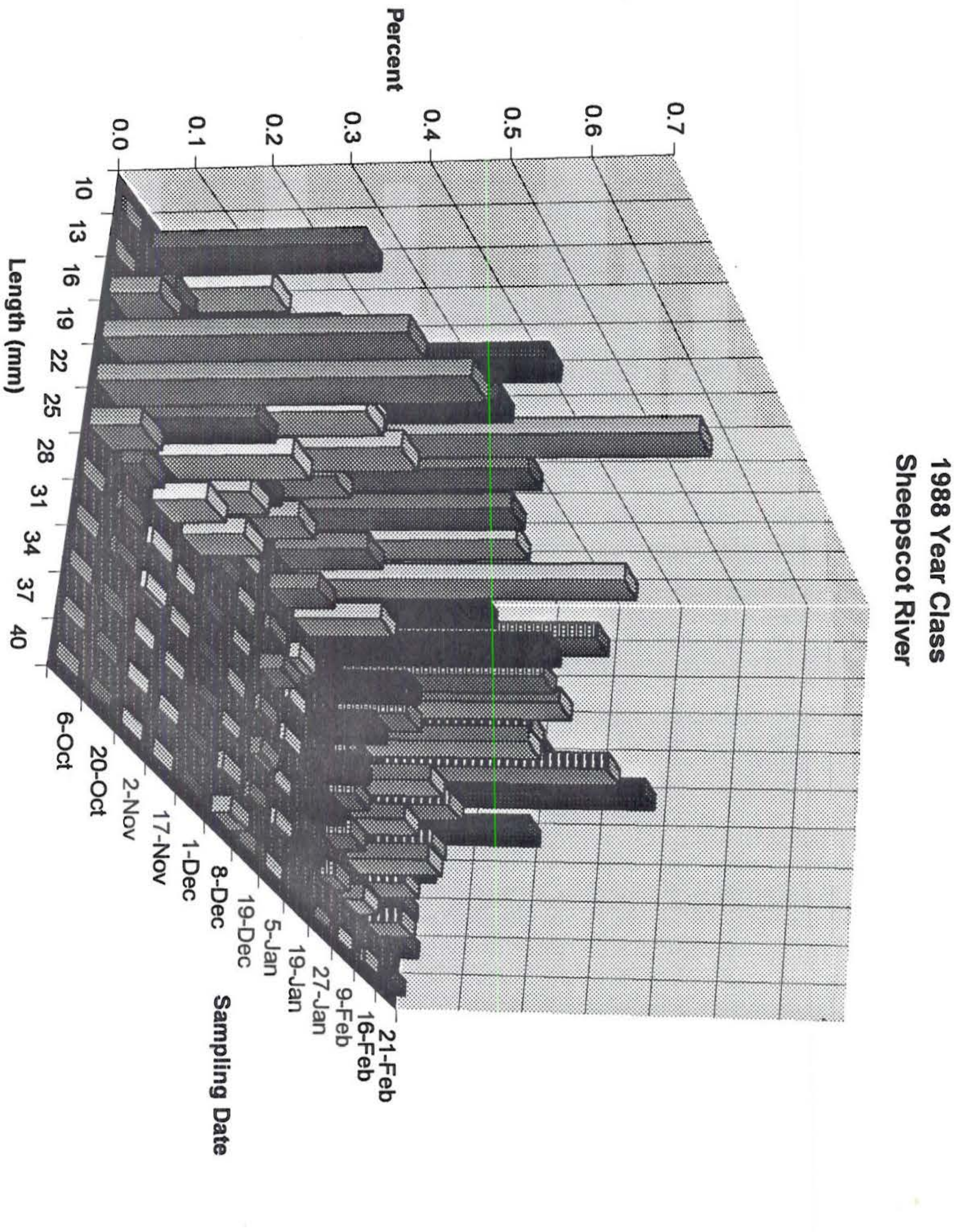
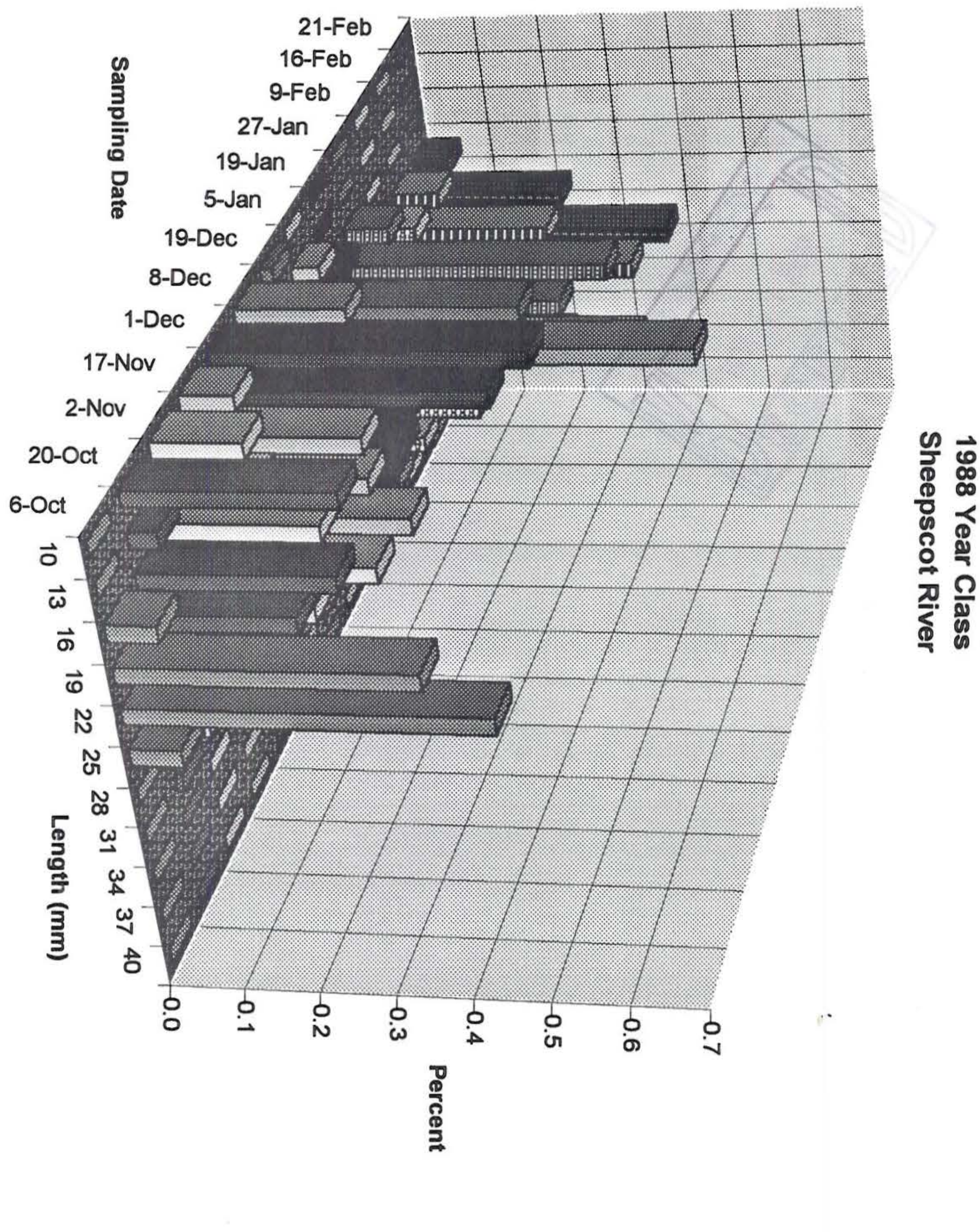


Figure 5. Length frequencies of larval Atlantic herring sampled in the Sheepscot River during October 1988 - February 1989.



APPENDIX A

1995 MAINE HERRING FISHERY STATISTICS

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Research Reference Document 96/2

February 1996

MAINE HERRING FISHERY STATISTICS

Collection and tabulation of the Maine herring landings data were performed by the Maine Department of Marine Resources (MDMR) from 1947 until September 1985. After that time, the duties were assumed by the U.S. National Marine Fisheries Service (NMFS) statistical office in Portland, Maine where they were maintained until April 1990. Since then, collection and tabulation duties have again become the responsibility of the MDMR. The recording of landings statistics for the Maine herring fishery is a joint effort by the NMFS, MDMR, the Maine Sardine Council and industry. Prior to 1991, data now provided by the Sardine Council were collected by Maine Department of Agriculture inspectors working in the canneries. Most landings data are currently provided by the Sardine Council, which collects primary data from the canneries and forwards them to the MDMR; additional data are provided directly by the plants, by fishermen and by NMFS port agents in Portland and Rockland.

When referring to the various tables, note that the amounts reported as Maine landings include all herring landed in Maine ports, regardless of the location of capture, except for fish caught in New Brunswick, Canada weirs. Internal Waters Processing operations (herring caught by Maine fishermen and processed aboard foreign ships anchored in Maine internal waters) are included as a component of total Maine landings. The landings data (Table 1) are complete from 1947 through 1995, except for minor gaps in the earlier records. Maine herring landings are listed by gear used (Table 2) and area caught (Table 3). The entire coast of Maine is divided into three major regions for summarizing landings data. These broad geographic regions are further divided into areas 5 through 19 (Figure 1). Tables 4, 5, and 6 summarize the 1995 Maine domestic, IWP, and total Maine herring landings by gear type, area caught, and month.

Table 7 summarizes the quantity and wholesale value of herring packed each year in Maine and the number of packing plants. Table 8 shows the quantity of herring imports and exports with Canada.

Some Tables may vary by 1 metric ton due to the rounding off to the nearest whole number from all entries.

Table 1
MAINE HERRING LANDINGS[1]
(metric tons)

Year	Total Maine Landings	Year	Total Maine Landings	Year	Total Maine Landings
1880	15,738	1940	17,244	1986	16,264
-	-	1941	32,931	1987	20,676 [2]
1887	15,277	1942	42,637	1988	16,575
1888	18,508	1943	25,941	1989	19,120 [3]
1889	14,586	1944	37,244	1990	22,397
-	-	1945	41,999	1991	27,489 [4]
1892	18,446	1946	36,337	1992	31,187 [5]
-	-	1947	65,486	1993	41,389 [6]
1897	51,079	1948	76,437	1994	37,973 [7]
1898	82,673	1949	74,029	1995	48,279 [8]
1899	56,086	1950	90,557		
1900	44,068	1951	34,411		
1901	67,390	1952	79,139		
1902	55,967	1953	58,337		
1903	55,549	1954	64,067		
1904	73,642	1955	43,506		
1905	78,694	1956	66,494		
1906	71,615	1957	68,623		
1907	27,649	1958	80,759		
1908	30,940	1959	53,037		
1909	49,716	1960	59,348		
1910	52,399	1961	24,131		
1911	79,466	1962	69,376		
1912	62,138	1963	66,895		
1913	17,772	1964	26,295		
1914	59,743	1965	32,088		
1915	-	1966	26,177		
1916	93,935	1967	28,576		
1917	-	1968	31,072		
1918	-	1969	23,852		
1919	39,453	1970	15,617		
-	-	1971	12,960		
1924	21,741	1972	20,271		
-	-	1973	16,886		
1928	29,341	1974	21,499		
1929	41,668	1975	17,348		
1930	33,538	1976	31,858		
1931	25,304	1977	33,135		
1932	14,510	1978	30,341		
1933	19,856	1979	40,454		
1934	-	1980	48,912		
1935	23,107	1981	51,976		
1936	-	1982	24,453		
1937	22,658	1983	19,824		
1938	7,283	1984	21,720		
1939	31,572	1985	14,657		

[1] Maine <u>landings</u> include all herring caught in Maine territorial waters, plus any herring caught in other state or federal waters and brought to Maine by boat, and include bait landings which were estimated from 1947 to 1970 according to the number of lobster traps used and after 1970 from actual landings data.

[2] Includes 300 metric tons from Internal Waters Processing operations.

[3] Includes 3,491 metric tons from Internal Waters Processing operations.

[4] Includes 2,918 metric tons from Internal Waters Processing operations.

[5] Includes 3,339 metric tons from Internal Waters Processing operations.

[6] Includes 6,647 metric tons from Internal Waters Processing operations.

[7] Includes 2,849 metric tons from Internal Waters Processing operations.

[8] Includes 8,776 metric tons from Internal Waters Processing operations.

Table 2
MAINE HERRING LANDINGS BY GEAR
(metric tons)

Year	Stop Seines	Weirs	Purse Seines	Floating Traps	Trawl	Gill Nets	Dip Nets	Unknown	Total [1]
1887		10,626 [3]	10			2,832		1,759	15,227
1888		13,179 [4]	4			3,206		2,119	18,508
–								–	
1919		33,586 [3]	5,740 [5]			4	48	75	39,454
–								–	
1924	6,551 [2]	13,217	1,931 [5]			1		42	21,741
–								–	
1928	9,820 [2]	13,914	5,213 [5]	395 [6]					29,341
1929	10,233 [2]	21,864	9,339 [5]	232 [6]					41,668
1930	1,162 [2]	14,013	17,683 [5]	669		3	3		33,541
1931	117 [2]	14,003	11,069 [5]	106		6			25,301
1932		7,194	7,190 [5]	91 [6]		35			14,510
1933		8,761	10,995 [5]	93 [6]		8			19,856
–								–	
1935		9,310	13,619 [5]	179		< 1			23,108
–								–	
1937	12,822	9,336	327 [5]	174					22,659
1938	4,722 [2]	2,111	363 [5]	86	< 1				7,282
1939	17,504 [2]	12,566	173 [5]	1,274			51		31,572
1940	7,183	9,492	491 [5]	59			18		17,244
–								–	
1942	25,178	16,886	573 [5]						42,637
1943	15,438	7,246	3,256 [5]	1					25,941
1944	13,026	19,289	4,643						37,244
1945									41,999 [7]
1946									36,336 [7]
1947	33,345	15,629	2,621					283	51,878
1948	46,030	17,665	1,045					316	65,057
1949	36,703	26,326	74					38	63,142
1950	53,873	26,793	379					372	81,417
1951	22,010	8,727	456					157	31,349
1952	57,336	16,789	1,814					33	75,971
1953	40,982	9,611	1,158					493	52,243
1954	46,375	11,070	493					76	58,014
1955	33,813	6,775	31					76	40,694
1956	52,504	7,386	404					2	60,296
1957	51,666	10,222	671	1					62,590
1958	64,942	8,522	156	10				230	73,860
1959	45,027	3,551	15						48,592
1960	43,899	6,011	284	2	1				50,198
1961	15,670	1,297	5,141	23	17				22,147
1962	50,918	5,407	2,683		41			89	59,138
1963	41,989	3,655	1,104	5	2			2,870	49,661

Table 2 (cont.)
MAINE HERRING LANDINGS BY GEAR
(metric tons)

Year	Stop Seines	Weirs	Purse Seines	Floating Traps	Trawl	Gill Nets	Dip Nets	Unknown	Total [1]
1964	20,047	1,961	2,843	8	112			159	25,129
1965	18,731	6,148	5,026		44			280	30,230
1966	9,156	6,236	7,523	18				29	22,962
1967	8,287	3,552	14,814	5				18	26,681
1968	14,128	5,039	8,681	3					27,852
1969	3,980	3,486	15,178	1				21	22,667
1970	2,259	925	12,311						15,495
1971	2,950	246	9,190					572	12,957
1972	15,495	1,731	3,031						20,257
1973	5,468	808	10,546	3	38			23	16,887
1974	2,644	2,726	16,130						21,500
1975	6,866	2,407	8,075						17,349
1976	25,226	1,848	4,782	1					31,857
1977	19,139	1,320	12,336	< 1	340				33,135
1978	8,429	6,071	15,242		599				30,341
1979	31,477	6,113	2,470	1	479				40,540
1980	32,623	3,284	12,764		240				48,911
1981	31,280	13,632	7,063		< 1				51,976
1982	6,680	4,278	13,495						24,453
1983	1,957	586	17,281						19,824
1984	149	231	21,279		61				21,720
1985	3,749	942	9,954		12				14,657
1986	1,284	383	14,587		10				16,264
1987	1,361	140	19,175						20,676 [8]
1988	732	1,240	14,219	1	382	2		–	16,575
1989	733	700	17,688						19,121 [9]
1990	216	422	21,760						22,398
1991	918	215	26,327					30	27,490 [10]
1992	3,440	397	27,350						31,187 [11]
1993	2,290	56	34,984		4,058				41,388 [12]
1994	292	168	32,749		4,572 [14]	19		173	37,973 [13]
1995	0	0	30,261		17,901			117	48,279 [15]

[1] Total landings for years 1947-1970 do not include estimated bait landings
[2] Includes haul seines
[3] Includes floating traps & pound nets
[4] Includes floating traps
[5] Incidental to mackerel purse seine catches
[6] Includes pound nets
[7] No gear data available
[8] Includes 300 metric tons from Internal Waters Processing operations.
[9] Includes 3,491 metric tons from Internal Waters Processing operations.
[10] Includes 2,918 metric tons from Internal Waters Processing operations.
[11] Includes 3,339 metric tons from Internal Waters Processing operations.
[12] Includes 6,647 metric tons from Internal Waters Processing operations.
[13] Includes 2,849 metric tons from Internal Waters Processing operations.
[14] Mid-water Trawl and Bottom Trawl have been combined under the heading "Trawl".
[15] Includes 8,776 metric tons from Internal Waters Processing operations.

Table 3
MAINE HERRING LANDINGS BY AREA CAUGHT
(metric tons)

Year	Western Coastal Maine	Central Coastal Maine	Eastern Coastal Maine	Offshore[1] Maine	Jeffreys NH & Mass.Bay	Canada[1]	Unknown Areas	Total
1947	25,251	21,587	20,106					66,944
1948	24,547	37,189	14,378				17	76,131
1949	20,873	21,638	33,182					75,693
1950	23,895	34,300	33,128					91,323
1951	6,672	17,273	10,442					34,387
1952	15,529	38,872	23,526				18	77,945
1953	19,415	27,830	10,983				15	58,243
1954	24,046	24,592	15,397				43	64,078
1955	16,504	16,675	7,530				36	40,745
1956	24,556	32,710	9,355					66,621
1957	22,584	30,378	15,638					68,600
1958	33,306	33,074	14,897					81,277
1959	25,560	19,721	7,425					52,706
1960	20,650	30,843	7,852					59,345
1961	12,322	10,106	1,665					24,093
1962	29,374	30,316	8,906				89	68,685
1963	21,804	33,388	8,011				2,830	66,033
1964	13,109	9,762	3,402				177	26,450
1965	9,368	12,848	9,581				1,037	32,834
1966	8,313	9,262	8,576					26,151
1967	6,413	17,148	4,837		12			28,410
1968	7,238	12,984	10,068		41		5	30,336
1969	5,653	13,816	4,685					24,154
1970	5,657	9,432	945		36			16,070
1971	3,944	7,577	575		664		370	13,130
1972	5,798	11,567	2,168		897			20,430
1973	2,852	12,184	1,339		488		23	16,886
1974	1,663	13,279	4,199		2358			21,499
1975	1,170	9,456	4,556		2166			17,348
1976	5,671	17,824	6,694		1668			31,857
1977	9,404	16,530	6,423		776			33,133
1978	10,503	6,548	12,804		486			30,341
1979	8,008	17,582	14,629		322			40,541
1980	4,701	20,301	21,200		2710			48,912
1981	4,924	18,527	24,795		3730			51,976
1982	5,175	11,614	7,218		446			24,453
1983	2,695	14,833	659		1637			19,824
1984	3,252	10,582	5,678		2208			21,720
1985	1,650	8,528	3,691		788			14,657
1986	2,112	11,036	2,384		732			16,264
1987	5,293	11,350	3,368		665			20,676 *
1988	4,060	8,120	1,920		1875			16,575
1989	4,010	13,228	812		1070			19,120 *
1990	6,731	13,462	528		1205		472	22,398
1991	2,240	21,382	479		2510		877	27,489 *
1992	7,951	17,640	694	1231	3671			31,187 *
1993	16,910	13.345	82	1213	9394	352	93	41,389 *
1994	9,520	11,604	911	2241	13131	20	546	37,973 *
1995	9,060	10,932	322	9828	16464		1674	48,279 *

[1] Offshore Maine areas and Canada included beginning in 1992.
* Includes Internal Waters Processing landings.

Table 4
1995 DOMESTIC MAINE HERRING LANDINGS BY AREA CAUGHT, GEAR AND MONTH[1]
(metric tons)

	Jeffreys Ledge & MA Bay			Offshore Western			Western Coastal Maine			Offshore Central Maine				Central Coastal Maine			Eastern Coastal Maine			Unknown Areas[2]				
Month	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Unknown Gear	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Unknown Gear	Total	Grand Total
Jan.	104	313	417																					417
Feb.																								0
Mar.																								
Apr.	492	658	1150																			1	1	1151
May	435	882	1317	36	22	58	442	42	484	658	3		661							431	26		457	2977
Jun.	1084	597	1681				329	186	515	2100			2100				21		21	33	223		256	4573
Jul.		240	240		81	81	228	1486	1714	3508	36	51	3595	1294		1294		23	23	101	148		249	7196
Aug.		758	758				576	398	974	2839	39	55	2933	1880		1880	36		36	122	190		312	6893
Sep.	21	740	761				1045	14	1059		114		114	4306	11	4317				205	63		268	6519
Oct.	3430	1033	4463				122		122	63			63	3363	78	3441		241	241	122			122	8452
Nov.	715	530	1245																			10	10	1255
Dec.		71	71																					71
Total	6281	5822	12103	36	103	139	2742	2126	4868	9168	192	106	9466	10843	89	10932	57	264	321	1014	650	11	1675	39504

[1]Does not include 8776 mt from Internal Water Processing operations.
[2]All herring caught in unknown areas were processed as bait.

Table 5
1995 MAINE HERRING LANDINGS FROM INTERNAL WATER PROCESSING OPERATIONS
BY AREA CAUGHT, GEAR AND MONTH
(metric tons)

Month	Jeffreys Ledge & Mass. Bay Trawl	Offshore Western Maine Trawl	Western Coastal Maine Purse Seine	Western Coastal Maine Trawl	Western Coastal Maine Total	Offshore Central Maine Purse Seine	Grand Total
Jan.							
Feb.							
Mar.							
Apr.							
May							
Jun.	84		20		20		104
Jul.	423	158	50	2980	3030	63	3674
Aug.	2774			1143	1143		3917
Sep.	1081						1018
Oct.							
Nov.							
Dec.							
Total	4362	158	70	4123	4193	63	8776

Table 6
1995 TOTAL MAINE HERRING LANDINGS BY AREA CAUGHT, GEAR AND MONTH[1]
(metric tons)

Month	Jeffreys Ledge & MA Bay			Offshore Western			Western Coastal Maine			Offshore Central Maine				Central Coastal Maine			Eastern Coastal Maine			Unknown Areas[2]				Grand Total
	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Unknown Gear	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Total	Purse Seine	Trawl	Unknown Gear	Total	
Jan.	104	313	417																					417
Feb.																								0
Mar.																								
Apr.	492	658	1150																			1	1	1151
May	435	882	1317	36	22	58	442	42	484	658	3		661							431	26		457	2977
Jun.	1084	681	1765				349	186	535	2100			2100				21		21	33	223		256	4677
Jul.		663	663		240	240	278	4466	4744	3571	36	51	3658	1294		1294		23	23	101	148		249	10871
Aug.		3532	3532				576	1540	2116	2839	39	55	2933	1880		1880	36		36	122	190		312	10809
Sep.	21	1821	1842				1045	14	1059		114		114	4306	11	4317				205	63		268	7600
Oct.	3430	1033	4463				122		122	63			63	3363	78	3441		241	241	122			122	8452
Nov.	715	530	1245																			10	10	1255
Dec.		71	71																					71
Total	6281	10184	16465	36	262	298	2812	6248	9060	9231	192	106	9529	10843	89	10932	57	264	321	1014	650	11	1675	48280

[1]Includes 8776 mt from Internal Water Processing operations.
[2]All herring caught in unknown areas were processed as bait.

Table 7
NUMBER AND VALUE OF STANDARD CASES[1] OF MAINE CANNED HERRING PRODUCTS AND NUMBER OF MAINE HERRING PACKING PLANTS[2]

Year	Standard Cases	Wholesale Value ($)	No. of Maine Packing Plants
1950	3,844,164	21,209,033	46
1951	1,676,764	14,635,352	44
1952	3,530,876	21,507,970	48
1953	2,782,495	16,954,119	44
1954	2,934,933	18,152,815	43
1955	1,268,843	9,333,350	35
1956	2,231,441	16,692,008	39
1957	2,217,688	14,733,259	37
1958	2,099,959	15,873,963	33
1959	1,753,145	14,902,142	31
1960	1,997,618	16,699,987	31
1961	753,647	7,559,619	31
1962	2,144,372	19,931,333	31
1963	1,637,348	13,547,306	27
1964	865,751	7,583,821	23
1965	1,226,903	10,868,060	23
1966	1,332,544	12,261,590	23
1967	1,250,411	13,862,330	23
1968	1,730,306	19,296,678	22
1969	1,042,806	11,531,342	21
1970	806,501	11,226,817	21
1971	950,821	11,796,509	20
1972	1,561,535	23,877,119	18
1973	995,056	15,688,156	17
1974	1,143,801	23,954,640	16
1975	1,248,929	27,998,614	15
1976	1,209,074	29,591,481	15
1977	1,269,955	34,407,778	15
1978	1,301,965	41,167,963	15
1979	1,429,646	49,370,005	14
1980	1,109,883	41,370,210	14
1981	1,468,809	49,433,137	14
1982	1,014,336	40,573,440	13
1983	724,103	26,450,000	12
1984	870,179	34,213,000	12
1985	983,651	37,800,000	11
1986	953,194	43,680,696	10
1987	882,178	40,414,536	10
1988	980,826 [3]	44,137,170	9
1989	770,224	34,660,080	8
1990	815,758	37,340,886	8
1991	847,319	42,317,602	7
1992	948,792	47,439,600	6
1993	924,298	46,214,900	6
1994	934,686	46,734,300	6
1995	872,924	43,646,200	6

[1] A "Standard Case" contains 100 cans. From 1990 on, no cans other than the 3¼ oz. size have been packed in Maine.
[2] Data prior to 1950 (1919-1949) are available from the Maine Department of Marine Resources.
[3] Maine & Massachusetts --- Mass. with 1 plant.

Table 8
MAINE IMPORTS AND EXPORTS OF WHOLE HERRING
(metric tons)

Year	Imports from Canada	Exports into Canada
1975[1]	39,571	314
1976	26,145	2,675
1977	17,791	3,069
1978	23,547	1,804
1979	16,162	7,502
1980	8,417	12,795
1981	5,095	11,746
1982	11,390	2,608
1983	11,674	297
1984	9,776	943
1985	18,651	215
1986	13,608	569
1987	11,721	568
1988	16,035	339
1989	13,020	40
1990	13,543	17
1991	14,176	59
1992	11,742	179
1993	8,200	6
1994	7,054	21

[1]Data for earlier years are available from the Maine Dept. of Marine Resources.

Note: Beginning in 1991, import/export data were obtained from the U.S. Dept. of Commerce, NOAA Fisheries Statistics Div., in Silver Springs, MD. Prior to 1991, these data were obtained from the U.S. Bureau of Census, Foreign Trade Div., Trade Data Inquiries and Controls Section, in Washington D.C.

Table 9
PRODUCT DESTINATION OF WHOLE HERRING LANDED IN OR IMPORTED TO MAINE
(metric tons)

	Sardines/Steaks/Kippers[1]						
Year	From Other States	From Canada	From Maine Landings (no IWP's)	Total	Bait	Herring Caught For Internal Waters Processing[2]	Other[3]
1975	4,033	23,595	16,559	44,187	0		1,165
1976	2,064	12,973	29,260	44,297	206		5,982
1977	4,908	9,776	27,976	42,660	144		12,983
1978	3,158	17,582	20,124	40,864	0		21,282
1979	4,777	8,569	34,445	47,791	303		16,223
1980	6,876	4,018	32,127	43,021	0		13,891
1981	5,486	3,316	42,172	50,974	1,460		5,251
1982	3,700	9,936	17,061	30,697	3,204		1,893
1983	527	12,237	13,406	14,170	4,088		1,650
1984	3,634	9,594	17,870	31,098	3,551		445
1985	5,098	17,468	9,513	32,079	4,684		342
1986	15,240	1,851	11,233	28,324	3,476		506
1987	10,627	11,347	12,248	34,222	6,880	300	1,313
1988	9,003	16,017	8,505	33,525	7,128	0	601
1989	5,452	4,813	5,146	15,411	10,065	3,491	8,480
1990	7,703	13,507	6,781	27,991	15,587	0	62
1991	10,150[4]	9,247[4]	13,884	33,281[4]	10,653	2,918	66
1992	9,111	11,742	14,482	35,335	13,253	3,339	0
1993	5,671	8,200	17,928	31,799	16,814	6,647	9
1994	8,244	7,054	17,576	32,874	17,516	2,849	33
1995	11,204	2,804	15,780	29,788	23,662	8,776	62

[1] Products packed by Maine plants.
[2] Internal Waters Processing operations began in 1987.
[3] Fresh, pickled, frozen, reduction, pet food or unknown.
[4] Incomplete data.

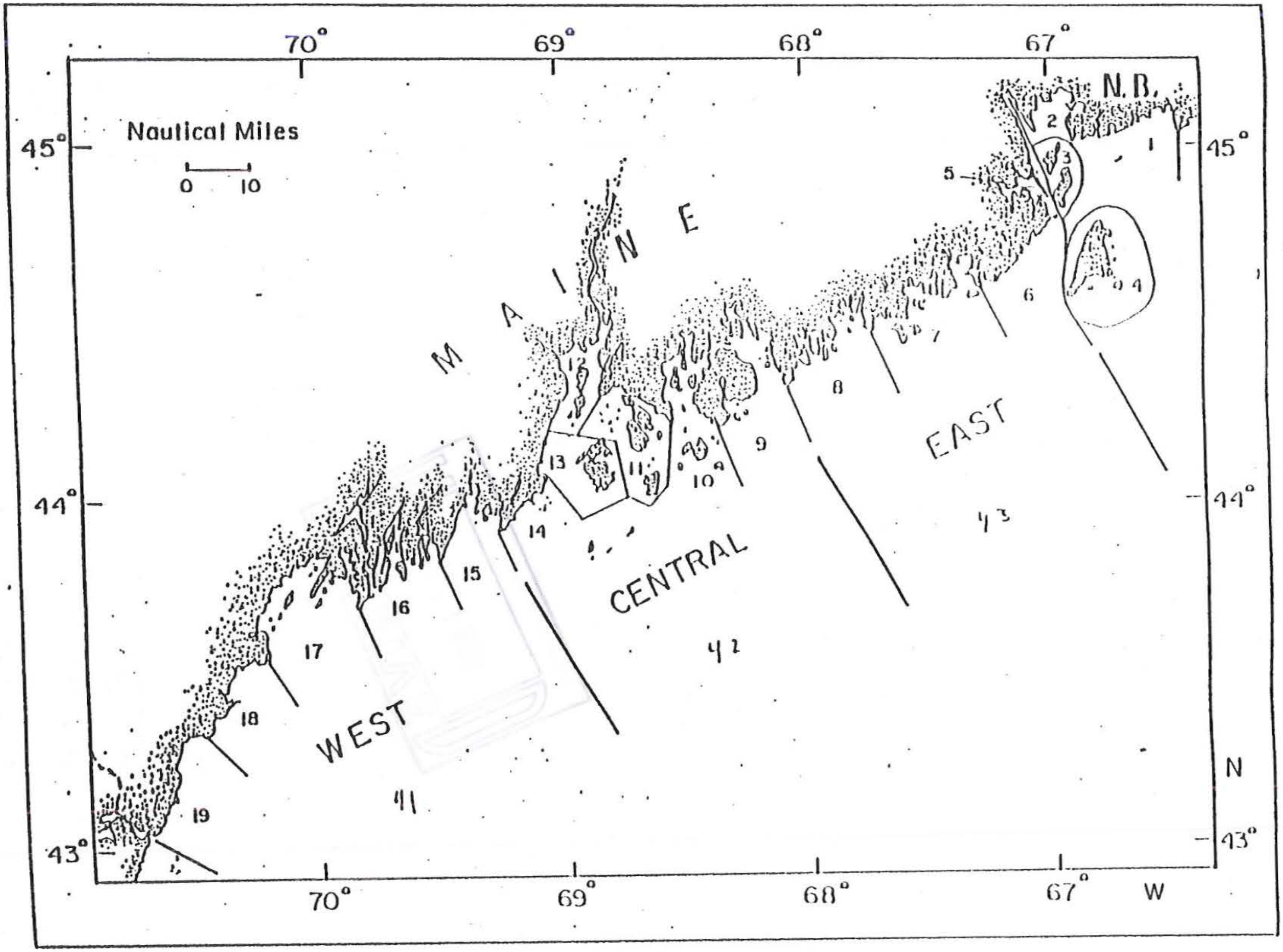

Figure 1. The Maine coast is divided by sections and subdivided by area. Herring landings are summarized within the sections and areas.