ATLANTIC HERRING

FISHERY MANAGEMENT PLAN

ATLANTIC STATES MARINE FISHERIES COMMISSION

Prepared by Atlantic Herring Plan Development Team

November 12 1993

CONTENTS OF ASMFC ATLANTIC HERRING MANAGEMENT PLAN

1. EXECUTIVE SUMMARY

This Atlantic States Marine Fisheries Commission (ASMFC) fishery management plan (FMP) establishes a management goal and eight management objectives for the U.S. Atlantic herring (Clupea harengus) resource, some of which are implemented in this plan and some of which are more long-term in nature and will be addressed in a joint ASMFC-New England Fishery Management Council (NEFMC) FMP. This FMP defines overfishing for the coastal herring stock on the basis of the fishing mortality rate (F) which would reduce to stock to 20% of its maximum spawning potential and provides a procedure for determining annual Internal Waters Processing (IWP) allocations between three management areas based on the target fishing mortality (F at 20% MSP). It also proposes an institutional framework for developing and implementing future management actions involving the Commission, the New England and Mid-Atlantic Councils, and (possibly) Canada, maintains existing state spawning closure regulations, and recommends a number of measures intended to prevent damage to herring spawning habitat and egg beds.

The overfishing definition is implemented in this FMP strictly for the purpose of making IWP allocations. In the event that the stock becomes over-exploited in the future, adult and/or juvenile catch limits may need to be imposed within individual areas according to guidelines which will be developed by the Plan Development Team following the adoption of this (ASMFC) management plan.

The U.S. Atlantic coastal herring resource which occupies the management unit area covered by this FMP (Virginia to New Brunswick) has grown rapidly from less than 100,000 metric tons (220 million pounds) in 1981 to an estimated 2.8 million mt (6.2 billion lbs) at the beginning of 1992. This increase is due largely to the recovery of the Georges Bank/Nantucket Shoals component of the stock which supported a large foreign fishery during the 1960's and early 1970's, but collapsed in the early 1970's as a result of over-exploitation. Currently, the stock is large and considerably underutilized, and may increase in size even further in the near future under current exploitation.

Commercial fisheries for Atlantic herring in New Brunswick and along the U.S. east coast only remove about 100,000 mt a year, or 3.5% of the 1992 population. It has been estimated that the resource could easily sustain a 25% annual fishing mortality rate without being overfished. Well over 90% of the total commercial harvest is taken from the Gulf of Maine in weirs (fixed gear) and with purse seines (mobile gear). Primary domestic uses of the resource are for canning and bait. The total wholesale value of canned herring products in Maine and New Brunswick in 1992 was about $100 million. Recently, under a provision of the Magnuson Fishery Conservation and Management Act, sales of adult herring to foreign processing ships operating in state internal waters have been conducted in Massachusetts, Maine, Rhode Island, New York, and New Jersey through issuance of Internal Waters Processing (IWP) permits. These IWP sales have provided a new market opportunity for U.S. fishermen. In general, however, the fishery remains market limited.

Atlantic herring have been managed on the U.S. east coast by means of an agreement between the states of Maine, New Hampshire, Massachusetts, and Rhode Island which established annual three to four week spawning closures. This agreement was adopted in 1983 and endorsed by the Atlantic States Marine Fisheries Commission (ASMFC). The agreement replaced a federal management plan which was implemented in 1978 and withdrawn by the Secretary of Commerce in 1982 once it became clear that catch quotas for adult herring in the Gulf of Maine were not going to be enforced in state waters. In the absence of a federal FMP for Atlantic herring, it was placed on the prohibited species list, which eliminated directed fisheries by foreign nationals or joint ventures for herring in the U.S. Exclusive Economic Zone (EEZ).

With the development of IWP fisheries in the mid-1980's, it became clear that the 1983 interstate agreement was no longer adequate to manage the U.S. Atlantic herring resource. This agreement is not comprehensive enough to manage the resource, primarily because an allocation process is needed to equitably divide IWP shares between states receiving IWP applications. To address this problem, the affected states, working through the ASMFC Atlantic Herring Section, have developed an IWP

allocation process over the past several years which needs to be established as part of a new FMP. In addition, a second memorandum of understanding was circulated for signature to the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey in 1993 to demonstrate the intent of these states to cooperatively manage Atlantic herring.

In addition to the need to establish an IWP allocation procedure, there have been other changes in the fishery and in resource assessment procedures that require a new approach for managing this resource throughout its range. With the dramatic growth of the stock, particularly offshore and in southern New England and mid-Atlantic coastal waters, more states have declared an interest in IWP opportunities and in the management of the resource. Indeed, as a transboundary stock, both the U.S. and Canada would benefit from the development of complementary management objectives.

For management purposes, this FMP establishes three management areas within U.S. waters of the northwest Atlantic, two areas (#1 and #2) which include state and federal waters north and south of Cape Cod and an area (#3) which includes federal waters on Georges Bank. A procedure is defined by which the ASMFC Herring Technical Advisory Committee (TAC), working with the National Marine Fisheries Service, and, if necessary, the Canadian Department of Fisheries and Oceans, will annually assess the coastal stock complex (defined as extending from New Brunswick to its southernmost extension on the U.S. Atlantic coast), estimate the total adult surplus biomass available for harvest, and recommend to the ASMFC Herring Section how much of the surplus to hold in reserve and how much to allocate for IWP harvest. The Section will act on these recommendations and divide the total IWP allocation between the three management areas and the individual states within each area, with no single area receiving more than 50% of the total. This FMP further recommends that each state ensure the monitoring of IWP landings through the use of trained observers placed aboard IWP processing vessels or through the use of log books.

This FMP is an Atlantic States Marine Fisheries Commission plan. Since it is not a joint Council-Commission plan, it can not be (nor is it intended to be) fully implemented in federal waters without the cooperation of the New England and Mid-Atlantic Fishery Management Councils and the development and implementation of a federal FMP. However, until such time as a joint FMP is completed and adopted which will allow full management of the resource throughout the EEZ, the management authority embodied in this plan will reside with the ASMFC and be implemented through the states' authority to regulate IWP landings. Furthermore, even though the states have the authority to regulate domestic landings of fish caught inside or outside of state waters, this management plan does not place any new restrictions or controls on the domestic herring fishery.

2.1 HISTORY OF HERRING MANAGEMENT

Management of USA Northwest Atlantic sea herring stocks beyond territorial waters was commenced in 1972 through the International Commission for the Northwest Atlantic Fisheries (ICNAF). The international fishery was regulated by ICNAF until USA withdrawal from the organization in 1976 with Congressional passage of the Magnuson Fishery Conservation and Management Act (MFCMA). Under the aegis of the MFCMA, the New England Fishery Management Council (Council) developed a Fishery Management Plan (FMP) for sea herring which was approved by the Secretary of Commerce and was implemented on December 28, 1978. Over the interim period (1976-1978), foreign fishing for sea herring in USA waters was regulated through a Preliminary Management Plan (PMP) prepared by the National Marine Fisheries Service (NMFS).

The international fishery for adult herring in the Gulf of Maine began in 1967, principally by USA and Canada with minor catches by the Federal Republic of Germany and the German Democratic Republic during the period 1969-1975. Catches averaged 38,500 mt from 1969 to 1972 as the accumulated stock was heavily exploited by small side trawlers using otter trawls and by purse seiners. Prior to 1975, the fishery primarily targetted spawning fish on spawning grounds in the Jeffryes Ledge - Cape Ann area. Subsequently, reduced catches ranging 16-24,000 mt through 1979 were taken exclusively by USA vessels including a newly developed pair-trawling system exploiting overwintering and migrating herring on grounds expanded into Massachusetts Bay and the Cape Cod area.

Under management by ICNAF, total allowable catches (TAC) from the Gulf of Maine stock were steadily reduced from 30,000 mt in 1972 to only 7,000 mt in 1976 and 1977. Consistent catch overages occurred, however, throughout the period reducing spawning stocks to low levels such that the fishery became heavily dependent upon the strength of recruiting year classes.

The Georges Bank herring fishery began in 1961 with the USSR taking 68,000 metric tons (mt) with extensive use of gill nets during

the first three years of the fishery. Purse seines were later introduced by the USSR and were used from 1968 until the fishery collapsed in 1977. Subsequently, a number of other foreign distant water fleets entered the fishery, most notably the German Democratic Republic, the Federal Republic of Germany, and Poland, with catches building rapidly to 374,000 mt in 1968, averaging 283,000 mt from 1967 to 1971. The dominant gear types used in the fishery were large, bottom tending otter trawls deployed from side and stern trawlers until the German Democratic Republic introduced mid-water trawls in 1971 (Anthony and Waring, 1980).

The history of Georges Bank herring management under ICNAF was characterized by catch quotas which were influenced more by considerations of social disruptions and short term economic gains than by conservation (Anthony and Waring, 1978). The Commission typically selected the highest catch options provided by assessment scientists and in some cases specified catch quotas one to three times higher than the recommended amounts. The result of this policy was that the Georges Bank and Gulf of Maine spawning stocks were reduced to low levels with the expectation that recruitment would also remain low with potentially disastrous consequences for the fishery and the resource (Clark and Anderson, 1977). The TAC recommended by assessment scientists to the Commission for Georges Bank never exceeded 150,000 mt with the range of options being as low as 50,000 mt. Despite the advice that catch levels should remain in the range 100-150,000 mt, provided that a minimum stock constraint of 225,000 mt was met, the allocations approved by the Commission totaled 150,000 mt from 1972 to 1975 even though stock sizes were plummeting to only 65,000 mt (age 4+) in 1975 (Anthony and Waring, 1980). The concern for the future of the resource was so great that the scientific advice in 1977 was a zero quota for the Gulf of Maine and 50,000 mt or less for Georges Bank, with only 8,000 mt being recommended for Georges Bank in 1978.

The Sea Herring FMP developed by the Council and implemented on December 28, 1978 sought to manage the Gulf of Maine and Georges Bank adult herring stocks so as to achieve levels of spawning biomass providing continued and relatively stable recruitment. The second

objective of the FMP was to manage the Gulf of Maine juvenile herring resource to stabilize and rebuild the sardine industry.

The FMP accepted the ICNAF recommendation of 60,000 mt as the minimum constraint for the Gulf of Maine spawning stock. In the context of the estimated level of spawning stock at the beginning of 1978 of only 68,000 mt, the assessment scientists recommended a 10-year rebuilding schedule whereby annual catches of adult herring (age 3 and older) would initially be restricted to only 1,000 mt so as to achieve an optimum spawning stock size of 100,000 mt. With regard to the Georges Bank resource, ICNAF had recommended a minimum stock constraint of 225,000 mt and an optimum stock size of 500,000 mt. The assessment had indicated that the spawning stock size in 1978 was at least 200,000 mt and that catch levels in the range 16-26,000 mt in 1978 would result in a spawning stock slightly above the mimimum constraint at the beginning of 1979. With the same level of recruitment, and catches remaining in the same range, the stock could be rebuilt at a rate of about 10% per year.

The Council decided to delay rebuilding the Gulf of Maine adult herring resource until at least 1980, choosing instead a maintenance strategy to minimize adverse impacts on the fishing industry. The initial OY for the Gulf of Maine stock was set at 8,000 mt for the 1978-79 fishing year, recognizing recent catch levels of adult fish along the coast of Maine but stipulating that such catches should not exceed 7,000 mt. Optimum yield for the Georges Bank stock (1978-79 fishing year) was set at 10,000 mt. These OY's were split between a winter-spring fishery (December-June) and a summer-fall fishery (July-November) in recognition of information regarding migratory movements of herring recently acquired from tagging studies. Thus, the winter-spring quota in the Georges Bank and South region was only 2,500 mt to minimize impacts on Gulf of Maine fish which overwinter with Georges Bank fish in the Southern New England area. The summer-fall quota in the region was set at 7,500 mt. OY in the Gulf of Maine was evenly split, 4,000 mt in the winter-spring fishery and 4,000 mt in the summer-fall fishery.

The Sea Herring FMP was initially implemented as emergency regulations on December 20, 1978, becoming final regulations effective on March 19, 1979. Amendment #1 to the FMP, published as emergency regulations (reflecting the Council's concern to remain abreast of conditions in the fishery) on March 28, 1979 (final regulations published on June 26, 1979), was intended to clarify the Council's policy with regard to the quota-setting mechanism for the Georges Bank and South winter-spring fishery. Based on the fact that all of the herring tagging studies had indicated that no Gulf of Maine fish migrate further south and west of the area of Montauk Point, Amendment #1 stipulated that all fish taken west of 71° 50' W. Long. would be counted against the relatively large Georges Bank and South summer-fall quota. Through this action, the Council was encouraging fishermen to concentrate fishing effort on Georges Bank herring and reduce fishing pressure on the Gulf of Maine stock wherever found during seasonal migrations.

Amendment #2 to the FMP, implemented as emergency regulations on July 1, 1979 (published as final regulations on September 28, 1979), at the beginning of the 1979-80 fishing year, extended the OY's and the summer-fall and winter-spring quotas, as established in the FMP. Simultaneously, the Council was engaged in preparation of Amendment #3. Recognizing deficiencies in the scientific basis to the previous stock assessments and the scheme for apportioning seasonal allocations of adult fish by management area, the Council formed a Regional Herring Assessment Working Group to address management of the entire herring resource. The resulting "pooled" assessment of the total herring resource formed the basis for substantial increases in Optimum Yield and for major changes in the area/period allocation scheme. Perhaps the most significant provision of Amendment #3 was a redefinition of the management unit to include all adult (age 3 and older) herring fisheries from the shoreline of the New England and Mid-Atlantic states out to the limit of the US EEZ. Previously, adult herring caught in territorial waters of the state of Maine were not explicitly counted against the Gulf of Maine quota. Amendment #3 specified OY's of 30,000 mt for the Gulf of Maine adult fishery and 15,000 mt for Georges Bank and South.

Moreover, Amendment #3 subdivided the Gulf of Maine annual quota of adult fish between a traditional "juvenile" fishery (north of Cape Elizabeth) and a traditional "adult" fishery (south of Cape Elizabeth), specifying a 35% - 65% split between the two areas, respectively. Amendment #3, which also specified an area/period allocation system somewhat more complex than that which was modified in Amendment #1, was implemented on August 27, 1980.

Prior to final implementation of Amendment #3, however, the NMFS Regional Director was obliged to close the Gulf of Maine adult fishery on October 1, 1979 when landings reached 17,000 mt (exceeding seasonal quota by 13,000 mt). In retrospect, the original 8,000 mt annual quota (4,000 mt seasonal quota) may have been overly restrictive (in light of the "pooled" assessment which indicated a 30,000 mt OY). Certainly, the assumption that no more than 7,000 mt of adults would be taken in the juvenile fishery along the coast of Maine was tested and found to be wanting. Moreover, the incentives offered by Amendment #1 to shift fishing effort to waters west of 71° 50' W. Long. (ie., away from Gulf of Maine fish) proved to be ineffective for two reasons. The extent of the collapse of the Georges Bank resource was underestimated by ICNAF. By accepting the final assessment advice provided by ICNAF, the Council compounded the error. Secondly, the Council underestimated the resistance by industry to reduce it's dependance on the traditional adult fishery in the Jeffrey's Ledge area.

A far more serious concern to the Council, however, was the regulatory ambiguity associated with catches of adult herring in state waters in the Gulf of Maine. The Maine sardine packers have traditionally employed small purse seiners taking mainly 3 year old fish to make up any shortfall in fixed gear catches of 2 year olds to achieve the total pack contracted for. Thus, availability of two year olds plus the world herring market conditions were major factors driving catches of adult fish in the state waters of Maine. Clearly, the Maine regulatory agencies would be very reluctant to enforce catch limitations promulgated by Federal agencies since to do so would involve closing down the operation of packing plants which often represented the sole

source of employment in many small communities. Despite considerable effort in attempts to arrive at an equitable solution to the problem, the Council was unable to resolve the ambiguity. Moreover, Massachusetts fishermen, experiencing higher fish availability than was suggested by the very restrictive catch quotas, and observing apparent wholesale quota busting in Maine waters, were able to bring sufficient pressure to bear on the Massachusetts regulatory agencies such that the latter declined to enforce the quotas in state waters.

Observing an increasingly chaotic situation, NMFS held hearings in May, 1981 to consider whether the Secretary of Commerce should rescind all or portions of the Sea Herring FMP, implement a Secretarial Amendment, preempt state management authority, or take no further action. Subsequently, the NOAA Assistant Administrator for Fisheries (AA) requested that the Council develop an amendment by July 1, 1982 which addressed major flaws in the FMP. It was clear to most observers that catch restrictions were unenforceable. NMFS also asserted that the FMP violated several of the National Standards. In the event, the Council was unable to meet the AA's request. On September 28, 1982, the Department of Commerce announced its initial determination to withdraw Secretarial approval of the Sea Herring FMP and repeal all implementing regulations. Concomittant to this action, sea herring was placed on the prohibited species list, eliminating directed fisheries for sea herring by foreign nationals within the US EEZ and requiring that any herring bycatches by such vessels be discarded.

In the midst of this controversy, fisheries officials from the states of Maine, New Hampshire, Massachusetts, and Rhode Island began a series of meetings on March 12, 1982 to discuss development of an interstate herring management plan. It was recognized that with the fishery occurring predominately in state waters, it was critical that all of the herring-producing states fully embrace an agreed management program. The lack of such a commitment by the states proved to be the most significant flaw in the Sea Herring FMP. The Atlantic States Marine Fisheries Commission (ASMFC) represented a potential vehicle for production of an interstate herring management plan. However, it was

decided that Maine and Massachusetts, with consultation from the other two states, could most expeditiously produce a new plan. That effort was commenced on October 25, 1982 with formation of a Plan Development Team (PDT) tasked with creation of a draft document by April 1983.

The final draft of the "Interstate Sea Herring Management Plan of Maine, New Hampshire, Massachusetts, and Rhode Island" (Plan) was presented by the PDT on November 28, 1983. The Plan was based on one objective and two sub-objectives. These were:

> "To acquire information that will allow development and facilitate implementation of management approaches designed to minimize prospects of a collapse of herring stocks on which New England fishermen depend.
>
> - To protect spawning herring.
>
> - To promote complementary management of all components of sea herring fisheries throughout the range of the stocks of interest to U.S. fishermen, including relevent Canadian waters."

The Plan deliberately chose not to embrace the conservative management espoused by the Council's FMP (ie., quota management) through disenchantment with the state of knowledge which had provided the basis for quantitative herring stock assessment technology. Both the states and the industry had observed lost opportunities in the world herring market in 1979 and 1980 when the NMFS Regional Director was obliged to close the fishery as quota overages occurred. Yet, in retrospect, if more accurate resource assessments had been available, the resulting higher allowable harvest levels might not have necessitated fishery closures. The Plan also rejected quota management due to the pernicious issues associated with equitability between the adult and juvenile fisheries. The Plan asserted that barring development of techniques for assessing the strength of year classes of fish recruiting to the

juvenile fishery, these issues would continue to undermine concerted action by the states which was critical to successful quota management.

The primary management measure implemented by the Interstate Sea Herring Management Plan was a system of spawning closures. The rationale for a prohibition on fishing during the spawning period was based on a widely held concern among the scientific community as well as industry that unrestrained fishing on spawning aggregations of pelagic species such as sea herring may lead to stock collapse. The dense schooling behavior of herring immediately prior to and during spawning make fish extremely vulnerable, especially to gear types such as pair trawls and purse seines, leading to very excessive levels of fishing mortality. Moreover, with disruption of normal behavior patterns, surviving fish may not necessarily spawn successfully. Accordingly, the Plan specified that spawning closures be instituted, as appropriate, and that such closures could either be in the form of fixed periods in time, on an annual basis, or could be based on measured biological criteria. If a state opted to take the former route, the most appropriate period of time was judged to be the 3-week period, October 1-21 for the Jeffrey's Ledge spawning area; if the latter, a spawning closure would be declared when the weight of the gonad in adult female herring reached 18% or more of the total weight of the fish.

An additional important provision of the Plan was that the Plan Development Team would continue to meet on an annual basis after plan implementation to conduct resource assessments and formulate recommendations regarding Plan Amendments, as needed, reporting such activity to the states and to the Council. As part of the consultative process, the PDT also would endeavor to promote cooperative arrangements with Canadian management authorities and assessment scientists.

References

Anthony, V.C. and G.T. Waring (1980) Assessment and management of the Georges Bank herring fishery. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 177:72-111.

2.2 NEW MANAGEMENT NEEDS

The Interstate Herring Management Plan which was adopted by Maine, Massachusetts, New Hampshire and Rhode Island in November 1983 is no longer adequate to manage the resource throughout its range in U.S. east coast waters for a number of reasons. First of all, there has been a fairly dramatic increase in the number of adults that are spawning on historical spawning grounds on Nantucket Shoals and Georges Bank, areas where there was little or no spawning activity reported for almost ten years following the collapse of the offshore fishery. The growth of the offshore portion of the population has resulted in greatly increased resource abundance in coastal waters of southern New England and the mid-Atlantic states where herring from the offshore area and the Gulf of Maine migrate in the winter.

As the size of the resource has grown, so has interest in Internal Waters Processing (IWP) operations, in which U.S. fishermen supply foreign-owned processing ships anchored within the internal waters of the states. The 1983 Interstate Management Plan only addresses resource management needs through spawning closures; it does not define overfishing or establish any direct measures for controlling harvest in order to maintain a healthy resource base. The states, acting through the Atlantic States Marine Fisheries Commission's Sea Herring Section (originally comprised of the states of Maine, New Hampshire, Massachusetts, and Rhode Island), and with the advice of a Technical Advisory Committee, have already implemented procedures for determining an annual total IWP allocation and dividing it between states who receive IWP applications. As interest in IWP's grew, membership in the Section began to expand, with New York joining in 1990 and New Jersey and Connecticut in 1992. A second memorandum of understanding (MOU) was circulated for signature to all Section member states in 1993 to demonstrate the intent of these states to cooperatively manage Atlantic herring (Appendix A) along with a revised set of IWP permit application and review procedures (Appendix B). Since neither the 1983 or 1993 agreements are comprehensive enough to manage the U.S. Atlantic herring resource, a new management plan is needed which will establish IWP

allocation procedures and lay the groundwork for future management of domestic fishing activity by the ASMFC, the New England Fishery Management Council (NEFMC), and (possibly) Canada.

Increased resource abundance south of Cape Cod during the last few years has stimulated interest in IWP operations in Rhode Island, New York, and New Jersey, caused an increase in domestic landings, and produced a herring by-catch in the mackerel mid-water trawl fishery in the mid-Atlantic region. At the same time, the catch of adults in the Gulf of Maine has been increasing as well, largely due to the development of IWP operations in Maine during the summer months and in Massachusetts in the winter. Also, there has been a noticeable shift in gear use in Maine where purse seines now account for a much larger percentage of the catch. Increased demand for bait in the lobster fishery and increased utilization of adults in the Maine canning industry have also encouraged the shift in recent years from a predominantly juvenile fishery to a predominantly adult fishery. Nevertheless, opportunities for inceased domestic utilization of the resource remains limited by limited market demand. The trend toward increased IWP landings is likely to continue, especially if fishermen are forced to reduce the number of days they spend trawling for groundfish and turn to underutilized species like herring and if more foreign processing ships become available. IWP's currently provide the only new market with a potential for growth and it is limited by the availablility of processing vessels and the number of suitable locations where they may anchor.

The increased abundance of herring, the development of IWP's, and the catch of herring in the mackerel joint venture fishery have created new resource allocation issues and required a broader regional management process involving a larger group of states and the New England and mid-Atlantic Fishery Management Councils. At the same time, industry and government representatives from the U.S. and Canada have begun informal discussions of complementary management of transboundary herring stocks in the Bay of Fundy and on Georges Bank.

A new management plan is needed which establishes a procedure for determining the quantity of surplus allowable catch each year and for allocating that surplus between the states for Internal Waters Processing operations without jeopardizing the health of the resource or the domestic fisheries. Once this is accomplished, a joint ASMFC-NEFMC management plan is needed which will establish a basis and a means for controlling domestic harvest throughout the range of the species (Cape Hatteras to New Brunswick), if and when that becomes necessary. A Council plan would also provide for joint venture opportunities in federal waters (outside three miles). Until a joint ASMFC-NEFMC management plan is prepared and approved, limitations on IWP landings will remain the only means by which exploitation of the resource can be controlled.

2.3 MANAGEMENT OBJECTIVES

The goal of this management plan is to manage Atlantic herring as an interjurisdictional resource in U.S. Atlantic coast waters for sustained optimum utilization while conserving the resource through complementary management between the New England and Mid-Atlantic Fishery Management Councils, the U.S. Atlantic coast states, and Canada in a manner which will provide the greatest benefit to the nation.

Managing the resource for optimum sustained utilization is defined to mean managing in a manner which will produce the greatest possible yield from the resource on a sustained basis given the constraints imposed by social and economic factors and by the need to maintain a large enough herring stock to support a healthy ecosystem. In other words, optimum utilization may be achieved with a yield that is somewhat less than the maximum biological yield.

The eight management objectives jointly developed by the ASMFC and the New England Fishery Management Council to achieve this goal are:

1. To maintain the U.S. northwest Atlantic sea herring resource at or above 20% of its maximum spawning potential for optimum utilization while reducing the risk of stock collapse.

This objective establishes an upper limit on harvest based on a maximum allowable fishing mortality rate which allows the stock to replace itself on an annual basis. This target F value would be produced by a fishery which reduces the stock to 20% of its maximum spawning potential (MSP). Analysis of existing spawning stock and recruitment data indicates that, under conditons of average recruitment, the stock could maintain itself at 13% MSP. 20% MSP is a more conservative management objective than 13% MSP and should ensure that the stock is maintained at a size sufficiently above the minimum required to avoid stock collapse, thus providing greater certainty of realizing the management goal of sustained optimum utilization. The fishing mortality rate that corresponds to 20% MSP reduces the stock by 25% a year. Total mortality, which includes natural mortality due to predation by other fish, birds, and marine mammals and discards of herring caught in other directed fisheries, removes 38% of the stock annually.

2. To promote U.S. and Canadian cooperation in order to improve herring assessment procedures and to establish complementary management practices.

The transboundary nature of the herring resource in eastern Maine-New Brunswick and on Georges Bank requires that U.S. and Canadian fisheries scientists collaborate in resource assessment activities. At the same time, if complementary management practices could be established in the two countries, the likelihood of achieving management goals in each country would be greatly enhanced.

3. To promote research and improve the collection of information in order to better understand herring population dynamics, biology and ecology, and to improve assessment procedures.

Research and the collection of certain types of fishery dependent and independent information is required in order to meet the resource assessment and management obligations outlined in this plan. A preliminary list of key research and data needs is included in this plan.

4. To provide adequate protection for spawning herring and prevent damage to herring egg beds.

The aim of this objective is to provide some additional protection for spawning herring in specific areas which may not be provided by limiting fishing mortality on the entire stock complex and to prevent trawling through demersal egg beds. Fishing effort would be controlled by means of spawning closures in a manner intended to protect spawning fish without prohibiting the capture of juveniles or spent adults. This objective does not totally rule out the capture of some mature fish in certain non-critical spawning areas or in times of resource abundance.

5. To avoid patterns of fishing mortality by age which are inconsistent with the goal.

The intent of this objective is to examine age specific patterns of mortality in the fishery and to establish a management strategy which to some extent distributes the total allowable fishing mortality out over a range of ages so that exploitation is not concentrated either on adults or juveniles. An excessive harvest of juveniles would be detrimental to the development of abundant adult age groups while the removal of large numbers of adults could jeopradize the reproductive capacity of the population. An overall limit on F (objective #1) may not be sufficient to prevent either of the above situations. The partitioning of F between age groups may only be necessary in a fully exploited or over-exploited fishery.

While a balancing of F between juveniles and adults would usually make sense from a strictly biological point of view, optimum utilization of the resource could mean, in certain circumstances, that a certain age

group be selectively harvested to satisfy a new or expanded market. The intention of this plan would not be to prevent this from happening as long as the management objectives of the plan were met.

6. To establish complementary management of all components of the fishery throughout the range of the species in U.S. waters of the northwest Atlantic.

This plan lays the groundwork for consistent and complementary management of the coastal stock complex in all coastal and offshore waters under state and federal jurisdiction using the management authority of the states acting under the advice and recommendations of the Atlantic States Marine Fisheries Commission and the New England Fishery Management Council acting in cooperation with the states, the Mid-Atlantic Fishery Management Council and the National Marine Fisheres Service.

7. To promote the utilization of the resource in a manner which maximizes social and economic benefits to the nation.

The herring resource in the northwest Atlantic is utilized in a number of different ways. Under any management regime that limits total fishing mortality, imposes spawning closures, and/or distributes fishing mortality between adult and juvenile age groups, it is the intention of this plan to encourage the development of those uses of the resource which maximize social and economic benefits to the nation. This objective is an integral part of an overall management strategy designed to achieve sustained optimum utilization of the resource. Cost-benefit information is currently not available, but will be developed for the joint ASMFC/NEFMC plan and/or published as an addendum to this (ASMFC) plan.

8. To promote recovery of the Atlantic herring resource on Georges Bank and to control development of the fishery.

Larval survey data indicate that the number of herring spawning on Georges Bank and Nantucket Shoals in recent years have increased sufficiently to permit a limited offshore exploratory fishery. Fish which spawn on these grounds are already being harvested south of Cape Cod in the winter time. Once the historical spawning grounds on Georges Bank are fully re-occupied and the quantity of fish spawning on these grounds has reached an acceptable level compared with peak spawning stock biomass estimates reached during the late 1960s and early 1970s, then a fully developed commercial fishery can be established subject to the management objectives and approach included in this plan. This plan provides for consultation with the NEFMC and other management agencies to lay the groundwork for appropriate management action on Georges Bank.

2.4 MANAGEMENT UNIT

The management unit for this Fishery Management Plan (FMP) is defined as the Atlantic herring resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the shoreline to the seaward boundary of the EEZ.

The Magnuson Act specifies that, wherever possible, the management unit should extend throughout the range of the species. The primary basis for establishing this definition is to preserve consistency with the December 1991 assessment which treated the entire resource in U.S. waters of the NW Atlantic as a single stock. Although limiting the management unit to U.S. waters, it is recognized that this a transboundary resource and that effective assessment and management would be enhanced by cooperative efforts with Canada.

3.1 HERRING BIOLOGY AND ECOLOGY

Atlantic herring (Clupea harengus) are distributed along the Atlantic coast from North Carolina to the Canadian maritime provinces. Almost always on the move, schools of adult herring undertake extensive migrations to areas where they feed, spawn, and overwinter. A typical late winter and early spring distribution (Fig. 3.1.1) shows that herring are found all along the coast in inshore and offshore waters to the edge of the continental shelf. In the spring, adults move north into the Gulf of Maine and in the summer and fall they segregate into more or less discrete spawning groups. Once they spawn, they move south again. This changing seasonal distribution has given rise to mobile and fixed gear fisheries taking fish of all ages to supply domestic and foreign markets for juvenile and adult herring -- markets that are not restricted to human food, but also include zoofood and bait.

Growing to a maximum size of about 17 inches (43 centimeters) and a weight of about 1 1/2 pounds (680 grams) and reaching ages of 11 and older, herring mature when they are three or four years old. A three year old herring weighs about 0.2 pounds (90 grams) while a four year old weighs about 0.3 pounds (129 grams), although growth varies a great deal from year to year, especially at the juvenile stage (REF).

Herring spawn on the bottom by depositing eggs which stick to gravel, sand, or algae and to each other to form mats or beds. For example, one egg bed surveyed on the eastern Maine coast in 1986 was determined to be about 0.3 square miles (or 0.8 km^2) in area -- a continuous carpet up to one inch thick containing an estimated 2-3 x 10^{12} eggs (Stevenson and Knowles 1988). Egg beds have also been surveyed on Jeffreys Ledge (Cooper et al. 1975) and Georges Bank (Anthony and Waring 1980), ranging up to XX square miles (XX km^2) in size. Depending on their size and age, female herring produce from 55,000 to 210,000 eggs (Kelly and Stevenson 1983). Once they are laid on the bottom, herring eggs are preyed upon by a number of species, including cod, haddock, red hake, spiny dogfish, sculpins, skates, and moonsnails. Egg predation and adverse environmental conditions (see 4.3) sometimes result in high egg mortalities.

Once they are old enough to undergo spawning migrations, Atlantic herring are believed to return to their natal spawning grounds throughout their lifetime. This behavior is fundamental to the species' ability to maintain more or less discrete spawning populations and is the basis for hypotheses concerning stock structure in the northwest Atlantic and elsewhere (see 3.2). Since fall spawning populations of herring in the northwest Atlantic can not be distinguished genetically (Kornfield et al. 1982), the only evidence for this "homing behavior" is provided by a tagging study in Newfoundland (Wheeler and Winters 1984) which showed that adult herring return to the same spawning grounds yeara after year. It could not be demonstrated, however, that these were necessarily the same spawning grounds where the fish were spawned.

Spawning occurs from year to year in specific locations in the Gulf of Maine in depths of 30-300 ft (10-100 meters) on coastal banks such as Jeffreys Ledge, along the eastern Maine coast (and at various other scattered locations along the Maine coast), south of Grand Manan Island (New Brunswick), and off southwest Nova Scotia (Fig. 3.1.2). Spawning also occurs on Nantucket Shoals and Georges Bank. The time of spawning differs along the coast with spawning occurring a bit earlier (August-September) in eastern Maine and south of Nova Scotia than in the southern Gulf of Maine (early to mid-October in the Jeffreys Ledge area and as late as November-December on Georges Bank). Preferred spawning substrate is coarse sand, gravel, and small cobble with or without attached macroalgae in areas with fairly strong bottom currents (see section 4) which are necessary to keep the egg mass aerated.

Larvae are about 0.25 inches (5-7 millimeters) in length at hatching which occurs 10-15 days after the eggs are deposited on the bottom. They remain pelagic through the winter in nearshore and estuarine waters in the Gulf of Maine (REFS???) and have been reported as far south as New Jersey (Ken Able, Rutgers University, personal communication). Metamorphosis occurs in the spring at a length of about 1.5 inches (40 mm). Schooling behavior begins in late larval and early juvenile ("brit") stages. Young-of-the-year undergo a general offshore movement in the summer and fall and are believed to spend the winter in deep coastal waters (REF?).

The location and movement of juveniles which originate from spawning on Georges Bank is not known with any certainty, although surface circulation patterns and the abundance of juveniles in southern New England and Long Island Sound in recent years suggests that juveniles move inshore south of Cape Cod or are transported there as larvae. There has always been speculation that some of the juveniles (age 2) along the western Gulf of Maine coast (Massachusetts to New Brunswick) are derived from spawning on Georges Bank, but no real evidence. Recent evidence relating to the distribution of juvenile Atlantic herring south of Cape Cod is summarized here.

New Jersey conducts a trawl survey during the months of January, April, June, August, and October. Adult Atlantic herring, averaging 26-27 cm, are abundant in survey catches in January, typically ranking with small elasmobranchs as the most abundant species caught by weight. Herring are found in all depth strata sampled (0-90 ft) along the New Jersey coast in January. Smaller herring, averaging 21-22 cm are present during April, but at lower abundance than observed in January. No herring are taken during summer period sampling and very few juvenile fish are taken at any time during the Survey (Don Byrne pers comm). Larval and early juvenile herring (2-5 cm) are abundant in Little Egg Inlet, NJ plankton samples between February and April (Ken Able, pers. comm).

Massachusetts conducts trawl surveys during spring (May), fall (September). Brit, or juvenile herring 4-7 cm in length are commonly taken in the spring trawl (May) and seine (June) surveys south of Cape Cod (SCC). Few adults are observed south of the Cape in state waters covered by the survey. Brit are taken in 3-4 ft of water in the June seine survey, typically in areas that are close to the open Sound. Late in June these fish appear to move east and northward into Cape Cod Bay and the Gulf of Maine. North of Cape Cod, fish tend to be larger (>12 cm) than observed SCC in the spring. Adult fish are taken in the fall survey, both north and south of the Cape (Arnold Howe, pers. comm).

Rhode Island fishery independent surveys take herring year round in Narragansett Bay. Fish range in size from 5-36 cm with fish greater than

15 cm occurring from November to April and smaller fish (<20 cm) present from June-October (Tim Lynch, pers. comm). Coastal ponds sampled with numerous gears primarily support large fish (25-38 cm). Herring are most abundant in coastal ponds between October and early June (Dick Satchwell, Pers. comm). Larval herring have been found from February to June in Mount Hope Bay as well as the Seekonk and Providence Rivers (Grace Kline-McPhee.

In New Hampshire, herring are present in gillnet samples throughout the year, with seasonal peaks in spring and late fall. Larval herring are present from October to April. While there is no extensive sampling throughout New Hampshire waters, it is expected that larvae are present throughout the coastal waters and estuaries including Great Bay (Paul Lindsay, Normandeau Assoc Inc., pers. comm).

In Connecticut, a trawl survey of Long Island Sound has been conducted between April-November. Adult herring (20-34 cm) are most common in April, with limited numbers of adult fish being taken in May and November. It appears these large fish are present in Long Island Sound before the survey begins in April. Juvenile herring are abundant in Long Island Sound during the summer. Two modes are apparent, the largest at 7-9 cm and a smaller mode at 15-18 cm. The largest concentrations of juvenile herring tend to occur in the western Sound with good catches occurring even in areas where bottom dissolved oxygen (DO) is below 3 mg/l. Herring are probably taken higher in the water column where DO concentrations are generally (but not always) higher.There is some speculation that juvenile herring may be feeding above hypoxic bottom waters in algae blooms near the surface which are often associated with hypoxic areas. Herring are found in all depths sampled from 15-120 ft, although concentrations tend to be higher in 30-90 ft depths (David Simpson, pers. com).

In New York, juvenile Atlantic herring (<18 cm) appear in trawl survey samples in the Peconic Bays area during the summer (Sherri Aicher, pers. comm).

Delaware's trawl survey takes adult herring (>20 cm) in the lower portion of Delaware Bay during March and April. Adult fish have also been observed

in adjacent ocean waters, often mixed with mackerel. Juvenile fish do not typically appear in survey catches (Rick Cole, pers. comm).

The persistence of discrete aggregations of larvae over tidally mixed continental shelf spawning grounds in the Gulf of Maine (and elsewhere) for several months after hatching, despite the presence of fairly strong longshore currents, has provided the basis for a larval "retention hypothesis" (Iles and Sinclair 1982). This hypothesis states that Atlantic herring stock structure in an area like the Gulf of Maine is determined by larval distribution (and retention) patterns and that the maximum stock size (in that area) is determined by the number, location, and extent of geographically stable retention areas.
Such retention areas have been described off southwest Nova Scotia, around Grand Manan Island, and on Georges Bank (Iles and Sinclair 1982), and, more recently, in eastern Maine waters adjacent to Grand Manan (Chenoweth et al. 1989).

The eastern Maine-Grand Manan spawning ground is an important source of larvae which are transported to the southwest along the Maine coast (Graham and Townsend 1985, Townsend et al. 1986), overwinter in bays, estuaries and nearshore waters, and become juveniles in the spring. Those juveniles ("brit") which survive until the following spring and summer (age 2) are harvested as sardines in the coastal fishery. Larvae which hatch on Jeffreys Ledge, another important coastal spawning ground in the Gulf of Maine, are mostly transported shoreward (Cooper et al. 19XX); some of them overwinter in nearshore waters on the Maine coast (Lazzari and Stevenson 1991).

Mortality in the larval stage is very high since larvae remain vulnerable to very low temperatures and a limited food supply for a prolonged period during the winter, especially in shallow nearshore and estuarine waters (Townsend and Graham 1981, Graham et al. 1991). Campbell and Graham (1991) developed an ecological model in order to examine which factors affected larval survival to the early juvenile (brit) stage. Some of the conclusions which were reached by applying this model were the following:

· Larval herring recruitment in Maine coastal waters is the result of a complex interaction of many processes, no one of which is truly dominant.

· Two-year-old recruitment to the Maine herring industry is established in the larval stage in some years and not until the brit stage in others.

· Larval food supply in autumn and winter, along with the quantity and distribution of spawning, are primary factors controlling herring recruitment [to the brit stage] for those years when the larval stage is critical.

· When larval survival is above a threshold, density-dependent predation on brit can reduce the year-class size. We assume that the brit become the food of choice for opportunistic pelagic and demersal predators when brit exceed an abundance threshold.

· Temperature and longshore transport are secondary factors determining larval survival that may be most important through their interaction with primary factors.

· In most years, more larvae survive the winter in the coastal areas than in the estuaries and embayments.

· The distribution of larvae along the Maine coast in springtime is largely a function of the variable inshore movement of larvae.

Juvenile herring, especially brit (age 1 juveniles) are preyed upon heavily due to their abundance and small size. Mortality due to predation during the first year of life is believed to be a major factor affecting recruitment to the fishery at age 2 the following spring and summer.

Herring of all ages feed on zooplankton with larvae preferring copepods, crustacean eggs, and nauplii (Sherman and Honey 1971, Cohen et al. 19XX) and adults preferring chaetognaths (arrow worms), euphausiids, and pteropods.

Herring is an important species in the food web of the northwest Atlantic. Its finfish predators include: cod, silver hake pollock, red hake, haddock, white hake, squid, spiny dogfish, porbeagle, blue shark, thresher shark, shortfin mako, clearnose skate, little skate, goosefish, hickory shad, Atlantic salmon, bluefin tuna, and swordfish. However, according to Grosslein et al. (1980), for many of these predators the information is qualitative, and the actual significance of herring as prey is unknown.

Nevertheless, some quantitative information is available which indicates the importance of herring as a food source for silver hake, cod, and dogfish. Overholtz et al. (1991) estimated that silver hake, cod, and dogfish consumed an average of about 1,500, 200, and 4,300 metric tons a year (3.3 million, 440,000, and 9.5 million pounds), respectively, of herring from 1988-1992 on the northeast U.S. continental shelf.

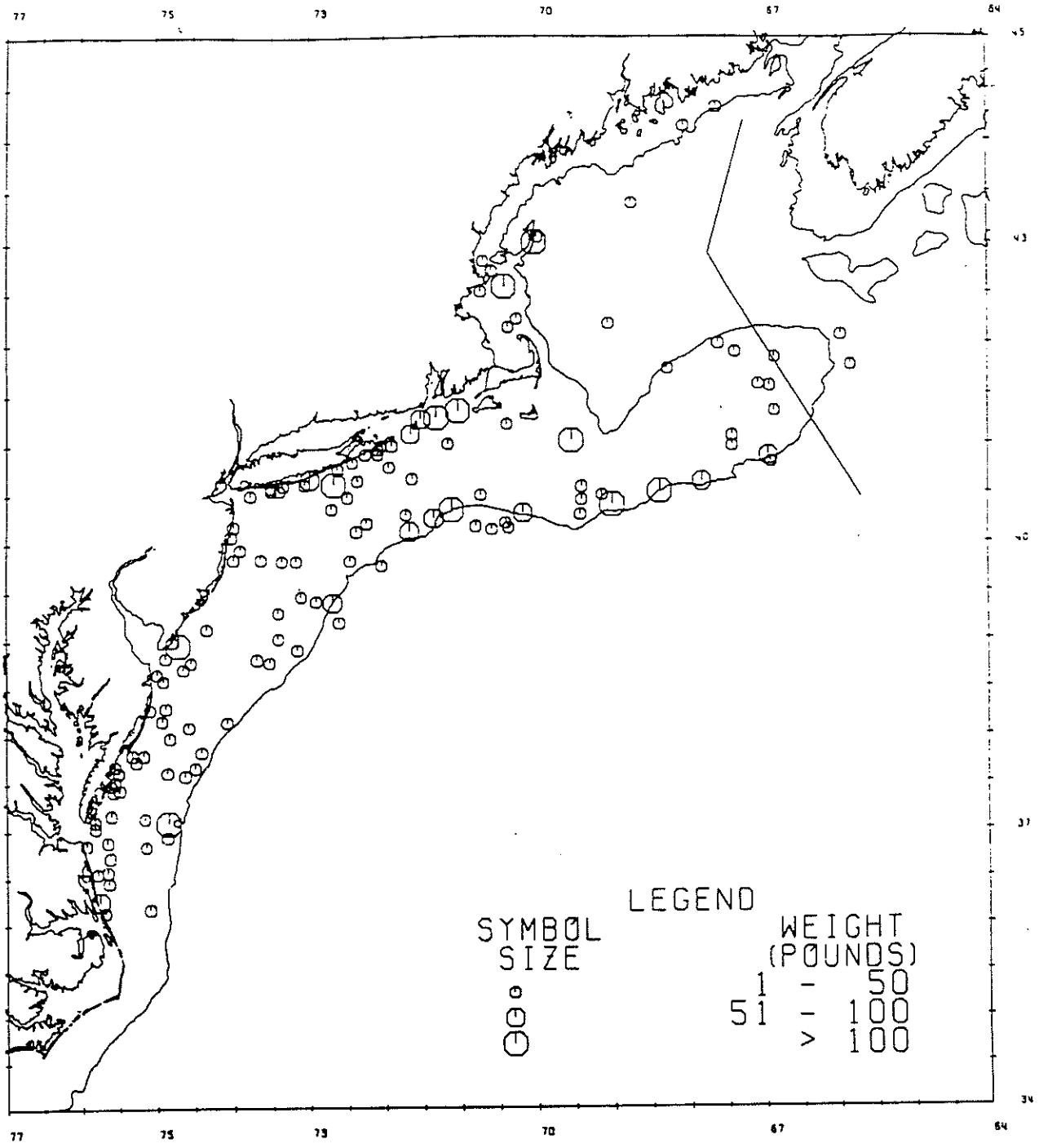
Overholtz et al. also calculated that five species of whales, three species of dolphins, harbor porpoises and harbor seals consumed, on average, 19,300 mt (42.5 million lbs) of herring a year from 1988-1992. Herring was the third most common prey species behind sandeels (55,760 tons) and mackerel (36,260 tons). Finback whales accounted for about 50% of the total quantity of herring consumed by the ten species of marine mammals (10,000 mt). Humpback whales (2,600 mt) and pilot whales (2,800 mt) also were significant consumers. Research on harbor seals off Monomoy Island, Cape Cod during 1984-1987 indicated that herring increased in the diet from 5% in January and February to 16% in March and April, although the importance of herring in the diet may have been much higher (Payne and Selzer 1989).

Seabirds also take a share. Estimates were that the northern gannet consumed about 3,000 mt and the shearwater about 250 mt a year during 1988-1992 on the U.S. northeast shelf (Overholtz et al. 1991).

Therefore, these calculations indicate that between piscivorous fish, marine mammals, and marine birds, about 30,000 metric tons (66 million pounds) of herring is consumed each year. This is probably an under-

estimate since it was based, among other things, on a presumed low abundance of herring on Georges Bank and herring, at least during the spawning season, are known to be much more abundant in recent years as the offshore portion of the stock has recovered (see 3.4). However, even using an estimate of 50,000 mt, this only represents 2.5% of the estimated total stock size of herring in 1990 (see 3.3) and 50% of the annual commercial harvest. The annual natural mortality rate used to estimate stock size, in contrast, is 18%.

Atlantic herring compete with other species such as Atlantic mackerel and sand lance (Ammodytes spp.) for some of the same food sources, e.g., euphausiids. In the mid to late-1970's, when mackerel and herring abundance declined, the abundance of sand lance increased explosively, giving rise to the speculation that some sort of competitive relationship existed between these three species, especially between sand lance and the mackerel/herring dyad. (HAS THIS SWITCHED IN MORE RECENT YEARS???).



3.1.1

Figure 5. Distribution and relative abundance of Atlantic herring on the Northeast's continental shelf during March 9 - April 30, 1993, based on catches at 329 sites during the Northeast Fisheries Science Center's spring 1993 research bottom-trawl survey. The location of each octagonal symbol indicates those sites at which this species was caught. The size of each symbol indicates the poundage of this species caught during a 30-minute haul of a research bottom-trawl net (small = 1-50 pounds; medium = 51-100 pounds; large = more than 100 pounds).

3.2 STOCK STRUCTURE AND MOVEMENTS

Historical Perspective

Defining the stock structure of herring in the Northwest Atlantic always has been a challenge for fisheries scientists who have the task of assessing the abundance of this important and highly migratory pelagic species. The inshore/offshore and north/south movements of this species cause it to range from the mid-Atlantic region to the Gulf of Maine and Georges Bank. Consequently, a variety of simplifying assumptions have been made over the years in the process of making assessments needed for resource management purposes. Those assumptions have been refined and modified over the years in response to management needs and to research on herring movement and stock identification and intermixture. Despite all the research, there are still great uncertainties.

Assessments performed during the early 1970's by the International Council for the Northwest Atlantic Fisheries (ICNAF) dealt with a Nova Scotia stock, a Gulf of Maine stock, and a Georges Bank stock (see also 3.3). The latter included herring spawning in the Nantucket Shoals area -- all overwintering in Division 5Zw and Subarea 6 (Fig. 3.2.1) from December through March. The assessments acknowledged that Gulf of Maine stock distribution in other than the spawning season was unknown, but it was likely that some of this stock mixed with fish from the Georges Bank stock in Div. 5Zw and Subarea 6 during the winter. Biochemical and serological data (ICNAF 1972) indicated that the Gulf of Maine stock could not contribute more than 10% of the herring overwintering in Division 5Zw and Subarea 6. However, Anthony and Waring (1980) noted that the biochemical and serological studies were in error or unreliable. Consequently, the extent to which herring from the Gulf of Maine overwinter in deep water from Long Island to the mid-Atlantic is unknown. Of interest, according to Anthony and Waring, most of these overwintering fish during the 1970's were age 4 and older.

As a result of this assumption (very little intermixing of Gulf of Maine herring south of Cape Cod), in previous assessments, all landings from Georges Bank and south were considered to be "Georges Bank" stock fish. Foreign catches of fish on Georges Bank and Nantucket Shoals near and during the spawning season, and catches of overwintering fish on southern New England and mid-Atlantic grounds, were combined. This helps to explain why the reported "Georges Bank" catches of herring during the late 1960's and early 1970's were so large (maximum of 373,000 metric tons or 820 million pouunds in 1968; see also 3.4), as were the stock size estimates which were based on those catches (maximum 1.2 million mt age 3 and older in 1968).

The distribution of "Georges Bank" fish during the 1960's, at the time when abundance was peaking and the catch was primarily by foreign nations, was described by Zinkevich (1967), using data collected from 1963-1965 by Soviet fishing and scouting vessels, concluded:

> "Herring were distributed over the greatest area in winter months. From November to March, herring were fished from 36 degrees N along the continental shelf to the northern extremity of Georges Bank. During that period the herring were active and did not form stable commercial concentrations. In February and March, the bulk of the fish was observed in the areas of Long Island, Hudson Canyon, and farther south. For instance, in March 1964, the bulk was found in the area from 36 degrees to 38 degrees N."
>
> "In the spring months, the herring moved from the area of Wilmington and Hudson Canyons to the southern parts of Georges Bank, where they gradually increased in numbers, whereas they decreased in number south of 40 degrees N."
>
> "From May to October, the bulk of the fish was feeding or spawning on Georges Bank."

These observations have been supported by tagging studies described by Grosslein (1986). After leaving wintering grounds and during the summer, herring move northward during feeding migrations.

Adult herring tagged off Cape Cod and in the western Gulf of Maine move north and eastward during the spring and summer and from April through September are distributed from the central region of the coast of Maine to southwestern Nova Scotia. Furthermore, according to Anthony and Waring (1980),

> "Herring tagged in the spring of 1977 in the Great South Channel and on Jeffreys Ledge have been recovered all along the coast from Ipswich Bay, Massachusetts, into the Bay of Fundy and along southwestern Nova Scotia in the summer and autumn herring fisheries. During the winter of 1978 recoveries of these fish were made in the winter fisheries in Chedabucto Bay (eastern Nova Scotia), Cape Cod Bay, and in Block Island Sound".

These scientists concluded:

> "These preliminary results indicate that there is a degree of stock intermixture, the extent of which has yet to be determined, among the herring inhabiting the coastal waters from Chedabucto Bay to southern New England...in the early years of the Georges Bank fishery, when catches were made in the winter south and west of Georges Bank, some of these fish may have been overwintering fish from Nova Scotia and from the Jeffreys Ledge spawning groups."

However, the validity of these conclusions is doubtful since it could not be determined, even for studies conducted during the spawning season, if tags were applied only to adults that would spawn at that location or to adults that were still migrating to other spawning grounds. Other problems plaguing these tagging studies were the low rates of recovery, in part due to high tagging mortalities of spawning fish and in part to reduced fishing effort in certain key locations (e.g., Georges Bank and south) following the collapse of the Georges Bank fishery.

Creaser and Libby (1988) found similar results from their tagging work along the Maine and New Hampshire coasts from 1976 to 1982. For

example, fish tagged as summer-feeding adults off eastern Maine were recaptured on overwintering grounds in Massachusetts and Cape Cod Bays and southern New England. Older juveniles (age 3), appearing to have migratory habits similar to adults, overwintered in waters off western Maine, Massachusetts and Cape Cod Bays, and southern New England. As in other tagging studies, however, the number of recoveries made south of Cape Cod was reduced significantly by the extremely low fishing effort there during this period.

Stock Definitions and Assessments

Prior to the involvement of the Atlantic States Marine Fisheries Commission (ASMFC) in sea herring management, the New England Fishery Management Council had to deal with the perplexing problem of uncertain stock structure and intermixing. The regulations of the Council's Atlantic Sea Herring FMP, which became effective as emergency regulations on December 28, 1978, implemented a management approach embracing seasonal quotas for the Gulf of Maine and Georges Bank, including southern New England and the mid-Atlantic area (for more information on the history of sea herring management, see Appendix C). To establish these area/season total allowable catches, an assumption regarding stock structure and intermixture had to be made. This assumption, critical for the biological model for generating TACs, was developed as a scientific consensus by a committee of herring biologists.

The consensus, used by the Council until FMP was withdrawn by the Secretary of Commerce in August 1982 and the regulations were repealed, was that during the period December and March (post-spawning and overwintering behavior), 50% of the Jeffreys stock (generalized designation for western Gulf of Maine spawning aggregations) resided in Division 5Y and 50% was found in Division 5Z and Subarea 6. The best scientific information at that time indicated that Gulf of Maine fish did not reside exclusively in the Gulf of Maine during the winter. A very substantial portion was believed to migrate south of Cape Cod as far south as the mid-Atlantic area.

According to the Council Plan, the Georges Bank stock (including herring that spawn on Nantucket Shoals) during the summer (June-July) was assumed to be distributed 75% in 5Z/SA6, 20% in 5Y, and 5% in 4WX (southwest Nova Scotia). The 4WX stock further complicates an understanding of stock intermixture since during December-March, 20% of the stock was assumed to be located in 5Z/SA6. As noted in the plan, these percentages were preliminary and subject to change as new evidence became available. It should be noted that 4WX stock assessments over the past decade (e.g., Stephenson et al. 1992) assume that all the fish which spawn off southwest Nova Scotia migrate north along the outer Nova Scotian coast in the winter, i.e., that there is no intermixture with the coastal Gulf of Maine or Georges Bank stocks.

In response to the assessment dilemma posed by stock intermixture, scientists have performed so-called "pooled" assessments. One of the first pooled assessments performed by Anthony (1977) combined herring catches from all areas including Chedabucto Bay, Nova Scotia, and New Brunswick. Two years later, Sissenwine and Waring (1979) used the same approach by pooling all catch-at-age data for all herring fisheries between southwest Nova Scotia and Cape Hatteras.

Modifying the pooled assessment approach, Anthony et al. (1981) developed a method for excluding Georges Bank herring from the analysis. Their assessment considered Georges Bank to be areas 5Ze and 5Zw with the fishery in 5Zw being termed the "USA southern New England winter fishery." This was a confusing mix of terms: if the 5Zw herring were from "Georges Bank" wouldn't the fishery be considered a "Georges Bank fishery?"

This confusion regarding the definition of Georges Bank versus Gulf of Maine herring continued in 1989, when, after a lapse of six years, a sea herring assessment was again performed. With the establishment of the ASMFC's Herring Technical Advisory Committee (TAC) and the states' need to allocate herring for internal waters processing operations (IWP's), sea herring assessments were urgent, and a new assessment (Fogarty et al. 1989) was conducted for the Gulf of Maine stock, which was defined as:

> "Atlantic herring throughout the Gulf of Maine, southern New England and Mid-Atlantic regions [which] are considered to be part of a single stock."

This definition contrasted with the stock definition used for the the subsequent (1990) assessment conducted by the Maine Department of Marine Resources in collaboration with the NMFS Northeast Fisheries Science Center (NEFSC) and the other states represented in the TAC. For this assessment, the TAC defined the Gulf of Maine stock as:

> "The Gulf of Maine stock was considered to include all fish found in NAFO areas 5Y and 5Zw (i.e., excluding fish from area 6, which were assumed to belong to either the Georges Bank or Nantucket Shoals stocks; and excluding fish from Sub-area 4, which were assumed to belong to Atlantic Canadian stocks). However, an unknown amount of mixing occurs during winter/spring between Gulf of Maine, Georges Bank, and Nantucket Shoals stocks in the Mid-Atlantic and Southern New England areas..."

Until this time, the TAC had used the definition adopted by Fogarty et. al. (1989). The TAC assumed that since herring still appeared to be spawning in relatively low numbers on Georges Bank, catches from southern New England and the mid-Atlantic area and NEFSC abundance indices were composed predominantly of Gulf of Maine origin fish. This approach, however, raised some serious questions concerning the affinity of Nantucket Shoals herring, which appeared to be recovering well (see 3.4). Did this spawning component belong to the Gulf of Maine or the Georges Bank spawning stock?

In an attempt to clear up this confusion, the TAC decided in 1991 that it would stop referring to Gulf of Maine and Nantucket Shoals fish separately and instead would treat these fish as part of a highly migratory coastal herring stock with distinct, major spawning areas (e.g., Jeffreys Ledge, the eastern Maine coast, and Nantucket Shoals). The assessment (VPA), which was tuned using the spring index of

abundance derived from bottom trawl tows from the mid-Atlantic to the Gulf of Maine, described the abundance of herring along the entire U.S. Atlantic coast and excluded New Brunswick and historical "Georges Bank" catch-at-age data. This was considered to be an improvement over previous assessments which were applied specifically to the Gulf of Maine stock, but which were tuned using NMFS spring bottom trawl survey indices between Cape Hatteras and the Gulf of Maine.

The remaining complication was Georges Bank. When abundance on Georges Bank is high and fish spawn on the bank and then intermix on offshore wintering grounds extending to the mid-Atlantic, spring survey abundance indices may overestimate the size of the coastal population. Unfortunately, since the abundance of Georges Bank herring was still not known with certainty in 1991, the TAC was unable to assess whether its 1990 estimate of spawning stock size for the coastal population was overestimated. One of the major sources of uncertainty identified in the fall of 1990 (NEFSC 1991) was the inclusion of survey areas in the spring abundance index which included Georges Bank fish. For this reason, the Stock Assessment Review Committee recommended an examination of which survey strata to include in the survey index used for tuning the virtual population analysis (VPA).

In further considering the affinity of the Nantucket Shoals spwning group to the rest of the coastal migratory stock, the TAC in 1991 examined the results of various tagging studies (see Appendix D) and concluded that herring originating from Nantucket Shoals spawning, after overwintering to the south, migrate back though the Shoals and into the Gulf of Maine. The amount of movement into the Gulf of Maine is unknown. Do herring linger and meander around the Shoals, thereby remaining in the area for three months or more? Tagging data suggested their summer feeding migration probably brings them along the coast of Maine to the Bay of Fundy and the southwestern Nova Scotia area. A return migration to spawning grounds on Nantucket Shoals is assumed since "homing" appears to have been demonstrated for herring (see 3.1).

Some fairly recent information regarding the relationship between Georges Bank and Nantucket Shoals herring was summarized in the report of the spring 1990 Stock Assessment Workshop (NEFSC 1990). That report noted:

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

In the fall of 1991, at the 13th Stock Assessment Workshop, an attempt was made to finally and conclusively settle the question of how to assess the herring resource in U.S. waters of the northwest Atlantic, i.e., which stocks and catch data to include in an assessment. The report from that workshop (NEFSC 1992) states:

> "After extensive review and discussion, the SARC consensus was that both the catch at age matrix and the spring survey indices of abundance reflect not only the "coastal" stock but also intermixing of fish from New Brunswick weir catches and Georges Bank stocks. The SARC, therefore, decided that the assessment should be based on an aggregate stock complex (emphasis added), including coastal, Georges Bank and New Brunswick weir caught fish."

An important conclusion of the Stock Assessment Review Committee was:

> "...These results cannot be directly compared with other assessments which were on parts of this stock complex. Insufficient information exists to separate spawning stock components for this assessment..."

Current Approach

The latest assessment (Stevenson et al. 1993, NEFSC 1993) was applied to the coastal stock complex as defined at the fall 1991 SAW. Consequently, the present position regarding stock structure for assessment purposes is:

The coastal stock complex consists of the Atlantic herring population(s) along the east coast of the U.S. and herring in Canada limited to the Canadian zone of the Georges Bank area and to the coastal fixed gear catch from New Brunswick. Therefore, it should be noted that the stock unit extends beyond the jurisdiction of the management unit adopted for this management plan. It is also recognized that the stock complex may consist of individual stocks or spawning components that can not be adequately separated for assessment purposes. These stocks or components are associated with discrete spawning areas such as coastal Maine (especially eastern Maine), Jeffreys Ledge, Nantucket Shoals, and Georges Bank.

The assessment of this stock complex (see 3.3) therefore was performed using the following approach (Stevenson et al. 1993):

> "...historical catch-at-age data from Georges Bank was combined with data from U.S. coastal fisheries in the Gulf of Maine and south of Cape Cod and with fixed gear catches from New Brunswick into a single catch-at-age matrix for the years 1967 to the current year [1992]. This approach is based on the fact that the primary data used to tune the virtual population analysis are derived from the spring NMFS bottom trawl survey and are collected

at a time of the year when Atlantic herring which might otherwise be assigned to individual spawning stocks (e.g., Gulf of Maine or Georges Bank, as in earlier assessments) have migrated south and occupy Massachusetts Bay and continental shelf waters in southern New England and the mid-Atlantic region. New Brunswick fixed gear catches which are included in this assessment are not included in the Nova Scotian 4WX stock assessment..."

Hstory of Tagging

Following a period of considerable tagging work in the early and mid-1970's, no tagging has been done since the late 1970's except for investigations of seasonal movements of juvenile and adult herring along the coasts of Maine and New Hampshire (Creaser and Libby 1988). The reason for this abrupt reduction in tagging work was the collapse of the Georges Bank/Nantucket Shoals spawning stock in the early 1970's. As a result, the key issue of the extent of intermixing of the Georges Bank stock with the coastal stock(s) could not be addressed and enthusiasm for tagging waned, at least in the U.S. Also, U.S. assessment scientists in the northeast have been preoccupied since the late 1970's with groundfish and other species that were high on the list of priorities of the New England and mid-Atlantic Fishery Management Councils.

Anthony and Waring (1980) summarized noteworthy tagging studies performed during the 1970's by the U.S. and Canada. The following table lists the number of fish tagged by area on eleven different occasions between 1973 and 1977.

Year	# fish	Area	Country	Condition
1973-74	48078	BF and SWNS	Can	
76fall	29500	CultSh	US	ripe & run
76fall	10693	JefL	US	ripe & run
77sp	10973	JefL	US	overw/migr
77sp	22882	GrtSChl	US	overw/migr
77sept	943	EastCC(12mi)	US	ripe

1976Jul-78Feb	40986	MaineCst	US
1976Jan-Feb	22467	ChedbBay	Can
1977Jan-Feb	1025	CedbBay	Can
1976Apr-Aug	48024	WGulfStLaw & StGrgeBay	Can
1977sum/fall	70000	SWNS incl. LurS/TrnLed	Can

The following points can be made about these studies:

· Canadian tagging studies indicate that herring tagged in the autumn in the Bay of Fundy and off Nova Scotia migrate north to Chedabucto Bay and south to Cape Cod Bay and Block Island Sound to overwinter. However, a key question is: were all the tagged fish, in fact, "in residence" on Lurcher Shoals and Trinity Ledge or were some of them "in transit" on their way back to Jeffreys Ledge and coastal Maine fish spawning grounds?

· Herring tagged in the spring of 1977 in Great South Channel and Jeffreys Ledge have been recovered: (a) all along the coast from Ipswich Bay into the Bay of Fundy and along southwest Nova Scotia in summer/fall fisheries, and (b) during winter 1978 fisheries in Chedabucto Bay, Cape Cod Bay, and in Block Island Sound.

· Returns of spawning fish tagged on Jeffreys Ledge and Georges Bank were negligible probably as a result of high tagging mortality and limited fishing effort in 1976 and 1977 on Georges Bank.

The following conclusions can be drawn from these studies:

· The degree of stock intermixture has yet to be determined for herring from Chedabucto Bay to southern New England.

· In the early years of the Georges Bank fishery when catches were made in the winter south and west of Georges Bank, some of these fish may have been overwintering fish from the Nova Scotia and Jeffreys Ledge spawning groups.

· Movement of Georges Bank herring have not been well-defined; furthermore, the movements of larvae and juveniles off Georges Bank are still not well known.

Creaser and Libby (1988) found similar results from their tagging work done along the Maine and New Hampshire coast from 1976 to 1982. They tagged 106,241 age 2 and older fish at 38 sites. Recoveries (5.9% for juveniles and 4.9% for adults) produced these findings:

· Fish tagged as summer feeding adults off eastern Maine were recaptured on overwintering grounds in Massachusetts and Cape Cod Bays and southern New England.

· Older juveniles (age 3), appearing to have migratory habits similar to adults, overwintered in waters off western Maine, Massachusetts and Cape Cod Bays, and southern New England.

· The potential for recoveries off southern New England was reduced because landings for the entire area during those years were very low in comparison to catches elsewhere; e.g., the greatest catch from January through March was in 1977 when about 2,000 mt was landed. The average from 1977-1984 was 1,000 mt.

Important conclusions were:

· Fish tagged as juveniles were infrequently recaptured south of Cape Cod and never recaptured beyond the southwest side of the Bay of Fundy (Grand Manan and NB) --i.e., never taken in the upper regions or eastern side of the Bay of Fundy (Nova Scotia).

· Adults were frequently recaptured south of Cape Cod and consistently recaptured as far east as Nova Scotia.

· Data suggested that summer-feeding adults may disperse over a wider feeding range or may consist of a mixture of stocks.

Most herring have been tagged when stocks were mixed -- summer-feeding and overwintering -- not when they are segregated into discrete spawning groups. The amount of tagging during spawning has been insufficient. That was the conclusion of the International Herring Tagging Program's ad hoc Working Group on Herring Tagging that recommended in 1982 that:

> First priority for tagging was spawning groups (ripe and running) in regions, 7, and 10, with tagging in 2 being contingent on recovery of Georges Bank stock.

As of 1993, there has been no progress in improving our understanding of herring stock structure and movements in the Gulf of Maine, southern New England, and the mid-Atlantic regions through tagging. There are still important unanswered questions:

· Do Nantucket Shoals adults, after overwintering to the south, pass through the Great South Channel or along the backside of Cape Cod and enter the Gulf of Maine, eventually moving to southwest Nova Scotia to be harvested in Canadian summer/fall fisheries?

· Do they move out to Georges Bank and remain on the Bank throughout the summer to return to Nantucket Shoals spawning areas in the fall?

· Do Georges Bank fish stay on the Bank or move elsewhere?

· Assuming they move south, how far to the south do they travel in the winter?

· Are Nantucket Shoals fish overwintering in the same areas and depths as fish from Georges Bank?

· Do Georges Bank fish overwinter farther to the south and in deeper water than Nantucket Shoals fish and fish from the Gulf of Maine (and perhaps Canada) that migrate south after they spawn?

Answers to these questions would help resource managers --states and Council --better understand the impact of different fisheries on individual components of the population. The stocks which right now are being looked at on a stock by stock basis -- but as a coastal stock complex.

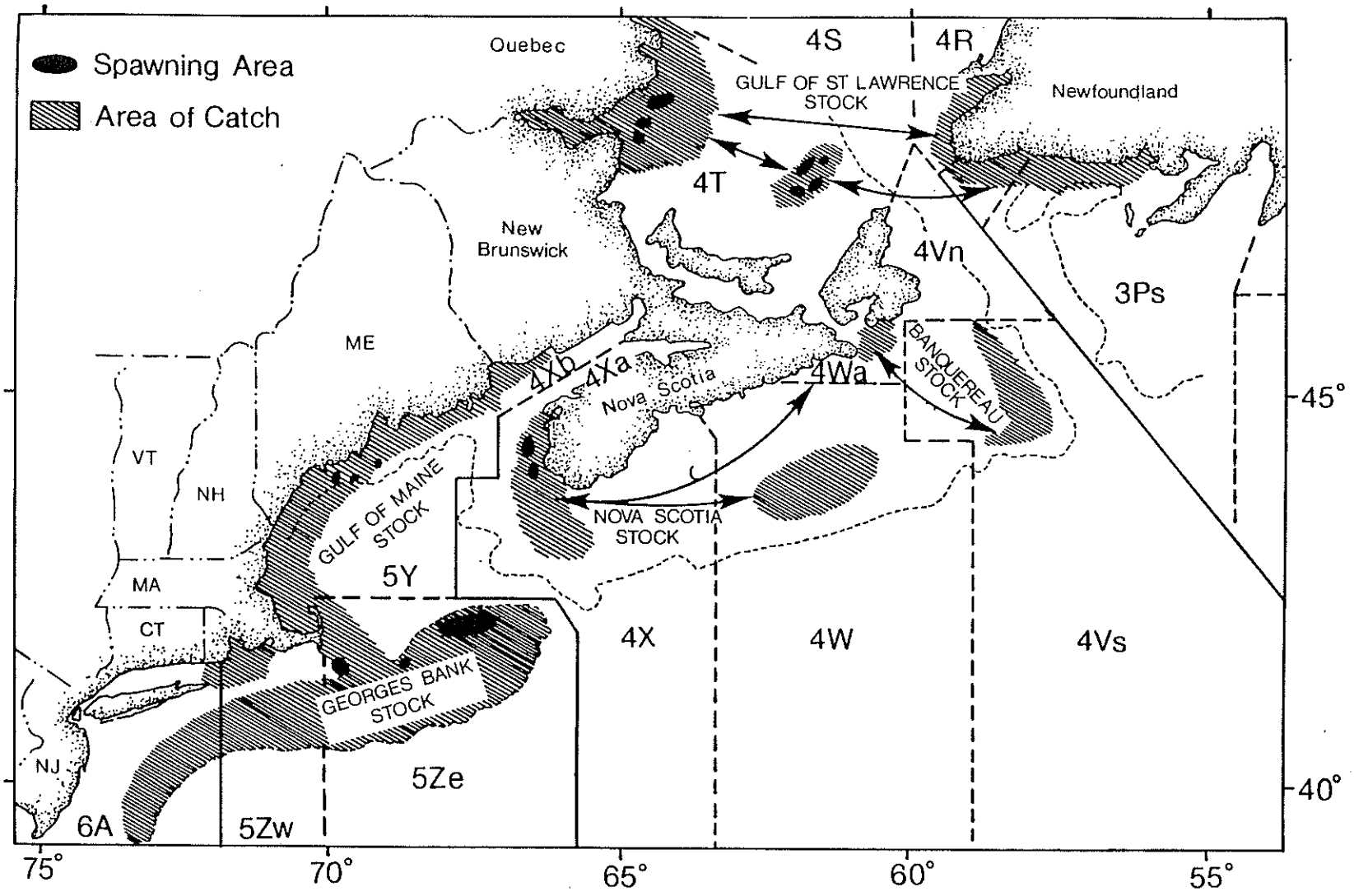


Figure 3. Herring stock structure in Subareas 4 and 5 and Statistical Area 6. (Solid lines indicate stock management areas; solid black areas indicate the general spawning grounds). (from Report of the Herring Working Group, ICNAF Redbook, App. II, 1972).

3.3 ATLANTIC HERRING COASTAL STOCK STATUS

Introduction

Atlantic herring (Clupea harengus) inhabit coastal and continental shelf waters on the east coast of the U.S. and Canada from Virginia north to Newfoundland and Labrador. The adults undergo substantial seasonal migrations along the coast. Three separate, more or less distinct spawning populations have been recognized in the Gulf of Maine, one off the southwest coast of Nova Scotia, another along the Maine, New Hampshire, and Massachusetts coast, and a third on Georges Bank and Nantucket Shoals. Spawning takes place as early as August in eastern Maine and off Nova Scotia and as late as October-December on Jeffreys Ledge, Georges Bank, and Nantucket Shoals. During the winter and spring, when the adults are migrating, fish from these separate spawning stocks are mixed and can not be distinguished.

Historically, assessments have been performed for individual stocks within the Gulf of Maine (Anthony and Waring 1980, Fogarty and Clark 1983, Fogarty et al. 1989, Stephenson at al. 1992) or for various "pooled" stocks. (For more information on earlier U.S. Gulf of Maine assessments and unit stock definitions which were used, see 3.2). No assessments have been performed on the Georges Bank stock, which collapsed under heavy foreign fishing pressure in the early 1970's, since 1980. The Nova Scotia (4WX) stock assessment is conducted by the Canadian Department of Fisheries and Oceans in St. Andrews, New Brunswick. Analytical assessments of this stock have not included catch-at-age estimates from the New Brunswick fishery since herring caught in fixed gear (mostly two and three-year-olds caught in weirs) on the western side of the Bay of Fundy are considered to be derived from spawning grounds near Grand Manan Island and in eastern Maine. However, assessments of the Gulf of Maine stock have likewise excluded catch-at-age data from the New Brunswick fixed gear fishery.

Beginning in 1991, the Gulf of Maine stock assessment was abandoned in favor of a single assessment of a stock complex that included New Brunswick (but not Nova Scotia), coastal U.S. waters north and south of Cape Cod, Nantucket Shoals, and Georges Bank (NEFSC 1992). This

approach was adopted after an examination of size composition and catch rate data by stratum (Fig. 3.3.1) from the spring NMFS bottom trawl survey over the entire time series (1967-present) failed to provide any rational basis for a geographical separation of herring belonging to the Gulf of Maine and Georges Bank/Nantucket Shoals stocks. Although it is recognized that a single assessment does not provide information on separate spawning stocks in the Gulf of Maine, it has been accepted (NEFSC 1992,1993) as the preferable approach, given the absence of a time series of fishery-independent estimates of abundance from individual spawning stocks and the problems associated with obtaining such data (Anon. 1993).

Information presented in this management plan is for the stock complex defined above and is based on the most recent available assessment information (NEFSC 1993, Stevenson et al. 1993). This assessment was based on 1967-1992 catch-at-age and bottom trawl survey data and included data for discards in the mid-Atlantic mackerel fishery and internal waters processing operations south of Cape Cod that were not included in previous assessments.

The Commercial Fishery

The commercial fishery for Atlantic herring is currently most active in coastal waters of the Gulf of Maine, principally in New Brunswick, Maine, and Massachusetts, with some additional activity in southern New England and the mid-Atlantic region (Tables 3.3.1 and 2). Landings tripled between 1983 and 1990, exceeding 100,000 mt (220 million lbs) in 1990, and have declined only slightly since then. The steady growth in the domestic fishery during the last decade has been most notable in the Gulf of Maine (including New Brunswick) which accounted for 94% of the 1991 and 1992 landings.

Catches on Georges Bank in the late 1960's and early 1970's far exceeded catches along the coast, but there has been no significant fishing on Georges Bank since that stock collapsed in the mid 1970's. This is true despite the fact that the herring population on Georges Bank and Nantucket Shoals has recovered dramatically during the last seven years.

Fishing on Georges Bank is not currently being pursued by any U.S. vessels because of the limited market demand for herring. Canada, however, will permit a 5000 mt exploratory fishery for herring on Georges Bank in the fall of 1993.

Atlantic herring are utilized in the Maine and New Brunswick canning industry and for bait, mostly in the lobster fishery. They are caught primarily with purse seines and trawls (mobile gear), although there is still a small quantity taken in Maine in weirs and stop seines (fixed gear). Fishing takes place primarily during the late spring, summer and fall (June-November) in Maine and New Brunswick while fishing in Massachusetts and south of Cape Cod is primarily from November-April.

Two recent developments in the fishery are Internal Waters Processing (IWP) operations and the incidental harvest of Atlantic herring in the Atlantic mackerel joint venture off the mid-Atlantic states in the winter. IWP landings (U.S. fishermen supplying foreign processing ships anchored in state internal waters) began in Massachusetts in 1985, but have only become significant during the last four years (1989-1992) in Massachusetts, Maine, Rhode Island, New York, and New Jersey (see Table 5.3.1). Discards of Atlantic herring were reported by observers aboard foreign processing ships operating off New Jersey between 1985 and 1991 (Table 3.3.3). There has been no mackerel JV fishery since 1991.

Stock Abundance Indices

Fishery-independent estimates of Atlantic herring stock abundance are available for the last 20-25 years from two sources: 1) NMFS larval surveys in the Georges Bank/Nantucket Shoals area (Fig. 3.3.2) since 1971, and 2) spring NMFS bottom trawl survey data for the area between Cape Hatteras and Nova Scotia (Fig. 3.3.1) for the entire time series covered by the assessment (1967-present). Fall NMFS bottom trawl survey data are also available, but do not provide reliable abundance estimates since herring congregate in large schools at this time of year in preparation for spawning, and catches are therefore extremely variable. Additional information on the distribution and abundance of juvenile and adult herring is also available from trawl surveys conducted in New Jersey, Massachusetts, New York, and Delaware and from the summer

northern shrimp trawl survey in the Gulf of Maine, but is not used explicitly for herring assessment purposes.

Bottom trawl surveys

Abundance indices (mean number caught per tow) are available for ages 2-6 for the whole time series (Fig. 3.3.2). These estimates were adjusted two years ago to account for a substantial difference in the fishing powers of the two survey vessels (NEFSC 1992). Bottom trawl survey abundance indices in 1991 and 1992 were high at all ages, continuing the upward trend from the extremely low values observed in the early 1980's.

Larval surveys

Larval surveys conducted by NMFS since 1971 on Nantucket Shoals, Georges Bank, and in Massachusetts Bay (Fig. 3.3.3) continue to provide valuable information on the degree of recovery of the Georges Bank and Nantucket Shoals spawning stocks (Fig. 3.3.4). Larval abundance (weighted mean catches of 4-7 mm larvae per 10 $m^{2)}$ was very high in 1989, 1990, and 1991, indicating that egg production has been high in recent years as the spawning stock has grown.

Assessment Results

Data sources

Catch-at-age estimates in numbers are derived from monthly landings data (U.S. domestic, IWP, and discards in the mackerel JV fishery) by gear type (mobile and fixed) for three fishing areas along the Maine coast (5Y North), New Hampshire and Massachusetts (5Y South), southern New England (RI, CT and NY) and the mid-Atlantic states (NJ, DE, MD, and VA), and estimated monthly age frequency distributions and mean weight-at-age estimates for each of these areas (and gear types). Age frequency data are derived from age-length keys applied to length frequency data for each area and gear type. Age-length keys are generated primarily from samples of fish obtained from commercial landings in Maine and Massachusetts.

For the 1993 assessment, some additional length frequency data were available from IWP landings south of Cape Cod and from discards in the mackerel joint venture off New Jersey for the period 1989-1992. The age distribution of these landings was estimated by applying age-length keys from samples obtained from NMFS spring bottom trawl surveys for those same years (Stevenson et al. 1993). Catch-at-age estimates for the New Brunswick fixed gear fishery were provided by the Canadian Department of Fisheries and Oceans and simply added to the final U.S. estimates. Historical Georges Bank catch-at-age estimates were available through 1979, when fishing stopped (Anthony and Waring 1980).

The ADAPT (Gavaris 1988, Conser and Powers 1990) calibration method was used to estimate terminal F values in 1992. The VPA was tuned using spring bottom trawl survey abundance indices for ages 4-6. In addition, larval abundance estimates were used to tune age 4+ spawning stock biomass.

Abundance estimates

Estimated total stock size has increased dramatically since the early 1980s, particularly at the older ages. Stock biomass in 1990 reached the same level (1,325,000 metric tons or nearly three billion pounds) as during the late 1960's, before the collapse of the Georges Bank stock (Fig. 3.3.5). Total stock biomass in 1992 was estimated roughly at 2.8 million mt, a 100% increase in only two years. Increasing numbers of older fish have recruited to the spawning stock during the last decade (Fig. 3.3.6). Spawning stock biomass reached an estimated 1.25 million mt (2.75 billion lbs) in 1992. There was an 80% probability that the 1992 spawning stock biomass was between 815,000 mt and 1,920,000 mt (NEFSC 1993).

Recruitment

Estimated recruitment (the number of two year-olds entering the stock at the beginning of the year) increased dramatically in 1991 and 1992 (Fig. 3.3.7). The 1989 and 1990 year classes produced many more recruits than any previous year class in the time series, although the actual size of

these two most recent year classes are not yet known with certainty. The high catch rates of larvae in 1989, 1990 and 1991 (Fig. 3.3.4) indicated that the last three year classes were strong. All indications are that stock biomass will continue to grow as these recent year classes recruit to the spawning stock.

Fishing mortality

Fishing mortality (averaged for ages 2+) is extremely low and has been declining steadily since 1985 after a prolonged period during the 1970s and early 1980s when it was much higher (Fig. 3.3.8). Instantaneous F (age 2+) in 1992 was only 0.0385, which is equivalent to a 3.8% annual mortality rate. (Natural mortality, by comparison, is estimated to remove 18% from the population every year). Fishing mortality has remained below the target F (20% MSP) level (0.29) since 1985. Average F values were between 0.5 and 1.2 (40% to 70% annual mortality) during the 1970's and early 1980's. Fishing mortality was 0.76 as recently as 1984, well after the demise of the Georges Bank fishery. Precision estimates indicate a 90% probability that the 1992 F was less than 0.056 (5.5% annual mortality).

REFERENCES

Anonymous 1993. Report of the workshop on Atlantic herring science and assessment in the Gulf of Maine/Georges Bank area (January 19-21 1993, Portland, ME). NOAA/NMFS/NEFSC 16th SAW Working Paper C2.

Anthony, V.C. and G. Waring 1980. The assessment and management of the Georges Bank herring fishery. Rapp. P.-v. Reun. Cons. int. Explor. Mer 177:72-111.

Conser, R.J. and J.E. Powers 1990. Extension of the ADAPT VPA tuning method designed to facilitate assessment work on tuna and swordfish stocks. ICCAT Coll. Vol. Sci. Pap. 32:461-467.

Fogarty, M.J. and S.H. Clark 1983. Status of Atlantic herring resources in the Gulf of Maine region - 1983. NMFS N.E. Fish. Ctr. Woods Hole Lab. Ref. Doc. 83-46.

Fogarty, M.J., F.P. Almeida, J. Chenoweth and J.S. Idoine 1989. Population dynamics of Atlantic herring in the Gulf of Maine. NMFS N.E. Fish. Sci. Ctr. Woods Hole Lab., SAW-9 Working Paper No. 7.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 88/29.

NEFSC [Northeast Fisheries Science Center] 1992. Report of the Thirteenth Northeast Regional Stock Assessment Workshop (13th SAW), Fall 1991. NOAA/NMFS/NEFSC Ref. Doc. 92-02:62-72.

NEFSC 1993a. Report of the Sixteenth Northeast Regional Stock Assessment Workshop (16th SAW). NOAA/NMFS/NEFSC Ref. Doc. 93-18:60-74.

Stephenson, R.L. M.J. Power, J.B. Sochasky, W.H. Dougherty, F.J. Fife, G.D. Melvin and D.E. Lane 1988. 1991 4WX assessment. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 92/69:51 p.

Stevenson, D.K., D. Libby and K. Friedland 1993. Analytical assessment of the Atlantic herring coastal stock complex. NOAA/NMFS/NEFSC Ref. Doc. 93-15.

3.3.1

Table 1. Landings (mt) of Atlantic herring from fisheries on Georges Bank (GB), in the Gulf of Maine (GOM), Southern New England(SNE), Middle Atlantic (MAT) and New Brunswick, Canada (NB) areas. Includes landings for Internal Waters Processing operations.

YEAR	GB	GOM[1]	SNE[2]	MAT[3]	NB[4]	TOTAL
1960	0	60237	261	152	34304	94954
1961	67655	25548	197	101	8054	101555
1962	152242	69980	131	98	20698	243149
1963	97968	67736	195	78	29366	195343
1964	131438	27226	200	148	29432	188444
1965	42882	34104	303	208	3346	80843
1966	142704	29167	3185	176	35805	211037
1967	218743	30191	247	524	30032	279737
1968	373598	40928	245	122	33145	448038
1969	310758	28336	2104	193	26539	367930
1970	247294	28070	1037	189	15840	292430
1971	267347	32631	1318	1151	12660	315107
1972	174190	37444	2310	409	32699	247052
1973	202335	21767	4249	233	19935	248519
1974	149525	29491	2918	200	20602	202736
1975	146096	31938	4119	117	30819	213089
1976	43502	49887	191	57	29206	122843
1977	2157	50348	301	33	23487	76326
1978	2059	48734	1730	46	38842	91411
1979	1270	63492	1341	31	37828	103962
1980	1700	82244	1200	21	13525	98690
1981	672	64324	749	16	19080	84841
1982	1378	32157	1394	20	25963	60912
1983	53	24824	72	21	11383	36353
1984	58	33958	79	10	8698	42803
1985	316	27197	196	13	27863	55585
1986	586	27987	632	20	27883	57108
1987	11	39299	376	87	27320	67093
1988		39382	1307	365	33421	74475
1989		52656	269	39	44112	97076
1990		62218	761	48	38778	101805
1991		52035	4007	402	24576	81020
1992		55183	716	4564	31968	92431

[1] ME,NH,MA; [2] RI, CT, NY; [3] NJ, DE, MD, VA; [4] NB landings for fixed gear only.

footnote mt = 2200 lbs

~~ATLAND.XLS~~

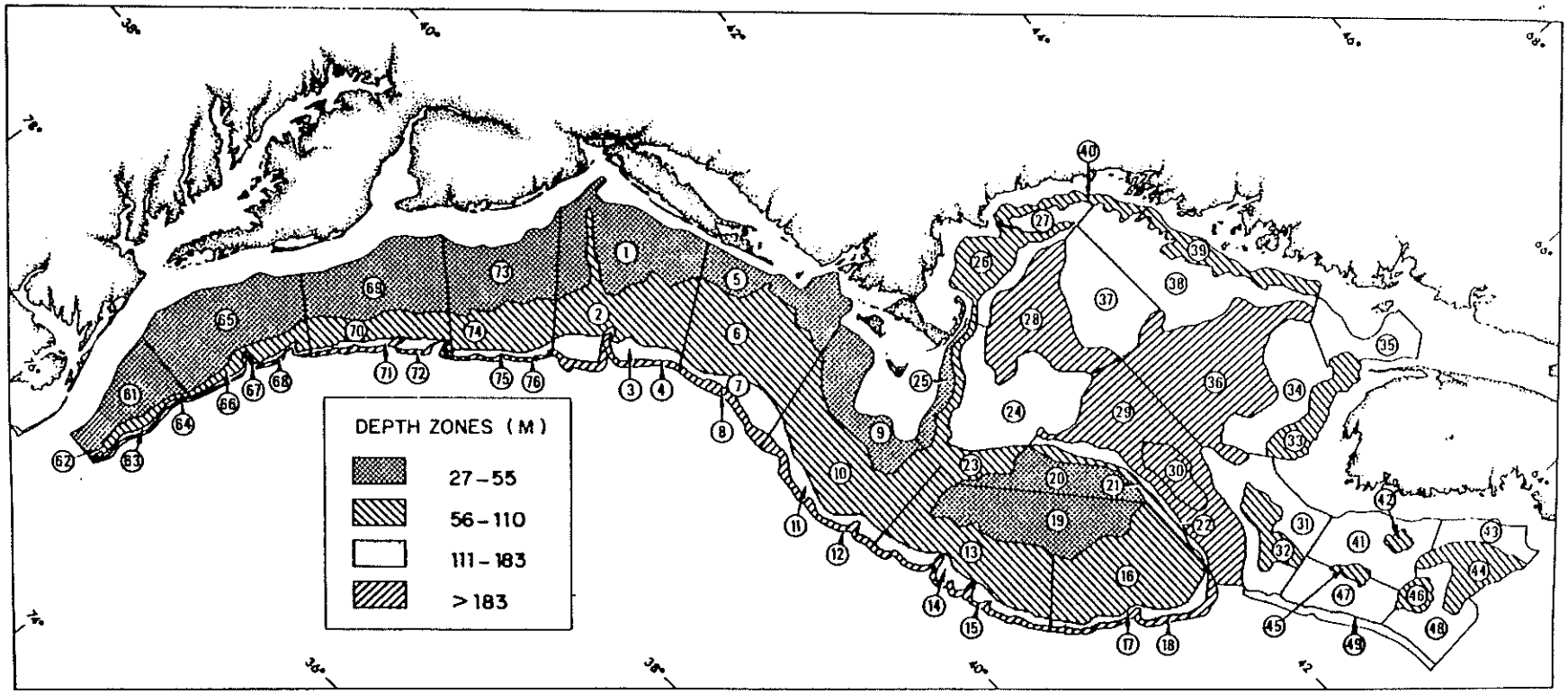
Table 3.3.2

ATLANTIC HERRING LANDINGS 1960-92						(no IWP's)					
YEAR	GB	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA
1960	0	59348		889	113	59	89	147		2	3
1961	67655	24131		1417	85	38	74	96		3	2
1962	152242	69376		604	76	26	29	93		5	
1963	97968	66895		841	142	14	39	69		4	5
1964	131438	26295		931	118	12	70	137	5	6	
1965	42882	32088		2016	172	5	126	113	3	4	88
1966	142704	26177		2990	273	5	2907	136	2	4	34
1967	218743	28576		1615	180		67	24		2	498
1968	373598	31072		9856	201		44	99		4	19
1969	310758	23852		4484	2044		60	168			25
1970	247294	15617		12453	1007	2	28	184			5
1971	267347	12960		19671	1310	1	7	39			1112
1972	174190	20271		17173	2298		12	92		1	316
1973	202335	16886		4881	4239		10	52		7	174
1974	149525	21499		7992	2905	6	7	157	1	16	26
1975	146096	17348		14590	4063		56	100		14	3
1976	43502	31858		18029	179		12	54		3	
1977	2157	33135	25	17188	293		8	33			
1978	2059	30341		18393	1688	29	13	43		3	
1979	1270	40454		23038	1281	2	58	30		1	
1980	1700	48912	3010	30322	1096		104	14		1	6
1981	672	51976	48	12300	688	12	49	16			
1982	1378	24453	581	7123	1363	13	18	11	7	2	
1983	53	19824	943	4057	46	6	20	20		1	
1984	58	21720	82	12156	49		30	10			
1985	316	14657	43	11137	154		42	11			2
1986	586	16264	96	11550	583		49	20			
1987	11	20376	120	18503	312	11	53	23			64
1988		16575		22807	1091		216	23			342
1989		15629	284	24504	214		55	31			8
1990		22397	68	28080	758		3	48			
1991		24571	173	21702	2045	4	124	362		26	14
1992		27848	255	22969	707		9	3744		48	

3.3.34

Table 3. Atlantic herring discards in the mackerel joint venture fishery in the mid-Atlantic area.

Year	Reported Catch (mt)
1985	16.8
1986	3.8
1987	132.9
1988	300.5
1989	742.4
1990	1395.0
1991	896.5
1992	0.0

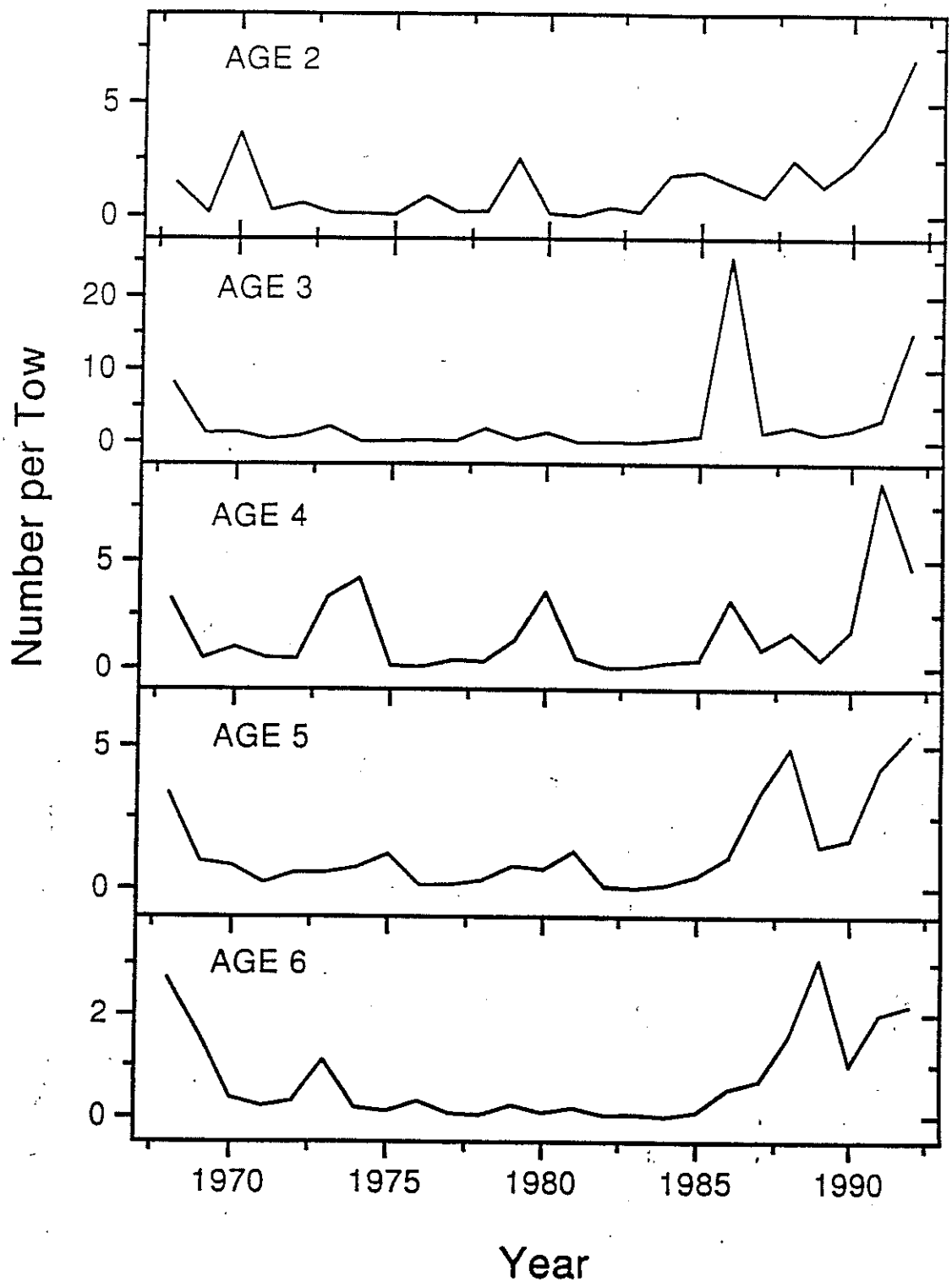


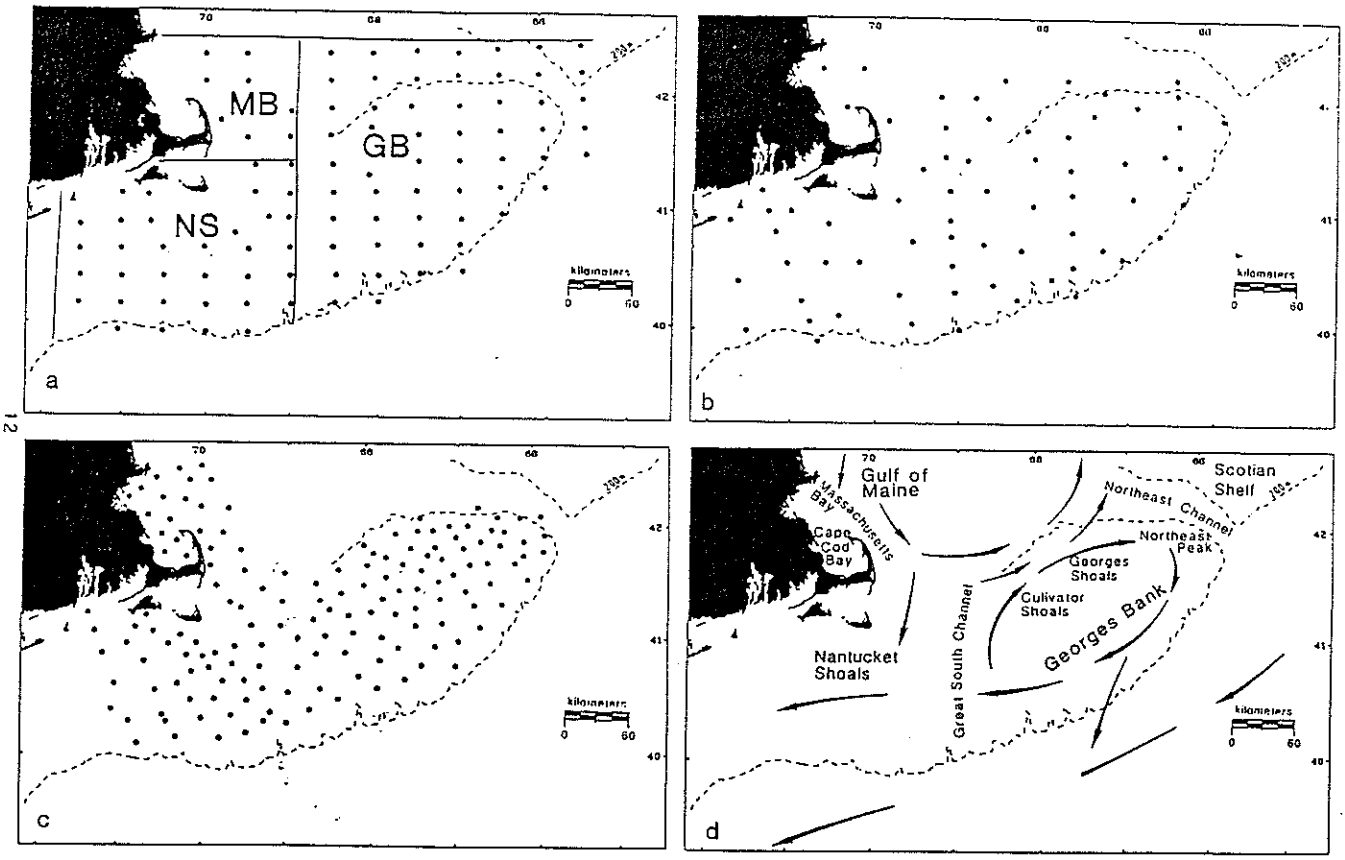
3.3.1

Figure 1. Strata sampled on NEFC offshore bottom trawl surveys.

3.3.2.

Figure 1. Spring bottom trawl survey index for Atlantic herring.



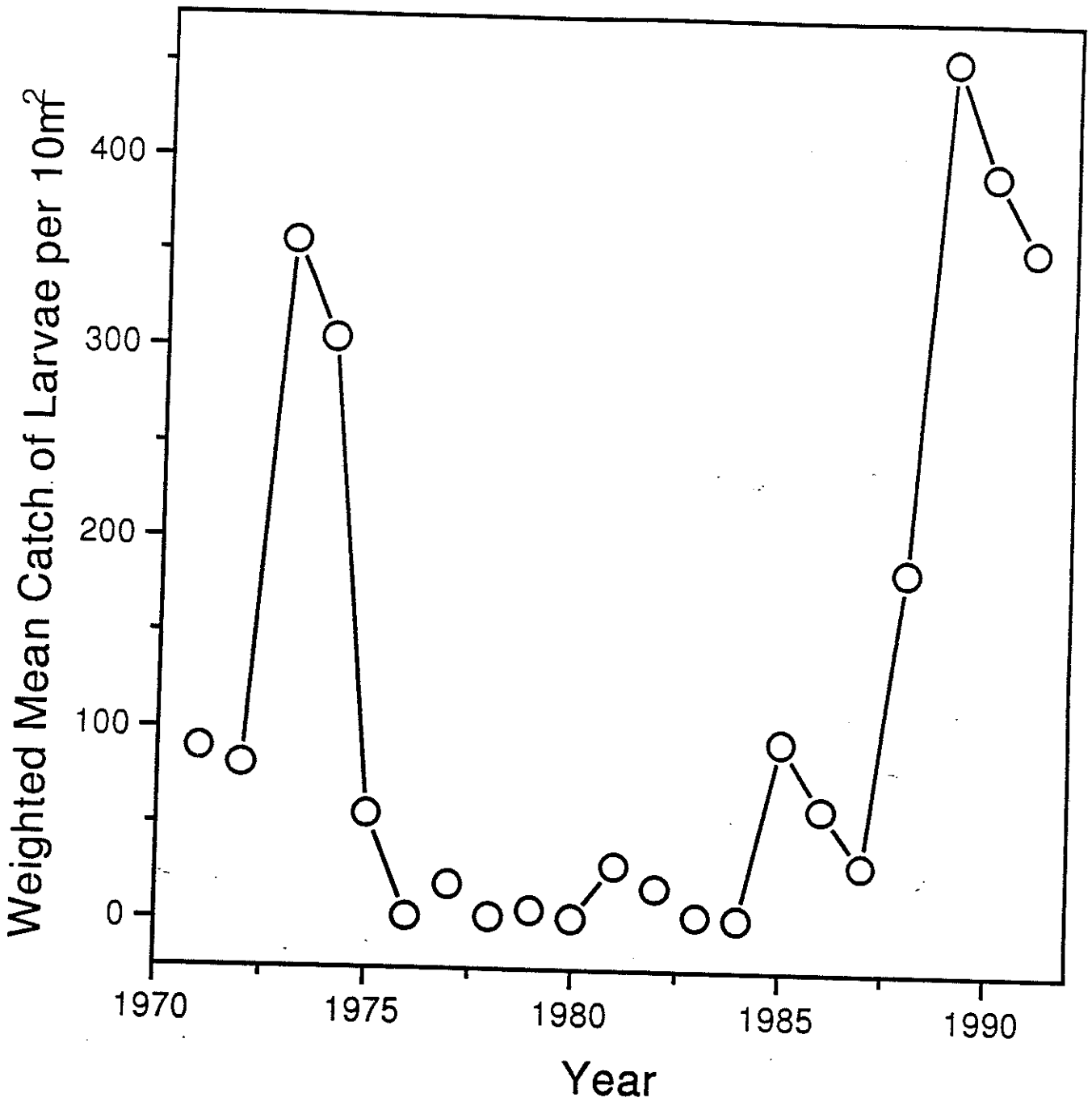


3.3.3.

Figure 2. Station plan for: (a) ICNAF larval herring surveys in the Georges Bank area, 1971-1976, MB=Massachusetts Bay, NS=Nantucket Shoals, and GB=Georges Bank subarea; (b) MARMAP surveys, 1977-1987; (c) 1988-1992 herring recovery cruises; and (d) general circulation in the Georges Bank area. Source: Smith, W.G. and W.W. Morse 1990. Larval distribution patterns: evidence for the collapse/recolonization of Atlantic herring on Georges Bank. ICES C.M./H:17, Pelagic Fish. Comm., 16 p.

3.3.4.

Figure 3. Larval abundance index for Atlantic herring.



ATLANTIC HERRING
TOTAL LANDINGS AND STOCK BIOMASS
1967-1990

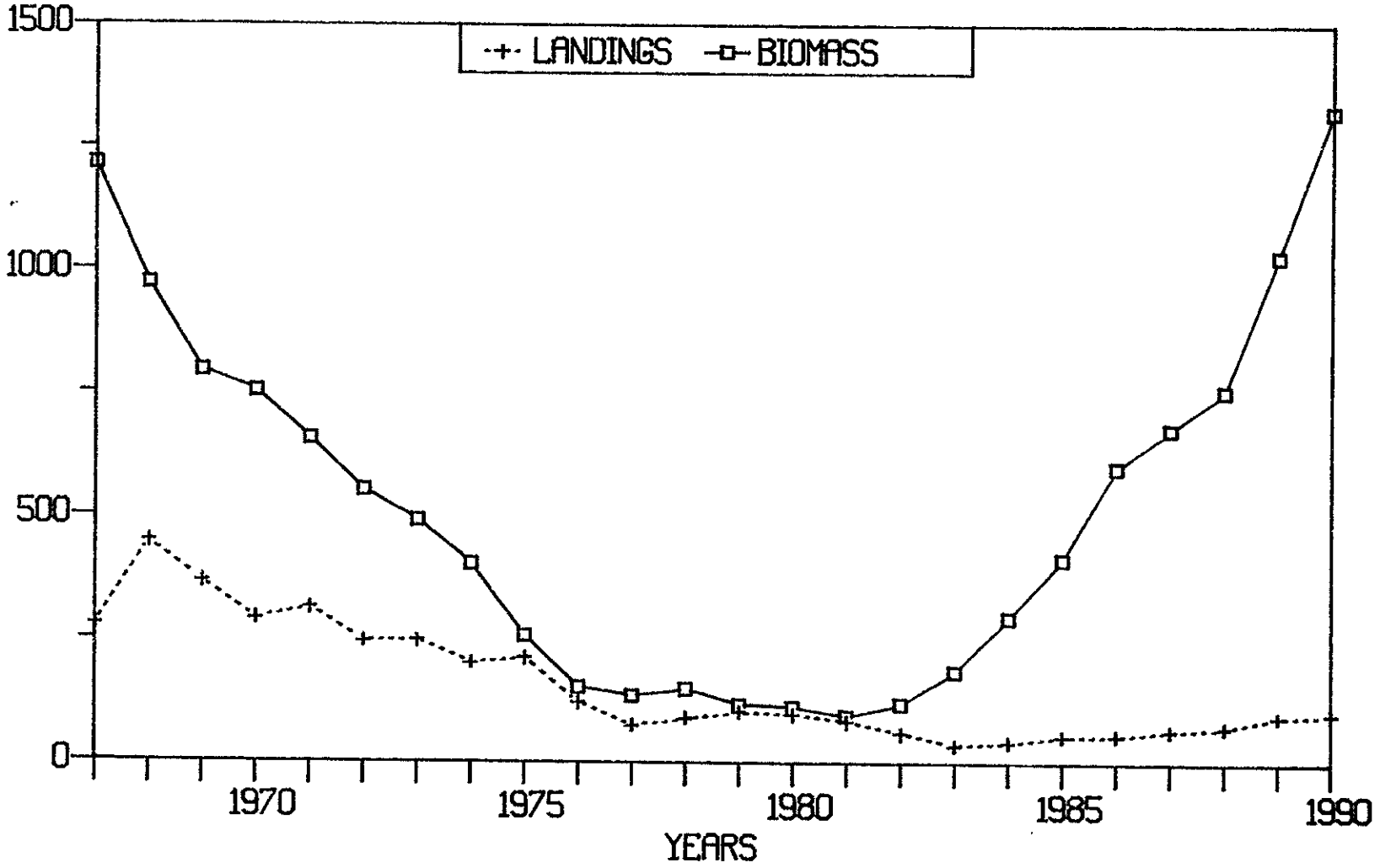


Fig 3.3.5

Fig 6

ATLANTIC HERRING
AGE STRUCTURE

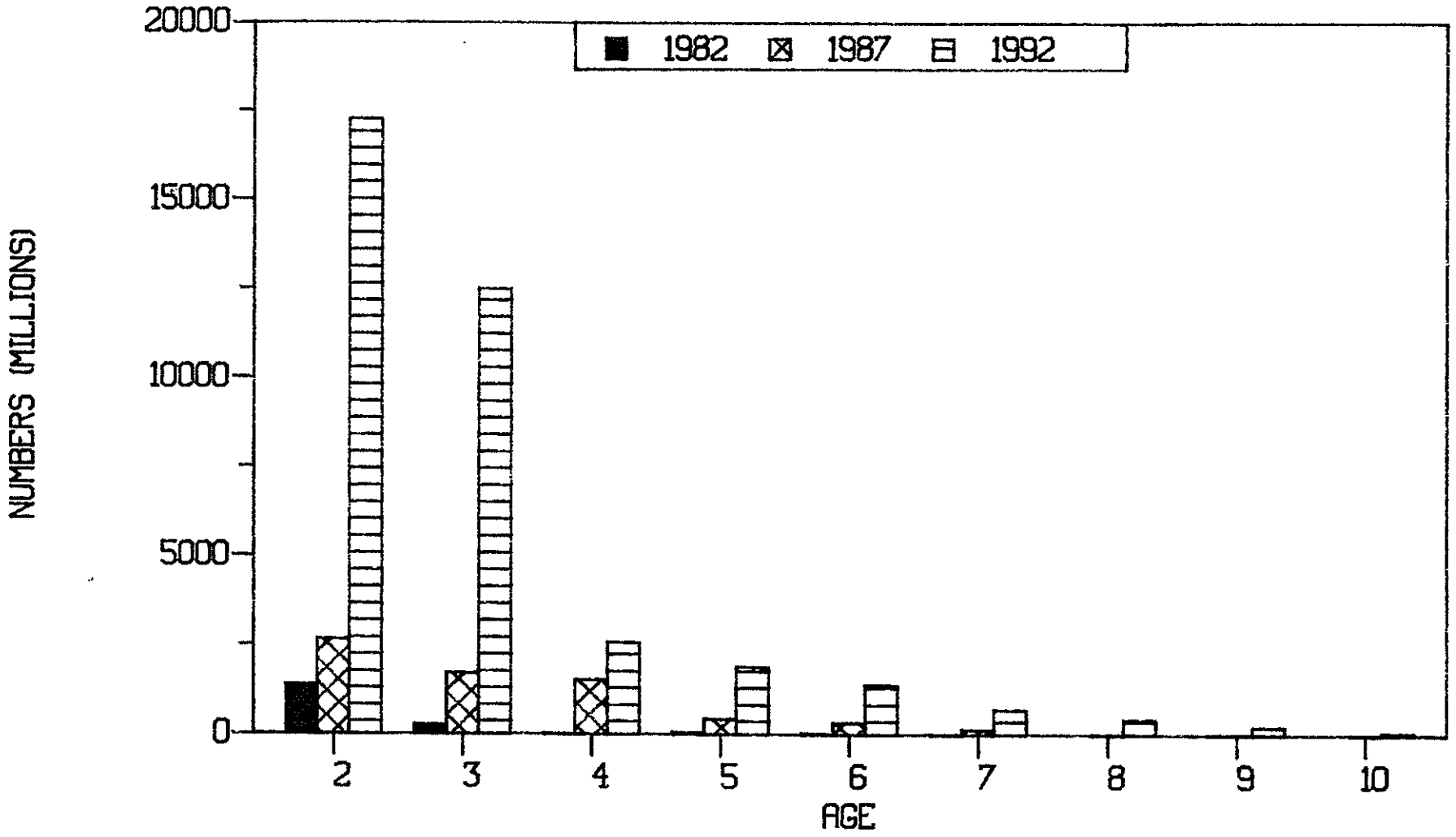


Fig 3.3.6

#

ATLANTIC HERRING
YEAR CLASS SIZE, 1965-1990

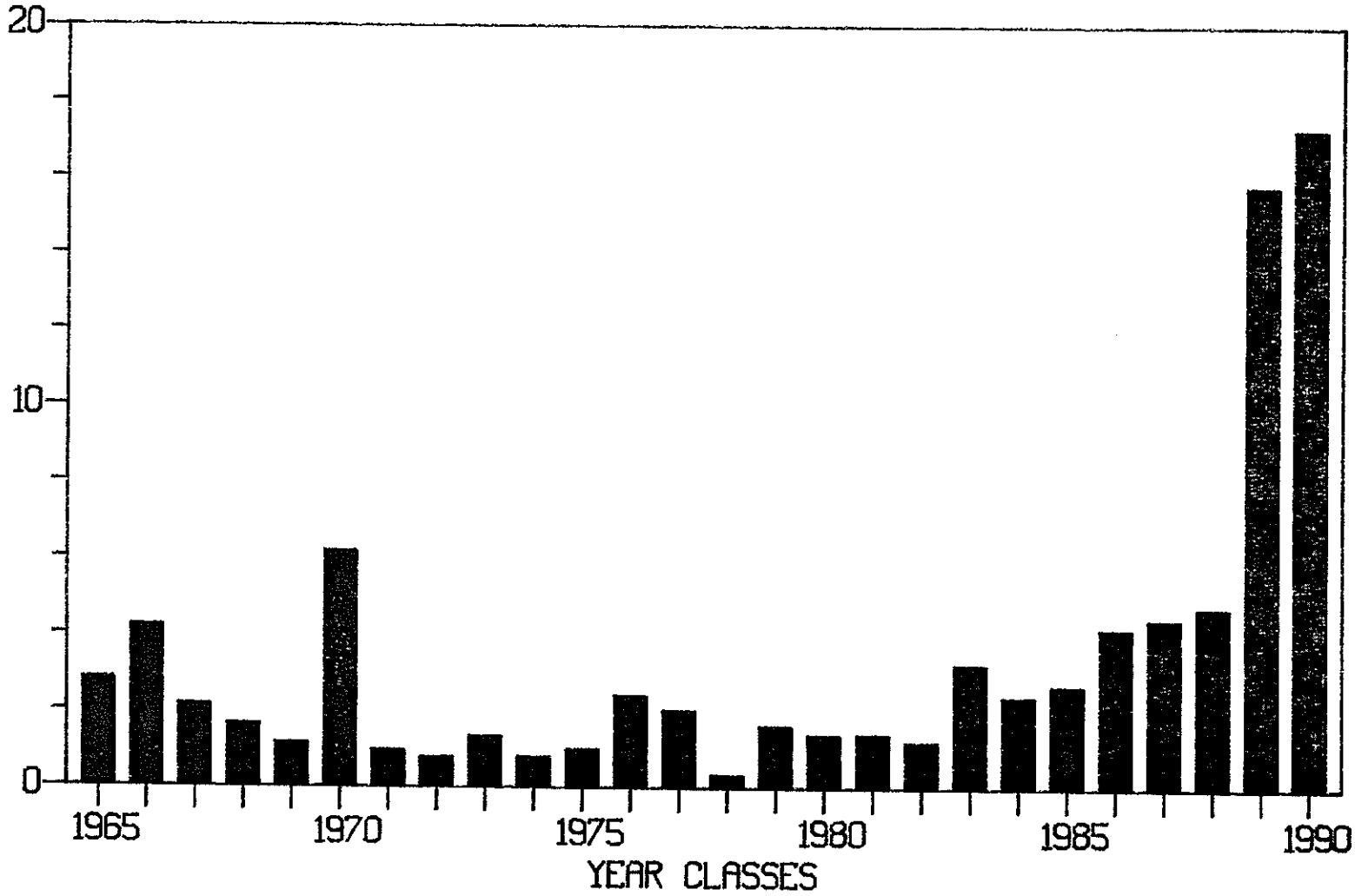


Fig. 3.3.7

Fig 8

ATLANTIC HERRING
FISHING MORTALITY (AGE 2+)

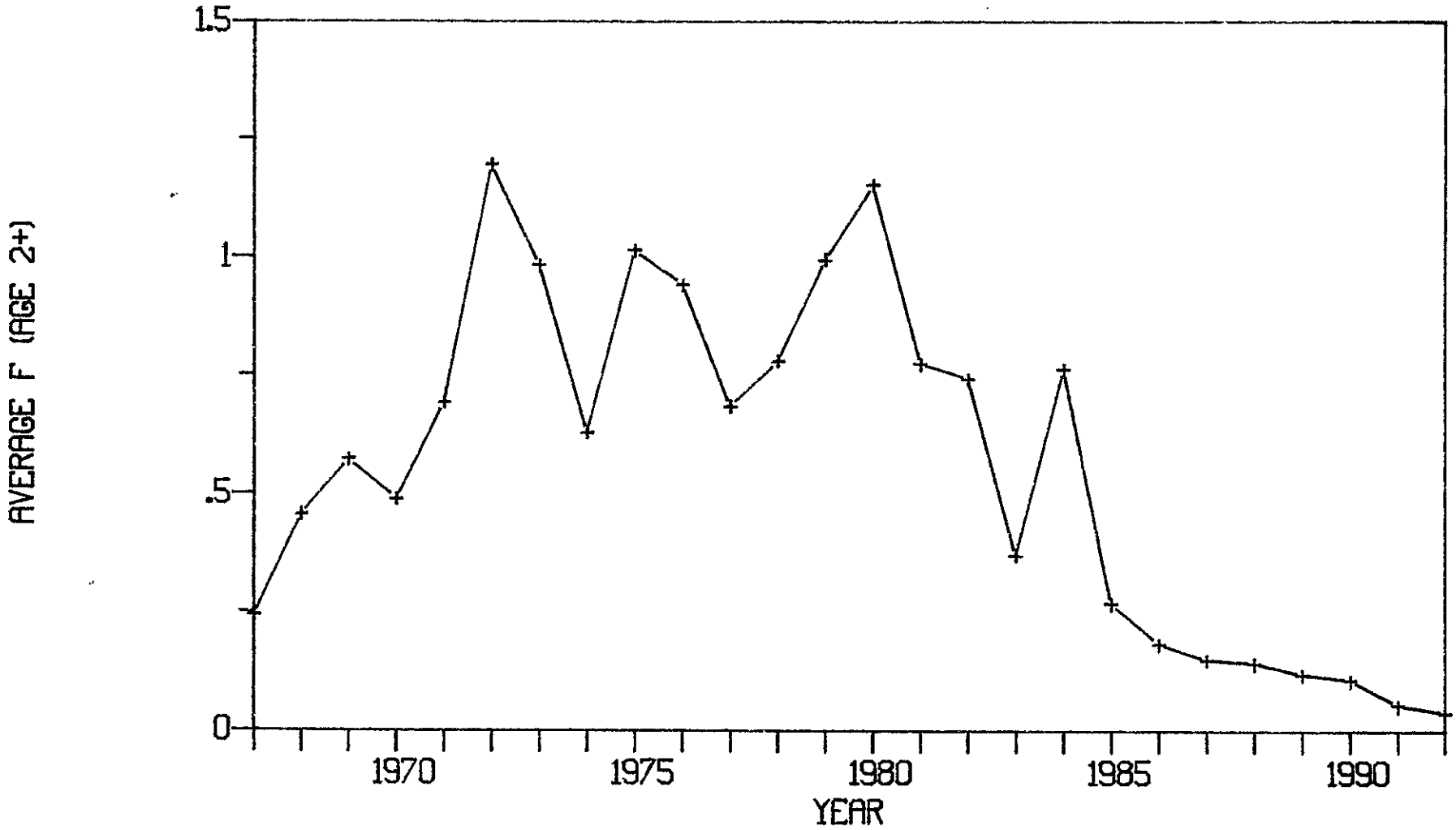


Fig. 2.3.8

3.4 Recovery of Atlantic Herring on Georges Bank and Nantucket Shoals

Atlantic herring were extremely abundant on Georges Bank and Nantucket Shoals during the 1960's and supported a fishery that extracted 2.7 million metric tons (6 billion pounds), before the stock collapsed in the early 1970's (see sections 2.1, 3.3 and 5.1). Spawning stock biomass estimates for the "Georges Bank" stock, which, in reality included the spawning population on Nantucket Shoals as well (see 3.2), exceeded one million metric tons (Anthony and Waring 1980). Principal spawning grounds on Georges Bank were located on the northeast peak of the bank and in the vicinity of Cultivator Shoals (Fig. 3.4.1).

Following the collapse of this stock, herring virtually disappeared from Georges Bank until 1986, a period of ten years. The absence of spawning herring on the bank during this time is best demonstrated by larval survey data. Small, recently-hatched larvae (4-7 mm) were abundant on the northest peak of the bank and in the vicinity of Nantucket Shoals during 1971-1976, but were entirely absent from Georges Bank and nearly so on Nantucket Shoals during 1977-1982 (Smith and Morse 1990, Figs. 3.4.2). Small larvae were found in large numbers on Nantucket Shoals beginning in 1985 (Figs. 3.4.3 and 4). The 1983 year class appeared on the bank as small juveniles in 1984, as immature adults in early 1986, and as mature adults in the fall of the same year (Stephenson and Kornfield 1990, Fig. 3.4.5). Mature adults were again found the following year (1987) and, in 1988, ripe and running adults were caught on the western portion of the bank (Melvin et al. 1991, Fig. 3.4.6).

Continued evidence of increasing numbers of spawning herring and larvae on Georges Bank/Nantucket Shoals in recent years (Figs. 3.4.4, 7 and 8) led Melvin et al. (1991) to conclude that the stock "is well on its way to recovery." There was no larval survey evidence, however, of any spawning east of the U.S.-Canada boundary during 1987-1991. All spawning appeared to be confined to Massachusetts Bay and the nearshore area around Cape Cod, Nantucket Shoals, and the western part of Georges Bank, in the vicinty of Cultivator Shoals. Finally, in 1992, small

larvae were caught in significant numbers on the northeast peak (W. Morse, pers. comm.).

The general increase in the fall bottom trawl survey index (U.S. and Canada) and in the abundance of small larvae since 1986-87, and the broadening of the adult age distribution to include other than just the 1983 year class, all indicate that this portion of the coastal stock complex is indeed recovering. The most conservative estimates of spawning stock biomass (based on larval production estimates) throughout the larval survey area (see Fig. 3.3.2) indicate an increase from <100,000 mt to over 500,000 mt between 1988 and 1990 (NEFSC, unpubl. data). If so, then it would seem that the spawning stock on Georges Bank and Nantucket Shoals may have recovered to about 50% of its previous (1968) high level by 1990 (and done so very rapidly).

A population "explosion" of this magnitude is also indicated by virtual population analysis of the entire stock complex and by increased catch rates in southern New England and the mid-Atlantic region in recent years (see 3.3). It seems the recovery of the Georges Bank/Nantucket Shoals portion of the stock complex is no longer "underway," but may, in fact, be completed. The dramatic increase in the size of the coastal herring stock which began in the early 1980's has clearly been "fueled" by the growth of the Georges Bank/Nantucket Shoals population. In the absence of fishing pressure and with the over-exploitation of many predators (e.g, cod, haddock) on the northeast continental shelf in the bottom trawl fishery, the herring resource will probably continue to increase in size until it reaches some naturally determined level beyond the maximum reached in the late 1960's.

References

Anthony, V.C. and G. Waring 1980. The assessment and management of the Georges Bank herring fishery. Rapp. P.-v. Reun. Cons. Int. Explor. Mer 177:72-111.

Stephenson, R.L. and I. Kornfield 1990. Reappearance of spawning Atlantic herring (Clupea harengus harengus) on Georges Bank: population resurgence not recolonization. Can. J. Fish. Aquat. Sci. 47:1060-1064.

Smith, W.G. and W.W. Morse 1990. Larval distribution patterns: evidence for the collapse/recolonization of Atlantic herring on Georges Bank. ICES C.M. 1990/H:17, Pelagic Fish Comm.:16 p.

Melvin,G.D., J.B. Sochasky, M.J. Power, D.J. Gordon and W.H. Dougherty 1991. An update on Georges Bank (5Z) herring. Can. Atl. Fish. Sci. Adv. Comm. 91/55:39 p.

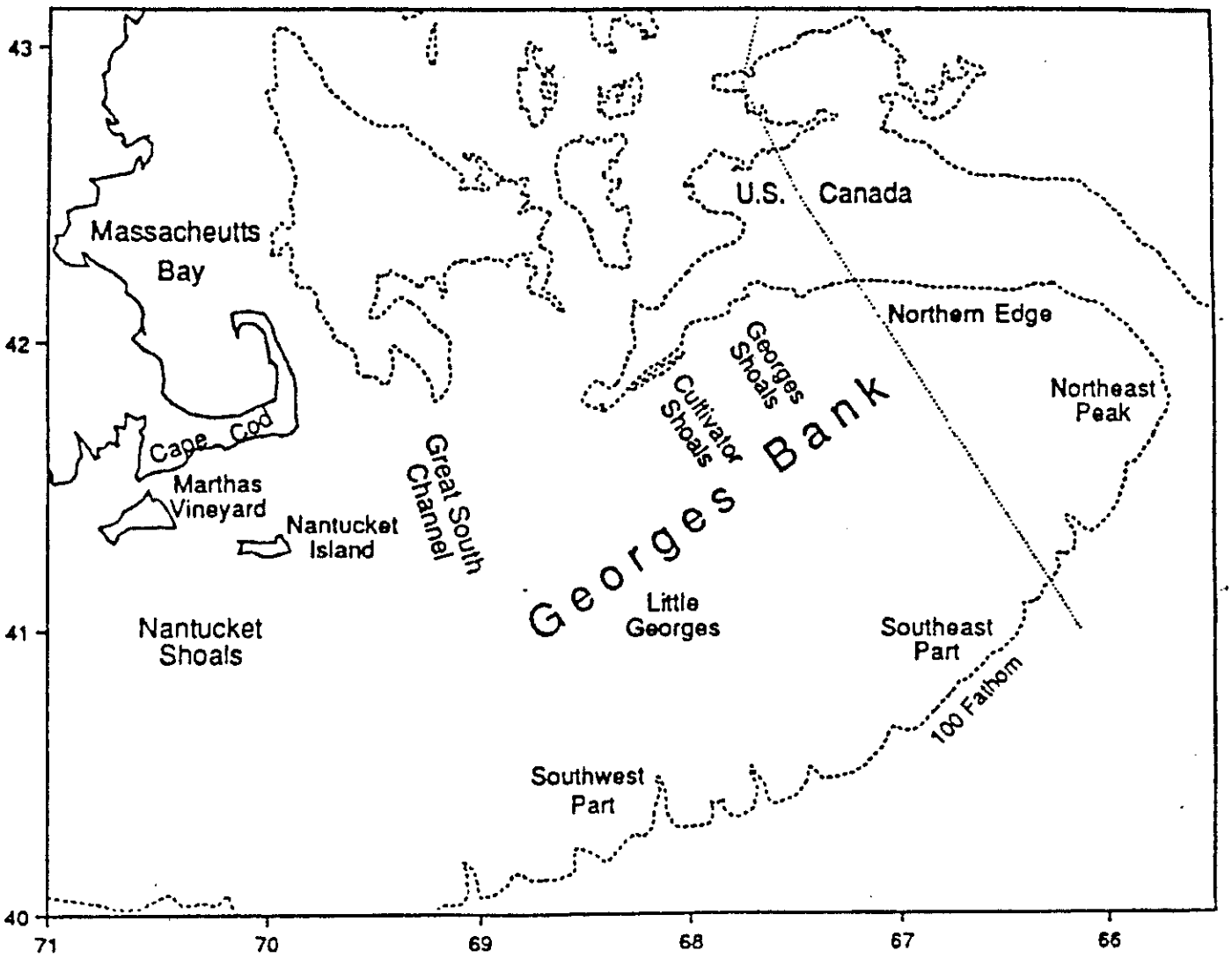
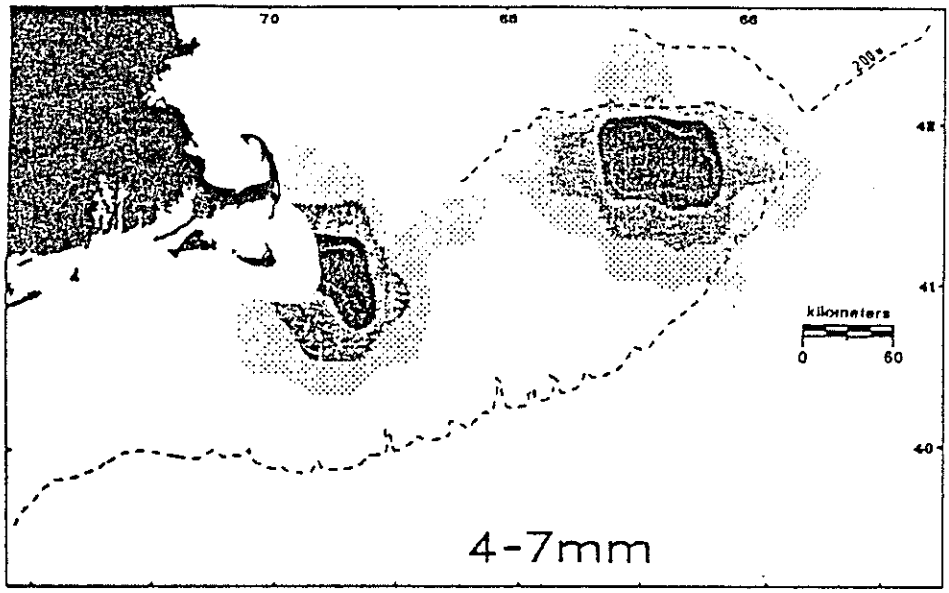


Figure 1. Map of Georges Bank and surrounding area.

F.J. 3.4.1

Fig. 3.4.2

1971-76



1977-82

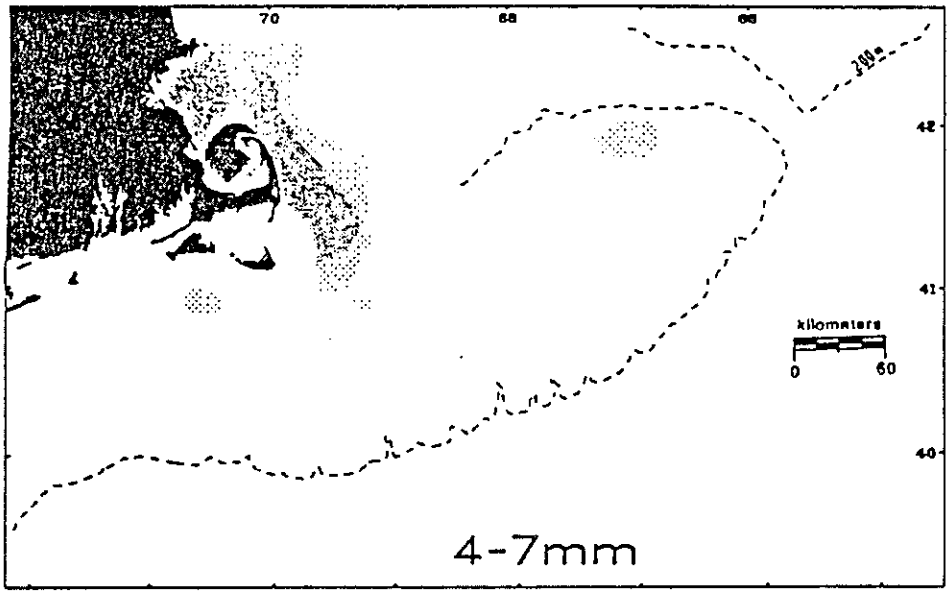
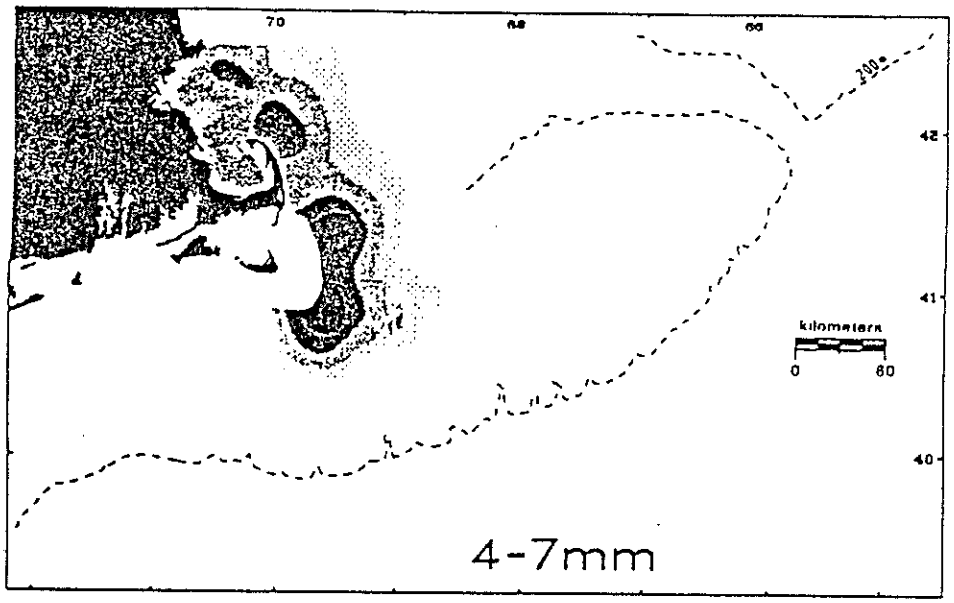


Fig. 3.4.3

1983-87



1988

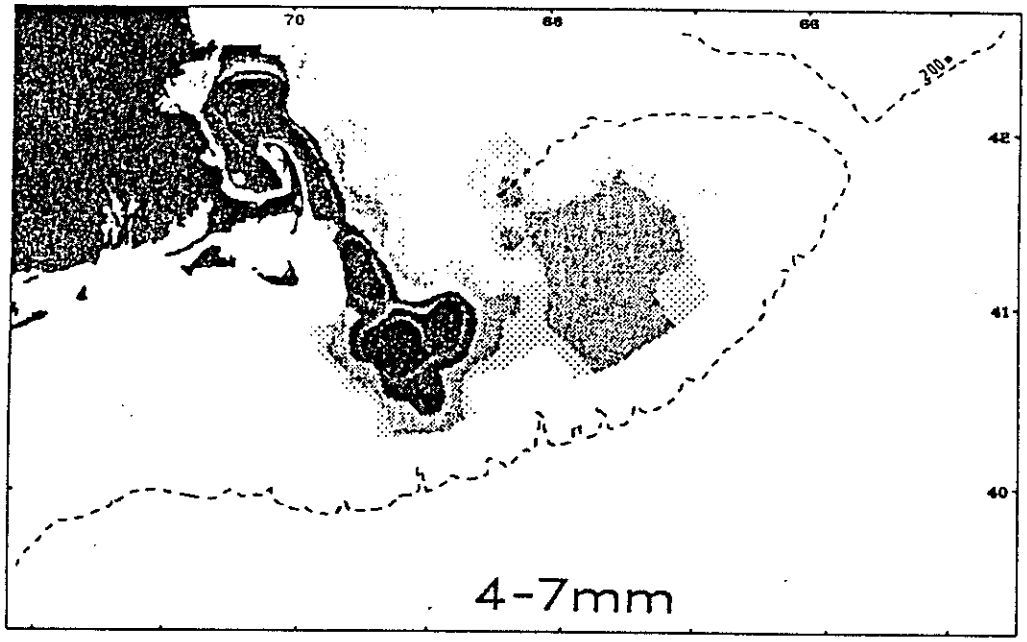
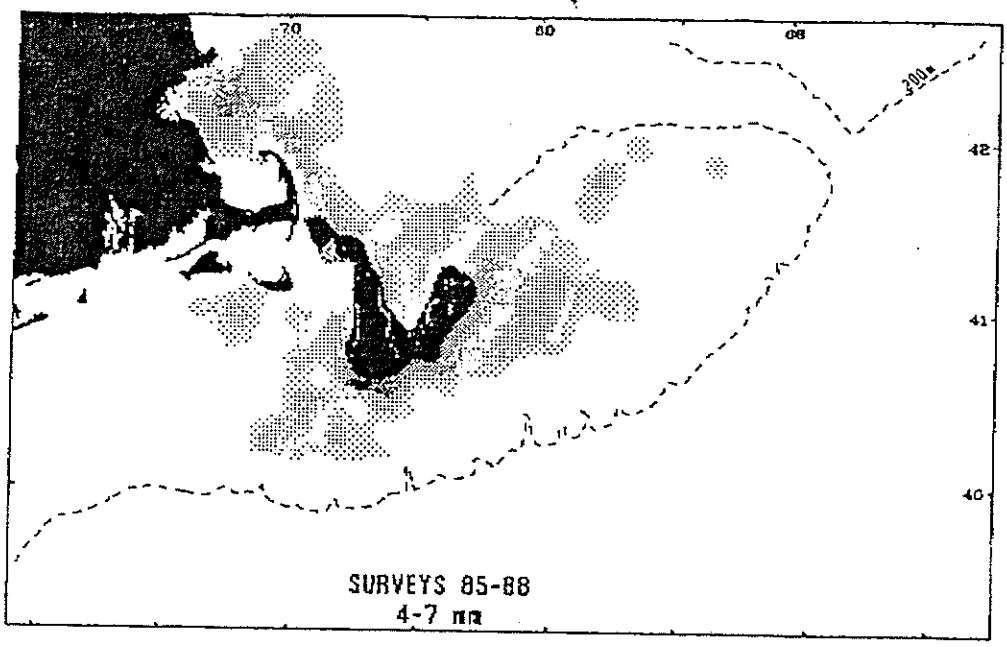


Fig. 3.4.4

1987



P.2

1990

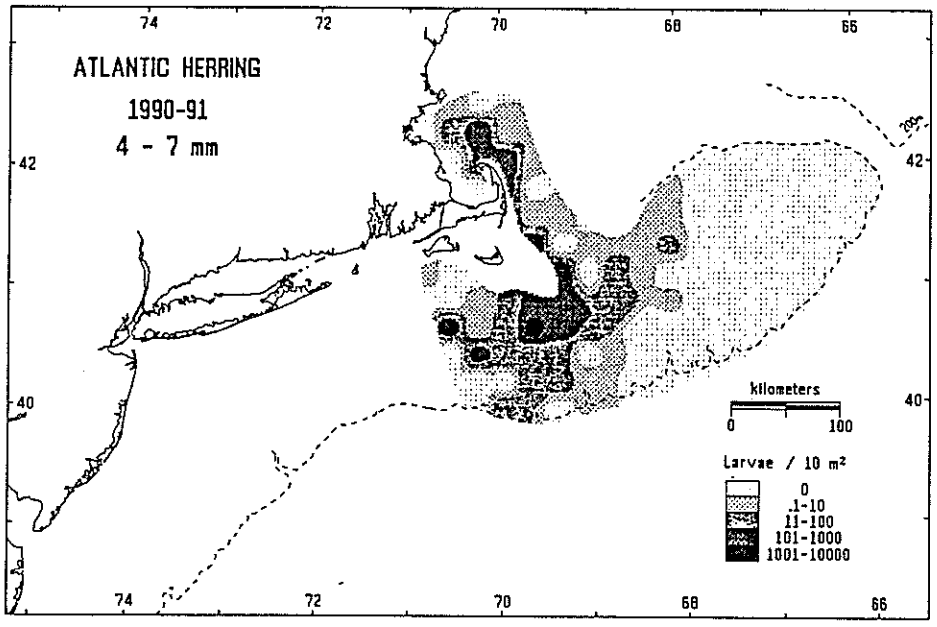


Fig 3.4.5

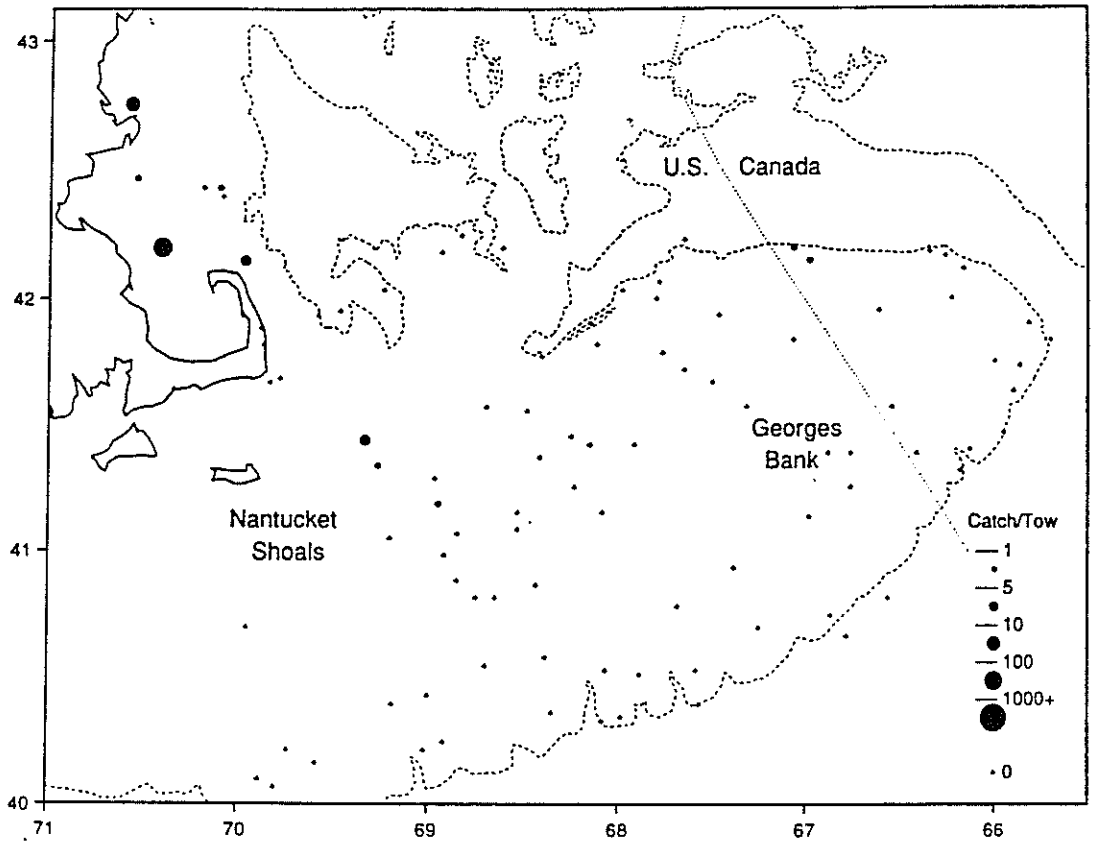


Figure 5. US Fall Bottom Trawl Survey - 1985.

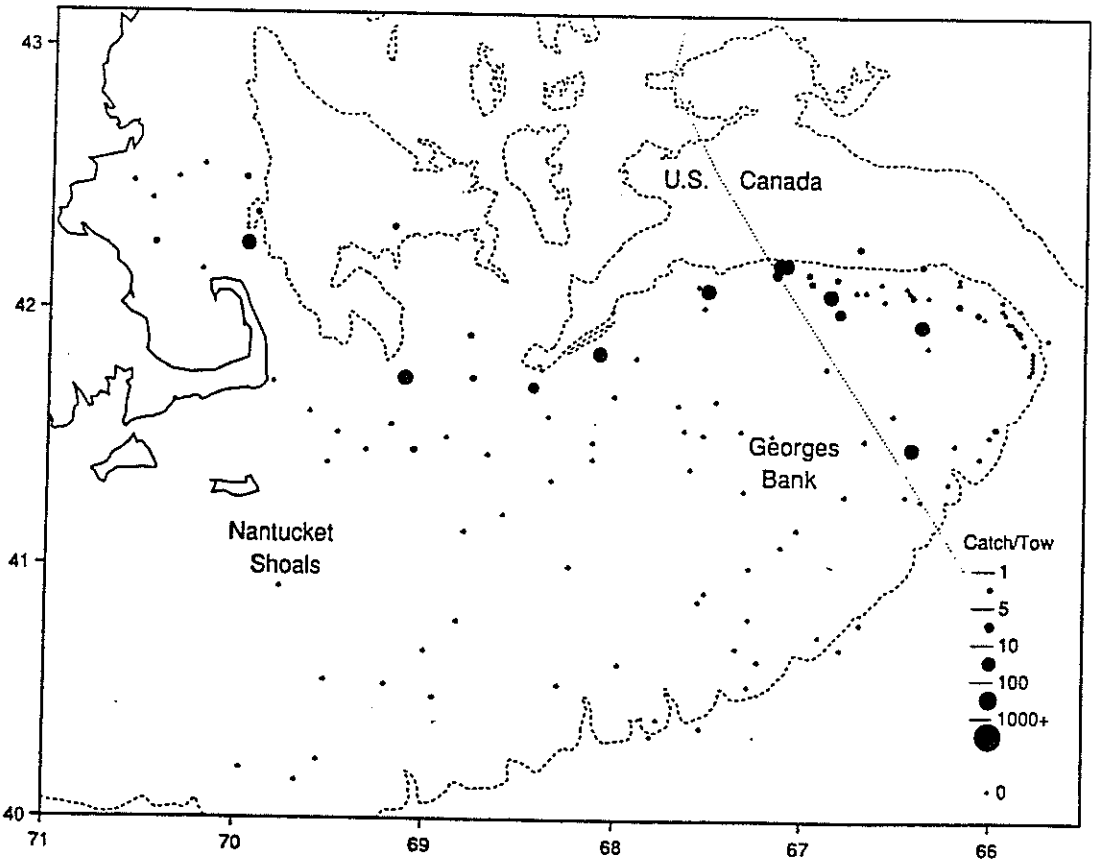


Figure 6. Canadian Herring and US bottom Trawl Survey - 1986.

Fig 3.4.6

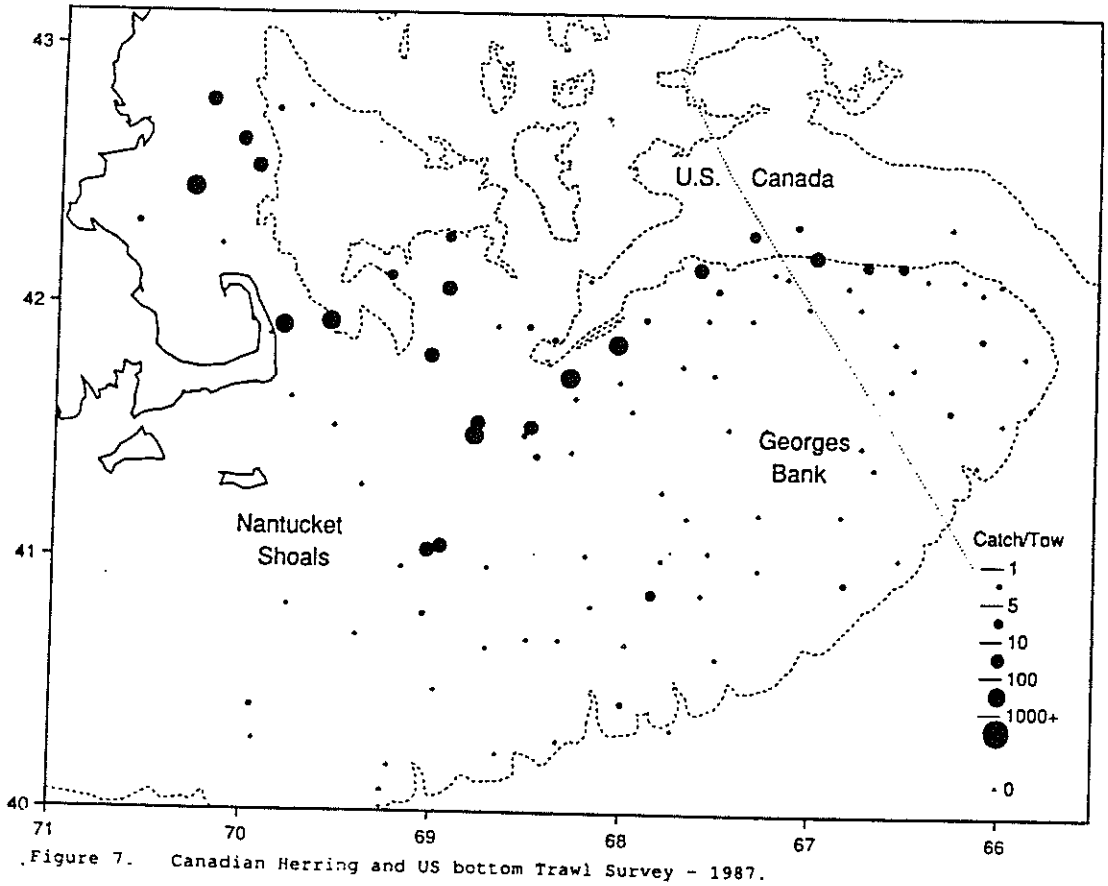


Figure 7. Canadian Herring and US bottom Trawl Survey - 1987.

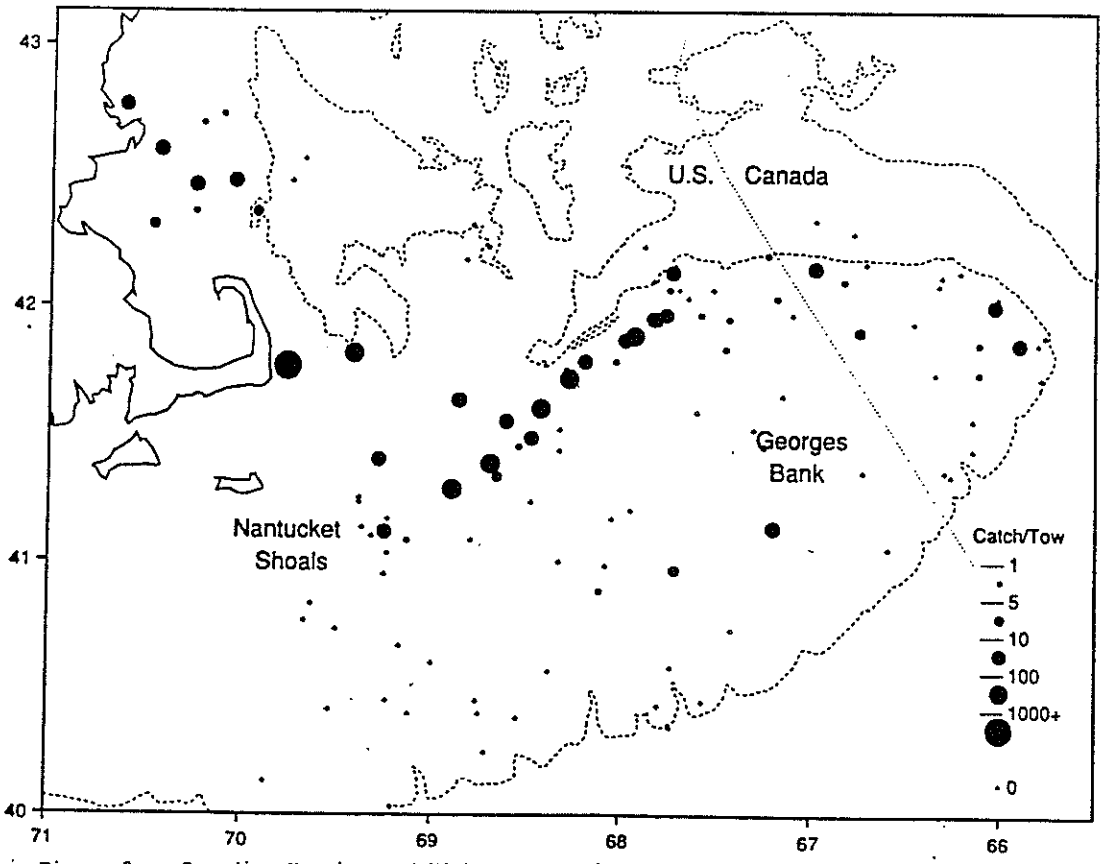


Figure 8. Canadian Herring and US bottom Trawl Survey - 1988.

21 Fig 3.4.7

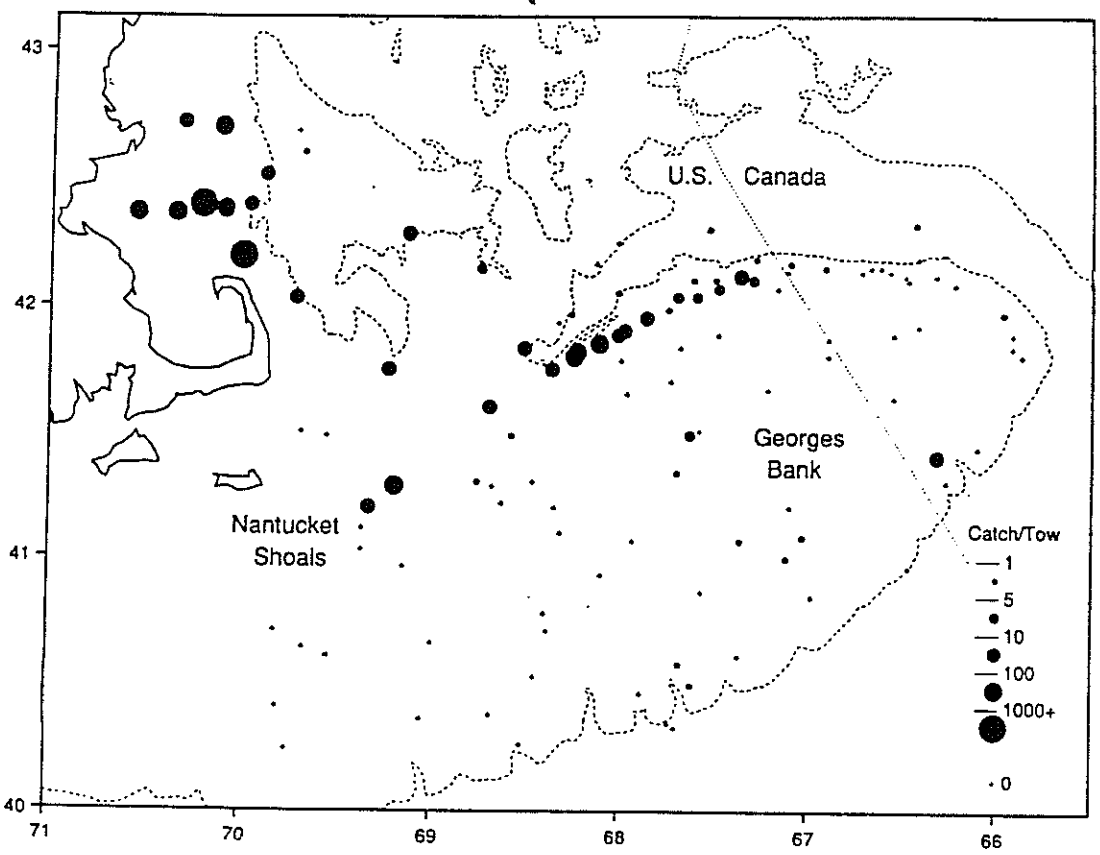


Figure 9. Canadian Herring and US bottom Trawl Survey - 1989.

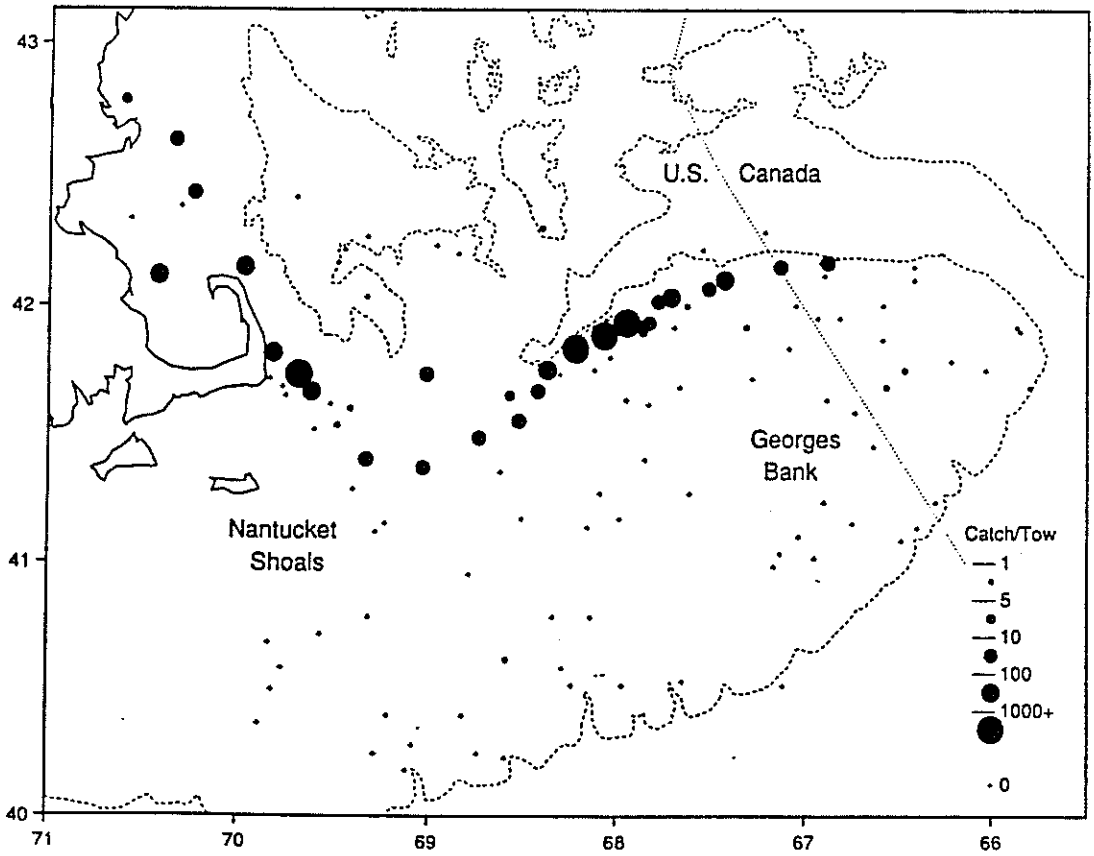


Figure 10. Canadian Herring and US bottom Trawl Survey - 1990.

Fig 3.4.8

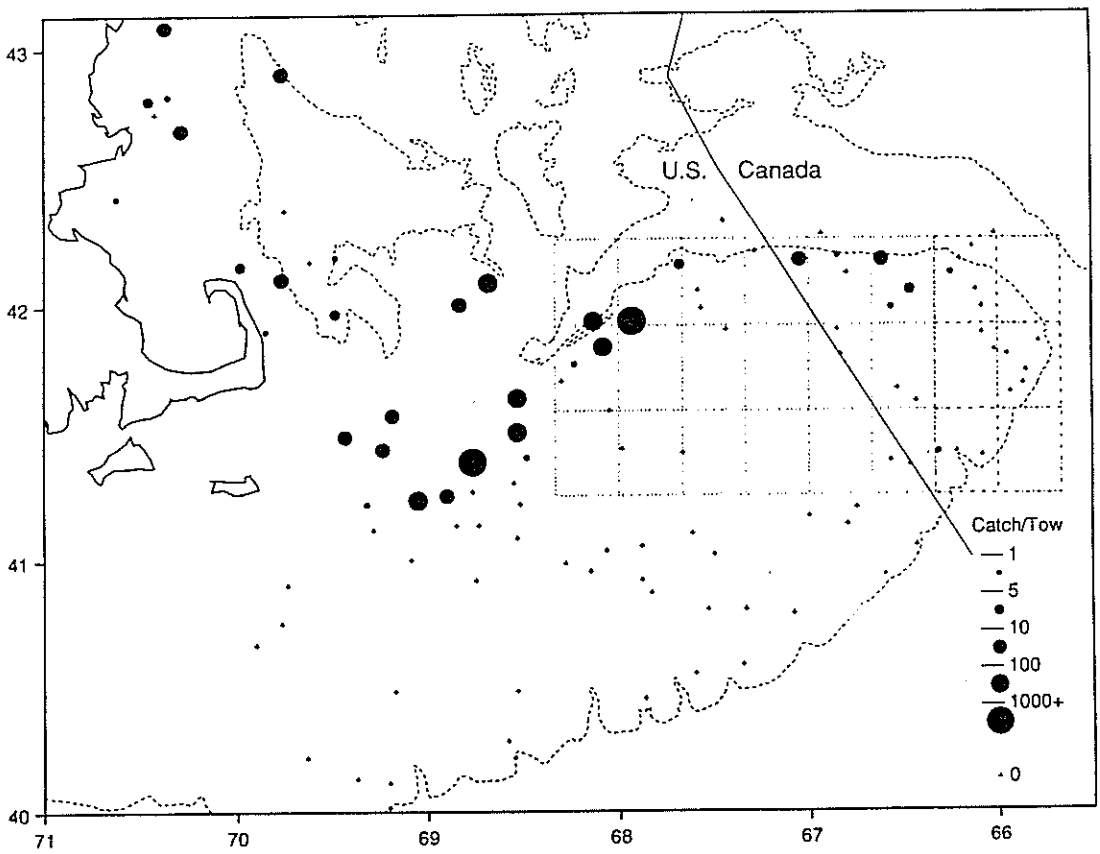


Figure 4. US and Canadian 1991 surveys combined. Herring as per scale

4. HABITAT

4.1 Physical Description of Habitat

Gulf of Maine

The Gulf of Maine is a semi-enclosed sea of 90,700 km^2 (35,000 square miles) bordered on the east, north and west by the coasts of Nova Scotia, New Brunswick and the New England states. To the south, the gulf is open to the North Atlantic Ocean. Below about 50 m depth, however, Georges Bank forms a southern boundary for the gulf. The gulf is connected to the deep North Atlantic Ocean by only three channels - the major passage being the Northeast Channel between Georges Bank and the Scotian shelf. The interior of the gulf is characterized by five major deep basins (>200 m) which are separated by irregular topography that includes shallow ridges, banks, and ledges. Water flows in and out of the Bay of Fundy around Grand Manan Island. Major rivers are the St. John, St. Croix, Penobscot, Kennebec, Androscoggin, Saco, and Merrimack.

The bottom type within the gulf is quite variable and generally related to the topography. The deep basins are characterized by very fine sediments, while the irregular topography between the basins generally has a higher fraction of sand and the various banks and ledges are either rocky or composed of sand and gravel. The near coastal region south of Casco Bay is largely sand, while to the north and east silt and clay generally predominates. The bottom type in near coastal areas is, however, extremely variable.

The predominantly rocky coast north of Portland, Maine is characterized by steep terrain and bathymetry with numerous islands, embayments, pocket beaches, and relatively small estuaries. Tidal marshes and mud flats occur along the margins of these estuaries. Further south, the coastline is more uniform with few sizable bays, inlets, or islands, but with many small coves. Tidal marshes, mud flats, and sandy beaches along this

portion of the coast are gently sloped and very extensive. Marshes exist along the open coast and within the coves and estuaries, but the amount of coastal wetlands (1,200 square miles) is small compared to other regions in the country. Tidal flats are, however, a predominant coastal feature north of Cape Cod: Maine alone has over 100,000 acres of tidal flats. Estuaries within the Gulf of Maine were formed by glaciers that carved steep-sided channels through the rocky shoreline through which rivers now run to the ocean.

Georges Bank is a large (roughly 45,000 km^2 or 17,500 square miles) shallow bank that appears as an eastward extension of the continental shelf. It was formed during the last ice age as the glaciers melted and retreated northward. The bank has a steep slope on its northern edge and a broad, flat, gently sloping southern flank intersected by several submarine canyons. It is separated from the rest of the continental shelf to the west by the Great South Channel. The central region of the bank is quite shallow, with areas less than 10 meters (30 ft) deep, and the bottom there is characterized by large amplitude sand waves. The rest of the bank is sandy and flat, with some regions of gravel on the northern and eastern parts of the bank.

The surface circulation of the Gulf of Maine is generally counterclockwise with an offshore flow at Cape Cod which joins a clockwise gyre on the northern edge of Georges Bank. Surface water flows eastward to the northeast part of the bank and then southwestward along the bank's broad southern flank. From there most of the water flows westward south of New England and through the Mid-Atlantic Bight. Some portion of the flow from the southern side of Georges Bank turns northward through the Great South Channel to recirculate around the bank. The counterclockwise gyre in the gulf is more pronounced in the spring when river runoff adds to the southwesterly flowing coastal current. Surface currents reach velocities of 80 cm sec^{-1} (1.5 knots) in eastern Maine and the Bay of Fundy region under the

influence of very strong tides and gradually diminish to 10-20 cm sec^{-1} in Massachusetts Bay where tidal amplitude is only 3 meters or so. The shoal region of Georges Bank also experiences large tidal currents of 70-100 cm sec^{-1}.

The seasonal variation in sea surface temperature in the gulf is extreme, ranging from 4°C in March throughout the gulf to 18°C in the western gulf and 14°C in the eastern gulf in August. The salinity of the surface layer also varies seasonally with minimum values in the west occurring during summer, from the accumulated spring river runoff, and during winter in the east under the influence of runoff from the St. Lawrence River (from the previous spring). With the seasonal temperature and salinity changes, the density stratification in the upper water column also exhibits a seasonal cycle. From well mixed, vertically uniform conditions in winter, statification develops through the spring and reaches a maximum in the summer. Stratification is more pronounced in the southwestern portion of the gulf where tidal mixing is diminished.

Middle Atlantic Region (Cape Cod to Cape Hatteras)

The coastal zone of the middle Atlantic states varies from a glaciated and rugged coastline from Cape Cod south to the New York Bight; further south the coast is bordered by a 160 km wide plain. Along the coastal plain, the beaches of the outer banks and barrier islands are wide, gently sloped, and sandy, with gradually deepening offshore waters. The area is characterized by a series of sounds, broad estuaries, large river basins (e.g., Connecticut, Hudson, Delaware, and Susquehanna), and barren islands. Conspicuous estuarine features are Narragansett Bay, Long Island Sound, the Hudson River, Delaware Bay, Chesapeake Bay, and the nearly continuous band of estuaries behind outer banks and barrier islands along southern Long Island, New Jersey, Delaware, Maryland, Virginia, and North Carolina. The complex estuary of Currituck, Albemarle, and Pamlico Sounds behind the outer banks of Cape Hatteras (covering an area of 6,500 km^2 or 2,500 square miles with 150,000 acres of salt marsh) is an important feature of the region. Chesapeake Bay is the largest estuary in the U.S., draining 64,000 square miles of land in five states, and includes almost 300,000 acres of salt marsh and 100,000 acres of tidal flats. Coastal marshes border small estuaries in Narragansett Bay

and all along the glaciated coast from Cape Cod around Long Island Sound. Nearly continuous marshes occur along the shores of the estuaries behind the outer banks and around Delaware Bay. As a whole, this region contains more than 3,500 square miles of wetlands, one-third of which are in Chesapeake Bay. Middle Atlantic coastal plain estuaries are characteristically shallow and subject to strong tidal circulation, thus creating ideal conditions for biological productivity.

At Cape Hatteras, the shelf extends seaward approximately 33 km, then widens gradually to 113 km off New Jersey and Rhode Island. It is intersected by numerous underwater canyons. Surface circulation north of Cape Hatteras is generally southwesterly during all seasons, although this may be interrupted by coastal indrafting and some reversal of flow at the northern and southern extremities of the area. Speeds of the drift are on the order of 9 km per day. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. The Gulf Stream is located about 160 km offshore of Cape Hatteras, but becomes less discrete and veers to the northeast north of the cape. Surface currents as high as 200 cm sec^{-1} (4 knots) have been measured in the Gulf Stream off Cape Hatteras.

Hydrographic conditions in the mid-Atlantic region vary seasonally due to river runoff and warming in spring and cooling in winter; the water column becomes increasingly stratified in the summer and homogeneous in the winter due to fall-winter cooling of surface waters. In winter, mean minimum and maximum sea surface temperatures are 0^{o} and $7^{o}C$ off Cape Cod and 1^{o} and $14^{o}C$ off Cape Charles (at the end of the Delmarva Peninsula); in summer, the mean minimums and maximums are 15^{o} and $21^{o}C$ off Cape Cod and 20^{o} and $27^{o}C$ off Cape Charles. The tidal range averages slightly over one meter on Cape Cod, decreasing to a meter at the tip of Long Island and on the Connecticut shore. Westward within Long Island Sound and along the south shore of Long Island tide ranges

gradually increase, reaching two meters at the head of the sound and in the New York bight. South of the bight, tide ranges decrease gradually to slightly over a meter at Cape Hatteras.

The waters of the coastal middle Atlantic region have a compex and seasonally dependent circulation pattern. Seasonally varying winds and irregularities in the coastline result in the formation of a complex system of local eddies and gyres. Surface currents tend to be strongest during the peak river discharge period in late spring and during periods of highest winds in the winter. In late summer, when winds are light and estuarine discharge is minimal, currents tend to be sluggish, and the water column is generally stratified.

4.2 Habitat Quality

Gulf of Maine

The North Atlantic region (Cape Cod to the Canadian border) is the third most densely populated of five coastal regions in the U.S. with a complete range from heavily populated (Boston) to very lightly populated (eastern Maine). Population in the region is expected to grow by 16% over the next 20 years. However, urban and agricultural land use together only account for 14% of the total land use in the region's total estuarine drainage area (23,000 square miles): the majority of the land is forested. Despite the presence of several large cities, this region has fewer point sources of pollution (<400) than any other region. The application of fertilizer to agricultural lands is low, but the runoff from agricultural land is a significant source of nutrients (phosphorus and nirtogen) in several estuarine drainage areas.

Despite the region's relatively low population density and industrialization, and the minor importance of agriculture, there are indications that the Gulf of Maine is not as pristine an

environment as one might expect. There is, in fact, plenty of evidence of sediment and biotic contamination. Sources of this contamination seem to be primarily land runoff, windborne pollution from heavily populated areas south of the region, and industries that were active in the earlier part of this century and in the 1800's.

Trace metal concentrations detected in sediments of Casco and Penobscot Bays in the early 1980's were well above pre-industrial levels. Boston and Salem harbors ranked at or near the top among northeastern sites for six different trace metals. Trace metals, DDT, polychlorinated biphenyls (PCB's), and total chlorinated pesticides were also commonly found in winter flounder livers from Boston and Salem harbors as well as several sites located downsteam from the Kennebec River, ME (Kennebec River Plume) and the mouth of the Merrimack River, MA. Among 14 U.S. east coast sites, the Kennebec River Plume ranked third; only Long Island Sound ranked higher. PCB's were also found in trace amounts in 1983 in Portland Harbor (there was none in 1980), in Penobscot Bay, and in the deep offshore basins. Polycyclic aromatic hydrocarbons (PAH's), delivered to the gulf by prevailing winds from the west and southwest, are ubiquitous in Gulf of Maine sediments. Also, six of eight Gulf of Maine sites ranked in the top ten northeast sites for lead in mussels, including sites a long way from populated or industrialized areas. Lead also has been reported in high concentrations in crabs from Boothbay Harbor, ME.

Middle Atlantic

The Middle Atlantic region (Cape Cod to Virginia) is the most densely populated coastal region in the U.S., with almost 33 million people (in 1980) concentrated in an urban corridor extending from Providence, RI to Norfolk, VA. Major population centers are New York, Philadelphia, Baltimore, and Washington, D.C. Despite the heavy population density, urban land use still

ranks behind forest and agricultural land uses in estuarine drainage areas (which total 48,000 square miles) in the region as a whole since these areas extend inland well beyond the limits of urban growth. Projected population growth in this region is the lowest of the five coastal regions (10% over the next 20 years). The region's large population centers have created a proliferation of major point sources of pollution (>2700); two-thirds of these are industrial facilities and one-third are municipal wastewater treatment plants. The Hudson River/Raritan Bay and Chespaeake Bay contain more point sources of pollution than any other EDA in the country, with the exception of Galveston Bay, Texas. Almost nine million pounds of pesticides were applied to agricultural lands in the region in 1982 (compared to only 0.25 million pounds in the North Atlantic). In the same year, the application of fertilizer was the third highest among the five regions (100,000 tons of nitrogen and 28,000 tons of phosphorus fertilizers): Chesapeake Bay and Delaware Bay drainage areas, which contain a high percentage of agricultural land, had the highest applications.

Preliminary information on the condition of estuaries in this region is provided by a recent report of results from the first year (1990) of data collection and analysis by the EPA Environmental Monitoring and Assessment Program (EMAP). This information was collected from 217 sampling sites in estuaries between Cape Cod and the mouth of the Chesapeake Bay. A series of indicators that are representative of the overall health of estuarine resources was measured at each site. These indicators were designed to address three major attributes of concern to estuarine scientists, environmental managers, and the public. Two of these were: 1) biotic integrity, or the existence of healthy, diverse, and sustainable biological communities; and 2) pollutant exposure, or the condition of the physico-chemical environment in which biota live.

Biotic integrity was assessed in terms of the species composition, abundance, and biomass of benthic animal assemblages and measures

of visible pathological abnormalities of fish. Degraded conditions, characterized by low species richness, low abundance and low mean weight of selected indicator species, were found in 23% (± 7%) of the estuarine area in the region, mostly in large tidal rivers. Thirty-six percent (±12%) of the area of Chesapeake Bay had "degraded" benthic resources compared with 15% (± 9%) in Delaware Bay and 5% (± 2%) in Long Island Sound. Poor benthic assemblages in the Chesapeake were associated with low bottom dissolved oxygen concentrations. Less than 2% of the benthic fish examined throughout the region had visible pathological disorders.

Regarding water and sediment quality, bottom dissolved oxygen concentrations below 5 ppm were detected in 21% (± 7%) of the estuarine area in the region and below 2 ppm in 9% (± 7%) of the area (in most cases, where the water column was strongly stratified). Bottom dissolved oxygen concentrations <5 ppm were most frequently observed in Long Island Sound whereas concentrations <2 ppm were most common in Chesapeake Bay. Based upon bioassay results, 8% (± 5%) of the region was estimated to contain sediment that was toxic to estuarine organisms. The most important contributors to acute toxicity were lead, mercury, and zinc. A much higher percentage (39% ± 9%) of the estuarine sediments in the region were estimated to contain contaminants at concentrations that could potentially cause sublethal biotic effects. Again, trace metals were the primary contaminants in this category. Of the three largest estuarine systems in the region (Chesapeake and Delaware Bays and Long Island Sound), toxic sediments were most prevalent in Chesapeake Bay; sub-lethal concentrations were most prevalent in Long Island Sound. In Delaware Bay, pesticides were above threshold levels for sublethal biological effects over an estimated 34% (± 19%) of the area of the estuary.

No comparable information relating to the condition of coastal waters or sediments in the mid-Atlantic region is available.

4.3 Environmental Requirements of Atlantic Herring

Atlantic herring adults, larvae and juveniles tolerate a wide range of temperatures and salinities (Table 4.3.1). Probably the most vulnerable stage in the life history of the species is the egg. Eggs do not tolerate salinities below 20 ppt and develop normally in temperatures between 8 and 13 C. They are also sensitive to low oxygen concentrations. High egg mortalities have been reported in egg masses where the underlying layers are not exposed to sufficient oxygen concentrations.

Spawning takes place at known locations in depths of 10-100 meters in the Gulf of Maine (see 3.1) in areas with fairly strong bottom currents (0.25 to 0.5 cm/sec or 1/2 to one knot). The bottom substrate in such areas is generally coarse sand, gravel, shell hash, or small cobble, with or without attached vegetation. In areas where relatively flat expanses of suitable spawning habitat are available, eggs are generally not deposited on large rocks. They are also not laid on soft sediment. Herring eggs have been observed on a variety of macroalgal species (e.g. Ptiloda serrata). Eggs are easily dislodged from the substrate as a result of turbulence or mechanical disturbance. Incubation generally lasts from 10 to 15 days, depending on water temperature.

The primary habitat of larval and juvenile Atlantic herring within the management area is the nearshore and estuarine zone of the Atlantic coast between New Jersey and the Bay of Fundy, although larvae are known to also occur offshore. Estuaries and coastal embayments serve as important nursery grounds for juveniles. Adults migrate extensively (see 3.1 and 3.2) and therefore are found in coastal as well as more offshore continental shelf pelagic habitats. Possible associations between water or sediment quality throughout the range of the species and survival or population size are unknown, with the possible exception of substrate type or quality and sediment load in the water column

and their effects on spawning behavior or egg survival. Since eggs are demersal and are deposited year after year in the same locations, they are vulnerable to disturbance (storms, bottom trawls or dredges), predation, or possible contamination effects.

References

Field, D.W., A.J. Reyer, P.V. Genovese, and B.D. Shearer (eds) 1991. Coastal wetlands of the United States: an accounting of a valuable national resource. NOAA/NOS Office of Oceanography and Marine Assessment, Ocean Assessments Division, Strategic Assessment Branch, in cooperation with USFWS National Wetlands Inventory and National Wetlands Research Center, Feb. 1991, 59 p.

Gusey, W.F. 1976. The fish and wildlife resources of the middle Atlantic bight. Environmental Affairs, Shell Oil Co., Houston, TX.

Gusey, W.F. 1977. The fish and wildlife resources of the Georges Bank region. Environmental Affairs, Shell Oil Co., Houston, TX.

Gusey, W.F. 1981. The fish and wildlife resources of the South Atlantic coast. Environmental Affairs, Shell Oil Co., Houston, TX.

Higgins, B.E., R. Rehfus, J.B. Pearce, R.J. Pawlowski, R.L. Lippson, T. Goodger, S.M. Roe, and D.W. Beach 1985. Regional action plan: Northeast Regional Office and Northeast Fisheries Center. NOAA Tech. Memo. NMFS-F/NEC-37.

Larsen, P.F. 1992. An overview of the environmental quality of the Gulf of Maine. The Gulf of Maine, NOAA Coastal Ocean Program Regional Synthesis Series No. 1: 71-95.

New England Fishery Management Council (NEFMC) 1993. Groundfish management plan, amendment #5 (draft).

NOAA 1990. Estuaries of the United States: Vital Statistics of a National Resource Base. National Oceanic and Atmospheric Admin., Rockville, MD: Strategic Assessment Branch, Ocean Assessments Division, 59 pp.

Weisberg, S.B., J.B. Frithsen, A.F. Holland, J.F. Paul, K.J. Scott, J.K. Summers, H.T. Wilson, R. Valente, D.G. Heimbuch, J. Gerritsen, S.C. Schimmel, and R.W. Latimer 1992. EMAP-Estuaries Virginian Province 1990 Demonstration Project Report. EPA 600/R-92/100. U.S. Environmental Protection Agency, Environmental Research Laboratory, Narragansett, RI.

ENVIRONMENTAL PARAMETERS - ATLANTIC HERRING (CLUPEA HARENGUS) - BY LIFE STAGE

Life Stage	Temperature (C)	Salinity (ppt)	Oxygen (DO)	Turbidity (mg/l)	Substrate	Water Currents	Contaminants (upper tls)
Spawning	8-12 pr 5-15 tl	>33 pr never brackish			rock,shells, gravel, vegetation, especially red algae	1-2 km/h pr	
Eggs	8-13 pr 5-20 tl	20-35 pr 5.9-52.5 tl	lower tl - 20% saturation	<7,000 tl	rock,shells, gravel, vegetation, no sand, mud	1-2 km/h pr .27-.52 m/sec lower tl	oil 1-20 ml/l; Cu 30 ug/l; FeSO4,H2SO4- 1:8,000 dil.; dinitrophenol- .01-.05 umol/l
Larvae	-1.8-25 tl	10-15 pr 2.5-52.5 tl	lower tls - 1.9-3.6 mg/l at 10 C; 11.6% sat.	>3.0 caused reduction in feeding		coastal,tidal currents - necessary for transport	oil 1-20 ml/l; Cu 1,000 ug/l, 300 vert.mig; FeSO4,H2SO4- 1:32,000 motor 1:8,000 death
Juveniles	8-12 pr tls- 4-16 stress -.95--1.01 low 19.5-21.2 high	28-32 pr 5 low tl		9.5-12 high tl- avoidance			
Adults	sluggish below 4.4	>28 pr 5 low tl					

NOTES: pr = preferred range; tl = tolerance limit

Info from: Kelly and Moreau, 1986
Species profile: Atlantic herring
U.S. Fish Wildl. Serv.
Biol. Rep. 82(11.38)

Chenoweth et. al.,1986
Early life histories of commercial shrimp and fish
NMFS/DMR Contract # NA83FAD MEBB
Final Report

54.1 Offshore Fisheries

Small quantities of herring were taken by domestic fishermen on Georges Bank as early as the seventeenth century, but primarily for bait in the cod fishery. In the winter of 1853-54, the schooner, *Flying Cloud*, unable to obtain the expected cargo of halibut from waters off Newfoundland, was loaded instead with frozen cod and herring. The herring was destined to be used partly as bait by Georges Bank cod fishermen, partly as food. Soon a significant winter fishery developed. About 1865, the frozen herring fishery turned to the Bay of Fundy for its supply of fish, gradually supplanting Newfoundland herring in US markets. Little attention was redirected towards US offshore grounds until the early 1960's when an intensive trawl fishery was developed on Georges Bank by the USSR. This foreign interest in developing fisheries on herring stocks in US offshore waters was precipitated by the collapse of herring stocks in the North Sea.

During 1961 the Soviet herring fleet on Georges Bank totaled 100 vessels, catching over 67,000 tons (Table 54.1.1). By 1965, 200-250 Soviet vessels were fishing for herring, red and silver hake, haddock, and cod on Georges Bank and off Southern New England and, over the period 1961-1965, reporting herring catches of 38,000 to 152,000 tons. By 1967, the Soviets were joined by vessels from the Federal Republic of Germany (FRG), the German Democratic Republic (GDR), Poland, Japan, Romania, and Canada. The total catch from Georges Bank and south reached a maximum of 374,000 tons in 1968. From 1965 to 1972 the total number of foreign fishing vessels sighted in waters off the US coast from Georges Bank to Cape Hatteras increased from about 450 to over 1,000, thereafter declining in response to reduced fish stocks and increasingly more stringent catch restrictions (Table 54.1.2). Much of this distant water fleet activity was directed towards herring. As many as 200 large Soviet stern trawlers were active in the New York Bight winter herring fishery while more than 100 Soviet side trawlers rigged for purse seining pursued a summer fishery on Georges Bank. Polish stern trawlers fished herring in conjunction with a winter mackerel fishery and exploited herring on Georges Bank during the summer and fall. GDR vessels were observed to follow a similar pattern.

The overwhelming majority of US adult herring landings from offshore fisheries were historically taken from nearshore grounds

in the western Gulf of Maine with Gloucester, Massachusetts being the major landings port. US participation in the ICNAF statistical areas 5Z and 6 fishery was typically limited to a winter fishery landing 4,600 tons or less at Pt Judith, Rhode Island.

A number of factors may explain the lack of an historic US interest in developing a significant offshore adult herring fishery on Georges Bank. The US seafood market for finfish has traditionally concentrated on the high value species, such as cod, haddock, and yellowtail. The low demand for herring as food in domestic markets meant that for fishermen to realize comparable revenues from fishing for herring, very high volumes for reduction would be required. However, even this market was limited since the bulk of raw material for reduction has historically been supplied by menhaden landings along the entire eastern seaboard. A potential European food market developed for US product with the collapse of North Sea herring in the late 1970's, but the demand was for high quality fish. However, there were no freezer-trawlers in the US fleet which would have been necessary to operate successfully on Georges Bank and to supply that high quality product. Lacking an economic incentive during prior years, the US industry was not able to develop the freezer-trawler technology in time to take advantage of the foreign market conditions. Finally, the demand for adult herring typically could be met (discounting unforeseen and perhaps transitory phenomena such as the North Sea collapse) almost in its entirety by nearshore catches in the western Gulf of Maine.

Table 5/4.1.1 Catch (metric tons) of sea herring in ICNAF Divisions 5Z and SA 6 by country.

Year	USA	Canada	USSR	Poland	FRG	GDR	Romania	Bulgaria	Others	Total
1961	105		67,550						0	67,655
1962	101		151,864	277					0	152,242
1963	322		97,646						0	97,968
1964	489		130,914	35					0	131,438
1965	1,191		38,262	1,447			1,982		0	42,882
1966	4,308		120,113	14,473		1,133	2,677		0	142,704
1967	1,211	1,306	126,759	37,677	28,171	22,159	1,420		40	218,743
1968	758	13,674	143,097	75,080	71,086	67,719	1,656		528	373,598
1969	3,678	945	138,673	45,021	61,990	44,624	337	812	14,678	310,758
1970	2,011	7	61,579	70,691	82,498	28,063	685	348	1,412	247,294
1971	3,822	12,863	81,258	88,325	54,744	18,447	898	4,551	2,466	267,374
1972	2,782	53	48,072	49,392	27,703	40,016	2,156	2,355	1,661	174,190
1973	4,627	5,083	52,340	49,275	31,501	53,326	297	1,380	4,506	202,335
1974	3,370	217	41,541	39,312	23,690	31,530	2,018	1,773	6,059	149,510
1975	4,583		40,945	38,392	22,957	30,901	1,544	421	6,353	146,096
1976	744		12,996	10,517	8,806	7,891	115	105	2,333	43,507
1977	381	2	1,492	119			9		154	2,157
1978	2,101						1		2	2,104
1979	1,290								0	1,290
1980	1,530			1					0	1,531

Sources: (1) United States Department of Commerce, Preliminary Fishery Management Plan for the Atlantic Herring Fishery in the Northwestern Atlantic, 1977. (2) Northwest Atlantic Fisheries Organization, Historical Catches of Selected Species by Stock Area and Country, NAFO SCS Doc. 86/2, 85/9.

Table 5.1.2 Catch (metric tons) of sea herring in ICNAF Division 5Y by country.

Year	USA	Canada	USSR	Poland	FRG	GDR	Bulgaria	Japan	Others	Total
1967	31,158	5,226							0	36,384
1968	41,476	21,497							0	62,973
1969	28,687	7,394			10,446	7,020		4	220	53,771
1970	29,181	5,005		43	6,079	2,580		9	0	42,897
1971	31,491	15,518			1,723	2,257			0	50,989
1972	38,196	11,638	256	100	2,930	9,296			0	62,416
1973	21,666	4,107	69	11	876	5,284	378		0	32,391
1974	29,371	4,044	98	103	2,463	1,008			149	37,236
1975	31,592	5,084		71	56				38	36,841
1976	49,398	921							0	50,319
1977	50,272	382							0	50,654
1978	48,416	582							0	48,998
1979	63,764								0	63,764
1980	81,933								0	81,933

Sources: (1) United States Department of Commerce, Preliminary Fishery Management Plan for the Atlantic Herring Fishery in the Northwestern Atlantic, 1977. (2) Northwest Atlantic Fisheries Organization, Historical Catches of Selected Species by Stock Area and Country, NAFO SCS Doc. 86/2, 85/9.

Table 5.4.1.3 Number of foreign fishing vessels sighted in ICNAF Divisions 5Z and SA 6 by type and country, 1971-1975.

YEAR	TYPE	USSR	Poland	GDR	FRG	Japan	Spain	Bulgaria	Romania	Italy	TOTAL
1971	Stern	186	40	28	26	17	4	11	8	1	321
	Side	359	57	24		18	34			1	493
	Support	105	20	8	7			2			142
	TOTAL	650	117	60	33	35	38	13	8	2	956
1972	Stern	211	50	33	18	19	7	11	7	4	360
	Side	379	59	26		24	47			1	536
	Support	90	14	9	4	1		2	1		121
	TOTAL	680	123	68	22	44	54	13	8	5	1,017
1973	Stern	207	50	32	19	18	36	11	7	14	394
	Side	234	19	29		22	77			2	383
	Support	67	18	7		1		2	1		96
	TOTAL	508	87	68	19	41	113	13	8	16	873
1974	Stern	218	46	23	17	21	57	13	4	11	410
	Side	144	14	29		30	86				303
	Support	81	16	7	4	2		4	2		116
	TOTAL	443	76	59	21	53	143	17	6	11	829
1975	Stern	252	37	22	18	15	38	16	2	8	408
	Side	145	12	20		6	82				265
	Support	81	16	5	5	5		3			115
	TOTAL	478	65	47	23	26	120	19	2	8	788

In addition, small numbers (<10) of stern trawlers belonging to France, Cuba, South Korea, Ireland, and Greece have been observed in SA 5 and 6.

Source: United States Department of Commerce, Preliminary Fishery Management Plan for the Atlantic Herring Fishery in the Northwestern Atlantic, 1977.

5.2.1 MAINE SEA HERRING FISHERY

History of Fishery

The herring fishery in Maine developed during the late 19th century along the eastern Maine coast. The growth of the fishery was stimulated by the development of the canning industry in eastern Maine and New Brunswick during this period and through the first half of the 20th century. There were nearly 50 canneries in operation along the coast during the late 1940's and early 1950's packing over three million cases (100 cans per case) of sardines a year. The establishment of the lobster fishery in the late 19th century also created an additonal market for herring as bait. Landings as high as 80,000-90,000 mt were recorded as early as 1898, 1905, 1911, and 1916 (Fig. 5.2.1). Landings of the same magnitude were recorded in the late 1940's and 1950's (Fig. 5.2.2). Historically, landings have been highly variable due largely to changes in the availability of juveniles along the coast. Annual landings have been consistently lower during the last 30 years or so, except for a brief period during 1979-1981 (Fig. 5.2.2). Herring landed in Maine have also been used for fertilizer, for smoking and pickling, as fresh herring (whole or fillets), and for reduction purposes (fish meal and oil). The use of whole herring for any purpose other than human consumption is currently prohibited by law. In the past, there was also a small pearl essence industry in eastern Maine.

Harvesting Sector

Herring are harvested in Maine with three different gear types: weirs and stop seines (called "fixed gear") and purse seines ("mobile gear"). During the first half of this century the fishery harvested mostly juvenile two-year-old herring ("sardines") using fixed gear. Weirs were by far the most common gear used until the 1940s, mostly in eastern Maine where strong tides and the presence of long, shallow bays make this method of fishing most suitable. By the 1950s, the fish had become more common in the central section of the coast and stop seines had become the dominant gear type. Purse seines accounted for a growing

percentage of the catch after 1960 and currently are the most important gear used in the fishery (Fig. 5.2.3) since they can be used offshore to catch a variety of ages and sizes of herring. Fixed gear have accounted for only a small percentage of the total Maine herring landings since 1983. The increased use of purse seines, a growing demand for adults as canned "steaks", for bait, and for sale to foreign processing ships (see 5.3), and the scarcity of juveniles in nearshore waters in recent years have caused a shift from a fishery dominated by juveniles to one that is more evenly divided between ages 2, 3 and 4+ (Fig. 5.2.4). The catch has been composed primarily of adults in recent years (75% age 3+ since 1986).

The most recent event affecting the herring fishery in Maine and other east coast states has been the development of Internal Waters Processing (IWP) operations involving U.S. owned purse seiners selling adult fish to foreign owned processing ships anchored in state internal waters. Modest IWP operations were undertaken in Maine in 1989, 1991, and 1992. IWP landings of 3,000-3,500 mt were reported during each of those three years (see 5.3).

There are currently (1992 statistics) 16 fishermen in Maine using purse seines, 24 using stop seines and only 5 using weirs. The reduced use of stop seines and weirs since the late 1970's and early 1980's has been dramatic (78 fishermen were reported using stop seines in 1981 and 88 using weirs in 1984), owing to the absence of herring in nearshore waters. Fixed gear landings in Maine during 1992 increased to 3,440 mt, but remained below 1000 mt between 1988 and 1991.

There are currently 10-15 purse seiners licensed to Maine fishermen, mostly under 50 feet in length. These vessels also harvest menhaden and, in some cases, are re-rigged for shrimp trawling during the winter. Most purse seiners supply more than one market, depending on price, the availability of different sizes or qualities of herring, and demand. Sales to the canneries are preferred because the price is higher (they also demand a better quality product). Most of the purse seine vessels are independently owned; two are owned by one of the packing companies.

Herring are caught in Maine coastal waters between June and November. In recent years, catches from the western and central areas of the coast have predominated with very little coming from eastern Maine (Table 5.2.1, Fig. 5.2.5). Some herring landed in Maine is caught in Massachusetts and New Hampshire state waters and in federal waters (>3 miles offshore). Total landings in 1992 were 31,187 mt (62.5 million lbs) with a landed value of $4 million and an average value of $126 per metric ton (or six cents a pound).

Atlantic herring are caught as a by-catch in the coastal trawl fishery and either landed for use as bait or discarded at sea. The by-catch of juvenile herring is reported to be high in the shrimp fishery during the winter.

Processing sector

Herring are currently processed as canned products in six packing plants, sold as bait (either as whole fish or cuttings left over after canning), or sold whole to Russian processing ships (IWP operations) where they are frozen or brined for transport to Russia. There is currently no domestic market for whole fresh fish or fillets. A few adult herring are smoked or pickled as specialty products and some are sold as zoo or pet food. No herring have been reduced to fish meal or oil since the closing of a reduction plant in Rockland in 1989.

The total production of seven packing plants operating in Maine in 1992 was 948,800 standard cases (35,335 mt) with a wholesale value of $47.4 million. Of the total production of sardines, steaks, and kippers in 1992, 41% was supplied by domestic Maine landings. The remainder was trucked to Maine plants from other states (26%), mostly from Gloucester, Massachusetts, or from Canada (33%). The movement of herring both ways across the border has been an important factor in the Maine sardine industry. In years when the supply of juveniles is higher in New Brunswick, imports from Canada have accounted for 50% of the production

by Maine plants (e.g., 1988 and 1990); at other times, Maine has exported a surplus to Canadian plants (most recently, in 1980 and 1981).

The six remaining packing plants employ roughly 1000 people full and part-time and have a payroll of $10 million. Three of the remaining six Maine packing plants are owned by one company. Four plants account for 90% of the total payroll.

Reported bait landings varied between 10,000 and 15,000 mt during 1989-92 All bait herring in Maine is utilized in the lobster fishery. Reported bait landings of menhaden, which is substituted for herring when herring is not available, were roughly 7,000 mt in 1991. Some herring landed in Maine is used for bait in Massachusetts and New Hampshire, and in the southern New England and mid-Atlantic region lobster and blue crab fisheries.

Laws and Regulations

Maine state law prohibits the taking, sale, transport, etc. of Atlantic herring less than 4.5 inches in length (a 25% tolerance is permitted) and prohibits their use as fish meal or oil. Maine regulations prohibit the use of bottom or mid-water trawls to catch herring in state waters and, beginning in the early 1980s, established four week spawning closures in three different areas of the coast and a three week closure south of Cape Elizabeth (Portland) that is consistent with New Hampshire and Massachusetts regulations for the same area. In the western, central, and eastern Maine coastal areas, up to 25% (by number) of any load can be composed of spawn herring (males or females containing milt or eggs) during the closed period. Also, in these two areas, the closure date can be delayed for successive one week periods if samples from the commercial catch indicate that females are not yet mature and ready to spawn. (See 6.2.3 for more detailed information).

FIG 15.2.1

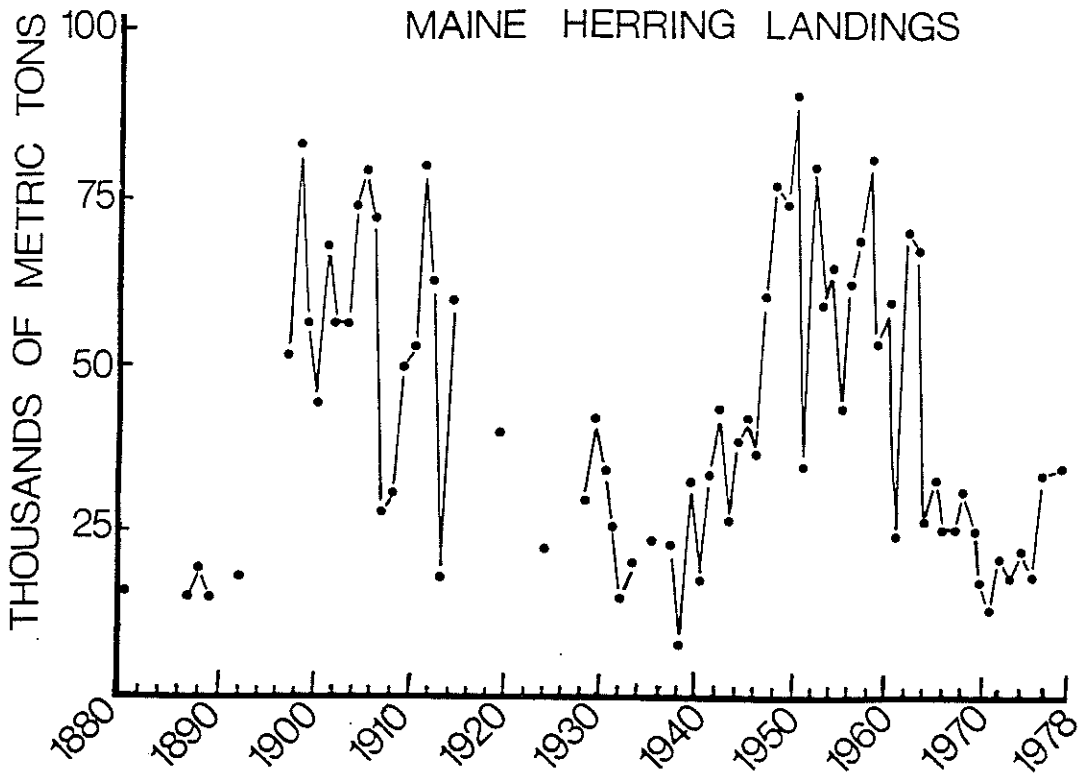

MAINE HERRING LANDINGS
THOUSANDS OF METRIC TONS
100
75
50
25
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1978

Fig 7

MAINE ATLANTIC HERRING LANDINGS

1937-1992

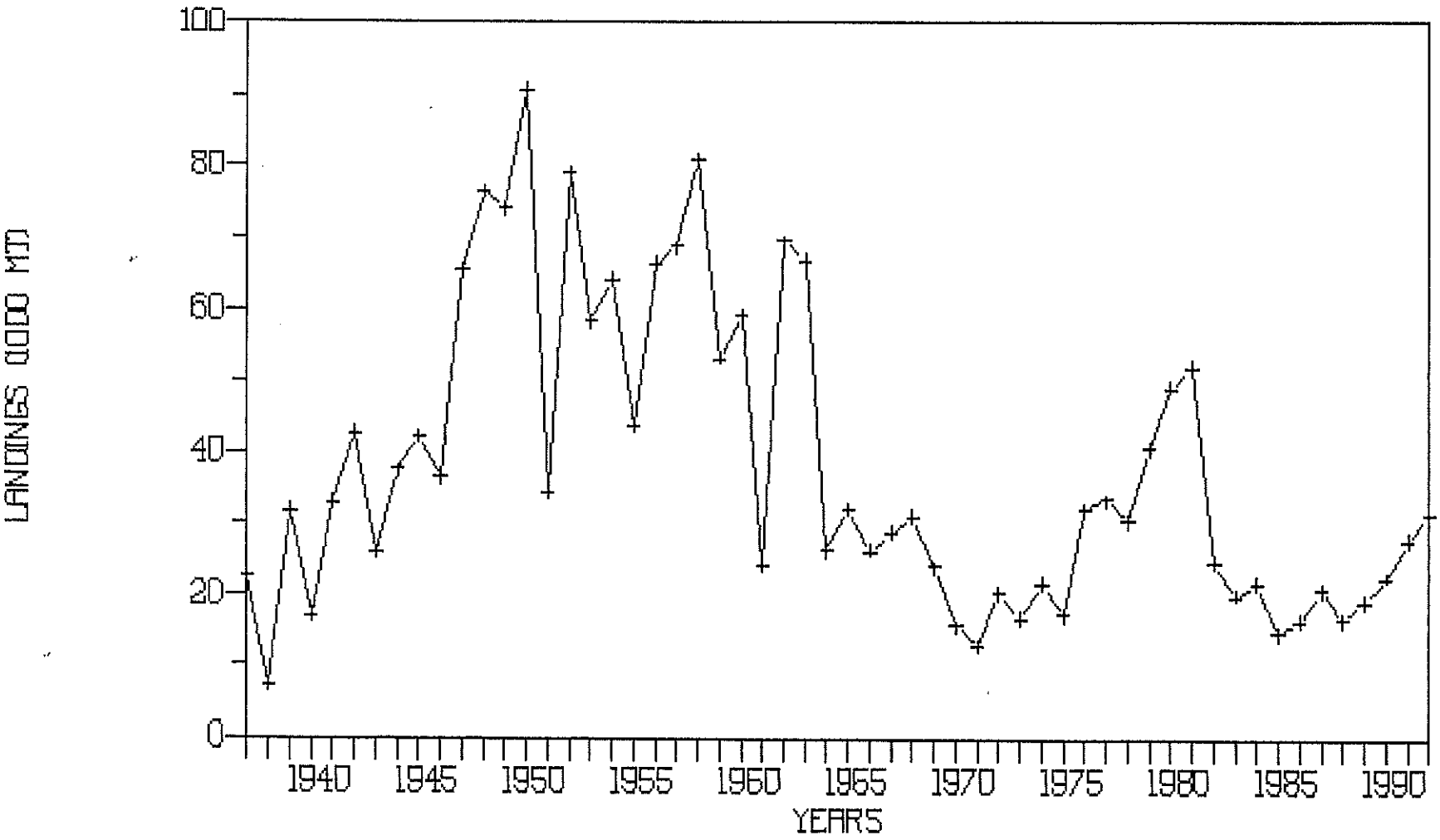


Fig 5.3.2

Fig 3

MAINE ATLANTIC HERRING LANDINGS BY GEAR TYPE

1973-1992

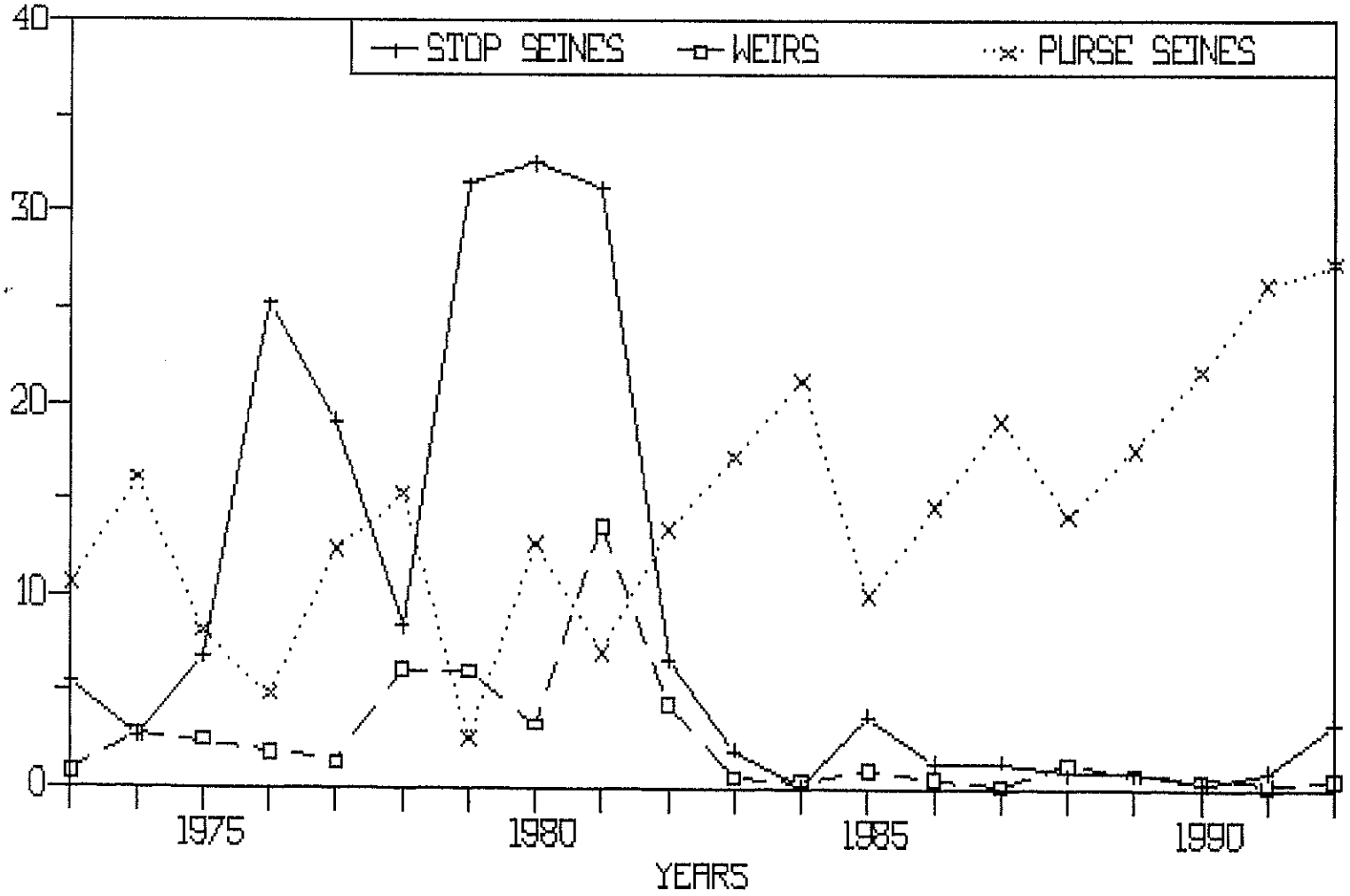


Fig 5.2.3

Fig 4

MAINE ATLANTIC HERRING LANDINGS BY AGE, 1975-1992

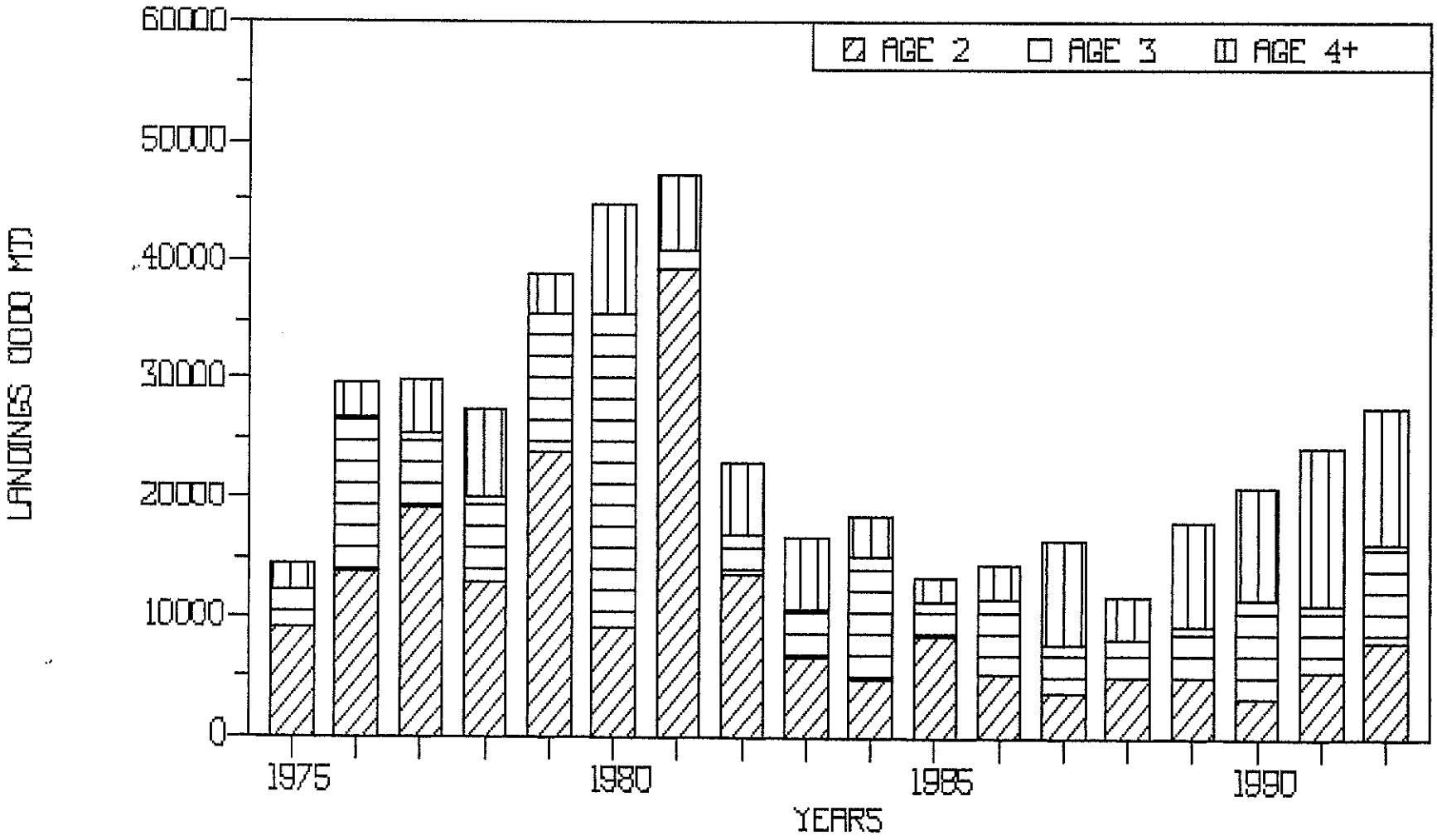


Fig. 5, 2, 4

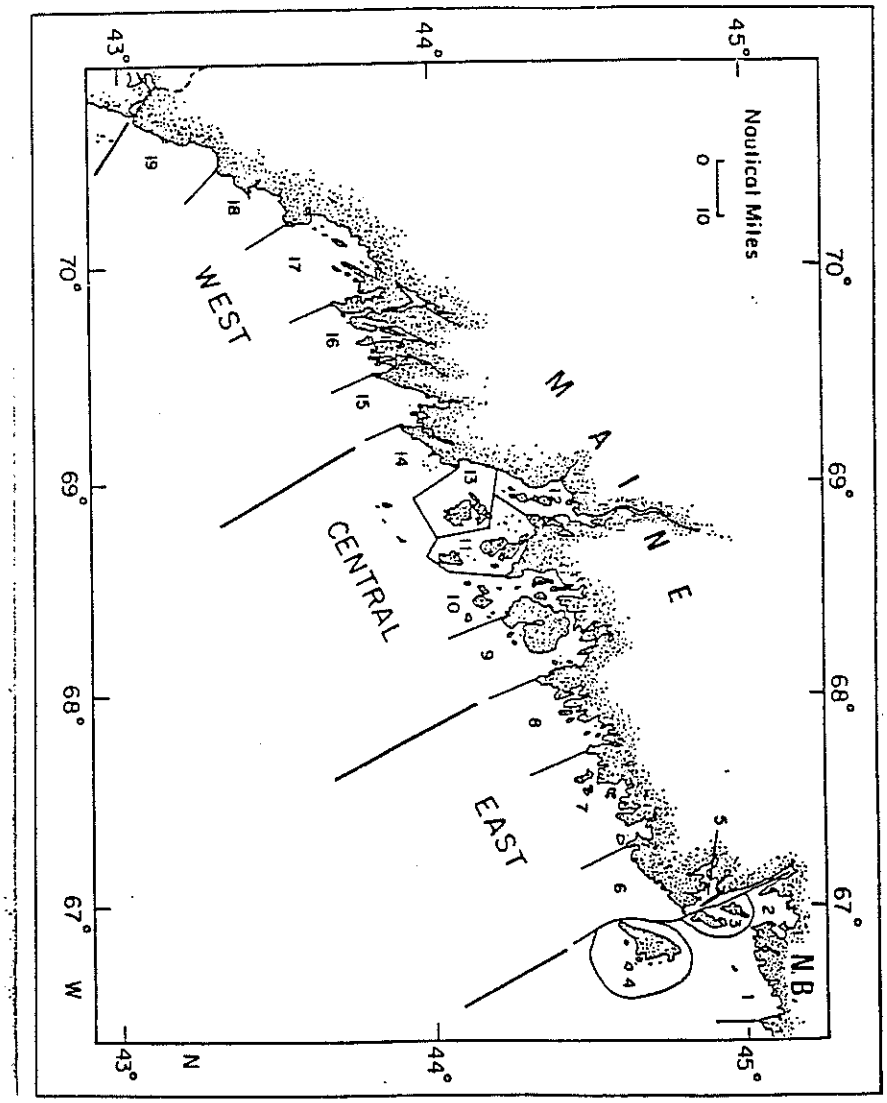

Nautical Miles
0
10
45°
44°
43°
70°
69°
68°
67°
W
N
N.B.
MAINE
WEST
CENTRAL
EAST
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

fig. 5.2.5

Table 5.2.1

1992 MAINE HERRING LANDINGS BY AREA AND MONTH

MONTH	OFFSHORE	WESTERN	CENTRAL	EASTERN	TOTAL
April	305	209			514
May	592	10	9		611
June	**1013**	437	**1951**	163	**3564**
July	42	341	**4588**	170	**5140**
August	367	481	**4576**	190	**5614**
September	**1373**	**1104**	**3620**	46	**6143**
October	171	**3624**	**2646**		**6441**
November	893	**1652**	250	126	**2921**
December	146	84			230
TOTAL	4902	7951	**17640**	694	31187

Table 5.2.1

5.2.2 New Hampshire Sea Herring Fishery

Background

The herring fishery in New Hampshire has been minimal according to records kept since 1879. Early fishery statistics show annual landings around the turn of the century that range from 20,000 to 358,000 pounds. The years 1908 to 1976 are not well documented as to New Hampshire herring landings. It is supposed the actual landings during these years were similarly low.

Commencing 1977 annual landings were recorded except for 1978 and 1979. One year, 1980, shows an anomalously high landing of 6.6 million pounds. This unusual record was the result of a regulatory inconsistency between New Hampshire and other Atlantic coastal states. Following that event, New Hampshire adopted regulations to prevent this from continuing.

In recent years the otter trawl herring fishery in New Hampshire has been limited to a few vessels that supply bait for local lobstermen and the bluefin tuna fishery. Occasionally landings of herring are trucked to Maine for processing. No processing of herring other than bait preparation is currently conducted in New Hampshire.

Landings for the past several years are shown in the following table. This data comes from NMFS preliminary unpublished computer printouts (1977-1991).

Management and Regulatory Authority

The New Hampshire Fish and Game Department is the agency responsible for management of the coastal fisheries. Herring were essentially unimportant due to the small fishery and escaped specific regulation until the 1980 interstate rules inconsistency problem. Following 1980 a set of regulations was promulgated to provide cooperative support for the regional effort to manage the herring fishery. These rules have been revised several times.

The Director of New Hampshire Fish and Game Department has the authority to manage the Atlantic sea herring fishery within the territorial waters of the state under RSA 211:62. The current rules are as follows:

Fis 603.07 Sea Herring.

(a) No person shall fish for, take, or possess unprocessed herring within the jurisdiction of New Hampshire from October 1 through October 21 except:

(1) during this spawning closure all vessels fishing for species other than sea herring shall be allowed an incidental catch of sea herring of not more than 5% by weight of the total catch of all fish on board said vessel at any given time, or one thousand pounds of sea herring on board said vessel at any given time, whichever is the greater amount; or

(2) unless the beginning of the closure has been postponed by the executive director as specified in Fis 603.07 (b).

(b) The executive director shall postpone the beginning of the closure if he determines that the mean gonad somatic index for female herring is 18% or less. For purposes of this section, "gonad somatic index: means the percentage obtained by the formula: [gonad weight/(total weight-gonad weight)] X 100.

(c) The closure shall be extended beyond October 21 for a time period equalling the length of the postponement of the closure's beginning.

(d) Any person, firm or organization engaged in the taking or landing of herring shall be required to obtain a permit so to do from the executive director.

(e) Nothing in the above provisions shall prohibit a person from possessing herring for use as bait while in the normal conduct of tending lobster and crab pots or any herring used as bait for angling purposes.

Table 5.2.1. Landings of Atlantic Sea Herring in New Hampshire (1977-1992)

Year	Landings (thousands of pounds)
1977	54
1978	(1)
1979	(1)
1980	6,636
1981	106
1982	1,217
1983	2,079
1984	181
1985	95
1986	103
1987	264
1988	(2)
1989	625
1990	151
1991	119

(1) data not available

(2) no bait fishermen report

Data from NMFS Preliminary Unpublished Computer Printouts, 1977-1992

MASSACHUSETTS

Purse seines, pair trawls, otter trawls, and fish traps are used to harvest sea herring in Massachusetts waters. Purse seines are responsible for the majority of herring landings with most of the seiners being from other states especially Maine. Most of the seiners fish on grounds outside of Massachusetts waters except in those years when for whatever reason (e.g., favorable water temperatures) fish are abundant and available fairly close to shore such as during the winter and early spring of 1989-90 in Cape Cod Bay.

The fishery is prosecuted from Cape Cod Bay to the New Hampshire border and during the summer and fall the fishery is most robust on productive grounds such as Jeffreys Ledge. Wherever this unpredictable fish may be found is where seiners and other fishermen will fish. Year to year variation in fish location and age composition/abundance of herring catches can be great. To date the recent high abundance of herring on the eastern shore of the arm of Cape Cod to Nantucket Shoals south of Nantucket has not supported a Massachusetts fishery due to the long steaming times and availability of herring closer to the ports where most herring is landed, i.e., Gloucester and Sandwich.

During the winter seiners take advantage of overwintering, smaller fish in Massachusetts Bay by offloading and trucking fish to Maine and Canadian processing plants. Massachusetts shoreside plants also are supplied with herring although shoreside demand is minimal except for use of herring as bait and food for zoos. The greatest demand for herring shoreside was in the late 70s and early 80s when the overseas market for filleted fish was strong, and Gloucester had a fish meal plant. With the loss of the plant and the absence of an overseas market during the latter part of the 80s and the 90s, internal waters processing operations took on great importance for Massachusetts.

Internal waters processing operations for sea herring began in 1985. The first operation was conducted during the summer by Mayflower International of Gloucester in 1985 and 1986 using an East German processor. In 1985, 1,360 mt of the allocated 3,000 mt were taken, and the operation was considered a success. Unfortunately, 1986 was a disappointment. Only 127 mt of an allocated 2,500 mt (7,500 mt requested) were taken. Poor results were blamed on purse seiner breakdowns and fish being unavailable in Massachusetts and adjacent waters.

During 1987 and 1988 there was a lull in IWP activity. This lull quickly changed to frenzy since the demand for IWP permits and allocations grew dramatically from 1989 through 1991 with the emphasis shifting from the summer/fall fishery to the winter/spring.

Three companies took 8,721 mt of an allocated 11,500 mt for 1988-1989. For the 1989-1990 fishing season, the demand for IWP allocations increased to unprecedented levels as did the confusion. A total of 45,000 mt was requested by four applicants. The Sea Herring Section of ASMFC became involved in 1990 and allocated 10,000 mt for the Massachusetts winter fishery. The applicants received allocations by the Governor acting on recommendations by the Commonwealth's Marine Fisheries Advisory Commission.

Resource Trading Company, working with Canal Marine, received 4,000 mt. Salt Water Seafoods acquired 4,000 mt as well. Mayflower obtained 2,000 mt. The allocation was taken by the three companies using four Soviet processors during the winter fishery.

In 1990-1991, Massachusetts IWPs were unsuccessful since fish were unavailable. Only 745 mt was taken and by one operation (RTC/Canal Marine) using a Soviet processor. The other operation (SaltWater) did not receive any fish despite the Soviet processor being anchored in Massachusetts waters for about two weeks. Warmer than normal water temperatures appeared to cause this reduced availability.

The catcher vessels participating in the IWPs were primarily Massachusetts seiners in years with small allocations (1985, 1986, 1991). When allocations were high (1989 and 1990), Maine seiners far outnumbered the Massachusetts vessels.

Like the previous year, 1991-1992 was unsuccessful. There were three applications totalling 20,000 mt. The Governor acting on a MFAC recommendation, allocated 2,000 mt for each operation. Only Canal Marine was able to catch a portion of its allocation -- 518 MT.

The last year, 1992-1993 including this spring, also was unsuccessful despite large IWP allocations to two operations.

From the aforementioned brief history of IWP activity in Massachusetts, it is evident that IWP are a risky proposition especially since high abundance of herring in Massachusetts and nearby waters doesn't necessarily guarantee a high catches. The following table summarizes the IWP catch history.

Herring IWP Mass. monthly catch (MT) -- 1987-1992

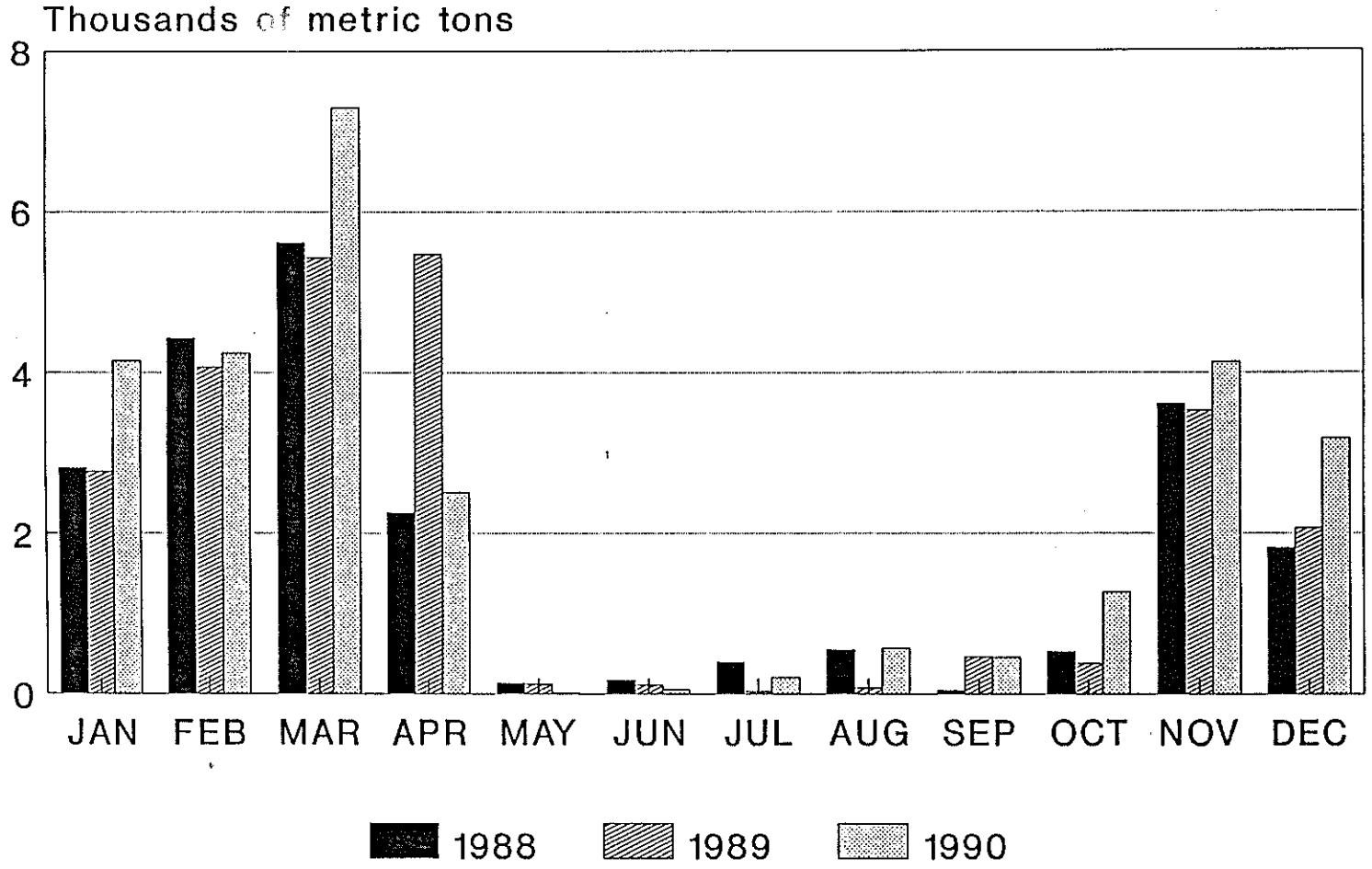
	87	88	89	90	91	92
Jan	0	0	780	4,792	547	518
Feb	0	0	1,472	3,025	0	0
Mar	0	0	3,235	1,620	0	0
Apr	0	0	2,938	38	0	0
May	0	0	249	0	0	0
Jun	0	0	0	0	0	0
Jul	0	0	0	0	0	0
Aug	0	0	74	0	0	0
Sept	0	0	0	0	0	0
Oct	0	0	0	0	0	0
Nov	0	0	0	0	0	0
Dec	0	0	0	198	350	0
Total	0	0	8,748	9,673	897	518

Massachusetts herring landings peaked in 1971 from previous low landings of many years, decreased in the mid-70s, then steadily increased with a peak of 30,330 mt in 1980 with a value of $3,787,000 (average of $155.60/metric ton). This contrasted with total 1980 state of Maine landings of about 48,900 mt (about $5,977,000).

Landings decreased dramatically from 1980 to 1982. Only 8,075 mt were landed for a value of $826,000. This decrease highlights how volatile the fishery can be. For example, this decrease was caused by a markedly reduced demand for U.S. herring caused by (a) a resurgence of North Sea herring stocks to meet the needs of the European economic community markets especially in Germany; (2) other species (e.g., mackerel) became a preferred alternative to herring since herring were scarce and consumers switched to more available species; and (3) a strong U.S. dollar created a lower demand for U.S. herring; e.g. in 1982 the dollar was stronger than the Canadian dollar by 20%, therefore, U.S. herring cost more than Canadian herring.

Ten years later sea herring landings have climbed back to more tha 20,000 mt. In 1991 and 1992, landings were about 21,600 and 22,980 mt, respectively. These landings contrasted with Maine 1991 landings of 24,570 mt and 1992 landings of 28,056 mt. High landings have been due in part to high spawning stock biomass, successful reproduction, and low fishing pressure. The winter/spring fishery also has taken on greater importance. Maine fishermen have increased their landings in Massachusetts.

GLOUCESTER SEA HERRING LANDINGS
1988, 1989, AND 1990 COMPARISON



NMFS PRELIMINARY DATA (IWP EXCLUDED)

5.2.4

Rhode Island Sea Herring Fisheries
Draft version for ASMFC Management Plan
First Draft: July 23, 1993
Author: Lisa Carcieri

Background:

The Atlantic herring fishery of Rhode Island developed during the late nineteenth century. Landings were low (under 2000 pounds/year) during the early years of the fishery, but catches increased dramatically in the early 1900's, with 214,000 pounds landed in 1908. Ranging from a low of 30,000 pounds in 1944 to a high of 9,342,000 pounds in 1973, Rhode Island's herring landings have been extremely variable since then. At times, the landings from one year to the next have changed by as much as 4,000,000 pounds.

Early in this century, floating traps dominated the Rhode Island fishing industry. Otter trawls were introduced to the state in the early 1930's; however, herring sometimes swim too high off of the ocean floor to be caught with traditional otter trawls. In 1968, the URI Marine Advisory Service introduced wing trawls (which have higher openings) to Point Judith's fishermen, and catches increased. In 1971, the MAS introduced the pelagic pair trawl. Today, almost all (>99%) of Rhode Island's Atlantic herring landings are caught with otter trawls, both on the bottom and in mid-water.

A fish dehydrating plant once operated in Galilee, R.I. After it closed in 1972, industrial fish (including herring) were trucked to Maine for processing. Today, there is another processing plant in Galilee, but an employee there states that the facility does not process herring.

Harvesting Sector:

The Rhode Island Atlantic herring season extends from November through March. Total landings in 1992 were 4,502,000 pounds. All but 62,000 pounds of this catch were landed between 3 and 200 miles off shore. The rest was landed within three miles of the shore. The total value of the 1992 landing was $101,000 ($.06 per pound). Table 1 lists Rhode Island's herring landings and their values for the years 1980-1992. Figure 1 illustrates the great variability in the herring catch over the last thirty years and shows a slight overall increase in the landings.

As was previously stated, otter trawls account for the majority of the landings. In 1992, more than 99% of the total landings was caught with these trawls. Smaller, but significant, amounts are caught with floating traps, usually during the summer months. Floating traps catch 1-5% of the total herring landings, except in 1984, when floating traps accounted for more than 33% of the total landings. In some years (1985 and 1987) purse seines have caught large amounts of herring (112,250 lbs. in 1985 and 4,280 lbs. in 1987). For a complete listing of landings by gear type, consult table 2.

Most of the herring landed in Rhode Island is caught in one of four NMFS areas:

537, 539, 611, and 613. During some years, large amounts of herring are caught outside of these areas (29% of 1991's landings were caught in area 521), but this is not the norm. For a map of Rhode Island's NMFS statistical areas, see Figure 2. Table 3 lists the landings from 1980-1992 by NMFS area.

There is currently no significant recreational Atlantic herring fishing in Rhode Island.

Processing Sector:

No processing of Rhode Island's Atlantic herring is done in the state. Most of the landed herring is trucked to Maine, where it is either canned in one of their six packing plants or sold as bait. The rest of Rhode Island's herring is sold to Russian processing ships anchored in the state's internal waters. Rhode Island has undertaken IWP operations in 1990 and 1991. In 1990, 2000.9 mt of Atlantic herring were sold to Russian ships. In 1991, 740.3mt were sold via IWP activities.

5.3.4.

Table 1.

Rhode Island's Atlantic Herring Landings, 1980-1992
(Numbers in thousands)

Year	Pounds	Dollars
1980	2,416	189
1981	1,516	81
1982	3,003	156
1983	100	19
1984	107	9
1985	339	26
1986	1,286	71
1987	687	44
1988	2,405	415
1989	472	67
1990	1,670	280
1991	4,502	488
1992	1,558	101

5.2.1.

Figure 1.

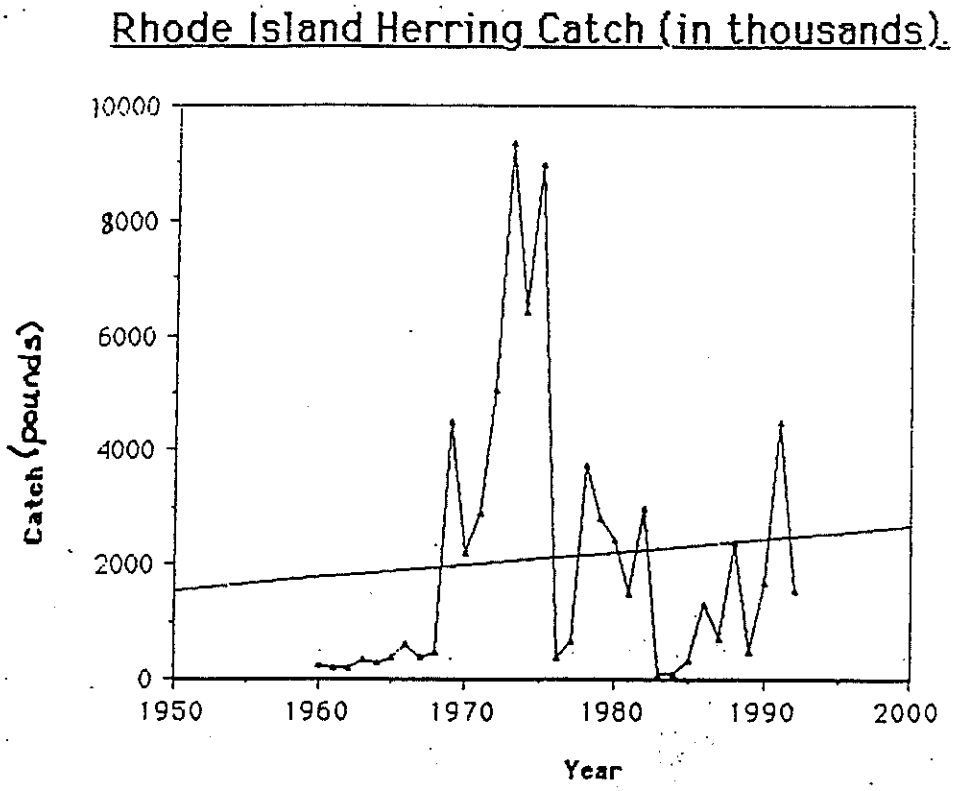


Table 2.

Rhode Island's Atlantic Herring Landings, 1980-1992
by Gear Type
(Numbers in thousands of pounds)

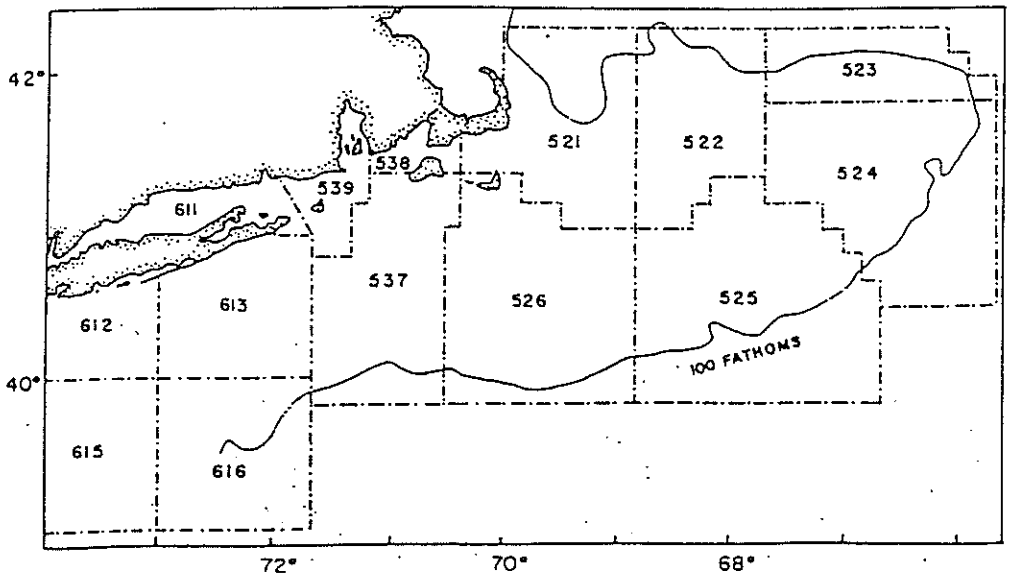
Year	Otter trawl, bottom	Otter trawl, midwater pair	Floating traps	Other-gill net, purse seine,etc	Total
1980	1,231	1,183	2	.02	2,416
1981	206	1,269	41	0	1,516
1982	66	2,853	84	0	3,003
1983	81	0	19	.03	100
1984	74	0	33	0	107
1985	209	0	17	112	339
1986	1,223	0	62	.04	1,286
1987	662	0	14	4	687
1988	614	1,707	40	0	2,405
1989	460	0	12	0	472
1990	1,633	5	33	0	1,670
1991	2,947	1,553	2	0	4,502
1992	1,558	0	0	.08	1,558

Table 3.5.2.4.1

Rhode Island's Atlantic Herring Landings, 1980-1992
By NMFS Statistical Area
(Numbers in thousands of pounds)

Year	Area 539	Area 537	Area 611	Area 613	Other	Total
1980	2,202	23	189	1	.5	2,416
1981	1,498	2	16	0	.3	1,516
1982	2,961	17	26	0	0	3,003
1983	71	24	5	0	.03	100
1984	87	.4	19	.3	0	107
1985	330	7	2	0	.03	339
1986	1,282	2	.6	0	.03	1,286
1987	359	37	281	.4	3	687
1988	513	11	18.5	0	1,819	2,405
1989	205	96	0	171	0	472
1990	198	235	42	782	1,195	1,670
1991	1,551	410	622	410	1,510	4,502
1992	429	.5	725	377	28	1,558

Figure 3.5.2.4.2



Connecticut Fishery

In Connecticut, Atlantic herring are taken principally by trawl and to a lesser extent in pound nets and gillnets. Catches within state waters are limited by seasonal (Nov-May) mesh size restrictions in the trawl fishery (4.5" mesh codend) and a year round 3" minimum mesh size for gillnets fished in marine waters. The trawl fishery takes herring mixed with mackerel outside of Long Island Sound between November and April. The pound net fishery typically took Atlantic herring from mid-March through April. However, catches have declined in recent years presumably due to fluctuations in local abundance. The gillnet fishery takes herring as an incidental bycatch.

5.2.5C

NEW YORK HERRING FISHERY

Commercial Fisheries

Atlantic herring fisheries in New York have not been of major importance over the years but they have been fairly constant. Landings in the domestic fishery have ranged from as low as 3 metric tons to as high as 2907 metric tons. The average for the most recent ten years, however, is 60 metric tons, which is on the high side of the longer term fishery. For example, if we look at the 20 year average, it is only 47 metric tons.

The domestic fishery in New York is predominantly a bait fishery because there is no local market for any other product. The market is extremely limited and there is little demand.

The primary gears used in the domestic herring fishery are trawl and seine. There have also been landings from the pound net fishery and gillnet fishery but these are limited. In 1991, however, New York fishermen participated in an Internal Waters Processing joint venture for herring. The gear used was a pair trawl and the landings from this venture were significant for the New York fishery. Over 1000 metric tons were taken. If this fishery continues, the New York landings will most likely increase.

Management

New York does not currently have any management restrictions directed at herring.

5.2.67

New Jersey's Atlantic Herring Fisheries

Commercial Fisheries

Historically, Atlantic herring were taken mostly within two miles of shore in pound nets from late fall to early winter and again in early spring. Catches then varied from year to year but were usually less than 500,000 pounds and nearly all of this was sold as bait. During most years then, otter trawl vessels accounted for less than 10 percent of the total herring catch.

Today the commercial fishery in New Jersey is almost exclusively conducted by otter trawl vessels which operated from two miles off the coast (New Jersey's law does not allow otter trawl vessels to operate closer to shore than this distance) and offshore over the entire breath of the Continental Shelf. Recent catches amount to approximately 8,000,000 pounds landed shoreside and another 1,700,000 million pounds that are offloading on foreign processing vessels in the State's internal waters. The commercial season normally extends from late November through mid March.

Until just the past few years, the herring were often taken incidental to Atlantic mackerel. But, with its increased abundance and growing market for its sale, there has developed a directed fishery for herring. Until just recently when increasing bait markets lead to an increase in demand, much of the herring catch was discarded at sea. The discard often equaled or exceeded the landings, sometimes several fold.

It should be noted that the catch of Atlantic herring and the river herrings, including alewives and bluebacks, are often grouped into the same category.

Any herrings caught at sea is often recorded as "sea herring" and listed as Atlantic herring but recent information indicates that most of New Jersey's catches made during April and May and reported as Atlantic herring are probably bluebacks or alewives. The existing market structure for herrings now requires that the various species be distinguished so that now Atlantic herring are reported as Clupea harengus and the species category, "alewives", include both Alosa species. As markets continue to expand, the catch of Atlantic herring will undoubtedly increase because of the local abundance of this species off the New Jersey coast from late fall to mid spring.

Recreational Fishery

A recreational fishery exists for Atlantic herring off the northern one third of New Jersey, being concentrated around the Mud Hole area, i.e., the inshore third of the Hudson River trough cutting across the Continental Shelf. This fishery is associated with Atlantic mackerel and silver hake and the catch of herring is a by-catch of these two directed recreational fisheries. The herring are taken on small teasers (plastic tubs covering a long-sharked hook) used for mackerel, as well as small bucktails and metal jigs. Most of the fish are kept for home consumption being pickled or smoked, or used as bait, either cut or whole. The great majority of this recreational fishery is conducted from party boats and, to a lesser extent, from charter boats that operate between November and April.

5.2.8. Other States

VIRGINIA ATLANTIC HERRING LANDINGS

	AREA CAUGHT	GEAR	POUNDS	VALUE
MARCH 1989	Offshore (beyond 12 miles)	Trawl	18383	1415
APRIL 1989	Lower Bay	Anchor Gill Net	10	1
MARCH 1990	Poquoson River	Anchor Gill Net	15	2
JANUARY 1991	Great Wicomico River	Anchor Gill Net	112	11
FEBRUARY 1991	Lower Bay	Anchor Gill Net	135	14
FEBRUARY 1991	Offshore (beyond 12 miles)	Trawl	30,000	1500
MARCH 1991	Lower Bay	Anchor Gill Net	254	25

5.3 History of Atlantic Herring Internal Waters Processing

Through the authority of the federal Magnuson Fishery Conservation and Management Act, Governors of individual states may give permission to foreign vessels to engage in fish processing (but not harvesting) within the internal waters of their states. The Governors must consult with the appropriate Fishery Management Council and Marine Fisheries Commission when issuing internal waters processing (IWP) permits. On the United States east coast, herring IWP operations have taken place since 1985 with vessels from the former East Germany and Soviet Union. Total IWP yearly landings have ranged from 0 to 12,239 metric tons (30 million pounds) between 1985 and 1992 (Table 5.3.1).

In 1983 the states of Maine, New Hampshire, Massachusetts, and Rhode Island entered into a Cooperative Agreement to manage Atlantic herring (see 2.1). In 1987, the Atlantic States Marine Fisheries Commission became party to a new Cooperative Agreement to manage the species. During the late 1980s, states became concerned that uncontrolled IWP harvest could damage the recovering status of the Atlantic herring resource. In response to this, the Commission passed resolutions in 1989 and 1992 to have its Geopoliticial and Atlantic Herring Sections undertake semi-annual reviews of IWP applications. Recommendations relative to allocations of fishery resources are developed by these two sections consistent with the advice of the Commission's Interstate Fisheries Management Program (ISFMP). The 1989 resolution was taken to the 1990 New England Governor's Conference which agreed to receive the advice of the Commission on matters pertaining to IWP fisheries. The 1992 resolution clarified that Commission Sections or Management Boards may undertake joint review procedures for IWP fisheries.

Since 1990, the Atlantic Herring Section and Atlantic Herring Technical Advisory Committee have adopted procedures for evaluating the status of the Atlantic herring resource and establishing annual IWP allocations. IWP permit application procedures include deadlines by which applications must be submitted to the states and by which the states need to forward valid applications to the Commission for review,

criteria to be used by the Commission in reviewing application information, and guidelines for the Commsiion to use in providing recommendations to the states and for the states to use in reviewing applications from potential operators (Appendix A). Specific allocation recommendations to date have been made for operations in Maine, Massachusetts, Rhode Island, New York, and New Jersey (Table 5.3.2). In addition to tonnage allocations, the Atlantic Herring Section has recommended that each state receiving an allocation require observers on board the processing vessel, and a minimum size of nine inches total length. A stipulation that fishing be done inside state waters was eliminated because it could not be enforced.

In 1992, the Commission's Atlantic Herring Section developed a comprehensive Memorandum of Understanding for Atlantic Herring Section member states (ME, NH, MA, RI, CT, NY and NJ) that outlined management areas, IWP allocation procedures, spawning closures (which have existed since the early 1980s) and law enforcement measures to be used in Atlantic herring management (Appendix B). To date, however, this MOU has not been adopted.

In most cases, Governors have conditioned operators of IWPs to stay within the Commission's recommendations. However, during 1990/1991, Rhode Island issued allowable permits for ~~~ mt (_____ lbs) when the Commission's recommendation was 2,400 mt (5.3 million lbs). Recently, as the Atlantic herring resource has grown and because the current assessment is for a larger area, the Commission's recommendations have allowed for considerable liberalization of IWP catch limits. The 1992/1993 and 1993/1994 recommendations were 100,000 mt (220.5 million lbs) for each fishing year. Total requests for IWP fisheries from various applicants have been equal to or have exceeded these Commission limits. In actuality, recent years performance of IWPs have fallen far short of expectations due to unavailability of herring and/or processing vessels.

Table 5.3.1.

Atlantic Herring Internal Waters Processing (IWP) Landings (mt)[1].

State	1985	1986	1987	1988	1989	1990	1991	1992
ME			300		3,491		2,918	3,339
MA	1,360	127			8,748	9,673	897	518
RI						2,000	740	
NY							1,034	
NJ							61[2]	771
Total	1,360	127	300	0	12,239	11,673	5,650	4,628

[1] mt = 2,205 lbs.

2 By-catch in mackerel joint venture landed under IWP allocation provision

Table 5.3.2.

ASMFC Internal Waters Processing Allocations By State and Fishing Year (mt)[1].

State	1989/90	1990/91	1991/92	1992/93	1993/94
ME	???	0	3,500?	25,000	30,000
MA	10,000	5,000	6,000	35,000	42,000
RI	12,000	2,400	3,000	15,000	18,000
NY			2,000	15,000	10,000
NJ			500	10,000	
Total	22,000	7,400	15,000?	100,000	100,000

[1] mt = 2,205 ~~2,204.6~~ lbs.

5.4 RECREATIONAL FISHERY

A recreational fishery for Atlantic herring has recently developed, providing late fall to early spring fishing opportunities for both shore and boat based anglers. The shore based fishery occurs in rivers and harbors at a limited number of sites, often at sites traditionally fished for blueback herring. In the boat fishery, particularly in the mid-Atlantic, Atlantic herring are taken along with mackerel and silver hake.

Most Atlantic herring catches are reported during Waves 2 (March-April) and 6 (Nov-Dec), with limited numbers of fish taken during Wave 5 (Sept-Oct). The Marine Recreational Fishery Statistical Survey (MRFSS) does not sample during Wave 1 (Jan-Feb) in the North Atlantic or mid-Atlantic subregions. However, herring are probably taken during this period, resulting in an underestimation of the total catch.

Shore based fishing methods are similar to those used in the blueback herring fishery. A common method employs a series of small gold hooks tied along the standing part of the line in front of a metal jig. In the boat based fishery, mackerel rigs consisting of several small plastic tube covered hooks and a small bucktail or metal jig are used. Several fish at a time are often taken with these techniques.

Atlantic Herring are used both as a food fish, typically being pickled or smoked, and as bait in other fisheries including lobster, bluefish, striped bass and tuna.

Several species of herring are reported in the Survey, including blueback herring, alewives, Atlantic herring, American shad and menhaden. Species identification is often difficult among the herrings leaving some uncertainty in the MRFSS statistics. Because of this uncertainty, total recreational landings by state were estimated as the fraction of Atlantic herring in "Species Group Herring" in each Wave according to the best judgement of biologists from each state between Maine and Virginia (Table 5.4.1).

Table 5.4.1. Recreational landings in numbers (x1000) (Catch Type A+B1) of Atlantic herring from Maine to Virginia between 1984 and 1992 based on the estimated* fraction of Atlantic herring in "species group herring" by Wave.

State	84	85	86	87	88	89	90	91	92
ME	.	.	.	.	.	.	.	.	.
NH	.	.	.	.	.	.	.	.	.
MA	.	.	.	.	.	.	.	.	.
RI	.	.	.	.	.	.	12	.	36
CT	.	.	.	.	.	.	34	.	2
Subregion	.	.	.	.	.	.	46	.	38
NY	.	.	.	50	.	5	272	373	137
NJ	.	.	.	.	.	0.5	35	.	29
DE	.	.	.	.	.	30	0.5	.	3
MD	.	.	.	.	.	.	.	.	.
VA	.	.	.	.	.	.	.	.	.
Subregion	.	.	.	50	.	36	307	373	169
TOTAL	.	.	.	50	.	36	353	373	207

* Estimates of the fraction of Atlantic herring in "Species Group Herring" are based on the best judgement of biologists in each state.

** MD,VA Have not reviewed data with these states yet.

RI assumed to be the same as CT in catch distribution.

5.5 CANADIAN FISHERIES IN THE SCOTIA-FUNDY REGION

Atlantic herring have been harvested in New Brunswick and Nova Scotia (Fig. 5.5.1) since the turn of the century. The Nova Scotian fishery is primarily a purse seine fishery on spawning and pre-spawning aggregations off the southwest coast of the peninsula and on over-wintering aggregations in the Chedabucto Bay area. The Nova Scotia (4WX) spawning stock is treated as a separate stock and is assessed annually whereas juvenile herring which are caught primarily with weirs in New Brunswick are believed to be migrants from the coastal Maine spawning stock (Stephenson et al. 1992).

Analytical stock assessments indicate that the Nova Scotian stock peaked at over 600,000 mt (1.32 billion lbs) in the late 1960's, decreased by about 50% during the 1970's, and increased again during the late 1980's. Recent assessments of this stock have been complicated by under-reporting of landings and poor agreement between various survey indices of stock abundance (Stephenson et al. 1992). Reported landings in the 4WX stock fishery varied from 74,000 to 125,000 mt (163 to 275 million lbs) between 1985 and 1991: revised landings varied between 134,000 and 177,000 mt (295 and 389 million lbs) over the same period. With the improved stock status during the 1980's the stock was considered to have reached its long-term yield of 150,000 mt (Rivard et al. 1988). The 4WX stock fishery has been regulated by limited entry since 1970 with total allowable catch (TAC) limits in place since 1972 and an individual transferable vessel quota (ITQ) scheme for purse seiners beginning in 1976. The current ten year management plan for 4WX stock herring is due to expire in 1993.

Herring caught in purse seines were used primarily for fish meal during the 1960's, but the reduction fishery was banned in 1976 in order to conserve the resource and to encourage the industry to take advantage of a higher priced market for food fish in Europe (brought about by the collapse of North Sea stocks). An "over-the-side" (OSS) program, which allowed for the sale of herring captured by Canadian fisherman to foreign processing vessels, was introduced in the same year, a program

which is still in existence. The most recent market affecting the Nova Scotian purse seine fishery is for herring roe. This market developed in 1984 and accounted for 72% of all herring landings in the Scotia-Fundy region in 1988 and 107,000 mt (235 million lbs) in 1990. During the last two years, however, price fluctuations have created problems in the roe fishery. Other significant markets for 4WX herring continue to be the adult shore-based domestic market, canned sardines, and over-the-side sales to foreign vessels.

Weirs are the predominant gear used to harvest herring in New Brunswick. As many as 60 weirs were in operation in the Passamaquoddy Bay area in 1850, with a similar number on the adjacent eastern Maine coast. With the growth of the canned sardine industry in the early 1900's, the number of weirs increased rapidly. In the 1970's, the number of active weirs in New Brunswick was limited to about 240. Currently, over 200 active weirs are located along the shore and around islands of the western Bay of Fundy (Stephenson et al. 1993a). The fixed gear fishery in Maine, by contrast, has declined dramatically from well over 100 in the 1950's to five or less in 1992 (Livingston and Stevenson 1993) as juvenile herring have become scarce along the eastern Maine coast. Fixed gear landings in New Brunswick have fluctuated widely over the past 30 years (Fig. 2). Peak landings of 38,800 and 44,100 mt (85.4 and 97 million lbs) were reported in 1989 and 1990 with more normal landings of 24,600 mt in 1991 and 32,000 mt in 1992 (Stephenson et al. 1993b). New Brunswick OSS landings only reached 1883 mt (4.1 million lbs) in 1991, but have been higher. Juveniles (two-year-olds) make up most of the domestic (non-OSS) fixed gear catch with some three-year-olds and very few age 4+ adults. Fishing takes place from spring through autumn. The sardine industry in the Scotia-Fundy region currently employs about 1,800 people (300 full-time) and its production is valued at CAN $70 million per year (Stephenson 1990).

Given the transboundary nature of the resource and the importance of the canning industry in Maine and New Brunswick, a special arrangement has existed for over a century whereby catches can be landed in ports of either country without restrictions. During the last decade, however,

herring have been imported into the U.S. for canning in Maine (10,000 to 20,000 mt or 22 to 44 million lbs a year), not exported to Canada (Livingston and Stevenson 1993). This arrangement is crucial to the canning industry of the two countries since it provides for a more sustained supply of raw material for the industry as a whole.

REFERENCES

Livingston, L. and D.K. Stevenson 1993. 1992 Maine herring fishery statistics. Maine Dept. Marine Resources Res. Ref. Doc. 93/1.

Rivard, D., W.D. McKone and R.W. Elner (ed.) 1988. Resource prospects for Canada's Atlantic fisheries, 1989-1993. Communications Directorate, Dept. Fisheries and Oceans, Ottawa. DFO/4061, 270 p.

Stephenson, R.L., D.E. Lane, D. Aldous and R. Nowak 1993a. Management of the 4WX herring (Clupea harengus) fishery: an evaluation of recent events. Can. J. Fish. Aquat. Sci. (in press).

Stephenson, R.L. et al. 1993b. 1992 4WX herring assessment. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc.

Stephenson, R.L., M.J. Power, J.B. Sochasky, W.H. Dougherty, F.J. Fife, G.D. Melvin and D.E. Lane 1992. 1991 4WX herring assessment. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 92/69, 51 p.

Stephenson, R.L. 1990. Multiuse conflict: aquaculture collides with traditional fisheries in Canada's Bay of Fundy. World Aquaculture 21:34-45.

ATLANTIC HERRING LANDINGS
NEW BRUNSWICK FIXED GEAR, 1960-1992

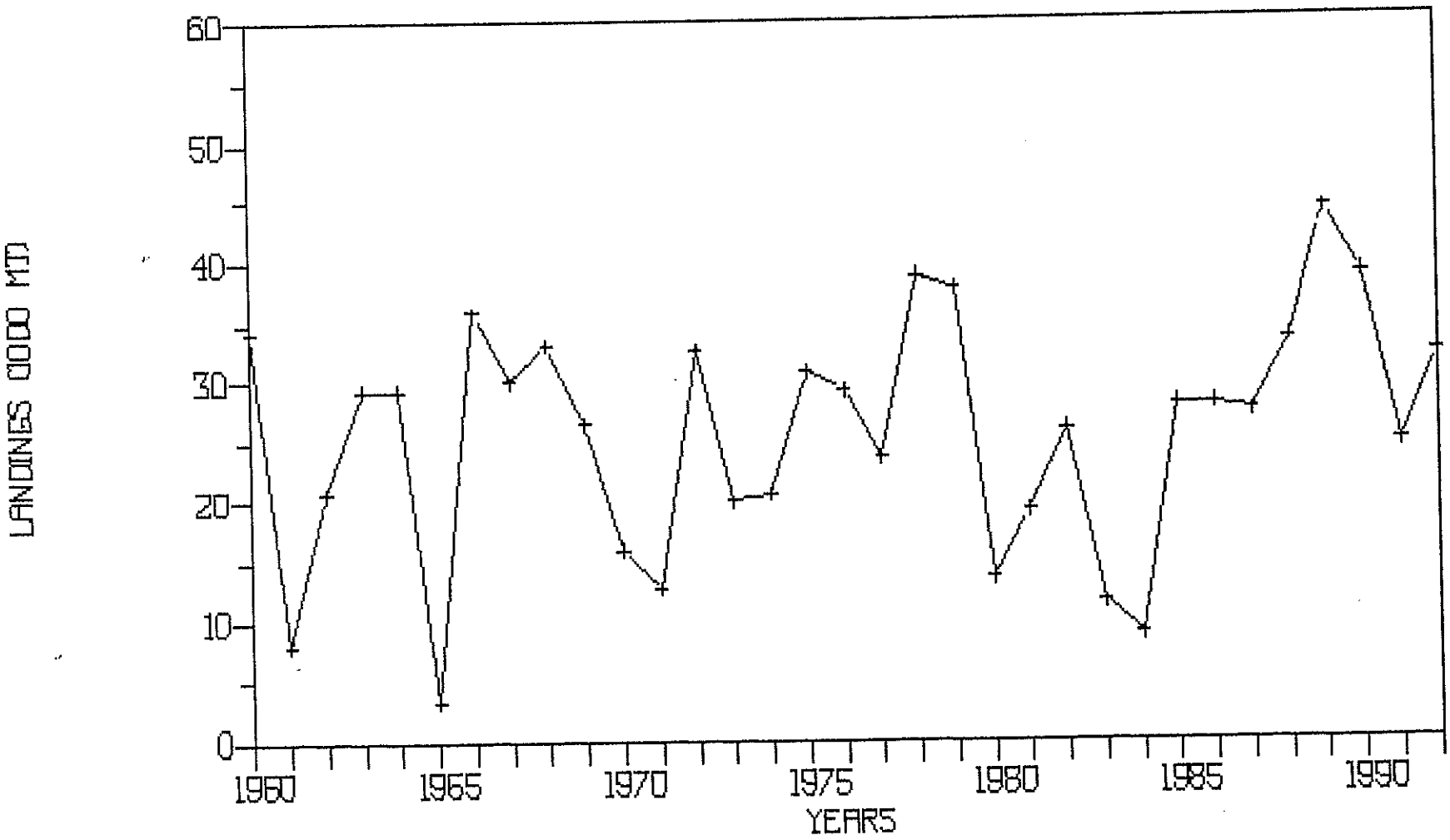


Fig. 5.5.4

6. FISHERY MANAGEMENT PROGRAM

6.1 Management Specifications

In this plan, optimum yield (OY) is based on the total allowable biological catch (ABC) which the coastal stock complex will sustain, as determined from an annual assessment of the stock (Fig. 6.1.1). Optimum yield may be adjusted for social, economic, or ecological reasons. The choice of OY and the conservation and management measures proposed to achieve it are intended to prevent overfishing. Optimum yield for Atlantic herring is all herring harvested pursuant to this management plan, including domestic and internal waters processing (IWP) operations in U.S. waters. In addition, this plan allows for expected Canadian harvest from this stock complex. OY will be determined annually as a specific quantity according to the procedure described below (section 6.2.2); it will change as stock abundance and the target fishing mortality rate vary.

Overfishing for the U.S. coastal Atlantic herring stock is defined as a fishing mortality rate greater than the rate which corresponds to the 20% maximum spawning potential (MSP) level. Under this definition, the target F value (F = 0.29) would be produced by a fishery which reduces the stock to 20% of its maximum spawning potential (NEFSC 1993), i.e., the spawning potential that would exist in the absence of any exploitation. The fishing mortality rate at 20% MSP would reduce the population by 25% a year. At this exploitation level, total mortality from fishing and natural causes would remove an estimated 38% of the population annually.

Recent stock assessment information indicates that Atlantic herring are substantially underexploited. There is currently an opportunity to expand this fishery if new markets can be developed. Internal waters processing arrangements provide an opportunity to take advantage of surplus adult biomass. The management measures described below provide a procedure for making annual allocations of surplus adult biomass between states which receive IWP applications in a manner designed to utilize surplus biomass without depleting the overall stock or

jeopardizing individual spawning components within the coastal stock complex. (See Appendix A for IWP permit application procedures).

6.2 MANAGEMENT MEASURES

6.2.1 Management Areas

The management unit is divided into three management areas to facilitate the overall management program (Fig. 6.2.2). This action is based on knowledge of the seasonal distribution and availability of juvenile and adult fish within the management unit, regional differences in the nature and degree of harvesting (different gear types) and processing activity (differences in sizes and ages of fish processed), differences between the inshore and offshore fishing grounds and habitat, and the location of known spawning grounds. One of the most important reasons for distinguishing management areas is the concern to avoid over-exploitation of individual spawning populations that are included within the stock complex. Despite the the fact that the management unit extends throughout the range of the species in U.S. waters, there is evidence that indicates that the U.S. Atlantic herring resource is comprised of separate spawning populations which occupy identifiable areas prior to and during spawning.

For the reasons given above, it is appropriate to establish an overall management program which is consistent with unique conditions of the resource and the fishery within separate management areas and allows for the cooperative management of the resource by different regulatory jurisdictions (the states, the Atlantic States Marine Fisheries Commission and the New England and Mid-Atlantic Fishery Management Councils). Specifically, the approach developed in this plan establishes a basis for allocating surplus adult biomass between three management areas for internal waters processing, and for implementing area-specific spawning closures and other state management regulations, as appropriate.

The three management areas (Fig. 6.2.2) are defined as:

Management Area 1 (North Coastal Area)

All U.S. waters of the Gulf of Maine north of a line extending from the eastern shore of Monomoy Island at 41° 35' N eastward to a point at 41° 35' N, 69° W, thence northeasterly to a point along the Hague Line at 42° 53' 14" N, 67° 44' 35" W, thence northerly along the Hague Line to the U.S.- Canada border, to include state and federal waters adjacent to Maine, New Hampshire, and Massachusetts.

Management Area 2 (South Coastal Area)

All waters west of 69° W and south of 41° 35' N, to include state and federal waters adjacent to Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia and North Carolina.

Management Area 3 (Georges Bank)

All U.S. waters east of 69° W and southeast of the line which runs from a point at 69° W and 41° 35' N, northeasterly to the Hague Line at 67° 44' 35" W and 42° 53' 14" N.

6.2.2 Allocation Procedures

The following describes procedures for determining the total allowable biological catch (ABC), the domestic annual harvest (DAH), the available surplus catch, the total catch available for foreign IWP processing, and IWP allocations between areas (Fig. 6.1.1). It also establishes an institutional framework for controlling the domestic fishery if and when the resource becomes overexploited. Such controls could be applied separately for juvenile and adult herring, and and could only be implemented as part of the joint ASMFC/NEFMC management plan.

Consistent with the management goal and objectives of this plan, the total allowable biological catch (ABC) is determined by applying the 20% MSP target F to age specific stock biomass estimates from the annual analytical assessment (virtual population analysis or VPA) weighted by the observed pattern of partial recruitment. The adult ABC is

calculated by applying the target F to stock biomass estimates for fish three years of age and older. (Since reliable estimates of juvenile (age 2) biomass can not be derived from the VPA for the most recent year, other procedures will be investigated for estimating juvenile abundance and included in the joint ASMFC/NEFMC plan as a prerequisite for calculating the juvenile ABC).

In order to calculate the available adult surplus each year, the annual domestic adult harvest by the United States and Canada is deducted from the total adult ABC. The expected US and estimated Canadian harvest of adult fish will be based on the recent performance of existing fisheries. The estimated Canadian catch includes New Brunswick (weirs and stop seines only) and Georges Bank. Deduction of the expected Canadian harvest assumes that Canada will adopt management goals and measures which are consistent with those described in this plan. If this does not happen, the management goal and objectives of this plan will be jeopardized.

The combined U.S. and expected Canadian domestic annual harvest of adults cannot exceed the total adult ABC for the coastal stock complex. Because the resource is currently under-utilized, no limits on the domestic harvest are necessary at this time. They will be considered as part of a joint ASMFC/NEFMC management planning process to be initiated following adoption of this plan. In the event that the stock becomes over-exploited (when the 20% MSP level is exceeded or when total harvest exceeds total ABC), adult and juvenile catch limits may need to be imposed and allocated to each area according to guidelines which will be developed by the Plan Development Team following the adoption of this (ASMFC) plan (see 6.3.3).

Adult surpluses can be expected as long as the stock remains under-utilized. A percentage of the adult surplus will be held in reserve to allow for growth and expansion of domestic fishing activity. The balance of the adult surplus is available for IWP harvest in areas 1, 2, and, while improbable, in area 3. However, until a ASMFC/NEFMC plan is adopted, no joint venture activities can be initiated in the EEZ. Following the procedures outlined in this (ASMFC) plan, IWP allocations will be made between all three management areas, with no single area

receiving more than 50% of the total. Decisions concerning the percentage of the adult surplus to hold in reserve and the percentage allocated for IWP harvest in each area will be made by the ASMFC Atlantic Herring Section each year, acting on advice from the Technical Advisory Committee. Advice on area IWP allocations will be based on biological as well as socioeconomic criteria.

Information concerning the quantity, age and size composition, and catch location of IWP landings is crucial for resource monitoring and assessment purposes. Each state will be responsible for monitoring the catch and developing a means to do it, either by placing observers aboard the processing vessels or requiring the use of logbooks by fishermen who are supplying fish for processing. Samples should be collected and provided to the Maine Department of Marine Resources for processing and/or length frequency data should be collected by the observers.

6.2.3 Spawning Closures

This plan retains existing spawning closure regulations which affect fishing in state and federal waters in the Gulf of Maine and which are embodied in the Interstate Sea Herring Management Plan, an agreement between Maine, New Hampshire, Rhode Island and Massachusetts which was adopted in November 1983 and which was formally recognized by the ASMFC in 1987. These regulations affect fishing activity in all three management areas designated in this plan. Additional spawning closure regulations may be considered in the process of developing a joint ASMFC/NEFMC management plan.

Existing spawning closure regulations in effect are:

1. A four week closure in eastern Maine beginning August 15 (unless samples of the commercial catch taken prior to the closure date indicate that females are delayed in reaching full maturity, see below) during which time it is unlawful to fish for or take herring containing spawn (milt or roe) when they make up more than 25% by number of any load.

2. A four week closure in two additional areas in central and western Maine beginning September 1 subject to the same monitoring of maturity and 25% tolerance exceptions.

3. A three week closure beginning October 1 for the area south of 43° 32'N (Cape Elizabeth) that is not subject to any tolerance exceptions. The closure date in this area is subject, however, to successive one week delays if sampling indicates that spawning will be delayed (identical to provisions which apply in the three areas north of 43° 32'N). This closure is enforced jointly by the four states which are party to the Interstate Herring Management Plan.

Monitored closures: Spawning closures in these four areas will be monitored by calculating the gonad somatic index (GSI) of mature females (ICNAF stages III-V) in two size classes obtained from commercial catch samples collected just prior to the automatic closure date. The GSI is calculated as the ratio of the gonad weight to the body (somatic) weight of the fish (total weight minus gonad weight). A one week delay in the automatic closure date will be implemented for any area if samples of at least 30 fish (in either defined size range) caught in that area indicate that the average GSI is below the threshold values for either of two size classes (18% for fish equal to or larger than 28 cm TL and 10% for fish >24 and <28 cm TL) prior to the automatic closure date. Additional one week delays will be implemented for any area in which additional samples indicate that at least one size class has not yet reached the threshold value.

Definition of areas subject to spawning closures

During the duration of designated spawning closures, it shall be unlawful to fish for, have on board, or land any Atlantic herring containing spawn (milt or roe) except as provided for above. Landings restrictions apply in Massachusetts regardless of where the fish are caught. In Maine, spawning closures refer to the capture of herring within designated areas; landings in ports within a closed area are permitted if the fish were caught outside the closed area. The New Hampshire regulations are consistent with the Massachusetts regulations except that an incidental herring catch of 5% by weight or 1000 pounds

(whichever is the greatest) is allowed. Spawning closures will continue to apply in the following areas (see Fig. 6.2.3.1).

Area 1 (eastern Maine): area northeast of Loran C 9960-W-12275 (Schoodic Point) to the U.S.-Canadian border.

Area 2 (central Maine): area east (or north) of Loran C 9960-W-12825 (Small Point) to Loran C 9960-W-12275 and north of 43° 32' N.

Area 3 (western Maine): area bounded by 43°32' N (Cape Elizabeth) on the south and by Loran C 9960-W-12825 on the east (or north).

Area 4: area south of 43° 32'N, including state and federal waters adjacent to Maine, New Hampshire and Massachusetts and the southern New England area.

6.2.4 Habitat Management Measures

The following habitat management measures are recommended:

1) Assure that the Clean Water Act (Section 319) Non-Point Source Plans and Coastal Non-Point Pollution Control Plans are developed and implemented such that adverse impacts of non-point source pollutants on Atlantic herring are minimized;

2) Strengthen enforcement of sewage discharge, or NPDES (National Pollutant Discharge Elimination System) permit effluent limits from treatment plants, and ensure proper maintenance and operation of domestic septic systems;

3) Implement effective oil and toxic chemical spill prevention and control programs to prevent accidental release, and prioritize cleanup plans to protect areas where Atlantic herring spawn or areas inhabited by Atlantic herring at different stages of their life history;

4) Establish and enforce vessel "no discharge" zones, and promote education of recreational boaters to reduce contamination of nearshore waters from chronic fuel spills and waste disposal;

5) Prohibit dredging activities, including disposal of dredge spoil, in areas where herring are known to deposit eggs;

6) Assist industrial siting councils in siting new power plants so that impingement and entrainment of Atlantic herring are minimized, and;

7) Establish critical spawning habitat areas or special management zones to protect spawning aggregations of herring and/or demersal egg masses.

6.2.5 Other management measures

In addition to spawning closure regulations and habitat management measures outlined in this plan, it is recommended that the use of bottom-tending gear (e.g., otter trawls and dredges) be prohibited in designated spawning areas during spawning closures. The exact locations of any such restricted areas would be determined by the Technical Advisory Committee.

6.3 INSTITUTIONAL REQUIREMENTS

6.3.1 IWP Policy and Allocation Process

Acting on the biological advice provided by the ASMFC Technical Advisory Committee (TAC), the ASMFC Atlantic Herring Section will meet annually in late April or early May to determine a total IWP allocation for the 12 month period beginning July 1 and to further allocate the total amount between management areas 1 and 2. The TAC and the Section will consult as needed with the Industry Advisory Committee and the New England and Mid-Atlantic Fishery Management Councils. State by state allocation decisions within areas 1 and 2 will be made by member states within each of those two areas each year. States currently involved in the IWP allocation process for the herring resource in Area 1 are Maine,

New Hampshire, and Massachusetts. States currently involved in Area 2 are Massachusetts, Rhode Island, Connecticut, New York and New Jersey.

6.3.2 Plan Review and Monitoring

Technical advice will be provided annually to the Atlantic Herring Section by the Technical Advisory Committee. A Plan Review Team will be designated by the ASMFC Management and Science Committee to review progress in implementing the provisions of this plan.

The Technical Advisory Committee (TAC) will annually provide the best available data including, but not limited to, commercial and recreational catch/landing statistics, current estimates of fishing mortality, stock status, the most recent estimates of recruitment, stock assessment results, and target mortality levels to the Section for review. A representative of the Canadian Department of Fisheries and Oceans (DFO) will be invited to observe at TAC meetings. Assessment procedures and results will periodically be reviewed by the Stock Assessment Review Committee (SARC), a group made up of assessment scientists from the states and the National Marine Fisheries Service. A DFO representative with expertise in pelagic resource assessment will be invited to participate in SARC proceedings. The TAC will prepare:

a) an annual assessment of the stock;

b) an annual estimate of total and adult ABC;

c) projections of expected U.S. and Canadian harvest (adults only) from the stock complex for the current year;

d) a calculated total adult surplus;

e) a recommended percentage of the adult surplus to hold in reserve; and

f) recommended allocations of the remaining adult surplus between management areas 1 and 2.

6.3.3 Future ASMFC/NEFMC Joint Management Planning

This ASMFC Atlantic Herring Management Plan is designed to be a precursor to a joint ASMFC/New England Fishery Management Council (NEFMC) management plan. Upon adoption of this plan by the Commission, it is recommended that a joint Management Plan Development Team (PDT) be maintained with membership from ASMFC, the Councils, and appropriate federal agencies. The responsibility of the PDT will be development of a more comprehensive Atlantic herring management plan. This plan will recommend measures to prevent overfishing throughout the entire management unit area while providing for an orderly development of the fishery. Such measures may include:

- restrictions on domestic harvest;
- further control of IWP harvest;
- establishment of joint ventures with appropriate controls and procedures;
- gear restrictions in certain areas and/or times of year;
- complementary management with Canada on Georges Bank and in eastern Maine-New Brunswick;

Responsibility for limiting total harvest and making allocations among the three management areas established by the ASMFC plan will be shared by the ASMFC and the New England Council. Joint management planning will be required. Final management responsibility within the two coastal areas will rest with the ASMFC. Final management responsibility in the offshore area will rest with the NEFMC. The ASMFC and the two Councils will need to develop a rationale and methods for controlling exploitation and allocating the total allowable catch (IWP and domestic) between areas. In the event it becomes necessary to allocate domestic sea herring landings among management areas, this shall be done as fairly and equitably as possible, with due consideration to the principles embodied in management objective #7 and based on the deliberations of the applicable management entity of the Commission.

Any future management actions in areas 1 and 3 hould, in some fashion, be coordinated with Canadian fishery management agencies.

6.3.4 Interactions with Canada

In order to facilitate complementary Atlantic herring management between the United States and Canada, it is recommended that there be an annual meeting held between representatives of industry, the ASMFC, NEFMC, and federal and provincial Canadian management agencies. As indicated above, a Canadian DFO representative will also be invited to observe at TAC meetings and to participate in periodic reviews of the U.S. assessment at the Stock Assessment Review Committee meeting at the NMFS Northeast Fisheries Science Center. A U.S. representative should also be encouraged to participate at the annual CAFSAC Pelagic Subcommittee meeting. In addition, Atlantic Herring Science and Assessment Workshops conducted jointly by U.S. and Canadian scientists should be held at least once every three years.

6.4 RESEARCH NEEDS

The following research has been identified as crucial to the success of the management plan and should be initiated as soon as possible:

a) develop socioeconomic analyses appropriate to the determination of optimum yield;

b) develop economic analyses necessary to evaluate the costs and benefits associated with different segments of the industry;

The following research is crucial for long term assessment and resource monitoring purposes and should be implemented:

a) continue resource monitoring activity, especially larval surveys which will indicate the relative importance of individual spawning areas and stocks and the degree of spawning stock recovery on Georges Bank and Nantucket Shoals;

b) develop new approaches to estimating recruitment (i.e., juvenile abundance) from fishery independent data;

c) organize annual U.S.-Canada workshops to coordinate stock assessment activities and optimize cooperation in management approaches between the two countries;

d) identify known spawning areas where herring deposit eggs.

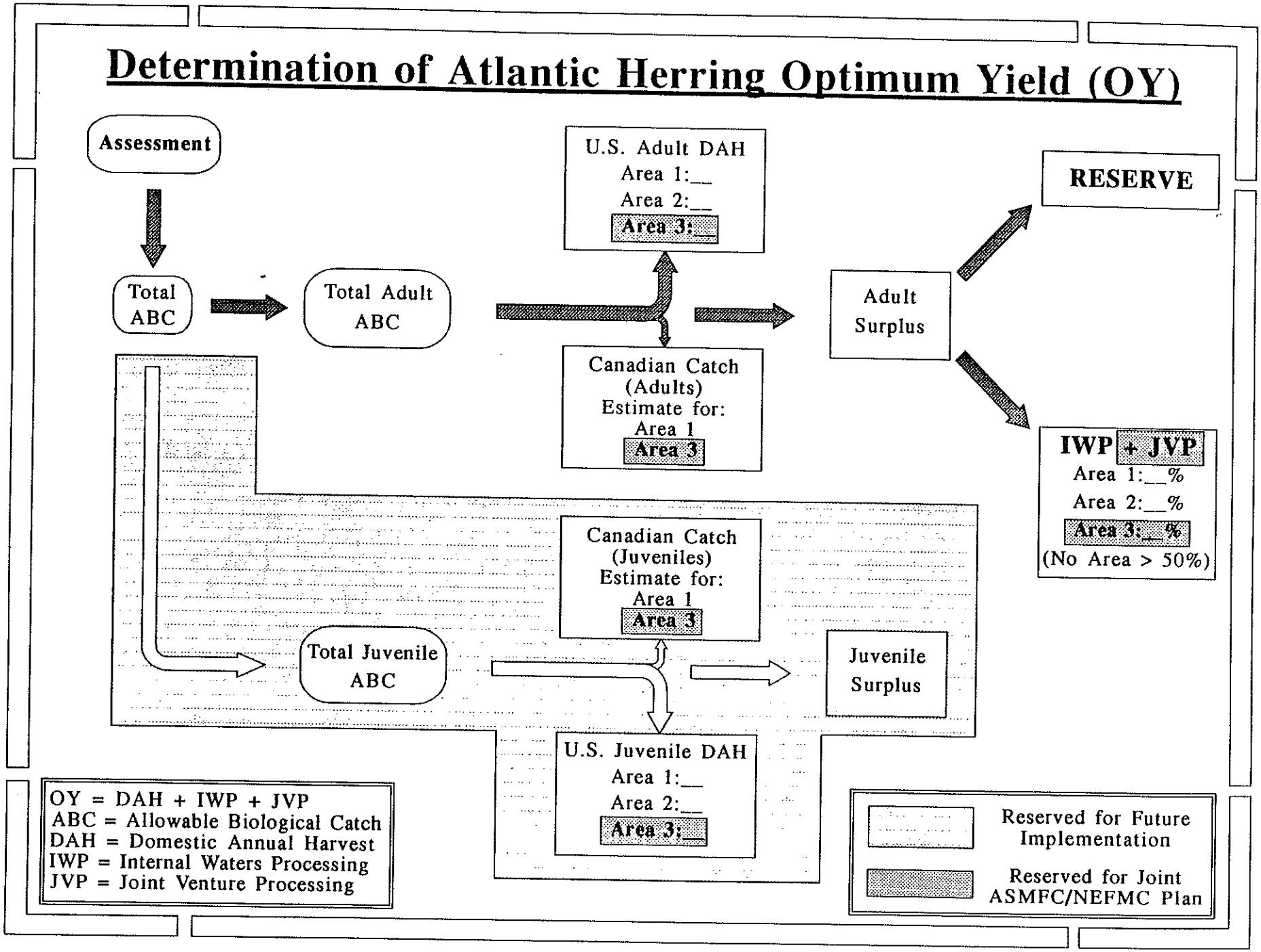
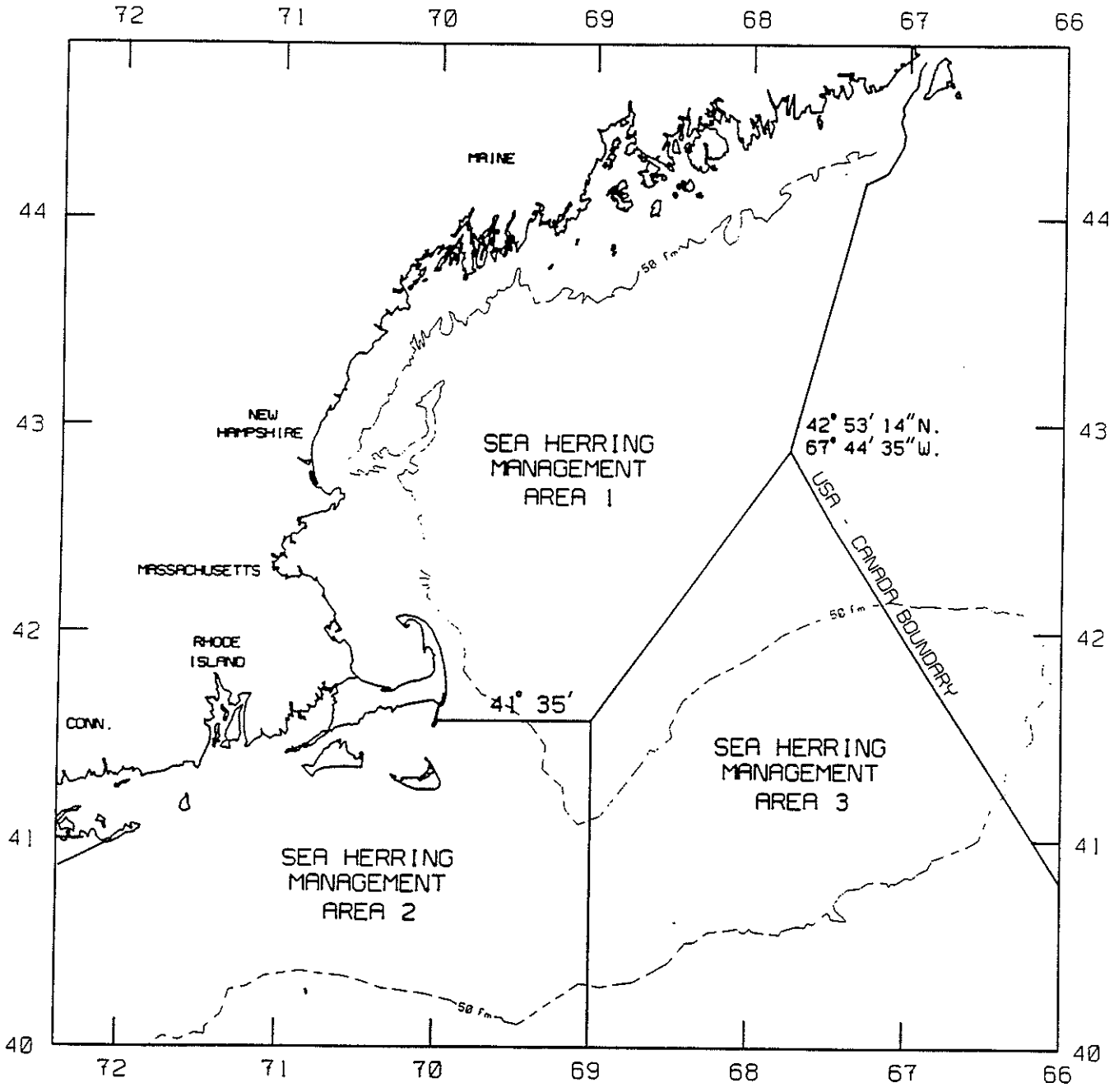

Determination of Atlantic Herring Optimum Yield (OY)
Assessment
Total ABC
Total Adult ABC
U.S. Adult DAH
Area 1:__
Area 2:__
Area 3:__
Canadian Catch (Adults) Estimate for:
Area 1
Area 3
Adult Surplus
RESERVE
IWP + JVP
Area 1:__%
Area 2:__%
Area 3:__%
(No Area > 50%)
Canadian Catch (Juveniles) Estimate for:
Area 1
Area 3
Total Juvenile ABC
Juvenile Surplus
U.S. Juvenile DAH
Area 1:__
Area 2:__
Area 3:__
OY = DAH + IWP + JVP
ABC = Allowable Biological Catch
DAH = Domestic Annual Harvest
IWP = Internal Waters Processing
JVP = Joint Venture Processing
Reserved for Future Implementation
Reserved for Joint ASMFC/NEFMC Plan

Figure 6.1.1

Fig. 6.2.1


72
71
70
69
68
67
66
44
43
42
41
40
MAINE
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONN.
50 fm
SEA HERRING MANAGEMENT AREA 1
SEA HERRING MANAGEMENT AREA 2
SEA HERRING MANAGEMENT AREA 3
42° 53' 14"N.
67° 44' 35"W.
USA - CANADA BOUNDARY
41° 35'

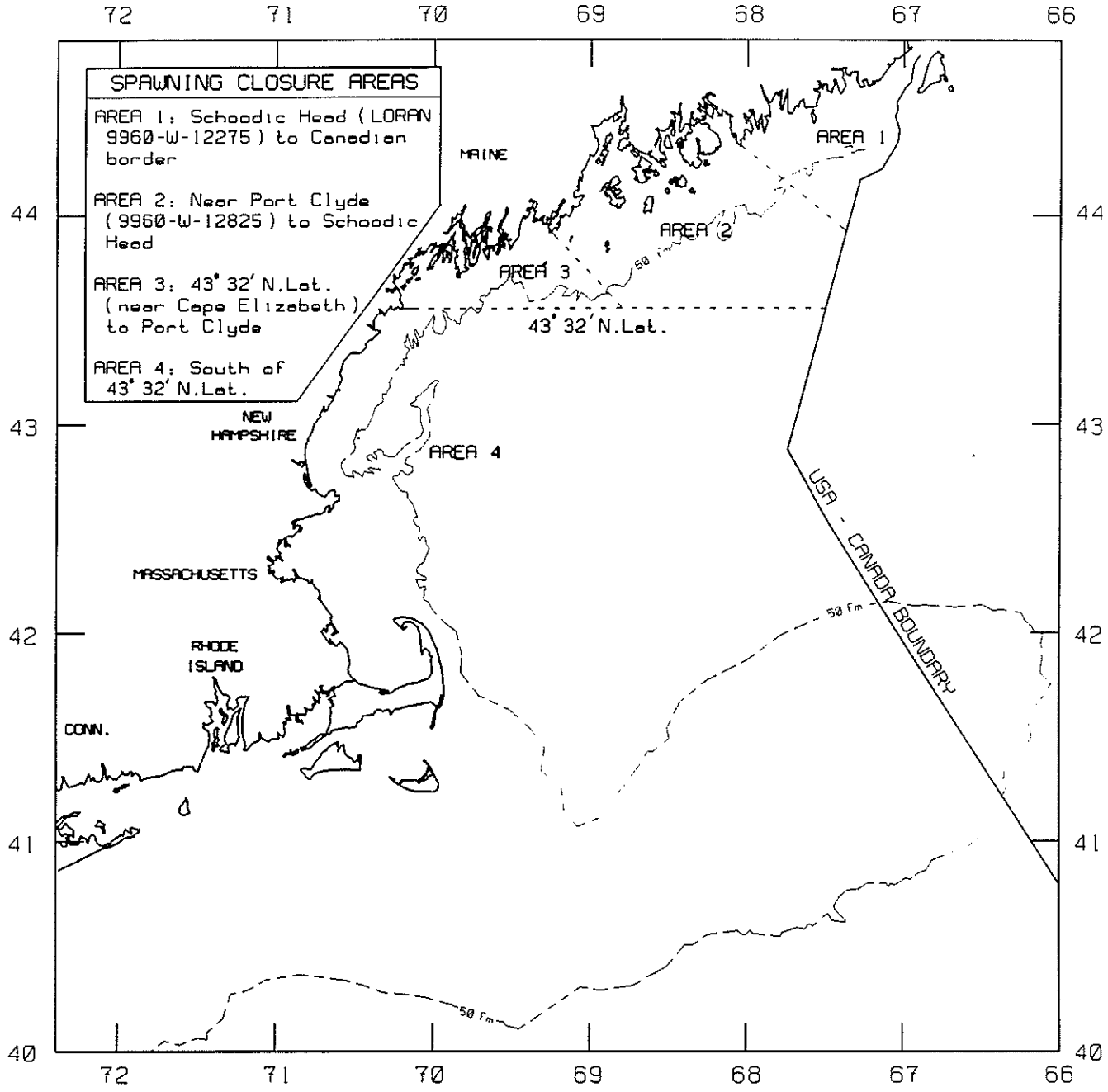

SPAWNING CLOSURE AREAS
AREA 1: Schoodic Head (LORAN 9960-W-12275) to Canadian border
AREA 2: Near Port Clyde (9960-W-12825) to Schoodic Head
AREA 3: 43° 32' N.Lat. (near Cape Elizabeth) to Port Clyde
AREA 4: South of 43° 32' N.Lat.
72
71
70
69
68
67
66
44
43
42
41
40
MAINE
NEW HAMPSHIRE
MASSACHUSETTS
RHODE ISLAND
CONN.
AREA 1
AREA 2
AREA 3
AREA 4
43° 32' N.Lat.
50 Fm
USA - CANADA BOUNDARY

Fig 6.2.2

APPENDIX A

ATLANTIC STATES MARINE FISHERIES COMMISSION
INTERNAL WATERS PROCESSING

PERMIT APPLICATION AND REVIEW PROCEDURES FOR ATLANTIC HERRING

1. The fishing year should consist of two periods, July 1 - October 31 (summer-fall), and November 1 - June 30 (winter-spring).

2. Permit applications shall be submitted to the individual states no later than March 1 for the next summer-fall and winter-spring fisheries.

3. The states' marine resources management agencies should review and cull the applications and provide the following information to ASMFC no later than April 15:

   (a) the quantity proposed to be processed and the processing methods to be used;

   (b) the time period(s) for which permission is sought;

   (c) the specific location(s) in the internal waters proposed for fish processing;

   (d) other information as needed.

4. In the review of IWP application information, the following criteria will be considered by ASMFC:

   (a) whether or not the cumulative amount requested by applicants will adversely impact the stock or the traditional fishery (advice specific to this issue will be solicited from the appropriate ASMFC/ISFMP Section or Management Board or Fishery Management Council);

   (b) whether or not the cumulative amount requested will cause catch levels from the region to exceed historical landings.

5. The ASMFC should provide recommendations to the governors of the individual states by May 15. Such advice may include:

   (a) total IWP species allocation by state
   (b) times and areas of operations
   (c) observer coverage
   (d) manner and method of harvest.

6. To assist the states in their review processes, the following information should be required of each applicant by each state:

   (a) the reasons the applicant does not believe that U.S. fish processors in the region have adequate capacity, or will use such capacity, to process all of the United States-harvested

fish from the U.S. fishery of concern that are landed in the region, including any relevant documentation supporting such statement;

(b) a description of the foreign fish processing vessel and other indentification information;

(c) the name(s) and description(s) of the vessel(s) from which the applicant expects to purchase fish;

(d) the quantity proposed to be processed and the processing methods to be used;

(e) the time period(s) for which permission is sought;

(f) the specific location(s) in the internal waters proposed for fish processing;

(g) the existence of a governing international fisheries agreement or treaty as described in 16 U.S.C. 1801 et seq..., as amended;

(h) the ability to comply with all applicable laws and regulations of the United States and the states involved and any permit conditions;

(i) the ultimate country of sale of the product;

(j) information showing how the fish processing will benefit development of the domestic fishing industry;

(k) whether past over-the-side sales commitments, permit conditions, and other requirements have been met; and,

(l) other information as needed.

APPENDIX B

MEMORANDUM OF UNDERSTANDING PROVIDING FOR THE REGIONAL MANAGEMENT OF ATLANTIC SEA HERRING (CLUPEA HARENGUS) UNDER AMENDMENT #1 OF THE ATLANTIC STATES MARINE FISHERIES COMMISSION

Section 1. Authority

By act of the United States Congress [50 Stat. 267 (codified at 16 U.S.C. § 667a (1974)] consent was given to the United States Marine Fisheries Compact and by Act of the United States Congress (64 Stat. 467) consent was given to an amendment to the Atlantic States Marine Fisheries Compact. Pursuant to those acts and under authorities conferred through 12 MRSA 460; et seq (1981 and Supp. 986-87) [Maine]; RSA 206:10, 206:23, 211:62 and 213:2 [New Hampshire]; G.L. c.21, §5 and G.L. c.21A, §§(1) and (6) [Massachusetts]; G.L.R.I. 20-8-2 [Rhode Island]; C.S.G. Chap. 290, Sec. 26-3 and Sec. 26-296 [Connecticut]; NYS Environmental Conservation Law, Title 3, Sec. 11-0303, and Sec. 13-0371 [New York]; and 23:2b-8 [New Jersey]; the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and New Jersey hereby enter into a cooperative agreement for the management of Atlantic sea herring throughout their respective jurisdictions.

Section 2. Purpose and Scope

The purpose and scope of this agreement shall be:

(a) To establish an Amendment One Section of the Atlantic States Marine Fisheries Commission to provide for the joint management of the Atlantic sea herring resource subject to the jurisdiction of the cooperating states and in which those states have a common interest;

(b) To harmonize the management of the herring resources;

(c) To assure that any allocation of herring resources by any management measure adopted pursuant to this agreement is fair and equitable to all affected persons, groups, or organizations;

(d) To assure that, where practicable, the herring resources which are subject to the jurisdictions of the States and the New England Fisheries Management Council are managed in a consistent manner by federal and state authorities and by the Commission;

(e) To assure that all affected users, States, and other interested parties have an opportunity to comment upon any proposed management measures contemplated under this agreement; and

(f) To promote the better utilization of the herring resources subject to the jurisdictions of the States by the development and implementation of a joint program for promoting and conserving such resources, for protecting those resources from overfishing, waste, depletion, or abuse, and for assuring a continuing yield of those resources.

Section 3. Enforcement

The states agree to cooperate with and assist one another in the enforcement of any management measures adopted pursuant to this agreement.

WITNESS, the hand and seal of the representatives of the management states:

Maine	Date
New Hampshire	Date
Massachusetts	Date
Rhode Island	Date
Connecticut	Date
New York	Date
New Jersey	Date

I do hereby attest to the above:

John H. Dunnigan Executive Director, Atlantic States Marine Fisheries Commission	Date