Fishery Management Report No. 42

of the

Atlantic States Marine Fisheries Commission

Working towards healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015.

Amendment 1 to the Interstate Fishery Management Plan For Northern Shrimp

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ATLANTIC STATES MARINE FISHERIES COMMISSION

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Prepared by

Atlantic States Marine Fisheries Commission
Northern Shrimp Plan Development Team

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This Management Plan was prepared under the guidance of the Atlantic States Marine Fisheries Commission's Northern Shrimp Section, chaired by Paul Diodati of Massachusetts. Technical and advisory assistance was provided by the Northern Shrimp Technical Committee and the Northern Shrimp Advisory Panel.

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The Northern Shrimp Fishery Management Plan (FMP) was approved in 1986, based on a plan developed in 1979. The October 1979 plan responded to deteriorating conditions in the fishery and a desire for cooperative management. The participating states – Maine, New Hampshire, and Massachusetts – designated the Atlantic States Marine Fisheries Commission (ASMFC) as the joint regulatory agency in managing the northern shrimp fishery through its Northern Shrimp Section, which is the management body that establishes the annual fishing regulations. The decision to amend the Plan was driven by three main issues: 1) the state of knowledge and tools available to manage the fishery have improved since 1986; 2) all ASMFC FMPs should be updated under the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) and the Interstate Fishery Management Program (ISFMP) Charter; 3) the need to address recent stock conditions while maintaining the current management structure.

Since the adoption of the Northern Shrimp FMP in 1986, the state of knowledge of the northern shrimp biology, population dynamics, and fishery has improved. The state-federal dedicated northern shrimp trawl survey, begun in 1984, has become a long-term data set providing the backbone of the current assessment methodology. A model-based analytical assessment was instituted in 1997 and has undergone two peer reviews. The role of environmental variables in shaping the dynamics of the shrimp population has been more completely explored. Industry representatives suggested alternative management approaches be pursued for the northern shrimp fishery that would provide more flexibility. The original FMP primarily relies on two options for management – season length and gear limitations. Additional management measures are needed to provide greater flexibility and alternatives. The current assessment methods incorporate several aspects of the fishery and survey data available and provide an integrated approach to understanding the dynamics of the stock and fishery. This assessment method and improved knowledge can support a more flexible management program.

The ASMFC improved its ability to cooperatively manage Atlantic coastal fishery resources. The U.S. Congress approved the Atlantic Coastal Fisheries Cooperative Management Act in 1993, providing a mechanism to ensure participating states comply with mandatory conservation measures in the Commission's FMPs. Such mechanisms were not explicitly included in the original FMP. The ISFMP Charter, approved in 1995, defines essential elements for all fishery management programs. These elements are designed to provide balanced conservation and use of coastal fisheries, allow the public to have effective participation in the management planning process, and help Commissioners make informed decisions on FMPs.

Finally, the past few stock assessments indicate that there is reason to be concerned about the northern shrimp population, as stock biomass has reached low levels. The National Marine Fisheries Service (NMFS) declared the northern shrimp resource in an "unknown" condition in 2002 (NMFS 2003).

2.0 GOAL, OBJECTIVES, AND OVERFISHING DEFINITION

The goal of Amendment 1 is to manage the northern shrimp fishery in a manner that is biologically, economically, and socially sound, while protecting the resource, its users, and opportunities for participation by all stakeholders.

OBJECTIVES (2.3)

The following objectives are selected to support of the goal of Amendment 1:

- Protect and maintain the northern shrimp stock at levels that will support a viable fishery
- Optimize utilization of the resource within the constraints imposed by distribution of the resource, available fishing areas, and harvesting, processing and marketing capacity
- Maintain the flexibility and timeliness of public involvement in the northern shrimp management program
- Maintain existing social and cultural features of the fishery to the extent possible
- Minimize the adverse impacts the shrimp fishery may have on other natural resources
- Minimize the adverse impacts of regulations, including increased cost to the shrimp industry and the associated coastal communities
- Promote research and improve the collection of information to better understand northern shrimp biology, ecology, and population dynamics, including variable natural mortality at age or by area
- Improve understanding of the economics of harvesting and processing northern shrimp
- Achieve compatible and equitable management measures through coordinated monitoring and law enforcement among jurisdictions throughout the fishery management unit

DEFINITION OF OVERFISHING (2.5)

Amendment 1 uses an overfishing definition with a fishing mortality target of $F_{target} = F50\% = 0.22$ and a fishing mortality limit of $F_{limit} = F_{20\%} = 0.6$. An F of greater than 0.22 is equal to overfishing. Amendment 1 establishes a stock biomass threshold of $B_{threshold} = 9{,}000$ metric ton and stock biomass limit of $B_{limit} = 6{,}000$ metric ton. If stock biomass is below 9,000 metric ton, the stock is considered overfished.

3.0 MONITORING PROGRAM

The Northern Shrimp Section encourages all state fishery management agencies to pursue full implementation of the Atlantic Coastal Cooperative Statistics Program (ACCSP), which will meet full implementation of the monitoring and reporting requirements of this amendment. The Section recommends that a transition or phased-in approach be adopted for full implementation of ACCSP. Until such time as the ACCSP is implemented, the Section encourages state fishery management agencies to initiate implementation of specific ACCSP module, and/or pursue pilot evaluation studies to assist in development of reporting programs to meet the ACCSP standards (please refer to the ACCSP Program Design document for specific reporting requirements and standards).

The states are encouraged to participate in the annual assessment of northern shrimp. The Northern Shrimp Technical Committee is responsible for conducting annual assessments of fishing mortality, stock biomass, and annual recruitment.

4.0 MANAGEMENT PROGRAM IMPLEMENTATION

COMMERCIAL MANAGEMENT MEASURES (4.1)

To achieve the biological reference points in Section 2.5, the Northern Shrimp Section shall adjust commercial fisheries management measures, based on input from the Technical Committee, Advisory Panel, and public. The Section may make adjustments at its annual fall public hearing only to the closed season (See Section 4.1.1). The Section may also establish incentive-based programs at the annual fall public hearing. Management measures listed in Sections 4.1.2 through 4.1.7 that are already in place may be carried over to the following season's regulations at the Section's annual fall hearing.

Amendment 1 provides the Section with a suite of management measures that were previously unavailable. Section 4.6.2 contains a list of management measures that may be implemented any time throughout the year by the Section. However, adjustment or establishment of any of the measures listed in Section 4.6.2 must be implemented through the addendum process. Please see Section 4.6 for a description of how the Section is able to implement adaptive management through the addendum process.

Once the Section approves management measures for the northern shrimp fishery, it is the individual state's responsibility to implement consistent regulations through its state agency.

Closed Season (4.1.1)

The Section will set the northern shrimp fishing season at its annual fall public hearing. It may establish a closed season or seasons to occur at any time during the year. Conversely, the Section may set a fishing season or seasons at any point during the year based on the biology and condition of the stock. The Section has the ability to set a closed season annually up to 365 days. The Section may set different seasons for the harvesting and processing sectors of the fishery to accommodate for the lag time of processing shrimp that are harvested late in the season.

Minimum Mesh Size (4.1.2)

It is unlawful to fish for, take transport or have in possession any northern shrimp on board any boat rigged for otter trawling with any net with a mesh opening of less than 1-3/4 inches stretched mesh opening between knots, or to have on board any net, netting or portions thereof, except an accelerator funnel of the size specified in Section 3(c), with an opening less than 1-3/4 inches stretched mesh opening between knots and except that a deflector panel of 1 inch mesh may be used in the cod end behind the second grate in a double grate system. The maximum length of the bottom legs of the bridle of any shrimp trawl shall not exceed 15 fathoms of uncovered or bare wire.

Tolerance. Due to the differences of net manufacturer mesh measurements and the mesh measurements used for enforcement of this regulation and other inherent variables a tolerance of

1/8 inch shall be applied to the average mesh size in the body and wings. No tolerance shall be applied to the mesh size in the cod end.

Fishing Gear (4.1.3)

All netting used to catch shrimp shall be of one layer only, with no liners of any kind attached, except that a cod end strengthener may be used as specified, and except that an accelerator funnel may be used and must have a mesh size of no less than 1-3/8 inch stretched mesh. It shall be lawful to attach chafing gear to the lower half of the circumference of the cod end unless a cod end strengthener is used. Cod end shall mean the terminal portion of an otter trawl, pair trawl, beam trawl, scottish seine or mid-water trawl in which the catch is normally retained.

Cod End Strengthener (4.1.4)

An outer mesh may be used as a cod end strengthener while fishing for northern shrimp. The outer mesh must be a minimum of 6 inches and the outer mesh must be at least three times larger than the size of the inner mesh. The mesh may be single or double twine, and diamond or square in shape. The hanging ratio must be the same as the mesh size ratio. Hanging ratio shall mean the number of meshes in the circumference of the cod end to the number of meshes in the circumference of the strengthener. The mesh size ratio shall mean the number of inner meshes to the number of outer meshes. The outer mesh may only cover the cod end. No chafing gear may be used with a cod end strengthener.

Exception. Herring seines or purse seines may be transported from one location to another provided a permit is obtained from a fisheries enforcement officer or the state fishery agency.

Method of Measurements. Mesh sizes are measured by a flat wedge-shaped gauge having a taper of 4 cm in 20 cm and a thickness of 2.3 mm, inserted into the meshes under a pressure or pull of 1.90 kg. The mesh size of a net shall be taken to be the average of the measurements of a series of any 20 consecutive meshes, at least 10 meshes from the lacings, and when measured in the cod end of the net beginning at the after end and running parallel to the long axis.

Finfish Excluder Devices (4.1.5)

It shall be unlawful for any vessel rigged for otter trawling, to fish for, land or have in possession northern shrimp except by using trawls equipped with finfish excluder devices approved by the same agency that permits such vessels. Such finfish excluder devices (commonly referred to as the "Nordmore Grate System") shall consist of:

- A rigid or semi-rigid grate consisting of parallel bars attached to the frame with spaces between the bars not to exceed 1 inch in width;
- A fish outlet, or hole, in the extension of the trawl forward of the cod end and grate; and
- A webbing funnel installed in front of the grate designed to direct the catch toward the grate to maximize the retention of the shrimp may be used but may not have mesh less than 1-3/8 inch stretched mesh.
- Vessels fishing in the shrimp fishery shall not be allowed to possess regulated groundfish species.

Double Nordmore Grate (4.1.6)

A double Nordmore grate may be used while fishing for northern shrimp. A double Nordmore grate is a second grate placed behind the currently required grate, whereby the second grate is intended to release small shrimp from the net while retaining larger shrimp. Such double Nordmore grate devices shall consist of:

- A second grate must be 8 feet behind the first grate (tolerance of greater than 6 feet, but less than 10 feet).
- The second grate must be hung at the same orientation as the first grate.
- The space between the bars shall be 7/16 of an inch.
- The exit holes to the cod end must be at the top and no more than 10% of the surface area.
- A funnel in front of the second grate designed to direct the catch toward the grate to maximize the retention of the shrimp may be used but may not have mesh less than 1-3/8 inch stretched mesh.
- A 1-inch mesh panel behind the second grate, 45 degrees down from the top of bars to the bottom of cod end.
- An escape hole in the cod end in front of the 1-inch mesh panel.

Mechanical "Shaking" Devices (4.1.7)

Mechanical "shakers" have been used to rid smaller shrimp from nets. It shall be unlawful to cull, grade, separate or shake shrimp aboard any vessel, except by implements operated solely by hand. It is illegal to possess aboard any vessel any powered mechanical device used to cull, grade, separate or shake shrimp.

ALTERNATIVE STATE MANAGEMENT REGIMES (4.5)

Once approved by the Northern Shrimp Section, a state may not change its regulatory program without approval by the Section. However, a state may implement more restrictive measures without Section approval. A state can request a change only if that state can show to the Section's satisfaction that the action will not contribute to overfishing of the resource. Changes to state plans must be submitted in writing to, and approved by, the Section prior to implementation.

ADAPTIVE MANAGEMENT (4.6)

The Northern Shrimp Section may vary the requirements specified in this Amendment as a part of adaptive management in order to conserve the northern shrimp resource. The elements that can be modified by adaptive management are listed in Section 4.6.2. The process under which adaptive management can occur is provided in Section 4.6.1.

Measures Subject to Change (4.6.2)

The following measures are subject to change under adaptive management upon approval by the Northern Shrimp Section:

(1) Overfishing definitions
(2) Rebuilding target and schedule
(3) Gear requirements or prohibitions
(4) Management areas
(5) Limited/controlled entry (including, but not limited to, days-at-sea and ITQs)

(6) Catch controls (quotas)
(7) Vessel limits
(8) Recommendations to the Secretary of Commerce for complementary action
(9) Research or monitoring requirements
(10) Frequency of stock assessments
(11) Any other management measures included in Amendment 1 that are not subject to annual specification

5.0 COMPLIANCE

Full implementation of the provisions of this amendment is necessary for the management program to be equitable, efficient and effective. States are expected to implement these measures faithfully under state laws. Although ASMFC does not have authority to directly compel the states to implement these measures, it will continually monitor the effectiveness of state implementation and determine whether states are in compliance with the provisions of this fishery management plan (FMP). The Section sets forth specific elements that the Commission will consider in determining state compliance with this FMP, and the procedures that will govern the evaluation of compliance. Additional details of the procedures are found in the ASMFC Interstate Fishery Management Program Charter (ASMFC 2003).

Compliance Schedule (5.1.2)

States must implement the provisions of this amendment no later than July 1, 2004. States may begin implementation prior to this date when approved by the full Commission.

Annually each state must submit reports on compliance must be submitted to the Commission, no later than September 30 each year.

6.0 MANAGEMENT AND RESEARCH NEEDS

Amendment 1 contains a list of research needs that should be addressed in order to improve the current state of knowledge of shrimp biology, stock assessment, population dynamics, habitat, and social and economic issues. The list is not inclusive. The research needs will be periodically reviewed and updated through the Commission's FMP review process.

7.0 PROTECTED SPECIES

Amendment 1 provides an overview of the protected species known to occur throughout the range of northern shrimp and potential interactions with the fishery.

ACKNOWLEDGEMENTS

Amendment 1 to the Interstate Fishery Management Plan for Northern Shrimp was developed under the supervision of the Atlantic States Marine Fisheries Commission's Northern Shrimp Section, chaired by Paul Diodati of Massachusetts. Members of the Northern Shrimp Plan Development Team (PDT) that contributed to the development of this amendment include: Dr. Clare McBane, New Hampshire Fish and Game; John Norton, Cozy Harbor Seafoods; Dr. Dan Schick, Maine Department of Marine Resources; Mike Lewis, Atlantic States Marine Fisheries Commission. Additional contributions by: Amy Schick, Atlantic States Marine Fisheries Commission; Brad Spear, Atlantic States Marine Fisheries Commission; Dr. Steve Clark, National Marine Fisheries Service; Robert Glenn, Massachusetts Division of Marine Fisheries; Dr. Josef Idoine, National Marine Fisheries Service; Anne Simpson, University of Maine; David McCarron, Gulf of Maine Lobster Foundation; Dr. Madeline Hall-Arbor, Massachusetts Institute of Technology; Christopher Finlayson and Jennifer Brewer. Considerable support was also provided by the Northern Shrimp Technical Committee, chaired by Margaret Hunter, Maine Department of Marine Resources.

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1.1 BACKGROUND INFORMATION

1.1.1 Statement of Management Needs

The Northern Shrimp Fishery Management Plan (FMP) was approved in 1986, based on a plan developed in 1979. The October 1979 plan responded to deteriorating conditions in the fishery and a desire for cooperative management. The participating states – Maine, New Hampshire, and Massachusetts – designated the Atlantic States Marine Fisheries Commission (ASMFC) as the joint regulatory agency in managing the northern shrimp fishery through its Northern Shrimp Section, which is the management body that establishes the annual fishing regulations. The decision to amend the Plan was driven by three main issues: 1) the state of knowledge and tools available to manage the fishery have improved since 1986; 2) all ASMFC FMPs should be updated under the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) and the Interstate Fishery Management Program (ISFMP) Charter; and 3) the need to address recent stock conditions while maintaining the current management structure.

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Finally, the past few stock assessments indicate that there is reason to be concerned about the northern shrimp population as stock biomass has reached low levels. The National Marine Fisheries Service (NMFS) declared the northern shrimp resource in an "unknown" condition in 2002 (NMFS 2003).

1.1.2 Benefits of Implementation

This amendment is designed to prevent a population collapse due to overfishing, minimize the risk of recruitment failure, and maintain a healthy and productive northern shrimp resource and fishery. It also provides a mechanism for monitoring the northern shrimp population, maintaining an efficient management regime and structure that is flexible and encourages public involvement in the management process.

Recent stock assessments and landings data indicate that the northern shrimp resource is in a depleted state and vulnerable to collapse – probably due to a combination of unfavorable environmental factors and fishing pressure. Regulatory action that effectively increases stock biomass to levels above the biomass threshold when the ocean climate is favorable will likely have short-term adverse effects on harvesting and processing sectors. When fishing mortality levels are consistently at or below the target and stock biomass is consistently above the threshold as defined by Amendment 1, long-term economic gains should be realized in the harvesting and processing sectors.

Amendment 1 should improve the Northern Shrimp Section's ability to more effectively assess the status of the resource, predict its responses to both changes in the ocean climate and to various management actions, and match fishing effort and fishing mortality with sustainable yield. Sustaining a viable shrimp fishery benefits the region by helping maintain diversity in the industry and providing opportunities to harvest, process, and further develop support industries. Specific benefits associated with the amendment will vary depending upon the management tools selected by the Section.

1.1.3 Ecological Benefits

Northern shrimp is an often identified link in marine food chains, preying on both planktonic and benthic invertebrates and in turn being consumed by many commercially important fish species, such as cod, redfish and silver and white hake. Therefore, maintaining a healthy northern shrimp population will, contribute to a balanced Gulf of Maine ecosystem. Shrimp will continue to play a roll in controlling the populations of its prey, while simultaneously providing fodder for carnivorous vertebrates throughout the Gulf. *Pandalus borealis* diet was well documented by Weinberg (1981). Species that include *P. borealis* in their diet are documented by many authors (See Synopsis: Shumway, Perkins, Schick and Stickney, 1985.) Over many years, Wigley, Langton and Bowman from NMFS have conducted many predator-prey studies showing the position of *P. borealis* in the food web of the Gulf of Maine.

1.2 DESCRIPTION OF THE RESOURCE

1.2.1 Northern Shrimp Life History

The biology of northern shrimp in the Gulf of Maine has been studied extensively (Apollonio and Dunton 1969; Apollonio *et al.* 1986; Haynes and Wigley 1969; and others). The species is hermaphroditic, maturing first as males at roughly 2 ½ years of age and then transforming to females at roughly 3 ½ years of age (Figure 1). Northern shrimp spawn in offshore waters beginning in late July. By early fall, most adult females extrude their eggs onto the abdomen. Egg bearing females move inshore in late autumn and winter, where the eggs hatch. Juveniles remain in coastal waters for a year or more before migrating to deeper offshore waters, where

they mature as males. The males pass through a series of transitional stages before maturing as females. Some females may survive to repeat the spawning process in succeeding years, although natural mortality seems to increase sharply following first hatching.

Though the mechanisms that effect sex change are not known, it is believed that population density and size at age are important factors. A certain segment of the population which should be maturing as males will essentially skip that phase and go into an "early maturing" female phase. This is a reaction to stress whereby the population assures its ability to maintain its maximum spawning potential.

There is considerable information on growth of the Gulf of Maine northern shrimp stocks (Haynes and Wigley 1969; Apollonio et al. 1986; Terceiro and Idoine 1990; and Fournier at al. 1991). Differences in size at age by area and season can be ascribed to temperature effects, with more rapid growth rates at higher temperatures (Apollonio et al. 1986).

Instantaneous natural mortality (M) for this stock has been estimated at 0.25 based on regressions of instantaneous total mortality (Z) estimate from research vessel surveys for 1968-1972 on total effort (Rinaldo 1981). The estimates of Z for 1978 (when the fishery was closed) from the State of Maine survey data was 0.17 (Clark 1982). Therefore it appears that M is low in the Gulf of Maine relative to other northern shrimp stocks, which has been estimated at a range from 0.25-1.0 (Shumway, Perkins, Schick, and Stickney, 1985).

1.2.2 Stock Assessment Summary

The 2003 stock assessment, conducted in the fall of 2003 by the Northern Shrimp Technical Committee, (NSTC) was based on commercial fishery data from the 2002-2003 fishing season (i.e. catch and catch-per-unit-effort), and fishery independent resource surveys (i.e. Northeast Fisheries Science Center spring and fall bottom trawl and state-federal summer shrimp surveys) through August 2001. In addition to previously used traditional methods of assessing the stock (i.e. landings data, commercial effort and CPUE estimates, indices of abundance, etc.) more innovative, quantitative tools, the Collie-Sissenwine Analysis, ASPIC surplus production, yield per recruit and eggs per recruit models were introduced in 1997 and continue to be used to provide guidance for management of the stock. The 2003 report indicates a cause for concern with the status of the northern (NSTC) shrimp stock.

Trends in abundance have been monitored since the late 1960's using data from Northeast Fisheries Science Center (NEFSC) spring and autumn bottom trawl surveys and summer surveys conducted by the State of Maine (discontinued in 1983). A state-federal shrimp survey was initiated by the NSTC in 1984. This survey is conducted each summer aboard R/V GLORIA MICHELLE and employs a stratified random sampling design and gear specifically designed for Gulf of Maine conditions. The strata sampled and catch per tow data for the 2001 summer survey cruise are plotted in Figure 2. The summer survey is considered to provide the most reliable information available on abundance, distribution, population age structure and other biological parameters of the Gulf of Maine northern shrimp resource. The NSTC has placed primary dependence on the summer survey for the fishery-independent data used in stock assessments, although the NEFSC spring and autumn survey data have been valuable as well.

There has been general agreement between the NEFSC autumn survey index (stratified mean catch per tow, kg) and fishery trends (Figure 2). The index declined precipitously as the fishery collapsed during the 1970s. This was followed by a substantial increase, indicated by peaks in 1986, 1990 and 1994, which reflect the growth and recruitment of the strong 1982, 1987 and 1992 year classes into the fishery. After declining to 1.1 kg per tow in 1996, with passage of the 1992 year class through the fishery, the index rose sharply in 1998, reflecting recruitment of the 1996 year class at age 2. It is important to note that trends in abundance from the NEFSC spring survey index are similar.

Abundance and biomass indices (stratified mean catch per tow in both numbers and weight) for the state-federal survey from 1984-2003 are given in Table 1, with length-frequencies by cruise provided in Figure 3 for up to 2001. Table 1 includes indices for all size/age groups, including those for age 1.5 animals and for shrimp >22 mm mid-dorsal carapace length. The catch per tow in numbers of 1.5-year old shrimp (the total number in the first size modes in Figure 3) represents a recruitment index, which, although the shrimp are not fully recruited to the survey gear, appears sufficient as a preliminary estimate of year-class strength. Individuals >22 mm will be fully recruited to the upcoming winter fishery (primarily age 3 and older) and thus survey catches of shrimp in this size category provide indices of harvestable numbers and biomass for the coming season. Again, all of these indices have shown peaks, which reflect recruitment of the strong 1982, 1987 and 1992 year-classes (Table 1, Figure 3).

The 1999 year class, seen for the first time in the summer 2000 survey, was classified as moderate to strong. Based on the 2003 summer survey, the 1999 year class (assumed 5-year olds) was classified as weak. The 2003 assessment reported that the while the 2001 year class (assumed 3-year olds) appeared to be moderate, the 2000 and 2002 year classes were virtually absent.

The mean number per tow of 1.5 year old shrimp from the State-Federal Northern Shrimp survey is used as a proxy for a recruitment index. Although the shrimp are not fully recruited to the survey gear at this age, it appears that this index is a sufficient representative of year class strength from the previous year.

The stratified mean weight (kg) per tow of northern shrimp >= 22 mm dorsal carapace length (CL) from the State/Federal Northern Shrimp Survey provides the index of spawning stock biomass (SSB). Northern shrimp are protandric hermaphrodites which start changing from male to female around 2.5 years of age, or 18 to 19 mm CL. The 22 mm dorsal carapace length is used as a cut off point because at this size close to 100% of shrimp are sexually mature females.

As indicated in Figure 4, the SSB index has exhibited a long term declining trend since achieving a high of over 7.5 kg/tow in 1987. Peaks in SSB were observed in 1987, 1991/1992, and 1996. The index of SSB has remained well below the time series mean of 4.0 kg/tow from 1997 to present and is reflective of poor recruitment in the last several years.

Fishing mortality estimates for the Gulf of Maine northern shrimp fishery are generated by two separate models; the modified Delury model, also called the Collie-Sissenwine Analysis (CSA), and a surplus production model. The CSA tracks the removals of shrimp using summer survey

indices of recruits and fully recruited shrimp scaled to total catch in numbers. The surplus production analysis models the biomass dynamics of the stock with a longer time series of total landings and three survey indices of stock biomass. The CSA estimates of fishing mortality are used as the primary point estimates for managing the fishery, while the surplus production estimates of fishing mortality are used to corroborate results from the CSA.

CSA estimates of annual fishing mortality (Table 6; Figure 5) averaged 0.22 (18% exploitation rate) for the 1985 to 1994 fishing seasons, peaked at 1.17 (62% exploitation rate) in the 1997 season and decreased to 0.09 (8% exploitation rate) in the 2003 season. Estimates of fishing mortality rates from the surplus production model generally confirm the pattern of estimates from the CSA model; fishing mortality rates in 2003 (F = 0.09) decreased from a peak of 0.60 in 1997.

1.2.3 Present condition of the stock

Landings in the Gulf of Maine northern shrimp fishery have declined since the mid 1990s, from a high for the decade of 9,166 mt in 1996 to 937 mt in 2003 (preliminary), the result of low abundance of shrimp and reductions in fishing effort. The number of fishing vessels and trawl trips have dropped from about 310 and 10,734, respectively in 1997 to 159 and 1,805 in 2003, although vessel reporting, particularly from the Maine small boat fleet, has probably improved. Fishing mortality rates, as calculated by CSA, have declined from 0.87 in 1997 to 0.09 in 2003. Although low in 2002 and 2003, the fishing mortality rate was considerably above the 1985-1994 average (recommended as a possible target by the 1997 Stock Assessment Review Committee) each year from 1995 through 2000.

Current landings, vessels, and trips are calculated from vessel trip reports (VTRs). Note that 2002 landings were incomplete when calculated from VTRs in October 2002 and went up by 12% when recalculated in October 2003 (Table 2; Figure 6). Thus, it must be assumed that 2003 vessel trip reports are also incomplete at this time. However, it can be concluded that the 2003 fishery was short, mostly inshore, with limited participation, moderate landed catches per trip and per hour, and high occurrences of small shrimp (assumed 2-year-old, 2001 year class). It is also likely that rates of discarding were high, at least during part of the season.

Exploitable biomass as estimated from CSA declined from 15,500 mt in 1995 to a time series low of 5,600 in 1999. Since then the biomass estimate has risen to 7,500 mt in 2003, as a result of the appearance of the moderate 1999 year class and the strong 2001 year class. This estimate is still well below the time-series average of 12,800 mt, and below the average of the relatively stable 1985-1994 period of 17,200 mt (Table 6).

Size composition data from both the fishery and summer surveys indicate that good landings have followed the recruitment of strong (dominant) year classes. Poor landings since 1997, as well as low biomass estimates, can be attributed in part to the below-average recruitment of the 1994, 1995, 1997, 1998, and 2000 year classes.

In 2004, the 1998 year class will have passed out of the fishery, and the moderate 1999 year class (assumed 5-year old females), virtually absent 2000 year class (assumed 4-year-old females), strong 2001 year class (assumed 3-year-old males, transitionals, and early-maturing females),

and virtually absent 2002 year class (juveniles) will remain. Unfortunately, survey indices for 2003 indicate that the 1999 and 2001 year classes have diminished substantially since previous assessments, and "moderate" and "strong" have become "weak" and "moderate" respectively.

1.2.3.1 Peer Review Panel Results from the 36th SAW

The northern shrimp stock assessment was peer-reviewed at the 36th Northeast Regional Stock Assessment Workshop (36th SAW) in December 2002, containing data through the 2002 summer survey. The following sections were taken from the Advisory Report:

"State of Stock: Currently there are no quantitative status determination criteria adopted by ASMFC. The stock is below the average level of biomass, and current fishing mortality rate (F) is below all standard fishing mortality rate reference points. For the period 1985–1995, the fishing mortality rates ranged from 0.15 to 0.57. Between 1996 and 1998, fishing mortality rates ranged from 0.70 to 1.18, the highest values seen since the stock collapsed in the late 1970s. From 1999 to 2002, it declined from 0.42 to 0.06. For the period 1985-1995 exploitable biomass ranged from 9,200 to 22,500 mt and averaged 16,800 mt. From 1998 to 2002, biomass ranged from 5,700 to 9,200 mt, averaged 6,600 mt, and is currently about 9,200 mt. The 2001 year class is among the largest on record while the 2000 year class was among the smallest on record.

Management Advice: Fishing mortality should be kept low to minimize the risk of further decline in stock size, and to protect the 1999 and 2001 year classes. Managers should establish appropriate reference points (targets, thresholds, and limits) and consider control rules that account for the unique life history characteristics of northern shrimp."

1.3 DESCRIPTION OF THE FISHERY

1.3.1 Commercial Fishery

Northern shrimp occur in boreal and sub-arctic waters throughout the North Atlantic and North Pacific, where they support important commercial fisheries. In the western North Atlantic, commercial concentrations occur off Greenland, Labrador, and Newfoundland, in the Gulf of St. Lawrence, and on the Scotian Shelf. The Gulf of Maine marks the southernmost extent of its Atlantic range. Primary concentrations occur in the western Gulf where bottom temperatures are coldest. In summer, adults are most common at depths of 90-180 meters.

The fishery has been seasonal in nature, peaking in late winter when egg-bearing females move into inshore waters and terminating in spring under regulatory closure. Table 3 identifies the season length and regulations for the northern shrimp fishery since 1973. Northern shrimp has been an accessible and important resource to fishermen working inshore areas in smaller vessels who otherwise have few options due to seasonal changes in availability of groundfish, lobsters and other species.

The fishery formally began in 1938, and during the 1940s and 1950s almost all of the landings were by Maine vessels from Portland and smaller Maine ports further east. This was an inshore winter fishery, directed towards egg-bearing females in inshore waters (Scattergood 1952). Landings reached a peak of 264 tons in 1945, but then declined into the 1950s and during 1954-1957 no commercial landings of shrimp were recorded.

In the late 1950s, the fishery began to recover due to the efforts of commercial interests in Portland, Maine, and presumably to improving resource conditions. Landings increased to a peak of 12,800 tons in 1969, of which 11,000 tons were taken by Maine vessels. New Hampshire vessels entered the fishery in 1966, but throughout the 1960s and 1970s New Hampshire landings were minor. Landings by Massachusetts vessels were insignificant until 1969, but in the early 1970s the fishery developed rapidly, with landings increasing from 14% of the Gulf of Maine total in 1969 to over 40% in 1974-1975. In contrast to the historical wintertime Maine fishery, these vessels fished continually throughout the year and made significant catches during summer months. Total landings averaged 11,000 tons from 1970-1972 and then declined rapidly until 1977 when only 400 tons were landed. The fishery was closed from mid-May of 1977 to February 1979.

Since 1980, landings and effort have fluctuated considerably in response to recruitment from several strong year classes. Annual landings peaked at 5,000 tons and 4,400 tons in 1987 and 1990, respectively, dropping to 2,300 tons in 1993. Landings then increased to 9,500 tons in 1996 before declining to 3,700 tons in 1998. In keeping with historic trends, the majority of the catch in these years has been taken by Maine vessels (76%), with Massachusetts vessels accounting for most of the remainder (17%). Numbers of participating vessels have fluctuated considerably, increasing to 300-400 vessels in some years. Many of the vessels that participate in the fishery are opportunistic, switching to shrimp trawling if the season's length, shrimp's price and accessibility warrant the effort.

A wide variety of vessels have been used in the fishery (Bruce 1971; Wigley 1973). The predominant type during the 1960s and 1970s appears to have been side-rigged trawlers in the 14-23 m range. During the 1980s and 1990s, side trawlers either re-rigged to stern trawling, or retired from the fleet. Currently, the shrimp fleet is comprised of lobster vessels in the 9-14 m range that re-rig for shrimping, small to mid-sized stern trawlers in the 12-17 m range, and larger trawlers primarily in the 17-24 m range. The otter trawl remains the primary gear employed and is typically chain or roller rigged, depending on area and bottom fished. There has been a trend in recent years towards the use of heavier, larger roller and/or rockhopper gear. These innovations, in concert with substantial improvements in electronic equipment, have allowed for much more accurate positioning and towing in formerly unfishable grounds, thus greatly increasing the fishing power of the Gulf of Maine fleet.

A small pot fishery has also existed in mid-coastal Maine since the 1970s, where in many areas bottom topography provides favorable shrimp habitat yet is too rough or restricted for trawling. The trapped product is of good quality, as the traps target only female shrimp once they have migrated inshore. The trap fishery has landed as high as 8% of the Maine landed total, but the annual average is usually around 5%. There is some indication that trap fishing for shrimp has grown in a few areas such as South Bristol (Lower mid-coast Maine). As the trap fishery is dependent on the availability of shrimp in a specific area, there is apparently a shorter season for traps than for draggers. However, the majority of the shrimp trappers also catch lobster, so shrimp is a supplemental portion of their annual production and income.

The majority of the shrimp boats work out of smaller ports, though not necessarily the same small ports every year. In at least one case the shrimp fishery has been the salvation of the local marketing organization. Yankee Co-op in Seabrook (NH) weathered a crisis precipitated by the curtailment of groundfish landings due to regulatory action when their members successfully turned to the shrimp fishery.

Fishermen commonly point out that fishing has always been cyclical. Shrimp, for instance, is thought to have a seven-year cycle between high points. Flexibility is critical, especially for small boats that are constrained by weather and safety considerations. A typical annual round for fishermen in the smaller ports is to lobster in the spring, summer and fall and then to go shrimping in winter (December-May). Where this flexibility is curtailed by license limitations, many fishermen feel that the resilience of both the fleet and their communities is compromised. It is precisely the ability to freely move in and out of the shrimp fishery in response to the relative availability of shrimp, other commercial species, market demand, the weather, and other factors that makes the shrimp fishery more valuable than the raw landings and income data may suggest. For some fishermen even a limited shrimp harvest is sufficient to make the difference between financial stability and failure.

Lower Mid-Coast Maine predominates in shrimping compared to the other sub-regions in Maine. Portland, Cundy's Harbor, Boothbay Harbor and South Bristol are all in Lower Mid-Coast Maine. The Portland Fish Exchange holds a daily shrimp auction in season. Portland, Boothbay, Rockland and South Bristol are all processing centers for shrimp.

1.3.2 Recreational Fishery

A very limited recreational fishery exists for northern shrimp. This fishery, using traps, has been for personal use and has not been licensed.

1.3.3 Subsistence Fishing

No significant subsistence fisheries for northern shrimp have been identified at this time; however, fishermen reportedly bring home 10 or 20 pounds of shrimp for home consumption or distribution to friends on a regular basis.

1.3.4 Non-Consumptive Factors

No non-consumptive factors in the northern shrimp fishery have been identified at this time.

1.3.5 Interactions with Other Fisheries, Species, or Users

1.3.5.1 Other Species

Northern shrimp is an important link in marine food chains, preying on both plankton and benthic invertebrates and, in turn, being consumed by many commercially important fish species, such as cod, redfish and silver and white hake. *P. borealis* diet was well documented by Weinberg (1981). Species that include *P. borealis* in their diet are documented by many authors (See Synopsis: Shumway et al., 1985.)

1.3.5.2 Other Fisheries

In recent history, the northern shrimp fishery has been prosecuted in the winter months from December through May at a time when other fishing activities in the Gulf of Maine are marginal or out of season.

Dunham and Mueller (1976) note that in response to shrimp harvest restrictions such as a closed season, most respondents indicated that they would fish for other species. Additionally, most would fish for species they typically target at other times of the year. These included lobster, scallop, or groundfish (mostly redfish, cod, and whiting). During the period this study took place, stock levels were extremely low, ultimately leading to the closure of the fishery in April 1977. Fishermen responded by spending more time prosecuting fisheries that they had historically participated in. This is indicated by notable increases in the landings for whiting and squid during the period.

Similarly, most shrimpers today also fish for other species during the year. Much the same behavior would be expected from a restricted or closed shrimp season, with most vessels extending their participation in other fisheries. The ability to switch between fisheries is most likely more important and much more strategic since the implementation of limited entry and days-at-sea effort restrictions in groundfish and scallops. Dunham and Mueller also note that although shrimp fishing may at times represent a marginal activity or a small fraction of annual stock, it is often the difference between a profitable year or not. The same is often true today, although lobster fishing alone has been very lucrative for the past decade.

Processing plants may switch between shrimp and lobster over the course of a year. However, the facilities and skills of the workers are specialized for the two species so switching can be expensive. Shrimp is highly perishable and proper handling is a requisite for quality product.

The interaction between mobile gear and fixed gear does exist during two time periods. If the shrimp fishery begins in December or January, coastal lobstermen are quick to pay heed and make sure that their gear has been removed at the end of their season before the mobile gear vessels begin working on shrimp. In January through March, some shrimp fishermen use fixed gear to harvest shrimp. They also must be careful to avoid bottom where draggers might fish. Most trap fishermen fish in and around hard bottom coves and holes where mobile gear can't reach.

1.4 HABITAT CONSIDERATIONS

1.4.1 Habitat Important to the Stocks

1.4.1.1 Description of the Habitat

Pandalus borealis, commonly known as northern or pink shrimp, has a discontinuous distribution throughout the North Atlantic, North Pacific, and Arctic Oceans. In the Gulf of Maine, northern shrimp populations comprise a single stock (Clark and Anthony 1981), which is concentrated in the southwestern region of the Gulf (Haynes and Wigley 1969; Clark et al 1999, see Figure 7). Water temperature, depth, and substrate type have all been cited as important

factors governing shrimp distribution in the Gulf of Maine (Haynes and Wigley 1969; Apollonio et al. 1986; Clark et al. 1999).

Temperature

Adult northern shrimp have been reported to live in waters from -1.6^0C (Gorbunow 1934; Ingraham 1981) up to around 12^0C (Bjork 1913; Allen 1959), while larvae can tolerate temperatures up to at least 14^0 C (Poulson 1946); however, the most common temperature range for this species is 0-5^0 C (Shumway et al 1985). The Gulf of Maine marks the southern-most extent of this species' range, and seasonal water temperatures in many areas regularly exceed the upper physiological limit for northern shrimp. This environmental limitation restricts the amount of available habitat occupied by this species to the western region of the Gulf (west of 68^0 W) where bottom topography and oceanographic conditions create submarine basins protected from seasonal warming by thermal stratification. The deep basins act as cold water refuges for adult shrimp populations. In northeastern region of the Gulf, large shrimp populations do not persist because bottom waters are not protected from seasonal warming due to continual mixing from intense tidal currents nearer to the Bay of Fundy.

Depth

In the Gulf of Maine, northern shrimp are most frequently found from about 10 m to over 300 m (Haynes and Wigley 1969), with juveniles and immature males occupying shallower, inshore waters and mature males and females occupying cooler, deeper offshore waters for most of the year (Apollonio and Dunton 1969; Haynes and Wigley 1969, Apollonio et al 1986). During the summer months, adult shrimp inhabit water from 93-183 m (Clark et al. 1999) (Table 5; Figure 10); ovigerous female shrimp are found in shallower near-shore waters during the late winter and spring (Clark et al. 1999; Table5; Figure 11) when their eggs are hatching.

Substrate

Within its preferred temperature range, northern shrimp most commonly inhabit organic-rich, mud bottoms or near-bottom waters (Wollebaek 1908; Hjort and Rund 1938; Horsted and Smidt 1956; Warren and Sheldon 1968), where they prey on benthic invertebrates; however, the shrimp is not limited to this habitat and has been observed on rocky substrate (Berkeley 1930; Balsiger 1981). Shrimp distribution in relation to substrate type determined by spring (Figure 12), summer (Figure 13), and autumn (Figure 14) fisheries independent trawl surveys, clearly show northern shrimp primarily occupy areas with fine sediments (sand, silt, and clay) (Table 5). Shrimp are often associated with biotic or abiotic structures such as cerianthid anemone tubes (Langton and Uzmann 1989) and occasional boulders (Dan Schick, Maine Department of Marine Resources, pers.comm.) in these fine sediment habitats.

Other Environmental and Life History Features Governing Northern Shrimp Distribution

Northern shrimp occupy a variety of habitats during their complex life history. Like all members of the family Pandalidae, northern shrimp are protandric hermaphrodites, developing first into functional males, and later undergoing a transformation into females. Distribution and migratory patterns of this species change with age, (and in the case of females, with season), causing habitat preference to shift with different life history stages.

In addition to age and seasonally correlated horizontal migrations, northern shrimp exhibit diel vertical migration in the water column. There is strong evidence that northern shrimp leave the

bottom at night and distribute themselves throughout the water column, presumably to feed (Wollebaek 1903; Hjort and Ruud 1938; Barr 1970). Gut contents of this species have been shown to include planktonic crustaceans (Horsted and Smidt 1956). In thermally stratified waters, northern shrimp will migrate up to, but not penetrate the thermocline (Apollonio and Dunton 1969). After spending the night dispersed in the water column, shrimp return to the bottom around dawn where they feed on a wide variety of soft bottom benthic invertebrates (Wienberg 1981).

As a stenohaline species, northern shrimp are restricted to water with moderately high salinities (Allen 1959). Their occurrence has been noted in waters with salinities ranging from a low of 23.4 to 35.7 (Shumway et al. 1985)

Spawning Habitat

In the Gulf of Maine, northern shrimp spawn in offshore waters beginning in late summer months (Haynes and Wigley 1969). The precise locations of spawning grounds are not well documented but it is reasonable to conclude that spawning occurs in offshore summertime population centers in deep mud basins in the southwestern Gulf (Haynes and Wigley 1969; Apollonio et al 1986). Ovigerous females remain in cold, stratified bottom waters offshore through the fall until near-shore waters have cooled, at which time they begin an inshore migration to release their eggs (Haynes and Wigley 1969; Apollonio et al. 1986). Inshore migration routes followed by the northern shrimp are not well known, but due to their well established preference for organic-rich mud bottoms, it has been suggested that female shrimp probably move inshore over muddy substrates and are eventually concentrated in, but not limited to, mud-bottom channels near-shore (Dan Schick, pers.comm.).

Eggs & Larval Habitat

After their arrival in nearshore waters, the female shrimp's mature eggs begin to hatch. Hatching occurs as early as February and lasts through April (Haynes and Wigley 1969; Stickney and Perkins 1979) after which time female shrimp return to offshore waters in the western Gulf. The pelagic larvae are planktotrophic, feeding primarily on diatoms and zooplankton (Stickney 1980). A survey of larval shrimp distribution conducted by Apollonio and Dunton (1969) showed that larvae were abundant almost exclusively within 10 miles of shore. Little is known about the vertical distribution of larval shrimp within the water column. While in the plankton, northern shrimp pass through six larval stages (Berkeley 1930; Stickney and Perkins 1979) before completing a final metamorphosis to a juvenile stage and settling to the bottom in near-shore waters after about 30 to 60 days (Rinaldo 1981). It is important to note that time of egg release and larval development rate are temperature related, with colder water temperatures resulting in slower developmental progress (Allen 1959). Thus, the timing of egg release and length of pelagic larval stages may vary slightly from year to year as a result of annual mean water temperature fluctuations in the Gulf of Maine.

Juvenile Habitat

By late summer, nearly all newly metamorphosed juveniles have settled to the bottom in relatively shallow, near-shore areas usually within 10 miles of the coast (Apollonio and Dunton 1969). These immature shrimp remain inshore for up to 20 months as they grow and develop into mature males (Apollonio and Dunton 1969). Relatively little is known about the distribution and habitat requirements of this life history stage. After as little as a year, some juveniles begin

to migrate offshore to deeper waters. Eventually, all juveniles will migrate offshore where they will complete their development into mature males around the age of 2 (29-30 months old) (Apollonio and Dunton 1969; Haynes and Wigley 1969). Their migration routes and factors triggering migration to deep, offshore, muddy basins are not well known.

Adult Habitat & Distribution in the Gulf of Maine
Adult shrimp distributions appear to be governed by seasonal changes in water temperature. During the summer months, adult shrimp are confined to cold waters (4-6^{0}C) found only in the deeper basins (92-183 m) in the southwestern Gulf of Maine (Figure 10). Female shrimp are found in abundance in near-shore waters only during the late winter and spring when coastal waters are coldest (Figure 2; Clark et al. 1999). Within their preferred temperature range, northern shrimp occur mainly on mud bottom habitats (see Clark et al. 1999 Figures 4, 5, 6) where the organic matter content of the sediment is high (Haynes and Wigley 1969). Bigelow and Schroeder (1939) and Wigley (1960) found a direct correlation between shrimp abundance and sediment organic matter content. Apollonio et al. (1986) argued that temperature is the most important factor driving the distributional patterns of shrimp in the Gulf. They suggest that correlations between shrimp abundance and fine sediments with high organic matter content may be purely coincidental because deep, quiescent environments in the Gulf of Maine are characterized by both cold, unmixed water and accumulation of fine sediments.

Mud bottom habitats which support large populations of shrimp include: Jeffrey's basin (Apollonio and Dunton 1969), Cashes basin, Scantum basin (Dan Schick, Maine Department of Marine Resources, pers.comm.) and the region southeast of Mount Desert Island, Maine (Haynes and Wigley 1969). There are small populations in deep, cold water pockets in Penobscot Bay (Dan Schick, pers.comm.) and in the Sheepscot River (Les Watling, University of Maine, pers. comm.).

During the winter and spring, when nearshore and offshore surface waters have cooled to the temperature range of shrimp, the amount of habitat available to adult shrimp increases. A wintertime fishery for northern shrimp extends as far south as the outer arm of Cape Cod, reaches as far north as Jonesport, Maine (Dan Schick, pers.comm.)

Figures 7-12 are GIS maps of northern shrimp distributions in relation to the following important habitat characteristics: temperature, depth, and substrate type were developed by Clarke et al. (1999) from fisheries independent time-series surveys carried out by National Fisheries Science Center (NFSC) and cooperative state and federal surveys carried out by Northern Shrimp Technical Committee (NSTC)

1.4.1.2 Identification and Distribution of Habitat Areas of Particular Concern

Nearshore waters (out to 10 miles)
Nearshore waters provide habitat for the larval and juvenile stages of northern shrimp. The survival of these early life-history stages is essential to the success of the species. Nearshore habitats are impacted by a myriad of anthropogenic activities including coastal development, pollutant run-off, harbor dredging, etc. The effects of these and other human activities on habitat quality for larval and juvenile northern shrimp are not known at this time.

Deep, muddy basins in the southern region of the Gulf of Maine
Deep, muddy basins in the southwestern region of the Gulf of Maine act as cold water refuges for adult shrimp during periods when most water in the Gulf reaches temperatures that are lethal to this arctic/sub-arctic species. Changes in the oceanographic conditions due to the North Atlantic Oscillation or other natural factors may cause warm water to intrude into some of the deep basins in the southwestern Gulf rendering this habitat unsuitable for shrimp and possibly resulting extirpation of local populations.

In addition to naturally occurring environmental changes, some deep, muddy bottom habitats are impacted by the use of mobile fishing gear to harvest groundfish (e.g.-trawls). Groundfish gear generally has a longer sweep and is towed much faster over the bottom. The small mesh in the shrimp gear creates more drag than a groundfish net and can't be towed as fast for the same size net. Also, groundfish gear generally has a larger diameter roller/rockhopper frame.

The effects this type fishing gear on habitat quality for shrimp are not known at this time. The use of mobile fishing gear has been shown to reduce structural complexity of bottom habitats (Auster et al. 1996). Such an effect could potentially reduce the survival of adult shrimp, which seem to utilize biotic and abiotic structures on mud bottoms, possibly to avoid predation.

1.4.1.3 Present Conditions of Habitats and Habitat Areas of Particular Concern

Near-shore waters
Near-shore habitats are impacted by a myriad of anthropogenic activities including coastal development, pollutant run-off, harbor dredging, etc. At this time, the inshore habitats occupied by larval and juvenile shrimp have not been mapped, and therefore it is not possible to identify the condition of, or specific anthropogenic threats to these habitats.

Deep, muddy basins
The effects of temperature on shrimp abundance have long been a subject of study, however, more information is required before it is possible to predict the effect of large-scale climatic events (like the North Atlantic oscillation) on the amount of suitable habitat available to adult shrimp.

Likewise, the effects of mobile fishing gear on bottom habitats have been a subject of study for over a decade; however, the short and long-term impacts of groundfish trawling on shrimp habitat in deep, muddy basins is not known at this time.

1.4.1.4 Temperature Considerations
While the manner by which temperature affects recruitment and abundance trends has not been precisely determined, record high sea surface temperatures during the early 1950s correlate with complete failure of the fishery from 1954-1957; and conversely, the cold temperature years of the early to mid-1960s appear to have been very favorable for recruitment, with rapid increases in abundance and record landings from 1969-1972. The collapse of the fishery during the 1970s was more problematic as it occurred during a period of warming temperatures, and high and increasing levels of fishing mortality rate; overfishing has been strongly implicated for the collapse. During the last two decades, significant recruitment events have coincided with normal to below normal spring sea surface temperature anomalies.

Given that this resource is at the southernmost extent of its Atlantic range, one would expect that temperature conditions would have a significant influence on long-term trends in abundance. Apollonio *et al*. (1986) concluded that this resource, because of its geographic location and its inherent susceptibility to environmental influences, would be inherently unstable. Dow (1977) found an inverse correlation between abundance and sea surface temperature (i.e. abundance is higher with lower sea surface temperatures) and has since been corroborated (Richards *et al*. 1996 and others). This stock appears to be one of the few for which previous relationships between environmental influences and abundance trends remained statistically significant when reexamined (Myers 1998).

1.5 IMPACTS OF THE FISHERY MANAGEMENT PROGRAM

1.5.1 Biological and Environmental Impacts

For the first time, this amendment establishes biological reference points for the northern shrimp fishery. It provides guidelines for managers to regulate the species in a biologically sustainable manner. If biomass is determined to be above the threshold and fishing mortality is at or below the target, biological collapse of the species will likely be prevented. However, unfavorable environmental conditions may severely impact northern shrimp regardless of stock biomass and fishing mortality levels.

If stock biomass is below the threshold established in this amendment or fishing mortality is above the target, the biological sustainability of northern shrimp is threatened. In either case, managers are required to take action to get biomass above the threshold or fishing mortality at or below the target.

Amendment 1 does not prescribe a specific rebuilding program. Managers are not required to rebuild biomass or reduce fishing mortality within a defined timeframe. However, as mentioned above they are required to take action when the reference points are exceeded. Managers have necessary flexibility in managing the shrimp fishery because of the volatile nature of the species and its vulnerability to changing environmental conditions.

When biomass is low or fishing mortality is high, managers have many options for taking action. Amendment 1 provides an extensive list of management tools from which they may choose. Depending on the tool or combination of tools chosen, the action may have varying impacts on the northern shrimp stock.

1.5.2 Social Impacts

Reduced landings have a significant impact on processors who need a steady supply of product to maintain their work force and market share. While shorter seasons limit fishing opportunities and landings, the impact of such measures on fishermen depends on what alternatives exist. Such alternatives are determined by the permits held by the fishermen and are constrained by weather and markets.

Since shrimping is often out of the smaller ports in the region, regulations may have short-term negative impacts on the associated communities. However, if management is successful in

ensuring a predictable and sustainable harvest, all sectors will have the opportunity to benefit over time.

The northern shrimp fishery is not sufficiently homogeneous to accurately predict and describe the impacts of proposed regulations. What might be a minor inconvenience to one diversified multiple vessel owner could be a disaster to smaller vessel owner. Furthermore, the actual impacts of regulations are not felt in isolation but are experienced in the larger context of the regulatory and economic environment of each operator and are cumulative over time.

1.5.3 Economic Impacts

The impact of management regulations will vary in relation to the dependence upon the fishery. A harvester with one vessel may be unable to cover the costs of operation in the face of a significant reduction in effort, while a more diversified fisherman with multiple vessels may be able to compensate. On a larger scale, a reduction in effort is likely to have a negative short-term economic impact on a community where the fishing industry is a primary source of revenue. However, a recovery of the shrimp stock will result in the opportunity for all sectors to participate in the fishery for a longer term.

The small ports where shrimp constitutes a significant proportion of landings consider fishing an important feature of their economy. It contributes to the overall productivity and total capital flow even if it is not the dominant industry in the community. It is often community members of the small ports who emphasize the importance of maximizing the numbers of jobs rather than maximizing income for a few individuals when choices among regulations are being made. Each of these ports, though, also face gentrification and increased competition for waterfront use.

Both Gloucester and Portland are urban areas that have retained strong support for their fishing industry including working waterfront zoning and fisheries administrators with recognized roles in city government. By a variety of indices, Portland is classified as a primary port and "essential provider." Gloucester ranks third (behind New Bedford and Portland) in fishing infrastructure differentiation, and low on the gentrification scale.

While the fishing industry in Portsmouth is dwarfed by the tourist industry, the city has retained a small, but complete infrastructure for the industry. Shrimp is an essential component of the year's fishing returns for individual vessels from Rye, Hampton and Portsmouth and for both of New Hampshire's fishing cooperatives. Furthermore, boats from Newburyport (Massachusetts) and York (Maine) are shrimp-landing members of the Yankee and Portsmouth Coops, respectively, so the shrimp networks clearly extend beyond the borders of states and sub-regions in New England.

Price depends on the size and quality of the shrimp. For example, the Japanese market pays a premium for larger, raw, frozen-at-sea product often available from Canada, but Japanese dealers will also purchase from the Portland auction when medium to large size, firm shrimp is available. The value of the shrimp landings in Maine in 1998-99 hovered at $0.96 per pound, though in 1997 and 2000, the average price was estimated as $0.81 and $0.80 per pound, respectively. Average price per pound of shrimp for 2001 and 2002 was $0.86 and $1.07,

respectively. However, preliminary reports for 2003 and 2004 indicate average prices below that seen in recent years.

Price is dependent on a suite of factors. The size and quality of the shrimp is important, but the quantity available also affects the market. For example, Canadian buyers need sufficient quantity to justify the expense of transporting the product. In 2000 harvesters received $.65/lb at the dock ($1.00 if they trucked it to the Portland auction) at the beginning of the season and $1/lb at the end of the season ($1.10-1.20 if trucked). Price is also affected by the size of the markets for northern shrimp.

Small-scale dealers play a significant role in the distribution of the shrimp catch. One informant estimated that a third of the product from Maine shrimpers passes through the hands of small businesses. Some of these are small-processors who peel and sell the raw product. Direct retail sale via roadside vending is common in Maine. Tourism can affect the success of these small-scale operations and ultimately, the price, with fluctuating demand.

It is the processing sector that is apparently the most vulnerable to variability in supply and unpredictability, whether due to the diminishment of the stock size or as an artifact of regulations. The costs of preparing the facility, engaging labor, and identifying markets is significant, so this sector is less able to reconfigure in the short-term than is the harvesting sector.

Prior to the institution of the Food and Drug Administration's Hazard Analysis Critical Control Point (HACCP) regulations, when home processing was easier to pursue, the flexibility of the cottage industry could more easily accommodate flexibility in the harvesting sector.

1.5.4 Other Resource Management Efforts

1.5.4.1 Artificial Reef Development/Management

There are currently no artificial reefs in place in the Gulf of Maine used by the northern shrimp fishery.

1.5.4.2 Bycatch

Bycatch of market size finfish in the shrimp fishery was accepted as usual practice up through the mid-1970s. The discard of juvenile, or sub-market individuals of market species of fish and of non-marketable species was simply not an issue, yet this discard accounted for considerable mortality. Bycatch and discards become an issue when groundfish stocks started to decline in the early 1980s. Reduction efforts began in the mid-1970s but were initially met with very limited success due to unreported landings and discards. In response, and in reaction to pressure from the New England Fishery Management Council (NEFMC), the Northern Shrimp Section made the fishery a zero bycatch fishery in 1993. The fishery remained a zero bycatch fishery until 2001, when a limited amount of silver hake has been allowed as bycatch.

Bycatch reduction improved radically with the advent of the Nordmore grate in the late 1980s. Developed in Nordmore County, Norway, this device is a grating of parallel bars mounted in the extension with an escape hole in the net in front of the grate. Testing of the Nordmore grate system by the NMFS-Northeast Region's Fisheries Engineering Group during 1991 and 1992

proved the grate's effectiveness for the fish assemblage present in the Gulf of Maine. The results showed over 95% loss of finfish by weight and over 95% retention of shrimp (Table 4) (Kenney et al, 1992). The excellent release of finfish as seen in Table 4 is seen across the length spectrum for flatfish, with a high percentage of even small flatfish escaping the net. The grate was instituted into the northern shrimp fishery for April and May, 1992 and beginning in December, 1992 the grate was required for the whole season. In 1993, an exception to the requirement of using the grate was made for the period January through March inside Maine state waters, as few groundfish were present at that time. This exception was dropped in 1994.

As effective as the Nordmore grate is, an examination of male shrimp length frequency, around 15 to 20mm carapace length, reveals more shrimp of that size range retained by the cod ends behind the grates. The increased retention of these smaller shrimp is a concern because they are below the target size for shrimp of $\geq$22mm that the current minimum mesh size regulation controls. This indicates that the Nordmore grate may be affecting the mesh selection curve for shrimp in the cod end. Square mesh in the cod end may resolve shifts in selectivity produced by the Nordmore grate as many recent trials have indicated. Trials conducted in the Gulf of Maine by MEDMR over several years have shown that square mesh of 1-5/8" produces a selectivity curve similar to 1-3/4" diamond mesh, but does release slightly more small shrimp.

A double Nordmore grate system was tested for reducing the amount of small shrimp caught with the single Nordmore grate. The second grate aids in releasing small shrimp and small fish that the cod end mesh size selection doesn't do very effectively. The Northern Shrimp Section approved the double Nordmore grate for use in the shrimp fishery in 1999.

Documentation of the bycatch/discard problem has occurred through a sea sampling program whereby samplers are placed aboard commercial vessels and all fish caught are noted, whether they are landed or not. Begun in 1994, this seven year effort has been mounted by the NEFSC and has given unprecedented accuracy to the data defining the problem (Clark and Power, 1991). An earlier study by Howell and Langan (1992) also documented bycatch and discard in the Gulf of Maine offshore northern shrimp fishery. Bycatch/discard is a variable problem depending upon time of year and location of the fishery. Inshore winter shrimping does not catch juvenile, or adult groundfish, but offshore shrimping, which often occurs concurrently with the inshore fishery does involve considerable bycatch/discard of juvenile and adult groundfish.

Information on the bycatch of protected species (e.g.: marine mammals, sea turtles) can be found in Section 7.

1.5.4.3 Land/Seabed Use Permitting

There is no impact of land or seabed use permitting on the northern shrimp fishery.

1.6 LOCATION OF TECHNICAL DOCUMENTATION FOR FMP

1.6.1 Review of Resource Life History and Biological Relationships

Northern shrimp life history information was summarized by Apollonio and Dunton 1969, Apollonio *et al.* 1986, Haynes and Wigley 1969, and Clark et al. 2000.

1.6.2 Stock Assessment Document

Detailed information pertaining to the northern shrimp stock assessment can be found in the 36th Northeast Regional Stock Assessment Workshop report. Annual assessment updates are prepared. The results are found in the most recent report of the Northern Shrimp Technical Committee.

1.6.3 Social Assessment Documents

No recent studies have been conducted to assess the social characteristics of the northern shrimp fishery. The most recent information is included in the 1986 FMP.

The 1986 ASMFC FMP for northern shrimp includes data on: a history of the fishery; a statistical portrait of the fleet with respect to vessel sizes, horsepower, home ports, ports of landing, and seasonal distribution of fishing effort; a quantitative description of the processing sector and markets; a description of the economic value of the fishery as compared with other fisheries in the region.

While these data have historical value and serve as a useful context for present and future management actions, they are 15 years old and must be updated and expanded before it will be possible to conduct a thorough and accurate analysis of the socioeconomic consequences of currently proposed management actions.

1.6.4 Economic Assessment Document

No recent studies have been conducted to assess the economic characteristics of the northern shrimp fishery. The most recent information is included in the 1986 FMP.

1.6.5 Law Enforcement Assessment Document

The Commission's Law Enforcement Committee has prepared a document entitled "Guidelines for Resource Managers on the Enforceability of Fishery Management Measures" (October 2000) which can be used to evaluate the effectiveness of future measures.

1.6.6 Habitat Background Document

The background for habitat of northern shrimp is compiled in Section 1.4 of this amendment.

2.0 GOALS AND OBJECTIVES

2.1 HISTORY AND PURPOSE OF THE PLAN

2.1.1 History of Prior Management Actions

The Northern Shrimp Section, consisting of representatives from Maine, New Hampshire and Massachusetts, is responsible for management based on input from the Northern Shrimp Technical Committee and industry Advisory Panel. This arrangement is one of the longest running instances of interstate cooperation in the history of fishery management in the United States. Management had its origins in 1972, when industry concerns over declining abundance and product quality led to exploration of options for cooperative management. Initial interest centered on curtailing harvest of small, non-marketable shrimp, which led to gear evaluation

studies and implementation of a uniform stretched mesh size regulation of 44 mm (1.75 inches) in the body and cod end of the trawl. The Technical Committee also conducted a series of stock assessments beginning in 1974, which documented that the resource was being overfished and that abundance was declining rapidly. As the stock deteriorated further, management became increasingly restrictive, finally culminating in closure of the fishery from May 1977 to February 1979.

In 1979, the Technical Committee prepared and submitted a draft management plan and environmental impact statement for the northern shrimp fishery, which recommended regulatory measures including mesh size limits, closed seasons, catch quotas and statistical reporting. Such regulations were to be implemented by the participating states through the Northern Shrimp Section, and ultimately by the Secretary of Commerce through the Fishery Conservation and Management Act of 1976 (NSSC, 1979). A revised plan reflecting public comment was accepted at the November 1979 Section meeting.

In 1981, the State-Federal Fishery Management Program in the Northeast Region was restructured as the Interstate Fisheries Management Program (ISFMP) of the Commission. The Section adopted a "Statement of Policy" which (1) stated its position relative to environmental issues, i.e., that despite natural fluctuations in abundance, the northern shrimp fishery is manageable; and (2) affirmed that it would provide for a continuing management program based on Technical Committee recommendations to maintain and rebuild the stock so as to "assure a viable northern shrimp fishery over time." The Section further stated its intent to allow a northern shrimp fishery through the mechanism of an annual open season, with the following regulatory measures endorsed as appropriate:

1. Gear limitations, conforming to the uniform mesh size regulation (44.5 mm, 1.75 inches stretched mesh in body and codend);
2. Seasonal limitations, open season to be set within a 183-day window beginning not earlier than December 1 and ending not later than May 31 for any one year;
3. Possession limitations; and
4. Information collection provisions, i.e., determination of participants, dealer and processor reporting, and dockside and sea sampling.

The above measures, and biological and socioeconomic research requirements for management, are embodied in the *Interstate Fishery Management Plan for the Northern Shrimp* (Pandalus borealis *Kroyer*) *Fishery in the Western Gulf of Maine* rewritten from the 1979 version (McInnes 1986). As well, there is substantial background information on stock assessment and survey data collection methods (Clark and Anthony 1981; Cadrin *et al*. 1999; and others). The FMP remained in effect until the passage of this amendment.

The mid-1980s witnessed a resurgence of the resource, accompanied by relatively low instantaneous fishing mortality (F) and exploitation rates. Improved recruitment, particularly from the strong 1982 year class, made it possible for the Technical Committee to advise, and the Section to implement, a gradual extension of the open season for 1982-1985 culminating in the maximum duration allowable for the 1986 and 1987 seasons. Fishing mortality and exploitation rates averaged about 0.2 during the mid-1980s, well below levels thought to be sustainable.

With good recruitment and continued moderate levels of exploitation, resource conditions remained healthy into the mid-1990s. During these years the Section was able to manage the resource effectively through closed seasons, monitoring resource trends using annual index-based assessments.

In 1993, the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) was enacted, which gave the ASMFC considerably more influence over management of coastal marine resources. ACFCMA obligated individual states to implement ASMFC-approved measures; and it authorized the Secretary of Commerce to declare a moratorium on a state's fishery for failure to comply with ASMFC plan provisions.

During the mid-1990s, effort increased rapidly, and landings reached 9,200 mt during the 1996 season -- a level not seen since the early 1970s. The first analytical assessment, completed and peer-reviewed at the 25th Northeast Regional Stock Assessment Workshop (SAW) in July 1997 (NEFSC MS 1997) revealed sharp increases in fishing mortality rates and reductions in biomass in 1996 (Cadrin *et al*. 1999). The update of this assessment for the November 1997 meeting of the Section, and subsequent assessments, have indicated substantially higher levels of fishing mortality rates since 1995 than were seen during the 1980s and early 1990s, and sharp declines in stock biomass and recruiting year-class size. The 1996 year class was estimated to be of about average size, but the 1997, 1998 and 2000 year classes appear to be among the weakest since the early 1980s. While the 1999 year class appears to be comparable to that from 1996, it is doubtful that it is strong enough by itself to lead to significant recovery of this stock. Based on the northern shrimp summer survey, the 2001 year class was initially strong and downgraded to moderate and the 2002 year class was virtually absent. The status of the stock of northern shrimp in the Gulf of Maine does not appear to be healthy. Unless the surveys have missed some major concentrations of shrimp, the stock is in poor shape as the survey indices are showing a protracted downward trend.

2.1.2 Purpose and Need for Action

The decision to amend the Plan has been driven by three main issues: 1) the state of knowledge and tools available to manage the fishery have improved since 1986; 2) all ASMFC FMPs should be updated under the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) and the Interstate Fishery Management Program (ISFMP) Charter; 3) the need to address recent stock conditions while maintaining the current management structure.

Since the adoption of the Northern Shrimp FMP in 1986, the state of knowledge of the northern shrimp biology, population dynamics, and fishery has improved. The state-federal dedicated northern shrimp trawl survey, begun in 1984, has become a long-term data set providing the backbone of the new assessment methodology. A model-based analytical assessment was instituted in 1997 and has undergone two peer reviews. The role of environmental variables in shaping the dynamics of the shrimp population has been more completely explored. Industry representatives have suggested alternative management approaches be pursued for the northern shrimp fishery that would provide more flexibility to the fishery. The original plan primarily relied on two options for management – season length and gear limitations. Additional management measures were needed to provide greater flexibility and alternatives. The new assessment methods incorporate several aspects of the fishery and survey data available and

provide an integrated approach to understanding the dynamics of the stock and fishery. This assessment method and improved knowledge can support a more flexible management program.

The ASMFC improved its ability to cooperatively manage Atlantic coastal fishery resources. The U.S. Congress approved the Atlantic Coastal Fisheries Cooperative Management Act in 1993, providing a mechanism to ensure participating states comply with mandatory conservation measures in the Commission's FMPs. Such mechanisms were not explicitly included in the original FMP. The ISFMP Charter defines essential elements for all fishery management programs. These elements are designed to provide balanced conservation and use of coastal fisheries, allow the public to have effective participation in the management planning process, and help Commissioners make informed decisions on fishery management plans.

Finally, the past few stock assessments indicate that there is reason to be concerned about the northern shrimp population as stock biomass has reached low levels. The National Marine Fisheries Service (NMFS) declared the northern shrimp resource in an "unknown" condition in 2003 (NMFS 2003).

2.2 GOAL

Amendment 1 to the Interstate Fishery Management Plan for Northern Shrimp replaces the 1986 FMP for Northern Shrimp.

The Northern Shrimp Section agrees that, despite natural fluctuations in stock abundance, the northern shrimp fishery is manageable. In addition, the Section will provide for a continuing management program based on recommendations of the Technical Committee and the Advisory Panel to ensure a viable northern shrimp fishery in the Gulf of Maine over time.

The goal of Amendment 1 is to manage the northern shrimp fishery in a manner that is biologically, economically, and socially sound, while protecting the resource, its users, and opportunities for participation by all stakeholders.

2.3 OBJECTIVES

The following objectives are selected to support of the goal of Amendment 1:

- Protect and maintain the northern shrimp stock at levels that will support a viable fishery
- Optimize utilization of the resource within the constraints imposed by distribution of the resource, available fishing areas, and harvesting, processing and marketing capacity
- Maintain the flexibility and timeliness of public involvement in the northern shrimp management program
- Maintain existing social and cultural features of the fishery to the extent possible
- Minimize the adverse impacts the shrimp fishery may have on other natural resources
- Minimize the adverse impacts of regulations, including increased cost to the shrimp industry and the associated coastal communities

- Promote research and improve the collection of information to better understand northern shrimp biology, ecology, and population dynamics, including variable natural mortality at age or by area
- Improve understanding of the economics of harvesting and processing northern shrimp
- Achieve compatible and equitable management measures through coordinated monitoring and law enforcement among jurisdictions throughout the fishery management unit

2.4 SPECIFICATION OF MANAGEMENT UNIT

The management unit for Amendment 1 is defined as the northern shrimp resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the shoreline to the seaward boundary of the Exclusive Economic Zone (EEZ). It is also recognized that the northern shrimp fishery, as defined here, is interstate and state-federal in nature, and that effective assessment and management can be enhanced through cooperative efforts with state and federal scientists and fishery managers.

2.5 MANAGEMENT TARGET

Amendment 1 includes biological reference points as benchmarks for developing future management measures. These management targets, thresholds, and limits are designed to provide managers with a guide to determine if changes in the regulations are necessary – given the current status of the stock – to sustain the resource over time.

The target represents an acceptable level of fishing effort or biomass that balances the need to sustain the stock and the desire to provide fishing opportunities. A threshold, on the other hand, defines a point of caution where regulations should become significantly more restrictive. At the very extreme is a limit, which represents the point where immediate and perhaps drastic action is necessary to protect and restore the resource.

There are two broad strategies for defining overfishing and stock status in practice today: 1) fishing mortality rate (F) strategies, and 2) stock biomass (B) strategies. Fishing mortality based reference points are designed to prevent fishing mortality rates from getting too high, which could result in a subsequent decline in the population because individual shrimp are being removed at too fast a rate. Fishing mortality rates above the threshold or target can be defined as a state of overfishing. Stock biomass based reference points are designed to prevent B from getting too low and compromising the ability of the stock to replenish itself. A B below the threshold can be considered to be depleted or overfished. To accurately categorize the status of a stock one should look at both fishing mortality and biomass, simultaneously.

Amendment 1 institutes biological reference points for northern shrimp that incorporates fishing mortality target and limit and spawning stock biomass threshold and limit. A fishing mortality rate value identified as one promoting a healthy stock is set as the target, with a higher fishing mortality rate value associated with an overfished stock set as the limit. When fishing mortality rate levels begin to exceed the target, it becomes necessary to restrict fishing effort. In the event that fishing mortality rate exceeds the limit, major steps would be undertaken to reduce fishing mortality rates immediately. When fishing mortality rates are below the target fishing mortality

rates, then fishing effort could most likely remain constant except in the event of a biomass decline due to another factor (i.e. poor recruitment).

A threshold and limit for B are used similarly. A relatively high B level is commonly set as the "everyday" target that the management program strives to maintain. The lower level is often identified as a threshold. When the biomass drops below this level it is a clear indication that the stock is depleted and management should take steps to allow for recovery. A biomass limit is a conservative level where the stock is in danger of complete collapse and major management effort must be considered. However, the intent is to avoid having B fall below the threshold level. In summary, management efforts will be tailored to keep B above the threshold level and fishing mortality rates at or below the target level.

The Section chose a fishing mortality target and limit based on Spawning Potential Ratio (SPR). The fishing mortality target of $F_{50\%} = 0.22$ was based on a level of the fishing mortality rate in the mid-1980s through mid-1990s when biomass and landings were "stable". The fishing mortality limit of $F_{20\%} = 0.6$ is based on the limit that was exceed in the early to mid-1970s when the stock collapsed.

When the 2002 stock assessment for northern shrimp was conducted, the fishing mortality rate for the 2002 fishing season was estimated to be a negative number, –0.01 (calculated using the log-ratio of stock and recruit abundance estimates at the beginning of the season to stock abundance at the end of the season, from Collie-Sissenwine Analysis (CSA) output). Since in reality fishing mortality could not be negative, the Technical Committee investigated alternative methods for calculating fishing mortality rates. Another method, recommended by Collie and Kruse (1998), employs harvest rates (based on the ratio of catch to CSA population abundance at the beginning of the fishing season), and gives a value for 2002 of 0.06, a small, but positive value. Note that the difference between the two values using the two different methods is small.

In December 2002, the stock assessment for northern shrimp was reviewed by the 36th Northeast Regional Stock Assessment Review Committee (SARC). The Technical Committee (TC) asked the SARC to review the "new" method of calculating fishing mortality rates (CSA harvest rate). The SARC concluded that: "The fishing mortality rates generated by this method is a more precise approximation than the log-ratio method" (NEFSC 2003).

The TC will use the harvest rate method for calculating fishing mortality rates in the future. The impact on Amendment 1 is that this method generates somewhat different values for fishing mortality rates than the old method. The fishing mortality rates for the "stable" period of the mid-1980s to mid-1990s will now be 0.22 instead of 0.34. Although this may be viewed as an attempt to "raise the bar", it is simply a change in scale.

The Section chose a stock biomass threshold and limit based on historical patterns. Amendment 1 does not employ a biomass target because the Section did not want to set unlikely goals for a species whose biomass can easily be affected by environmental conditions. The stock biomass threshold of $B_{Threshold} = 9{,}000$ metric ton and limit of $B_{Limit} = 6{,}000$ metric ton are based on historical abundance estimates and response to fishing pressure. The limit was set at 2,000 metric ton higher than the lowest observed biomass. The Section stresses that the threshold is

not a substitute for a target. It will manage the fishery to maintain stock biomass above the threshold. Furthermore, the Section's management decisions will be affected by the year class composition of the stock.

2.6 STOCK REBUILDING PROGRAM

Should the stock biomass go below the threshold as determined by the annual assessment, the stock is defined as overfished and the Section is required to take action to recover the stock above the threshold. Should fishing mortality go above $F_{50\%}$ = 0.22, overfishing is then occurring and the Section is required take action to reduce the fishing mortality to the target level. If fishing mortality exceeds the limit level and biomass is less than the threshold level, the Section must act immediately to reduce fishing mortality.

The Section chose not to set specific rebuilding timeframes. It maintains the flexibility to rebuild stocks within a reasonable amount of time. This flexibility is necessary for the Section to manage a species that is volatile and easily affected by change in environmental conditions.

2.7 RESOURCE COMMUNITY ASPECTS

See Section 1.4.1.4 for the role northern shrimp play in ecosystem dynamics.

2.8 IMPLEMENTATION SCHEDULE

Amendment 1 to the Interstate Fishery Management Plan for Northern Shrimp was approved and adopted by the Commission in May of 2004. States are required to implement the provisions of Amendment 1 no later than July 1, 2004.

3.0 MONITORING PROGRAM SPECIFICATIONS/ELEMENTS

3.1 SUMMARY OF MONITORING PROGRAMS

In order to achieve the goals and objectives of Amendment 1, the collection and maintenance of quality data is necessary.

3.1.1 Catch and Landings Information

The Northern Shrimp Section encourages all state fishery management agencies to pursue full implementation of the Atlantic Coastal Cooperative Statistics Program (ACCSP), which will meet full implementation of the monitoring and reporting requirements of this amendment. The Section recommends that a transition or phased-in approach be adopted for full implementation of ACCSP. Until such time as the ACCSP is implemented, the Section encourages state fishery management agencies to initiate implementation of specific ACCSP module, and/or pursue pilot evaluation studies to assist in development of reporting programs to meet the ACCSP standards (please refer to the ACCSP Program Design document for specific reporting requirements and standards). The ACCSP partners are the 15 Atlantic coastal states (Maine-Florida), the District of Columbia, the Potomac River Fisheries Commission, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, the three regional fishery management councils, and the Atlantic States Marine Fisheries Commission. Participation by program partners in the ACCSP does not relieve states from their responsibilities in collating and submitting annual technical reports to the Commission as required under this amendment.

3.1.2 Biological Information

The ACCSP will require the collection of baseline biological data on commercial, for-hire, and recreational fisheries. Biological data for commercial fisheries will be collected through port sampling programs and at-sea observers. Biological data for recreational fisheries will be collected in conjunction with the access-intercept survey. Biological data for for-hire fisheries will be collected through existing surveys and at-sea observer programs. A minimum set of standard data elements will be collected in all biological sampling programs. Refer to the ACCSP Program Design document for details. Priorities and target sampling levels will be determined by the ACCSP Biological Review Panel, in coordination with the Discard/Release Prioritization Committee.

3.1.3 Social Information

In New England today, there is no consistent, long-term monitoring program focused either on the collection and analysis of social and economic data or on the social and economic impacts of regulatory change. However, there are several steps being taken that may eventually lead to such a program. ACCSP is currently conducting a pilot project for the collection and analysis of such data from a random sample of fishermen involved in summer flounder or blue crab fisheries. Hall-Arber, et al (2001) collected a wealth of information to serve as a baseline for such data collection in New England. A few towns in Maine have, or are in the process of developing, planning processes that include analyses of their fishing industry's current and anticipated needs. Conduct of the research and analyses identified as needed in this amendment would help place the necessary decision-making on a more objective foundation.

3.1.4 Economic Information

There is very little direct monitoring of economic conditions in the Gulf of Maine northern shrimp fishery for either harvesters or processors. Ex-vessel value of shrimp landings is collected for almost the entire catch through the NMFS dealer weighout program. Many vessels in the shrimp fleet fill out the NMFS Vessel Trip Reports for each trip. These logbooks do give an indication of fishing effort and crew size. There is no direct source of cost data for this fleet except where a particular vessel has supplied these data to another NMFS program such as the Capital Construction Fund or the MARFIN survey of groundfish trawlers.

Historically, there has been a modest level of at-sea sampling of the shrimp fleet by the NMFS and state agencies. Up until about 1998, the NMFS funded shrimp sampling trips through the observer program at the Manomet Center for Conservation Science. State agencies also conduct routine sea sampling programs particularly since the wintertime is slow for fieldwork and shrimp boats are an excellent source of day trips. While aboard, both state and Federal sea samplers follow the same sampling protocols that do include some economic data gathering. Observers note many physical characteristics of the vessel and the gear including gear quantity and size and the amount of electronics in the wheelhouse. If time permits there are additional economic questions in the sea sampling forms although it is expected that very few of these interviews are conducted on day trips.

As noted above, dealers and processors provide the ex-vessel price paid to boats at the first point of sale. After this point there is very little economic monitoring of the processing sector. Much of the New England shrimp production is sold to Canada, Europe and Asia, hence U.S Customs

documentation of shipments abroad is available including product form and declared value. Unfortunately, shrimp shipments leaving through a New England port of departure do not necessarily indicate that this domestic product was landed in the Gulf of Maine Pandalid fishery and further distinction of the product to the species level is not required on Customs paperwork.

The ACCSP Socioeconomic data collection programs are quite capable of overcoming these gaps in data for this fishery. Industry acceptance of an expanded and more focused data collection program would be key to its success. Funding and the sheer scale of implementation for the ACCSP program have slowed down the implementation of socioeconomic data collection programs.

3.1.5 Observer Programs

The ACCSP at-sea observer program is a mandatory program. As a condition of state and/or federal permitting, vessels should be required to carry at-sea observers when requested. A minimum set of standard data elements will be collected through the ACCSP at-sea observer program (refer to the ACCSP Program Design document for details). Specific fisheries priorities and sampling levels will be determined by the Discard/Release Prioritization Committee.

3.2 ANNUAL ASSESSMENT

3.2.1 Assessment of Fishing Mortality Target and Measurement

Fishing mortality estimates for the Gulf of Maine northern shrimp fishery are generated by two separate models; the modified Delury analysis, also called Collie-Sissenwine Analysis (CSA), and a surplus production model. The CSA tracks the removals of shrimp using summer survey indices of recruits and fully recruited shrimp scaled to total catch in numbers. The surplus production analysis models the biomass dynamics of the stock with a longer time series of total landings and three survey indices of stock biomass. The CSA estimates of fishing mortality are used as the primary point estimates for managing the fishery, while the surplus production estimates of fishing mortality are used to corroborate results from the CSA and provide historical perspective.

The Northern Shrimp Technical Committee will perform a northern shrimp stock assessment on an annual basis. The Technical Committee and Advisory Panel will meet to review the stock assessment and all other relevant data sources. An annual report will be prepared for the Section in a timely fashion (currently mid-October, depending on when data from the summer survey becomes available) in order to make annual adjustments to the management program as necessary.

Criteria

The stock assessment report will comprise landings, effort, survey indices, abundance, biomass, recruitment, fishing mortality, yield-per-recruit and spawning potential. Two primary surveys are examined: the state-federal summer shrimp survey and the NMFS fall ground fish survey. Trends in abundance, biomass, recruitment and fishing mortality are derived from the Collie-Sissenwine model. Fishing mortality estimates and stock size are corroborated using the surplus

production analysis. Yield-per-recruit and egg-per-recruit models are used to estimate yield-per-recruit and maximum spawning potential.

Process
The Northern Shrimp Technical Committee prepares a stock assessment report each fall, using the best available scientific information and fishery statistics. If major changes are made to the stock assessment models used in the management process, or the Section requests a higher level of review, the Section may recommend to the ISFMP Policy Board that an external review of the stock assessment be conducted.

3.2.2 Assessment of Annual Recruitment
The mean number per tow of 1.5 year old shrimp from the State-Federal Northern Shrimp Survey is used as a proxy for a recruitment index. Although the shrimp are not fully recruited to the survey gear at this age, it appears that this index is a sufficient representative of year class strength from the previous year.

3.2.3 Assessment of Spawning Stock Biomass
The stratified mean weight (kg) per tow of northern shrimp >= 22-mm dorsal carapace length (CL) from the State/Federal Northern Shrimp Survey provides the index of spawning stock biomass (SSB). Northern shrimp are protandric hermaphrodites, which start changing from male to female around 2.5 years of age, or 18 to 19 mm CL. The 22 mm dorsal carapace length is used as a cut off point because at this size close to 100 % of shrimp are sexually mature females.

3.3 BYCATCH MONITORING PROGRAM
The ACCSP will require a combination of quantitative and qualitative methods for monitoring discard, release, and protected species interactions in commercial, recreational, and for-hire fisheries. Commercial fisheries will be monitored through an at-sea observer program and several qualitative programs, including strandings, entanglements, trend analysis of logbook reported data, and port sampling. Recreational fisheries will be monitored through add-ons to existing intercept surveys and additional questions added to the telephone survey. For-hire fisheries will be monitored through an at-sea observer program and several qualitative programs (refer to the ACCSP Program Design for details).

3.4 HABITAT PROGRAM
No habitat monitoring program is currently in place for the Gulf of Maine.

4.0 MANAGEMENT PROGRAM IMPLEMENTATION

4.1 COMMERCIAL FISHERIES MANAGEMENT MEASURES
To achieve the biological reference points in Section 2.5, the Northern Shrimp Section shall adjust commercial fisheries management measures, based on input from the Technical Committee, Advisory Panel, and public. The Section may make adjustments at its annual fall public hearing only to the closed season (See Section 4.1.1). The Section may also establish incentive-based programs at the annual fall public hearing. Management measures listed in

Sections 4.1.2 through 4.1.7 that are already in place may be carried over to the following season's regulations at the Section's annual fall hearing.

Amendment 1 provides the Section with a suite of management measures that were previously unavailable. Section 4.6.2 contains a list of management measures that may be implemented any time throughout the year by the Section. However, adjustment or establishment of any of the measures listed in Section 4.6.2 must be implemented through the addendum process. Please see Section 4.6 for a description of how the Section is able to implement adaptive management through the addendum process.

Once the Section approves management measures for the northern shrimp fishery, it is the individual state's responsibility to implement consistent regulations through its state agency.

4.1.1 Closed Season

The Section will set the northern shrimp fishing season at its annual fall public hearing. It may establish a closed season or seasons to occur at any time during the year. Conversely, the Section may set a fishing season or seasons at any point during the year based on the biology and condition of the stock. The Section has the ability to set a closed season annually up to 365 days. The Section may set different seasons for the harvesting and processing sectors of the fishery to accommodate for the lag time of processing shrimp that are harvested late in the season.

4.1.2 Minimum Mesh Size

It is unlawful to fish for, take, transport or have in possession any northern shrimp on board any boat rigged for otter trawling with any net with a mesh opening of less than 1-3/4 inches stretched mesh opening between knots, or to have on board any net, netting or portions thereof, except an accelerator funnel of the size specified in Section 3(c), with an opening less than 1-3/4 inches stretched mesh opening between knots and except that a deflector panel of 1 inch mesh may be used in the cod end behind the second grate in a double grate system. The maximum length of the bottom legs of the bridle of any shrimp trawl shall not exceed 15 fathoms of uncovered or bare wire.

Tolerance. Due to the differences of net manufacturer mesh measurements and the mesh measurements used for enforcement of this regulation and other inherent variables a tolerance of 1/8 inch shall be applied to the average mesh size in the body and wings. No tolerance shall be applied to the mesh size in the cod end.

4.1.3 Fishing Gear

All netting used to catch shrimp shall be of one layer only, with no liners of any kind attached, except that a cod end strengthener may be used as specified, and except that an accelerator funnel may be used and must have a mesh size of no less than 1-3/8 inch stretched mesh. It shall be lawful to attach chafing gear to the lower half of the circumference of the cod end unless a cod end strengthener is used. Cod end shall mean the terminal portion of an otter trawl, pair trawl, beam trawl, scottish seine or mid-water trawl in which the catch is normally retained.

4.1.4 Cod End Strengthener

An outer mesh may be used as a cod end strengthener while fishing for northern shrimp. The outer mesh must be a minimum of 6 inches and the outer mesh must be at least three times larger than the size of the inner mesh. The mesh may be single or double twine, and diamond or square in shape. The hanging ratio must be the same as the mesh size ratio. Hanging ratio shall mean the number of meshes in the circumference of the cod end to the number of meshes in the circumference of the strengthener. The mesh size ratio shall mean the number of inner meshes to the number of outer meshes. The outer mesh may only cover the cod end. No chafing gear may be used with a cod end strengthener.

Exception. Herring seines or purse seines may be transported from one location to another provided a permit is obtained from a fisheries enforcement officer or the state fishery agency.

Method of Measurements. Mesh sizes are measured by a flat wedge-shaped gauge having a taper of 4 cm in 20 cm and a thickness of 2.3 mm, inserted into the meshes under a pressure or pull of 1.90 kg. The mesh size of a net shall be taken to be the average of the measurements of a series of any 20 consecutive meshes, at least 10 meshes from the lacings, and when measured in the cod end of the net beginning at the after end and running parallel to the long axis.

4.1.5 Finfish Excluder Devices

It shall be unlawful for any vessel rigged for otter trawling, to fish for, land or have in possession northern shrimp except by using trawls equipped with finfish excluder devices approved by the same agency that permits such vessels. Such finfish excluder devices (commonly referred to as the "Nordmore Grate System") shall consist of:

- A rigid or semi-rigid grate consisting of parallel bars attached to the frame with spaces between the bars not to exceed 1 inch in width;
- A fish outlet, or hole, in the extension of the trawl forward of the cod end and grate; and
- A webbing funnel installed in front of the grate designed to direct the catch toward the grate to maximize the retention of the shrimp may be used but may not have mesh less than 1-3/8 inch stretched mesh.
- Vessels fishing in the shrimp fishery shall not be allowed to possess regulated groundfish species.

4.1.6 Double Nordmore Grate

A double Nordmore grate may be used while fishing for northern shrimp. A double Nordmore grate is a second grate placed behind the currently required grate, whereby the second grate has the purpose of releasing small shrimp from the net while retaining larger shrimp. Such double Nordmore grate devices shall consist of:

- A second grate must be 8 feet behind the first grate (tolerance of greater than 6 feet, but less than 10 feet).
- The second grate must be hung at the same orientation as the first grate.
- The space between the bars shall be 7/16 of an inch.
- The exit holes to the cod end must be at the top and no more than 10% of the surface area.
- A funnel in front of the second grate designed to direct the catch toward the grate to maximize the retention of the shrimp may be used but may not have mesh less than 1-3/8 inch stretched mesh.

- A 1 inch mesh panel behind the second grate, 45 degrees down from the top of bars to the bottom of cod end.
- An escape hole in the cod end in front of the 1-inch mesh panel.

4.1.7 Mechanical "Shaking" Devices

Mechanical "shakers" have been used to rid from nets smaller shrimp. It shall be unlawful to cull, grade, separate or shake shrimp, aboard any vessel, except by implements operated solely by hand. It is illegal to possess, aboard any vessel, any powered mechanical device used to cull, grade, separate or shake shrimp.

4.2 RECREATIONAL FISHERIES MANAGEMENT MEASURES

No management measures are included for the recreational fisheries as this fishery is very limited, is usually carried out with the recreational lobster trap fishery, and is for personnel use.

4.3 HABITAT CONSERVATION AND RESTORATION

4.3.1 Preservation of Existing Habitat

Until the habitat requirements for larval, juvenile, and adult shrimp are understood and maps of essential habitat for these life history stages are developed it is not feasible to make recommendations or develop requirements to conserve the inshore habitats utilized by these life history stages.

4.3.2 Habitat Restoration, Improvement, and Enhancement

Until the habitat requirements for larval, juvenile, and adult shrimp are understood and maps of essential habitat for these life history stages are developed it is not feasible to make recommendations or develop requirements to conserve the inshore habitats utilized by these life history stages.

4.5 ALTERNATIVE STATE MANAGEMENT REGIMES

Once approved by the Northern Shrimp Section, a state may not change its regulatory program without prior approval by the Section. However, a state may implement more restrictive measures without Section approval. A state can request a change only if that state can show to the Section's satisfaction that the action will not contribute to overfishing of the resource. Changes to state plans must be submitted in writing to, and approved by, the Section prior to implementation.

4.5.1 General Procedures

A state may submit a proposal for a change to its regulatory program or any mandatory compliance measure under this amendment. Such changes shall be submitted to the chair of the Plan Review Team, who shall distribute the proposal to the Section, the Plan Review Team, the Technical Committee, the Stock Assessment Committee and the Advisory Panel.

The Plan Review Team is responsible for gathering the comments of the Technical Committee, the Stock Assessment Committee and the Advisory Panel, and presenting these comments as soon as possible to the Section for decision.

The Section will decide whether to approve the state proposal for an alternative management

program if it determines that it is consistent with the target fishing mortality rate, and the goals and objectives of this amendment.

4.5.2 Management Program Equivalency

The Northern Shrimp Technical Committee will review any alternative state proposals under this section and provide to the Section its evaluation of the adequacy of such proposals.

4.6 ADAPTIVE MANAGEMENT

4.6.1 General Procedures

The Northern Shrimp Section may vary the requirements specified in this Amendment as a part of adaptive management in order to conserve the northern shrimp resource. The elements that can be modified by adaptive management are listed in Section 4.6.2. The process under which adaptive management can occur is laid out below.

The Plan Review Team (PRT) will monitor the status of the fishery and the resource and report on that status to the Section annually, or when directed to do so by the Section. The PRT will consult with the Technical Committee, the Stock Assessment Committee and the Advisory Panel in making such review and report. The report will contain recommendations concerning proposed adaptive management revisions to the management program if necessary.

The Section will review the report of the PRT, and may consult further with the Technical Committee, the Stock Assessment Committee or the Advisory Panel. The Section may direct the PRT to prepare the documentation necessary to make any changes to the management program.

Should the Section deem that an addendum to the fishery management plan is necessary, the PRT will prepare a draft addendum and shall distribute it to all states for review and comment. A public hearing will be held in any state that requests one. The PRT will also request comment from federal agencies and the public at large. After a 30-day review period, the PRT will summarize the comments and prepare a final version of the addendum for the Section.

The Section shall review the final version of the addendum prepared by the PRT, and shall also consider the public comments received and the recommendations of the Technical Committee, the Stock Assessment Subcommittee and the Advisory Panel; and shall then decide whether to adopt or revise and adopt the addendum.

Upon adoption of an addendum implementing adaptive management by the Section, states shall prepare proposals in which their plans to carry out the addendum are outlined and submit them to the Section for approval, according to a schedule to be contained in the addendum. Such changes will be instituted on the first fishing day of the following fishing year, but may be put in place at an alternative time as deemed necessary by the Section.

4.6.2 Measures Subject to Change

The following measures are subject to change under adaptive management upon approval by the Northern Shrimp Section:

(1) Overfishing definitions
(2) Rebuilding target and schedule

(3) Gear requirements or prohibitions
(4) Management areas
(5) Limited/controlled entry (including, but not limited to, days-at-sea and ITQs)
(6) Catch controls (quotas)
(7) Vessel limits
(8) Recommendations to the Secretary of Commerce for complementary action
(9) Research or monitoring requirements
(10) Frequency of stock assessments
(11) Any other management measures included in Amendment 1 that are not subject to annual specification

4.7 EMERGENCY PROCEDURES

Emergency procedures may be used by the Northern Shrimp Section to require any emergency action that is not covered by or is an exception or change to any provision in Amendment 1. Procedures for implementation are addressed in the ASMFC ISFMP Charter, Section 6(c)(10) (ASMFC 2003).

4.8 MANAGEMENT INSTITUTIONS

4.8.1 Atlantic States Marine Fisheries Commission and ISFMP Policy Board

The Atlantic States Marine Fisheries Commission and the ISFMP Policy Board are generally responsible for the oversight and management of the Commissions fisheries management activities. The Commission must approve all fishery management plans and amendments thereto, including this Amendment; and must also make all final determinations concerning state compliance or noncompliance. The ISFMP Policy Board reviews recommendations of the various Management Boards and Sections and, if it concurs, forwards them on to the Commission for action.

4.8.2 Northern Shrimp Section

The Northern Shrimp Section was established by the Commission's ISFMP Policy Board and is generally responsible for carrying out all activities under this Amendment. It is responsible for the development of fishery management plans, amendments and addenda with respect to the northern shrimp fishery, and for soliciting public participation during their development. The Section establishes and oversees the activities of the Plan Review Team and the Technical Committee; and requests the establishment of the Commission's Northern Shrimp Advisory Panel. In addition, the Section makes changes to the management program under adaptive management and approves state programs implementing the amendment and alternative state programs. The Section reviews the status of state compliance with the FMP at least annually and, if it determines that a state is out of compliance, reports that determination to the ISFMP Policy Board under the terms of the ISFMP Charter.

4.8.3 Northern Shrimp Plan Development/Review Team

The Plan Development Team (PDT) and the Plan Review Team (PRT) are composed of a small group of scientists and managers whose responsibility is to provide all of the staff support necessary to carry out and document the decisions of the Section. The ASMFC Northern Shrimp Management Plan Coordinator chairs both teams. The Northern Shrimp PRT is directly

responsible to the Section for providing information and documentation concerning the implementation, review, monitoring and enforcement of Amendment 1. The Northern Shrimp PDT is comprised of personnel from state and federal agencies who have scientific and management ability and knowledge of northern shrimp. The PDT prepared all documentation necessary for the development of Amendment 1, using the best scientific information available and the most current stock assessment information. The PDT assumes inactive status with completion of Amendment 1.

4.8.4 Northern Shrimp Technical Committee

The Northern Shrimp Technical Committee consists of, at a minimum, one representative from each state agency with an interest in the Northern Shrimp fishery and one representative from the National Marine Fisheries Service, and two social scientists. Its role is to act as a liaison to the individual state agencies, providing information to the management process and review and recommendations concerning the management program. The Technical Committee reports to the Section. The Section may appoint additional members to the Technical Committee.

4.8.5 Northern Shrimp Advisory Panel

The Northern Shrimp Advisory Panel is established according to the Commission's Advisory Committee Charter. Members of the Advisory Panel are citizens who represent a cross-section of commercial fishing interests. The Advisory Panel provides advice concerning the Commission's northern shrimp management program directly to the Section.

4.9 RECOMMENDATIONS TO THE SECRETARY FOR COMPLEMENTARY ACTIONS IN FEDERAL JURISDICTIONS

The Section may make recommendations to the Secretary of Commerce for complementary action in federal waters through the addendum or amendment process.

4.10 COOPERATION WITH OTHER MANAGEMENT INSTITUTIONS

The Section will cooperate, when necessary, with other management institutions during the implementation of this amendment, including the National Marine Fisheries Service and the New England Fishery Management Council.

5.0 COMPLIANCE

Full implementation of the provisions of this amendment is necessary for the management program to be equitable, efficient and effective. States are expected to implement these measures faithfully under state laws. Although ASMFC does not have authority to directly compel states implementation of these measures, it will continually monitor the effectiveness of state implementation and determine whether states are in compliance with the provisions of this fishery management plan. The Section sets forth specific elements that the Commission will consider in determining state compliance with this fishery management plan, and the procedures that will govern the evaluation of compliance. Additional details of the procedures are found in the ASMFC Interstate Fishery Management Program Charter (ASMFC 2003).

5.1 MANDATORY COMPLIANCE ELEMENTS FOR STATES

A state will be determined to be out of compliance with the provision of this fishery management plan according to the terms of Section 7 of the ISFMP Charter if:

- It fails to meet any schedule required by Section 5.1.2, or any addendum prepared under adaptive management (Section 4.6); or
- It has failed to implement a change to its program when determined necessary by the Northern Shrimp Section; or
- It makes a change to its regulations required under Section 4 without prior approval of the Northern Shrimp Section.

5.1.1 Mandatory Elements of State Programs

To be considered in compliance with this fishery management plan, all state programs must include harvest controls on shrimp fisheries consistent with the requirements in Section 4.1; except that a state may propose an alternative management program under Section 4.5. If the alternative program is approved by the Section, it shall be implemented as an alternative regulatory requirement for compliance.

5.1.1.1 Regulatory Requirements

States may begin to implement Amendment 1 after final approval by the Commission. States may not implement any regulatory changes concerning northern shrimp, nor any management program changes that affect their responsibilities under this amendment, without first having those changes approved by the Section.

5.1.1.2 Monitoring Requirements

The Section will defer action on this measure until the Atlantic Coastal Cooperative Statistics Program comes forward with their recommendation for establishment of a coastwide statistics program. However, it is the sense of the Section that a program to collect accurate and comprehensive statistics, not only on the northern shrimp fishery but for all fisheries, is necessary in order to manage in a timely and proactive manner. The Section will work to ensure that this is accomplished as soon as possible.

States must maintain at least their current reporting and data collection programs and are encouraged to adopt the recommendations forwarded by the ACCSP.

5.1.1.3 Research Requirements

No mandatory research requirements have been identified at this time. However, elements of state plans may be added to address any needs identified through implementation of Amendment 1.

5.1.1.4 Law Enforcement Requirements

All state programs must include law enforcement capabilities adequate for successfully implementing the jurisdiction's northern shrimp regulations. The adequacy of a state's enforcement activity will be measured by annual report to the ASMFC Law Enforcement Committee and the PRT.

5.1.1.5 Habitat Requirements

No mandatory habitat requirements have been identified at this time. However, elements of state plans may be added to address any needs identified through implementation of Amendment 1.

5.1.2 Compliance Schedule

States must implement the provisions of this amendment no later than July 1, 2004. States may begin implementation prior to this date when approved by the full Commission.

Reports on compliance must be submitted to the Commission by each jurisdiction annually, no later than September 30 each year.

5.1.3 Compliance/Technical Report Content

Each state must submit to the Commission and Technical Committee an annual report concerning its northern shrimp fisheries and management program for the previous year. The report shall cover:

- the previous calendar year's fishery and management program including activity and results of monitoring, regulations that were in effect, and harvest, including estimates of non-harvest losses; and
    - the planned management program for the current calendar year summarizing regulations that will be in effect and monitoring programs that will be performed, highlighting any changes from the previous year.

5.2 PROCEDURES FOR DETERMINING COMPLIANCE

Detailed procedures regarding compliance determinations are contained in the ISFMP Charter, Section Seven (ASMFC 2003).

In brief, all states are responsible for the full and effective implementation and enforcement of fishery management plans in areas subject to their jurisdiction. Written compliance reports as specified in the Plan or Amendment must be submitted annually by each state with a declared interest. Compliance with Amendment 1 will be reviewed at least annually. The Section, Policy Board or the ASMFC may request the Plan Review Team to conduct a review of Plan implementation and compliance at any time.

The Northern Shrimp Section will review the written findings of the PRT within 60 days of receipt of a State's compliance report. Should the Section recommend to the Policy Board that a state be determined to be out of compliance, a rationale for the recommended noncompliance finding will be addressed in a report. The report will include the required measures of Amendment 1 that the state has not implemented or enforced, a statement of how failure to implement or enforce required measures jeopardizes northern shrimp conservation, and the actions a state must take in order to comply with Amendment 1 requirements.

The ISFMP Policy Board will review any recommendation of noncompliance from the Northern Shrimp Section within 30 days. If it concurs in the recommendation, it shall recommend at that time to the ASMFC that a state be found out of compliance.

The Commission shall consider any noncompliance recommendation from the ISFMP Policy Board within 30 days. Any state that is the subject of a recommendation for a noncompliance

finding is given an opportunity to present written and/or oral testimony concerning whether it should be found out of compliance. If the Commission agrees with the recommendation of the ISFMP Policy Board, it may determine that a state is not in compliance with the Amendment 1, and specify the actions the state must take to come into compliance.

Any state that has been determined to be out of compliance may request that the Commission rescind its noncompliance findings, provided the state has revised its northern shrimp conservation measures.

5.3 ANALYSIS OF THE ENFORCEABILITY OF PROPOSED MEASURES

Amendment 1 does not prescribe a specific management measures. The northern shrimp management program will be developed through the annual public hearing and addendum process. Enforceability of management measures will be analyzed as specific measures are being contemplated.

6.0 MANAGEMENT AND RESEARCH NEEDS

6.1 STOCK ASSESSMENT AND POPULATION DYNAMICS

6.1.1 Biology/Community Ecology

- Evaluate appropriate biological reference points and sustainable harvest levels.
- Monitor landings, size, age, gear and harvest area of northern shrimp fishery, and enhance bio-statistical sampling of northern shrimp fishery.
- Evaluate precision of the assessment results.
- Determine the effects of regulations on the fishery, the participants and the resource.
- Develop bycatch studies of northern shrimp on other fisheries.
- Periodically monitor the economic structure and sociological characteristics of the northern shrimp fishery.

6.2 RESEARCH AND DATA NEEDS

6.2.1 Biological

- Re-evaluate natural mortality estimate.
- Evaluate effects of environmental factors on growth, survival and abundance of northern shrimp.
- Evaluate distribution and migration of larval, juvenile, and adult shrimp.

6.2.2 Social and Economic

- The data needs identified by the 1986 FMP remain important today. While the FMP did respond to the basic requisite, a much fuller examination of the industry is needed to

properly analyze the potential impacts of the plan and the current amendment. Additional research needs include:

- Broad-based and detailed socioeconomic description and analysis of the structure, operations, markets, revenues and expenditures of the northern shrimp fishery itself and in relation to other commercial fisheries in northern New England.
- Ground-truthing for all of the data gathered via Federal and State databases. Contradictions and inaccuracies abound, so face-to-face interviews with a randomized sample of participants in all sectors of the fishery are needed.
- Develop a bioeconomic model to study the interactions between four variables: movements of shrimp, catchability of shrimp, days fished, and market price.
- Develop and economic-management model to determine (1) the most profitable times to fish, (2) how harvest timing effects markets, and (3) how the market effects the timing of harvesting.
- Determine the relative power relationships between the harvesting and processing sector and the larger markets for shrimp and shrimp products. Identify significant variables driving market prices and how their dynamic interactions result in the observed intra-annual and inter-annual fluctuations in market price for northern shrimp.

6.2.3 Habitat

- Study specific habitat requirements for all life history stages.
- Develop habitat maps for all life history stages.
- Identify migration routes of immature males offshore, and ovigerous females inshore.
- Study the effects of large-scale climatic events (like the North Atlantic Oscillation) on the cold water refuges for shrimp in the Gulf of Maine.
- Determine the short and long-term effects of mobile fishing gear on shrimp habitat.
- Evaluate effects of habitat loss/degradation on northern shrimp.

7.0 PROTECTED SPECIES

In the fall of 1995, Commission member states, the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) began discussing ways to improve implementation of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) in state waters. Historically, these policies have been only minimally implemented and enforced in state waters (0-3 miles). In November 1995, the Commission, through its Interstate Fisheries Management Program (ISFMP) Policy Board, approved amendment of its ISFMP Charter (Section 6(b)(2)) so that protected species/fishery interactions are addressed in the Commission's fisheries management planning process. Specifically, the Commission's fishery management plans will describe impacts of state fisheries on certain marine mammals and endangered species (collectively termed "protected species"), and recommend ways to minimize these impacts. The following section outlines: (1) the federal legislation which guides protection of marine mammals and sea turtles, (2) the protected species with potential fishery

interactions; (3) the specific type(s) of fishery interaction; (4) population status of the affected protected species; and (5) potential impacts to Atlantic coastal state and interstate fisheries.

7.1 MARINE MAMMAL PROTECTION ACT (MMPA) REQUIREMENTS

Since its passage in 1972, one of the underlying goals of the MMPA has been to reduce the incidental serious injury and mortality of marine mammals permitted in the course of commercial fishing operations to insignificant levels approaching a zero mortality and serious injury rate. The 1994 Amendments to the MMPA established section 118 to govern the taking of marine mammals incidental to commercial fishing operations. Under section 118, the National Marine Fisheries Service (NMFS) is required to develop and implement a take reduction plan to assist in the recovery or prevent the depletion of each strategic stock that interacts with a Category I or II fishery. Category I and II fisheries are those that have frequent or occasional incidental mortality and serious injury of marine mammals, respectively. In addition to complying with any applicable take reduction plans, vessels operating in Category I or II fisheries are required to annually register with NMFS and obtain an authorization certificate and carry observers if requested. All commercial fishermen, regardless of Category, are required to report all incidental mortality or serious injury of marine mammals that occurs incidental to commercial fishing to NMFS.

A strategic stock is defined as a stock: (1) for which the level of direct human caused mortality exceeds the potential biological removal (PBR) level; (2) which is declining and is likely to be listed under the Endangered Species Act (ESA) in the foreseeable future; or (3) which is listed as a threatened or endangered species under the ESA or as a depleted species under the MMPA.

Section 101(a)(5)(E) of the MMPA requires the authorization of the incidental taking of individuals from marine mammal stocks listed as threatened or endangered under the ESA in the course of commercial fishing operations if it is determined that: (1) incidental mortality and serious injury will have a negligible impact on the affected species or stock; (2) a recovery plan has been developed or is being developed for such species or stock under the ESA; and (3) where required under section 118 of the MMPA, a monitoring program has been established, vessels engaged in such fisheries are registered in accordance with section 118 of the MMPA, and a take reduction plan has been developed or is being developed for such species or stock. Currently, there are no permits that authorize takes of threatened or endangered species by any commercial fishery in the Atlantic.

7.2 ENDANGERED SPECIES ACT (ESA) REQUIREMENTS

The taking of endangered sea turtles and marine mammals is prohibited under Section 9 of the ESA. In addition, NMFS may issue Section 4(d) protective regulations necessary and advisable to provide for the conservation of threatened species. There are several mechanisms established in the ESA to avoid the takings prohibition in Section 9. First, a 4(d) regulation may include less stringent requirements intended to reduce incidental take and thus allow for the exemption from the taking prohibition. Section 10(a)(1)(B) of the ESA authorizes NMFS to permit, under prescribed terms and conditions, any taking otherwise prohibited by Section 9 of the ESA, if the taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Finally, Section 7(a) requires NMFS to consult with each federal agency to ensure that any action that is authorized, funded, or carried out by such agency is not likely to jeopardize the continued

existence of any listed species. Section 7(b) authorizes incidental take of listed species after full consultation and identification of reasonable and prudent alternatives or measure to monitor and minimize such take.

7.3 PROTECTED SPECIES WITH POTENTIAL FISHERY INTERACTIONS

The threatened and protected species found in coastal Northwest Atlantic waters are listed below. Three mammals and three turtles are classified as endangered and two turtles are classified as threatened under the ESA; the remainder of mammal species in the Gulf of Maine are protected under provisions of the MMPA. Other marine mammals inhabit Gulf of Maine waters, but because the fishery is primarily inshore, they are not listed here.

	Mammals	Turtles
Endangered	Right whale (*Eubalaena glacialis*) Humpback whale (*Megaptera novaeangliae*) Fin whale (*Balaenoptera physalus*)	Leatherback turtle (*Dermochelys coriacea*) Kemp's ridley (*Lepidochelys kempii*) Green sea turtle (*Chelonia mydas*)
Threatened	None	Loggerhead (*Caretta caretta*) Green turtle (*Chelonia mydas*)
Proposed for ESA Listing	Harbor porpoise (*Phocoena phocoena*)	
MMPA	Minke whale (*Balaenoptera acutorostrata*) Bottlenose dolphin (*Tursiops truncatus*) Harbor seal (*Phoca vitulina*) Grey seal (*Halichoerus grypus*) Harp seal (*Phoca groenlandica*)	

In the Northwest Atlantic waters, protected species utilize marine habitats for purposes of feeding, reproduction, as nursery areas and as migratory corridors. Some species occupy the area year round while others use the region only seasonally or move intermittently nearshore, inshore and offshore. Interactions may occur whenever fishing gear and marine mammals overlap spatially and temporally.

For sea turtles, the Atlantic seaboard is considered to provide important developmental habitat for post-pelagic juveniles, as well as foraging and nesting habitat for adults. The distribution and abundance of sea turtles along the Atlantic coast is related to geographic location and seasonal variations in water temperatures. Water temperatures dictate how early northward migration begins each year and is a useful factor for assessing when turtles will be found in certain areas. Moderate to high abundances of sea turtles have been observed both offshore and nearshore when water temperatures are greater than or equal to 21^{o} C. As water temperatures decline below 11^{o} C, abundance declines markedly and turtles typically move from cold inshore waters in the late fall to move offshore to the warmer waters in the Gulf Stream, generally south of Cape Hatteras, North Carolina. Conversely, in the late spring and early summer, they migrate from the Gulf Stream waters into the sounds and embayments.

7.4 PROTECTED SPECIES INTERACTIONS WITH EXISTING FISHERIES

7.4.1 Marine Mammals

No marine mammal species are known to become entangled or caught in gear used by the northern shrimp trawl fishery. However, the fishery was last observed in 1997, so it is not known whether interactions have occurred since 1997. NMFS observer program out of the Northeast Fishery Science Center observed 36 trips in 1996 and 17 trips in 1997 of the northern shrimp trawl fishery. Of the 1996 trips, 18 were in Maine, 12 were in Massachusetts, and 6 were in New Hampshire. Of the 1997 trips, 4 were in Maine, 5 were in Massachusetts, and 8 were in New Hampshire. No marine mammal takes were observed during these trips.

The Gulf of Maine northern shrimp trawl fishery is a Category III fishery on NMFS MMPA List of Fisheries. No marine mammal interactions have been documented between this fishery and marine mammals (2001 List of Fisheries, 66 FR 42780, August 15, 2001).

7.4.2 Sea Turtles

The gear types used in the northern shrimp fishery include trawls and traps (pots). Sea turtles are known to exist in the Gulf of Maine waters. Both gear types have the potential to interact with sea turtles and result in the take of these species.

All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the Endangered Species Act of 1973 (ESA). The Kemp's ridley (*Lepidochelys kempii*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*) are listed as endangered. The loggerhead (*Caretta caretta*) and green turtle (*Chelonia mydas*) are listed as threatened, except for breeding populations of green turtles in Florida and on the Pacific coast of Mexico, which are listed as endangered. All five of these species inhabit the waters of the U.S. Atlantic and Gulf of Mexico.

Atlantic coastal waters provide important developmental, migration, and feeding habitat for sea turtles. The distribution and abundance of sea turtles along the Atlantic coast is related to geographic location, reproductive cycles, food availability, and seasonal variations in water temperatures. Water temperatures dictate how early northward migration begins each year and is a useful factor for assessing when turtles will be found in certain areas. Sea turtles can occur in offshore as well as inshore waters, including sounds and embayments, and have been recorded in waters as far north as the coast of Canada.

Trawls

Trawl fisheries are listed as marine habitat threats in sea turtle recovery plans (NMFS and USFWS, 1991a; USFWS and NMFS, 1992; NMFS and USFWS, 1991b; NMFS and USFWS, 1992; NMFS and USFWS, 1993). Numerous trawl fisheries in state waters along the Atlantic coast adversely affect threatened and endangered sea turtles. In particular, the shrimp and summer flounder trawl fisheries are documented to take turtles. Before the implementation of TEDs (turtle excluder device) in the shrimp and flounder fisheries, large numbers of sea turtles were determined to be dying annually due to these trawl fisheries. Non-TED equipped trawl nets fishing in an area where sea turtles occur have the potential to capture, stress (weaken), and drown sea turtles.

Traps (Pots)
Sea turtles can become entangled in fishing gear including fish trap warps, buoy anchor lines and other ropes and cables. This can lead to serious injuries and/or death by drowning (NMFS 1992). The traps (pots) of this fishery could potentially interact with sea turtles and result in the take of these species.

7.4.3 Seabirds

Like marine mammals, seabirds are vulnerable to entanglement in commercial fishing gear. The interaction has not been quantified in the northern shrimp fishery, but impacts are not considered to be significant. Human activities such as coastal development, habitat degradation and destruction, and the presence of organochlorine contaminants are considered to be the major threats to some seabird populations. Endangered and threatened bird species, which include the roseate tern and piping plover, are unlikely to be impacted by the gear types employed in the northern shrimp fishery.

7.5 POPULATION STATUS REVIEW OF RELEVANT PROTECTED SPECIES

7.5.1 Marine Mammals

The status of marine mammal populations inhabiting the Gulf of Maine has been discussed in great detail in the U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessment Reports (Waring, *et al.* 2000). The reports present information on stock definition, geographic range, population size, productivity rates, potential biological removal (PBR) level, fishery specific mortality estimates, and a comparison of the PBR level to estimated human-caused mortality for each stock.

7.6 EXISTING AND PROPOSED FEDERAL REGULATIONS AND ACTIONS/POTENTIAL IMPACTS TO ATLANTIC COASTAL STATE AND INTERSTATE FISHERIES

There are no known existing or proposed federal marine mammal, sea turtle, or seabird regulations or actions pertaining to the northern shrimp trawl fishery.

There are two marine mammal regulations in place that affect Atlantic coastal fisheries. However, these regulations do not pertain to trawl fisheries. The Northeast sink and Mid-Atlantic coastal gillnet fisheries are regulated by the Harbor Porpoise Take Reduction Plan. The Atlantic Large Whale Take Reduction Plan addresses the incidental bycatch of large baleen whales, primarily the northern right whale and the humpback whale in several fisheries, including the Northeast sink gillnet, the Mid-Atlantic coastal gillnet, and the Northeast/Mid-Atlantic American lobster trap/pot fisheries.

7.7 IDENTIFICATION OF CURRENT DATA GAPS AND RESEARCH NEEDS

A lack of sea sampling data in regard to protected species interactions in the Gulf of Maine northern shrimp fishery has been identified. Additional observer coverage in this fishery is needed to understand whether interaction occurs between the Gulf of Maine northern shrimp fishery and protected species.

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9.0 TABLES

Table 1. Stratified mean number per tow* of northern shrimp collected during R/V Gloria Michelle summer surveys 1984-2003.

Untransformed

Year	Total Number	Age-1.5 Number	>22 mm** Number	Weight (kg)	Weight** >22 mm (kg)
1984	3,005	48	826	22.6	8.9
1985	3,531	643	2,262	29.4	22.3
1986	3,327	703	1,688	29.7	19.6
1987	2,419	535	1,350	21.0	15.1
1988	4,310	2,812	1,012	26.6	11.7
1989	3,580	525	1,072	27.3	11.5
1990	3,021	264	2,097	29.4	22.2
1991	1,992	765	1,042	18.2	12.6
1992	1,503	443	625	12.9	7.6
1993	3,569	2,334	772	17.9	8.5
1994	3,435	1,285	849	21.1	9.3
1995	2,856	576	1,238	21.1	13.8
1996	2,651	793	1,223	20.2	13.8
1997	3,161	1,551	1,017	19.8	11.6
1998	2,318	533	676	15.1	7.4
1999	1,648	471	719	11.9	7.8
2000	1,844	997	647	11.9	7.2
2001	870	69	281	6.5	2.9
2002	3,157	2,313	571	15.0	6.3
2003	1,809	157	554	12.2	5.4

Log_e Transformed

Year	Total Number	Age-1.5 Number	>22 mm** Number	Weight (kg)	Weight** >22 mm (kg)
1984	1,152	18	316	10.5	3.4
1985	1,849	337	1,184	17.7	11.7
1986	1,695	358	860	19.6	10.0
1987	1,385	306	773	14.8	8.6
1988	1,269	828	298	12.8	3.4
1989	1,883	276	564	17.0	6.1
1990	1,624	142	1,127	18.1	12.0
1991	1,255	482	657	11.7	8.0
1992	955	282	397	9.4	4.8
1993	1,156	756	250	9.1	2.8
1994	984	368	243	8.7	2.7
1995	1,449	292	628	13.3	7.0
1996	776	232	358	8.8	4.0
1997	762	374	245	7.7	2.8
1998	583	134	170	6.3	1.9
1999	398	114	174	5.8	1.9
2000	807	437	283	6.4	3.2
2001	451	36	146	4.3	1.5
2002	1,446	1,059	261	9.2	2.9
2003	564	49	173	5.5	1.7

*Based on strata 1, 3, 5, 6, 7 and 8. **Will be fully recruited to the winter fishery.

Table 2. Commercial landings (mt) of northern shrimp in the western Gulf of Maine, 1958-2003.

Year	Maine		New Hampshire		Massachusetts		Total	
1958	2.3		0.0		0.0		2.3	
1959	5.4		0.0		2.3		7.7	
1960	40.4		0.0		0.5		40.9	
1961	30.4		0.0		0.5		30.9	
1962	159.7		0.0		16.3		176.0	
1963	244.0		0.0		10.4		254.4	
1964	419.4		0.0		3.1		422.5	
1965	947.0		0.0		8.0		955.0	
1966	1,737.8		18.1		10.5		1,766.4	
1967	3,141.1		20.0		10.0		3,171.1	
1968	6,515.0		43.1		51.9		6,610.0	
1969	10,992.9		58.1		1,772.9		12,823.9	
1970	7,712.8		54.4		2,902.1		10,669.3	
1971	8,354.7		50.8		2,723.8		11,129.3	
1972	7,515.6		74.8		3,504.5		11,094.9	
1973	5,476.7		59.9		3,868.2		9,404.8	
1974	4,430.7		36.7		3,477.3		7,944.7	
1975	3,177.0		29.5		2,080.2		5,286.7	
1976	617.2		7.3		397.8		1,022.3	
1977	148.0		2.3		236.9		387.2	
1978	0.0		0.0		0.0		0.0	
1979	32.9		2.3		451.3		486.5	
1980	71.4		7.4		260.3		339.1	
1981	528.6		4.5		538.1		1,071.2	
1982	883.2	*(853.3)	32.8	(21.6)	658.5	(655.3)	1,574.5	(1,530.2)
1983	1,022.0	(892.5)	36.5	(46.2)	508.0	(458.4)	1,566.5	(1,397.1)
1984	2,564.7	(2,394.9)	96.8	(30.7)	565.3	(525.1)	3,226.8	(2,950.7)
1985	2,956.9	(2,946.4)	207.4	(216.5)	1,030.6	(968.0)	4,194.9	(4,130.9)
1986	3,407.3	(3,268.2)	191.1	(230.5)	1,085.6	(1,136.3)	4,684.0	(4,635.0)
1987	3,534.2	(3,673.2)	152.5	(157.8)	1,338.7	(1,422.2)	5,025.4	(5,253.2)
1988	2,272.4	(2,257.2)	173.1	(154.5)	631.5	(619.6)	3,077.0	(3,031.3)
1989	2,542.6	(2,384.0)	314.3	(231.5)	749.6	(699.9)	3,606.5	(3,315.4)
1990	2,961.5	(3,236.1)	447.3	(451.2)	993.2	(974.3)	4,402.0	(4,661.6)
1991	2,431.1	(2,488.1)	208.2	(282.2)	727.6	(801.1)	3,366.9	(3,571.4)
1992	2,973.9	(3,054.1)	100.1	(100.0)	291.6	(289.1)	3,365.6	(3,443.6)
1993	1,562.8	(1,492.2)	441.1	(357.4)	300.3	(292.8)	2,304.7	(2,142.9)
1994	2,815.5	(2,239.3)	520.9	(428.0)	374.4	(247.5)	3,710.8	(2,914.8)
1995		(5,022.7)		(764.9)		(678.8)		(6,466.4)
1996		(7,737.0)		(771.0)		(658.0)		(9,166.1)
1997		(6,050.0)		(666.3)		(362.8)		(7,079.1)
1998		(3,482.0)		(445.2)		(247.2)		(4,174.4)
1999		(1,523.4)		(217.0)		(75.7)		(1,816.1)
2000		(2,067.3)		(212.3)		(109.9)		(2,389.5)
2001		(1071.8)		(205.8)		(49.1)		(1,326.7)
2002		**(362.7)		**(51.2)		**(7.7)		**(421.6)
2003		**(807.9)		**(106.6)		**(22.7)		**(937.1)

*Numbers in parenthesis are computed on a seasonal basis

**Preliminary.

Table 3. Management of the Gulf of Maine Northern Shrimp Resource, 1973 – 2004

	NSS ACTION TAKEN
1973	Provisions for gear evaluation Establishment of studies
1974	Adoption of interim minimum mesh size regulation requiring use of trawls with stretched mesh sizes of not less than 38 mm (1.5 inches) in the body and 44.5 mm (1.75 in) in the codend.
1975	Establishment of regulations requiring use of trawls with stretched mesh sizes of not less than 44.5 mm (1.75 inches) in the body and cod end (effective October, 1975) Closure of the fishery from July – September, 1975.
1976	Open season from January 1 – May 15, 1976, followed by indefinite closure. Continuation of mesh regulations.
1977	Open season from January 1 – May 15, 1977, followed by indefinite closure. Restrictions of 1977 harvest to 1,600 mt (3.5 million lbs) Continuation of mesh regulations.
1978	Continuation of closure through 1978.
1979	Open season from February 1 – March 31, 1979, followed by indefinite closure. Continuation of mesh regulations.
1980	Open season from February 15 – May 31, 1980, followed by indefinite closure. Continuation of mesh regulations.
1981	Open season from January 1 – May 15, 1981, followed by indefinite closure. Continuations of mesh regulations.
1982	Open season from January 1 – April 15, 1982. Continuation of mesh regulations.
1983	Open season December 15, 1982 – April 30, 1983 with possible 15 day extension with 70 count size limit. Continuation of mesh regulations.
1984	Open seson December 15, 1983 – April 30, 1984 with a possible extension of 15 days or until count exceeds 70/pound for any one trip. Continuation of mesh regulations.
1985	Open season December 1, 1984 – May 15, 1985. During May, landed count shall not exceed 70/pound or season closed immediately. Continuation of mesh regulations.

Table 3., continued:

	NSS ACTION TAKEN
1986	Open season December 1, 1985 – May 31, 1986. Continuation of mesh regulations. Two week emergency opening June 8 – June 21 with 70 count maximum.
1987	Open season December 1, 1986 – May 31, 1987. Continuation of mesh regulations. Eliminate mesh size tolerance (1/4 Inch) in codend by 1988 season.
1988	Full season. December 1, 1987 – May 31, 1988. 1-3/4 inch mesh required, 1/8 inch tolerance in body and wings, 2 inch mesh in cod end in April and May, 1988.
1989	Full season. December 1, 1988 – May 31, 1989. 1/8 inch tolerance in net, no tolerance in cod end. Approved separator trawl used in April and May, 1989.
1990	Full season. December 1, 1989 – May 31, 1990. 1-3/4 inch mesh net with no tolerance. Approved separator trawl must be used December, April and May.
1991	Full season. December 1, 1990 – May 31, 1991. 1-3/4 inch mesh net, separator panel must be 11 inch mesh, quarter to quarter.
1992	Season December 16, 1991 – May 15, 1992. 1-3/4 inch mesh net. No Sunday fishing. Separator trawl December 16, 1991 through March 31, 1992. Nordmore grate April 1, 1992 – May 15, 1992.
1993	Season December 14, 1992 – April 30, 1993. 1-3/4 inch mesh net. No Sunday fishing. Nordmore grate and 11 inch panel required. Exemption to Nordmore grate January – March if bycatch proven to be low.
1994	Season December 1, 1993 – April 15, 1994. 1-3/4 inch mesh net. 15 fathom bare wire bottom legs. Nordmore grate all season, no exemptions. (122 days)
1995	Season December 1, 1994 – April 30, 1995. 1-3/4 inch mesh net. 15 Fathom bare wire bottom legs. Nordmore grate all season, no exemptions. No fishing on Sunday (or Friday as substitute). (128 days)
1996	Full season with one day/week off. Also, trappers to start January 1, 1996. (Review of effort at mid-season?) (152 days)

Table 3., continued:

	NSS ACTION TAKEN
1997	Season December 1, 1996 – May 27, 1997 with two 5-day and four 4-day blocks off. (156 days)
1998	Season December 8 – 24, 1997; January 1, 1998 – March 15, 1998; April 1, 1998 – May 22, 1998 with weekends off. (105 days)
1999	Season December 15 – 23, January 4 - 26, February 1 – 23, March 1 – 16, April 1 – 28, May 2 – 25 with weekends off. (90 days)
2000	Season January 17, 2000 – March 15, 2000. (59 days)
2001	Season January 9, 2001 – March 17, 2001, April 16 – 30, 2001. (83 days)
2002	Season February 15 – March 11, 2002. (25 days)
2003	Season January 19 – March 12, 2003 with Saturdays and Sundays off. (38 days)
2004	Season January 19 – March 12, 2004 with Saturdays and Sundays off. (40 days)

Table 4. Catch Summary for 46 tows. (from Kenney et al. 1992).

Nordmore Catch Data: All Weights in Kg.

F/V Mary Ellen Jan 6 - 10, 1992

Tow No	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Gear	¾	C	C	3/4	3/4	C	C	3/4	3/4	C	C	3/4	1	1	3/4	C	1	C	3/4	1	C	3/4
Date	6	6	6	6	7	7	7	7	7	7	9	9	9	9	9	9	10	10	10	10	10	10
Depth (fm)	Foul		64	62	63	65	65	65	60	59	62	64	64	65	68	65	45	46	48	46	47	48
Total Catch	Set 14.95	183.05	105	93.25	76.25	162.05	184.6	82.75	66.25	115.75	141	62	52.5	69.25	59.75	149.5	103	134.95	68.25	105.75	145.5	102.75
Shrimp wt.	12	68	58	85.5	64	88.5	74.5	73.5	58.5	37.5	58	49.5	42.5	53	50	42.5	93.5	66	64	98.5	90.5	99.5
% of Catch	80	42	55	92	84	42	40	89	88	32	41	80	81	77	84	28	91	49	94	93	62	97
Blackback	0.15	3	5.5			5	1.8	0.25		3.25	2			0.25		2.25	0.25	4	0.25	0.5	5.25	0.5
Cod		1	2.5	0.25		9	2.5	0.25		0.25	2.5	0.25	0.25		0.25	22	0.25	2.2		0.25	0.25	
Dab	0.3	3.5	2		0.25	2	4.8	0.25	0.25	1.75	4	0.25	0.5		0.25	4	0.25	0.75		0.25	1	0.25
Graysole		0.9			0.25	0.5	1	0.25	0.25	0.25	0.75	0.25	0.5	0.25		1	0.25	0.25			0.25	
Haddock		0.25					0.25			0.25	0.25										0.25	
Pollock		0.4				0.25	0.5				1		0.25	0.25		1	0.25	0.25				
Redfish		0.2	0.25				0.25				0.25											
Yellowtail		4.5				0.25	4.5			2.75	4					2.5		2	0.5		2.25	
Total Reg Sp.	0.45	13.85	10.25	0.25	0.5	19.25	15.6	1	0.5	8.5	14.75	0.75	1.5	0.75	0.5	32.75	1.25	9.45	0.75	1	9.25	0.75
% Reduction of Reg. Sp.		3/4" gear / 1" gear		97.60%		97.40%		93.60%		94.10%		94.90%	89.80%	97.70%	98.50%		86.80%			89.20%		91.90%
Alewife				0.5																		
Eelpout		*																				
Hakes	0.05	18	3	0.25		10.5	13.5	0.25		3.5	9.5	0.25	1.25	1.25		12.5	0.25	1.25		0.25	0.5	
herring	1.1	0.8	1.25		0.25	0.8	0.25	0.25	1	0.25	1.75	0.75	0.5	0.5	1	0.25	0.75	0.5	0.25	0.5	0.25	0.5
mackerel		0.8														0.25						
monkfish		0.8	0.5	*		1	1.5				0.5					1						
rockling		*		0.25								0.25				1						
sculpin						0.75			0.25	0.5						0.75				0.5	4	
scup	0.05	0.2																				
sea raven		2.8	3.5				1.25			1						2.5					0.25	
sea robin		0.4								0.25							0.25					
skate		27	13.5			30.5	48			51	35					36	1	43.5		0.25	38	0.25
squid		0.7								5				0.25								
windowpane						0.25				0.25							0.25	0.25		0.25		
whiting	1.3	28	15	6.5	11.25	30.5	30	7.5	6	12	20	10.5	6	13.5	8	20	5.75	8.5	3.25			
misc.		0.9						0.25		0.5	1.5		0.75		0.25			5.5				
Total Other	2.5	81.2	38.75	7.5	11.25	74.3	94.5	8.25	7.25	69.75	68.25	11.75	8.5	15.5	9.25	74.25	8.25	59.5	3.5	1.75	43	0.75

* Wt less than 0.25 kg

Table 5. Important factors affecting shrimp distribution in the Gulf of Maine

LIFE HISTORY STAGE	TIME OF YEAR	LOCATION	TEMPERATURE	DEPTH	SALINITY	SUBSTRATE	ESTUARINE USE
Spawning Adults	Late summer through fall (Haynes and Wigley 1969)	Deep cold water refuges in southwestern Gulf of Maine (Apollonio et al. 1986)	< 7 0 C (Clark et al. 1999)	92-183 m (Clark et al. 1999)	Most common in waters from 32.3 to around 33 (Haynes and Wigley 1969)	Mud (Clark et al. 1999)	-
Eggs	Eggs retained on pleopods of female after extrusion in late summer/early fall until hatch in winter	Hatch in near-shore waters (Apollonio and Dunton 1969)	Same as for ovigerous females (see below).	Same as for ovigerous females (see below).	Same as for ovigerous females (see below).		Unknown
Larvae **(30 to 60 days; Rinaldo 1980)**	Larvae: in water column winter – late summer (Apollonio and Dunton 1969)	Near-shore waters out to ~ 10 miles (Apollonio and Dunton 1969)	Unknown, likely below 14 0 C (Poulson 1946)	Unknown	Often in water < 30 (Haynes and Wigley 1969)	Water column near-shore (Apollonio and Dunton 1969)	Unknown
Juvenile/ Immature Male **(Age 1 to 2 months until 27 to 28 months**	Late summer / early fall through the following summer (Apollonio and Dunton 1969) Juvenile stage up to 20 months ()	Near-shore waters, beginning migration to offshore waters (>10 miles) around age 20 months (Apollonio and Dunton 1969)	Unknown	Unknown	Unknown	Unknown, probably mud	Unknown
Mature Male **(Age 29-30 months)**	Summer/fall through the following (Apollonio and Dunton 1969)	Deep offshore basins in southwestern Gulf of Maine (Apollonio and Dunton 1969)	0-6 0C (Shumway et al. 1985	92 – 183 m (Clark et al. 1999)	Most common in waters from 32.3 to around 33 (Haynes and Wigley 1969)	Mud (Clark et al. 1999)	-
Transitional Stage	Fall – Spring (Apollonio and Dunton 1969)	Deep offshore basins in southwestern Gulf of Maine (Apollonio and Dunton 1969)	0-6 0C (Shumway et al. 1985	92 – 183 m (Clark et al. 1999)	Most common in waters from 32.3 to around 33 (Haynes and Wigley 1969)	Mud (Clark et al. 1999)	-
Mature Female **Age 41-42 months until death around ages 54-66 months)**	Spring – live one or two more years until death (Apollonio and Dunton 1969)	Deep offshore basins in southwestern Gulf of Maine (Apollonio and Dunton 1969)	0-6 0C (Shumway et al. 1985	92 – 183 m (Clark et al. 1999)	Most common in waters from 32.3 to around 33 (Haynes and Wigley 1969)	Mud (Clark et al. 1999)	
Ovigerous Females	Early fall – late winter (Apollonio and Dunton 1969)	Migration to near-shore waters (Haynes and Wigley 19690	0-6 0C (Shumway et al. 1985	Most < 60 m (Haynes and Wigley 1969)	Coastal	Mud (Clark et al. 1999); few and sandy and rocky bottoms	Unknown

Table 6: Summary of results from Collie-Sissenwine Analysis of Gulf of Maine Shrimp

10.0

Fishing Season	New Recruits (millions)	Fully-Recruited (millions)	F (NR+FR)	Biomass (mt)	Exploitation Rate
1985	985	945	0.26	14,025	21%
1986	1,177	1,367	0.20	21,674	16%
1987	983	1,494	0.25	22,452	19%
1988	756	1,296	0.15	18,758	13%
1989	1,174	985	0.18	14,190	15%
1990	1,311	1,400	0.23	20,595	18%
1991	828	1,516	0.19	22,143	15%
1992	607	1,175	0.21	16,927	17%
1993	511	879	0.20	12,371	16%
1994	710	711	0.28	9,182	22%
1995	975	807	0.57	12,365	39%
1996	884	1,003	0.76	15,520	48%
1997	536	767	1.17	11,055	62%
1998	473	432	0.74	6,599	47%
1999	409	381	0.42	5,705	31%
2000	303	389	0.48	5,616	34%
2001	439	405	0.24	6,166	19%
2002	345	435	0.07	5,912	6%
2003	770	564	0.09	7,680	8%
2004	404	632		7,489	
Overall average			0.35	12,821	
1985-94 average			0.22	17,232	

10.0 FIGURES

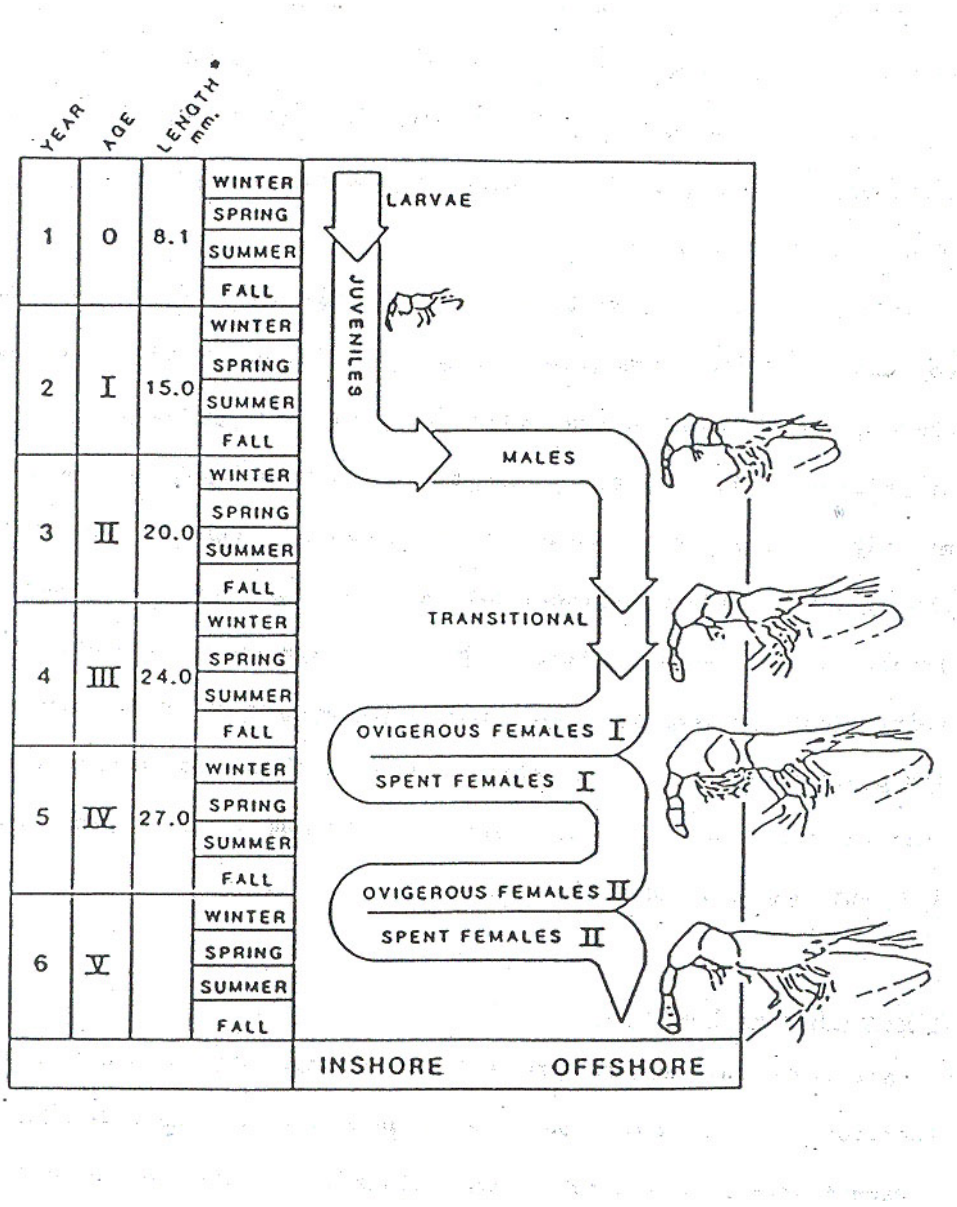

Figure 1: Schematic diagram of the life cycle of *Pandalus borealis* in the Gulf of Maine (modified from Shumway et. al. 1985)

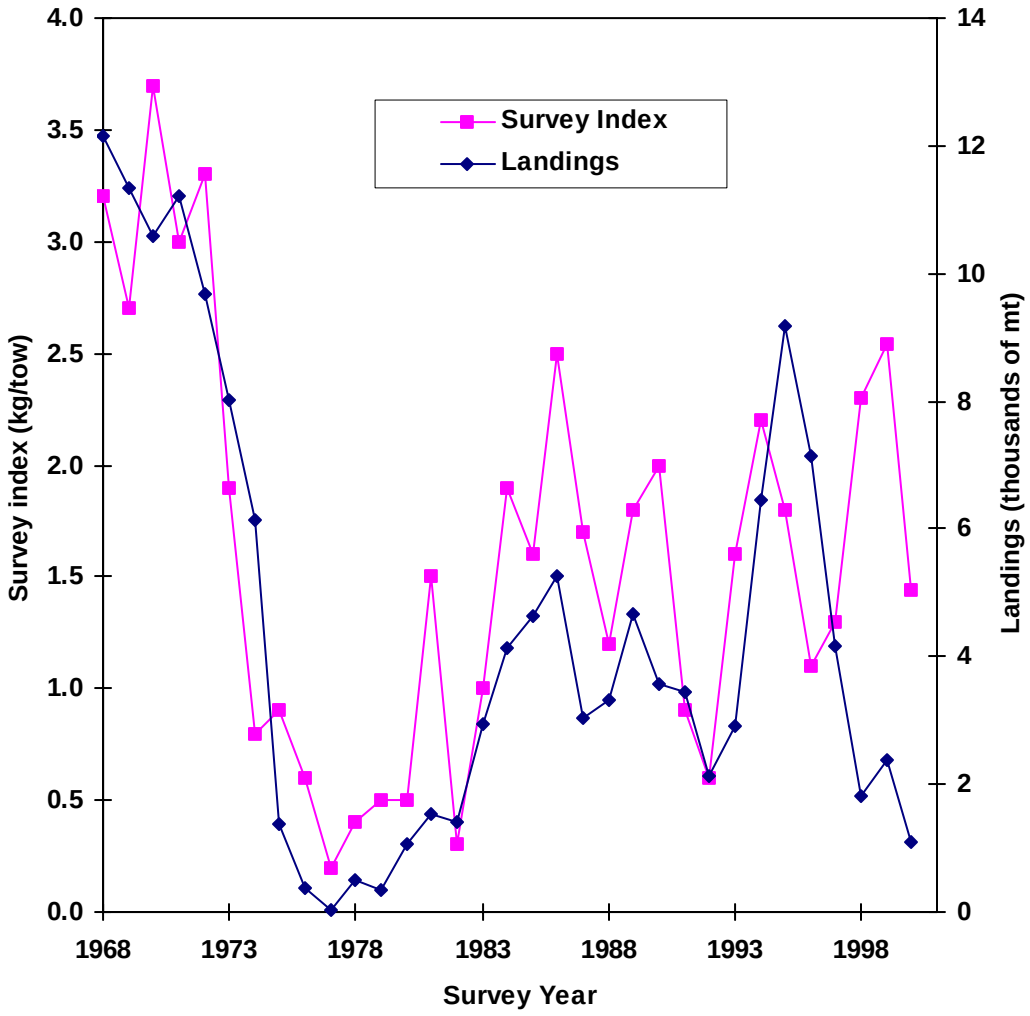

Figure 2. Fall survey index (lagged) and landings of Gulf of Maine northern shrimp.

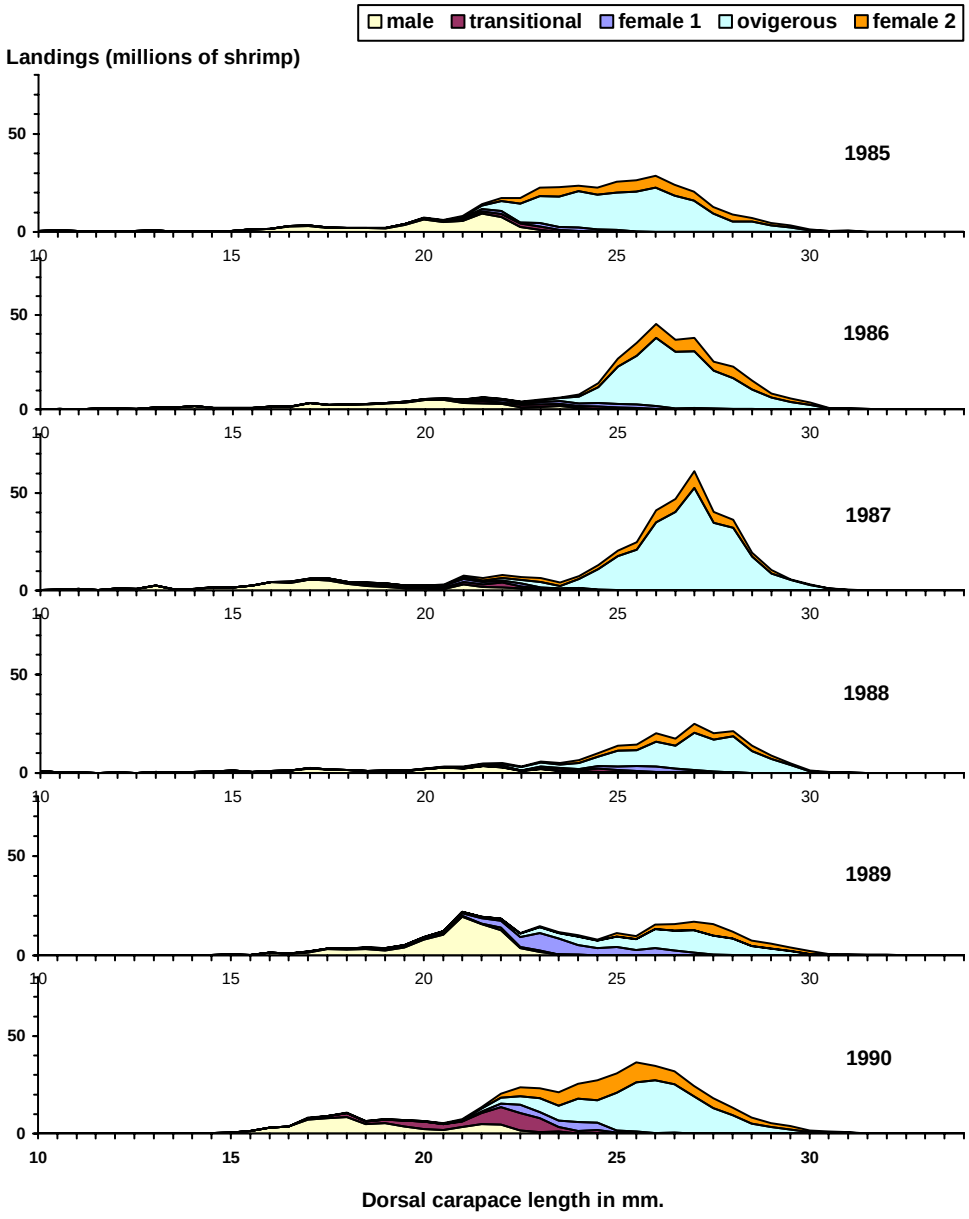

Figure 3. Gulf of Maine northern shrimp summer survey mean catch per tow by length and development stage.

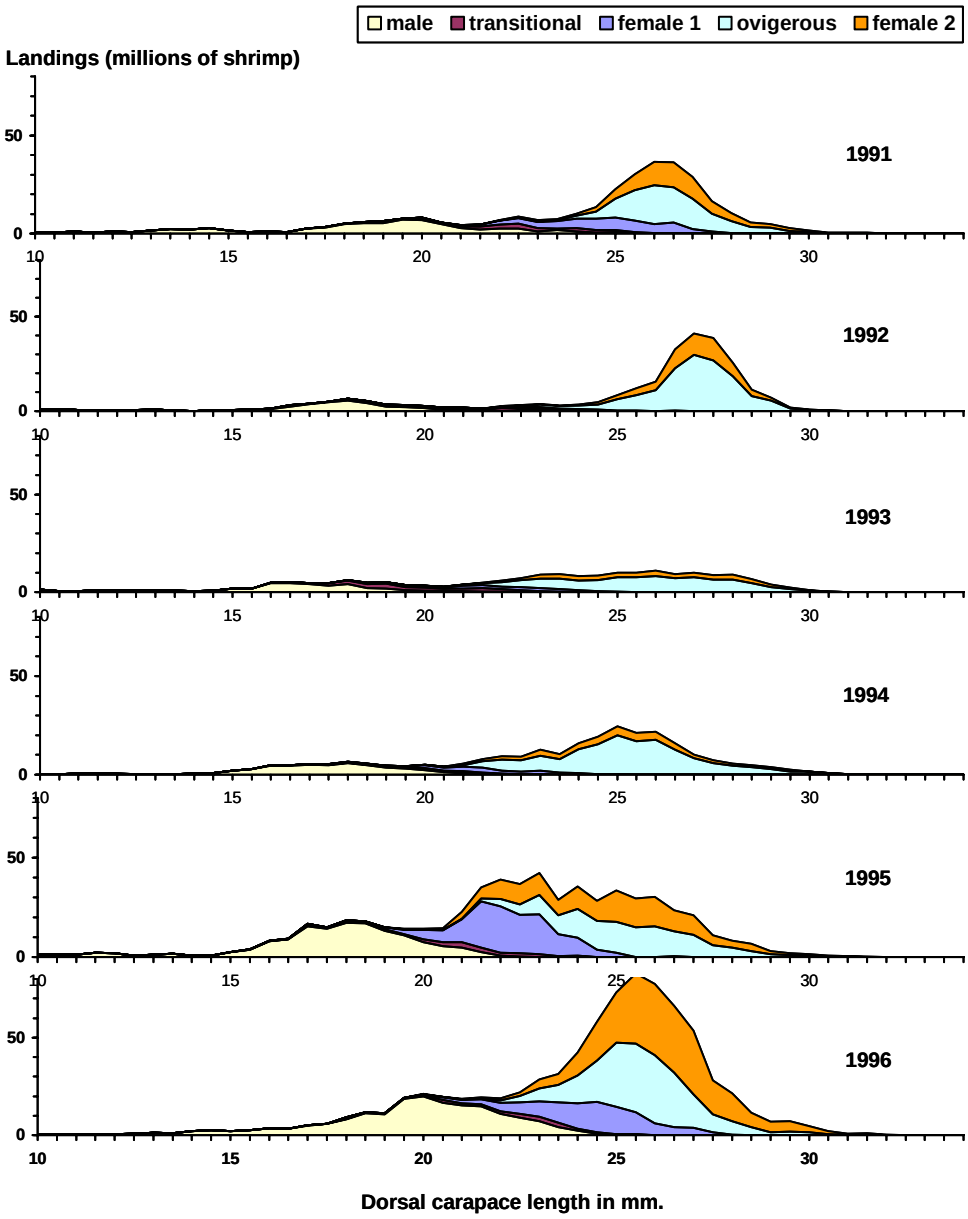

Figure 3 continued

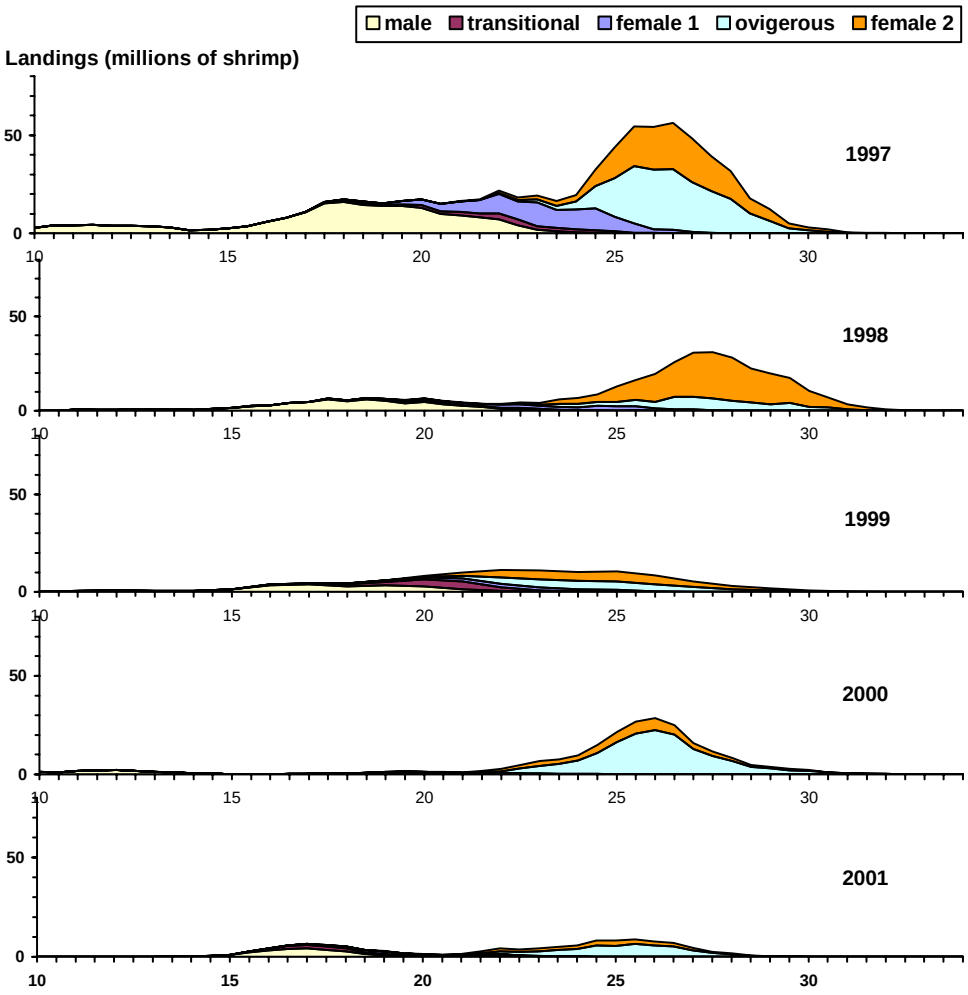

Figure 3 continued

Figure 4: Northern Shrimp Index of Spawning Stock Biomass

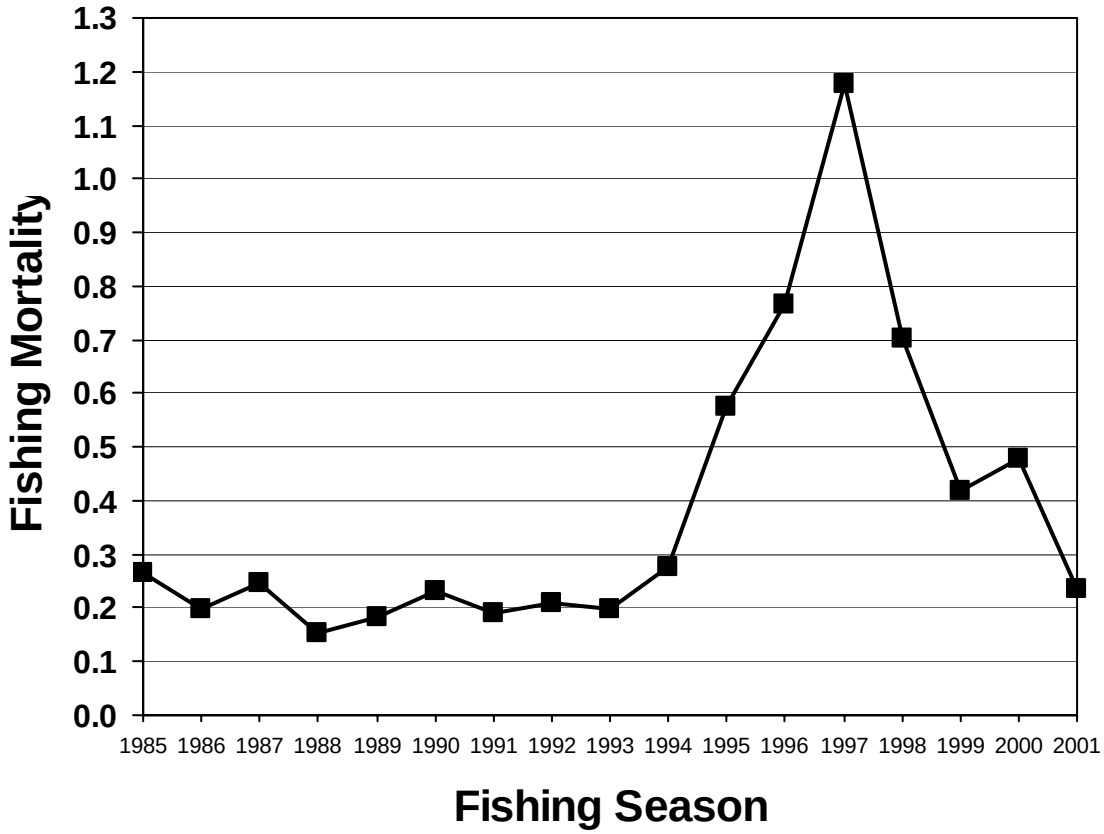

Figure 5: CSA Estimates of Fishing Mortality on Gulf of Maine Northern Shrimp

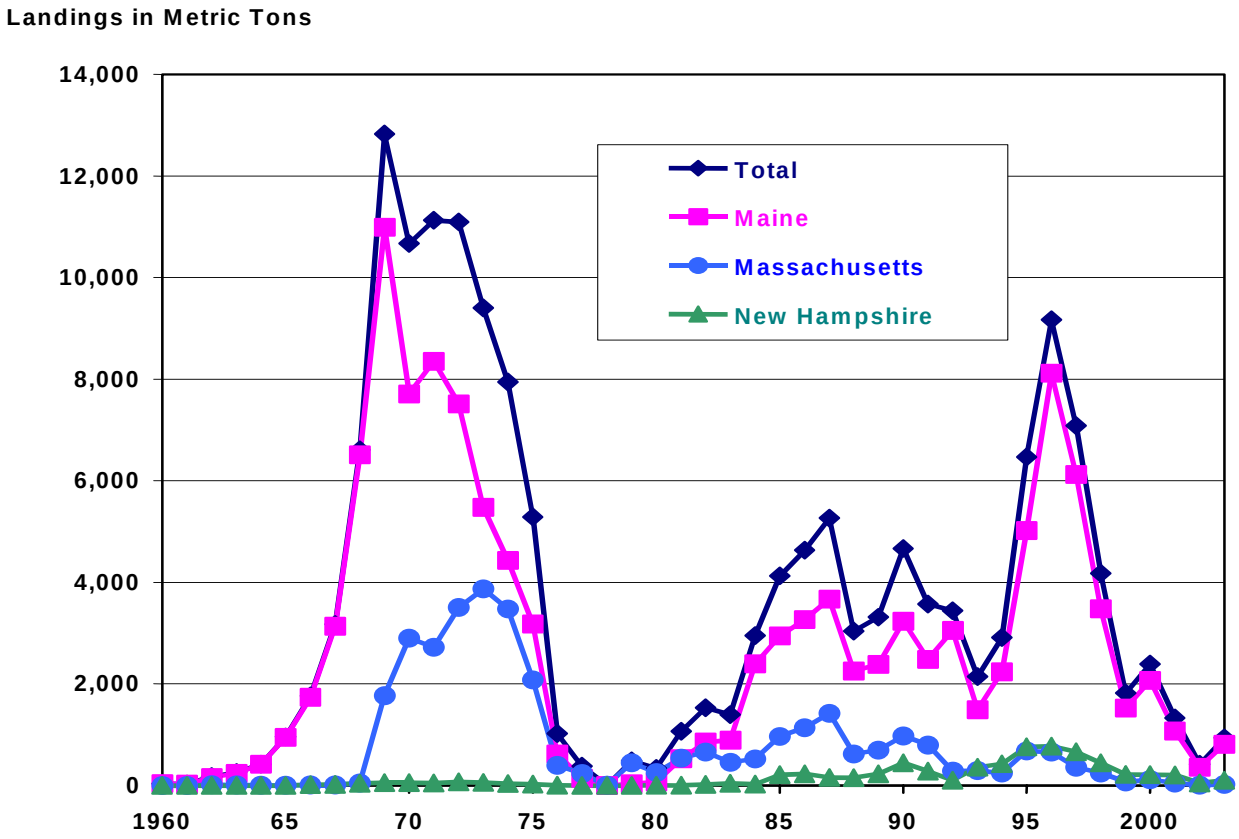

Figure 6. Gulf of Maine northern shrimp landings by fishing season (December to May)

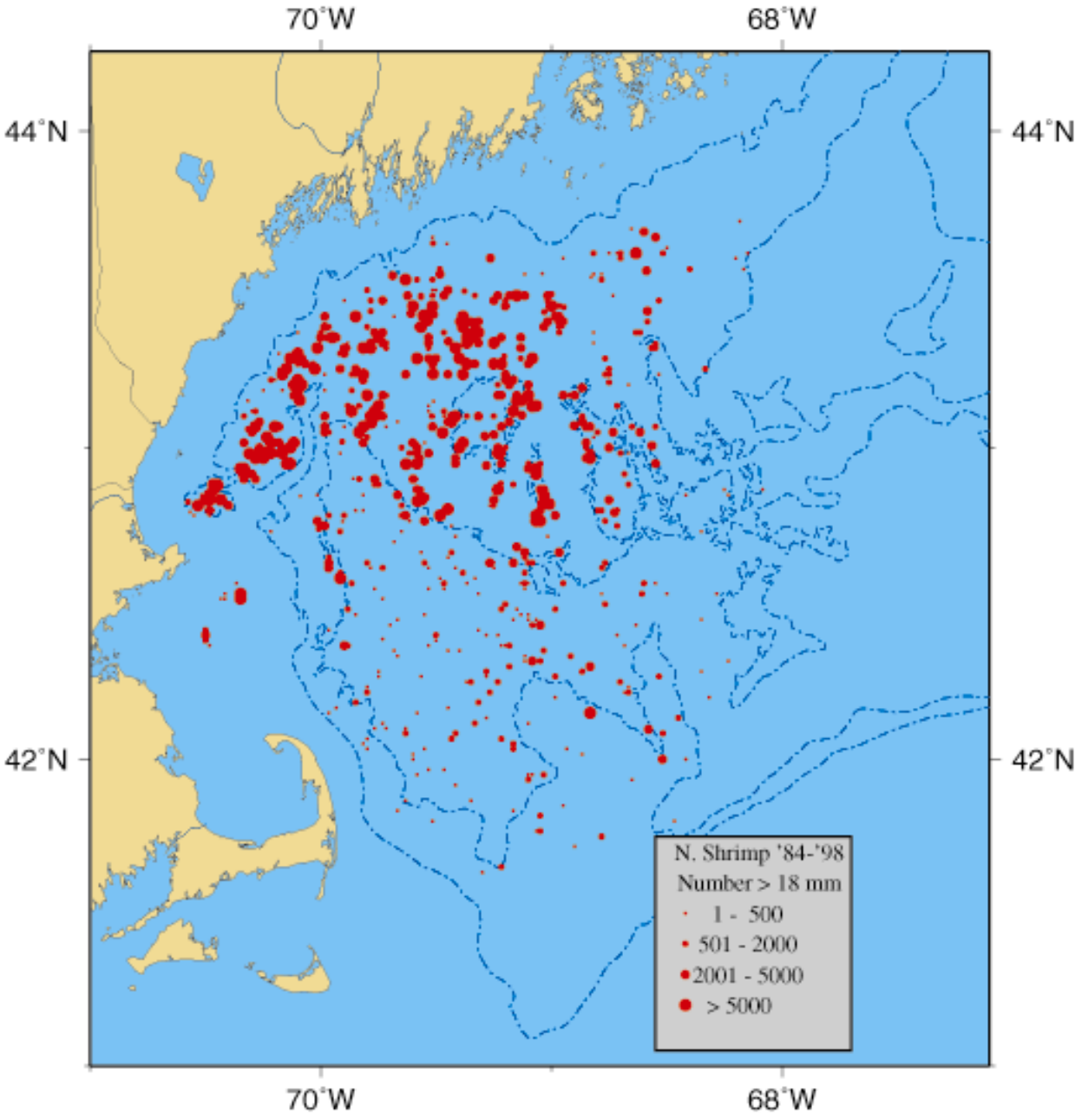

Figure 7. Adult northern shrimp distribution (1984-1998)

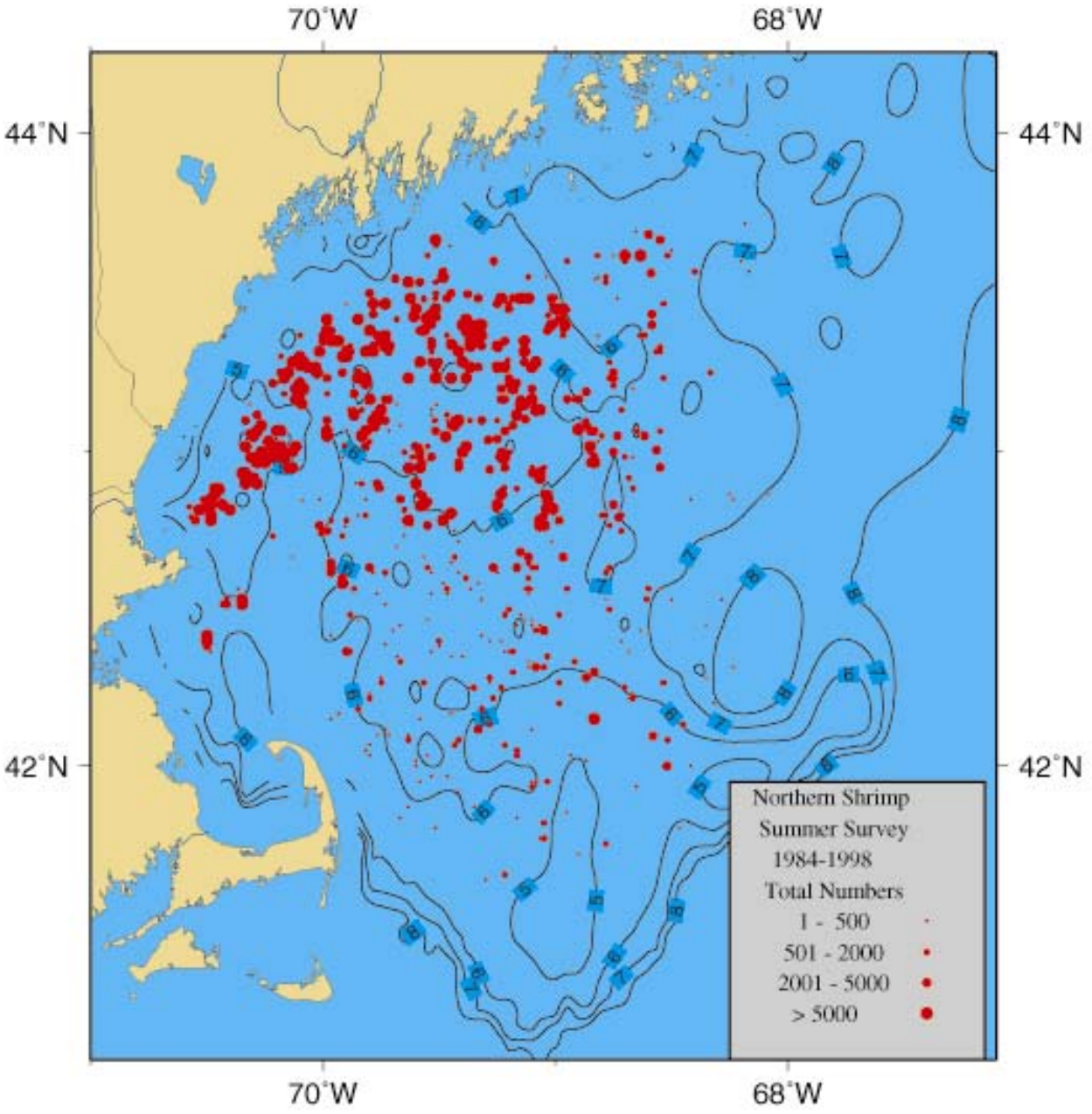

Figure 8. Adult northern shrimp distribution during the summer (1984-1998) in relation to bottom water temperatures

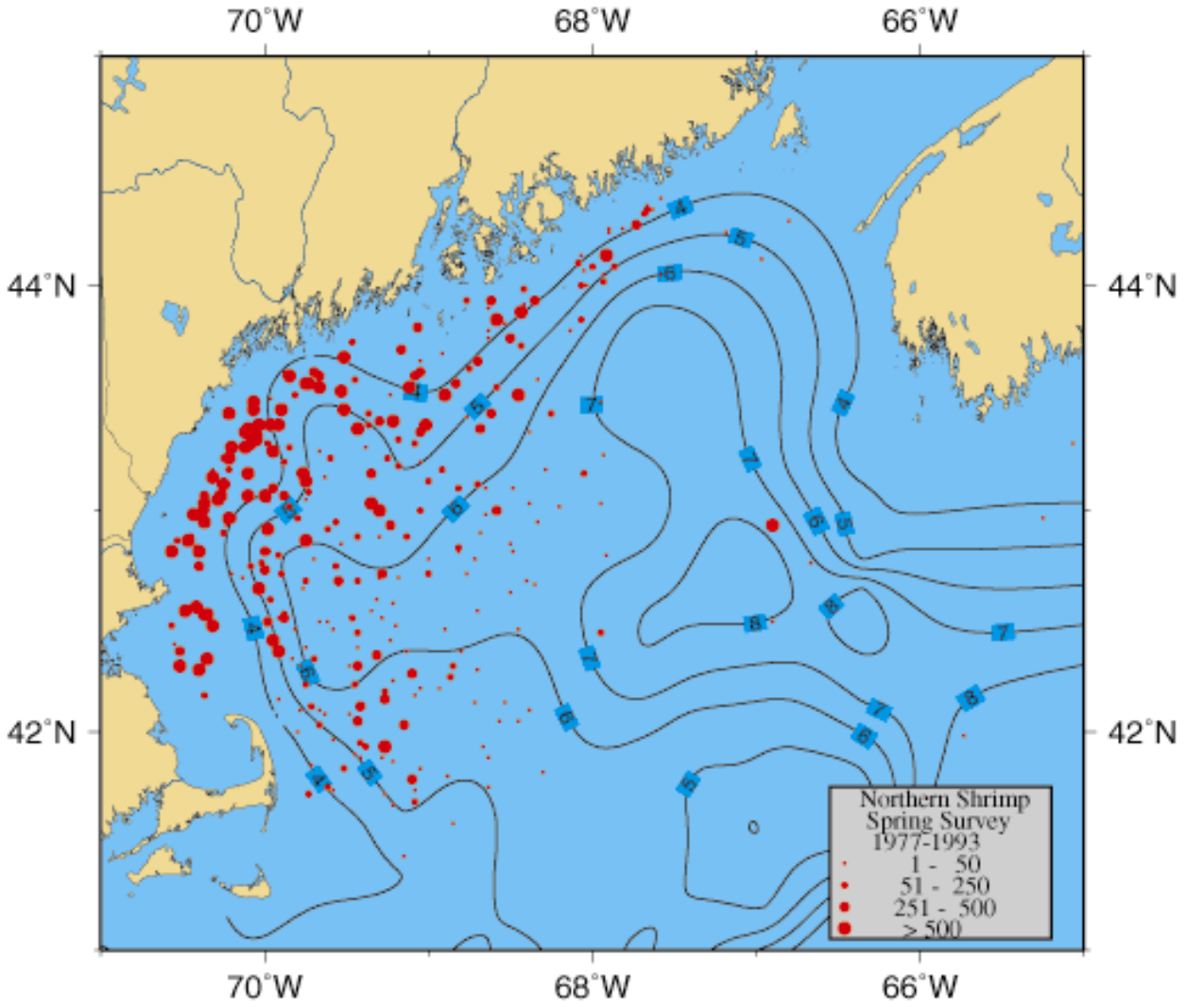

Figure 9. Shrimp distribution during the spring (1977-1993), in relation to water temperature.

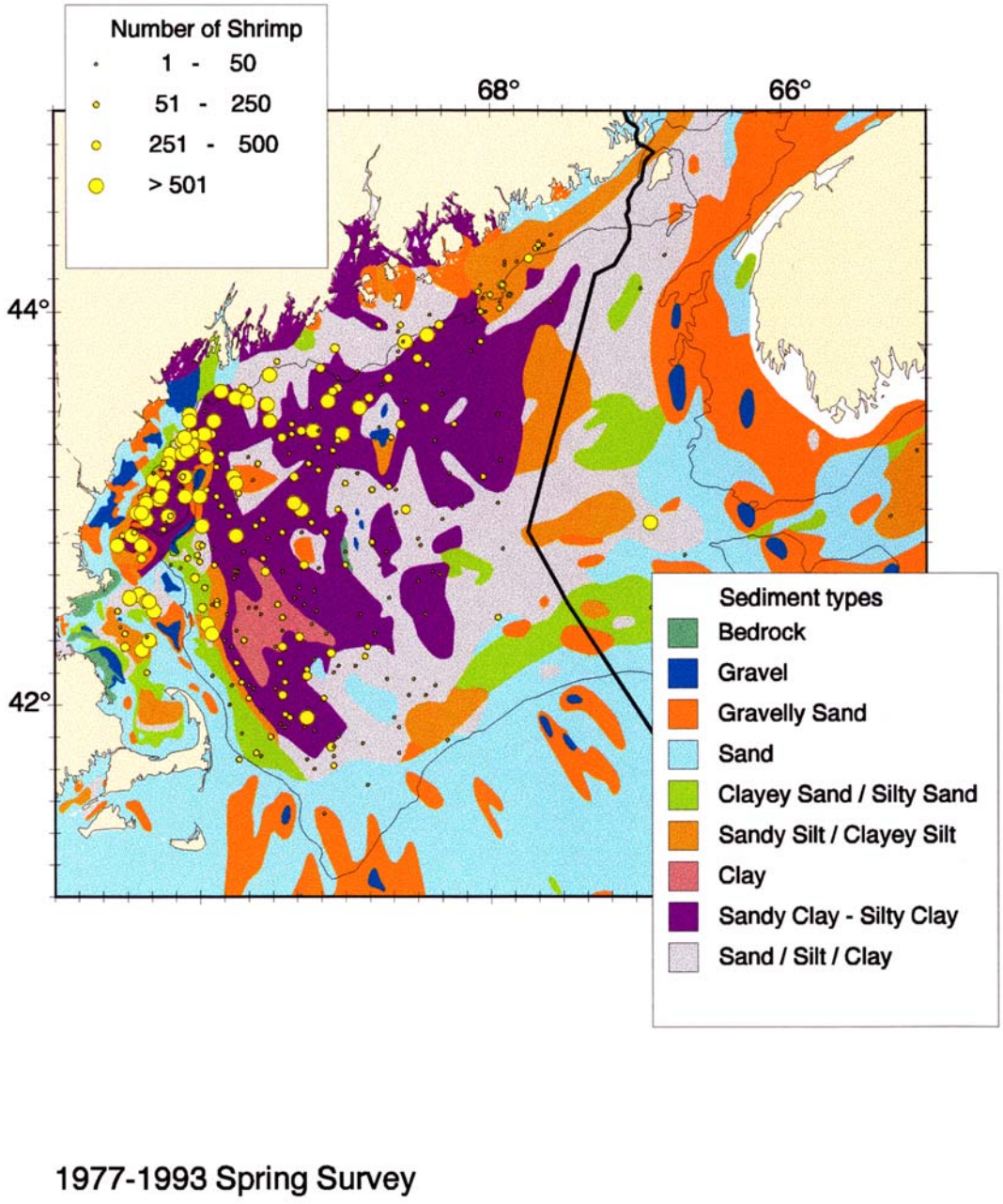

Figure 10. Northern shrimp distribution during the spring (1977-1993) in relation to substrate type (from Clark et al. 1999).

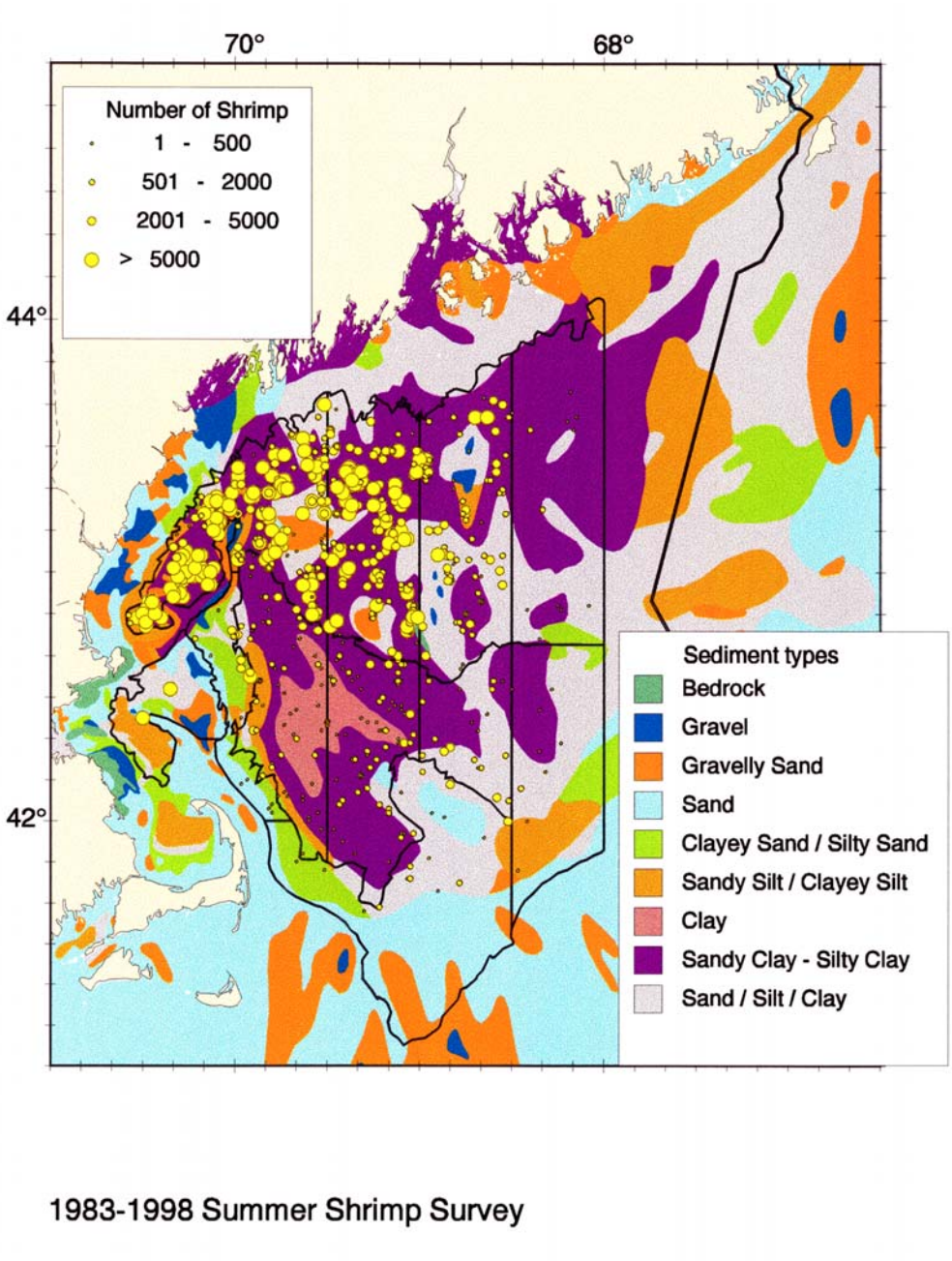

Figure 11. Northern shrimp distribution during the summer (1983-1998) in relation to substrate type (from Clark et al. 1999).

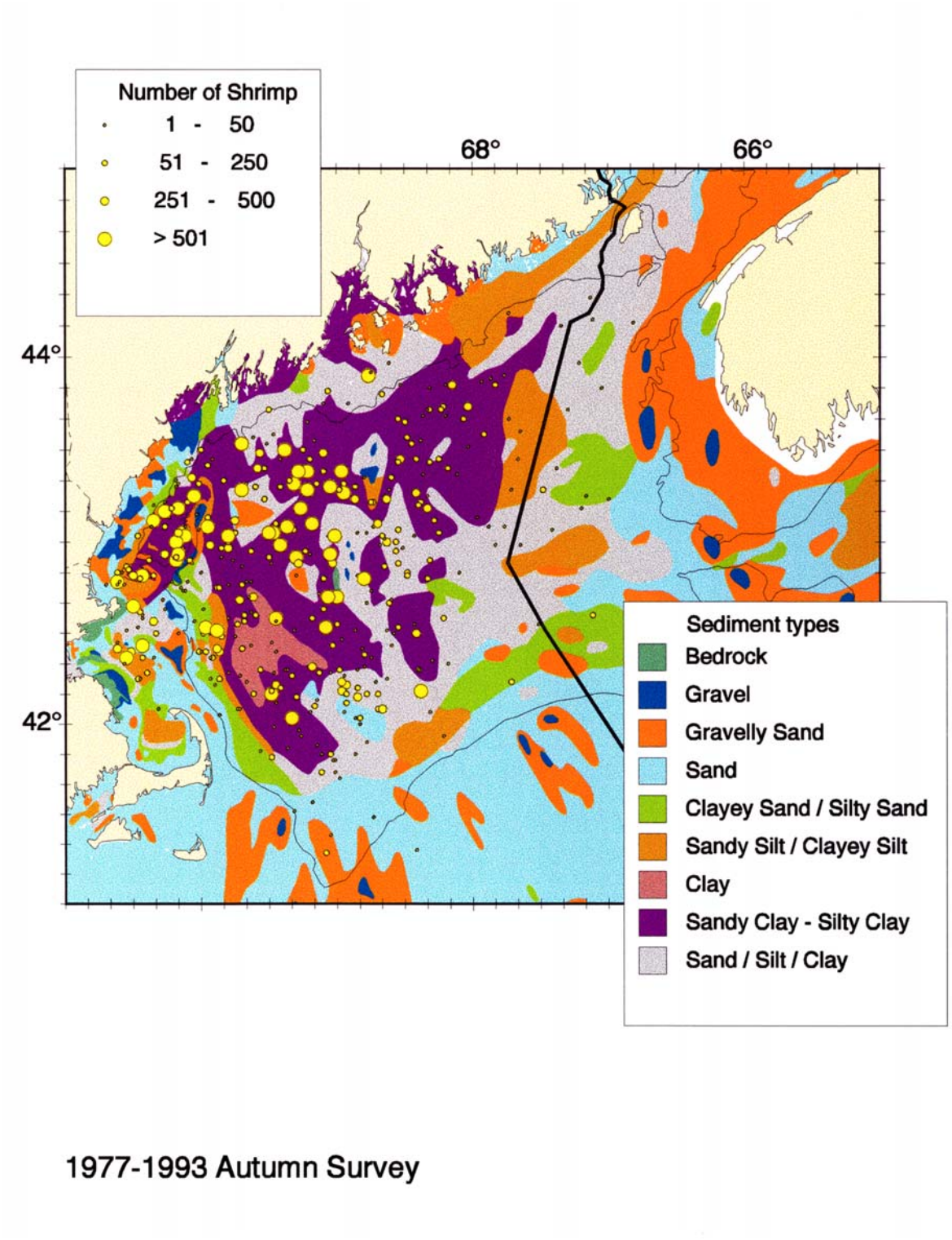

Figure 12. Northern shrimp distribution during the autumn (1977-1993) in relation to substrate type (from Clark et al. 1999).