7.0 Relationship with Other Applicable Laws

7.1 National Environmental Policy Act (NEPA)

The Environmental Impact Statement (EIS) is incorporated into this document. For ease in recognition, all sections of the EIS are numbered beginning with the letter "E". The EIS begins with the following cover sheet.

COVER SHEET

RESPONSIBLE AGENCIES:

Assistant Administrator for Fisheries
National Oceanic and Atmospheric Administration
U. S. Department of Commerce
Washington, D. C. 20235

New England Fishery Management Council
Suntaug Office Park
5 Broadway (Route 1)
Saugus, MA 01906

PROPOSED ACTIONS:

Adoption, approval, and implementation of the fishery management Plan for Atlantic Herring (Clupea Harengus).

FOR FURTHER INFORMATION CONTACT:

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TYPE OF STATEMENT

( ) DRAFT (X) FINAL

ABSTRACT:
The New England Fishery Management Council and the NOAA Assistant Administrator for Fisheries propose to adopt, approve and implement pursuant to the Magnuson-Stevens Fishery Conservation and Management Act a fishery management plan (FMP) for Atlantic Herring. The FEIS present the details of a long-term herring management program which is designed to address identified management problems. Elements of the program include the adoption of management objectives and supporting management strategy which incorporates measures for immediate implementation. The management measures selected by the Council are intended to achieve the management objective through their positive effects on the long-term abundance and productivity of the herring resource. Specifically, measures being recommended for the management program include: (1) establishment of an overfishing definition, (2) the adoption of a Total Allowable Catch (TAC) for the herring fishery and distribution of the TAC across time and area (3) closure of the fishery in an area when the TAC is reached (4) the permitting of all participating vessels, operators, and dealers (5) the requirement that licensed vessels and dealers be subject to mandatory data reporting (6) implementation of effort controls (7) restrictions on size and type of vessels allowed in the fishery (8) a series of spawning area closures.

DATE BY WHICH COMMENTS MUST BE RECEIVED: __________ _

E.1.0 Environmental Impact Statement Cover Sheet

Preceding page.

E.2.0 Table of Contents

The Table of Contents for the EIS is integrated into the table of contents on page iv of this document.

E.3.0 Summary

E.3.1 Background

The Magnuson-Stevens Fishery Conservation and Management Act (M-SFCMA) established a national program of fisheries management designed to achieve the optimum yield from the fishery resources of the U.S. The M-SFCMA authorizes eight regional fishery management councils to prepare comprehensive fishery management plan (FMP) for the resources within their geographical areas of authority. These FMPs are in turn submitted to the Secretary of Commerce for approval and implementation through the promulgation of federal regulations.

The National Environmental Policy Act (NEPA) requires all agencies of the federal government to include in every proposal for "major federal actions significantly affecting the quality of the human environment" a detailed statement on the environmental impacts of and alternatives to the proposed action. NOAA has determined that actions initially adopting and implementing natural resource management plans, programs or policies, including fishery management plans, are action which normally require an environmental impact statement (NAO 216-6).

The "major federal action" described in this statement is a process, prescribed by the M-SFCMA, with three identifiable phases, i.e. adoption, approval, and implementation of an Atlantic Herring FMP. The first step in the process is taken by the New England Fishery Management Council (Council). The second and third steps are taken by the Assistant Administrator for Fisheries of NOAA, under authority delegated by the Secretary of Commerce.

The Fishery Management Plan for Atlantic Herring has been under development by the Council since 1996. The proposed management measures were developed in consultation with the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fishery Management Council (MAFMC). This draft environmental impact statement (DEIS or statement) is intended to accompany the proposed measures through the M-SFCMA process and serve as a vehicle for further public and agency review. Comment received on the DEIS were thoroughly considered by the Council in its preparation of the final Atlantic Herring FMP and the final EIS.

This EIS draws directly from the proposed management measures for Atlantic herring for the background of herring management, the problems to be addressed, and the description of the proposed management measures. In some parts, these sections have been restructured and edited liberally to fully comply with the NEPA standard format for environmental impact statements. (Where appropriate, extensive references are given to more complete technical and descriptive discussions within the proposed management measures.)

A detailed background of herring management is contained in section 2.1 of this document. The New England Fishery Management Council has reviewed the status of the sea herring resource and the condition of the industry which utilizes this resource. The Council has determined that sufficient management problems exist to warrant the development and implementation of a federal program for conservation and management. The Council consulted with the Atlantic States Marine Fisheries Commission when making this determination.

The U.S. Atlantic herring fishery is currently managed as one stock complex along the East Coast from Maine to Cape Hatteras although there is evidence to suggest there are at least two separate biological stocks. Generally, the resource has been divided into an inshore Gulf of Maine (GOM) and an offshore Georges Bank (GB)/Nantucket Shoals component. The most recent fully reviewed assessment (NEFSC 1998a) concluded that the abundance of the coastal stock complex is currently at a record high level of 2.9 million metric tons (mt) while the most recent estimate of spawning stock biomass (SSB) is 1.8 million mt.

The herring resource is in an under-exploited state. There is increasing commercial interest in developing this fishery. There are, however, concerns that specific spawning components (notably the Gulf of Maine (GOM) stock) may be unable to sustain current or increased fishing pressure over the long term. There is also concern that uncontrolled exploitation of this component may lead to a stock collapse in the future. Other issues that are to be addressed by this FMP are listed in the goals and objectives section of the proposed management measures (section 2.3).

To address these concerns, the proposed management measures for Atlantic herring establish a continuing management program for the herring resources within the Exclusive Economic Zone (EEZ) of the U.S. This FMP has been coordinated with the Atlantic States Marine Fisheries Commission (ASMFC) to insure its consistency with measures taken within state waters.

E.3.2 Major Conclusions

The EIS concludes that the proposed measures will have positive impacts on the physical, biological, and human environment.

E.3.3 Areas of Controversy

NOAA Administrative Order 216-6 defines "controversial" as referring to a substantial dispute which may concern the nature, size, or environmental effects, but not the propriety, of a proposed action. The need for management is widely recognized through the herring industry. There is near universal agreement with the proposed requirements for permits, spawning closures, reporting systems, and a method to limit catch if it appears sustainable harvests are being exceeded. There are, however, several proposed measures that spark considerable controversy.

The Council considered a controlled access proposal to limit participation in the fishery, depending on qualification criteria selected to issue permits. There is disagreement in the industry on the need for a controlled access system and on the possible qualification criteria. Some view the proposed criteria as overly restrictive for a fishery that is not presently over-exploited. Others believe that a controlled access system should be implemented immediately to protect the resource, particularly the Gulf of Maine spawning component. The Council recommends managing the herring fishery as an open access fishery.

The action recommended for limiting vessel size in the fishery is the subject of considerable debate. The proposed limitation to prevent vessels over the size limits to catch, take or harvest herring was opposed by some segments of the industry. At least one company was preparing to enter the fishery with a vessel that exceeded the size limits, but was prevented from doing so through legislation adopted by Congress. This vessel has not caught or processed any herring in the Northeast Atlantic. This plan would prevent that vessel from entering the fishery. Since this vessel was modified with the intent of entering the east coast herring and mackerel fisheries before any restrictions were in place, there are some in the industry who view the Council's continued ban as an unfair action. At the same time, there was considerable support for limiting the overall size of vessels. An indicator of this support was the passage of the American Fisheries Act in October, 1998, which constrains the future ability of any vessel over 165 feet in length, 750 GRT, or 3,000 horsepower to receive a fisheries endorsement on its documentation.

Similarly, the Council's decision to constrain the ability of boats over the size limit to process herring at-sea polarized participants in the decision process. Many supported an outright ban on this activity, rather than the Council's recommendation to provide an allocation to this sector. At the same time, the Council's decision to recommend this allocation be set at zero for the initial year of the plan drew criticism from those who view at-sea processors as an effective way to make use of the offshore herring resource and develop products for foreign markets.

E.3.4 Issues to be Resolved

The primary scientific issue to be resolved is the identification of specific herring spawning stocks. Because this information is not adequately described, the management plan makes assumptions on the distribution of herring. These assumptions directly impact many of the selected management measures. For example, because of lack of information on spawning locations, the spawning area closures may not be of the correct size, at the right time, or in the correct location, to protect spawning stocks while minimizing impact of the closure on the fishery. A better understanding of the stock structure of herring would lead to better management of the resource.

Another issue concerns the trans-boundary nature of the resource. The management unit is only part of the coastal stock complex, which includes herring in Canadian waters, beyond the jurisdiction of this plan. The size of the Canadian fishery will impact the status of the stocks and the size of the total allowable catch (TAC) available for U. S. fishermen. This fact has been recognized throughout the plan's development. Close cooperation between U.S. and Canadian scientists and fishery managers will be necessary to successfully manage the herring resource.

E.4.0 Purpose and Need for Action

The purpose and need for action is discussed in detail in section 2.2 of this document. Briefly, the primary issue to be resolved is to establish a management regime that will allow the orderly development of a fishery for the herring resource in the EEZ while preventing damage to specific spawning stocks. The Council is concerned that absent a management program, the herring resource—including specific spawning components—could be overfished as a result of increasing commercial interest in the resource. The proposed management measures also provide a framework for the management of joint venture operations in the EEZ. The goals and objectives of the FMP are listed in section 2.3.

E.5.0 Alternatives Including the Proposed Action

E.5.1 Description of the Proposed Action

The proposed action is described in section 3.0 of the document.

E.5.2 Alternatives to the Proposed Action

In the development of the proposed action, the Council considered a number of variations of the measures that were finally adopted. For example, the Council considered different methods to determine the starting or ending dates for spawning area closures. These variations do no constitute a true alternative to the proposed action. Impacts of these variations are discussed in the same sections that summarize the impacts of the adopted measures. The two alternatives considered were no action and the adoption of a limited entry or controlled access system. Impacts of these measures are described individually.

E.5.2.1 No Action Alternative (status quo)

Under the no action alternative, Atlantic herring would continue to be managed under a combination of the Commission's Fishery Management Plan, a Preliminary Management Plan in federal waters, and state regulations. Since Section 314(c) of the M-SFCMA directs the Council to prepare a fishery management plan for any under-utilized species of the northwest Atlantic Ocean to prevent overfishing, and herring are identified as underutilized, the Council is constrained from choosing this alternative.

The Commission is adopting Amendment One to its management plan for Atlantic herring. This amendment was coordinated with the Council so that management in federal and state waters would be complementary. The following list summarizes management provisions that would exist if the Council did not adopt its plan, but the Commission did adopt its amendment for state waters.

ASFMC

- Overfishing reference points and target fishing mortalities
- Adoption of four management areas
- Spawning area restrictions for state waters in the Gulf of Maine
- Vessel, dealer and operator permits
- Vessel and dealer reporting requirements
- Area specific TACs
- Imposition of effort controls as the TAC is approached
- Limitations on directed mealing and the roe fishery
- Prohibition on vessels larger than 165 feet and 3,000 horsepower from harvesting herring

PMP

- Identification of specifications for the herring fishery
- Regulations for the conduct of joint ventures for herring in the EEZ

State

- Existing state regulations are listed in section 4.6. State regulations will change to implement the Commission's amendment to its management plan.

E.5.2.2 Limited Entry/Controlled Access

The primary alternative to the open access system recommended by the Council is a limited entry or controlled access system. The Council considered a comprehensive system that could be adopted for either the entire management unit or for specific management areas. Elements of the open access system (in particular, the use of a TAC) were considered as part of these controlled access proposals.

E.5.2.2.1 Discussion

The controlled access approach was designed to:

1. Conserve the Gulf of Maine stock component which is fully exploited;
2. Provide for continuous fishing throughout the year;
3. Provide opportunities for profitable exploitation of all herring and associated resources;
4. Prevent the development of overcapacity in harvesting or processing by providing appropriate investment signals for the utilization of each stock component, and
5. Permit the safe exploitation of unusually large stocks when they occur.

Under this alternative catches are limited by controlling the amount of fishing effort exerted on a stock. This is done by controlling the number and kinds of permits that apply and on the effort associated with each permit. Two kinds of permits are discussed below: Conservation Permits which guide the harvest of the sustainable portion of the stock , and temporary Development Permits which deal with amounts available above what the Conservation permit holders will take.

The alternative suggested controlling access to the sustainable portions of two components using two controlled access programs: one for the Gulf of Maine component (referred to below as the Gulf of Maine Controlled Access Fishery) and another for the resources outside the first including the Georges Bank and Nantucket Shoals stock components (for convenience referred to as the GB/NS Controlled Access Fishery).

The control on access could have been effective in the Gulf of Maine as soon as the FMP is adopted because sufficient effort may already exist on the sustainable portion of that stock to issue a complete set of Conservation Permits for that area. Different options for this are discussed below. For the other areas, entry into the fishery would be encouraged until 50% of the TAC defined for those areas is taken in a given year. At that time, qualifying factors similar to those proposed to apply for the Gulf of Maine fishery (see below) could be evaluated and a set of Conservation Permits defined for those stock areas will be issued.

E.5.2.2.2 Gulf of Maine Controlled Access Area Options

Two options for defining the area for the Gulf of Maine controlled access fishery are described below based on alternative ways to protect that coastal stock.

Area option 1 Controlled Access Fishery for Gulf of Maine Area 1A.
The controlled access fishery for Gulf of Maine Area 1A (see section 3.4) would draw on the near coastal Gulf of Maine stock. Beside the vessels which will be brought into that program, others fishing on this portion of the Gulf of Maine stock will include:

1. the Maine, Massachusetts and New Hampshire territorial sea open access herring fisheries,
2. those taking a 2000 lb per trip incidental catch of herring in the EEZ in this area and
3. vessels harvesting for any IWP fishery.

The initial allowable harvest from area 1A for controlled access qualifiers would be based on the proportion of a conservative lower bound of the estimate of MSY for the Gulf of Maine component which is considered to be in area 1A, less estimates of what these other fisheries are expected to take. For all areas outside 1A taken together (i.e. Georges Bank and Nantucket Shoals), the available harvest far exceeds the actual harvest.

If this option to defining the Gulf of Maine stock area were chosen, some consideration might be given to restrictions on fishing in area 1B and others may be put on the winter fishery in area 2 to conserve the Gulf of Maine spawning component. These additional measures wouldn't be based on access control, but on some other measures to limit the harvest of the Gulf of Maine spawning component outside of 1A. They would be designed to minimize the impact on the larger herring fishery in those areas.

Area Option 2 Controlled access fishery for Gulf of Maine management area 1 (1A+1B).
Area 1 encompasses almost all of the Gulf of Maine (see section 3.4 and Figure 4). As in option 1, the stock defined for this area would be harvested by those in the controlled access fishery, those in the open access territorial sea fisheries of New Hampshire, Maine and Massachusetts, those taking a 2,000 lb. incidental catch per trip and by those participating in any IWP. The initial

allowable harvest from stock area 1 for controlled access qualifiers would be based on a conservative lower bound estimate of the Gulf of Maine stock's MSY, less what these other fisheries are expected to take. For all areas outside area 1 taken together, e.g. Management Areas 2 and 3, the available harvest is significantly above what is currently caught.

If this option to defining the Gulf of Maine stock area were chosen, some consideration might be given to restrictions on fishing on the Gulf of Maine stock in the winter fishery in area 2. These additional regulations wouldn't be based on controlled access, but would be designed to minimize the impact on the fishery in that area.

E.5.2.2.3 Limits on Catches and Effort

In the simplest TAC arrangement, a "hard" TAC would apply to each of the two controlled access fisheries. More complex arrangements could be based on management areas or different time periods. Each controlled access fishery would have a cap on effort based on individual Days at Sea (DAS). This system would be designed to allow harvesting to occur over the entire fishing year without interruption. A participant in a controlled access fishery would have a Conservation Permit for that fishery which would have a number of DAS associated with it which would be set annually. In general, the initial number of DAS any individual receives would be determined by the number of people who "qualify" into the fishery and how much effort these qualifiers represent. How many people qualify into the fishery is determined by the criteria used. Some options are suggested below. The DAS qualification program for the fishery outside of area 1 (or 1A) would be determined when 50% of the TAC is harvested. Some options for guiding that qualification are suggested in a later section.

In both fisheries, once the qualifiers are identified, the DAS they used would be summed and scaled up or down so that the total effort allowed would be compatible with the allowable harvest. A statistical relationship between DAS and landings would be used to relate catch and the effort that produced it. This relationship would include vessel characteristics (including net size), days at sea, fishing time, landings and possibly other variables. A similar process was developed for the scallop fleet.

The available harvest each year will be expressed at the individual vessel level as days at sea for that particular vessel. Adjustments would be made in individual DAS allocations for individual vessel upgrades so that the total harvesting potential for the fleet is capped. The choice of more complicated TAC options than the two discussed here may make the arrangements described more complicated.

E.5.2.2.3.1 Options for Qualifying for Participation in Area 1 or 1A

The criteria most often used to "qualify" vessels into a controlled access system are the existence of permits and participation in the particular fishery as reflected by landings. Given the lack of herring permits, four options are examined below. Each uses different criteria to qualify participants into the Gulf of Maine controlled access fishery for area 1 or 1A. Some idea of the outcomes from applying these criteria are shown.

Qualifying Option 1 Those who fished in Area 1 and landed herring under a letter of authorization from the Regional Administrator in 1996 or 1997.

Under this option, 15 vessels would be brought into the controlled access program. If this group were to fish as much as the most active vessel in this group (133 DAS), their total catches would be twice the available resource for area 1A or 133,000 mt -- exceeding the MSY estimate for the entire Gulf of Maine stock. If they were to fish the same number of days as their maximum number of days in either year, the projected harvest (35,000 mt) would fall short of the resource available for the controlled access fishery (60,000 mt for 1A and 65,000 mt for area 1). This group contains half the number who would qualify under the next option. Some statistics on the vessels which would qualify under this criterion are listed in section E.7.3.11.2.1 on page 283.

Qualifying Option 2 Those who fished in Area 1 in 1996 or 1997 and who landed 2000 or more pounds on average per trip on which herring was landed.

Under this option, 54 vessels would qualify into the controlled access program by having, on average, larger landings than that provided by the proposed incidental catch regulation (2,000 lb/trip). If this group were permitted to fish as much as the most active vessel (165 trips) in the group, their landings would be more than four times (262,000 mt) the allowable catch for the controlled access program in area 1 If allocated days at sea equivalent to each individual vessel's maximum number of days fished in 1996 or 1997, the total harvest is projected to be 75,000 mt. If each vessels days at sea were reduced proportionately to meet the available harvest, they would have approximately 85% of the maximum number of DAS they used in 1996 or 1997. Some statistical information on those who would qualify under this scheme are included in section E.7.3.11.2.1.

Qualifying Option 3 Those reported fishing in Area 1 in from 1988 through 1997 and who landed 2000 or more pounds on average per trip on which herring was landed.

Under this option, 48 more vessels would be added to the 54 included above under option 2. If they were allocated the maximum number of days they fished in any one year in those ten, their additional contribution to landings would be 18,000 metric tons. By including these vessels, the number of days at sea any one vessel would have available would be their maximum in any one year reduced by thirty percent. Some statistical information on those who would qualify under this scheme are included in section E.7.3.11.2.1.

Qualifying Option 4 Those who possess a multispecies, scallop or squid, mackerel, butterfish permit.

Under this option. 2,848 permits would be issued to the qualifying fleet to fish in area 1 or 1A. The per-vessel allocation of DAS would be quite small on average and close to zero for most participants if the DAS were prorated by landings in recent years. Some vessel characteristics of four tonnage classes of this fleet are included in section E.7.3.11.2.1.

Qualifying Option 5 Reserve 10,000 metric tons of whatever formula is adopted for Area 1 or 1A for performance based qualifying into the Gulf of Maine limited access fishery by vessels with a Northeast multispecies permit.

This option reserves roughly one sixth of the available Gulf of Maine resource in area 1 or 1A for those with groundfish permits who wish to convert to herring fishing. If the vessels involved choose to upgrade in the conversion, they might be required to forego their groundfish permits or, be required to acquire another, probably latent groundfish permit to forego in the upgrading. In this case, the DAS available for those others qualifying would be reduced proportionately. As in the process described below in qualifying for a Conservation Permit for Areas 2 and 3, information on the amount of capacity participating through this route would be monitored closely to prevent the development of overcapacity.

Qualifying Option 6: Option 6 solicits public comment on additional qualifying criteria.

E.5.2.2.4 Options for Qualifying Outside Area 1 or 1A

The GB/NS fishery (defined as all areas outside the Gulf of Maine Controlled Access fishery) would operate as an open access fishery until approximately 50% of the conservative estimate of MSY for those stock areas is taken in a given year. Qualifying criteria for participation in this fishery beside actual fishing and/or evidence of investment for participation could include one or more of the following:

Qualifying Criteria Option 1 Ownership of a vessel having any Northeast Region Permit

Qualifying Criteria Option 2 Meeting a Reserved Vessel Categories Requirement. Categories might be reserved for vessels with a particular mix of qualifications such as those capable of offshore fishing or those possessing mackerel permits (assuming reciprocal arrangements exist).

Qualifying Criteria Option 3 Other

If criteria additional to fishing for and landing herring in anticipation of qualifying for a Conservation Permit for the GB/NS are to be applied, they need to be suggested, adopted and specified before that activity begins. At the point where 50% of the available resource in the GB/NS controlled access fishery is reached several processes for completing the qualification of vessels into the fishery can be pursued. For example:

Option 1 Prorate the activity of participants (DAS) up to a full year's fishing counting only participants and their landings.

Option 2 Prorate the activity of participants (DAS) up to a full year's fishing and an estimate of the potential activity of others having undertaken investments (contracted vessel starts and conversions).

Option 3 Allocate the equivalent of existing DAS utilized by each participant and apply the average to other vessels having undertaken investments to enter the herring fishery.

Option 4 Take into consideration the allocations a vessel has in other fisheries.

Regardless of the nature of process above, estimates of actual and potential capacity in the second controlled access stock areas will be maintained as it develops and the information will be made available to the public.

E.5.2.2.5 Transferability: Conservation Permits and Associated DAS

Once a controlled access fishery is fully subscribed, i.e. the available effort is spoken for, questions about the transferability of either or both the permit itself and the associated DAS arise from a desire for flexibility in taking advantage of market and resource conditions. These needs must be weighed against the administrative burdens and costs of keeping track of such transfers (e.g. leases, grants, consolidation, etc.) and their conditions, and against the desire to maintain local control. From a national perspective, benefits from resources available for harvest should be realized to the extent that they can safely be realized. Initially these are issues for the Gulf of Maine controlled access fishery only. Some options on the transferability of Conservation Permits are:

Conservation Permit Option 1 Conservation Permits may be transferred freely.

Conservation Permit Option 2 Conservation Permits may not be transferred.

Conservation Permit Option 3 Other

Subject to, in all cases, an adjustment (rescaling) of DAS to the particular vessel using them, several options on the transferability of DAS associated with a permit are possible.

CP DAS Option 1 Subject to approval of the Regional Administrator, the annual days at sea (DAS) associated with a Conservation Permit may be transferred (leased or granted or consolidated over vessels) in whole or part but must be utilized in the fishery for which they were designed.

CP DAS Option 2 Days at sea associated with a Conservation Permit may not be transferred (leased, granted or consolidated).

CP DAS Option Subject to approval of the Regional Administrator, other conditions on DAS apply.

Suggestions are solicited which would facilitate the flow of appropriate scale fishing effort to profitable opportunities.

E.5.2.2.6 Fishery Development Permits

The remaining 75% of the herring stock which is found in Areas 2 and 3 is underexploited in a biological sense. Goals 3, 4 and 5 of this alternative are aimed at establishing a system which will allow this currently underutilized resource to provide benefits without the region incurring the long term cost of overcapitalizing harvesting or processing capacity. Guidance can be adopted now which would help minimize the risk of building and investing in excess capacity while not hampering opportunities which exist now or which may soon be available.

Under the controlled access alternative, all fishing in the EEZ for herring outside of that permitted for as incidental catch would be governed by either Conservation Permits or Development Permits. Unlike Conservation Permits, Development Permits exist for a limited time only. In general, development permits are temporary permits which may allow for:

1. the harvest of quantities of resource above the conservative estimates of MSY which govern Conservation Permits (but less than F_{MSY} applied to the current biomass);
2. the harvest of whatever portion of the sustainable resource available for permanent Conservation Permits is not likely to be harvested in a given year as the GB/NS Controlled Access fishery develops in areas 2 and 3; and
3. the harvest of a portion of the sustainable resources in areas 2 and 3 set aside for distressed fisheries.

Other features of Development Permits are designed to discourage permanent over-investment. In the long run, when all of the Conservation permits for the sustainable fishery for herring in areas 2 and 3 have been assigned, the only uses for development permits will be to fish resources above the sustainable yield which are temporarily available if all indications are that this can be done safely and possibly to fish some set aside portion of the sustainable harvest intended for distressed fisheries as determined by the Council and the Regional Administrator. Under these circumstances the following rules would apply to Development Permits:

1. that fishing conducted under these permits provides no “history” for future consideration in the allocation of Conservation Permits; and
2. that in the face of resource contractions, fishing under these permits ceases before downward adjustments are made to the allocation of DAS of Conservation permit holders.

However, prior to the time when all Conservation Permits for fishing herring in areas 2 and 3 are assigned, it may be profitable to conduct fisheries on the unassigned proportion of the sustainable resource as well as any temporarily available resource above MSY. For example it might be possible to have a temporarily expanded set aside for distressed fisheries or one or more of the following activities:

1. IWP arrangements
2. Joint Venture (US harvester-Foreign Processor) arrangements
3. Mealing arrangements
4. Community allocated DAS leased to out of region vessels and even
5. Community allocated DAS leased to foreign fishing enterprises

The Council may deem that some of the above activities and others may be appropriate for conduct under a Development Permit and not in the run-up to establishing history for a Conservation Permit. It is appropriate that some guidance be established which will provide the appropriate signals to fishermen and investors distinguishing what activity will need to be conducted under a Development Permit in this period and which can be conducted and counted as performance for qualifying for a Conservation Permit for this area. The follow options are given as examples of that guidance:

Development Permit Guidance Option 1 Not less than fifty percent of any resource amount harvestable under development permits will be made available to holders of any valid Northeast region permit. Within a reasonable planning period, the remaining resource available for harvest under development permits may be made available to any person or company which meets performance standards, including evidence of a sound business plan, adequate financial safeguards and technical skills, to the satisfaction of the Regional Administrator may apply for access to those resources under a development permit.

E.5.2.2.7 Other Guidance in Permit Structure

The Council could consider the path of development of conservation permits in the two controlled access areas once and act to realign that development by providing further guidance and/or provide incentives for the realignment so that profitable opportunities for herring harvest and processing are not forgone. Some consideration might include:

1. Vessel size
2. Vessel harvesting capacity
3. Vessel range
4. Vessel processing capacity
5. Regional, national and international markets

E.5.2.3 Alternatives Outside the Council's Authority

An alternative management approach that was not considered by the Council is the use of individual fishing quotas. Under this concept, the right to catch a specific amount of fish is distributed to vessel owners. Generally, these rights can be traded, rented, used, or harvested at the discretion of the owner of the quota. Councils are prohibited from implementing such systems by section 303(d) of the M-SFCMA until after October 1, 2000.

E.6.0 Affected Environment

E.6.1 Data Considerations

A description of the system for collecting and using fisheries data is given in the SEIS for Amendment 5 to the Northeast Multispecies Plan and is also provided in each issue of the NEFSC publication *Status of the Fisheries Resources of the Northeastern United States*, "Status of the Stocks". The management information system has undergone a number of changes in recent years, most notably a shift from voluntary to mandatory vessel reporting in 1994 pursuant to Amendment 5, and continues to evolve to address changing needs and improvements. The following paragraphs describe some of the components of the data and information systems used by the Council, including changes and improvements currently underway.

E.6.1.1 Stock Assessment Workshops

The Northeast Regional Stock Assessment Workshop (SAW) process is a partnership of the NMFS Northeast Fisheries Science Center (NEFSC), NMFS Northeast Region (NER), New England Fishery Management Council (NEFMC), Mid-Atlantic Fishery Management Council (MAFMC), and Atlantic States Marine Fisheries Commission (Commission). The SAW objective is to produce stock assessments, perform peer reviews of those assessments, and prepare scientific advice based on the peer-reviewed assessment results for fisheries management. This is the process that provides the primary biological information used in the management and conservation of the fishery resources in the region.

The SAW process began in 1985 and has gradually evolved in structure and procedure to its present format of two SAW cycles per year. There are three stages to the process which are overseen by a Steering Committee.

Working Groups

There are currently five standing Working Groups (Northern Demersal, Southern Demersal, Coastal/Pelagic, Invertebrate, and Assessment Methods), with each Group responsible for assessing assigned stocks. The Working Groups have no formal membership other than a Chair (generally from the NEFSC) appointed by the Steering Committee (see below). Meetings are attended mainly by NEFSC personnel whose assessment responsibilities or expertise coincide with the stocks being considered at a given meeting, but scientists from states, the two Council staffs, the Commission staff, universities, and Canada are welcome to attend. Fishing industry representatives are also welcome. Each Working Group has the following broad mandate:

- assembly of relevant input data;
- analysis of input data, performance of assessment, and investigation of analytical options;
- formulation of research recommendations;
- production of Working Paper (and ultimately the NEFSC Reference Document) and draft Advisory Report on Stock Status document for submission to SARC (see below);
- drafting of the appropriate section of the SARC Consensus Summary of Assessments document.

Depending on the stocks on the agenda for a particular SAW cycle, some or all of the Working Groups meet 1-2 months in advance of the SARC meeting to perform the assessments and prepare the necessary documentation. Either the Working Group Chair or the lead person for the specific assessment gives an oral presentation of the assessment at the SARC meeting.

Stock Assessment Review Committee

The Stock Assessment Review Committee (SARC) meets once during each SAW cycle (generally two each year, although three in 1997) usually in late June and late November or early December, with each meeting lasting five days. The SARC is chaired by the SAW Chair, and membership (at least 12 scientists which varies from meeting to meeting) includes four assessment experts chosen by the Chair from the NEFSC, two state people, one person each from the two Council staffs, one person from the NER, and generally at least one person each from Canada (DFO), academia, and another NMFS Fisheries Science Center. SARC meetings are open to the public and are frequently attended by members of the fishing industry, academia, state agencies, Councils, and environmental groups. However, only the SARC members are responsible for developing the Consensus Summary of Assessments and Advisory Report on Stock Status. The SARC has the following mandate:

- peer review Working Papers (containing assessments) submitted by Working Groups, undertake dialogue on analytical options and, if necessary, conduct re-analyses to clarify issues, and refer assessment back to Working Group if problems persist;
- determine management advice;
- formulate research recommendations;
- produce Consensus Summary of Assessments and Advisory Report on Stock Status.

The SAW Chair is responsible for editing and assembling the draft Consensus Summary of Assessments and the draft Advisory Report on Stock Status and forwarding these documents to the Steering Committee (see below) for their approval prior to their distribution to the Councils.

Public Review Workshop
The Public Review Workshop consists of two half-day sessions, one each held in conjunction with a NEFMC and MAFMC meeting, at which time the assessment results and management advice from the SARC are presented and explained by the SAW Chair (with assistance from the Working Group Chairs). These sessions are open to the public and offer an opportunity for dialogue among Council members, scientists, and members of the fishing industry on the assessment results and management advice.

SAW Steering Committee
The Steering Committee is an executive group comprised of the NMFS Regional Administrator, NEFSC Science and Research Director, and the Executive Directors of the NEFMC, MAFMC, and ASMFC and chaired by the SAW Chair. The Steering Committee determines the stocks to be reviewed at each SAW and approves terms of reference, allocates personnel and funding resources to facilitate the assessment and peer review process, oversees the assessment and advisory process, sets dates and venues for SARC and Public Review Workshop sessions, evaluates the sufficiency and style of the SAW Reports and any additional communication required, and guides the SAW policy.

SAW Schedule
Normally, there are two SAW cycles annually. For the first one, the SARC meeting is generally held in late June and the Public Review Workshop sessions completed by August, while for the second, the SARC meeting is held in late November or early December and the Public Review Workshop sessions completed in January or February.

The SAW generally considers stocks considered by the SAW are generally on a multi-year schedule. Whether or not a stock is addressed at the spring or autumn SAW is based on survey timing, data availability, and management schedules. Working Group meetings for spring SAWs are generally held in April or early May. The NEFSC conducts its annual autumn trawl survey in September and October, and its annual spring survey in March and April, but the spring data are not available for use in any assessments for the spring SAW.

E.6.1.2 NRC Review of Northeast Fishery Stock Assessments

In response to public questions, particularly among the harvester sector, about the scientific basis for management restrictions, Congress mandated in the SFA that the National Research Council (NRC) of the National Academy of Sciences conduct a review of stock assessments, information collection methodologies, biological assumptions and projections and other relevant scientific information used as the basis for conservation and management in the Northeast multispecies fishery. The NRC report concluded that "the current assessment process, despite the need for improvements, appears to provide a valid scientific context for evaluating the status of fish populations and the effects of fishery management."

The report also contained eight recommendations to NMFS to improve the assessments. These are:

1. Improve the collection, analysis, and modeling of stock assessment data as detailed in Chapter 3. Such improvements could include evaluations of sample size, design, and data collection in the fishery and the surveys; the use of alternative methods for data analysis; consideration of a wider variety of assessment models; and better treatment of uncertainty in forecasting;

2. Improve relationships and collaborations between NMFS and harvesters by providing, for example, an opportunity to involve harvesters in the stock assessment process and using harvesters to collect and assess disaggregated catch per unit effort data;

3. Continue to educate stock assessment scientists through short-term exchanges among NMFS centers so that each center can keep abreast of the latest improvements in stock assessment technologies being used at other NMFS fishery science centers and other organizations in the United States or elsewhere;

4. Ensure that a greater number of independent scientists from academia and elsewhere participate in the Stock Assessment Review Committee (SARC) process; where necessary, pay competitive rates for such outside participation to ensure that a sufficient number of the best people are involved in the review;

5. Increase the frequency of stock assessments. As the New England Fishery Management Council intensifies its management of the Northeast fishery, stock assessments may have to be performed more frequently than every three years (the current timing);

6. Consider a wider range of scenarios (e.g., recruitment, individual growth, survival, sub-stock structure, ecosystem, data quality, compliance with regulations, long-term industry response) in evaluating management strategies;

7. Investigate the effects of specific management actions, such as closed areas and days at sea limitations, on fishing mortality and related parameters;

8. Work toward a comprehensive management model that links stock assessments with ecological, social and economic responses, and adaptation for given long-term management strategies. This involves input from the social sciences (economics, social and political science, operations research) and from a wider range of natural sciences (ecology, genetics, oceanography) than traditionally is the case in fisheries management.

The NRC Review of Northeast Fishery Stock Assessments is available from:

National Academy Press
2101 Constitution Avenue, N.W.
Box 285
Washington, D.C. 20055
http://www.nap.edu

E.6.1.3 NMFS Strategic Plan for Research

Also in response to an SFA mandate, NMFS has recently published a national "Strategic Plan for Fisheries Research" which outlines the agency's goals and objectives for research in all areas, including biology and population dynamics, ecology, conservation engineering, information management, and socioeconomic aspects of the fishery. The report also contains specific regional research priorities for the NEFSC which will result in programs to improve collection, management and analysis of data specific to fisheries in this region.

E.6.1.4 Atlantic Coastal Cooperative Statistics Program

NMFS and the Council are participating in the Atlantic Coastal Cooperative Statistics Program (ACCSP) along with the Atlantic States Marine Fisheries Commission, coastal state fishery agencies and the U.S. Fish and Wildlife Service. The ACCSP is a cooperative state-federal marine and coastal fisheries data collection program. It is intended to coordinate present and future marine and coastal data collection and data management activities through cooperative planning, innovative uses of statistical theory and design, and consolidation of appropriate data into a useful database system.

The mission of the ACCSP is to cooperatively collect, manage, and disseminate fishery statistical data and information for the conservation and management of fishery resources for the Atlantic coast and to support the development and operation of a national program.

The four goals of the ACCSP are:

(1) plan, manage, and evaluate a cooperative, coordinated, cost-effective, dependable, non-duplicative and accurate state-federal marine and coastal fisheries data collection program for the Atlantic coast in which the general public, fishermen, and fisheries managers have confidence;

(2) undertake a unified state-federal marine and coastal fisheries data collection system for

the Atlantic coast, including both commercial and recreational sectors, to provide to the general public, fishermen, fisheries managers and stock assessment biologists, the best scientific and technical data needed for effective management on a timely basis;

(3) establish and maintain an integrated cooperative coastwide fisheries data management system among all Atlantic Coastal states from Maine to Florida, the regional fishery management councils, the National Marine Fisheries Service, the US Fish and Wildlife Service and other state or federal agencies involved in the collection, compilation, and management of marine, estuarine, anadromous and catadromous fisheries statistics; and

(4) support the continued development and operation of a national system to collect, manage, and disseminate marine fisheries information for use by states, councils, interstate commissions, and federal marine fishery management agencies using the existing regional programs as building blocks.

Development of the ACCSP began in 1996 and implementation is scheduled for 1999.

E.6.1.5 Transboundary Resources Assessment Committee

Since 1977, Canada and the USA have independently developed peer review processes for their stock assessments. In Canada, in late 1992, the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) was disbanded and the Regional Advisory Process (RAP) put in its place. RAP in the DFO Maritimes Region currently provides advice on about 120 marine and freshwater finfish, shellfish and marine plant resources. In the Northeast Region of the National Marine Fisheries Service (NMFS), the SAW process currently provides advice on about 44 marine finfish and shellfish resources.

Collaboration between Canada and the USA on stock assessments and related research has been strong. Regular scientific meetings are held to co-ordinate joint research programs and facilitate inter-lab communication. Protocols for routine data exchange, particularly commercial and survey, have been established and joint work on assessment related issues is common. Finally, participation in each other's peer review process is routine.

The 1996 Canada/USA Scientific Discussions noted that it would be desirable to conduct joint assessments of the Georges Bank groundfish stocks during the 1997 assessment cycle. Thus in April 1997, scientists from Canada and the USA combined efforts to prepare assessments of Georges Bank cod, haddock, and yellowtail flounder. The peer review of these assessments was subsequently conducted first by RAP in Canada and then by the SAW Stock Assessment Review Committee (SARC) in the USA. Upon completion of the 1997 process, it was evident that there would be efficiencies realized by eliminating the duplication in the peer review process. This would also ensure that RAP and SARC would not produce divergent and inconsistent status reports on these stocks.

An outline of a joint Canada/USA peer review process has been agreed to by both Canada and the USA and the first joint assessment is currently in process. The following is a summary of this process.

Stocks to Consider

There are a number of stocks that could be considered in a combined process, however, for the initial joint assessment only three principal stocks are being addressed to allow the incremental development of the new joint process. Since the U.S. and Canada have had close interaction (data sharing and participation in each other's assessments) on 5Z cod, haddock, and yellowtail flounder, these stocks are the focus of the initial joint process. Other groundfish stocks in the Georges Bank - Gulf of Maine region that may also be considered include Southern New England yellowtail flounder, Gulf of Maine cod, Gulf of Maine - Georges Bank plaice, and Georges Bank winter flounder. Atlantic sea herring may be incorporated into the process in 1999.

Structure of the Peer Review

Transboundary Assessment Working Group

A multidisciplinary Transboundary Assessment Working Group (TAWG) has been established with membership composed of Canadian and USA scientists with a range of backgrounds. Industry participation from both countries is also encouraged. Its mandate is to:

- analyze pertinent assessment information and produce stock assessments on identified stocks;
- formulate research recommendations which will lead to long-term improvements in the assessments.

Meetings of the TAWG are arranged on a mutually agreed basis by both countries. The Chair of the TAWG will be determined by the RAP and SAW Chairs (see below).

Transboundary Resources Assessment Committee

A new Transboundary Resources Assessment Committee (TRAC) has been established to peer review the stock assessments produced by the TAWG. The TRAC will be distinct from RAP and SARC. The TRAC will be co-chaired by the Chairs of RAP and SAW who are also responsible for all logistical arrangements associated with TRAC meetings (e.g., dates, venue, participation). The TRAC is charged with producing final, approved assessments and resulting documentation on the status of the transboundary resources.

Participation at the first TRAC meeting was by invitation and will consist of a limited number of representatives. The policy on participation at future meetings will be developed based on experience with the new process. The TRAC will alternate its venue between Canada and the USA, with the host country serving as chair. The first meeting was held in St. Andrew's, N.B., Canada 20-24 April , 1998.

TRAC Coordination

The RAP and SARC Chairs, with the guidance of their respective steering committees, will oversee the activities of the TRAC and TAWG.

Management Advice and Public Meetings

Once the TRAC review process has completed its deliberations, the results may be used by either country for fisheries management purposes as appropriate e.g., preparation of management advice in Canada by the Fisheries Resource Conservation Council (FRCC) and in the USA by the SARC. Each country may conduct independent consultations with clients or disseminate the information to the public, informing the other side as required.

Documentation

Technical Documents

The current plan is not to establish a new technical document series for resources reviewed by the TRAC. For 1998, when the TAWG and TRAC meetings will be held in Canada, the Canadian Stock Assessment Secretariat (CSAS) Research Document series will be used to catalogue the technical reports produced by the TRAC and the TAWG. For 1999, when the meetings will be held in the USA, the Northeast Fisheries Science Center (NEFSC) Reference Document series might be used. A definitive policy for the cataloguing of future documents in either of the existing Canadian or USA series remains to be developed.

Stock Status/Advisory Documents

The purpose of the joint Canada/USA stock assessment process for transboundary resources will be only to produce and peer review assessments of stocks of mutual interest and not to prepare management advice. Each country will use the assessment results from this joint process for their respective fisheries management purposes. The document series currently employed by each country at RAP and SARC meetings to convey a brief summary of stock status and management advice for individual stocks (i.e., the DFO Science Stock Status Report series in Canada and the SAW Advisory Report on Stock Status in the USA) will continue to be used for those purposes in each country because they serve different purposes and clients in each country. For stocks reviewed at a given TRAC meeting, the TRAC will produce final, approved documents for the Canadian SSR series. These documents, as well as the technical documents noted above, will provide the basis for management advice to be prepared by the SARC, following the TRAC meeting, and reported in the SAW Advisory Report on Stock Status.

E.6.1.6 Herring Fishery Data Limitations

Atlantic herring is currently regulated by a management plan adopted by the Commission and implemented by individual states. The federal preliminary management plan does not address domestic vessels. While the states have permitting and recordkeeping requirements, an overall system does not exist that tracks all participants in the fishery and centralizes collection of all catch data in one location. This lack of a central reporting system complicates analysis of the fishery and the impacts of the proposed management program.

Some herring vessels possess federal permits for other fisheries that require the vessel operators to report all landings and discards through the vessel trip report system described above. In addition, many purchasers of herring also purchase other federally regulated species and are required to have federal dealer permits and comply with federal dealer reporting requirements. Landings from these vessels and dealers can be identified in the vessel logbook and dealer databases. In addition to these sources of information, the Maine Department of Marine Resources tracks landings information from several vessels that do not have federal permits and do not report through the federal reporting system. Maine combines this information with dealer and vessel logbook data to construct a more complete file of the major participants in the industry, but excludes trips of less than one metric ton in order to facilitate data handling. The Maine database also does not include revenue information. While this has little impact on the assessment of the resource, it complicates analysis of the economic impacts of the management measures.

There are discrepancies between these three databases. For example, in attempting to identify 1997 landings from small otter trawl vessels that use the various whiting fishery exemption programs to target herring at certain times of the year, analysts noted the landings attributed to bottom trawl gear in the dealer database are almost double the amount in the vessel logbook database. A cursory investigation suggested some landings in the dealer database may have the gear type mis-coded. In another example, some vessels in the Maine database are not included in either the dealer or vessel logbook databases. In describing the fishery and analyzing the impacts of the proposed management program, all three databases were used. There are some differences between each of the databases The discussion that follows identifies the data sources that support the analyses. In the following discussions, there are minor differences between the data sources that will be noticed. These are not considered significant and do not affect the analysis of impacts.

Another difficulty with analyzing impacts is the lack of information on the operating costs of herring vessels. While Capital Construction Fund and survey information is available for many of the gear types used in the Northeast Region, there is almost no information available for mid-water trawl and purse seine vessels. The NMFS is funding a project to collect this information for mid-water trawl and purse seine vessels, but it is not finished. The Council's proposal to incorporate the herring fishery into the Northeast Region reporting system, coupled with improvements in state and federal reporting that will be adopted through ACCSP, should improve the quality and reliability of herring landings in the future, identify participants in the fishery, and help develop information on operating costs.

E.6.2 Physical Environment

This section contains a general description of the physical environment in the region. Pursuant to the mandates of the Sustainable Fisheries Act (SFA), the Council, after receiving recommendations from NMFS, has:

- identified and described the essential habitat for the fish species managed by the Council;
- described adverse impacts to that habitat from fishing activities;
- described adverse impacts to that habitat from non-fishing activities;
- recommended conservation and enhancement measures necessary to help minimize impacts and protect and restore habitat.

The essential fish habitat for the species managed by the Council (including herring) is described in a comprehensive document submitted to NMFS for approval in October, 1998. In addition to the description of the physical habitat, this document includes a summary of the life cycle stages of herring and the observed range and preferred habitat for each stage. The applicable sections of this document are incorporated by reference into this FMP. The Essential Fish Habitat Source Document is attached as Appendix IV.

E.6.2.1 Gulf of Maine

The Gulf of Maine is a semi-enclosed sea of 90,700 km2 (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 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 Manaan Island. Major rivers include 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 has a higher fraction of sand. 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 predominate. 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.

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 Georges Bank and then southwestward along the bank's broad southern flank. From there most o 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 of Maine is more pronounced in the spring when river runoff adds to the southwesterly flowing coastal current. Surface currents reach velocities of 80 cm per second (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 per second in Massachusetts Bay, where tidal amplitude is only 3 m or so. The shoal region of Georges Bank also experiences large tidal currents of 70-100 cm per second.

The seasonal variation in sea surface temperature in the Gulf of Maine 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, stratification develops through the spring and reaches a maximum in the summer. Stratification is more pronounced in the southwestern portion o the gulf where tidal mixing is diminished.

E.6.2.2 Georges Bank

Georges Bank is a large (roughly 45,000 km2 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 m (30 feet) deep, and the bottom is sandy and flat, with some regions of gravel on the northern and eastern parts of the bank.

E.6.2.3 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 barrier 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 o Cape Hatteras (covering an area of 6,500 km2 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 per second (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 homogenous in the winter due to fall-winter cooling of surface waters. In winter, mean minimum and maximum sea surface temperatures are 0 and 7 C off Cape Cod and 1 and 14 C off Cape Charles (at the end of the Delmarva Peninsula); in summer, the mean minimums and maximums are 15 and 21 C off Cape Cod, and 20 and 27 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 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 complex 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

E.6.3 Biological Environment

E.6.3.1 Species Life History

E.6.3.1.1 General

Atlantic herring (*Clupea harengus harengus*) are distributed along the Atlantic coast from North Carolina to the Canadian Maritime provinces. Schools of adult herring undertake extensive migrations to areas where they feed, spawn and overwinter. Herring are found all along the coast in inshore and offshore waters to the edge of the continental shelf during late winter and early spring. Adult herring move north into the Gulf of Maine in the spring, and in the summer and fall they segregate into more or less discrete spawning aggregations. After spawning, the adults migrate south again. This changing seasonal distribution has given rise to both mobile and fixed gear fisheries which harvest herring of all age groups. The catch supplies domestic and foreign markets for juvenile and adult herring which are used for human consumption, bait and food for zoo animals.

Adult herring undertake extensive seasonal movements, which have been best defined for the Georges Bank stock. Three phases are apparent: (1) a late summer-early autumn spawning migration of ripening fish; (2) a rapid post-spawning migration to warmer waters to the south for overwintering; and (3) a spring-early summer feeding migration. The Soviets followed adult herring from Georges Bank after spawning. They found that post-spawners moved southwest to off Chesapeake Bay in November and overwintered there. The larger and older fish seemed to move furthest south. Feeding migrations back to Georges Bank began in May or early June, and to shallower spawning sites on the northern edge in September. The waters off Cape Cod seemed to constitute a mixing area, with different groups passing at different times of the year (Sindermann 1979).

The essential fish habitat for the life stages of herring are identified in the Council's Essential Fish Habitat amendment (NEFMC 1998). The sections of this document that are applicable to Atlantic herring are incorporated by reference into this FMP.

E.6.3.1.2 Age and Growth

Atlantic herring grow to a maximum length of about 43 centimeters (17 inches) and a weight of 680 grams (1.5 pounds). The maximum age of Atlantic herring is reported to be 18 years and they reach maturity at three or four years of age. A three year-old herring weighs approximately 90 g (0.2 pounds), while a four year-old weighs about 129 g (0.3 pounds).

Growth rates can vary greatly from stock to stock and from year to year. Some herring will mature by age-3, most will mature by age-5. Growth is highly variable and appears to be influenced by many factors, including temperature, food availability, and population size. During periods of low population levels herring may mature at a smaller size while growth may be accelerated in a large year class. In general, there appears to be evidence of overall environmental control of growth (Moores and Winters 1982, Sinclair et al. 1982, Tibbo 1957).

Larval herring from coastal Maine grow about 2.0 mm per week from October to early January and from late February to early March; little growth, if any, occurs during midwinter (Townsend and Graham 1981). Other growth rates reported from the Gulf of Maine-Georges Bank area were 1.75 mm per week after hatching, 2.1 mm per week for larvae 20 days old in September and October, and <1.0 mm per week for fish 75 days old in winter (Lough et al. 1982). The average daily growth increment for larvae from Georges Bank-Nantucket Shoals was 0.2 mm (Lough 1976).

Most of the growth of juvenile herring occurs during summer. In New Brunswick, the average growth of two year-old herring during May to September ranged from 30 mm in 1965 to 55 mm in 1978 (Sinclair et al. 1981). Both sexes are about 90 to 125 mm TL at the end of their first year, and 190 to 200 mm TL after the second (Bigelow and Schroeder 1953).

Anthony (1971), in comparing juvenile growth from different areas in Maine, reported modal lengths of fish in the 1960 yearclass (age group II) in October from eastern, central, and western Maine of 142, 155, and 175 mm, respectively. The lengths of the 1959 yearclass for the same age groups and areas were 190, 216, and 214 mm. In fish up to three years old, growth was inversely related to population density, and was faster in western than in eastern Maine.

Von Bertalanffy growth curve parameters, k (growth rate) and L (maximum length), were 0.251 and 37.4 cm in eastern Maine (Anthony 1971). The same parameters for southern and central Maine combined were 0.267 and 36.0 cm. A Newfoundland study provided little evidence to support density-dependent growth in the first year, but suggested density-independent growth regulated by temperature (Moores and Winters 1982).

Anthony and Waring (1980) reported that adult herring reach their peak weight each year in August or September, and are at their lightest in February-March. They also reported that herring of both sexes from Nova Scotia, eastern and western Maine, and Jeffreys Ledge all had “oceanic” (offshore) growth characteristics common to fish of the northeast Atlantic. These characteristics included large maximum size, slow growth rate, and maximum ages of 15-18 years.

Georges Bank herring are more similar in growth characteristics to northwest Atlantic “shelf” (inshore) populations, which have a smaller maximum size, higher growth rate, and lower maximum age (Anthony and Waring 1980). The von Bertalanffy growth rate (k) of Georges Bank herring increased from 0.350 (1960-63 year classes) to 0.357 (1964-67 year classes) to 0.510 (1968-71 year classes). The increased growth rate of all year classes after 1968 may have been related to the decline in abundance (Anthony and Waring 1980).

E.6.3.1.3 Spawning/Reproduction/Early Life History

Atlantic herring are believed to return to natal spawning grounds throughout their lifetime (Ridgeway 1975, Sindermann 1979). This behavior is fundamental to the species’ ability to maintain discrete spawning aggregations and is the basis for hypotheses concerning stock structure in the northwest Atlantic and elsewhere. Since fall spawning aggregations of herring in the northwest Atlantic can not be distinguished genetically (Kornfield et al. 1982), the only direct evidence for this homing behavior is provided by a tagging study in Newfoundland which showed that adult Atlantic herring returned to the same spawning grounds year after year (Wheeler and Winters 1984). It could not be demonstrated, however, that these were 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 10-100 meters (30-300 feet) 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 (Figure E.9). Jeffreys Ledge appears to be the most important spawning ground in the Gulf of Maine based on the number of spawning and near-spawning adults (Boyar et al. 1973). Spawning also occurs on Nantucket Shoals and Georges Bank (Boyar et al. 1973). Spawning concentrations of herring on Georges Bank in 1962 were reported to be as long as 64 to 80 km and as wide as 6 to 13 km. A spawning bed in Miramichi Bay, New Brunswick was examined by divers (Pottle et al. 1981) where most eggs were found attached to bottom vegetation at depths of 0.9-4.3 m, with the greatest concentration of eggs at 1.4-4.0 m. Spawning occurs earlier along the eastern Maine coast and southwest Nova Scotia (August – September) 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).

Atlantic herring spawn on the bottom by depositing adhesive eggs of 1.0-1.4 mm in diameter (Messieh 1976), which stick to gravel, sand, or algae, and to each other to form mats or beds. Gravel is the preferred substrate (Drapeau 1973). A single egg bed surveyed on the eastern Maine coast in 1986 was determined to be 0.8 square kilometers (km2) or 0.3 square miles in area, a continuous carpet up to one inch thick and containing an estimated 2-3 x 1012 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, Valentine and Lough 1991). One egg bed surveyed on Georges Bank in 1964 covered an area of about 25 square miles (Noskov and Zinkevich 1967). Depending on their size and age, female herring can 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 often result in high egg mortalities.

Larvae are about 4-10 mm (0.25 in) in length at hatching which occurs 10-15 days after the eggs are deposited on the bottom (Fahay 1983). The larvae remain pelagic through the winter in nearshore and estuarine waters in the Gulf of Maine (Chenoweth 1980; Chenoweth et al., 1989), and have been reported as far south as New Jersey (Ken Able, Rutgers University, pers. comm.). Metamorphosis occurs in the spring at a length of about 40 mm (1.5 in). Schooling behavior begins in the late larval and early juvenile, or “brit” stages. Young-of-the-year herring undergo a general offshore movement in the summer and fall, and they are believed to spend the winter in deep coastal waters.

The persistence of discrete aggregations of larvae for several months after hatching over tidally mixed continental shelf spawning grounds in the Gulf of Maine and elsewhere, 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 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). The larvae overwinter in bays, estuaries and nearshore waters, and become juveniles in the spring. Those juveniles 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 at al. 1975), although some overwinter in nearshore waters on the Maine coast (Lazzari and Stevenson 1991).

Mortality of Atlantic herring in the larval stage is very high since the larvae remain vulnerable to very low temperatures and a limited food supply for a prolonged period during the winter, especially in the 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 stage. Some of the conclusions of that study were:

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

- Two year-old recruitment to the Maine herring fishery 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 in which the larval stage is critical;

- When larval survival is above a threshold, density-dependent predation on brit can reduce year-class size (the assumption being 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 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 movement of larvae.

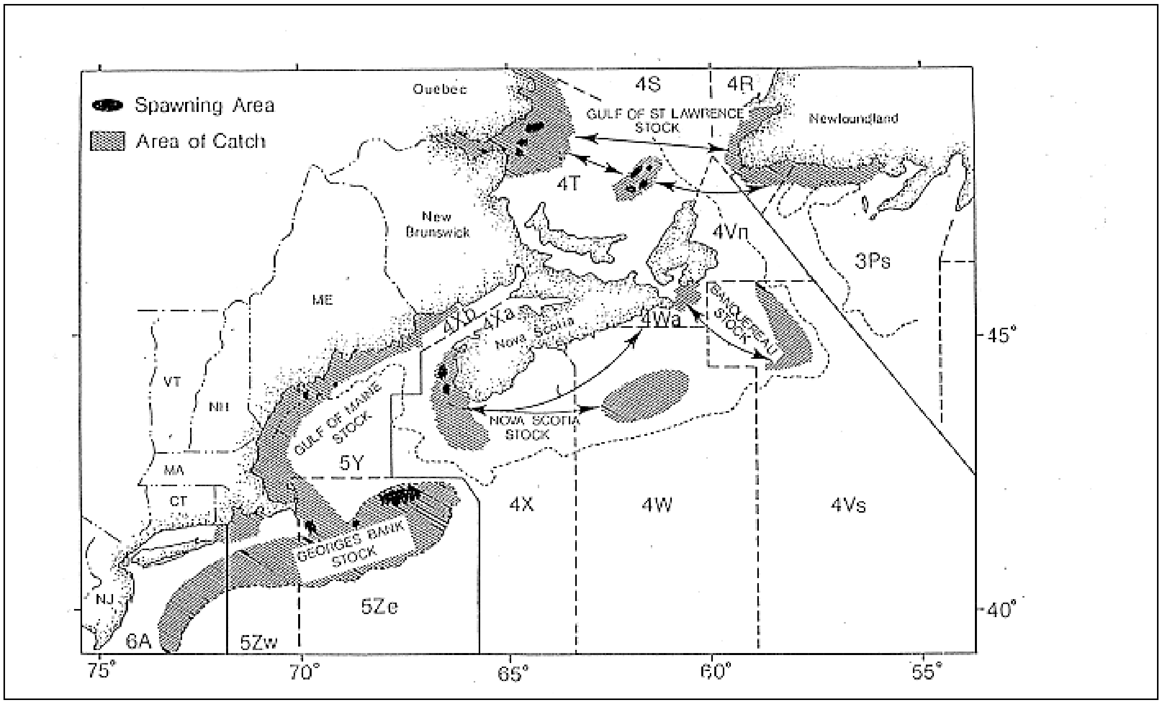

Figure E.6 - Map of the northeastern U.S. and eastern Canada showing distribution and spawning locations of major Atlantic herring stocks (Iles, 1972)

E.6.3.1.4 Distribution

Juvenile and adult herring range from south of Cape Hatteras to the Bay of Fundy and Browns Bank (Reid et al. 1998). The Essential Fish Habitat Source Document for Atlantic herring (Reid et al. 1998, Appendix IV) contains chartlets that reflect the observed distribution of herring at various life stages.

The location and movement of juvenile Atlantic herring 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 some speculation that a portion of the juvenile (age-2) herring found along the western Gulf of Maine coast (Massachusetts to New Brunswick) are derived from spawning on Georges Bank, but there is no real evidence so far. Recent evidence relating to the distribution of Atlantic herring south of Cape Cod and in the Gulf of Maine is summarized here.

Delaware's trawl survey takes adult herring (>20 cm) in the lower portion of Delaware bay during March and April. Adults have also been observed in the adjacent ocean waters, often mixed with mackerel. Juvenile herring do not typically appear in survey catches (Rick Cole, Delaware Div. Fish. & Wild., pers. comm.).

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-sized elasmobranches, as the most abundant species by weight. Herring are found in all depth strata sampled (0-30 meters) along the New Jersey coast in January. Smaller herring, averaging 21-22 cm, are present during April but at a lower abundance than observed in January. No herring are taken during the summer sampling period, and very few juvenile fish are taken at any time during the survey. Larval and early juvenile herring (2-5 cm) are abundant in plankton samples from Little Egg Inlet, NJ during February to April (Ken Able, pers. comm.) and in Delaware Bay and its tributaries (Bruce Freeman, pers. comm.).

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

A trawl survey of Long Island Sound has been conducted by the Connecticut DEP from April to November. Adult herring (20-34 cm) are most common in April, with limited numbers of adult fish taken in May and November. It appears that the adult herring are present in Long Island Sound before the survey begins in April. Juvenile herring are abundant in Long Island Sound during the summer. Two length modes are apparent in the survey data, 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) concentrations are below 3 mg/l. There is some speculation that juvenile herring may be feeding above hypoxic bottom waters in algal blooms near the surface which are often associated with hypoxic areas. Herring are found in all depths sampled from 5-40 m, although concentrations tend to be higher in 10-30 m depths (David Simpson, CT DEP, pers. comm.).

Rhode Island fishery independent surveys take Atlantic 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 to October (Tim Lynch, RI DEM, pers. comm.). Coastal ponds sampled with numerous gear types primarily support large (25-38 cm) fish. Herring are most abundant in coastal ponds between October and early June (Dick Satchwell, RI 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, RI, pers. comm.).

Massachusetts conducts trawl surveys during the spring (May), and fall (September). Brit, or juvenile herring 4-7 cm are commonly taken in the spring trawl and June seine surveys south of Cape Cod. Few adults are observed south of the Cape in state waters covered by the survey. Brit are taken in about 1 m 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 north into Cape Cod Bay and the Gulf of Maine. North of Cape Cod, fish tend to be larger (>12 cm) than observed south of Cape Cod in the spring. Adult herring are taken in the fall survey, both north and south of the Cape.

Atlantic herring are present in New Hampshire gillnet samples throughout the year, with seasonal peaks in the 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 in the coastal waters and estuaries including Great Bay.

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 1963-65 by Soviet fishing and scouting vessels. He concluded:

> "Herring were distributed over the greatest area in winter months. From November to March, herring were fished from 36^o N along the continental shelf to the northern extremity of Georges Bank. During that period the herring were active and did not form stable 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 (of the fish) was found in the area from 36^o to 38^o 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 numbers south of 40^o N.
>
> From May to October, the bulk of the fish was feeding or spawning on Georges Bank."

E.6.3.1.5 Foods/Feeding

Atlantic herring are visual feeders, consuming plankton during daylight hours (Blaxter 1966), filtering out small organisms with long, well-developed gill rakers. Young herring begin to feed on small phytoplankton, eating larger organisms as they grow. Fingerlings or larger-size herring (brit) consume large quantities of copepods. Adult herring feed heavily on the euphausiid crustacean *Meganyctiphanes norvegica*, but may also eat copepods, fish eggs, pteropods, mollusk larvae and the larvae of small fish such as sand lance, silversides, herring and capelin (Scott and Scott 1988). Legare and Maclellan (1960) found copepod genera *Calanus*, *Pseudocalanus*, *Eurytemora*, *Acartia* and *Tortanus*, to be important prey items of herring in the Quoddy region of New Brunswick. They found the most active feeding period to be September to November. Sherman and Perkins (1971) concluded the diet of juvenile herring in Maine coastal waters was varied with copepods the most important prey, especially in summer. Other zooplankton preyed upon included cladocerans, larval cirripeds (barnacles), decapods and pelecypods. Herring in Newfoundland waters were found to eat very little in winter (December to April), apparently living on their accumulated fat (Hodder 1972).

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

E.6.3.1.6 Predator/Prey Relationships

Herring is an important species in the food web of the northwest Atlantic. Herring eggs or spawn are subject to predation by a variety of bottom creatures, including winter flounder (Pottle et al. 1981, Tibbo et al. 1963), cod, haddock and red hake (Caddy and Iles 1973), and sculpins, skates and smelt. 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 finfish predators include: cod, pollock, haddock, red hake, white hake, silver 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 only, and the actual quantity of herring consumed as prey is unknown.

Analysis of stomach contents data collected during NMFS bottom trawl surveys in late 1969-72 showed herring to be an important prey item for cod, pollock, haddock, silver hake and white hake (12.5-27.4% by weight) and not for a number of other gadiform fishes or for any species of flounder (Langton and Bowman 1980, 1981). Of these five species, cod ranked the highest. In another study conducted in 1973-76, silver hake diets were composed 80% of fish but only 2.7% of herring (Bowman 1980). More recent information, based on 1978-1990 NMFS food habits data, indicates that large amounts of herring were consumed by silver hake and dogfish on Georges Bank. Other predators that also fed on herring, but did not have a very large impact on the herring population because of their low abundance, were cod and winter skate (Tsou and Collie 1997).

Some quantitative information is available which indicates the importance of herring as a food source for other species. Overholtz et al. (1991) estimated that silver hake, cod, and dogfish annually consumed an average of about 1500, 200 and 4300 metric tons (respectively) of herring from 1988-92 on the northeast U.S. continental shelf. Overholtz et al. (1991) 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 1988-92. Herring was the third most common prey species behind sandeels (55,760 mt) and mackerel (36,260 mt). 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) were also significant consumers. Research on harbor seals off Monomoy Island, Cape Cod during 1984-87 indicated that herring increased in their 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). A review of the stomach contents of 95 harbor porpoise caught in gillnets in the Gulf of Maine during the fall from 1989-1994 showed that herring occurred in 78% of non-calf stomachs and contributed 44% of ingested mass, the largest proportion of any species (Gannon et al. 1998). Seabirds also take a share of the herring resource. Estimates were that the northern gannet consumed about 3,000 mt and the shearwater about 250 mt a year during 1988-92 on the U.S. northeast shelf (Overholtz et al. 1991).

These calculations indicate that between piscivorous fish, marine mammals and marine birds, approximately 30,000 mt of herring is consumed each year. This is probably an underestimate 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. However, even using an estimate of 50,000 mt, this only represents 2.5% of the estimated total stock size of Atlantic herring in 1990, and 50% of the current commercial harvest. The annual natural mortality rate used to estimate stock size, in contrast, is 18%.

Natural mortality rate estimates for Gulf of Maine herring at different ages (Anthony 1972) indicated that M increases from values of 0.2-0.3 at ages 1-3, then increases exponentially at older ages, reaching 0.8 at age 8. These estimates were based on the relative abundance of adult herring caught incidentally in other fisheries (e.g., bottom trawls) along the coast of Maine in the 1960s, at a time when the only demand was for juvenile herring. Total mortality rates estimated by this technique at that time were thus attributed entirely to natural mortality. This assumption is probably correct, but the rapid increase in M at older ages is illogical and contrary to results based on feeding rates (see above). It is likely that the decline in the catch rates of older herring was biased by an increasing ability of larger fish to avoid capture or to leave coastal areas where the catches were made in favor of deeper, offshore waters.

On Georges Bank, Tsou and Collie (1997) estimated predation mortality rates on herring that varied from 1.2 (70%) at age 0 to 0.01 at age 5. The biomass of herring consumed by silver hake, dogfish, cod, haddock and winter skate varied roughly between 5,000 mt and 35,000 mt between 1978 and 1990. Predation mortality on the two principal prey species, herring and silver hake, was estimated to be much higher than fishing mortality and higher than the constant M=0.2 rate that is generally assumed.

The ICES Multi-Species Working Group compiles annual stomach contents data for the important predatory species in the North Sea and estimates composite predation mortalities on each key prey species, taking into account the stock sizes of each predator and prey population. The mean multi-species predation mortality rates for herring for the period 1974-1994 declined from a high value of 0.72 at age 0 to 0.07 at age 5, with an additional residual M value of 0.1 at all ages (ICES 1997). At ages 0 and 1, these long-term mean M values were lower than the estimates currently used by the ICES Herring Assessment Working Group for the North Sea, but at the older ages they were higher. The MS Working Group calculated that a million metric tons of herring were consumed by the other species included in their analysis in 1987 and that residual natural mortality removed an additional 200,000 mt a year. The fishery at that time harvested 700,000 mt. In more recent years (1991-1995), natural mortality was estimated to be about 400,000 mt of herring a year (300,000 mt from predation) and yield was between 500,000 and 600,000 mt a year. Stock biomass in the North Sea has dropped from a high of 1.9 million mt in 1987 to about 700,000 mt in 1995.

In a recent study, estimates of prey consumption by four species of seals in the maritime provinces of Canada during 1990-1996 showed that capelin, sand lance, and arctic cod accounted for most of the estimated consumption. The estimated consumption of herring in 1996 was 131,000 mt and was mostly small fish. Another study in the northeast Atlantic concluded that a population of 85,000 minke whales consumed 633,000 mt of herring a year between 1992 and 1995.

Juvenile herring collected in inshore waters of the Gulf of Maine in 1968 were feeding primarily on copepods (Sherman and Perkins 1971). Adult herring collected during NMFS bottom trawl surveys were feeding primarily on euphausiids and chaetognaths in the early 1970s (Maurer 1976) and on euphausiids, copepods, and other crustaceans during 1973-1980 (Reid et al. 1998). Information collected during 1981-1990 (Reid at al. 1998) indicates that herring in other locations had more varied diets than herring in the Gulf of Maine: primary prey taxa were amphipods and mysids on Georges Bank; amphipods, chaetognaths, fish, crustaceans, mysids, copepods, and euphausiids in southern New England; and amphipods, crustaceans, mysids, sand lance, euphausiids, and shrimp in the Mid Atlantic Bight.

Herring are also known to feed on pelagic fish eggs and may in some cases have an effect on the recruitment of these species. A study in the North Sea estimated that herring only consumed 0.7 to 1.9% of all the plaice eggs and 0.04 to 0.19% of all the cod eggs produced in 1980, 1982 and 1983 (Daan et al. 1985). Fluctuations in Pacific cod and herring stocks in British Columbia between 1950 and the early 1980s suggest that herring recruitment rates were strongly influenced by cod predation. Also, cod recruitment rates were positively correlated with herring abundance, but it is impossible to tell whether this correlation reflects predator-prey interdependence or the effects of cannibalism by older cod on their own offspring (Walters et al. 1986).

Fogarty et al. (1998), in an analysis of the large-scale disturbances caused by fishery impacts on Georges Bank, note the current large biomass of pelagic species and the potential impact this may have on other species. The reduction in predation pressure on herring and mackerel stocks caused by the decline in groundfish populations may have contributed to the explosive growth in these species. This, in turn, may impact other species. For example, Sherman et al. (1994) linked declines in zooplankton levels to the abundance of pelagic fish.

E.6.3.1.7 Parasites/Disease

Atlantic herring are infected by a number of parasites, some of which can cause mass mortalities. Margolis and Arthur (1979) listed the following as known parasites: protozoans (3), myxosporidians (3), trematodes (6), cestode (1), nematodes (4), and copepod (1). Arthur and Arai (1984) reviewed the known parasites of herring throughout its holarctic range, listing over 80 species. The presence of some parasites, such as *Anisakis* and the coccidians *Goussia clupearum* and *Eimeria sardiniae*, may be useful in distinguishing certain herring stocks (Hodder and Parsons 1971, Morrison and Hawkins 1984). Some parasites may be more obvious than others, such as pigment-spot disease, caused by the larval trematode *Cryptocotyle lingua*, whose intermediate host is the common periwinkle and definitive host the herring gull.

The systemic fungus pathogen *Ichthyosporidium hoferi* has been known to cause large-scale mortalities of herring (Sindermann 1963, 1965). Herring may also be infected by the piscine erythrocytic necrosis (PEN) virus (Reno et al. 1978). A mass mortality of herring in the Bay of Fundy caused by a toxic dinoflagellate, *Gonyaulax excavata*, contained in pteropods and zooplankton, which had been consumed by the herring (White 1977, 1980).

During the winter of 1969, a series of extensive herring mortalities occurred in the Placentia Bay, Newfoundland region. The dead herring were red in color (fins and body) and attracted much publicity. Mortality was first thought to be caused by a disease but was later shown to be the result of industrial pollution, mainly phosphorus, from a nearby industrial plant (Jangaard 1970).

E.6.3.1.8 Stock Structure and Migration

There are three major stocks of Atlantic herring in the Gulf of Maine region that spawn in geographically discrete areas on Georges Bank and Nantucket Shoals, in coastal waters of the Gulf of Maine, and off southwest Nova Scotia (Figure E.6). Each of these major spawning areas is composed of a number of smaller spawning grounds. Observations of year to year changes in the abundance of adults on individual spawning grounds, in response to fishing pressure, tend to confirm the view that each of these areas supports a discrete spawning aggregation (or sub-stock) of herring (Stephenson 1998). Some of these discrete spawning grounds are located within 10-15 miles of each other (e.g., Trinity Ledge and Lurcher Shoals, off the southwest coast of Nova Scotia). Adults from the two U.S. stocks mix during their winter migration to southern New England and mid-Atlantic waters and separate out onto their respective spawning grounds following a return northward migration in the spring. Adults that spawn off southwest Nova Scotia (the 4WX stock) for the most part migrate north after spawning and are not believed to mix to any significant degree with herring that spawn on Georges Bank or in the Gulf of Maine (Stephenson et al. 1998). Spawning takes place in the late summer and fall in fairly shallow tidally-mixed shelf waters where larvae are retained for varying periods of time before being dispersed to overwintering areas (Iles and Sinclair 1982).

The evidence for separate stocks in the Gulf of Maine region is derived from discrete larval distribution patterns (Iles and Sinclair 1982), differences in spawning times and locations (Boyar et al. 1973, Haegele and Schweigert (1985), and distinct biological characteristics, such as growth rates (Anthony and Waring 1980), meristic and morphometric counts and measurements (Anthony 1981, Safford 1985), and the incidence of parasites (McGladdery and Burt 1985). Some degree of stock differentiation was achieved with early enzyme electrophoresis research (Ridgway et al. 1970, 1971), but more recent attempts to differentiate geographically isolated fall spawning stocks in eastern Canada and the northeast U.S. on the basis of genetic characteristics have been unsuccessful (Kornfield et al. 1982, Kornfield & Bogdanowicz 1987). Evidence for homing is provided by tagging studies (Wheeler and Winters 1984) which showed that the same fish return to the same spawning grounds year after year. Tagging studies conducted on spawning herring in Nova Scotia, on Cultivator Shoals and Jeffreys Ledge, and along the Maine coast during the late 1970's and 1980's demonstrated considerable affinity for home spawning grounds, with some intermixing in the winter, spring and early summer (Stobo 1983, Creaser and Libby (1988).

The most compelling evidence supporting the existence of separate Gulf of Maine and Georges Bank/Nantucket Shoals stocks was the collapse of the large Georges Bank/Nantucket Shoals stock in the early 1970s after several years of heavy exploitation by foreign fishing fleets. This stock remained in a depressed state for about ten years, during which time the smaller Gulf of Maine stock continued to support a strong coastal fishery. Both of these stocks are transboundary stocks since adult herring occupy both sides of the U.S.-Canada boundary on Georges Bank and because juvenile and adult herring on the New Brunswick shore of the Bay of Fundy are believed to originate from spawning grounds in U.S. and Canadian waters (Stephenson et al. 1998).

E.6.3.1.9 Abundance and Present Condition

For the purpose of this FMP, the U.S. Atlantic herring coastal stock complex is defined to include all herring occupying continental shelf waters over the entire range of the species between the Gulf of Maine and North Carolina, including Canadian waters on Georges Bank and in New Brunswick (Bay of Fundy). The stock complex comprises separate spawning components on

Georges Bank, Nantucket Shoals, and in coastal waters and on nearshore banks in the Gulf of Maine. The aggregation of biologically discrete spawning stocks into a single stock complex was first adopted in the fall of 1991 (NEFSC 1992) and has been the convention for U.S. herring assessments ever since then. The decision was based on the fact that there was insufficient data to support independent assessments for individual spawning components and the view that juvenile herring harvested in the New Brunswick fixed gear fishery originated from spawning grounds located in U.S. waters, not from spawning grounds located off southwest Nova Scotia (Stephenson et al. 1995).

All available resource survey and assessment information indicates that the coastal stock complex has grown rapidly in size since the early 1980's. Results from the most recent assessment (Figure E.7) indicate that stock biomass started to increase in the early 1990’s, climbing rapidly from 500,000 mt in 1992 to 2.9 million mt at the beginning of 1997 (NEFSC 1998a and b). Spawning stock biomass in 1997 was 1.8 million mt, with an 80% probability that it was between 1.4 and 2.2 million mt. This dramatic increase in abundance in recent years is due largely to the recovery of the Georges Bank/Nantucket Shoals components of the stock complex which supported a large foreign fishery during the 1960’s and early 1970’s, but collapsed in the mid-70’s as a result of over-exploitation. Current stock size estimates are more than double what they were in the late 1960’s. Annual fishing mortality rates exceeded 50% for a number of years following the collapse of the Georges Bank stock and have declined rapidly during the last 15 years. The fishing mortality rate in 1996 was only 5%. Currently, the stock complex is large and underutilized. It may increase in size even further in the near future under current exploitation and recruitment patterns.

Population size and fishing mortality rate estimates for the Atlantic coastal stock complex are based on a virtual population analysis that relies on historical estimates of the number of fish harvested at each age and spring and winter trawl survey abundance indices by age for the time period 1967 to the present. (Trawl survey data are used to select the terminal fishing mortality rates for the VPA in a process that is called “tuning”). Fall trawl survey data can not be used because they are too variable from tow to tow, the result of the aggregation of adults in certain locations during the spawning season. Trawl surveys conducted in the winter and spring, after spawning is over, are not prone to this problem, but at this time of year adult herring belonging to different spawning stocks are mixed (primarily in southern New England and the mid-Atlantic region) and can not be distinguished from each other. For this reason, separate “tuned” VPA’s for the two principal spawning stocks cannot be performed. Larval survey data collected every year between 1971 and 1994 were used in the past as a second tuning index for the VPA, but are no longer available since NMFS larval herring surveys were discontinued in 1994.

The growth of the stock is also evident in the increased abundance of herring caught during fall and spring bottom trawl surveys conducted by the National Marine Fisheries Service along the Atlantic coast over the past 30-35 years (Figure E.8). Catch rates during the fall spawning season averaged 0.5-1 kg/tow during the 1960’s, were negligible throughout the 1970’s and early 1980’s and then, starting in 1987, increased to values as high as 10 kg/tow. Catch rates in 1996 and 1997 were about 3.5 kg/tow and the five year moving average was easily five times higher than it was during the 1960’s at the height of the offshore fishery on Georges Bank. There has been a very similar increase in catch rates in the spring survey from extremely low abundance in the mid

1980’s to about 3.5 kg/tow during the last four years, with a high value of 7.5 kg/tow in 1993. Unlike the fall survey data, the catch rates at the beginning of the spring time series (1968-1969) are very similar to catch rates in recent years, suggesting that the stock has recovered, but not beyond the point where it was in the late 1960’s.

VPA-derived population size estimates for the stock complex are substantially over-estimated for the most recent years in the time series. To illustrate the nature of the problem, the last time an assessment of this resource was done (in 1995), the 1994 stock size estimate was 3.6 million mt. In 1998, with the addition of three more years (1995-1997) of catch at age and survey data to the analysis, the 1994 biomass estimate dropped by 2/3, to 1.1 million mt. Comparison of stock size estimates from the 1998 VPA with the results of previous assessments (NEFSC 1996) and an examination of catch rates in the spring trawl survey (Figure E.8) and winter larval survey (Figure E.10) also indicate that the increase in stock size started in the mid to late 1980’s.

Results of an assessment of the U.S. Atlantic coastal stock complex of herring using a surplus production model (Prager 1994,1995) were presented to the Overfishing Definition Review Panel (Applegate et al. 1998) in the winter of 1997-1998. New overfishing definitions for this stock that were recommended by the Panel and subsequently adopted by the New England Fishery Management Council were based on this model and the 1995 VPA results (Applegate et al. 1998). (See Table 2 and section 2.6 of this FMP). Results of the more recent 1998 VPA were not available when the ODRP met to review overfishing definitions for Atlantic herring. The ODRP established a maximum sustainable yield (MSY) of 317,000 mt for the stock complex, biomass (B) at MSY of 1,066,000 mt, a biomass based fishing mortality rate (F) at MSY of 0.30, a target F of 0.28, and a minimum biomass level of ¼ B_{MSY} (which was subsequently increased by the New England Fishery Management Council to ½BMSY, or 500,000 mt). It also defined a stock rebuilding strategy that would be required if the stock were to drop below the threshold or minimum biomass levels. (See section 2.6 for a more complete explanation of overfishing definitions and MSY control rules for this stock).

The 1998 stock status report (NEFSC 1998b) included projected estimates of stock biomass and fishing mortality under three different scenarios. These scenarios included catch constant at the 1997 level (119,000 mt), catch constant at 200,000 mt (the MSY level estimated by the SARC), and a catch level of 317,000 mt (equal to MSY). Under all three scenarios, spawning stock biomass would increase from 1998 through 2000. The results of these projections are summarized in the following table. It should be noted, however, that these projections are median values based on the over-estimated 1997 VPA stock size estimate. A total stock size estimate of 1.92 million mt, derived from the surplus production model (Applegate et al. 1998) is probably more accurate.

There is some information on the relative sizes of the two principal spawning stocks that make up the stock complex. Historical assessment information indicates that the western Gulf of Maine stock (herring spawning on Jeffreys Ledge and other locations in Massachusetts Bay) was only 10-15% as large as the Georges Bank/Nantucket Shoals stock during the 1960’s and 1970’s, prior to stock collapses produced by excessive foreign fishing (Anthony and Waring 1980, ICNAF 1976). The NMFS fall trawl survey provides more up-to-date information on the relative size of each spawning component since it is conducted when adult herring occupy their traditional spawning grounds. An examination of the fall trawl survey data by the 27th SAW (NEFSC 1998) resulted in estimates of minimum population size (biomass) for each of the three areas for the time periods 1988-97 and 1993-97. Coastal Maine (Management Area 1) accounted for 27% of the population during 1988-97 and 26% in the more recent time period. Nantucket Shoals (Area 2) accounted for 63% of the population from 1988- 97 and declined to 57% during 1993-97. Georges Bank (Area 3) accounted for 10% of the biomass in 1988-97 and has increased to 17% in the recent period, a reflection of the increased amount of spawning on Georges Bank during the last five years. These data indicate that the Gulf of Maine spawning stock accounts for about 25% of the total spawning stock biomass and the Georges Bank-Nantucket Shoals stock for the remaining 75%. These estimates are consistent with the historical assessment results when one considers that herring which spawn in the western Gulf of Maine probably represent about half of the total coastal spawning population.

Larval surveys conducted by the National Marine Fisheries Service between 1971 and 1994 clearly document the collapse of the offshore portion of the stock complex in the early 1970’s and its recovery over the past ten years. Catch rates of small, recently-hatched herring larvae on Georges Bank and Nantucket Shoals were moderately high in 1973 and 1974, then declined to very low levels until the late 1980's and early 1990’s (Figure E.9). Larval catch rates on Nantucket Shoals increased from <100 larvae per 10 m^2 in 1987 to 800-1700 per 10 m^2 between 1990 and 1994, indicating that considerably more herring were spawning there than on Georges Bank or in Massachusetts Bay. There was no evidence that spawning had resumed on northeast peak of Georges Bank until 1992, when small larvae first appeared in Canadian waters (Melvin et al. 1996). Moderately high larval catch rates in Massachusetts Bay in 1981-1982 (but not in 1973 and 1974) and from 1985 through 1994 indicate that spawning in the western Gulf of Maine proceeded independently of spawning on Nantucket Shoals and Georges Bank.

Catch rates of herring in the spring bottom trawl survey started to increase in the mid-1980’s and reached record high levels in 1996 and 1997 (Figure E.9). High catch rates of two year olds in 1996 and three year olds in 1997 in both the winter and spring surveys indicate that the 1994 year class is large and that the stock will continue to increase in size as fish from this year class recruit to the spawning stock. The 1989 and 1990 year classes also show up as strong ones through ages 5-7 in both surveys.

Despite the continued growth and large size of the stock complex, the fishery is still primarily conducted as a near shore fishery in the Gulf of Maine, on the smaller Gulf of Maine spawning stock and migrants from the Georges Bank stock which occupy this area to some extent in the spring. Concerns have repeatedly been expressed by the scientific community that current levels of exploitation could threaten smaller localized spawning populations in the Gulf of Maine. The 1998 assessment included an un-tuned exploratory VPA of the coastal Gulf of Maine stock. The results of this VPA indicate that biomass was relatively stable (130-200,000 mt) between 1976 and 1984, tripled between 1984 and 1986, remained relatively stable (300-350,000 mt) through 1995 and then increased again (to 400-450,000 mt). The rapid increase in biomass between 1984 and 1986 corresponded with the decline of the fixed gear juvenile fishery along the Maine coast after 1982 and the sharp reduction in juvenile fishing mortality rates. Population growth was stimulated by the influx of these juveniles into the adult population and by the recruitment of the large 1983 year class. Juvenile and adult fishing mortality rates were high through 1982, then dropped and remained between 0.20 and 0.60 for the next 15 years, indicating that this stock was fully utilized throughout this time period, despite the increase in stock size.

Fishing mortality rates between 0.30 and 0.50 (equivalent to 25-40% annual removal rates) in the Gulf of Maine in recent years indicate that this component of the stock complex may, in fact, be overfished. Without an overfishing reference point or MSY estimate for this stock, it is impossible to be sure. Also, as pointed out by the SAW 27 Stock Assessment Review Committee, it is possible that there is some emigration of adults from the large and growing offshore portion of the stock complex into coastal Gulf of Maine waters. Such an emigration could in part account for the relatively high stock size during a time period when fishing mortality rates are also high, and support the single stock and management approach.

1998			**1999**			**2000**			**Implications**
F	Landings	SSB	F	Landings	SSB	F	Landings	SSB	
0.031	119	2,444	0.029	119	3,170	0.028	119	3,715	SSB increases about 52%
			0.049	200	3,121	0.048	200	3,589	SSB increases about 47%
			0.078	317	3,051	0.080	317	3,405	SSB increases about 39%

Table E.7 – Projections for the coastal stock complex of Atlantic herring (landings and SSB estimates in thousands of metric tons) (NEFSC 1998a)

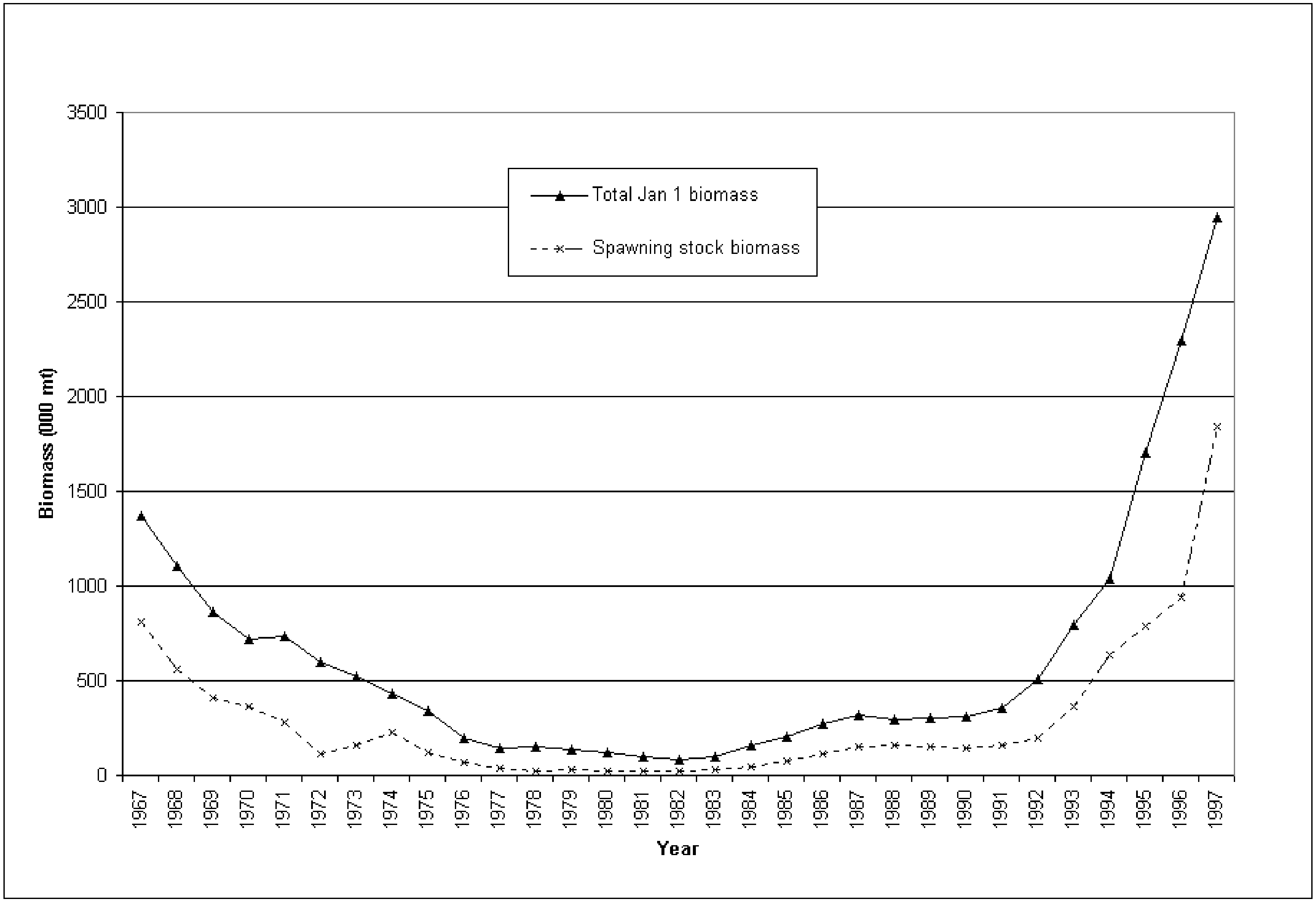

Figure E.7 - U. S. Atlantic herring coastal stock complex biomass (NEFSC 1998a)

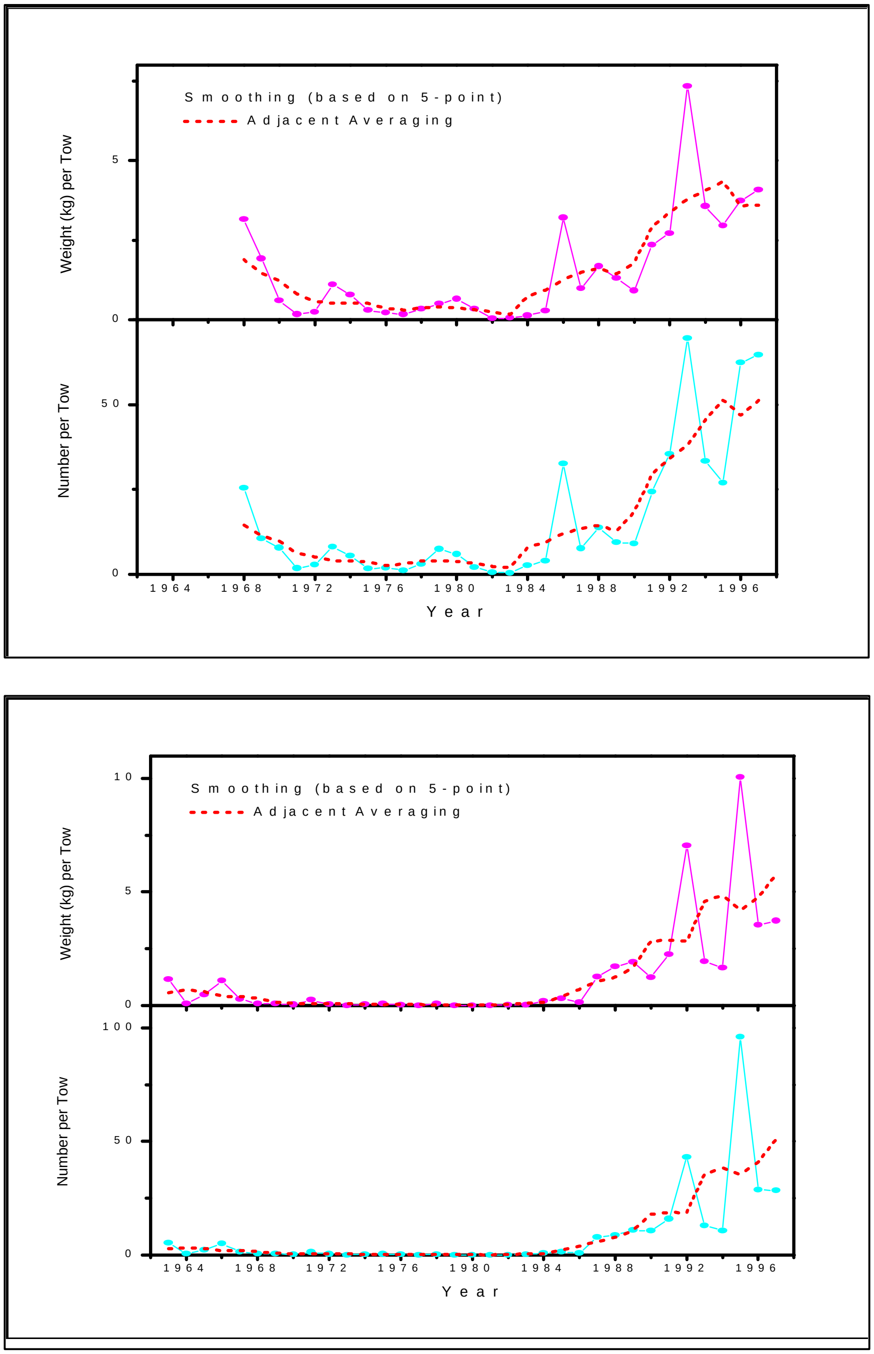

Figure E.8 – NMFS spring (above) and fall (below) bottom trawl surveys (Source: NEFSC 1998a)

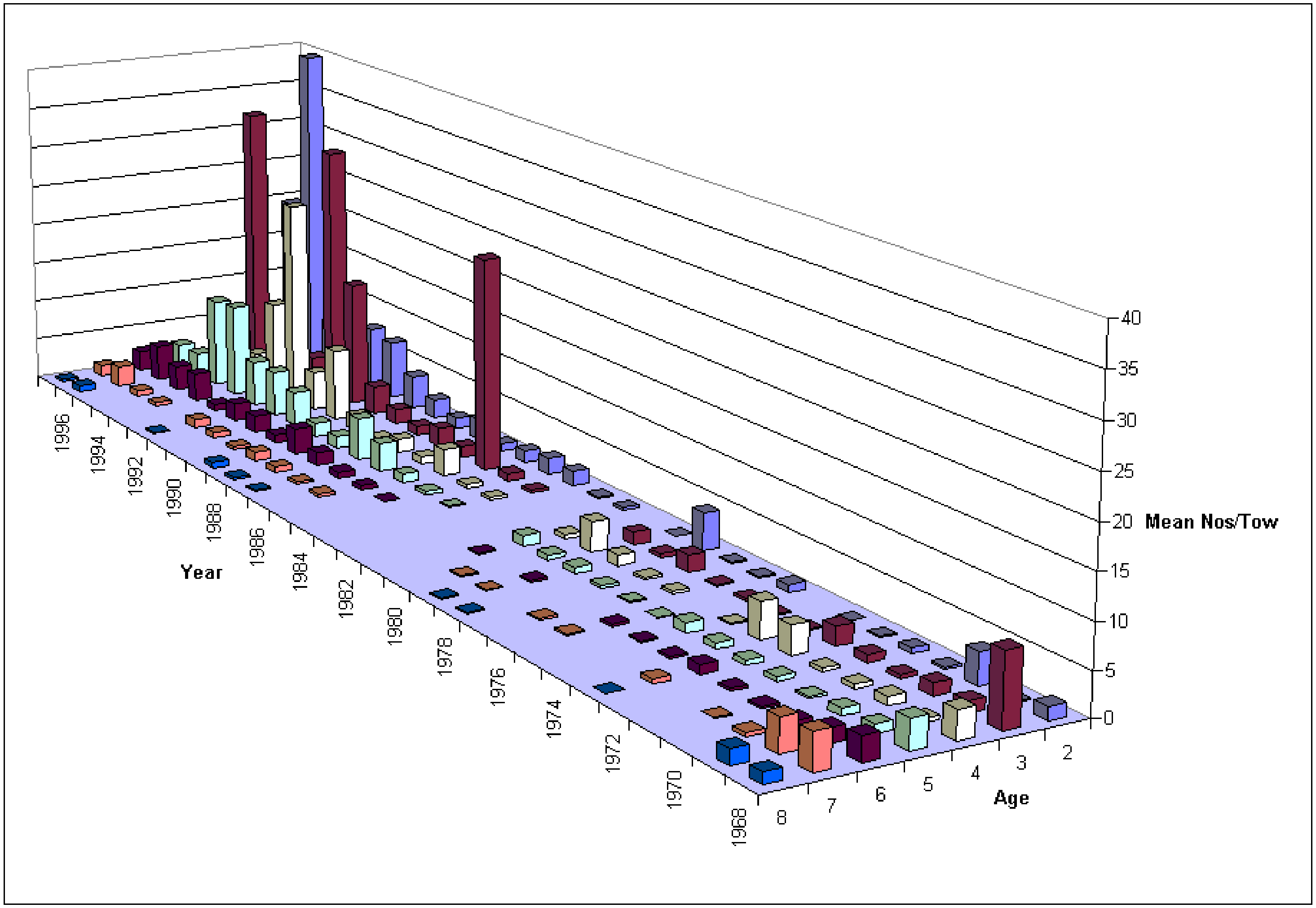

Figure E.9 - NMFS spring bottom trawl survey (from Stevenson et al. 1997)

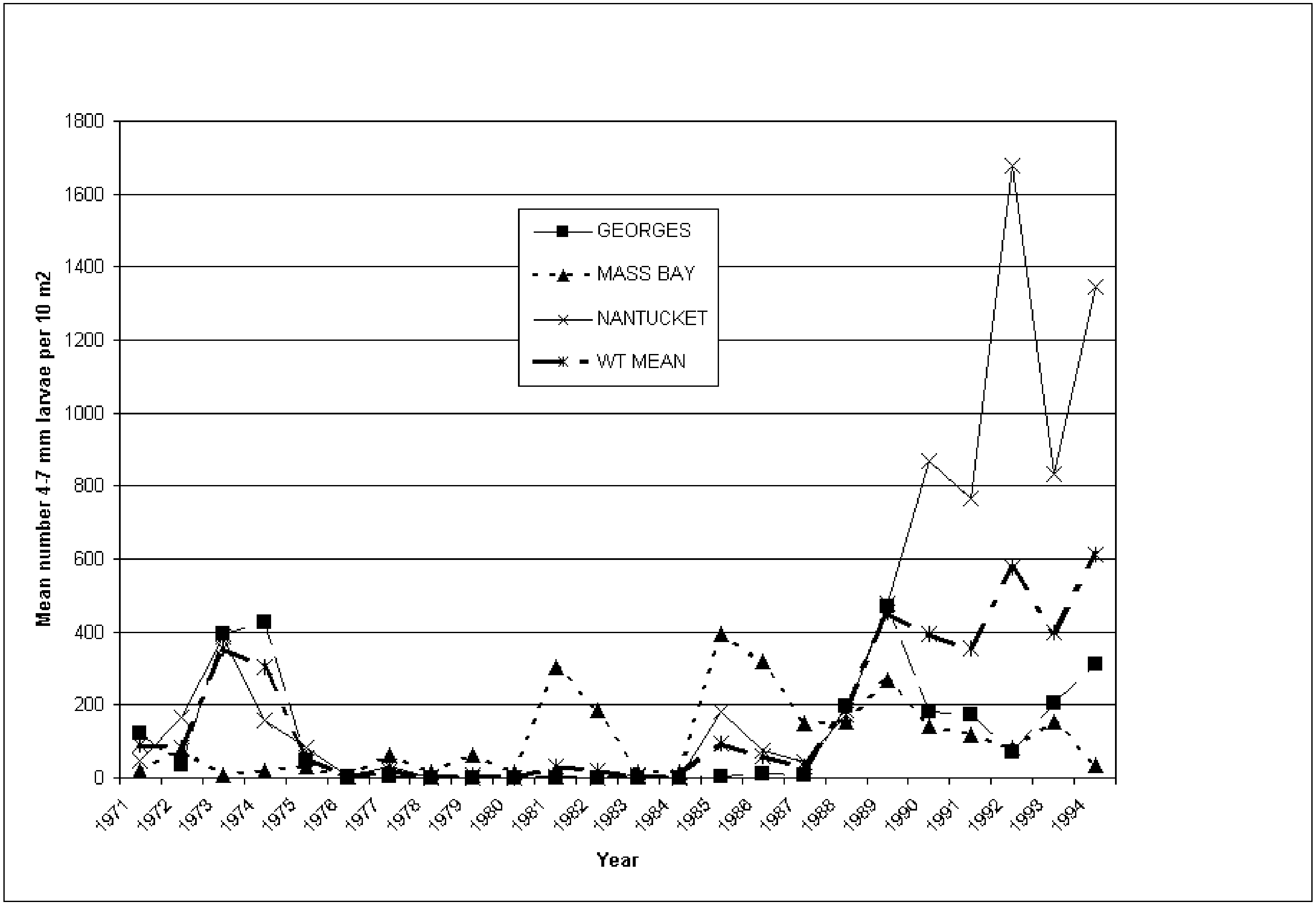

Figure E.10 - NMFS larval herring abundance indices (from Stevenson et al. 1997)