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STATUS OF ATLANTIC HERRING RESOURCES IN THE GULF OF MAINE REGION - 1983

by

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TABLE OF CONTENTS

SUMMARY ii

INTRODUCTION 1

MANAGEMENT 2

COMMERCIAL FISHERY 3
- Coastal Maine 3
- Jeffreys Ledge 5
- Cape Hatteras-Nova Scotia 6

RESEARCH VESSEL SURVEY INDICES 7

RECRUITMENT 9

MORTALITY 11
- Fishing Mortality in 1982 11
- Gulf of Maine Option 13
- Pooled Area Option 13

STOCK SIZE 14
- Gulf of Maine Option 14
- Pooled Area Option 14

DISCUSSION 14

LITERATURE CITED 17

TABLES 18-25

FIGURES 26-33

SUMMARY

Nominal catches of herring in the coastal Maine fixed gear fisheries decreased from 48,245 mt in 1981 to 24,007 mt in 1982. Decreased landings during 1982 appear to reflect both reduced abundance and changes in availability. The mobile gear component of the coastal Maine fishery accounted for 54.3% of the total in 1982, in contrast with the 1979-1981 mean level of 16.6%. The greater flexibility of the mobile gear fleet in locating herring concentrations is apparently responsible for increased purse seine catches in 1982. The 1980 year class dominated both fixed and mobile gear catches in the coastal Maine fishery, accounting for 55.5% by weight of total landings. The 1976-1979 year classes contributed 8.5, 17.1, 1.4. and 14.2% by weight of the landed total, respectively.

Herring landings in the Jeffreys Ledge fishery during 1982 declined to 7,663 mt, a 50% reduction relative to 1981 levels and a 78.8% decline from the 1980 catch of 36,175 mt. Changing market conditions, coupled with potential changes in abundance and availability have made interpretation of events in this fishery particularly difficult. The 1982 Jeffreys Ledge fishery was dominated by the 1976 and 1977 cohorts which comprised 34.3% and 37.9%, respectively, of the landed total by weight. The 1979 year class (partially recruited) comprised 12.7% by weight of the total; the 1978 year class contributed just 4.8% of the total, indicating low abundance of this cohort.

NEFC spring bottom trawl survey indices have closely tracked changes in herring abundance and biomass as measured by virtual population analyses. NEFC survey indices declined for 1981-1982, suggesting that decreased landings in 1982 were not strictly a function of decreased availability to the fishery. Results of inshore surveys conducted by the Massachusetts Division of Marine Fisheries indicate similar trends. Estuarine sampling work by the Massachusetts Division of Marine Fisheries indicates the 1980 year class to be of moderate size. Larval herring surveys conducted by the State of Maine indicate reduced larval densities for the 1981 and 1982 year classes for several localized spawning groups.

Results of virtual population analysis for the Gulf of Maine indicate a decline in abundance relative to 1979-1980 levels. The short-term outlook for Gulf of Maine herring fisheries appears to be one of reduced catch levels as a consequence of decreased abundance and changes in availability. Market conditions affected the adult herring fishery considerably in 1982 and it is probable that this scenario will continue during 1983-1984.

INTRODUCTION

The Atlantic herring (*Clupea harengus*) is widely distributed in the western North Atlantic, occurring in continental shelf waters from Labrador to Cape Hatteras. Atlantic herring support important commercial fisheries in the Gulf of Maine and adjacent Scotian Shelf (NAFO[1] Divisions 5Y and 4WX; Figure 1). Juvenile herring have been exploited along the coasts of Maine, New Brunswick, and Nova Scotia since the last century. Fisheries for adult[2] herring have developed during the last two decades, primarily on Georges Bank, in the western Gulf of Maine, and on the Scotian Shelf.

Tagging results indicate that both juvenile and adult herring overwinter in Cape Cod Bay and in the Southern New England - Mid-Atlantic region (Speirs, 1977; Chenoweth et al., 1980; Almeida and Burns, 1978). Larger (older) individuals typically undertake more extensive seasonal migrations. Seasonal intermixture of herring stocks throughout the Nova Scotia - Gulf of Maine region has also been demonstrated (Almeida and Burns, 1978; Stobo, 1982) although the level of mixing has not been quantified.

The present document provides an update of the analytical assessment by Fogarty and Anthony (1982), based largely on landings statistics and biological samples obtained by the National Marine Fisheries Service (NMFS) and the Maine Department of Marine Resources (DMR). Due to annual variability in stock composition and levels of intermixture, two alternative analytical assessments are provided. The Gulf of Maine assessment treats

[1] Northwest Atlantic Fisheries Organization

[2] In this document, fisheries for adult herring are considered to be directed at age 3 and older fish by mobile gear (purse seine, pair trawls, demersal trawls).

the coastal Maine juvenile herring fishery and the western Gulf of Maine adult herring fishery as interdependent (i.e., it is assumed that these fisheries exploit the same stock but with markedly different selection patterns). The Pooled Area assessment provides an analysis of combined herring stocks throughout the Cape Hatteras - Nova Scotia region in recognition of seasonal stock intermixtures in the Scotian Shelf - Gulf of Maine area. The Pooled Area assessment incorporates the discounting procedure of Anthony et al. (1980) to account for the effects of the collapse of the Georges Bank fishery. The reader is referred to Anthony and Waring (1980) for additional information on the Georges Bank and Gulf of Maine herring fisheries.

MANAGEMENT

Herring resources within NAFO Subareas 5 and 6 were regulated by the New England Fishery Management Council (NEFMC) during 1978-1982 under the provisions of the Fishery Management Plan (FMP) for Atlantic herring. Quota allocations for domestic fishermen were established for a July 1-June 30 fishing year; quotas of 8,000 mt and 10,000 mt of age 3 and older herring imposed within NAFO Division 5Y (excluding Maine territorial waters) and Division 5Z - Subarea 6, respectively. Seasonal suballocations were devised based on summer-fall (July-November) and winter-spring (December-June) fishing patterns. No foreign fishery allocations were established nor were provisions for management of juvenile herring (ages 1-2) resources specified.

The FMP was subsequently amended in March 1980 to increase quota allocations for NAFO Division 5Y and to establish separate subquotas north and south of Cape Elizabeth, Maine (43°34'N) (Figure 1). Fishing-year allocations of 10,470 mt and 22,530 mt for age 3 and older herring were set in 5Y north and 5Y south (including Division 5Z - Subarea 6), respectively. The amendment further eliminated the exemption for catches of age 3 and older herring within Maine territorial waters.

Due to massive quota overages during 1980, difficulty in coordinating complementary management programs within state territorial waters, the prospect of further quota overages in 1982, and the perception of increased abundance levels, the National Marine Fisheries Service (NMFS) recommended withdrawal of the FMP in August 1982. The FMP was officially withdrawn in January 1983. A new draft management plan is currently under development by the states of Maine, New Hampshire, Massachusetts, and Rhode Island[3]. The draft interstate management plan is intended to regulate herring fisheries within state territorial waters. Development of a new herring management plan for the Fishery Conservation Zone is contingent on state management efforts and future fishing trends.

COMMERCIAL FISHERY

Coastal Maine

Nominal 1982 catches (landings exclusive of any discard, hereafter referred to as landings) of coastal Maine herring declined to 24,007 mt in 1982, a 50% decrease relative to 1981 landings of 48,245 mt (Table 1;

[3]David Pierce, Massachusetts Division of Marine Fisheries, Boston, Massachusetts, pers. comm., October 1983.

Figure 2). Landings averaged 44,788 mt during 1979-1981, the highest level since 1963. Increased landings during this period were attributable to recruitment of a succession of strong year classes. Decreased 1982 landings appear to be related in part to reduced availability of herring to the fixed gear fishery. This inference is supported by a marked increase in mobile gear landings relative to landings by fixed gear in 1982 (Table 2). Purse seine landings accounted for 54% of the coastal Maine total in 1982, compared to 17% of the 1979-1981 total. Mobile gear landings during 1982 were the highest since 1978.

The coastal Maine herring fishery is typically selective for age 2 herring (Figure 3); the 1980 year class comprised 55% by weight of the coastal Maine total during 1982 (Table 3) and 83% by weight of 1982 stop seine and weir landings (Table 5b). Corresponding catches in numbers by age class are provided in Tables 4 and 5a. Dominance of age 2 herring in coastal Maine catches for most years reflects selection by the fixed gear fisheries; however, during periods of reduced abundance or availability of age 2 herring the catch may be comprised largely of age 1 or age 3 herring. The mobile gear fishery is typically selective for older fish.

The 1979 year class, which supported the highest landings at age 2 since 1963, accounted for 14% by weight of the landed total in 1982 (Tables 3 and 5b); corresponding figures for the 1977 and 1976 year classes, both of which contributed strongly to recovery of the fishery during 1979-1981, were 17% and 9%, respectively. In contrast, the 1978 year class comprised just 1% of the coastal Maine total in 1982, indicating this year class to be among the weakest on record.

Preliminary 1983 landings totaled 18,187 mt, of which 15,644 mt (86%) were taken using mobile gear. Mobile gear landings were among the highest observed during the last two decades while fixed gear landings were among the lowest (Table 2).

Jeffreys Ledge

Total 1982 landings from the Jeffreys Ledge adult herring fishery (including landings from NAFO Division 5Z and Subarea 6) were 7,663 mt, a 50% decline relative to 1981 landings and a 79% decline from the 1980 level of 36,175 mt (Table 1; Figure 2). Market conditions, influenced by recovery of European herring fisheries (notably in the North Sea), has resulted in reduced demand for domestically produced adult herring for export over the last several years. Preliminary 1983 landings of 4,280 mt indicate continued declines in the Jeffreys Ledge fishery.

The 1982 fishery was dominated by the 1977 and 1976 year classes which comprised 38% and 34%, respectively, of the landed total (Table 6; see Table 7 for corresponding catch in numbers-at-age data). The 1979 year class contributed 1,147 mt (13%). On the basis of the strong contribution of the 1979 year class to the juvenile herring fishery along the Maine coast, it was anticipated that this cohort would contribute substantially to the 1982 Jeffreys Ledge fishery. The 1978 year class comprised 4.8% (433 mt) of total landings and appears to be among the weakest year classes since the inception of the directed fishery in 1967.

Age composition of Jeffreys Ledge herring landings has undergone dramatic changes since 1967 (Figure 4). Age composition shifted from a relatively robust structure characterized by contribution of numerous

age classes to a marked dependency on a few strong cohorts (e.g., the 1970 and 1976 year classes). The recent pattern is one which must be considered potentially destabilizing.

Cape Hatteras - Nova Scotia

In contrast with the sharp decline noted in the USA juvenile and adult herring fisheries in 1982, the Canadian fixed and mobile gear fisheries remained relatively stable. New Brunswick (NAFO Division 4Xb) landings[4] increased from 20,448 mt in 1981 to 26,066 mt in 1982 (Table 1). Nova Scotia (NAFO Divisions 4W and 4Xa) landings[4] decreased slightly from 86,338 mt in 1981 to 84,630 mt in 1982. Fixed gear landings in Nova Scotia and New Brunswick were dominated by the 1980 year class which comprised 68% and 78% of catch in numbers, respectively[4].

Year-class strength estimates have typically paralleled each other throughout the Gulf of Maine - Scotian Shelf region (Anthony and Waring, 1980), possibly reflecting broad scale hydrographic or climatological effects on year class success and/or stock intermixture during different phases of the annual migration. However, the 1977 and 1979 year classes were represented more strongly at age 2 in coastal Maine fixed gear landings than in Canadian waters. Shifts in distribution may at least partially account for some of the apparent discrepancies noted. Dominant year classes (e.g., 1960, 1963, 1966, 1970, 1976) have been strongly represented in both Canadian and USA catches while the apparent abundance of the 1977 and 1979 year classes may be a result of increased availability

[4]T. D. Iles, Dept. Fisheries and Oceans Canada, St. Andrews, N.B., pers. comm. August 1983.

within NAFO Division 5Y. Interestingly, the 1979 year class unexpectedly contributed strongly to the Division 4WX purse seine fishery in 1982. It is possible that some movement of this year class from the Gulf of Maine to the Scotian Shelf may have occurred.

RESEARCH VESSEL SURVEY INDICES

Standardized bottom trawl surveys have been conducted by the Northeast Fisheries Center (NEFC) in offshore (>27 m) waters from Cape Hatteras - Nova Scotia during spring since 1968. A stratified random sampling design has been employed in all surveys, with stations allocated in proportion to stratum area (Grosslein, 1969). Standardized surveys have also been conducted in autumn since 1963, but data have been more difficult to interpret due to high variability; accordingly, only spring survey results are considered in this document. A No. 36 Yankee trawl was employed during spring surveys during 1968-1972, and from 1982 onward. During 1973-1981, a modified high-opening No. 41 Yankee otter trawl was used for spring surveys. Both trawls were equipped with a 1.5 cm mesh liner in the codend to retain juvenile fish. Suitable conversion factors are not available to adjust for differences in fishing power for this species between the two trawls.

Strata sets considered for Atlantic herring include Strata 1-12, 24, and 61-76 (Southern New England - Mid-Atlantic) and Strata 23 and 25-42 (Gulf of Maine - Scotian Shelf) (Figure 5). Data from Georges Bank were not included due to extremely reduced abundance levels since 1977.

Inshore surveys have been conducted within the territorial waters of the State of Massachusetts since 1978 (Howe et al., 1979, 1980, 1981). A stratified sampling design has been employed in all surveys with

stations allocated in proportion to stratum area. The survey area and major subregions are depicted in Figure 6. A three-quarter whiting trawl has been used in each survey.

Stratified mean number per tow of age 2 and older Atlantic herring for the Mid-Atlantic - Nova Scotia region (excluding Georges Bank) declined sharply from 29.8 in 1968 to a mean of 1.6 during 1975-1977 (Table 8). Survey indices remained at uniformly low levels during 1971-1978 with the exception of 1973 (Table 8). Increased catches of age 3+ (Table 9) herring in 1973 may have been due to sampling variability. Stratified mean number per tow subsequently increased during 1979-1980 to a mean of 9.9 with recruitment of the 1976 and 1977 year classes. Survey indices subsequently declined to 2.7 and 1.2 during 1981 and 1982, respectively. It is not known if the change to the No. 36 trawl resulted in decreased survey catches in 1982.

Stratified mean catch-per-tow-at-age data for Gulf of Maine - Nova Scotia strata and Southern New England - Mid-Atlantic strata from NEFC spring surveys is provided in Tables 9 and 10. In general, age 2 herring comprise a high fraction of the total survey catches in the Gulf of Maine - Scotian Shelf region while age 3 and older fish dominate in the Southern New England - Mid-Atlantic survey catches (Tables 9 and 10). These results are consistent with known migratory patterns (Almeida and Burns, 1978). In general, strong year classes have been well represented in survey catches. The 1979 year class, however, was well represented in the coastal Maine commercial fishery, but not in the 1981-82 surveys.

Massachusetts inshore survey results also indicate a steady decline in abundance, decreasing from 34.6 individuals per tow in 1978 to 3.4 per tow in 1982 (Table 11). Thus, both the NEFC offshore survey and Massachusetts inshore survey indicate general declines in herring abundance.

RECRUITMENT

Reliable indices of year-class strength have proven particularly difficult to develop for Atlantic herring. Catches in the fixed gear fisheries have been used as indicators of cohort strength under the assumption that passive gear fisheries harvest a relatively constant fraction of the available stock (Anthony, 1972). Although availability may change annually in response to environmental factors (e.g., hydrographic conditions, abundance of prey or predators) the coastal Maine fixed gear landings have proved to be reasonable indicators of recruitment (Fogarty and Anthony, 1982).

Initial estimates of year-class strength for the 1980 year class (at age 2) and the 1979 year class (at age 3) have been made based on regressions of year-class size from virtual population analysis (VPA) on catch-at-age from fixed gear fisheries (see Fogarty and Anthony, 1982). Multiple linear regressions of cohort strength at age 2 from VPA on catch at ages 1 and 2 resulted in an estimated abundance of 570 million fish for the 1980 year class at age 2, while the 1979 year class was estimated at 160 million fish at age 3 based on multiple linear regression of VPA year-class sizes at age 3 on catch at ages 1-3. These estimates

are conservative due to the possibility of reduced availability and decreased market demand during 1982. Detailed description of the statistical methodology and special considerations for the use of this method is given in Fogarty and Anthony (1982).

Independent estimates of herring year-class strength are particularly desirable since changes in availability may result in biased estimates of abundance using catch-at-age information alone. The Massachusetts Division of Marine Fisheries has conducted annual seine surveys in six Massachusetts estuaries since 1975 (Howe et al., in press). Brit herring (age 1) have been collected during these surveys since 1976 (Table 12), suggesting its use as a qualitative index of cohort strength. Due to the highly contagious distribution of juvenile herring, the percent occurrence (i.e., proportion of seine hauls containing herring) may be a more valid index of year class size than mean number per haul. A comparatively strong 1977 year class was indicated by the estuarine index while the 1978 year class appeared to be considerably weaker (Table 12), supporting inferences based on catches in the fixed gear fisheries (Fogarty and Anthony, 1982). The 1980 year class appeared to be of moderate size based on proportion of hauls containing herring although few individuals were collected (Table 12). Although the 1981 year class appeared to be very promising based on the seine haul index, preliminary estimates of the 1983 catch of age 2 herring were low. Due to the short time series available and uncertainty in estimates of year-class strength for more recent years based on VPA, it was not currently possible to quantify the relationship between year-class size and the Massachusetts seine index.

MORTALITY

Fishing Mortality in 1982

Instantaneous fishing mortality (F) rates for the period 1965-1981 were estimated by virtual population analysis (VPA), for the Gulf of Maine and pooled area (Cape Hatteras - Nova Scotia) options. Catch-at-age data for the Gulf of Maine region for 1965-1981 were as described previously; comparable data are also available for NAFO Divisions 4WX[4]. Terminal fishing mortality rates for the Gulf of Maine option were determined using two methods. In the first (Method I) multiple linear regressions of abundance at age 2 on catch at ages 1 and 2 and of abundance at age 3 on catch at ages 1-3 were used to determine year-class strength at age 2 for the 1980 year class and at age 3 for the 1979 year class, respectively. These regression equations were based on estimates for the 1963-1976 cohorts (which were insensitive to the terminal fishing mortality rates employed). Fishing mortality rates were estimated by iteratively solving the relationship:

$$\frac{C_i}{N_i} = \frac{F_i}{Z_i} (1-\exp(-Z_i) \qquad (1)$$

where C_i and N_i are the catch and abundance at age (i) and $Z_i = F_i+M$, the instantaneous natural mortality rate (0.2). Fishing mortality rates for the 1977 and 1978 cohorts were determined by estimating abundance at age 3 using the regression approach described above and then adjusting these estimates for subsequent mortality. These estimates of 1982 abundance levels were then used to obtain F_i estimates for 1982. Herring were considered to be fully recruited to the adult fishery at age 5, hence the

estimated fishing mortality rate for the 1977 year class was applied to older age groups. These estimates were then used as the vector of fishing mortality rates for 1982 in a preliminary VPA (weighted mean = 0.46).

The estimated mean fishing mortality rate (weighted by stock size) is highly dependent on estimates obtained at age 2. As discussed previously, it is possible that the availability of age 2 herring was reduced in 1982, resulting in an underestimate of abundance (and therefore an overestimate of fishing mortality) by the regression approach outlined above. Accordingly, an alternate approach was employed (Method II) based on research vessel survey results (Figure 8). A linear regression of stock size (age 2 and older) determined by VPA on (NEFC spring survey) stratified mean catch per tow (age 2 and older) was used to predict 1982 stock size and the 1982 fishing mortality rate was estimated using (1) as described previously. Fishing mortality rate in 1982 for ages 2 and older was estimated at F = 0.39 using this method.

The above estimates of mean fishing mortality on age 2 and older herring were similar; the lower estimate based on research vessel survey results is consistent with the suggestion that 1982 stock size for age 2 herring may have been underestimated using Method I. Accordingly, an adjusted estimate of fishing mortality on age 2 herring was derived by setting fishing mortality of all other age classes to the value determined by Method I, adjusting the age 2 fishing mortality rate to provide a weighted mean fishing mortality rate of F = 0.39. It was, therefore, implicitly assumed that estimation errors under Method I were confined to age 2 fish. The resulting vector of terminal fishing mortality rates was then employed in a final virtual population analysis (Table 13).

For the pooled (Cape Hatteras - Nova Scotia) option, terminal fishing mortality rates were determined using Method I as described above. This method was used in the previous assessment (Fogarty and Anthony, 1982).

Gulf of Maine Option

Increased levels of fishing mortality for age 2 and older herring determined by VPA have been evident since 1976 (Table 13, Figure 8). Although mortality rates derived for the most recent years are sensitive to terminal fishing mortality rates employed in the analysis, these estimates indicate that the increase in landings since 1976 may be due, in part, to increased fishing mortality levels.

High estimates of fishing mortality on age 2 herring (1979 year class) during 1981 (Figure 8) indicate that this year class may have been unusually available to the fixed gear fisheries, contributing to high catch rates. It should be noted, however, that mortality estimates for 1981 are sensitive to terminal fishing mortality rates employed in the analysis.

Pooled Area Option

Estimated fishing mortality rates for recent years on age 2+ herring declined from peak values noted during 1976-1977 (Table 14, Figure 9) although estimated fishing mortality remained in excess of $F_{0.1}$ levels (Fogarty et al., 1981) during 1978-1981. Given the possibility of recent shifts in distribution and availability in the Gulf of Maine, the pooled area option may provide a more reasonable overview.

STOCK SIZE

Gulf of Maine Option

Steady declines in spawning stock biomass (age 4+) were evident during 1967-1973 (Figure 10). Recruitment of the 1970 year class to the spawning stock biomass in 1974 resulted in recovery to 120,000 mt but biomass levels during 1974-1981 remained considerably below the 1967-1970 mean level of 170,000 mt. Recruitment of the 1976 and 1977 year classes to the spawning stock resulted in an increase in spawning stock biomass to approximately 100,000 mt in 1980-1981. Estimated spawning stock biomass declined during 1982 since the poor 1978 year class is assumed to have contributed little to stock size and the 1979 year class was not fully recruited to the spawning stock.

Pooled Area Option

Spawning stock biomass (age 4+) in the pooled area analyses averaged 710,000 mt during 1965-1970 and declined sharply to 230,000 mt in 1973 (Figure 11). Biomass subsequently increased to an average of 570,000 mt during 1974-1976. Increased levels of spawning stock biomass were predicted for 1981 with a slight reduction during 1982 due to recruitment of the 1976-1977 year classes.

DISCUSSION

Apparent changes in availability of herring in the fixed gear fisheries and variable market conditions for adult herring have made interpretation of recruitment and stock size particularly difficult. Landings decreased by 50% in the juvenile herring fisheries during 1982 relative to 1981 levels. Similar reductions were noted in the adult

herring fisheries, continuing declines noted since 1981. Although both availability and market conditions influenced herring landings in the Gulf of Maine, independent abundance indices based on research vessel surveys also indicate decreased abundance. Thus, reduced stock size may have contributed to sharply decreased landings during 1982. Of particular concern is the apparent high fishing mortality rate on the 1979 year class at age 2. Several recent year classes, most notably the 1977 and 1979 cohorts have appeared to be more available in the coastal Maine region than in Canadian waters (Fogarty and Anthony, 1982) and increased availability most probably resulted in increased fishing mortality rates within the Gulf of Maine. Interestingly, the 1979 year class contributed strongly and unexpectedly to Canadian catches during 1982, possibly as a result of a shift in distribution. The pooled area option is provided to specifically account for annual changes in stock composition of herring fisheries in NAFO Subarea 5 and Division 4WX.

Evidence based on commercial catch rates, research vessel surveys and Massachusetts estuarine seine surveys indicates that the 1980 year class is of average size. The 1979 cohort, which was considered to be a strong year class in the Gulf of Maine (Fogarty and Anthony, 1982) may have been sharply reduced by high fishing mortality rates during 1981. Research vessel surveys do not indicate high abundance levels for this cohort at age 3. Thus, landings during 1983 and possibly 1984 should remain at reduced levels relative to recent (1980-1981) landings. Catches in the fixed gear fisheries are almost entirely dependent on recruitment of two-year-old herring. Although the strength of the 1982 year class cannot be determined with certainty, preliminary results of the 1983

Massachusetts estuarine survey do not indicate a strong year class; brit herring (n = 169) were collected in 8.8% of the seine hauls[5]. Similarly, forecasts based on the larval herring sampling program conducted by the State of Maine suggest a continuation of decreased larval abundance for several localized spawning groups (Graham and Crosby, 1983). In addition, areal surveys of brit herring distribution and abundance indicate reduced abundance and greater dispersal of schools during 1983 (Graham and Crosby, 1983).

These results suggest that the outlook for the immediate future is not favorable for the coastal Maine juvenile herring fisheries. Reduced abundance and availability is expected to result in continued low catch levels. Similarly, the apparent lack of strong recruitment into the spawning stock is expected to result in continued declines in the adult herring fishery in 1983 and 1984.

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Table 1. Atlantic herring landings (mt) for primary fisheries.

Year	Coastal Maine	Jeffreys Ledge	Georges Bank	New Brunswick[1]	Nova Scotia
1960	59,348	1,126	-	49,563	32,216
1961	24,131	3,178	67,655	18,614	41,272
1962	69,376	2,485	152,242	34,403	35,367
1963	66,895	3,217	97,968	36,237	23,393
1964	26,295	8,815	131,438	45,023	41,405
1965	32,088	2,635	42,882	49,101	70,639
1966	26,178	4,360	142,704	61,450	124,681
1967	28,490	7,807	218,743	50,190	135,855
1968	30,205	31,900	373,598	75,368	154,139
1969	23,852	32,406	310,758	39,741	137,250
1970	15,581	40,187	247,294	30,589	175,633
1971	12,407	38,575	267,347	17,528	124,233
1972	19,313	42,918	174,190	32,720	153,428
1973	16,400	15,926	202,335	22,102	120,093
1974	19,143	18,098	149,525	30,733	139,170
1975	15,182	21,076	146,096	31,971	142,745
1976	30,195	20,124	43,502	30,046	114,006
1977	32,357	17,891	2,157	34,723	115,935
1978	29,857	18,558	2,059	45,361	89,353
1979	40,218	23,546	1,270	41,021	55,182
1980	45,902	36,175	1,700	14,969	108,131
1981	48,245	15,321	672	20,448	86,338
1982	24,007	7,663	1,378	26,066	84,630

[1]Includes 5Zw catches.

Table 2. Coastal Maine herring landings (mt) by gear type.

	Gear Type				
Year	Stop seine	Weir	Purse seine	Trap	Trawl
1960	43,899	6,011	284	3	1
1961	15,670	1,297	5,141	23	17
1962	50,918	5,407	2,683	-	41
1963	41,989	3,655	1,104	5	2
1964	20,025	1,960	2,854	8	112
1965	18,731	6,148	5,026	-	44
1966	9,156	6,236	7,523	18	-
1967	8,287	3,552	14,814	5	-
1968	14,128	5,039	8,681	3	-
1969	3,980	3,486	15,178	1	-
1970	2,259	925	12,311	-	-
1971	2,950	246	9,190	-	-
1972	15,495	1,731	3,031	-	-
1973	5,468	808	10,546	3	38
1974	2,644	2,726	16,130	-	-
1975	6,866	2,407	8,075	-	-
1976	25,226	1,848	4,782	1	-
1977	19,139	1,320	12,336	0	340
1978	8,429	6,071	15,242	-	599
1979	31,477	6,113	2,470	1	479
1980	32,623	3,284	12,764	-	240
1981	31,280	13,632	7,063	-	0
1982	6,680	4,278	13,049	-	-

Table 3. Coastal Maine herring catch at age (mt) for combined fixed and mobile gear components.

	Age								
Year	1	2	3	4	5	6	7	8	9+
1965	449	24,676	5,872	353	738	-	-	-	-
1966	174	6,330	18,452	275	648	199	75	25	-
1967	225	6,635	14,575	5,819	113	698	-	-	424
1968	80	21,037	7,932	744	376	-	36	-	-
1969	72	6,702	15,909	833	72	95	72	24	24
1970	294	6,258	4,422	2,672	531	726	294	265	118
1971	1,909	2,838	1,731	3,388	1,793	409	127	126	86
1972	3	17,360	833	492	242	318	264	-	-
1973	164	8,100	7,456	193	164	80	121	55	65
1974	486	9,074	5,489	3,779	230	75	9	-	-
1975	797	9,451	2,539	925	1,249	96	8	40	80
1976	478	13,228	12,740	1,203	1,122	1,390	11	6	6
1977	1,316	18,541	8,022	2,161	535	381	1,358	3	40
1978	648	12,840	7,348	1,743	2,933	367	715	3,040	212
1979	27	25,942	11,531	1,715	192	330	197	104	180
1980	1,012	9,050	26,538	8,605	440	24	101	-	133
1981	108	39,588	1,545	2,630	3,839	371	23	22	121
1982	451	13,311	3,410	328	4,115	2,045	194	18	135

Table 4. Coastal Maine herring catch at age (millions).

	Age									
Year	1	2	3	4	5	6	7	8	9+	Total
1965	40.9	932.9	57.8	2.4	4.2	-	-	-	-	1,038.2
1966	21.0	291.7	208.5	2.2	10.1	1.3	0.4	0.2	-	535.2
1967	21.5	268.1	122.1	33.7	17.7	3.5	-	-	1.8	468.4
1968	7.8	877.3	151.6	5.6	2.0	-	0.1	-	-	1,044.4
1969	5.7	216.6	249.0	11.5	0.6	0.5	0.3	0.2	0.2	484.5
1970	1.9	183.1	45.2	17.2	8.4	3.4	1.7	1.6	0.5	263.0
1971	109.0	61.9	17.7	21.0	7.8	1.6	0.5	0.4	0.3	220.1
1972	0.2	338.9	7.1	3.1	1.2	1.4	0.9	-	-	352.6
1973	10.6	154.9	72.4	1.1	0.8	0.4	0.5	0.2	0.2	241.5
1974	30.5	174.9	52.6	20.8	1.2	0.3	-	-	-	280.3
1975	35.2	171.8	25.2	4.7	5.5	0.4	-	-	0.4	243.2
1976	24.8	310.1	111.4	6.4	5.3	5.8	0.4	0.2	0.6	463.9
1977	76.2	429.7	71.4	13.1	2.6	1.9	6.8	0.1	0.1	601.0
1978	50.5	324.1	57.9	7.8	10.5	1.2	2.1	8.6	0.5	463.0
1979	3.5	747.0	131.7	9.0	0.9	1.3	0.9	0.4	0.5	895.0
1980	65.1	222.5	253.0	48.8	1.6	0.4	-	0.2	0.2	591.8
1981	9.1	876.5	13.7	12.9	14.8	1.1	0.1	0.1	0.3	928.6
1982	22.4	273.2	27.3	1.5	14.6	6.6	0.6	0.1	0.2	346.5

Table 5a. Age composition of coastal Maine Atlantic herring landings (millions) in 1982 by area and gear type.

	Year Class (Age)												
	1981 (1)	1980 (2)	1979 (3)	1978 (4)	1977 (5)	1976 (6)	1975 (7)	1974 (8)	1973 (9)	1972 (10)	1971 (11)	1970 (12)	Total
LOCATION*						FIXED GEAR							
Western	13.671	52.189	2.042	-	-	-	-	-	-	-	-	-	67.9
Central	1.296	17.206	2.089	-	0.052	-	-	-	-	-	-	-	20.6
Eastern	6.884	130.273	8.762	-	-	-	-	-	-	-	-	-	145.4
TOTAL	21.851	199.668	12.892	-	-	-	-	-	-	-	-	-	234.4
LOCATION*						MOBILE GEAR							
Western	-	0.069	1.996	0.419	4.113	1.195	0.113	0.051	0.031	0.028	-	0.028	8.0
Central	0.085	69.388	10.774	1.006	10.417	5.353	0.444	-	0.201	-	-	0.043	97.7
Eastern	0.500	4.092	1.644	0.056	-	0.083	-	-	-	-	-	-	6.4
TOTAL	0.585	73.548	14.414	1.481	14.531	6.631	0.557	0.051	0.232	0.028	-	0.071	112.1
GRAND TOTAL	22.436	273.217	27.306	1.481	14.583	6.631	0.557	0.051	0.232	0.028	-	0.071	346.5

*See Figure

Table 5b. Age composition of coastal Maine Atlantic herring landings (mt) in 1982 by area and gear type.

	Year Class (Age)												
	1981 (1)	1980 (2)	1979 (3)	1978 (4)	1977 (5)	1976 (6)	1975 (7)	1974 (8)	1973 (9)	1972 (10)	1971 (11)	1970 (12)	TOTAL
LOCATION*						FIXED GEAR							
Western	305.4	2501.6	271.1	-	-	-	-	-	-	-	-	-	3078.1
Central	18.1	936.0	247.1	-	10.4	-	-	-	-	-	-	-	1211.6
Eastern	121.0	5701.6	845.4	-	-	-	-	-	-	-	-	-	6668.0
TOTAL	444.5	9139.2	1363.6	-	10.4	-	-	-	-	-	-	-	10957.7
LOCATION*						MOBILE GEAR							
Western	-	4.7	334.6	94.8	1191.1	373.2	41.7	17.5	14.3	12.0	-	12.6	2096.5
Central	1.3	3887.7	1479.0	221.8	2914.0	1650.0	152.1	-	78.3	-	-	17.8	10402.5
Eastern	5.0	279.2	232.6	11.7	-	21.8	-	-	-	-	-	-	550.3
TOTAL	6.3	4171.6	2046.2	328.3	4105.1	2045.5	193.8	17.5	92.6	12.0	-	30.4	13049.3
Grand Total	450.8	13310.8	3409.8	328.3	4115.5	2045.5	193.8	17.5	92.6	12.0	-	30.4	24007.8

*See Figure 1.

Table 6. Catch at age (mt) for the Jeffreys Ledge adult herring fishery during 1967-1982 (includes catches in Division 5YZ and 6).

	AGE										
YEAR	2	3	4	5	6	7	8	9	10	11	12
1967	2	47	511	1,567	3,084	2,167	163	106	74	87	-
1968	45	2,495	2,854	5,882	6,378	6,973	5,006	920	621	729	-
1969	145	5,868	1,081	2,101	5,230	7,098	6,145	3,422	554	764	-
1970	260	1,265	4,154	3,532	5,636	6,483	6,128	7,838	2,250	2,611	-
1971	49	3,202	3,646	6,677	7,876	6,468	4,290	3,150	1,479	1,736	-
1972	959	2,426	7,086	9,710	10,561	8,063	2,981	424	463	246	-
1973	144	2,484	1,012	2,531	3,427	3,208	2,171	677	137	134	-
1974	235	1,682	10,825	1,531	1,253	958	848	415	243	84	24
1975	204	2,223	3,346	12,079	1,181	1,027	610	378	170	143	-
1976	4	2,696	2,374	2,383	11,085	996	196	285	56	42	9
1977	60	641	3,940	1,815	1,964	8,714	521	69	100	53	15
1978	204	2,087	1,880	5,194	1,011	1,575	5,980	287	136	51	37
1979	182	4,666	6,864	3,668	4,078	819	1,036	2,107	91	-	1
1980	34	4,611	19,219	5,308	1,991	2,779	282	173	1,728	32	15
1981	8	185	7,914	5,356	893	397	346	-	29	193	-
1982	11	1,147	433	3,429	3,098	420	173	185	81	-	63

Table 7. Jeffreys Ledge herring catch at age (millions).

	Age										
Year	2	3	4	5	6	7	8	9	10	11+	Total
1967	0.0	0.6	3.6	8.0	14.2	8.8	0.6	0.4	0.4	0.2	36.8
1968	0.6	18.1	18.0	30.0	29.9	28.9	19.0	3.2	2.5	0.6	151.0
1969	1.5	33.8	13.4	14.2	24.1	22.2	22.8	20.0	5.7	1.0	158.8
1970	3.6	9.7	20.0	19.0	24.8	32.7	26.5	31.1	14.7	2.9	185.0
1971	0.7	25.4	24.9	37.3	40.3	28.9	17.6	12.1	8.1	3.5	198.9
1972	21.5	16.7	42.1	42.6	48.0	24.2	9.5	2.9	2.7	1.6	211.8
1973	1.3	23.3	6.2	11.1	13.3	12.8	7.2	1.8	0.5	0.3	77.7
1974	9.2	14.4	89.0	7.5	5.1	2.8	2.0	0.9	0.4	0.3	131.8
1975	0.9	16.7	20.9	85.0	9.3	3.7	2.2	1.1	0.4	0.2	140.3
1976	0.2	23.5	14.1	11.9	54.0	3.7	0.7	0.8	0.2	0.1	109.0
1977	2.5	10.0	33.1	11.5	10.4	41.8	2.3	0.4	0.4	0.2	112.6
1978	3.3	25.7	13.6	29.5	5.0	6.9	25.3	1.1	0.4	0.2	111.0
1979	4.3	37.3	34.2	14.3	14.2	2.6	3.2	6.4	0.3	0.0	116.7
1980	0.7	45.2	115.1	19.4	6.0	7.8	0.8	0.6	4.2	0.1	199.9
1981	0.3	1.6	44.1	26.4	3.4	1.3	1.1	0.0	0.1	0.6	79.0
1982	0.3	8.1	2.3	15.3	12.4	1.5	0.5	0.6	0.2	0.2	40.4

Table 8. Stratified mean catch per tow of Atlantic herring from NEFC spring bottom trawl surveys in the Gulf of Maine - Nova Scotia regions and the southern New England - Mid-Atlantic area, 1968-1980.

Year	S. New England		Gulf of Maine		Combined	
	No.	Wt.	No.	Wt.	No.	Wt.
1968	56.555	7.224	1.691	.033	29.826	3.729
1969	23.869	4.385	.243	.018	12.385	2.762
1970	16.402	1.298	.693	.025	8.766	.679
1971	3.551	.377	.361	-	2.001	.194
1972	3.681	.482	.876	.007	2.317	.251
1973	15.374	1.783	5.472	1.170	10.561	1.485
1974	7.963	1.185	1.132	.117	4.643	.666
1975	0.179	.030	2.485	.416	1.289	.084
1976	1.568	.315	2.833	.207	2.183	.263
1977	1.594	.285	1.132	.137	1.369	.213
1978	6.108	.675	.464	.061	3.365	.377
1979	8.864	1.492	12.293	.308	10.531	0.917
1980	8.323	1.129	10.065	1.040	9.170	1.086
1981	4.460	.842	0.736	.100	2.650	.481
1982	.353	.070	2.003	.089	1.155	.080

Table 9. Stratified mean catch per tow at age (numbers) of Atlantic herring in the Gulf of Maine - Scotian Shelf region from NEFC spring surveys, 1968-1982.

Year	AGE				
	2	3	4	5	6+
1968	1.187	0.457	0.016	-	0.031
1969	0.013	0.173	0.011	-	0.045
1970	0.417	0.197	0.007	0.009	0.062
1971	0.266	0.075	0.008	-	0.011
1972	0.808	0.011	0.008	0.008	0.040
1973	0.188	0.655	0.403	0.764	3.389
1974	0.328	0.062	0.596	0.051	0.084
1975	0.157	0.311	0.177	1.475	0.349
1976	2.112	0.257	0.039	0.168	0.269
1977	0.393	0.139	0.224	0.062	0.348
1978	0.215	0.042	0.014	0.024	0.142
1979	10.403	1.103	0.698	0.055	0.041
1980	0.539	2.898	5.042	0.507	1.079
1981	0.101	0.093	0.306	0.131	0.113
1982	1.412	0.413	0.031	0.046	0.053

Table 10. Stratified mean catch per tow at age (numbers) for Atlantic herring in Southern New England - Middle Atlantic strata.

Year	Age				
	2	3	4	5	6+
1968	2.240	19.625	5.352	10.809	16.320
1969	0.447	2.790	1.074	4.139	15.420
1970	7.714	2.627	2.456	1.949	1.583
1971	0.274	1.536	0.420	0.445	0.877
1972	0.129	1.504	0.912	0.683	0.467
1973	0.056	11.739	1.337	0.803	1.439
1974	0.026	0.104	6.848	0.425	0.559
1975	0.012	0.009	0.006	0.113	0.040
1976	0.074	0.300	0.019	0.088	1.149
1977	0.020	0.120	0.798	0.187	0.470
1978	0.139	4.351	0.617	0.765	0.391
1979	0.135	1.014	2.541	0.979	4.191
1980	0.045	2.690	4.896	0.612	0.169
1981	0.011	0.045	0.138	2.663	1.653
1982	-	0.013	0.016	0.119	0.205

Table 11. **Stratified mean number per tow for Atlantic herring obtained in Massachusetts inshore surveys, 1978-82.**

YEAR	REGION 1	2	3	4	5	Total Area (Regions 1-5)
1978	146.26	-	0.08	1.14	23.71	34.56
1979	27.42	-	0.09	44.68	6.67	17.35
1980	10.35	0.79	-	41.20	13.54	14.89
1981	0.06	-	-	0.32	25.81	5.66 *
1982	2.52	-	-	8.99	3.77	3.44 *

*1981 and 1982 estimates preliminary.

Table 12 Brit herring (Age 1) collected during Massachusetts estuarine seine sampling program, 1975-1982.

YEAR	NUMBER COLLECTED	NUMBER PER SET	PERCENT OCCURRENCE	YEAR CLASS
1975	-	-	-	1974
1976	6	0.005	0.9	1975
1977	*	*	5.4	1976
1978	2,773	26.410	20.4	1977
1979	187	1.685	4.5	1978
1980	288	2.667	13.0	1979
1981	10	0.101	9.1	1980
1982	2,322	15.480	30.7	1981

*counts not made

Table 13. Fishing mortality rates and stock size estimates determined by virtual population analysis for the Gulf of Maine region.

HERRING VPA GULF OF MAINE (COASTAL MAINE+JEFFREYS LEDGE)

YEAR	AGE 1	2	3	4	5	6	7	8	9	10	11+	100% RECRUITMENT MEAN F	AGE
					FISHING MORTALITY								
1965	0.048	0.937	0.190	0.009	0.025	0.000	0.001	0.003	0.024	0.000	0.000	0.635	2+
1966	0.023	0.546	0.556	0.010	0.047	0.010	0.012	0.018	0.003	0.030	0.000	0.366	2+
1967	0.012	0.439	0.468	0.178	0.151	0.108	0.035	0.022	0.279	0.178	1.000	0.322	2+
1968	0.013	0.859	0.554	0.158	0.230	0.263	0.259	0.265	0.167	0.575	0.500	0.644	2+
1969	0.013	0.587	0.767	0.143	0.134	0.276	0.324	0.336	0.499	0.495	0.500	0.514	2+
1970	0.009	0.735	0.284	0.287	0.232	0.404	0.776	0.862	1.082	0.848	0.500	0.504	2+
1971	0.070	0.466	0.368	0.407	0.415	0.662	0.990	1.352	1.325	0.941	0.500	0.537	2+
1972	0.000	0.342	0.323	0.833	0.871	1.138	1.145	1.093	0.838	1.299	0.500	0.453	2+
1973	0.027	0.538	0.142	0.154	0.543	0.758	1.187	1.456	1.012	0.531	0.500	0.314	2+
1974	0.045	0.856	0.468	0.241	0.279	0.513	0.341	0.548	0.715	0.480	0.500	0.468	2+
1975	0.058	0.378	0.476	0.327	0.319	0.567	0.799	0.501	0.931	0.955	0.500	0.375	2+
1976	0.025	1.008	0.575	0.454	0.382	0.361	0.497	0.437	0.702	0.253	0.500	0.709	2+
1977	0.060	0.763	0.819	0.394	0.658	0.523	0.564	0.643	0.480	0.480	0.500	0.701	2+
1978	0.028	0.393	0.318	0.524	0.710	0.581	0.929	1.021	1.093	1.944	0.500	0.429	2+
1979	0.009	0.706	0.362	0.269	0.983	0.873	1.155	1.304	0.589	0.675	0.500	0.591	2+
1980	0.052	1.208	0.689	0.728	0.204	1.251	0.952	0.911	1.208	0.981	0.500	0.783	2+
1981	0.012	1.897	0.222	0.254	0.392	0.061	1.118	0.330	0.122	0.695	0.500	1.332	2+
1982	0.030	0.500	0.250	0.030	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.398	2+
					STOCK SIZE							AGE 2+ NUMBERS	AGE 2+ WGHTUNAD
1965	971.2	1868.7	367.2	300.2	184.0	42.4	15.1	4.0	0.5	0.0	0.0	2580.1	237.6
1966	1032.9	758.3	534.7	248.6	243.7	146.9	35.8	12.5	3.2	0.4	0.0	1984.2	250.6
1967	2047.7	828.5	369.8	251.1	201.7	190.5	119.2	28.9	10.0	8.6	0.3	1990.7	265.5
1968	663.6	1657.5	436.3	184.6	172.0	142.0	140.0	89.7	23.2	6.2	1.8	2853.1	315.9
1969	483.9	538.4	575.1	205.2	129.9	111.9	89.4	88.5	56.3	16.1	2.9	1811.5	263.8
1970	226.7	391.2	244.0	218.6	145.6	93.0	69.5	52.9	51.8	28.0	8.0	1302.6	206.5
1971	1788.6	184.0	153.8	150.4	145.5	94.8	50.8	26.2	18.3	14.4	9.8	847.7	145.5
1972	490.5	1366.1	94.5	87.1	82.0	78.7	39.9	15.5	5.5	4.0	4.6	1778.0	152.6
1973	436.9	410.4	794.8	58.1	31.0	28.1	20.6	10.4	4.2	2.0	0.9	1358.5	150.7
1974	767.7	348.2	196.2	584.6	39.3	14.7	10.8	5.2	2.0	1.3	0.9	1183.1	160.7
1975	686.6	601.0	121.1	100.5	363.4	24.4	7.2	6.3	2.4	0.8	0.6	1227.8	153.6
1976	1104.3	530.4	337.0	61.8	59.4	216.2	11.3	2.7	3.1	0.8	0.3	1222.7	148.3
1977	1432.9	882.0	158.5	155.3	32.8	33.2	123.4	5.6	1.4	1.3	0.5	1393.2	142.8
1978	2030.6	1104.5	336.8	57.2	85.7	13.8	16.1	57.5	2.4	0.7	0.8	1676.1	151.0
1979	424.6	1817.2	619.6	290.5	27.8	34.5	5.8	5.2	17.0	0.7	0.1	2519.0	213.4
1980	1420.9	344.4	853.3	348.1	125.4	9.2	14.4	1.5	1.2	7.7	0.3	1505.3	196.5
1981	818.8	1104.8	84.2	258.5	138.8	83.7	2.2	4.5	0.5	0.3	2.4	1689.8	167.4
1982	838.9	661.5	126.7	56.2	168.8	76.7	64.5	0.6	2.7	0.3	0.1	1166.1	133.8
					CATCH AT AGE							TOTAL	
1965	40.9	932.9	57.8	2.4	4.2	0.0	0.0	0.0	0.0	0.0	0.0	1038.3	
1966	21.0	291.7	208.5	2.2	10.1	1.3	0.4	0.2	0.0	0.0	0.0	535.4	
1967	21.5	258.1	122.7	37.3	25.7	17.7	8.8	0.6	2.2	0.4	0.2	505.2	
1968	7.8	877.9	169.8	23.6	32.2	29.9	29.1	19.0	3.2	2.5	0.6	1195.5	
1969	5.7	218.1	282.8	24.9	14.8	24.6	22.5	23.0	20.2	5.7	1.0	643.4	
1970	1.9	186.7	54.9	37.2	27.4	28.2	34.4	28.1	31.6	14.7	2.9	448.0	
1971	109.0	62.6	43.1	45.9	45.1	42.0	29.4	18.0	12.4	8.1	3.5	419.1	
1972	0.2	360.4	23.8	45.2	43.8	49.4	25.1	9.5	2.9	2.7	1.6	564.6	
1973	10.6	156.2	95.7	7.3	11.9	13.7	13.3	7.4	2.5	0.7	0.3	319.5	
1974	30.5	184.1	67.0	109.8	8.7	5.4	2.8	2.0	0.9	0.4	0.3	412.1	
1975	35.2	172.7	41.9	25.6	90.5	9.6	3.7	2.3	1.4	0.4	0.2	383.5	
1976	24.8	310.3	134.9	20.5	17.2	59.8	4.1	0.9	1.4	0.2	0.1	574.0	
1977	76.2	432.1	81.4	46.2	14.1	12.3	48.6	2.5	0.5	0.4	0.2	714.6	
1978	50.5	327.3	83.6	21.3	40.0	8.2	9.0	33.9	1.5	0.6	0.2	574.0	
1979	3.3	751.2	169.0	43.1	15.2	15.6	3.6	3.5	6.9	0.3	0.0	1011.7	
1980	65.1	223.2	298.2	163.8	21.0	6.1	8.2	0.8	0.8	4.4	0.1	791.6	
1981	9.1	876.7	15.3	56.8	41.1	4.5	1.3	1.2	0.1	0.1	0.9	1007.0	
1982	22.4	273.2	27.3	1.5	14.6	6.8	5.8	0.1	0.2	0.0	0.0	351.5	

Table 14. Fishing mortality rates and stock size estimates determined by virtual population analysis for the pooled Cape-Hatteras-Nova Scotia region.

HERRING UPA POOLED ANALYSIS(W/O GEORGES BANK)

YEAR	AGE 1	2	3	4	5	6	7	8	9	10	11+	100% RECRUITMENT MEAN F	AGE
					FISHING MORTALITY								
1965	0.047	0.318	0.112	0.192	0.127	0.089	0.047	0.058	0.008	0.000	0.000	0.246	2+
1966	0.030	0.290	0.425	0.121	0.388	0.141	0.164	0.292	0.208	0.243	0.000	0.323	2+
1967	0.078	0.252	0.228	0.284	0.207	0.343	0.299	0.082	0.149	0.120	0.500	0.256	2+
1968	0.055	0.609	0.342	0.130	0.418	0.226	0.411	0.390	0.467	0.922	0.500	0.452	2+
1969	0.052	0.425	0.628	0.200	0.276	0.301	0.308	0.277	0.362	0.397	0.500	0.414	2+
1970	0.231	0.492	0.232	0.498	0.494	0.379	0.576	0.413	0.564	0.561	0.500	0.450	2+
1971	0.024	0.368	0.460	0.448	0.480	0.506	0.624	0.584	0.574	0.320	0.500	0.455	2+
1972	0.004	0.186	0.172	0.797	0.769	0.875	0.702	0.688	0.529	0.382	0.500	0.274	2+
1973	0.017	0.324	0.229	0.349	0.425	0.593	0.588	0.544	0.608	0.354	0.500	0.279	2+
1974	0.018	0.667	0.262	0.343	0.281	0.335	0.323	0.247	0.540	0.340	0.500	0.444	2+
1975	0.049	0.538	0.382	0.294	0.391	0.496	0.401	0.315	0.281	0.288	0.500	0.442	2+
1976	0.044	1.058	0.515	0.427	0.417	0.422	0.369	0.309	0.492	0.178	0.500	0.593	2+
1977	0.088	0.676	0.690	0.650	0.660	0.601	0.598	0.410	0.266	0.277	0.500	0.649	2+
1978	0.078	0.345	0.356	0.462	1.143	0.924	0.675	1.010	0.608	0.356	0.500	0.409	2+
1979	0.007	0.683	0.235	0.362	0.517	0.994	0.771	0.630	1.176	0.470	0.500	0.455	2+
1980	0.063	0.419	0.489	0.422	0.448	0.555	1.303	0.626	0.906	0.771	0.500	0.449	2+
1981	0.039	0.362	0.199	0.277	0.400	0.306	0.300	1.628	0.275	0.117	0.500	0.350	2+
1982	0.050	0.312	0.070	0.090	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.193	2+
					STOCK SIZE							AGE 2+ NUMBERS	AGE 2+ WGHTUMAD
1965	3788.6	5783.0	1642.2	1826.1	562.3	140.0	43.8	13.0	1.4	0.0	0.0	10011.9	842.4
1966	3344.4	2961.4	3446.3	1202.1	1234.0	405.3	184.8	34.3	10.1	1.2	0.0	9398.5	1059.0
1967	6366.2	2657.2	1814.7	1843.6	871.8	635.3	288.2	72.8	20.9	6.7	0.8	8262.0	1084.0
1968	1805.9	4819.3	1691.3	1185.5	1136.3	580.3	398.3	175.0	54.9	14.8	4.9	10060.5	1138.8
1969	2016.5	1399.7	2145.6	983.6	851.9	612.7	378.8	216.3	97.0	28.2	4.8	6718.5	1000.2
1970	1930.5	1567.3	749.5	937.7	659.2	529.2	371.4	227.9	134.2	55.3	15.5	5247.3	836.9
1971	8096.4	1254.3	784.8	486.5	466.7	329.5	296.7	171.0	123.5	62.5	25.8	4001.2	611.0
1972	1804.8	6472.3	710.7	405.6	254.4	236.4	162.6	130.2	78.1	57.0	37.2	8544.4	609.7
1973	2855.2	1474.0	4398.5	489.8	149.7	96.6	89.6	66.0	53.8	37.7	31.8	6878.3	658.9
1974	2939.7	2299.7	872.9	2865.4	282.9	80.1	43.7	36.8	31.4	23.9	21.6	6558.4	806.8
1975	1189.3	2364.7	965.9	550.2	1565.6	174.8	46.9	25.9	23.5	15.0	13.9	5846.4	751.8
1976	1981.1	926.8	1130.0	539.5	335.8	922.6	87.2	25.7	15.5	14.5	9.2	4006.8	598.7
1977	7770.1	1552.9	263.4	562.9	288.2	181.2	495.5	49.4	15.5	7.8	10.0	3416.6	460.5
1978	3916.5	5828.7	646.9	108.1	238.3	122.0	81.4	223.2	26.8	9.7	4.8	7287.8	454.7
1979	938.2	2968.0	3378.6	370.9	55.8	61.7	39.7	33.9	86.6	12.0	5.6	6990.7	527.9
1980	5864.1	761.4	1226.5	2188.0	211.8	27.2	18.7	15.0	14.8	16.8	6.1	4486.1	606.8
1981	1797.9	4508.4	410.1	816.0	1174.5	118.8	12.8	4.2	6.6	4.9	6.4	6854.3	616.0
1982	588.2	1416.7	2571.3	275.2	382.2	644.7	66.7	7.8	0.7	4.1	3.6	5371.9	603.2
					CATCH AT AGE							TOTAL	
1965	156.2	1435.0	158.0	289.9	61.1	10.8	1.8	0.7	0.0	0.0	0.0	2113.6	
1966	89.6	678.5	1089.4	124.7	362.1	48.4	14.4	7.9	1.7	0.2	0.0	2417.1	
1967	435.6	538.3	333.7	414.9	148.3	181.2	67.9	5.2	2.6	0.7	0.3	2128.7	
1968	87.5	2012.9	446.6	131.7	354.1	107.0	122.5	51.6	18.7	8.2	1.8	3342.5	
1969	92.9	442.0	916.0	162.3	187.1	145.0	91.5	47.7	26.8	8.4	1.7	2121.4	
1970	362.6	556.3	141.3	336.0	234.7	152.2	148.7	70.3	52.9	21.7	5.6	2082.3	
1971	173.3	352.2	264.3	160.5	162.6	119.6	126.1	69.2	49.4	15.6	9.3	1502.1	
1972	7.1	1000.1	102.2	204.6	125.3	126.8	75.2	59.3	29.3	16.5	13.4	1759.7	
1973	43.2	371.6	817.6	131.6	47.3	39.5	32.7	25.3	22.4	10.2	11.4	1552.8	
1974	47.9	1026.3	182.9	757.6	63.1	20.8	11.0	7.3	12.0	6.3	7.8	2142.9	
1975	52.1	900.2	280.0	127.7	491.5	62.4	14.2	6.4	5.3	3.4	5.0	1948.0	
1976	76.6	558.0	415.7	171.1	104.4	289.7	24.5	6.2	5.5	2.2	3.3	1657.2	
1977	591.1	699.1	120.3	242.2	127.5	74.9	204.0	15.1	3.3	1.7	3.6	2083.0	
1978	266.9	1551.5	176.7	36.6	148.6	67.7	36.6	130.7	11.2	2.7	1.7	2430.8	
1979	6.1	1345.5	642.7	102.6	20.6	35.8	19.6	14.5	42.5	4.1	2.0	2236.1	
1980	325.1	237.8	433.2	687.7	69.8	10.6	12.6	6.4	8.1	8.3	2.2	1801.8	
1981	62.4	1247.1	67.2	135.8	353.1	26.5	3.0	3.1	1.4	0.5	2.3	1902.6	
1982	26.0	346.1	157.7	21.5	102.9	173.6	18.0	2.1	0.2	1.1	1.0	850.1	

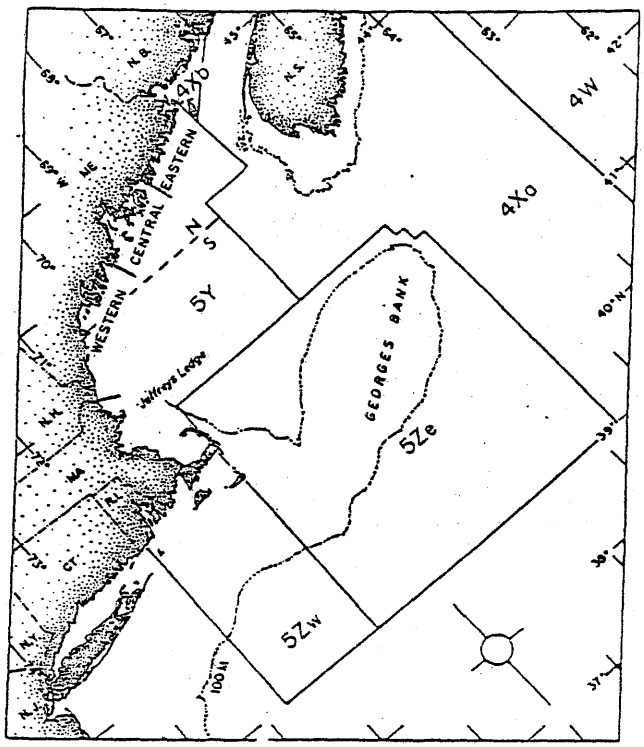

Figure 1. Location of primary fisheries for Atlantic herring in the Gulf of Maine-Nova Scotia region (Northwest Atlantic Fisheries Organization or NAFO Divisions 4WX and Subarea 5).

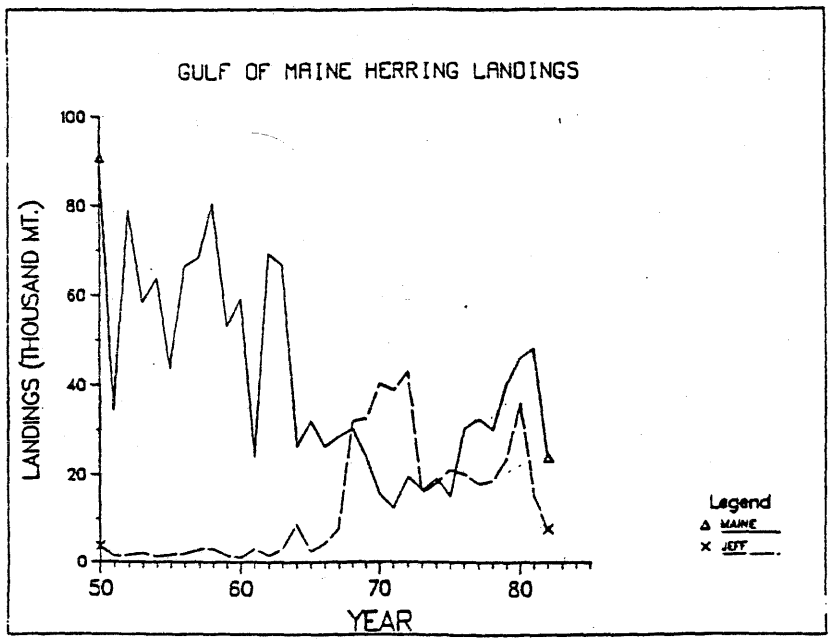

Figure 2. Atlantic herring landings in the coastal Maine fishery (solid line) and Jeffreys Ledge fishery (dashed line).

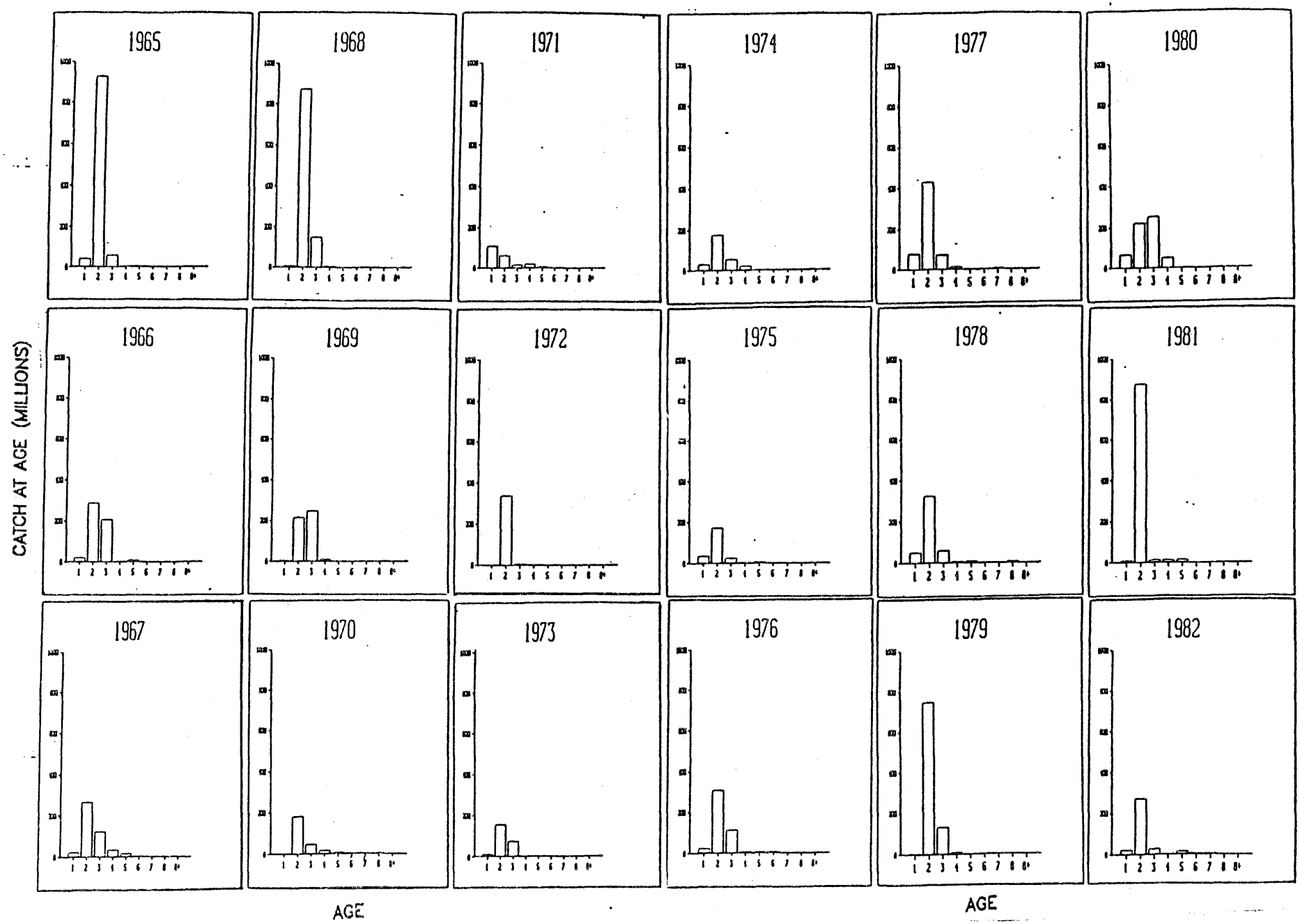

Figure 3. Age composition of Atlantic herring landings in the coastal Maine fishery.

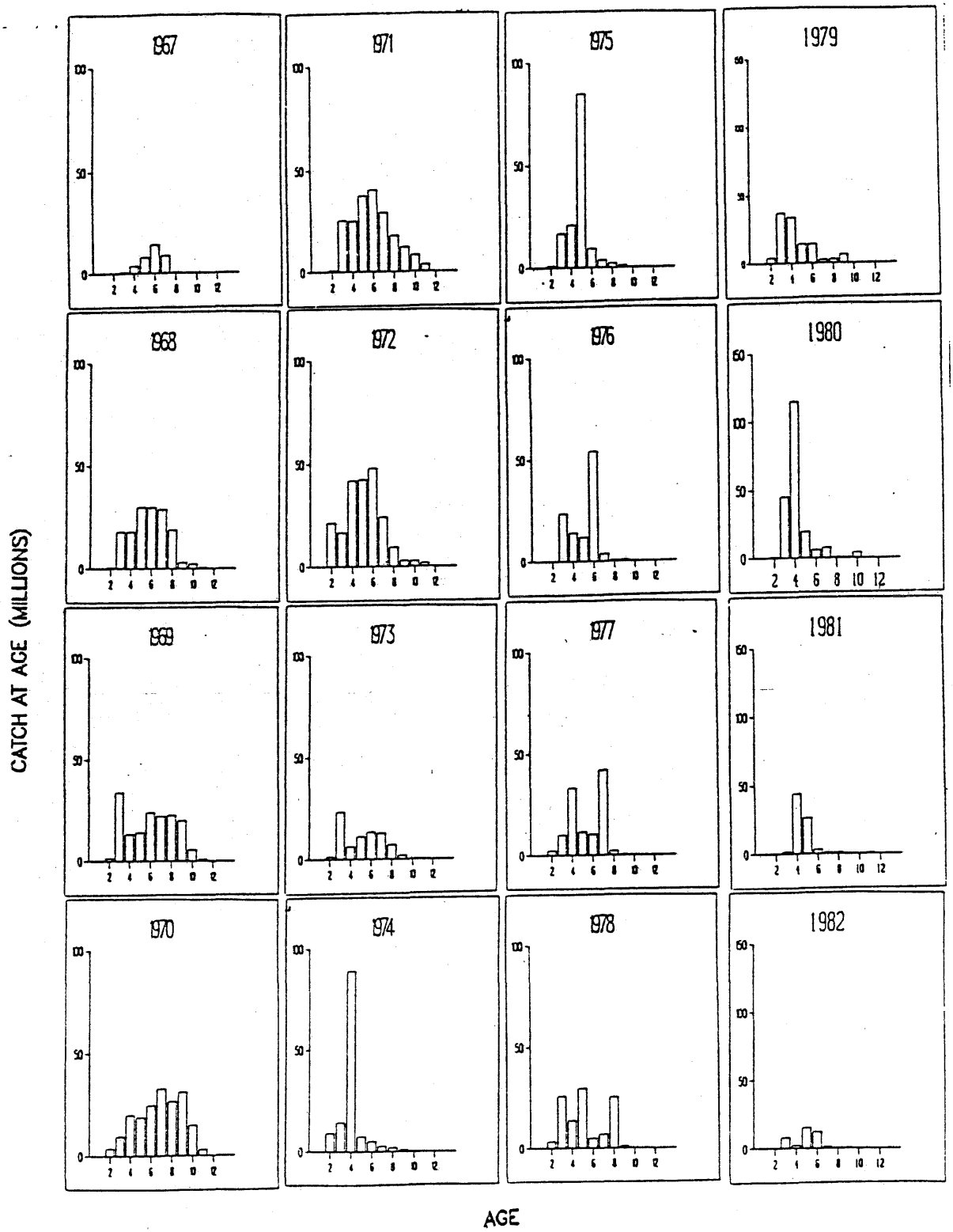

Figure 4. Age composition of Atlantic herring landings in the Jeffreys Ledge fishery.

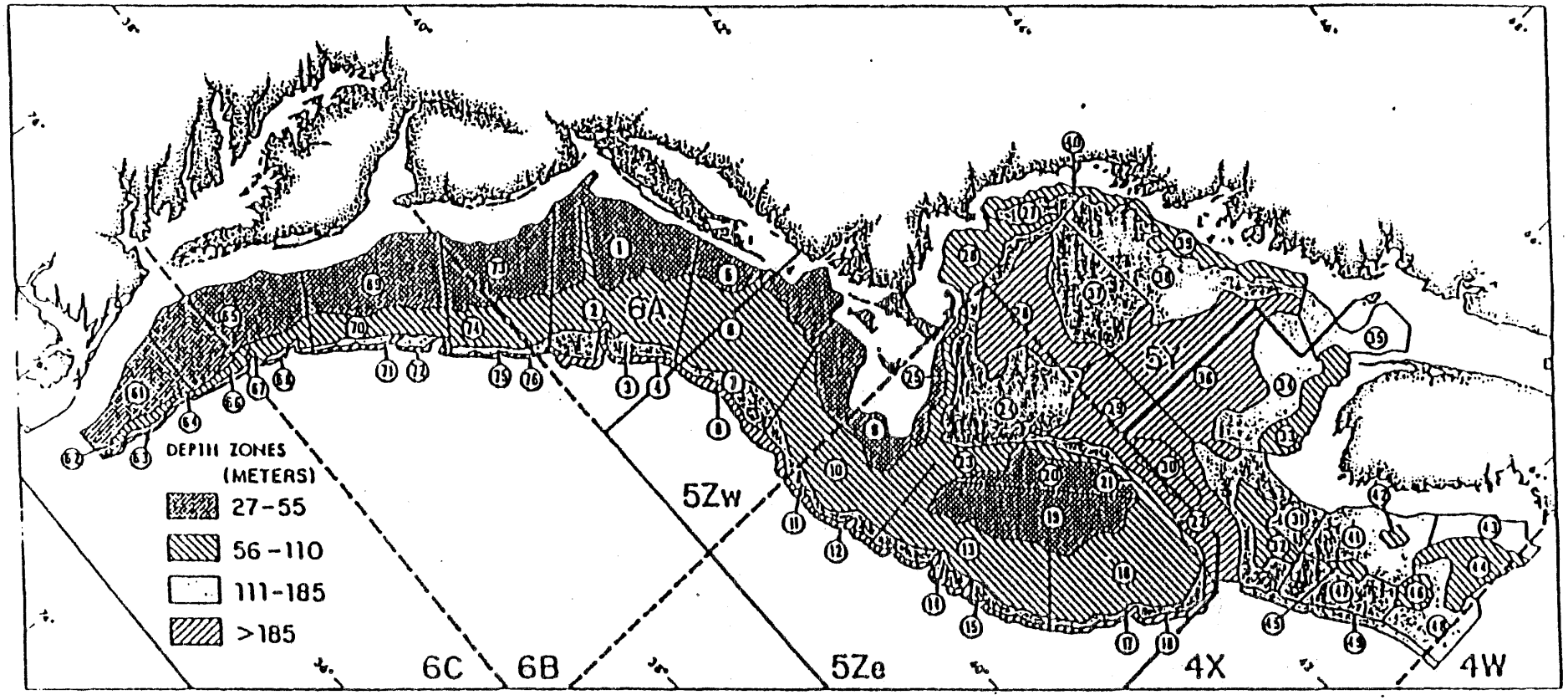

Figure 5. Strata used in NEFC offshore (>27 m) bottom trawl surveys.

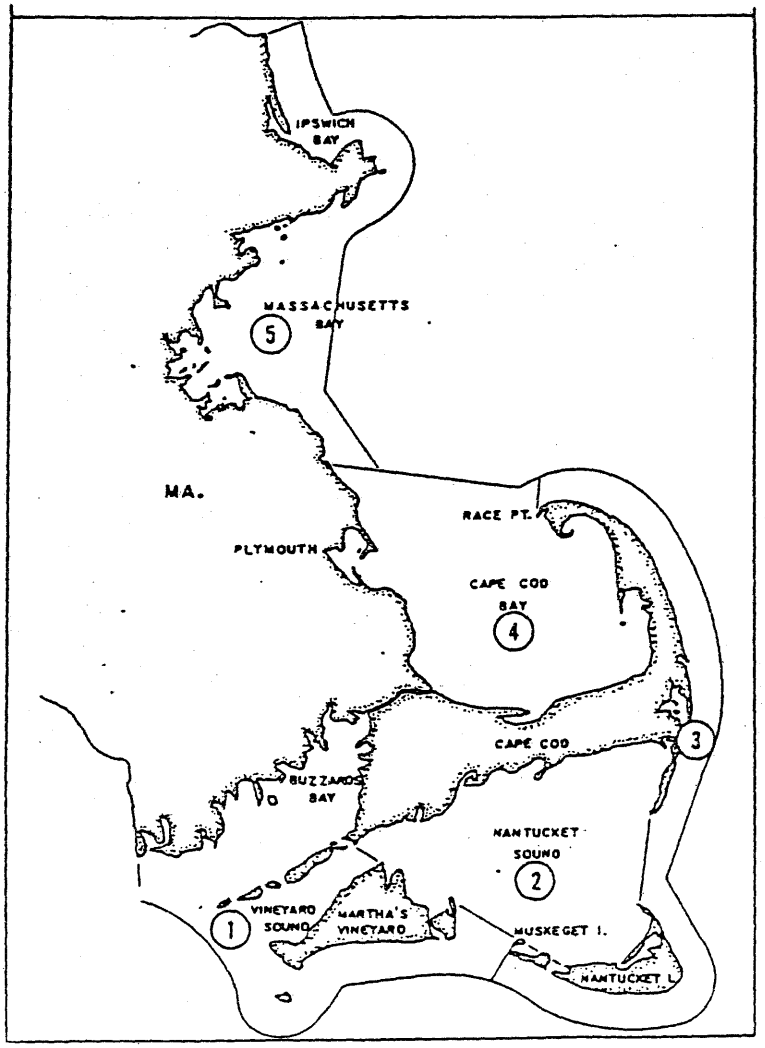

Figure 6. Massachusetts inshore survey area delineated by regions.

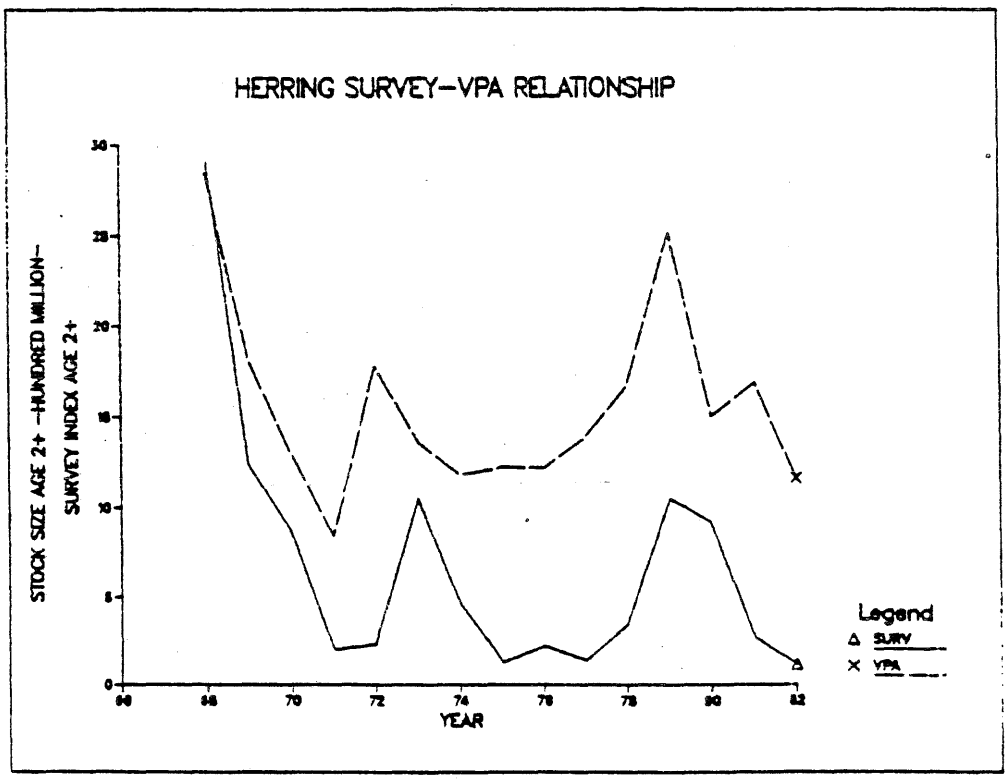

Figure 7. Trends in abundance of Atlantic herring determined by virtual population analysis (age 2+; dashed line) and research vessel surveys (age 2+ stratified mean number per tow; solid line).

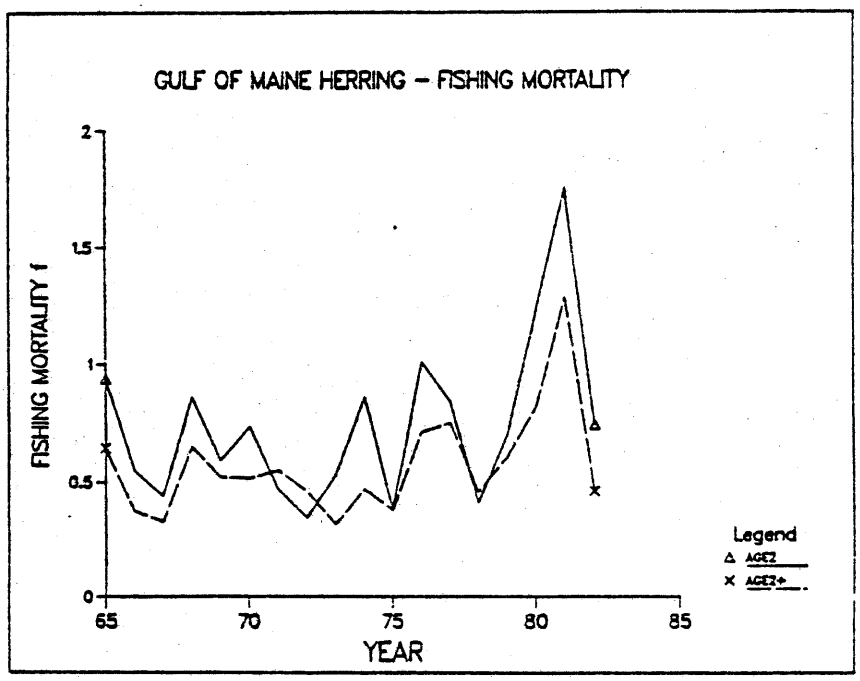

Figure 8. Fishing mortality rates for the Gulf of Maine region determined by virtual population analysis.

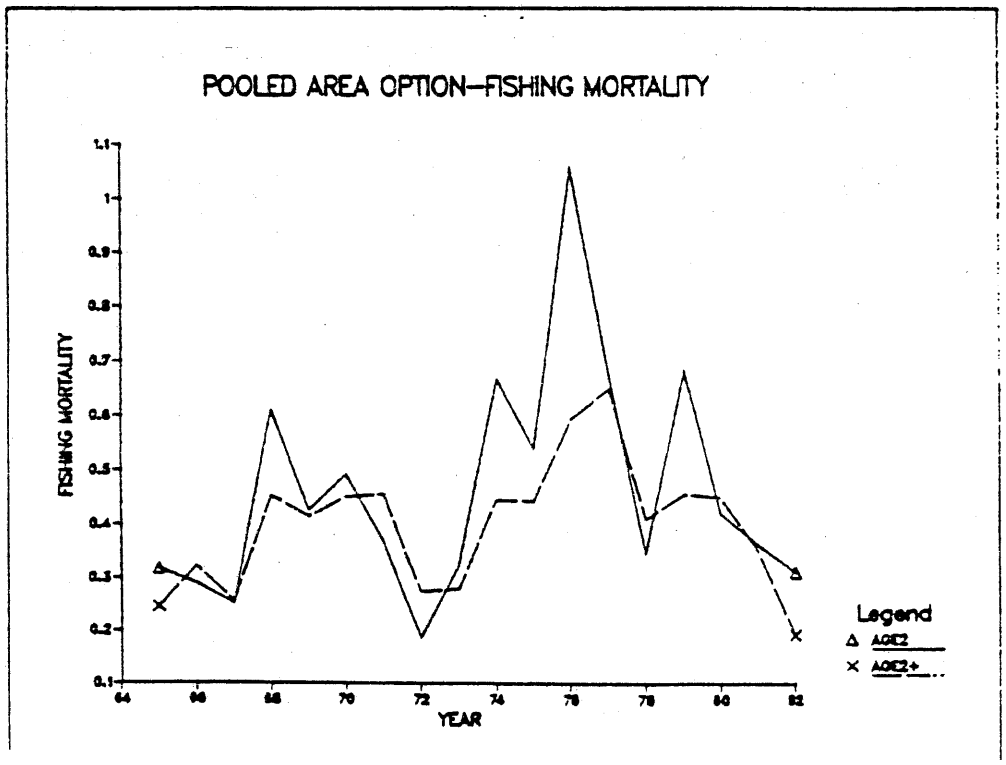

Figure 9. Fishing mortality rates for the Cape Hatteras - Nova Scotia region determined by virtual population analysis.

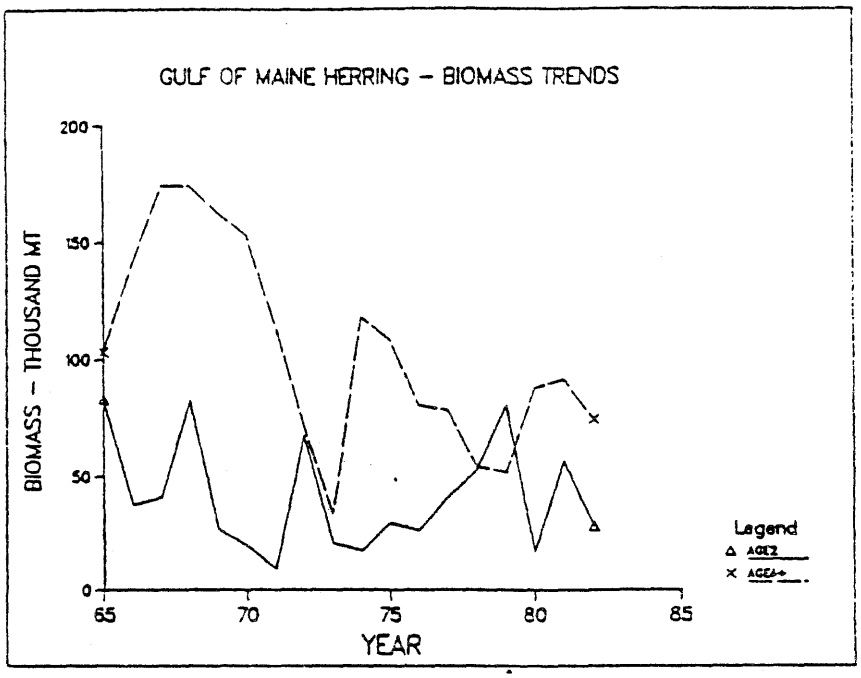

Figure 10. Biomass trends for Atlantic herring in the Gulf of Maine region determined by virtual population analysis.

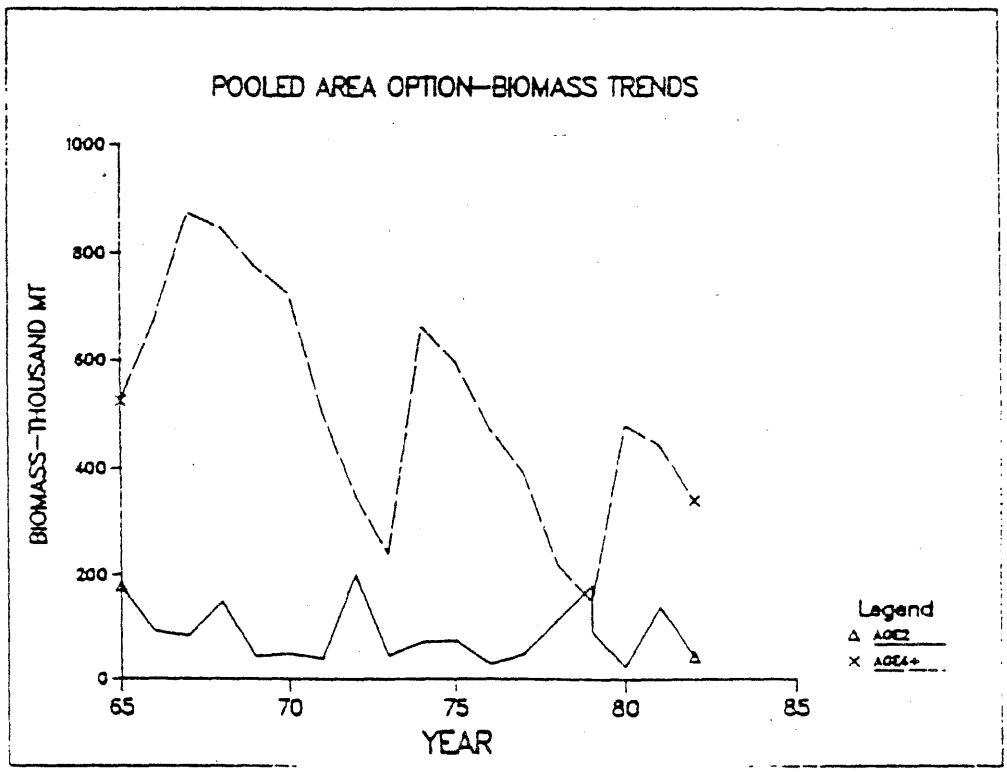

Figure 11. Biomass trends for Atlantic herring in the Cape Hatteras - Nova Scotia region determined by virtual population analysis.