Fishery Management Report No. 37

of the

Atlantic States Marine Fisheries Commission

Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden

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Prepared by

Atlantic States Marine Fisheries Commission
Atlantic Menhaden Plan Development Team

Plan Development Team Members:

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This Amendment was prepared under the guidance of the Atlantic States Marine Fisheries Commission's Atlantic Menhaden Management Board, Chaired by Mr. William Pruitt of the Virginia Marine Resources Commission. Technical assistance was provided by the Atlantic Menhaden Advisory Committee, the ad hoc Atlantic Menhaden Stock Assessment Committee and the NMFS Population Dynamics Team.

This is a report of the Atlantic States Marine Fisheries Commission pursuant to U.S. Department of Commerce, National Oceanic and Atmospheric Administration Award Nos. NA97FG0034, NA07FG0024 and NA17FG1050.

EXECUTIVE SUMMARY

1. Introduction

Concern over a real and/or perceived decline in the Atlantic menhaden population, plus the ecological importance of menhaden, led the Atlantic Menhaden Management Board to recommend that ASMFC conduct an external peer review of the menhaden stock assessment. The peer review was completed in November 1998 and provided recommendations for improving the assessment and management of menhaden (ASMFC 1999). Upon receiving the report of the Peer Review Panel in January 1999, the Board recommended that a full amendment to the current FMP be developed, and that the recommendations of the Peer Review Panel be addressed through the development of this amendment. Members of the public have also expressed concern over the composition of the Management Board, where only some of the Atlantic coast states were represented while including industry representatives as members. This amendment addresses these issues along with a number of management measures and sets up a process for the future management of Atlantic menhaden pursuant to the requirements of the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA 1993). Amendment 1 also adopts a new overfishing definition by which the Management Board shall measure the status of the resource. In addition, Amendment 1 requires mandatory reporting from all menhaden purse seine fisheries.

2. Goals, Objectives, Management Unit, Overfishing Definition

Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden completely replaces all previous Commission management plans for Atlantic menhaden. The goal of Amendment 1 is:

C To manage the Atlantic menhaden fishery in a manner that is biologically, economically, socially and ecologically sound, while protecting the resource and those who benefit from it.

In support of this goal, the following objectives are recommended for Amendment 1:

<u>Biological Objectives</u>

< Protect and maintain the Atlantic menhaden stock at levels to maintain viable fisheries and the forage base with sufficient spawning stock biomass to prevent stock depletion and guard against recruitment failure.

< Maintain a uniform data collection system for the reduction fishery and develop new protocols for other harvesting sectors, including biological, economic, and sociological data (ACCSP protocols as a minimum; NMFS reduction fishery monitoring system should be continued).

< Evaluate, develop, and improve approaches or methodologies for stock assessment including fishery-independent surveys and variable natural mortality at age or by area.

< Optimize utilization of the resource within the constraints imposed by distribution of the resource, available fishing areas, and harvest capacity.

<u>Social/Economic Objectives</u>

< Maintain existing social and cultural features of the fishery to the extent possible.

< Develop a public information program for Atlantic menhaden, including the fishery, biology, estuarine ecology and role of menhaden in the ecosystem.

<u>Ecological Objectives</u>

< Protect fishery habitats and water quality in the nursery grounds to insure recruitment levels are adequate to support and maintain a healthy menhaden population.

< Improve understanding of menhaden biology, food web ecology and multispecies interactions that may bear upon predator-prey and recruitment dynamics.

< Protect and maintain the important ecological role Atlantic menhaden play along the coast.

<u>Management Objectives</u>

< Insure adequate accessibility to fishing grounds.

< Develop options or programs to control or limit effort, and regulate fishing mortality by time or area.

< Base regulatory measures upon the best available scientific information and coordinate management efforts among the various political entities having jurisdiction over the fisheries.

Management Unit/Area

The management unit for Amendment 1 is defined as the Atlantic menhaden resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundaries of the EEZ. The management area for Amendment 1 shall be the entire coastwide distribution of the resource.

Overfishing Definition

A target and threshold approach will be used to define stock status of Atlantic menhaden incorporating both fishing mortality and spawning stock biomass reference points. The Management Board has adopted F_{max} (F = 1.04) and F_{rep} (F = 1.33) as the fishing mortality target and threshold, respectively, for the Atlantic menhaden overfishing definition. Furthermore, the Board has adopted a spawning stock biomass target of 37,400 mt (as a proxy for B_{MSY}) and a spawning stock biomass of 20,570 mt as the threshold level, or Minimum Spawning Stock Threshold (MSST).

3. Monitoring Program Specifications/Elements

An Atlantic menhaden stock assessment will be performed on an annual basis by the stock assessment subcommittee. The technical committee and advisory panel will meet to review the stock assessment and all other relevant data sources. An annual report will be presented to the Management Board in a timely fashion (usually May or June depending on Commission meeting week scheduling) in order to make annual adjustments to the management program as necessary. In addition to the general content of the report as specified in the outline, the stock assessment report will also contain information on age/size structure, recruitment, spawning stock biomass, fishing mortality rates, catch and landings data and fishery-independent surveys.

4. Management Program Elements/Implementation

Recreational Fishery Management Measures (*4.1*)

No recreational fishery management measures are contained in Amendment 1. Recreational landings of Atlantic menhaden for bait are currently believed to be very small; therefore, regulation of this fishery is unnecessary at this time. Evaluation of the extent of this harvest is needed.

Commercial Fishery Management Measures (*4.2*)

Amendment 1 does not implement specific commercial fishery management measures to control the harvest of menhaden or limit effort in the fisheries at this time. This amendment does set up a process for implementing future management measures through addenda prepared under Adaptive Management (*Section 4.6*). The Management Board will review the status of the resource in relation to the overfishing definition and decide whether additional measures are required to meet the goal and objectives of this plan.

Habitat Measures (*4.4*)

No mandatory measures related to habitat or habitat protection are implemented through this amendment.

De minimis Fishery Guidelines (*4.5.3*)

The ASMFC Interstate Fisheries Management Program Charter defines *de minimis* as “a situation in which, under existing condition of the stock and scope of the fishery, conservation, and enforcement actions taken by an individual state would be expected to contribute insignificantly to a coastwide conservation program required by a Fishery Management Plan or amendment.”

As future management measures are implemented through addenda prepared subsequent to Amendment 1, a state may be granted *de minimis* status if, the Management Board determines that action by the state would contribute insignificantly to the overall management program. States may petition the Atlantic Menhaden Management Board at any time for *de minimis* status. Once *de minimis* status is granted, designated states must submit annual reports to the Management Board justifying the continuance of *de minimis* status. States must include *de minimis* requests as part of their annual compliance reports.

Recommendations to the Secretaries (*4.9*)
The Atlantic States Marine Fisheries Commission believes that the measures contained in Amendment 1 are necessary to prevent the overfishing of the Atlantic menhaden resource. Due to the preponderance of the Atlantic menhaden resource occurring in state waters, the Commission through Amendment 1, recommends to the Secretary of Commerce that no additional management measures be implemented in federal waters at this time. In addition, Amendment 1 calls for the Atlantic Menhaden Management Board to make additional changes via adaptive management, and as such changes are made, the Board may recommend additional measures to the Secretary. The Commission recognizes that such action may be taken under the Atlantic Coastal Fisheries Cooperative Management Act or the Magnuson-Stevens Fishery Conservation and Management Act.

5. Compliance

Mandatory Compliance Elements for States (*5.1*)
A state will be determined to be out of compliance with the provisions of this fishery management plan, according to the terms of Section Seven of the ISFMP Charter if:

- its regulatory and management programs to implement *Section 4* have not been approved by the Atlantic Menhaden Management Board; or
- 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 Atlantic Menhaden Management Board; or
- it makes a change to its regulations required under *Section 4* or any addenda prepared under Adaptive Management (*Section 4.6*), without prior approval of the Atlantic Menhaden Management Board.

Mandatory Elements of State Programs (*5.1.1*)
To be considered in compliance with this fishery management plan, all state programs must include a regime of restrictions on Atlantic menhaden fisheries consistent with the requirements of *Sections 4.1* and *4.2*; except that a state may propose an alternative management program under *Section 4.5*, which, if approved by the Atlantic Menhaden Management Board, may be implemented as an alternative regulatory requirement for compliance.

Regulatory Requirements (*5.1.1.1*)
States may begin to implement Amendment 1 after final approval by the Commission. Each state must submit its required Atlantic menhaden regulatory program to the Commission through the Commission staff for approval by the Atlantic Menhaden Management Board. During the period from submission until the Atlantic Menhaden Management Board makes a decision on a state's program, a state may not adopt a less protective management program than contained in this Amendment or contained in current state law.

1. All states shall implement the reporting requirement contained in *Section 4.2.5.1*, that all menhaden purse seine and bait seine vessels (or snapper rigs) be required to submit the Captain's Daily Fishing Reports (CDFRs). Existing reporting requirements may serve as an alternative to implementing this measure.

Once approved by the Atlantic Menhaden Management Board, states are required to obtain prior approval from the Board of any changes to their management program for which a compliance requirement is in effect. Other measures must be reported to the Board but may be implemented without prior Board approval A state can request permission to implement an alternative to any mandatory compliance measure only if that state can show to the Board's satisfaction that its alternative proposal will have the same conservation value as the measure contained in this amendment or any addenda prepared under Adaptive Management (*Section 4.6*). States submitting alternative proposals must demonstrate that the proposed action will not contribute to overfishing of the resource. All changes in state plans must be submitted in writing to the Board and to the Commission either as part of the annual FMP Review process or the Annual Compliance Reports.

Compliance Schedule (*5.1.2*)
States must implement this Amendment according to the following schedule:

August 1st, 2001:	States must submit state programs to implement Amendment 1 for approval by the Atlantic Menhaden Management Board. Programs must be implemented upon approval by the Atlantic Menhaden Management Board.
January 1st, 2002:	States with approved management programs must implement Amendment 1. States may begin implementing management programs prior to this deadline if approved by the Management Board.

Compliance reports should be submitted to the Commission by each jurisdiction annually, no later than April 1st of each year, beginning in 2002.

Compliance Report Content (*5.1.3*)
Each state must submit an annual report concerning its Atlantic menhaden fisheries and management program for the previous year. Reports should follow the standard format for compliance reports. 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;
- 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;

6. Management and Research Needs

Amendment 1 contains a list of management and research needs that should be addressed in the future in order to improve the current state of knowledge of Atlantic menhaden biology, stock assessment, population dynamics, habitat issues, and social and economic issues. By no means are these lists of research needs all-inclusive, and they will be reviewed and updated annually through the Commission's FMP Review process.

7. Protected Species

Amendment 1 provides an overview of protected species known to occur throughout the range of Atlantic menhaden. Currently, no significant interactions between Atlantic menhaden purse seine fisheries and protected species have been documented. The NMFS has published the Proposed List of Fisheries for 2001 and this fishery is designated as a Category III fishery in regards to the Western North Atlantic stock of bottlenose dolphin. A Category III listing assumes that annual mortality and serious injury of a protected species stock in a given fishery is less than or equal to one percent of the Potential Biological Removal (PBR) level.

ACKNOWLEDGMENTS

Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden was developed under the supervision of the Atlantic States Marine Fisheries Commission's Atlantic Menhaden Management Board, chaired by Mr. William Pruitt of Virginia. Members of the Plan Development Team (PDT) included: Dr. Joseph C. Desfosse (ASMFC, Chair), Dr. Michael Armstrong (Massachusetts Division of Marine Fisheries), Ellen Cosby (Virginia Marine Resources Commission), Peter Himchak (New Jersey Division of Fish & Wildlife), Dr. John Merriner (National Marine Fisheries Service), Dr. Alexei Sharov (Maryland Department of Natural Resources), and Michael Street (North Carolina Division of Marine Fisheries).

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1. INTRODUCTION

1.1 BACKGROUND INFORMATION

1.1.1 Statement of the Problem

Atlantic menhaden are currently managed through the Commission's 1992 Atlantic Menhaden Fishery Management Plan (FMP) (ASMFC 1992). The menhaden program functions under the Commission's Interstate Fisheries Management Program (ISFMP), with immediate oversight provided by the Atlantic Menhaden Management Board. The Board is composed of up to five state directors, five industry representatives, and one representative from the National Marine Fisheries Service and one from the National Fish Meal and Oil Association (the industry trade association). In 1997, the ISFMP Policy Board approved the addition of one Legislator, one Governor's Appointee and two public representatives to the Menhaden Board. The Board in turn, appoints members to the Atlantic Menhaden Advisory Committee (AMAC), which serves as both the technical and advisory body for the Board. One of the reasons the Commission is initiating the amendment process is to examine the current structure of the menhaden management process. Concerns have been raised recently over the mixed composition of both the management board and the technical/advisory committee because they differ from the traditional board/technical committee structure followed in all other Commission fishery management programs.

Recent concern over declines in the Atlantic menhaden population led the Menhaden Board to recommend that the Commission conduct an external peer review of the menhaden stock assessment which is conducted annually through AMAC (ASMFC 1999a). This peer review was completed in November 1998 and provided some major recommendations for improving the assessment and management of menhaden (ASMFC 1999b). Upon receiving the report of the Peer Review Panel in January 1999, the Board recommended that a full amendment to the current FMP be developed and that the recommendations of the Peer Review Panel be addressed through the development of this amendment. Concerns over apparent reductions in the forage fish base in Chesapeake Bay and northeastern Florida have also been expressed by members of the public and state fisheries personnel.

In 1998, AMAC also suggested that changes to the menhaden management process be addressed through an addendum to the current FMP (AMAC 1998). The addendum would address: 1) updating the FMP in accordance with changes to the Commission's ISFMP FMP outline; 2) updating the data with particular attention to the 1998 reduction of the Virginia fleet; 3) strengthening the Habitat section of the FMP; and 4) examining the trigger levels based on recent data and analysis.

The Atlantic menhaden spawning stock is currently considered to be healthy, although there has been a decline in recruitment over the last ten years (Fig. 1) (AMAC 2000). The overall spawning stock biomass is currently high, but is expected to decline over the next few years unless the trend in recruitment is reversed. There has also been a general decline in the stock size (numbers and biomass), concurrent with the decline in recruitment. The most recent estimates of maximum sustainable yield (MSY) for Atlantic menhaden is 350,000-450,000 metric tons (mt) (Vaughan et al. in press). Natural environmental conditions, as well as overall stock status, may influence the geographic distribution of the menhaden population. Recent poor recruitment of menhaden is dependent on natural environmental conditions and appears to be unrelated to fishing effort (AMAC 2000).

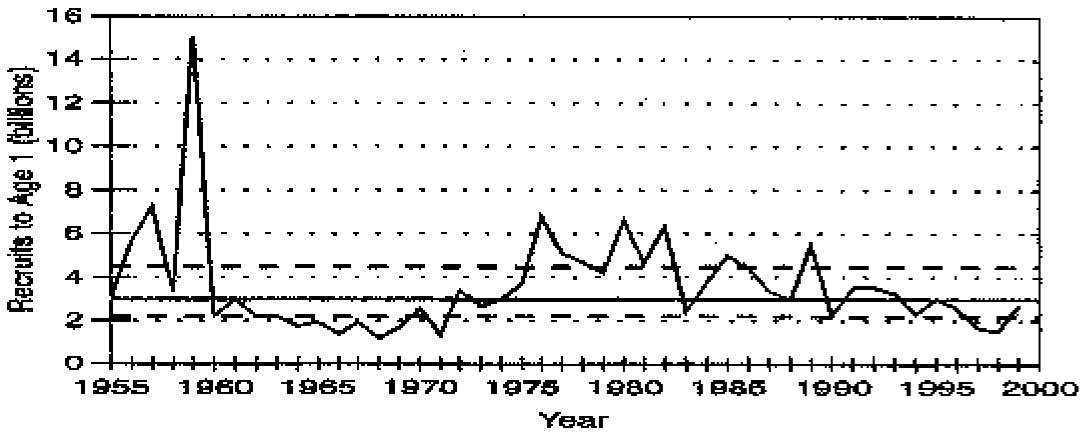

Figure 1. Atlantic menhaden recruits to age-1 with median and interquartile range.

The main source of stock assessment data is the reduction fishery. A coastwide sampling program for the reduction fishery conducted by NMFS has been in effect since 1955. A limited bait fishery sampling program has been in effect since 1994. There is no sport fishery to sample. Other potential sources of information regarding menhaden stock status include fishery-independent surveys such as the Virginia and Maryland juvenile seine surveys and juvenile surveys conducted by the states of Rhode Island, Connecticut and North Carolina. The Menhaden Peer Review Panel agreed that the current reduction fishery sampling program was adequate both spatially and temporally and that the stock assessment methodology and analysis were reasonable given the available data (ASMFC 1999b).

The primary concern over management of the stock appears to be the allocation of fish between fisheries and ecological functions. Fishermen and environmental groups have emphasized the forage role of menhaden for piscivorous fishes and its ecological role in filtering phytoplankton. Commercial fisheries interests advocate maintenance of the traditional reduction and bait fisheries. In recent years there have been allegations that sport fishing may be negatively affected by menhaden purse seine fishing activities in the same general areas; data are not presently available to evaluate this issue.

1.1.2 Benefits of Implementation

Amendment 1 when fully implemented, is designed to minimize the chance of a population collapse due to overfishing, reduce the risk of recruitment failure, reduce impacts to species which are ecologically dependent on Atlantic menhaden, promote improved water quality through the maintenance of a healthy menhaden population, and minimize adverse effects on participants in the fishery. This amendment also provides a mechanism for monitoring the health of the menhaden population and a management regime and structure that is both flexible and broad based.

1.2 DESCRIPTION OF THE RESOURCE

1.2.1 Species Life History

1.2.1.1 General Information

Atlantic menhaden are members of the worldwide family Clupeidae, one of the most important families of fishes both economically and ecologically (Ahrenholz 1991). Clupeids are characteristically very numerous and form large, dense schools. Many of the species are filter feeders, being either primary consumers, feeding on phytoplankton, or secondary consumers, feeding on zooplankton, or both. Many clupeids are in turn, prey for various piscivorous predators through virtually their entire life.

Atlantic menhaden are euryhaline species that inhabit nearshore and inland tidal waters from Florida to Nova Scotia, Canada (Ahrenholz 1991). Spawning occurs principally at sea with some activity in bays and sounds in the northern portion of its range. Eggs hatch at sea and the larvae are transported to estuaries by ocean currents where they metamorphose and develop as juveniles. Adults stratify by size during the summer, with older, larger individuals found farther north. During the fall, Atlantic menhaden migrate south and disperse from nearshore surface waters off North Carolina by late January or early February. Schools of adult menhaden reassemble in late March or early April and migrate northward. By June the population is redistributed from Florida to Maine (Ahrenholz 1991).

1.2.1.2 Age and Growth

Some Atlantic menhaden become sexually mature during their second year (late age-1), but most do not mature until their third year (late age-2) (Higham and Nicholson 1964; Lewis et al. 1987). Spawning occurs primarily in late fall and winter (see *Section 1.2.1.3*). Thus, most Atlantic menhaden spawn for the first time at age-2 or 3, i.e., just before or after their third birthday (by convention, on March 1), and continue spawning every year until death. First-spawning age-3 fish have accounted for most of the stock's egg production since 1965 (Vaughan and Smith 1988). Atlantic menhaden mature at smaller sizes at the southern end of their range, 180 mm FL in the south Atlantic region versus 210 mm FL in the Chesapeake Bay area and 230 mm in the north and middle Atlantic regions, because of latitudinal differences in size-at-age and the fact that larger fish of a given age are distributed farther north than smaller fish of the same cohort (Lewis et al. 1987).

The growing season begins in the spring and ends in the fall as water temperatures rise above and fall below 15°C (Kroger et al. 1974). Atlantic menhaden reach lengths of about 500 mm TL and weights of over 1.5 kg (Cooper 1965). Fish as old as age-8 were fairly common in the spawning population during the 1950s and early 1960s, but fish older than age-6 have been rare in recent years (Vaughan and Smith 1988). Smith and O'Bier (1996) recently described an exceptionally large (433 mm FL; 1,551 g) Atlantic menhaden from Chesapeake Bay taken in August 1996.

Due to their greater migratory range (see *Section 1.2.1.7*), larger fish of a given age are captured farther north than smaller fish of the same age (Nicholson 1978; Reish et al. 1985). This fact complicates any attempt to estimate overall growth for the entire stock from size-at-age data compiled from any individual area along the coast. To solve this problem, Vaughan and Smith (1988) generated weighted averages of mean lengths at age for five fishing areas along the coast and used these averages to estimate growth parameters for the 1955-1981 year classes.

Average estimates of the three parameters required by the von Bertalanffy growth equation were derived for 23 year classes during 1955-1981 and used to determine lengths at age for age 1-6 fish[1]. These estimated lengths generally describe the expected sizes for an average year class over the entire coast, ignoring variations in growth that occur over time (Table 1). These length estimates were then used to estimate the corresponding weights at age using the weight-length regression equation and parameter values given in Vaughan and Smith (1988).

Table 1. Estimated fork lengths and weights for Atlantic menhaden ages 1-6.

Age	Fork length (mm)	Weight (g)
1	141.6	42.5
2	214.9	161.5
3	262.9	307.9
4	294.3	441.7
5	314.8	547.9
6	328.3	626.8

These estimated sizes at age are very similar to those estimated by C.E. Richards (VIMS, pers. comm.; as reported in Reintjes 1969) for fish collected from the North Carolina fall fishery. They do not differentiate between male and female fish. As the fish mature, females can be expected to attain weights about 50 g heavier, on average, than males of the same age (Reintjes 1969).

There is evidence for density-dependent growth in Atlantic menhaden, at least in young fish. Comparison of annual weights at age for age-1, -2, and -3 fish and age-1+ population size estimates for the 1955-84 period (Vaughan and Smith 1988) indicated an inverse relationship between the two parameters, suggesting that growth was accelerated during the late 1960s in response to low population size and reduced during the mid-1970s and early 1980s when population size was high. The reduction in mean weight at age 3 was particularly dramatic, declining 60% between 1976 and 1978 and remaining low through 1984. However, Reish at al. (1985) demonstrated that the growth rates of fish after recruitment in their first year of life was not correlated with abundance, but did depend on size at recruitment, indicating that fish probably recruited at smaller sizes in years of high juvenile population size and vice-versa. Thus, density-dependent effects probably occur during the estuarine nursery period. Negative correlations between the mean lengths of age 0.5 and 0.75 fish and the number of recruits at age 0.5 (Vaughan and Smith 1988) support this hypothesis. The observed decline in sizes at age in the fishery is also due in part to a shift in fishing to the south where smaller fish at a given age are found (Vaughan and

[1]Growth parameters estimated by Vaughan and Smith (1988) for the 1965 and 1979-1981 year classes were biologically unrealistic and were therefore omitted when averaging values over the entire time period. Parameter estimates used to calculate lengths at ages 1-6 were: L_{inf} = 353.7 mm FL, K = 0.424, and t_o = -0.2056 years.

Smith 1988).

1.2.1.3 Spawning and Reproduction

Most Atlantic menhaden reach sexual maturity during their third year of life (late age 2) at lengths of 180 - 230 mm fork length (FL). Spawning occurs year-round throughout much of the species' range, with maximum spawning off the North Carolina coast during late fall and winter. Adults then move inshore and northward in spring and stratify by age and size along the Atlantic coast (Rogers and Van Den Avyle 1989). During this northern migration, spawning occurs progressively closer inshore and by late spring, some spawning occurs within coastal embayments. There are definite spring and fall spawning peaks in the Middle and North Atlantic Regions, with some spawning occurring during the winter in the shelf waters of the Mid-Atlantic Region.

Atlantic menhaden are relatively prolific spawners. Predicted fecundities range from 38,000 eggs for a small female (180 mm FL) to 362,000 for a large female (330 mm FL) according to an equation derived by Lewis et al. (1987):

$$\text{number of eggs} = 2563 * e^{0.015*FL}.$$

This equation was derived by fitting an exponential model to length-specific fecundity data for fish collected in 1978, 1979 and 1981, as well as data reported in two earlier studies (Higham and Nicholson 1964; Dietrich 1979) for fish collected during 1956-1959 and in 1970. Fish in all three studies were collected from the North Carolina fall fishery, which harvests fish of all ages.

Analysis of eggs and larvae collected at various locations along the Atlantic coast during 1953-75 (e.g., Judy and Lewis 1983) generally confirmed earlier knowledge of spawning times and locations based on observations of adults with maturing or spent ovaries (e.g., Reintjes and Pacheco 1966). During December-March, most spawning-age fish congregate in offshore waters south of Cape Hatteras. Maximum spawning probably occurs at this time. Checkley et al. (1988) reported maximum spawning off North Carolina in January 1986 during periods of strong northeast winds in up-welled water near the western edge of the Gulf Stream. Spawning continues at a decreasing rate closer inshore as fish migrate north in late March. By May, most spawning is restricted to coastal waters north of Cape Hatteras. Spawning reaches a minimum in June, but continues at a low level until September north of Long Island. As mature fish migrate south in October, spawning increases from Long Island to Virginia.

The capture of a 138 mm juvenile Atlantic menhaden in an estuary on the Maine coast in October 1990 (T. Creaser, Maine DMR, pers. comm.; as cited in ASMFC 1992) suggests that a limited amount of spawning may occur as far north as the Gulf of Maine. Some ripening female menhaden were offloaded on to the Soviet processing ship near Portland, Maine in August and September 1991 (S. Young, Maine DMR observer on the M/V RIGA, pers. comm.; as cited in ASMFC 1992). Egg and larval surveys have been restricted to waters south of Cape Cod (Judy and Lewis 1983) and, thus, would not have produced any evidence for spawning in the Gulf of Maine.

1.2.1.4 Early Life History

Atlantic menhaden produce pelagic eggs about 1.5 mm in diameter which hatch within 2.5-2.9 days at an average temperature of 15.5°C (Hettler 1981). Embryonic development is completed in <36 hr at 20-

25°C, but takes about 200 hr at 10°C (Ferraro 1980). Egg mortalities observed in the laboratory were >90% at 10°C, and 48-92% at 15, 20 and 25°C (Ferraro 1980).

A full morphological description of Atlantic menhaden eggs and larvae was provided by Jones et al. (1978). Hettler (1984) compared Atlantic menhaden (*Brevoortia tyrannus*) larvae with gulf and yellowfin menhaden (*B. patronus* and *B. smithi*) larvae. Atlantic menhaden larvae co-occur with yellowfin menhaden larvae along the east coast of Florida to North Carolina, but not with gulf menhaden. A fourth species (*B. gunteri*) occurs exclusively in the Gulf of Mexico. Powell and Phonlor (1986) also compared early life history characteristics of Atlantic and gulf menhaden.

Yolk-sac larvae hatched at 3-4 mm standard length (SL) and maintained at 16° and 24°C began to feed at 4.5-5 mm SL (Powell and Phonlor 1986). First feeding was a function of size, not age. Larvae raised at 16°C began feeding after 5 days, while larvae raised at 24°C began feeding after only 2 days. Larvae reached 10.7 mm SL after 21 days at 20°C. Caudal and dorsal fins developed at 9 mm, and all fin rays were developed by 23 mm (Reintjes 1969). The swimbladder and acoustico-lateralis system become functional in larvae measuring approximately 20 mm (Hoss and Blaxter 1982).

Low temperatures (<3°C for >2 days) killed most larvae held in laboratory experiments (Lewis 1965, 1966), although mortality depended on acclimation temperature and the rate of thermal change. Best survival occurred at temperatures >4°C and salinities of 10-20‰.

Larvae which hatch offshore are transported shoreward and enter estuaries in the south Atlantic region after 1-3 months at sea (Reintjes 1961) at a size of 14-34 mm FL (Reintjes and Pacheco 1966). Larval migration into estuaries occurs during May-October in the north Atlantic region, October-June in the mid-Atlantic, and December-May in the south Atlantic (Reintjes and Pacheco 1966). Larval condition improved rapidly after fish entered two North Carolina inlets (Lewis and Mann 1971).

Metamorphosis to the juvenile stage occurs at about 38 mm total length (TL) during late April-May in North Carolina estuaries and later in the year farther north. Most larvae entered the White Oak estuary (North Carolina) in March and moved upstream to a fresh water-low salinity zone where they transformed into "pre-juveniles" in late March-April and then into juveniles in late April-May (Wilkens and Lewis 1971). Other studies (Weinstein 1979; Weinstein et al. 1980; Rogers et al. 1984) also show young menhaden are more abundant in shallow, low salinity (< 5‰) estuarine zones. Metamorphosis to the "pre-juvenile" stage occurs at lengths >30 mm TL and to the juvenile stage beyond 38 mm TL (Lewis et al. 1972). Metamorphosis is rarely successful outside of the low-salinity estuarine zone (Kroger et al. 1974), although Atlantic menhaden have been successfully reared from eggs to juveniles in high salinity water (Hettler 1981).

The morphological changes that occur at metamorphosis are associated with a change in feeding behavior. Larvae feed on individual zooplankters, whereas juveniles rely more heavily on filter feeding (June and Carlson 1971; Durbin and Durbin 1975). This shift in feeding behavior is associated with a loss of teeth and an increase in the number and complexity of the gill rakers through which sea water is filtered as it passes through the gills. Older larvae (25-32 mm) feed on large copepods, but only rarely on small zooplanktonic organisms (Kjelson et al. 1975). Fish larger than 40 mm FL feed primarily on phytoplankton (June and Carlson 1971), but zooplankton has also been reported as an equally important food source in juvenile Atlantic menhaden (Richards 1963; Jeffries 1975). Juveniles are capable of filtering particles as small as 7-9 microns (Friedland et al. 1984) and, thus, directly utilize the abundant small photosynthetic organisms that are not consumed by most other species of fish. Detritus derived from saltmarsh cordgrass (*Spartina alterniflora*) has also been reported as a primary food source for juveniles in North Carolina saltmarshes (Lewis and Peters 1984). Based on calculations incorporating feeding rates and population estimates from eight east coast estuaries, Peters and Schaaf (1981) concluded that juveniles must consume more food during estuarine residency than is available from a strictly phytoplankton-based food chain.

Young-of-the-year menhaden congregate in dense schools as they leave shallow, estuarine waters for the ocean, principally during August to November (earliest in the north Atlantic region) at lengths of 75-110 mm TL (Nicholson 1978). Many of these juveniles migrate south along the North Carolina coast as far as Florida in late fall and early winter and then redistribute northward by size as age-1 fish during the following spring and summer (Kroger and Guthrie 1973; Nicholson 1978). Larvae which enter the estuaries late in the season may remain there for an additional year and emigrate to the ocean at age 1. Age-1 menhaden migrate north and south along the coast over a greater distance than young-of-the-year juveniles (Nicholson 1978). Abundance and distribution of juvenile Atlantic menhaden is monitored by the marine resource agencies of most Atlantic coast states under a variety of estuarine surveys using trawls and seines. According to a survey conducted by AMAC in February 1990, juvenile menhaden have been taken from Massachusetts to Georgia (there is no survey on the Atlantic coast of Florida.). Juvenile menhaden were observed in Gulf of Maine estuaries during 1998 and 1999.

Juveniles collected at 2-3 day intervals have shown growth rates of nearly 1 mm/day (Reintjes 1969). Water temperatures >33°C caused death in young-of-the-year and age-1 Atlantic menhaden (Lewis and Hettler 1968), although the time until death depended, in part, on acclimation factors. Sudden exposure to lethal temperatures, for example, caused greater mortality. Juvenile Atlantic menhaden can adjust rapidly to abrupt changes (increase or decrease) in salinity from 3.5 to 35‰ and vice-versa (Engel et al. 1987). Juveniles raised in low salinity water (5-10‰) were more active, ate more, had higher metabolic rates, and grew faster than juveniles raised in high salinity water (28-34‰) (Hettler 1976).

1.2.1.5 Adults

Adult Atlantic menhaden are strictly filter feeders, grazing on planktonic organisms. They can be observed swimming slowly in circles, in tightly packed schools, with their mouths wide open and their opercula (gill flaps) flaring. In lab experiments (Durbin and Durbin 1975), they fed on small adult copepods as well as phytoplankton. Organisms smaller than 13-16 microns (slightly larger than the minimum size reported by Friedland et al. (1984) for juveniles) were not retained in the gills. Menhaden did not feed on large zooplankton (10 mm brine shrimp) in these experiments. The filtering process is purely mechanical; particles are not selected by size (Durbin and Durbin 1975). These experiments showed that the filtering rate depended on mouth size, swimming speed, food particle concentration, and the mechanical efficiency of the gill rakers. The structure of the "branchial basket," the area underneath the opercula where the extremely fine and closely-spaced gill filaments and gill rakers are located, was described in detail by Friedland (1985).

Growth occurs primarily during the warmer months. Fish as old as age 8 were fairly common during the 1950s and early 1960s, but in more recent years, fish older than age 6 have been rare. Older (age-6) fish reach an average length of 330 mm FL and a weight of 630 g, although growth varies from year to year and is inversely density-dependent. Growth rates appear to be accelerated during the first year when juvenile population size is low and are reduced when juvenile population size is high.

Adults migrate extensively along the entire United States East Coast. Following winter dispersal along the south Atlantic coast, adults begin migrating north in early spring, reaching as far north as the Gulf of Maine in June. Older and larger fish migrate farther than younger, smaller fish. The return southern migration occurs in late fall and early winter.

1.2.1.6 Distribution

Atlantic menhaden are abundant in the estuarine and nearshore ocean waters of North America from Nova Scotia to central Florida. They have been taken in commercial quantities from northern Florida to southern Maine. A few individuals have been taken as far north as St. John, New Brunswick, and St. Mary Bay, Nova Scotia. The southern limit seems to be Indian River City, Florida (Hildebrand 1963). Spawning occurs in the ocean, while larvae and juveniles utilize coastal estuaries. The adult population stratifies by age and size, with the older and larger individuals farther northward, and the younger and smaller fish in the southern half of the species' range (Ahrenholz 1991).

1.2.1.7 Stock Structure and Migration

The Atlantic menhaden resource is believed to consist of a single unit stock or population, based on tagging studies (Dryfoos et al. 1973; Nicholson 1978). Adult Atlantic menhaden undergo extensive seasonal migrations north and south along the United States East Coast. Early reports of this migratory behavior were made by Roithmayr (1963) based on the decrease in the number of purse seine sets north of Cape Cod in September. Also, Reintjes (1969) observed the disappearance of fish in October north of Chesapeake Bay and their appearance off the coast of North Carolina in November. Nicholson (1971) examined latitudinal differences in length-frequency distributions of individual age groups at different times of year and described a cyclic north-south movement with the largest and oldest fish proceeding farthest north such that the population stratifies itself by age and size along the coast during summer. A study of length frequencies at the time of first annulus formation on scales (Nicholson 1972) supported the concept of a north-south migratory movement and also indicated that a great deal of mixing of fish from all areas occurs off the North Carolina coast before fish move northward in spring.

Returns of tagged Atlantic menhaden (Dryfoos et al. 1973; Nicholson 1978) have generally confirmed what was already concluded from earlier work and added some important details. Adults begin migrating inshore and north in early spring following the end of the major spawning season off the North Carolina coast during December-February. The oldest and largest fish migrate farthest, reaching the Gulf of Maine in May and June. Adults that remain in the south Atlantic region for the spring and summer migrate south later in the year, reaching northern Florida by fall. Fish begin migrating south from northern areas to the Carolinas in late fall. During November, most of the adult population that summered north of Chesapeake Bay moves south around Cape Hatteras.

1.2.1.8 Mortality

The Atlantic menhaden population is subject to a high natural mortality rate. There is a somewhat reduced probability of death from natural causes when the population is being harvested. Natural mortality is also higher during the first two years of life than during subsequent years. Ahrenholz et al. (1987a) reported an annual instantaneous natural mortality rate (M) of 0.45 in the absence of fishing; this rate is equivalent to an annual reduction in population numbers of 36%. This rate is quite high compared to other pelagic marine species. Atlantic herring, for example, is characterized by an 18% annual natural mortality rate (Fogarty et al. 1989). During the 1955-1987 period, under exploitation, the annual natural mortality rate for age-1 Atlantic menhaden was 30% and, for ages 2 and older, it was 20% [see *Section 1.2.2.2* and Vaughan (1990)]. Natural mortality removes an estimated 30% of the exploited population at age 1 and 20% each year thereafter.

Menhaden natural mortality is probably due primarily to predation, since the fish are so abundant in coastal waters during the warmer months of the year. All large piscivorous sea mammals, birds, and fish are potential predators on Atlantic menhaden. Menhaden are preyed upon by species such as bluefish, striped bass, king mackerel, Spanish mackerel, pollock, cod, weakfish, silver hake, tunas, swordfish, bonito, tarpon, and a variety of sharks.

Coastal pollution and habitat degradation threaten marine fish species, such as Atlantic menhaden, which spend their first year of life in estuarine waters and the rest of their life in both ocean and estuarine waters.

Other poorly understood sources of natural mortality for Atlantic menhaden are diseases and parasites. A partial list of parasites was given in Reintjes (1969), but there is no information available concerning the extent of parasitism or its possible effect on survival. Ahrenholz et al. (1987b) described the incidence of ulcerative mycosis (UM), a fungal infestation which was observed in menhaden over much of their range in 1984 and 1985 and in a more restricted area in 1986. A large fish kill in Pamlico Sound, North Carolina in November, 1984 was associated with UM, but its primary effect may be to weaken fish, making them more susceptible to other causes of mortality, such as predation, parasites, other diseases, and low dissolved oxygen concentrations. The overall impact of UM on the 1984 and 1985 year classes could not be assessed, but it was not believed to be significant (Ahrenholz et al. 1987b). However, Vaughan et al. (1986b) believed that the mortality effects of a disease or other event must be "truly catastrophic" to be detectable.

Another source of natural mortality for Atlantic menhaden (and many other species) may be "red tide." The term refers to the color of water caused by the rapid multiplication (a "bloom") of single-celled planktonic organisms called dinoflagellates, which produce a toxic compound. The toxin accumulates in the tissues of filter-feeding animals which ingest the dinoflagellate. An outbreak of red tide occurred along the coast of the Carolinas during November, 1987 - April, 1988 when Gulf Stream water containing the dinoflagellates was transported into coastal waters. Menhaden recruitment in Beaufort Inlet during this period was severely reduced (S. Warlen, NMFS, Beaufort N.C., pers. comm.; as cited in ASMFC 1992). A new species of toxic dinoflagellate was identified as the causative agent in a major menhaden kill in the Pamlico River, North Carolina, in May, 1991. Problems with toxic phytoplankton organisms may increase in the future since their appearance has been correlated with increasing nutrient enrichment in estuarine and coastal waters which are subject to increasing organic pollution (Smayda 1989).

An additional source of mortality are fish "kills" which occur when schools of menhaden enter enclosed inshore bodies of water in such large numbers that they consume all available oxygen and suffocate. The mean lethal dissolved oxygen concentration for menhaden has been reported to be 0.4 mg/l (Burton et al. 1980). Bluefish are known to follow (or even chase) schools of menhaden inshore, feeding on them, and may contribute to their mortality by preventing them from leaving an area before the oxygen supply is depleted. Oxygen depletion is accelerated by high water temperatures which increase the metabolic rate of the fish; at the same time, oxygen is less soluble in warm water. Menhaden which die from low oxygen stress can immediately be recognized by the red coloration on their heads caused by bursting blood capillaries. Just before death, the fish can be seen swimming very slowly in a disoriented manner just below the surface of the water. This is a common phenomenon which has been observed throughout the range of the species. Menhaden spotter pilots have reported menhaden "boiling up" from the middle of dense schools, and washing up on the beach, apparently from oxygen depletion within the school. This phenomenon was observed during December, 1979 in the ocean off Atlantic Beach, North Carolina (M. Street, NC DMF, pers. comm.; as cited in ASMFC 1992). Smith (1999a) reported a similar event off Core Banks, North Carolina, in December 1997. Other species are not nearly as susceptible simply because they do not enter enclosed inshore waters in such large numbers.

1.2.1.9 Foods/Feeding

Menhaden are extremely abundant in nearshore coastal waters because of their ability to directly utilize phytoplankton, which is the basic food resource in aquatic systems. Other species of marine fish are not equipped to filter such small organisms from the water. Consequently, such large populations of other species cannot be supported. Because menhaden are so abundant in nearshore coastal and estuarine waters, they are an important forage fish for a variety of larger piscivorous fishes, birds, and marine mammals. In ecological terms, menhaden occupy a very important link in the coastal marine food chain, transferring planktonic material into animal biomass. As a result of this, menhaden influence the conversion and exchange of energy and organic matter within the coastal ecosystem throughout their range (Peters and Schaaf 1981; Lewis and Peters 1984; Peters and Lewis 1984).

Because menhaden only remove planktonic organisms larger than 13-16 microns (7 microns for juveniles) from the water, the presence of large numbers of fish in a localized area could alter the composition of plankton assemblages (Durbin and Durbin 1975). Peters and Schaaf (1981) estimated that juvenile menhaden consumed 6-9% of the annual phytoplankton production in eight estuaries on the east coast, and up to 100% of the daily production in some instances.

A large school of menhaden can also deplete oxygen supplies and increase nutrient levels in the vicinity of the school. Enrichment of coastal waters by large numbers of menhaden can be expected to stimulate phytoplankton production. Oviatt et al. (1972) measured ammonia concentrations (from excretion) inside menhaden schools that were five times higher than ambient levels 4.5 km away. At the same time, chlorophyll values increased by a factor of five over the same distance, indicating the grazing effect of the fish on the phytoplankton standing crop. Oxygen values were not significantly reduced by the fish, but were much more variable inside the schools than outside them.

Also, in a study of energy and nitrogen budgets (Durbin and Durbin 1981), food consumption rates, energy expenditures, and growth efficiency were examined. Results indicated that swimming speed, the duration of the daily feeding period, and the concentration of plankton in the water controlled the energy and nitrogen budgets for this species.

1.2.1.10 Predator/Prey Relationships

Atlantic menhaden are a major forage species for a wide number of important predatory fish species including, but not limited to, bluefish, striped bass, weakfish, king mackerel, bluefin tuna and sharks (Grant 1962; Reintjes and Pacheco 1966; Manooch 1973; DeVane 1978; Saloman and Naughton 1983; Juanes et al. 1993; Hartman and Brandt 1995a, 1995b). Marine mammals, including whales and porpoises, also have been reported to feed on menhaden (Bigelow and Schroeder 1953). Since Atlantic menhaden are eaten by predators in several ecosystems, they serve as a direct pelagic link in the food web between detritus and plankton and top predators (Rogers and Van Den Avyle 1989).

1.2.1.11 Ecological Role

Atlantic menhaden occupy two distinct types of feeding niches during their lifetime. They are size-selective plankton feeders as larvae and filter feeders as juveniles and adults. Data on the food of larvae before they enter the estuary is currently unavailable. After entering the estuary, menhaden larvae appear to be extremely selective for prey of certain sizes and species. Larvae from the Newport River estuary, North Carolina, ranging in size from 26-31 mm TL (mean = 29 mm TL), consumed copepods and copepodites of only four taxa, which composed 99% by number and volume of their gut contents (Kjelson et al. 1975). These prey items, ranging from 300 to 1200 microns in length (mean = 750 microns), were eaten despite an abundance of copepod nauplii, barnacle larvae, and small adult copepods in plankton tows. Larvae that were offered copepods in the laboratory ignored all other food items, including *Artemia* and *Balanus* nauplii (June and Carlson 1971). Larval menhaden in the Newport River estuary, North Carolina, fed primarily during daylight (Kjelson et al. 1975).

Juvenile and adult Atlantic menhaden strain particulates from the water column with a complex set of gill rakers. The rakers can sieve particles down to 7-9 microns (Friedland et al. 1984), including zooplankton, larger phytoplankton, and chain-forming diatoms. Biochemical analyses indicated that the gut contents of juveniles vary with prey availability; reliance on zooplankton decreases as the fish move from open waters to marshes (Jeffries 1975). Atlantic menhaden may also be capable of eating epibenthic materials (Edgar and Hoff 1976). Peters and Schaaf (1981) speculated that the annual phytoplankton and phytoplankton-based production in east coast estuaries is not sufficient to support the juvenile Atlantic menhaden population during its residency and that the abundant organic detritus may be eaten in addition to copepods, etc. Lewis and Peters (1984) reported that juvenile Atlantic menhaden in North Carolina salt marshes primarily ate detritus.

The role of Atlantic menhaden in systems function and community dynamics has received little attention. Larvae and juveniles are seasonally important components of estuarine fish assemblages (Tagatz and Dudley 1961; Cain and Dean 1976; Bozeman and Dean 1980). Estimates of the mean daily ration for larvae range from 4.9% (Kjelson et al. 1975) to 20% (Peters and Schaaf 1981) of wet body weight. Assimilation of ingested energy exceeded 80% for plant and animal material (Durbin and Durbin 1981). Because of their tremendous numbers, individual growth rates, and seasonal movements, these fish annually consume and redistribute large amounts of energy and materials, including exchanges between estuarine and shelf waters.

Kjelson et al. (1975) noted that the copepod taxa preferred by larval menhaden and other species decreased from a mean value (2 years) of 81% to 48% of the total zooplankton biomass during the period of larval residence. They speculated that this decrease may be partly explained by larval feeding. Durbin and Durbin (1975) suggested that Atlantic menhaden in coastal waters may also alter the composition of plankton assemblages by grazing on certain size ranges.

1.2.1.12 Related Species and Hybrids

There are two species of menhadens that occur on the Atlantic coast, the Atlantic menhaden, *Brevoortia tyrannus*, and the yellowfin menhaden, *B. smithi*. Yellowfin menhaden range from Cape Lookout, North Carolina, to the Mississippi River delta (Ahrenholz 1991). The numbers of Atlantic menhaden relative to yellowfin menhaden become reduced proceeding southward along the Atlantic coast of Florida. A large amount of hybridization occurs between these two species and areas with pure strains of yellowfin menhaden have yet to be defined. As the relative density of Atlantic menhaden decreases as one proceeds southward, the number of Atlantic x yellowfin menhaden hybrids increases along with pure strains of yellowfin menhaden. Historically, the menhaden gill net fishery in Indian River, Florida, was dominated by yellowfin menhaden and the Atlantic x yellowfin menhaden hybrid (Dahlberg 1970). Yellowfin menhaden were traditionally targeted by specialized bait fisheries in Florida but this may have changed due to the net ban implemented by that state in 1995.

1.2.2 Stock Assessment Summary

Information presented in this section is drawn primarily from Ahrenholz et al. (1987a), Vaughan and Smith (1988), and Vaughan (1990). Sampling methodology was described in Chester (1984). Early stock assessment results are summarized in Powers (1983) and Vaughan et al. (1986a). Based on tagging studies, the Atlantic menhaden fishery is believed to exploit a single stock or population of fish (Dryfoos et al. 1973; Nicholson 1978). For analytical purposes, the Atlantic menhaden fishing season for the reduction fishery extends from March 1 through the end of February of the following calendar year. Population age structure and fishing mortality rates are estimated by virtual population analysis (VPA) from the estimated catch in numbers-at-age matrix (Table 2) as described most recently in Vaughan (1990).

1.2.2.1 Abundance and Structure

Annual Atlantic menhaden population size (age 1 and older at the start of the fishing season) has ranged from 2.0 to 17.6 billion fish since 1955 (Table 3). Population size averaged 9.2 billion menhaden during 1955-1961 when landings were high (averaging 1,331.6 million lb or 604,000 mt), while the average was 3.2 billion menhaden between 1962 and 1974 when landings were low (averaging 637.1 million lb or 289,000 mt). From 1975 to 1992 population size averaged 7.3 billion menhaden, comparing favorably to population sizes between 1955 and 1961, but landings improved by only 15% to an average of 753.1 million lb (342,000 mt). The inability of the modern fishery to regain former high levels of landings (in weight) is due primarily to reduced mean weight-at-age which occurred during the 1970s (Fig. 2), and was caused in part by changes in fishing patterns, both geographically and seasonally. As has been noted, the migratory behavior of Atlantic menhaden results in older and larger menhaden moving farther north during spring and summer. Part of the decline in landings is due to the shift of the center of the fishing activity southward and subsequent fishing on smaller fish at age. Part can also be explained by the inverse relationship noted between first year growth of Atlantic menhaden and year class strength (Reish et al. 1985; Ahrenholz et al. 1987a). These factors, however, do not account for all of the decline in mean weight-at-age. The remainder is attributable to unknown biological or environmental factors.

The weight of Atlantic menhaden spawners (age 3 and older at the start of the fishing year) has ranged from 9,100 mt in 1966 to 360,300 mt in 1961 (Fig. 3). High spawning stock size (averaging 208,110 mt) was the rule between 1955 and 1962, while low spawning stock size predominated from 1963 to 1974 (averaging 23,560 mt). Improvement in spawning stock size has occurred since 1975. Between 1955 and 1961, high spawning stock size produced excellent recruitment to age 1 (averaging 5.1 billion) for menhaden entering the fishable stock. Low spawning stock size, present from 1962 through 1974, produced poor recruitment (averaging 2.2 billion menhaden). However, the somewhat improved spawning stock (averaging 37,890 mt) from 1975 to 1991 produced very good to excellent recruitment (averaging 4.4 billion menhaden), comparable to that produced during the high spawning stock years

(1955-61). Poor recruitment since 1992 (averaging 2.3 billion menhaden) has coincided with relatively high levels of spawning stock biomass (52,420 mt).

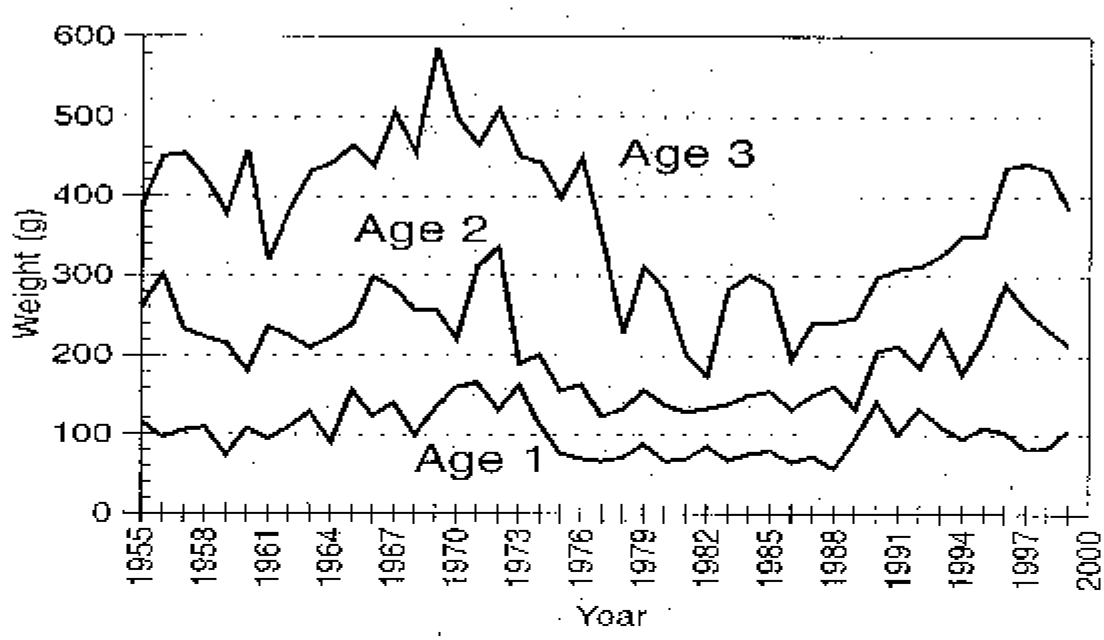

Figure 2. Atlantic menhaden mean weight at ages 1, 2 and 3, for 1955-99.

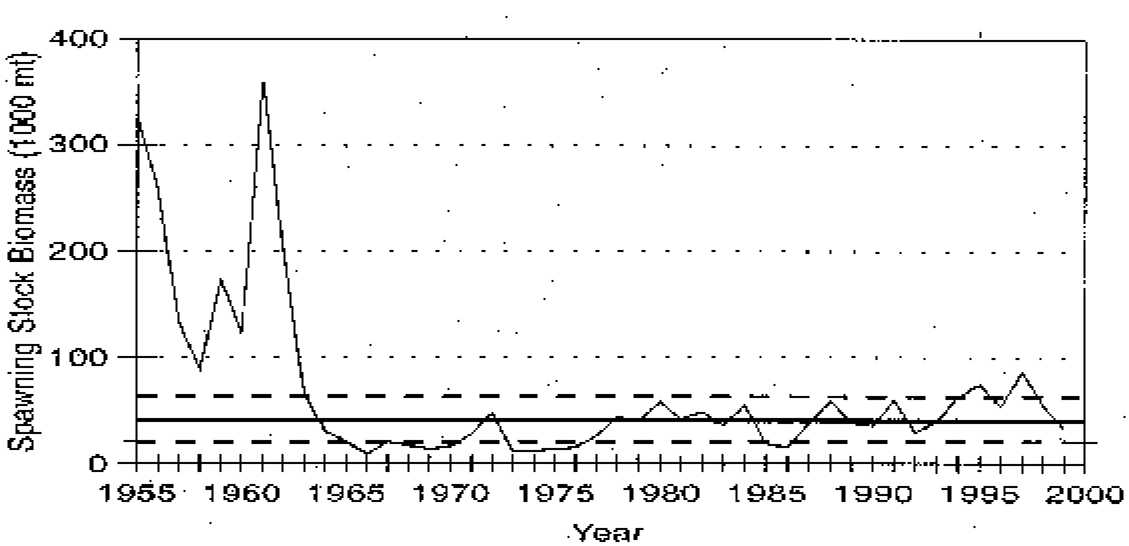

Figure 3. Spawning stock biomass (ages 3-8) of Atlantic menhaden with median and interquartile range.

1.2.2.2 Fishing Mortality

Short-term losses to the Atlantic menhaden stock due to the fishery can be assessed by considering the exploitation rate (Fig. 4), which is the fraction of the remaining stock removed by the fishery during some specified period of time (usually 1 year). Population exploitation rates (based on age-1 and older Atlantic menhaden) averaged 38% of the population removed annually by fishing during 1955 through 1990 (Table 3). From 1955 through 1962, when population size and landings were high, the population exploitation rate averaged 36%. During the period of low population size and landings from 1963 through 1974, the population exploitation rate averaged 43% (initially high during the mid-1960's and lower during the late 1960s and early 1970s). The population exploitation rate averaged 35% from 1975-91, when population size and landings improved significantly. For fishing years 1955 through 1990, an average of 24% of age-1 menhaden and 65% of age-2 and older menhaden were taken by the fishery annually, with 30% and 20%, respectively, being lost to natural causes annually (compared to 36% lost to natural causes annually in the absence of fishing mortality). Exploitation rates for age-0 menhaden ranged from less than 1% up to 17%.

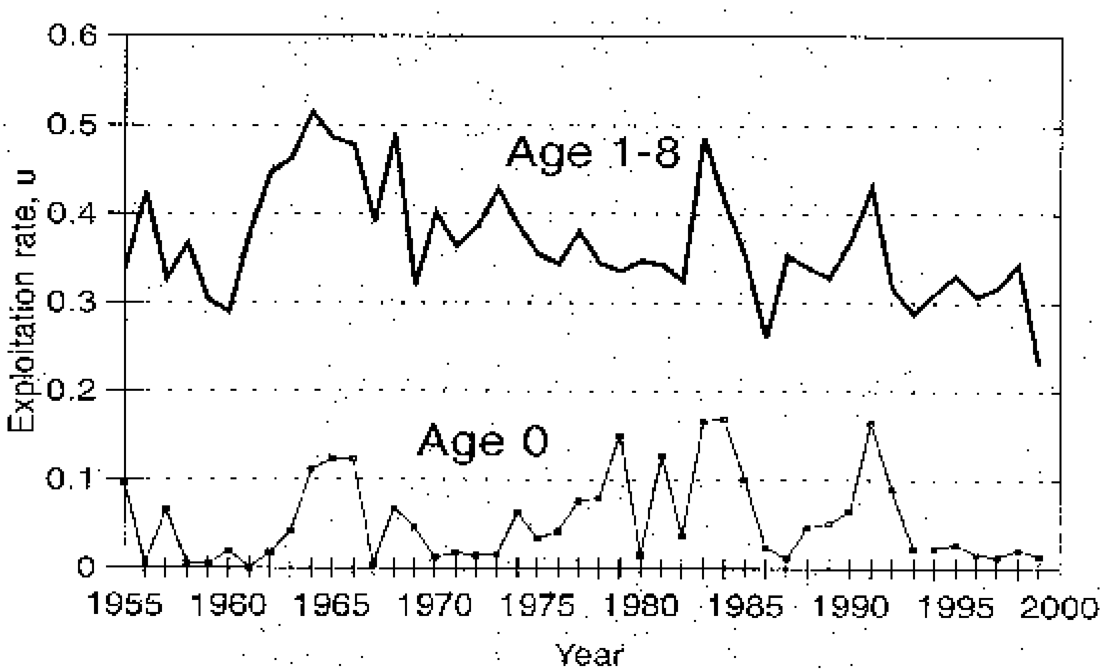

Figure 4. Exploitation rates (u) for age-0 and ages 1-8 Atlantic menhaden, 1955-99.

1.2.2.3 Recruitment Mechanisms

In addition to the stock assessments of Atlantic menhaden already referenced, a study by Nelson et al. (1977) attempted to relate Atlantic menhaden recruitment to Ekman transport. Conceptually, it was believed that if the prevailing winds along the middle Atlantic coast of the United States created onshore currents during winter, survival of Atlantic menhaden larvae during their transport into estuarine nursery areas would be increased. Checkley et al. (1988) suggested that Atlantic menhaden "have evolved to reproduce in winter near warm boundary currents [e.g., Gulf Stream] as a result of physical conditions that permit the rapid development and shoreward drift of their eggs and larvae, with consequent high recruitment and fitness." However, the statistically-derived relationship with Ekman transport is no longer significant with the addition of more recent data (W. Schaaf, pers. comm.; as cited in ASMFC 1992), and is not useful for predictive purposes. No other mechanisms have been proposed which account for variations in recruitment.

1.2.2.4 Spawner-Recruit Relations and Maximum Spawning Potential

Since 1955, the contribution of age-3 spawners to the spawning stock has averaged about 76% in numbers and 66% in index of egg production (Fig. 5). These values were exceptionally high during the 1970s (87% and 78%, respectively), but declined somewhat during the 1980s (77% and 66%, respectively), lessening the concern that recruitment failure in a single year class could have significant consequences on future year classes. When spawner and recruit data are fit to the Ricker model (Ricker 1975), a statistically significant relationship is obtained (Fig. 6). However, considerable scatter (or unexplained variability) about the estimated spawner-recruit curve suggests that recruitment variability depends little on spawning stock size, and that environmental factors are probably more important in controlling recruitment success or failure.

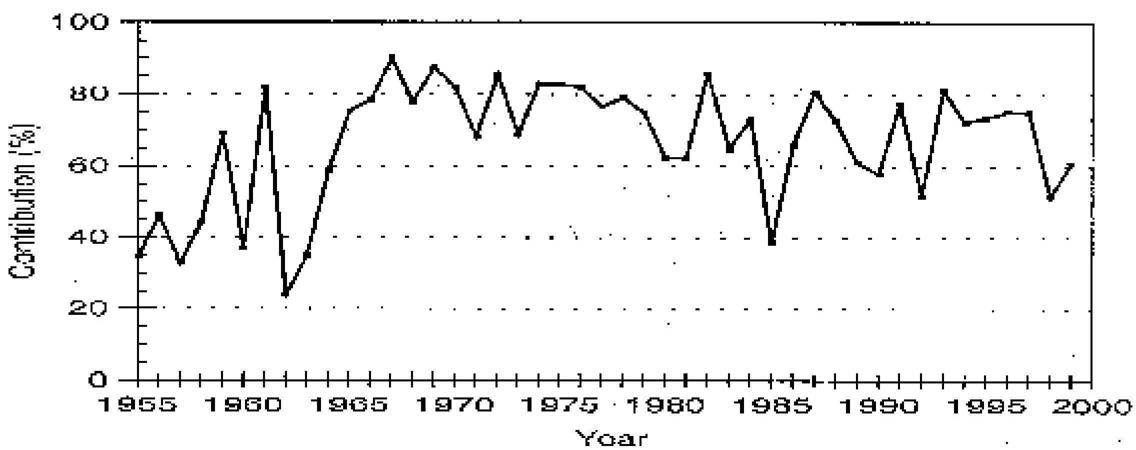

Figure 5. Contribution to spawning stock (as eggs) by age-3 Atlantic menhaden.

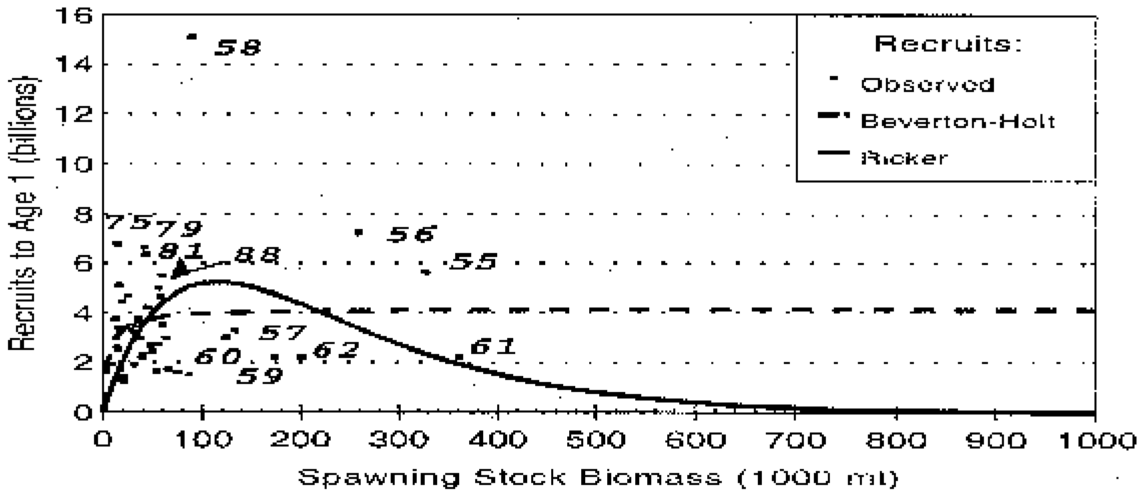

Figure 6. Observed, Ricker and Beverton-Holt model estimates of age-1 Atlantic menhaden.

Gabriel et al. (1989) developed an index of "percent maximum spawning potential" (%MSP) equal to the ratio of spawning stock biomass calculated when fishing mortality (F) is equal to that estimated or observed, divided by the spawning stock biomass calculated when F = 0 (unfished spawning stock). This ratio assumes such compensatory mechanisms as increased growth rate or earlier maturity when a fish stock is exploited. As the spawning stock size decreases relative to the unfished state, the risk of recruitment failure increases. Whether there is a threshold below which recruitment failure is certain or a gradual increase in risk of recruitment failure with decreasing spawning stock size is unknown. These ratios (Fig. 7) are calculated under the assumption of equilibrium; that is, annual age-specific estimates of F are used to project a fixed number of recruits throughout their lifespan, and spawning stock size in biomass or index of egg production is summed over the mature ages. The index of egg production for Atlantic menhaden is based on the egg-length relation provided in Lewis et al. (1987).

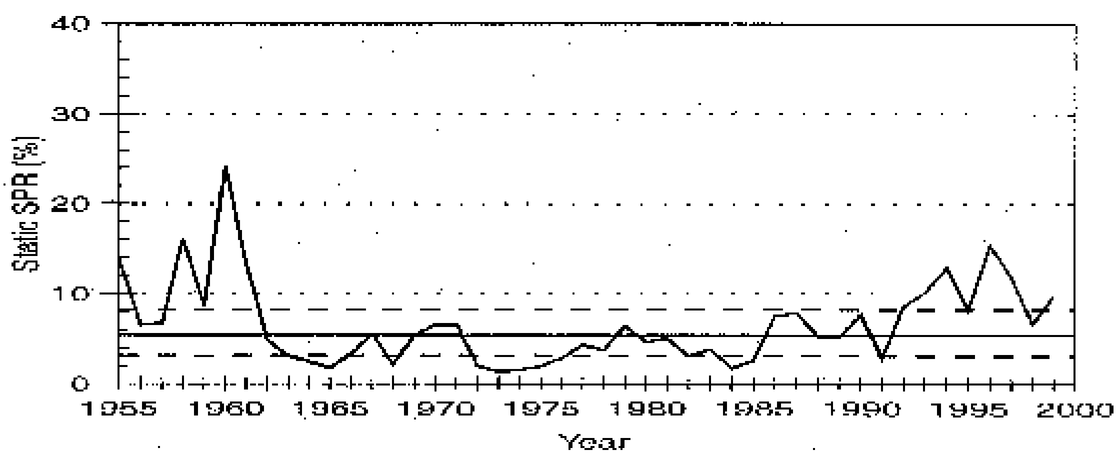

Figure 7. Annual static spawning potential ratio (SPR) for Atlantic menhaden with median and interquartile range.

From 1962 to 1992, the percent maximum spawning potential was below 10%. Periods of both poor (less than 2 billion fish) and excellent recruitment (greater than 4.7 billion fish) have occurred, reinforcing the concept that environmental conditions are more important than spawning stock abundance in determining recruitment success or failure. Because %MSP values of 20% to 40% have been used by the Gulf of Mexico and South Atlantic Fishery Management councils in their definitions of overfishing for a number of fish stocks, these low values for Atlantic menhaden have raised some concern. On average, however, the Atlantic menhaden stock has been able to replace itself at low %MSP values. Thus, a value much lower than 20% - 40% of MSP appears to apply to Atlantic menhaden.

Recent estimates of percent MSP have been quite high, ranging from 8.4 to 14.9%, from 1992 to 1998. Recruitment of fish to age-1 though, has been below the median level of 3.4 billion during this time, and fell below the 25th percentile value of 2.2 billion during 1997 and 1998.

1.2.2.5 Potential Yield

Yield-per-recruit (YPR) models are used to determine whether or not fish are being harvested at an age which provides maximum yield. The models can indicate if fish are being removed at too young an age, resulting in growth overfishing. This analysis shows gains and losses of YPR as a function of the fishing mortality rate and age at entry to the fishery (Fig. 8). Overall YPR for the age at entry of 0.5 yr and F-multiple of 1.0 (existing conditions) has been generally decreasing since 1971, with an average of 78.5 g during the 1970s and 52.1 g during the 1980s (Table 4). The proportional contribution of younger age groups to the landings has increased, and the average size at age (as noted earlier) has decreased. Reduced growth and redirection of effort towards younger fish has contributed to the reduced levels in YPR.

Landings of Atlantic menhaden have been highly dependent on age-0 fish in certain fishing years (e.g., 1979, 1981, 1983, 1984, and 1985, as noted in Vaughan and Smith 1991), and most recently in 1990-92. Potential gains in YPR from increasing age at entry from age 0.5 to age 1 ranged from 0.4% in 1970 to 6.5% in 1979 and about 6.0% in 1983 and 1984 (Table 4). Even greater gains in YPR could be obtained by raising the age at entry to age 2 (e.g., 16.1% in 1983 and 17.7% in 1984). Such an increase is unlikely, given the current and probable future geographic distribution of fish and fishing effort.

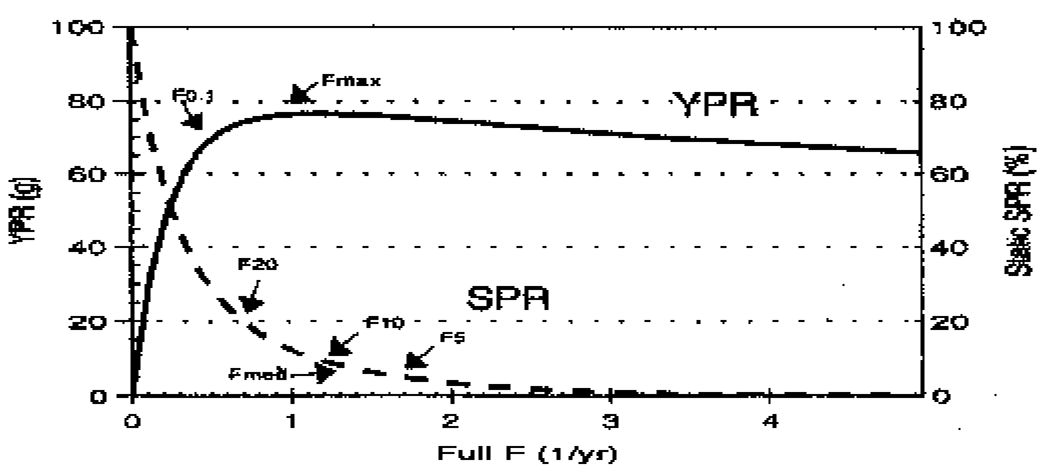

Figure 8. Yield-per-recruit (YPR) and static spawning potential ratio (SPR) for Atlantic menhaden.

In general, increasing the age at entry causes an increase in YPR, except for small F-multiples; e.g., F-multiple = 0.2 (Fig. 8). Decreasing fishing mortality to F-multiple = 0.5 generally causes a decrease in yield per recruit at the current age at entry (0.5 yr), with exceptions in the 1970-1971, 1979, 1986-1987, and 1990 fishing years. Except in 1990, increasing fishing mortality to F-multiple = 2.0 causes a decrease in YPR at the current age at entry (0.5 yr). These results suggest that the age at entry should be raised to increase potential yield from the stock. However, current plant locations in southern areas where fish are generally smaller (Virginia and North Carolina) and very restrictive fishing regulations in many areas greatly restrict the ability to obtain optimal yield per recruit.

1.2.2.6 MSY and Production Models

Estimates of maximum sustainable yield (MSY) are developed to obtain an approximate estimate of the production of a stock available to a fishery. As normally estimated, it assumes relatively constant environmental conditions. However, as environmental conditions change, MSY will also vary. The value of MSY for Atlantic menhaden depends heavily on recruitment success, which in turn, is highly dependent on unknown, unmanageable environmental conditions. This level of uncertainty precludes the direct use of MSY for determining quotas for menhaden management.

Historical estimates of MSY range from 815.7 million lb (370,000 mt) to 1,234.6 million lb (560,000 mt) (Schaaf and Huntsman 1972; Schaaf 1975, 1979; Ahrenholz et al. 1987a; Vaughan and Smith 1988; Vaughan 1990). The most recent application of the generalized production model (Pella and Tomlinson 1969), which relates landings and fishing effort, suggested estimates of MSY of 1,068 million lb ± 191.8 million pounds (484,000 mt ± 87,000 mt) based on landings and adjusted fishing effort data through 1986 (Vaughan 1990). Relatively high recruitment during 1975-1986 indicated potential yields from a given year class of 363.8 million lb (165,000 mt) to 1,161.8 million lb (527,000 mt) based on YPR analysis. In general, estimates of MSY exceed recent landings of Atlantic menhaden, which have ranged from 377.5 million lb (171,200 mt) to 922.9 million lb (418,600 mt) since 1980.

1.2.3 Abundance and Present Condition

Section 1.2.1.7 describes the current understanding of the stock structure of Atlantic menhaden. A complete review of historical assessments and resource surveys will be found in the Source Document for Amendment 1.

Good recruitment during the mid-1970s to the mid-1980s supported landings between 661 and 881 million lb (300,000 and 400,000 mt). Poor recruitment during the 1960s and early 1970s supported landings between 441 and 661 million lb (200,000 and 300,000 mt). Most recently, landings have decreased to the levels seen in the 1960s - early 1970s. Part of this decline may be a result of the lowered recruitment but is also a result of industry consolidation (economic conditions) and area closures (social and political conditions), which have greatly reduced the geographic distribution of the fishery. The current estimate of spawning stock biomass is 32,800 mt, with the three-year running average of 58,300 mt. Spawning stock biomass has started to decline due to recent poor recruitment and may continue to decline until recruitment improves and the recruits enter the spawning stock. A precise understanding of the role of environmental conditions on menhaden recruitment is not available but would be extremely useful for predictive purposes.

1.2.4 1998 ASMFC Peer Review Panel Results

Twice annually, the Commission's ISFMP Policy Board prioritizes all Commission managed species based on species Management Board advice and other prioritization criteria. The species with the highest priorities are assigned to a review process to be conducted in a timely manner. In June 1998, the Atlantic menhaden stock assessment was prioritized for an external peer review. An external peer review panel was formed, including four stock assessment biologists with expertise in menhaden life history, stock assessment techniques, and multispecies interactions. The external peer review for the Atlantic Menhaden stock assessment was conducted November 16-18, 1998, in Baltimore, Maryland (ASMFC 1999a & b).

The Menhaden Peer Review Panel convened to review the stock assessment methodology and other issues including: 1) the type of model and data sources used in the assessment; 2) evaluate the extent of any statistical bias; 3) identify and evaluate other potential sources of mortality; 4) review the trigger mechanisms used to monitor the stock and fishery; 5) evaluate the status of the stock as a whole and locally; 6) evaluate the ecological significance of menhaden and suggest other trigger mechanisms which may reflect this role; and 7) review existing management and research needs and identify any new needs.

The Panel concluded that the model used to assess the menhaden population was reasonable given the available data, and sampling was comprehensive with sufficient temporal and spatial resolution. The "triggers" were not triggers because firings do not lead to specific management actions. Recruitment has declined during the 1990s, and fisheries-dependent data strongly suggest that the stock has contracted from the northern and southern extent of its range in the last few years. The Panel did not receive any direct evidence of local depletion of menhaden in Chesapeake Bay or northeastern Florida waters. A comprehensive analysis of the ecological significance of menhaden was not presented to the Panel. A further examination of this issue should be addressed through a future Commission workshop on multispecies interactions. Finally, the Panel concluded that the trigger-based management system has not served the function of guiding regulatory actions in the menhaden fishery.

The Panel made a number of recommendations to improve the stock assessment, including evaluation of the sampling methodology, estimates of natural mortality, sensitivity analyses of spawning stock biomass (SSB) estimates and recruitment, evaluation of fishery-independent and -dependent measures of abundance and evaluation of current reproductive parameters of the population. The Panel recommended renaming the triggers as "biological reference points" or "variables used to evaluate stock status" since they do not trigger any specific management action. The Panel recommended replacing certain variables with those based on fishery-independent data to reflect the condition of the stock and not the fishery. The Panel also recommended that a reference point responsive to menhaden as a forage species be developed to take into account the allocation of fish between fishing and natural mortality (predator-prey interactions). Specific management recommendations made by the Panel included: developing a quota-based management system allocated by season and area; development of biological reference points based on recruitment and spawning stock biomass; and inclusion of a greater diversity of scientific and public participation in the technical and advisory process.

1.3 DESCRIPTION OF THE FISHERY

1.3.1 Commercial Fishery

Atlantic menhaden have supported one of the United States' largest fisheries since colonial times.

Landings records indicate that over 18 million mt of Atlantic menhaden have been caught by fishing fleets operating from Maine to Florida since 1940.

Native Americans were the first to use menhaden, primarily for fertilizer. During the 1940s, the primary use changed to high protein animal feeds and oil production. Menhaden meal was mixed into poultry, swine, and cattle feeds as the amount used for fertilizer was decreasing. The oil was used in the manufacture of soap, linoleum, waterproof fabrics, and certain types of paint.

Following World War II, the industry grew rapidly, reaching peak production during 1953-62. Sharp declines in landings thereafter resulted in factory closings and fleet reductions through the 1960s and into the early 1980s. Since that time, the menhaden industry has experienced major changes in processing capacity, resource accessibility, and development of new product markets.

1.3.1.1 Description of State Fisheries (Refer to *Sections 1.3.1.3 - 1.3.1.11*)

1.3.1.2 Internal Waters Processing

Section 306 of the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265) allows foreign fish processing vessels to operate within the internal waters of a state with the permission of the Governor of that state. Before granting such permission, the Governor must: 1) determine that the harvest of the target species of the proposed IWP operation exceeds the processing capacity for that species within the state, and 2) consult with the Governors of other states within which the fishery occurs, as well as with the appropriate regional fishery management council and interstate fisheries commission.

The commercial menhaden fleet operating in the North Atlantic region underwent considerable changes during the late 1980s and early 1990s, including the introduction of two conventional menhaden steamers, the addition of a number of small menhaden boats active in other fisheries during the off-season, and the development of a menhaden IWP venture with up to three Russian processing ships. In 1987, two New England-based menhaden vessels began to fish the Gulf of Maine area, landing the catch at a Canadian processing plant. Another Canadian factory in Nova Scotia processed menhaden in 1992 and 1993. No menhaden have been processed in the North Atlantic since the summer of 1993.

Up to three IWP ventures operated within Maine's coastal waters during 1988-93. Under state jurisdiction, a foreign vessel was permitted to process menhaden caught by US vessels into fish meal and oil during the 1988-93 fishing seasons. The Gulf of Maine Atlantic menhaden fleet included about 20 small purse seine vessels and carriers serving the reduction and lobster bait markets. These vessels included some that were seasonal (boats active in other fisheries during the off-season), as well as vessels specifically built and rigged for purse seine fisheries (both menhaden and Atlantic herring). The majority of the vessels were based in Maine, but some operated out of the Boston area. Several of the catcher boats could hold their catch for direct transfer to the foreign processing vessel. Smaller catcher boats normally pumped the fish from the seine onto a carrier vessel for later transfer to the processing vessel. The small vessels used in the Gulf of Maine were not refrigerated and utilized a single purse boat.

1.3.1.3 Vessels and Domestic Harvesting Capacity

The early menhaden purse seine fishery utilized sailing vessels, while coal-fired steamers were introduced after the Civil War. In the 1930s, diesel-powered vessels began to replace the steamers, although a few sailing vessels were still in use. Reintjes (1969) described modern menhaden vessels and purse seines and summarized the significant technological advancements since World War II as follows:

1946	Use of spotter aircraft. Setting on a school is now directed by the spotter pilot via radio communication with the purse boats.
1946	Use of pumps to transfer fish from the nets to the carrier vessel resulted in shorter transfer time and more fishing time.
1954	Use of synthetic net material rather than cotton twine resulted in increased net life.
1957	Use of hydraulic power blocks in the purse boats to haul in the net permitted a reduction in crew size and reduced net retrieval time. Strong synthetic net material was able to withstand the increased strain from the new haul technique.
1958	Introduction of lighter, stronger, and faster aluminum purse boats to replace wooden boats.

The refrigeration of vessel holds in the 1960s and 1970s was crucial for the industry to maintain its viability. Despite restricted access to a number of traditional grounds and a reduced fleet size, refrigerated holds enabled the fleet to maximize the harvest during peak resource availability. Refrigeration also allowed the fleet to range over a larger area and stay out longer, greatly improving the ability to catch fish when and where they are available.

Currently, commercial menhaden purse seine fishing operations utilize spotter aircraft to locate schools of menhaden and direct vessels to the fish. When a school is located, two purse boats with a net stretched between them are deployed. The purse boats encircle the school and close the net to form a purse or bag. The net is then retrieved to concentrate the catch, and the mother ship comes along-side and pumps the catch into refrigerated holds. Individual sets can vary from 10 to more than 100 mt, and large vessels can carry 400-600 mt of refrigerated fish.

Over the years, vessels participating in the Atlantic menhaden purse seine fishery have varied considerably in size, fishing methods, gear type, and intensity of effort. During the early 1960s, the commercial menhaden fleet experienced significant changes as larger, faster vessels replaced outdated models. Today, the 12 vessels operating in North Carolina and Virginia range from 166 ft (51 m) to 200 ft (61 m) in length. Typical menhaden vessels generally carry two purse boats approximately 39 ft (13 m) in length. A few small vessels have only one purse boat and are called "snapper rigs." These small boats have the ability to fish in shallow areas not available to the larger vessels. The catches of the snapper rigs (a small fraction of the total) are mostly sold for bait (sport fishery, crab pots, etc.) with minor quantities processed into meal, oil, and solubles.

The typical purse seine net has a bar mesh of 3/4 in (1.9 cm) to 7/8 in (2.2 cm). The net length ranges from about 1,000 ft (305 m) to about 1,400 ft (427 m) and the depth from about 65 ft (20 m) to about 90 ft (27 m).

Historically, the total number of vessels fishing for menhaden was generally related to the availability of the resource. Greer (1915) reported 147 vessels in 1912. During 1955-1959, about 115-130 vessels fished during the summer season, while 30-60 participated in the North Carolina fall fishery. As the resource declined during the 1960s, fleet size decreased more than 50%. Through the 1970s, approximately 40 vessels fished during the summer season, while nearly 20 were active in the fall fishery. During 1980-1990, 16-33 vessels fished the summer season, and the level of effort in the fall fishery ranged from a low of 3 vessels in 1986 to a maximum of 25 (Table 5).

During the 1990 season, the mid-Atlantic fleet, based in Virginia was composed of 20 vessels, and the south Atlantic fleet, based in North Carolina, consisted of one large vessel and two smaller vessels, each using two purse boats. One of the smaller vessels, however, fished exclusively for bait. An additional 3-4 large vessels from Virginia and/or the Gulf of Mexico fished in the south Atlantic during the fall fishery. Due to company consolidation in 1997, there are presently 10 vessels in the mid-Atlantic fleet (at Reedville, Virginia) and two vessels in the south Atlantic (at Beaufort, North Carolina).

Changes in fleet size since the 1980s are attributable to a number of factors. Reductions in effort during the mid-1980s were related largely to world commodity markets and economic considerations. The addition of vessels participating in the Gulf of Maine IWP ventures reflected resource availability in Maine. Reduction of the Chesapeake fleet by several vessels was accompanied by improved operating efficiency. Vessels from the Gulf of Mexico fishery were added to the Atlantic fleet for the fall fishery in order to maximize harvest when weather and fish migratory behavior provided opportunities for large catches. In November 1997, Omega Protein purchased its competitor in Reedville, AMPRO Fisheries. For the 1998 fishing season, Omega dismantled the AMPRO factory and reduced the Virginia reduction fleet from 20 to 13 vessels. Further reductions in fleet size occurred during 1999, and there are 12 vessels expected to participate in the reduction fishery in 2000.

All twelve vessels in the menhaden fleet currently utilize refrigerated fish holds, compared to only 60% of the fleet in 1980 (Table 5). Refrigeration enables vessels to deliver better quality raw material and serves to increase vessel range and extend time on the fishing grounds. This ability to maximize peak resource availability was critical in the 1970s and 1980s for the maintenance of the industry in the face of restricted access to traditional grounds and a reduced number of vessels landing at fewer plants.

Average hold capacity of menhaden vessels in the summer fishery declined from 1,101,000 standard fish (737,670 lb or 334.6 mt) in 1980, to 997,000 standard fish (667,990 lb or 303 mt) in 1990, a decrease of 9.4% (Table 5). The total hold capacity of the current twelve vessel menhaden fleet is well below that of the late 1950s.

During peak landing years (1953-1962), an average of 112 vessels with a mean vessel capacity of about 678,000 standard fish (representing a total fleet capacity of approximately 76,000,000 standard fish) supplied the industry (Nicholson 1971). The fleet landed daily catches at 20 menhaden reduction plants from New York to Florida. In comparison, the 1990 fleet of 33 vessels, which operated within a more restrictive and regulated environment, landed their catch at five plants, including the foreign processing vessel. As previously noted, the current fleet of twelve vessels unloads menhaden at only two ports, Reedville, Virginia and Beaufort, North Carolina.

1.3.1.4 Fishing and Landing Areas

The Chesapeake Bay area (including the mid-Atlantic area) accounted for about 77% of the Atlantic menhaden landings in 1990 and about 73% during the 1980-1990 period (Table 6; Fig. 9). Plants in the north and south Atlantic areas, including one plant active during the fall fishery, processed about 27% of the annual landings. Three plants located in Virginia and North Carolina processed about 90% of the harvest (Fig. 9). The data in Table 6 illustrate the recent year-to-year variations in regional landings.

In 1991, Chesapeake Bay, including the mid-Atlantic area, accounted for about 74% of the menhaden landings. The North Atlantic area contributed most of the balance of the landings, while the south Atlantic area contributed the remainder. The catch was landed at shoreside processing plants in Beaufort, North Carolina; Reedville, Virginia. (2 plants); and Blacks Harbour, N.B., Canada. A Russian factory ship anchored at various locations within the territorial waters of southern Maine also processed menhaden under an IWP arrangement.

As no menhaden landings for reduction have occurred in New England since the summer of 1993, landings of Atlantic menhaden for reduction have been made exclusively by the Virginia and North Carolina vessels at Reedville, Virginia and Beaufort, North Carolina. Between 1994-1997, the factories at Reedville processed an average 89% of the Atlantic menhaden catch for reduction; the remainder was unloaded at Beaufort.

Recently, Smith (1999b) summarized catch estimates of menhaden vessel captains in the Virginia and North Carolina fleets (excluding New England vessels) from Captains Daily Fishing Reports (CDFR's) during 1985-96. On average, over the twelve year study period, 52% of the catch by the Virginia and North Carolina fleets came from the Virginia portion of Chesapeake Bay, 17% was caught in North Carolina coastal waters, 16% in Virginia ocean waters, and 15% in ocean waters of Rhode Island, New York, New Jersey, Delaware, and Maryland and Delaware Bay combined. However, the New Jersey portion of Delaware Bay has been closed to the reduction fishery since mid-1989, the Delaware portion in mid-1992, and most of Long Island Sound has now been closed to the reduction fishery.

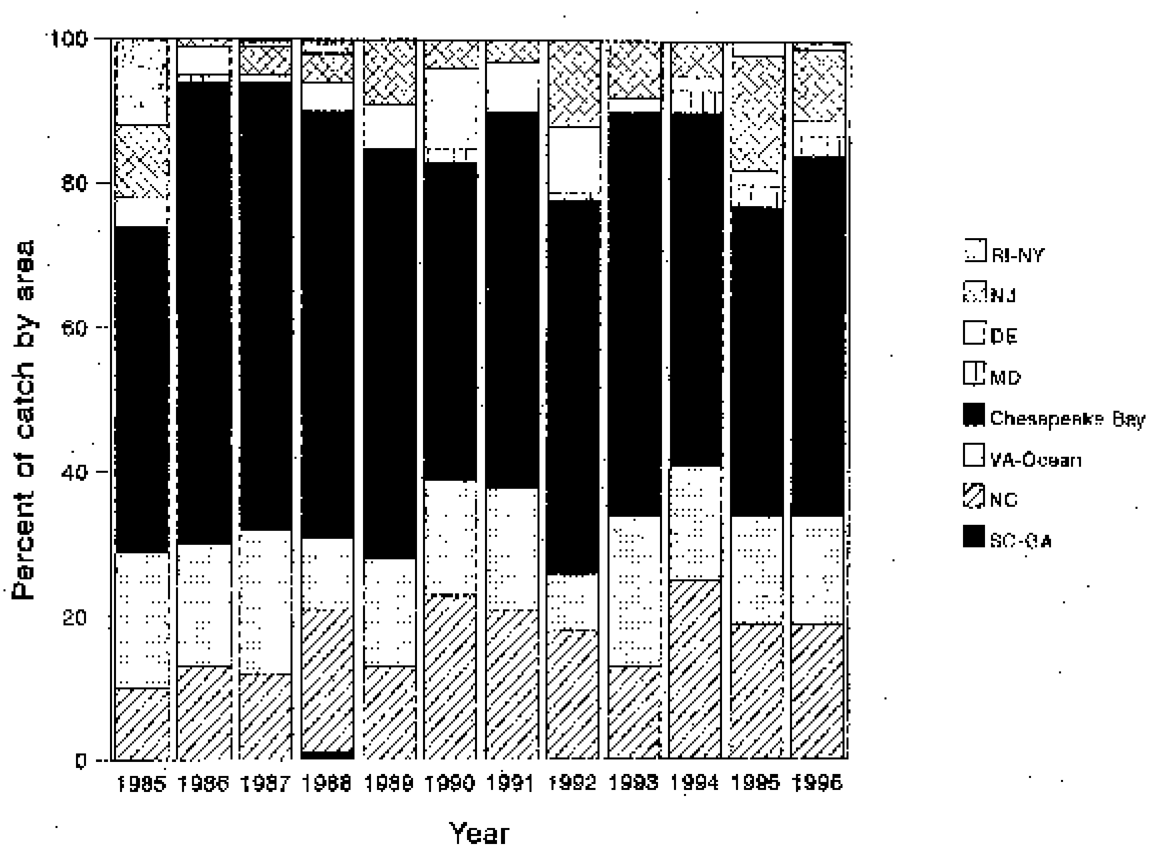

Figure 9. Proportion of the annual catch (in metric tons) of Atlantic menhaden caught in different fishing areas, 1985-96, as estimated from CDFR's (from Smith 1999b).

1.3.1.5 Fishing Seasons

The directed menhaden purse seine fishery for reduction is seasonal. The presence of menhaden schools is dependent on the temperature of coastal waters. Two fairly distinct fishing seasons occur, the "summer fishery" and the "fall fishery". The summer fishery begins in April with the appearance of schools of menhaden off the North Carolina coast. The fish migrate northward, appearing off southern New England in May-June. The fishery in the Gulf of Maine may extend into early October, although menhaden may not appear in the Gulf of Maine at all in some years. Menhaden stratify by age along their migration route as smaller, younger fish remain in the southern area, while larger, older fish travel farther to the north. Peak landings occur during June-September (Table 7).

The fall fishery begins about 1 November as migratory fish appear off Virginia and North Carolina. In early fall, this southward migration is initiated by cooling ocean temperatures. By late November-early December, most of the fish are found between Cape Hatteras and Cape Fear, North Carolina. Menhaden vessels based in Beaufort, North Carolina and Reedville, Virginia harvest these fish during the fall fishery. Fishing may continue into January (and sometimes February), but is highly weather-dependent. Menhaden generally leave the nearshore coastal fishing grounds in January, dispersing in ocean waters off the south Atlantic states.

1.3.1.6 Commercial Reduction Fishery

Atlantic menhaden have supported one of the United State's largest fisheries since colonial times. Menhaden have repeatedly been listed as one the nation's most important commercial fisheries species in terms of quantity. Total menhaden landings (Gulf of Mexico and Atlantic) in 1998 were 1.7 billion lb (816,467 mt) valued at $103.8 million (NMFS 1999). Preliminary Atlantic menhaden landings in 1999 totaled 416 million lb (188,662 mt) with an estimated ex-vessel value of $33.2 million (NMFS 2000).

Native Americans may have used menhaden for fertilizer before the European settlement of North America. Colonists soon recognized the value of whole menhaden for fertilizer, and local seine fisheries gradually developed from New York to Maine. Farmers applied 6,000 to 8,000 fish per acre (Harrison 1931). The use of whole fish as fertilizer continued into the nineteenth century. Union soldiers returning home from North Carolina and Virginia after the Civil War provided anecdotal reports on the abundance of menhaden in Chesapeake Bay and coastal North Carolina, sparking interest in a southern fishery, which soon developed.

The menhaden oil industry began in Rhode Island in 1811 (Frye 1999). It has grown steadily, with significant mechanization, including boilers for rendering raw fish and presses for removing oil. Oil was initially used for fuel and industrial processes, while the remaining solids (scrap) were used for fertilizer. Numerous small factories were located along the coasts of the northeastern states. However, their supply was limited to fish that could be captured by the traditional shore-based seines. In 1845, the purse seine was introduced, and an adequate supply of raw material was no longer a problem. By 1870, the industry had expanded southward, with several plants in the Chesapeake Bay and North Carolina areas (Whitehurst 1973).

The industry gradually developed during the late 1800s and early 1900s and was described in considerable detail prior to World War I by Greer (1915). During this period the number of factories and vessels varied with the supply of menhaden. The principal use for the scrap was fertilizer, with different companies each producing their own formulation. A small amount of scrap was used to feed cattle and chickens.

The primary use of menhaden changed from fertilizer to animal feed during the period following World War I. Harrison (1931) described the uses of menhaden during the late 1920s as follows: "... much is being used in mixed feeds for poultry, swine, and cattle and the amount going to fertilizer is steadily decreasing. Menhaden oil is used primarily in the manufacture of soap, linoleum, water proof fabrics, and certain types of paints."

Following World War II the industry grew rapidly, reaching peak production during 1953-62. Sharp declines in landings thereafter resulted in factory closings and fleet reductions through the 1960s and into the early 1970s. Since that time, the menhaden industry has experienced major changes in processing capacity, resource accessibility, and access to new product markets.

Nine menhaden reduction plants on the Atlantic coast closed permanently during the 1980s while two new operations began (Table 8). In 1990, five reduction plants with 37 vessels processed Atlantic menhaden for fish meal and oil. In the United States, land-based plants are currently located at Beaufort, North Carolina and Reedville, Virginia. An IWP venture operated in Maine state waters during 1988-92. Menhaden have also been caught off the coast of Maine and transported to a reduction plant in Blacks Harbour, New Brunswick, Canada (Vaughan 1990).

Since preparation of the 1981 Atlantic Menhaden FMP (AMMB 1981), there have been numerous regulatory changes affecting the menhaden fishery, such as season limits, area closures, and changes in license fees. In some state waters, a prohibition on commercial menhaden fishing operations using purse seines has been implemented (see *Section 2.1.1*).

1.3.1.7 Commercial Bait Fishery

Information on the harvest and use of menhaden for bait is difficult to obtain because of the nature of the bait fisheries and data collection systems. Harvest comes from directed fisheries, primarily small purse seines, pound nets, and gill nets, and bycatch in various food-fish fisheries, such as pound nets, haul seines, and trawls. Menhaden are taken for bait in almost all Atlantic coast states and are used for bait in crab pots, lobster pots, and hook and line fisheries (both sport and commercial). A specialized use involves live menhaden as bait for coastal pelagic species.

Reported annual landings of Atlantic menhaden for bait along the Atlantic coast averaged about 33.7 mt (about 70.0 million pounds) for the period 1985-99 (Table 9). Reported bait landings usually accounted for approximately 10% ot the total Atlantic menhaden landings each year from 1985-97. In 1998 and 1999, reported bait landings accounted for 13.7% and 17.3%, respectively, of the total Atlantic menhaden landings. The increase in percent of coastal landings are attributed to better data collection in the Virginia snapper rig bait seine fishery and a decline in coastal reduction landings due to reductions in processing plants and fleet size. Appendix A.1 contains each state's menhaden bait landings recorded by gear for 1985-99.

Closure of reduction plants in New England and the mid-Atlantic may have influenced growth in the bait fishery, making more product available for the lobster and crab pot fisheries, as well as bait and chum for sport fishermen. Additionally, the passage of a net ban in Florida in November 1994 reduced the availability of bait and chum in that state, which opened up new markets for menhaden bait caught in Virginia and the mid-Atlantic states. The appearance of growth in the Atlantic coast bait fishery (Table 9) must be tempered by the knowledge that reporting systems for bait landings, particularly for Atlantic menhaden, have historically been incomplete at best. In most cases, recent landings estimates are more accurate, but for some states, bait landings continue to be underestimated. The nature of the fishery and its unregulated marketing are causes of the under-reporting problem. There are some well-documented, large-scale, directed bait fisheries for menhaden using gears such as purse seines, pound nets, and gill nets. There are also many smaller-scale directed bait fisheries and bycatch fisheries supplying large quantities of bait with few, if any reporting requirements. Menhaden taken as bycatch in other commercial fisheries is often reported as "bait" together with other fish species. The "over-the-side" sale of menhaden for bait among commercial fishermen is under-reported (and often unreported). Common practices, such as utilizing menhaden for bait or chum in sportfishing tournaments is difficult to estimate when quantity sales are made to individual marinas and fishing clubs.

Despite problems associated with estimating menhaden bait landings, data collection has improved in many areas. Some states license directed bait fisheries and require detailed landings records. Catch-per-unit-of-effort (CPUE) data, pounds caught per hour set and pounds caught per yard of net set are also reported for directed gill net fisheries in some states. Each state's reported annual bait landings are presented for the period 1985-99 in Appendix A.1.

1.3.1.8 New England Bait Fisheries

In the New England region, purse seine landings in Maine, Massachusetts and Rhode Island account for the majority of the recorded bait landings. In past years, an ocean trap net fishery operated in Rhode Island and Massachusetts. In New Hampshire and Connecticut, smaller directed gill net fisheries are well-regulated and monitored. The bulk of menhaden landings for bait in New England is utilized in the lobster fishery. Schools of large menhaden have been scarce in the New England region since the early 1990s.

1.3.1.9 Mid-Atlantic Bait Fisheries

New Jersey dominates current mid-Atlantic reported bait landings. Reports of catch by fishing area are required by New Jersey under licensing of bait purse seine vessels. Pound nets and gill nets contribute significantly to bait landings in New York and New Jersey. Delaware closely regulates its directed gill net fishery, obtaining detailed catch/effort data each year.

1.3.1.10 Chesapeake Bay Bait Fisheries

Virginia snapper rigs (small purse seiners) dominate the reported menhaden bait landings in the Chesapeake Bay region, as documented in the Captain's Daily Fishing Reports for 1998 and 1999. Pound net landings also contribute significantly in Maryland, Virginia and the Potomac River (PRFC). Most of the catch is used in the blue crab pot fishery.

1.3.1.11 South Atlantic Bait Fisheries

Part of North Carolina's landings are reported directly, while the rest are estimated from fishery-dependent sampling. The principal use for menhaden as bait in North Carolina is in the blue crab pot fishery. South Carolina and Georgia have no directed menhaden fisheries, shrimp trawl bycatch and cast netting supply menhaden to crab potters and sport fishermen in those states. Florida's east coast had substantial menhaden landings for bait from gill nets and purse seines prior to the implementation of a net ban in 1994.

1.3.1.12 Domestic Processing Activities and Products

Menhaden reduction plants, through a process of heating, separating, and drying, produce fish meal, fish oil, and fish solubles from fresh menhaden. Meal is a valuable ingredient in poultry and livestock feeds because of its high protein content (at least 60%). The broiler (chicken) industry is currently the largest user of menhaden meal, followed by the turkey, swine, pet food, and ruminant industries. The aquaculture industry has recently demonstrated an increased demand for fish meal as well.

Menhaden oil has been used for many years as an edible oil in Europe. The oil is refined and used extensively in cooking oils and margarine. In 1989, the United States Food and Drug Administration (FDA) concluded that fully and partially hydrogenated menhaden oil is a safe ingredient for human consumption. In 1990, the FDA proposed an amendment, based on an industry petition, to the standard of identity for margarine to permit the use of marine oils. It was approved in 1997 and could provide a significant new market for omega-3 rich menhaden oil.

Solubles are the aqueous liquid component remaining after oil removal. In general, most meal producers add the soluble component to the meal to create a product termed "full meal." The use of solubles as an export product is limited because most companies in the feed industry are not equipped with the necessary storage tanks, pumps, and meters to handle a liquid product.

The world fish meal industry is in the process of adopting low temperature meal technology, a process which yields significantly higher protein content than previous technologies and produces feed components particularly valuable to aquaculturists. Investment in these new processes represents an opportunity for the U.S. industry to broaden its market base and add value to its products. Public sector support, in the form of research on markets, technology development, and new products, will be a key factor in maintaining the domestic menhaden industry's global competitive status.

1.3.2 Recreational Fishery
No significant directed recreational fisheries exist for menhaden. However, menhaden are an important bait in many recreational fisheries; some recreational fishermen employ cast nets to capture menhaden or snag them with hook and line for use as bait, both dead and live.

1.3.3 Subsistence Fishery
No subsistence fisheries for Atlantic menhaden have been identified at this time.

1.3.4 Non-consumptive Factors
Outside of providing a forage base for various predators and the ecological role which menhaden serve (see *Sections 1.2.1.10; 1.2.1.11; 2.7*), other non-consumptive factors have not been identified at this time.

1.3.5 Interactions with Other Fisheries, Species, and Other Users
Incidental bycatch of other finfish species in menhaden purse seines has been a topic of interest and concern for many years to the commercial and recreational fishing industry, as well as the scientific community (Smith 1896; Christmas et al. 1960; Oviatt 1977). Numerous past studies have shown that there is little or no bycatch in the menhaden purse seine fishery. Some states restrict bycatch to 1% or less of the total catch on a vessel by regulation.

A study of bycatch of other species in the Atlantic menhaden fishery was recently completed through funding provided by the Federal Saltonstall-Kennedy grant program (Austin et al. 1994). The Virginia Institute of Marine Science studied bycatch levels of finfish, turtles, and marine mammals in the Atlantic menhaden fishery. Results from that study indicated that bycatch in the 1992 Atlantic menhaden reduction fishery was minimal, comprising about 0.04% by number. The maximum percentage bycatch occurred in August (0.14%) and was lowest in September (0.002%). Among important recreational species, bluefish accounted for the largest bycatch, 1,206 fish (0.0075% of the total menhaden catch). No marine mammals, sea turtles, or other protected species were killed, captured, entangled or observed during sampling. A concurrent study was conducted by Louisiana State University for the Gulf of Mexico menhaden fishery (de Silva and Condrey 1997).

Additional data are available from the Gulf of Maine IWP fishery in 1991. Every catch unloaded onto the processing vessel was inspected by a state observer. A total of 93 fish were taken as bycatch along with about 60,000,000 individual menhaden (D. Stevenson, Maine DMR, pers. comm.; as cited in ASMFC

1992).

1.4 HABITAT

1.4.1 Physical Description of Habitat

Atlantic menhaden occupy a wide variety of habitats during their life history. Adult Atlantic menhaden spawn primarily offshore in continental shelf waters. Larvae enter estuaries and transform into juveniles, utilizing coastal estuaries as nursery areas before migrating to ocean waters in the fall. They make extensive north-south migrations in the near-shore ocean.

1.4.1.1 Gulf of Maine

The Gulf of Maine is a semi-enclosed sea of 36,300 mi^2 (90,700 km^2) bordered on the east, north and west by the coasts of Nova Scotia, New Brunswick, and the New England states. To the south, the Gulf is open to the North Atlantic Ocean. Below about 165 ft (50 m) depth, however, Georges Bank forms a southern boundary for the Gulf. The interior of the Gulf of Maine is characterized by five major deep basins (>600 ft, 200 m) which are separated by irregular topography that includes shallow ridges, banks, and ledges. Water flows in and out of the Bay of Fundy around Grand Manan Island. Major tributary rivers are the St. John in New Brunswick; St. Croix, Penobscot, Kennebec, Androscoggin, and Saco in Maine; and Merrimack in Massachusetts.

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

The surface circulation of the Gulf of Maine is generally counterclockwise, with an offshore flow at Cape Cod which joins the clockwise gyre on the northern edge of Georges Bank. The counterclockwise gyre in the Gulf is more pronounced in the spring when river runoff adds to the southwesterly flowing coastal current. Surface currents reach velocities of 1.5 knots (80 cm sec) in eastern Maine and the Bay of Fundy region under the influence of extreme tides, up to 30 ft (9 m) and gradually diminish to 0.2 knots (10-20 cm/sec) in Massachusetts Bay where tidal amplitude is about 10 ft (3 m).

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

1.4.1.2 Middle Atlantic Region (Cape Cod, MA to Cape Hatteras, NC)

The coastal zone of the middle Atlantic states varies from a glaciated coastline in southern New England to the flat and swampy coastal plain of North Carolina. Along the coastal plain, the beaches of the barrier islands are wide, gently sloped, and sandy, with gradually deepening offshore waters. The area is characterized by a series of sounds, broad estuaries, large river basins (e.g., Connecticut, Hudson, Delaware, and Susquehanna), and barrier islands. Conspicuous estuarine features are Narragansett Bay (Rhode Island), Long Island Sound and Hudson River (New York), Delaware Bay (New Jersey and Delaware), Chesapeake Bay (Maryland and Virginia), and the nearly continuous band of estuaries behind barrier islands along southern Long Island, New Jersey, Delaware, Maryland, Virginia, and North Carolina. The complex estuary of Currituck, Albemarle, and Pamlico Sounds behind the Outer Banks of North Carolina (covering an area of 2,500 square miles) is an important feature of the region. Coastal marshes border small estuaries in Narragansett Bay and much of the glaciated coast from Cape Cod to Long Island Sound. Nearly continuous marshes occur along the shores of the estuaries behind the barrier islands and around Delaware Bay.

At Cape Hatteras, the Continental Shelf extends seaward approximately 20 mi (33 km), and widens gradually northward to about 68 mi (113 km) off New Jersey and Rhode Island where it is intersected by numerous underwater canyons. Surface circulation north of Cape Hatteras is generally southwesterly during all seasons, although this may be interrupted by coastal indrafting and some reversal of flow at the northern and southern extremities of the area. Speeds of the drift north of Cape Hatteras are on the order of six miles (9.7 km) per day. There may be a shoreward component to this drift during the warm half of the year and an offshore component during the cold half. The western edge of the Gulf Stream meanders in and out off Cape Hatteras, sometimes coming within 12 mi (20 km) of the shore, but it becomes less discrete and veers to the northeast north of the Cape. Surface currents as high as 4 knots (200 cm/sec) have been measured in the Gulf Stream off Cape Hatteras.

Hydrographic conditions in the mid-Atlantic region vary seasonally due to river runoff and warming in spring and cooling in winter. The water column becomes increasingly stratified in the summer and homogeneous in the winter due to fall-winter cooling of surface waters. In winter, the mean range of sea surface temperatures is 0-7°C off Cape Cod and 1-14°C off Cape Charles (at the southern end of the Delmarva Peninsula); in summer, the mean range is 15-21°C off Cape Cod and 20-27°C off Cape Charles. The tidal range averages slightly over 3 ft (1 m) on Cape Cod, decreasing to the west. Within Long Island Sound and along the south shore of Long Island, tide ranges gradually increase, reaching 6 ft (2 m) at the head of the Sound and in the New York Bight. South of the Bight, tide ranges decrease gradually to slightly over 3 ft (1 m) at Cape Hatteras. Prevailing southwest winds during the summer along the Outer Banks often lead to nearshore upwelling of colder bottom water from offshore, so that surface water temperatures can vary widely during that period (15-27°C over a period of a few days).

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

1.4.1.3 South Atlantic Region

The south Atlantic coastal zone extends in a large oceanic bight from Cape Hatteras south to Biscayne

Bay and the Florida Keys. North of Florida it is bordered by a coastal plain that stretches inland for a hundred miles and a broad continental shelf that reaches into the ocean for nearly an equal distance. This broad shelf tapers down to a very narrow and precipitous shelf off the southeastern coast of Florida. The irregular coastline of North Carolina, South Carolina, Georgia, and eastern Florida is generally endowed with extensive bays and estuarine waters, bordered by nutrient-rich marshlands. Barrier beaches and dunes protect much of the shoreline. Along much of the southern coast from central South Carolina to northern Florida estuarine salt-marsh is prominent. Most of the east coast of Florida varies little in general form. Sand beaches with dunes are sporadically interrupted by mangrove swamps and low banks of earth and rock.

The movements of oceanic waters along the South Atlantic coast have not been well defined. The surface currents, countercurrents, and eddies are all affected by environmental factors, particularly by winds. The Gulf Stream flows along the coast at 6-7 miles per hour (10-11 km/hr). It is nearest the coast off southern Florida and gradually moves away from the coast as it flows northward. A gyral current that flows southward inshore of the Gulf Stream exists for most of the year north of Cape Canaveral.

Sea surface temperatures during the winter increase southward from Cape Hatteras to Fort Lauderdale, Florida, with mean minimums ranging from 2-20°C and maximums ranging from 17-26°C. In the summer, the increases are more gradual, ranging north to south from minimums of 21-27°C to maximums of 28-30°C. Mean sea-surface salinity is generally in the range of 34 to 36 ppt year round. Mean tidal range is just over 3 ft (1 m) at Cape Hatteras and increases gradually to about 6-7 ft (2 m) along the Georgia coast. Tides decrease south of Cape Canaveral to 3 ft (1 m) at Fort Lauderdale.

1.4.2 Habitat Quality

Of primary importance is the fact that Atlantic menhaden are estuarine-dependent. Following oceanic spawning, menhaden larvae are transported into the coastal estuaries where they transform into juveniles. They utilize the estuary from low salinity headwaters to high salinity areas near inlets as nursery areas for most of their first year.

Prior to passage of coastal protection laws, principally during the 1970s, wetlands were viewed as wastelands, and dredging and filling was encouraged. Large areas of productive habitat were permanently altered, eliminating their value for fisheries production. Since implementation of coastal habitat protection programs, however, very little of the remaining Atlantic coastal wetlands has been lost. Productivity of the remaining coastal wetlands continues to be compromised, however, by pollution from towns and cities, industry, and run-off from urban surfaces, agriculture, and silviculture. Under current habitat management programs, most Atlantic coast estuaries remain fairly productive. The general migration of the U.S. population to the coastal zone will place increasing stress on estuaries, and protection programs will have to be strengthened.

1.4.3 Environmental Requirements of Atlantic Menhaden (adapted from Rogers and Van Den Avyle (1989)

1.4.3.1 Temperature, Salinity and Dissolved Oxygen

Atlantic menhaden occur through a wide range of physicochemical conditions. Several studies have raised questions about limits of tolerance and optimum conditions. June and Chamberlin (1959) and Reintjes and Pacheco (1966) reported that larval menhaden did not enter estuarine waters at temperatures below 3^{o}C. Many studies have noted an affinity of young menhaden for low salinity waters. Wilkens and Lewis (1971) speculated that larval menhaden require low salinity water to metamorphose properly, and Lewis (1966) found that although larvae metamorphosed in salinities of 15-40 ppt, one-third of the juveniles developed slightly crooked vertebral columns. However, larvae held in the laboratory at 25-40 ppt metamorphosed completely with no abnormalities (Reintjes and Pacheco 1966; Hettler 1981), and larvae trapped in a natural cove at Beaufort, North Carolina, transformed into juveniles at 24-36 ppt (Kroger et al. 1974).

Salinity affects temperature tolerance, activity, metabolism and growth. Low salinities decreased survival at temperatures below 5^{o}C, and survival was poor at 6^{o}C in freshwater (Lewis 1966). The effect of salinity on upper temperature tolerance was not significant (Lewis and Hettler 1968). Larvae that Hettler (1976) reared at 5-10 ppt exhibited significantly higher activity levels, metabolic rates, and growth rates than those reared at 28-34 ppt. Lewis (1966) also noted slower growth at high salinities. Subtle physiological adaptations to low salinity may be an evolutionary response to larvae "seeking" the food-rich estuarine environment. Rogers et al. (1984) noted that pre-juveniles of many fishes, including those of *Brevoortia* species, entered estuarine habitats during seasonal peaks of freshwater influx when the area of low salinity and fresh tidal water was greatest.

A potential management consideration is that, historically, estuarine zones received freshwater from contiguous wetlands and riverine systems. However, channelization, diking of river courses, ditching and draining of marginal wetlands, and urbanization have reduced the freshwater retention capacities of coastal wetlands. Furthermore, extensive filling of estuarine marshlands has diminished the area receiving runoff in many locations. In combination, these changes cause rapid discharge of high volumes of freshwater during brief periods and reduced amounts of freshwater at other times. High inflows, particularly those that occur in early spring after the arrival of pre-juvenile menhaden, can expose fish to extreme fluctuations of temperature, turbidity, and other environmental conditions. Although the effects of altered freshwater flow regimes on Atlantic menhaden are not known, effects on other estuarine-dependent, offshore spawned fishes range from disappearance (Rogers et al. 1984) to death (Nordlie et al. 1982). These effects are also mediated by temperature (Nordlie 1976).

Salinities of 10-30 ppt did not affect developing embryos, though temperature did (Ferraro 1980). Mortality of embryos was complete at temperatures less than 7^{o}C and was significantly higher at 10^{o}C than at 15, 20, and 25^{o}C. Time to hatching was significantly shorter at each progressively higher temperature. Surface temperature in the spawning areas of the South Atlantic Region during the months of highest egg capture were generally 12-20^{o}C (Walford and Wicklund 1968). The lowest temperatures at which Atlantic menhaden eggs and larvae were collected in the North Atlantic region were between 10 and 13^{o}C (Ferraro 1980). The temperature range for the Middle Atlantic region was 0-25^{o}C, but most eggs and larvae were collected at 16-19^{o}C (Kendall and Reintjes 1975).

The limits of larval temperature tolerance are also affected by acclimation time. Survival above 30^{o}C (Lewis and Hettler 1968) and below 5^{o}C (Lewis 1965) was progressively extended by acclimation temperatures closer to test values, suggesting that rapid changes to extreme temperatures are more likely to be lethal than prolonged exposure to slowly changing values. Winter shutdown of power plant operations may result in rapid temperature decreases near the effluent discharge area. Mortality of juvenile Atlantic menhaden to a temperature decrease of 10^{o}C (from 15 to 5^{o}C) was less at rates of decrease of 6.7^{o}C /h or lower than at faster rates. Winter menhaden kills can be minimized by reducing the rate of decrease as the power plant discharge is shut down (Burton et al. 1979).

Hettler and Colby (1979) demonstrated that photoperiod at least partly explains variation in resistance to heat stress. Median lethal time increased linearly with photoperiod at 34^{o}C. They also speculated that it may be important to other types of physiological stress. Lewis and Hettler (1968) observed increased survival of juveniles at 35.5^{o}C with increased dissolved oxygen (DO) saturation. Burton et al. (1980) reported a mean lethal DO concentration of 0.4 mg/l, but warned against interpretation of this value as "safe," in view of the interactive nature of environmental factors. Westman and Nigrelli (1955) observed mass mortalities from gas embolism only in areas with highly variable salinity and organic pollution sufficiently severe to make shellfish unfit for human consumption. Lewis and Hettler (1968) observed decreased survival at high temperatures by fish affected by gill parasites. The interaction of environmental factors must be considered when one defines healthy ranges for an organism.

1.4.3.2 Sediments and Turbidity

The seasonal depth distribution of Atlantic menhaden is tied to migration patterns. Some fish occur year-round in depths of 1 to 200 m (3 to 656 ft). The role of turbidity in Atlantic menhaden biology apparently has not been studied. Blaber and Blaber (1980) proposed that gradients of turbidity, nutrients, and salinity could provide cues that enable fry to locate estuarine nursery areas along the Australian coast. The "seeking" of turbid zones is probably related to differential mortality linked to food supply and predation (Blaber and Blaber 1980; Norcross and Shaw 1984; Rogers and Van Den Avyle 1989).

1.4.3.3 Water Movement

Since Atlantic menhaden spawn predominately in open ocean waters, larvae are dependent on water movement for transport to the inlets and subsequent immigration into the estuaries along the U.S. mid- and south Atlantic coast. Earlier research emphasized across-shelf larval transport mechanisms (Nelson et al. 1977; Checkley et al. 1988). Research results from the NOAA, South Atlantic Bight Recruitment Experiment (SABRE) suggest that across-shelf transport appeared to be associated with shoals such as those off Cape Lookout and Cape Hatteras, and that along-shelf currents may have a more dominate impact on the transport process (Hare et al. 1999). Results of physical computer models suggest that wind-driven circulation appears to be the most prevalent form of water movement (Werner et al. 1999). A movement of Atlantic menhaden larvae from north to south along the mid Atlantic seaboard to the Carolina estuaries during the fall and winter was hypothesized on the basis of computer-modeled movement of passive and vertically-oriented particles (Werner et al. 1999; Hare et al. 1999). The modeled transport patterns were geo-temporally refined on the basis of satellite, sea surface temperature data which permitted the delineation of potential spawning areas (Stegmann et al. 1999). Some empirical evidence relative to the credence of the computer models was presented by Rice et al. (1999). Actual inlet entry and retention in estuarine areas depended on inlet physical characteristics, tidal flows, and vertical distributional behavior of larvae (Forward et al. 1999).

1.4.3.4 Environmental Contaminants

In a study of chlorinated hydrocarbon residues in menhaden fishery products from the Atlantic and Gulf of Mexico, Stout et al. (1981) showed that overall levels have decreased since the late 1960s, although significant differences between years for levels of polychlorinated biphenyls (PCB's) in the South Atlantic region and for dieldrin in the Mid-Atlantic region could not be demonstrated. There was also a general lack of significant differences between areas within years, although this may have been due to the sampling regime. They speculated that PCB levels have remained somewhat high because of leakage from sources established prior to regulation and continued allowance of limited specialty uses. Menhaden oil products carry the highest concentrations of such non-polar compounds and some samples contained levels in excess of USFDA temporary tolerances as of 1977. Warlen et al. (1977) demonstrated that C^{14} - DDT uptake by Atlantic menhaden is dose-dependent, with an assimilation value between 17 and 27%. Application of their model to field data suggested that uptake was by way of plankton and detritus. Little information exists about the toxicity of contaminants to Atlantic menhaden (Rogers and Van Den Avyle 1989).

1.4.3.5 Substrate and System Features

The association of Atlantic menhaden with estuarine and nearshore systems during all phases of its life cycle is well documented. It is evident that young menhaden require these food rich waters to survive and grow, and the fishery is concentrated near major estuarine systems. Filling of estuarine wetlands, in addition to exacerbating extremes in environmental conditions, has physically limited the nursery habitat available to Atlantic menhaden and other estuarine-dependent species. The relative importance, however, of different habitat types (i.e. sounds, channels, marshes) and salinity regimes has received little detailed attention (Rogers and Van Den Avyle 1989).

1.4.4 Identification and Distribution of Essential Habitat

Almost all of the estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia, serve as important habitat for juvenile and/or adult Atlantic menhaden. Spawning occurs in oceanic waters along the Continental Shelf, as well as in sounds and bays in the northern extent of their range (Judy and Lewis 1983). Larvae are carried by inshore currents into estuaries from May to October in the New England area, from October to June in the mid-Atlantic area, and from December to May in the south Atlantic area (Reintjes and Pacheco 1966). After entering the estuary, larvae congregate in large concentrations near the upstream limits of the tidal zone, where they undergo metamorphosis into juveniles (June and Chamberlin 1959). The relative densities of juvenile menhaden have been shown to be positively correlated with higher chlorophyll *a* levels in the lower salinity zones of estuaries (Friedland et al. 1996). As juvenile menhaden grow and develop, they form dense schools and range throughout the lower salinity portions of the estuary, most eventually migrating to the ocean in late fall-winter.

Many factors in the estuarine environment affect the behavior and well-being of menhaden. The combined influence of weather, tides, and river flow can expose estuarine fish to rapid changes in temperature and salinity. It has been reported that salinity affects menhaden temperature tolerance, activity and metabolic levels, and growth (Lewis 1966; Hettler 1976). Factors such as waves, currents, turbidity, and dissolved oxygen levels can impact the suitability of the habitat, as well as the distribution of fish and their feeding behavior (Reintjes and Pacheco 1966). However, the most important factors affecting natural mortality in Atlantic menhaden are considered to be predators, parasites and fluctuating environmental conditions (Reish et al. 1985).

It is clearly evident that estuarine and coastal areas along the Atlantic coast provide essential habitat for most life stages of Atlantic menhaden. However, an increasing number of people live near the coast, which precipitates associated industrial and municipal expansion, thus, accelerating competition for use of the same habitats. Consequently, estuarine and coastal habitats have been significantly reduced and continue to be stressed adversely by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human-related activities.

Estuaries of the mid-Atlantic and south Atlantic states provide almost all of the nursery areas utilized by Atlantic menhaden. Areas such as Chesapeake Bay and the Albemarle-Pamlico system are especially susceptible to pollution because they are generally shallow, have a high total volume relative to freshwater inflow, low tidal exchange, and a long retention time. Most tributaries of these systems originate in the Coastal Plain and have relatively little freshwater flow to remove pollutants. Shorelines of most estuarine areas are becoming increasingly developed, even with existing habitat protection programs. Thus, the specific habitats of greatest long-term importance to the menhaden stock and fishery are increasingly at risk.

1.4.5 Anthropogenic Impacts on Atlantic Menhaden and their Habitat

Pollution and habitat degradation threaten the Atlantic menhaden population, particularly during the estuarine residency of larvae and juveniles. Concern has been expressed (Ahrenholz et al. 1987b) that the outbreaks of ulcerative mycosis in the 1980s may have been symptomatic of deteriorating water quality in estuarine waters along the east coast. The growth of the human population and increasing development in the coastal zone are expected to further reduce water quality unless steps are taken to ameliorate their effect on the environment (Cross et al. 1985). Other potential threats to the coastal menhaden population are posed by offshore dumping of sewage sludge, dredge spoil, and industrial wastes, as well as oil spills. Stout et al. (1981) showed that overall levels of chlorinated hydrocarbons in menhaden products have declined since the late 1960s. Warlen et al. (1977) showed that DDT was taken up by menhaden as a result of their feeding on plankton and detritus.

1.4.6 Description of Programs to Protect, Restore, Preserve and Enhance Atlantic Menhaden Habitat

The federal Coastal Zone Management Act provides a framework under which individual coastal states have developed their own coastal habitat protection programs. In general, wholesale dredging and filling are not allowed. Individual development projects are subject to state and federal review and permit limitations. Every Atlantic coast state has a coastal habitat protection program in place (Table 11.27 in ASMFC 1992). These protection programs have greatly reduced the loss of vital coastal habitat to dredging and filling since the mid-1970s. Virtually all proposals affecting coastal habitat are now reviewed by a variety of local, state, and federal agencies, and wholesale destruction of coastal wetlands is rare. Many important estuarine habitats are now protected as part of various wildlife refuges, national and state parks, and public and private nature preserves. In addition, a federal permit program is conducted by the U.S. Army Corps of Engineers, generally in cooperation with the state programs. Every state also conducts water quality protection programs under the federal Clean Water Act. National Pollution Discharge Elimination System permits are required for point-source discharges. Unfortunately, these programs provide much less control over non-point pollution, especially that originating from agricultural and silvicultural activities.

1.4.7 Recommendations for Further Habitat Research

There are currently two sensitive types of habitat that need immediate research attention. One of these types are estuarine inlets. The impact of jetties or groins and dredging at or near inlets on the success of larval menhaden immigration needs to be determined. The upstream, low salinity zones are also very critical. These zones (normally with single digit salinities) appear to be the areas where menhaden larval to juvenile transformation takes place, as well as early juvenile growth. This type of habitat area is highly vulnerable to anthropogenic effects. Sources of nutrients and contaminants as well as threshold levels for a variety of impacts such as ulcerative mycosis, anoxic zones, and *Pfiesteria* and *Pfiesteria*-

like dinoflagellate blooms and fish kills, should be determined.

1.5 IMPACTS OF THE FISHERY MANAGEMENT PROGRAM

1.5.1 Biological and Environmental Impacts

1.5.1.1 Management Areas
No new management areas are proposed in this amendment, therefore impacts should be minimal.

1.5.1.2 Overfishing Definition
The new reference points contained in the ovefishing definition are more conservative than the previous management approach. Implementation of new management measures, if and when necessary, will prevent fishing mortality rates and harvest levels from approaching levels seen in the past. However, since the reduction fishery has consolidated, future harvest levels should remain within the scope allowed by the overfishing definition.

1.5.1.3 Stock Rebuilding Program
In the event that the Atlantic menhaden stock becomes overfished or depleted, the Board will recommend measures to rebuild the stock in a timeframe not to exceed ten years. Rebuilding may be accomplished in as little as one year, the actual time will depend on a number of factors including recruitment, population age structure, ecological and environmental factors, and fishery conditions. Given the retrospective problems with the stock assessment, this timeframe should act as a buffer of sorts to allow the Board to evaluate the necessity and urgency of implementing new regulations.

1.5.1.4 Spawning Area Restrictions
No specific measures are to be implemented through this amendment to protect menhaden as they gather to spawn. Some spawning occurs throughout the year and as such, states that have implemented area closures have created sanctuaries for both spawning menhaden and juvenile nursery areas.

1.5.1.5 Specification of MSY, OY
No negative impacts can be identified at this time related to the inability to estimate maximum sustainable yield (MSY) or optimum yield (OY). Current harvest levels are well below previous estimates of MSY so the chance of overharvesting should be minimal.

1.5.1.6 Internal Waters Processing (IWP) Recommendations
Amendment 1 continues essentially the same process for evaluating the suitability of IWP applications that the Board had in place for the 1992 FMP. All applications are to be reviewed by the technical committee and based on stock status, the Board will provide recommendations to the state(s) applying for an IWP operation.

1.5.1.7 Data Collection and Reporting Requirements
Implementing reporting criteria for menhaden bait fishermen that are not currently reporting will cause some minimal impacts due to increasing the time needed to fill out reports.

1.5.1.8 FMP Monitoring

No negative impacts to fishermen can be identified at this time related to the FMP monitoring process laid out in Amendment 1. Conducting an annual review of stock status and the fisheries ensures that a consistent approach to evaluating existing menhaden management measures remains in place.

1.5.1.9 Catch Controls

Limiting the catch by imposing a simple quota would not serve to protect the younger age-classes and could reduce income to both the fishermen and the companies.

1.5.1.10 Effort Controls

Limiting effort would have the adverse effects of limiting or reducing the number of crews hired or reducing the length of the season of employment. They could be inspired to work harder while they are fishing and the companies would be encouraged to make their units of effort more effective, thus offsetting the effect of a reduction in effort.

1.5.1.11 Gear Regulations

Limiting the catch by a mesh size restriction would make the fishing unit less effective and would temporarily reduce income to the workers and firms somewhat. However, they would have the option of searching for larger fish and perhaps offsetting this reduction in income to some degree. It would have the beneficial effect of reducing mortality on the smaller fish in any given area, and could be designed to spread the burden of mortality reduction on the younger age-classes over the geographic range of the fishery.

1.5.1.12 Season or Area Closures

Limiting the length of the season would have essentially the same effect as limiting effort. Efficiency may be increased and the season of employment would be reduced.

Limiting the area of fishing would have an effect similar to limiting season, but might increase travel time to fishing grounds. Numerous areas closed to the menhaden reduction fishery are already in place along the Atlantic coast.

1.5.1.13 Measures to Reduce/Monitor Bycatch

No measures are implemented through Amendment 1 to reduce or monitor bycatch in menhaden fisheries. If future problems are identified, the Board will evaluate potential solutions and implement measures as necessary.

1.5.1.14 Management Institutions

Restructuring the Menhaden Management Board to reflect the composition of all other Commission boards will allay some of the concerns expressed by the public citing potential conflict of interest. What the Board loses in terms of first-hand experience and advice at the Board level should be incorporated into the Advisory Panel process and be available for the Board’s consideration.

Positive impacts such as a more inclusive process for the states will be realized by a reconstituted technical committee, which will also lead to the sharing of more information among the states/jurisdictions.

By forming an Advisory Panel similar to those for other Commission-managed species, the Board will incorporate the perspective of a wider group of participants into the management process.

1.5.1.15 No Action

The menhaden fishery would be managed under the existing rules and regulations enforced throughout the Atlantic coastal fishery by the individual states/jurisdictions. Management would be piecemeal and subject to regional perceptions and influences.

This option would allow existing fisheries to operate so that the participants can maximize their benefits (full flexibility given existing regulations), with minimal additional costs to administer and enforce. However, taking no action may lead to over-exploitation of the resource resulting in significant economic problems in the menhaden fisheries as well as fisheries for species that feed on menhaden. Increased disruptions to the marine ecosystem may also occur which could lead to additional problems. No action may also lead to increased social and political conflicts and could also result in additional area closures based on socio-economic concerns rather than a biological basis.

This option also assumes the stock is healthy. Given the results of the Peer Review Panel, discussions at the Management Board level, and public comment, this is not a viable option at this time.

1.5.2 Social Impacts

An analysis of the social impacts of the measures included in this amendment are not available at this time.

1.5.3 Economic Impacts

An analysis of the economic impacts of the measures included in this amendment are not available at this time.

1.5.4 Other Resource Management Efforts

Single species management of various predators of Atlantic menhaden will have a direct effect on the status of the menhaden population and should be considered in a multispecies management approach. Such an approach is not available at this time but the Commission has sponsored a workshop to investigate the feasibility of various modeling approaches in relation to Atlantic menhaden and has awarded a grant to develop a multispecies model incorporating menhaden, striped bass, bluefish and weakfish abundance and interactions. Results of this effort should ultimately lead to a better understanding of the dynamics involving these species and could lead to alternative management approaches in the future.

Habitat and water quality management efforts can also impact the status of the menhaden population.

1.6 LOCATION OF TECHNICAL DOCUMENTATION FOR AMENDMENT 1

1.6.1 Review of Resource Life History and Biological Relationships

Atlantic menhaden life history information was summarized by Arhenholz (1991) and Rogers and Van Den Avyle (1989).

1.6.2 Stock Assessment Documentation

Detailed information pertaining to the menhaden stock assessment and methodology can be found in the report of the Menhaden Peer Review Panel (ASMFC 1999a), and in the following research publications: Vaughan (1993); Cadrin and Vaughan (1997); and Vaughan et al. (in press). Annual assessment updates have been prepared and the results are found in the most recent report of the technical and advisory committee (AMAC 2000).

1.6.3 Social Assessment Documentation

No recent studies have been conducted to assess the social characteristics of the menhaden fisheries. The most recent information is included in the 1992 FMP (ASMFC 1992).

1.6.4 Economic Assessment Documentation

No recent studies have been conducted to assess the economic characteristics of the menhaden fisheries. The most recent information is included in the 1992 FMP (ASMFC 1992).

1.6.5 Law Enforcement Assessment Documentation

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 Documentation

A full documentation of habitat information pertaining to Atlantic menhaden is being prepared and will be incorporated in the Source Document for Amendment 1.

2. GOALS AND OBJECTIVES

2.1 HISTORY AND PURPOSE OF THE PLAN

2.1.1 History of Prior Management Actions

The original Atlantic menhaden fishery management plan (FMP) was prepared during 1976-1981 (AMMB 1981) and approved by the Atlantic States Marine Fisheries Commission (Commission) in October, 1981. This plan did not recommend any specific management measures, but provided a discussion of options, should they be needed. In 1982, the Atlantic Menhaden Management Board (AMMB) recommended seasonal limits as a means to provide long-term benefits to the fishery. The recommendation was approved by the Commission and referred to the states for implementation. Full implementation was not achieved. Changes in operation of the Commission's Interstate Fisheries Management Program (ISFMP), of which the menhaden program is a component, resulted in disbanding the AMMB during the mid-1980s. Oversight for the menhaden program passed to the ISFMP Policy Board, which was concerned with numerous fishery management plans (FMPs) in addition to menhaden.

Major changes occurred in the Atlantic menhaden industry since the completion of the 1981 Atlantic Menhaden FMP (AMMB 1981). The Atlantic fishery became relatively more important due, in part, to improvement of the Atlantic menhaden population and a decrease in Gulf of Mexico landings. However, state government regulatory actions, local government land use rules, and changing economic conditions combined have resulted in plant closures (Table 8). During the mid-1980s, historical low prices occurred for fish meal, while oil prices fell to lows during 1987 and 1989-90. Menhaden companies have either gone out of business or have adapted with internal restructuring, as well as adopting new organizational procedures and technology. An Internal Waters Processing (IWP) fishery operated in Maine waters from 1988-93, which maintained the menhaden fishing industry in that area. Controversy over operation of menhaden boats in coastal waters has caused the closure of some states' waters and restricted access in others. Currently, New Hampshire, New York, Connecticut, New Jersey, Maine, Rhode Island, Virginia, and North Carolina have established seasons for menhaden purse seine fishing. Purse seine fishing is prohibited in Maryland, Delaware, South Carolina and Florida.

A number of developments in the late 1980s greatly affected the Atlantic menhaden fishery, resulting in the need to amend the 1981 FMP. The most important of these developments included the following:

1. The Atlantic menhaden stock progressed toward recovery from a severely depressed condition during the mid 1960s-mid 1970s to the point where it was considered healthy in the early 1990s. There was an improved spawning stock biomass, good recruitment, and improved age structure. Commercial fishing continued throughout this period of recovery, although at a less intensive level.

2. Most Atlantic menhaden processing plants operating in 1981 were closed by 1988. Of 11 plants which processed menhaden along the United States Atlantic coast in 1981, only two are still in business. Closures were related to international market conditions which affect the prices of menhaden products, as well as to localized social problems involving menhaden processing plants and neighboring residential areas. Thus, the processing sector of the industry has changed significantly in the last few years.

3. In 1987, a Canadian plant began processing menhaden caught by United States vessels in the Gulf of Maine, the first direct foreign use of menhaden as a raw product.

4. In 1988, a Maine company contracted with the Soviet Union to conduct an Internal Waters Processing (IWP) venture in the Gulf of Maine under Section 306 of the Magnuson Fishery Conservation and Management Act of 1976. About 7-10 small purse-seine vessels supplied raw product to the Russian factory processing ship anchored within the internal territorial waters of the State of Maine. The IWP provisions of the Magnuson Act opened new harvesting and processing opportunities which were not considered in the original FMP.

5. Research on specialty meals for aquaculture, the use of menhaden oil for human food and medicinal products in the United States, and potential production of surimi from fresh menhaden gave promise for development of diversified products and markets for the menhaden industry.

In light of these and other social and economic developments, the Commission determined in 1988 that the 1981 Menhaden FMP was no longer sufficient to guide management of the fishery and authorized preparation of a revision to the plan. The "Atlantic Menhaden Fishery Management Plan, 1992 Revision" was prepared by the Atlantic Menhaden Advisory Committee (AMAC) under the Commission's ISFMP. This revision replaced the Commission's 1981 Menhaden FMP, which had been rendered obsolete by significant changes in the Atlantic menhaden stock and fishery.

The goal of the 1992 plan revision was *"To manage the menhaden fishery in a manner that is biologically, economically, and socially sound, while protecting the resource and its users"*. Plan objectives included public education; continuation of the existing fishery monitoring program; improvement in collection of data on menhaden taken in directed bait fisheries and as bycatch in other fisheries; improvement of the Captains Daily Fishing Report program; promotion of needed research on biological, economic, sociological, and habitat issues; encouragement of product research; maintenance of an adequate stock; optimal utilization of the available resource; habitat maintenance and enhancement; and utilization of the best available scientific data as the basis for coordinated management actions.

Regulatory authority over the Atlantic menhaden fishery is vested in the coastal states rather than the federal government. The vast majority of the harvest occurs in waters under state jurisdiction.

Under the 1992 FMP, the menhaden program has functioned under the Commission's ISFMP, with direction provided by the Atlantic Menhaden Management Board, composed of up to five state directors, up to five industry representatives, one National Marine Fisheries Service member, and one representative from the National Fish Meal and Oil Association. In 1997, the ISFMP Policy Board approved the addition of four new members to the Menhaden Board, one Legislative Commissioner, one Governor's Appointee Commissioner, and two public representatives. The Menhaden Board designates the members of AMAC, the technical and advisory committee which conducts the analytical activities for the program.

Members of AMAC have expertise in menhaden life history, fishing, processing, and population dynamics. Each spring, AMAC conducts three specific tasks: 1) review of the status of the stock and fishery relative to six defined "triggers" [landings, proportion of age-0 fish in the catch, proportion of adults (age 3^+) in the catch, recruitment to age 1, spawning stock biomass, and percent maximum spawning potential]; 2) review of state applications for allocation of menhaden for harvest under internal waters processing (IWP) arrangements as provided in Section 306 of the Magnuson Fishery Conservation and Management Act (PL 94-265); and 3) review of implementation status of the plan, including any recommendations for regulatory action.

Public concern over inclusion of industry representatives as members of the management body was one of the reasons for developing Amendment 1. This amendment, once adopted by the Commission, modifies the entire management structure for the menhaden fishery including a new management board constituted in the same or similar fashion as other Commission management boards, with separate technical and advisory committees.

2.1.2 Regulatory Trend

Since 1981, a number of areas along the Atlantic coast have been closed to menhaden purse seine fishing. These closures were not recommended in the 1981 FMP, nor were they based on the biological condition of the stock at that time. Combined with national and international economic factors, the closures affected the viability of the Atlantic menhaden industry in spite of improved stock conditions during the 1980s. Some states have closed specific riverine, estuarine, or near-shore ocean areas to menhaden purse seine fishing. Other states have more general area closures, such as in New Jersey where menhaden purse seine fishing for reduction is not allowed within 1.2 mi (1.9 km) of shore. Menhaden purse seine fishing is not allowed at all in the state waters of South Carolina, Maryland, and Delaware. State officials have often responded to pressure groups by restricting purse seine fishing access to traditional fishing grounds as conflicts have developed. Such decisions have generally not been based on analyses of biological or economic data.

2.1.3 Conflict and Competition in the Menhaden Fishery

Management of coastal fisheries is inherently controversial because of the wide range of interests involved and the need to protect critical habitat. Conflict occurs when the activity of a group or individual interferes, either in reality or in perception, with the activities of another group or individual to such an extent that one party seeks dominance over the other. Competition takes place in fisheries when groups or individuals seek the same resource using different methods or try to utilize the same space for their activities, with neither party seeking dominance (Maiolo 1981). Both competition and conflict occur, depending on one's view, among the purse seine fishery, other fisheries, and other users of coastal resources.

As use of public waters, especially in the estuary and near-shore ocean areas, has grown, competition for space has increased, escalating spatial competition to conflict in some areas. In most states, various areas are closed to menhaden purse seining to separate purse seiners from other commercial gears, such as crab and lobster pots or pound nets; to separate commercial from sport fishing activities; or to protect other uses of the coastal zone. Today's menhaden fleet is greatly reduced in the number of vessels from that of the past, but most of the vessels are quite large and operate during the peak tourist and sport fishing seasons (summer/fall) in areas where marine sportfishing is concentrated. Most conflicts have occurred in North Carolina, Virginia, Delaware, New Jersey, and New York.

The natural behavior of menhaden generates spatial competition. Menhaden are not randomly distributed; they form dense schools in limited areas at any given time during the fishing season, principally in estuarine and near-shore ocean waters. For purse seine vessels to harvest them, the vessels must go to the fish, often bringing these large vessels into areas near tourist facilities or with concentrations of sport fishermen. The mere sight of menhaden vessels sometimes elicits telephone calls expressing concern to state agencies.

Menhaden serve as a forage fish for sport fish, such as striped bass (Versar, Inc. 1990), bluefish (Wilk 1977), weakfish (Merriner 1975), and king mackerel (Saloman and Naughton 1983). Because menhaden serve this ecological role, some anglers insist that menhaden be abundantly available as prey for fishes higher in the food chain. The above studies all show that the noted game fish consume many other food items besides menhaden. In addition, especially in the south Atlantic area, sport fishermen harvest live menhaden for bait to use in the "slow trolling" method of fishing, which is quite selective for large king mackerel.

A perception frequently cited by anglers is that menhaden purse seines "entrap all fish within a large chunk of water. Anything bigger than a few inches is rounded up, and pulled alongside ..." the menhaden vessels (Richard 1989). Studies on the menhaden bycatch issue have been conducted since the late 1800s (Smith 1896) to more recent times (Knapp 1950; Baughman 1950; Christmas et al. 1960; Gunter 1964; White and Lane 1968; Ganz 1975; Oviatt 1977; Guillory and Hutton 1982; Austin et al. 1994). Bycatches have been extremely low, generally zero or much less than 1%, with thousands of sets examined over the years. Most of the bycatch in the historical studies has been of species of little importance to anglers, such as alewife, mullet, threadfin shad, and sea catfish. States which allow menhaden purse seine fishing generally have a limit on bycatch; for example, a 1% bycatch of foodfish is allowed in Virginia (by weight) and North Carolina (by number).

No studies have shown that the menhaden purse seine fishery has any significant biological effect on any other species or fishery. Yet, conflicts have developed from misconceptions concerning the competition and a lack of acceptance of scientific evidence demonstrated by many years of research. It can be concluded that existing competition between the menhaden fishery and other fisheries has been principally for space rather than for menhaden.

In an effort to reduce conflicts, the menhaden industry instituted an education program for other fishermen, management agencies, and the general public. These efforts included taking interested persons on their vessels to observe fishing activities. Individual menhaden companies follow internal codes of conduct for their fishing operations indicating the industry's concern with other fisheries and water-based activities. Areas addressed include cooperation with management agencies, adherence to water quality standards, and courtesy in vessel operations.

2.1.4 Purpose and Need for Action

Atlantic menhaden are currently managed through the Commission’s 1992 Atlantic Menhaden Fishery Management Plan (FMP) (ASMFC 1992). The menhaden program functions under the Commission’s ISFMP, with immediate oversight provided by the Atlantic Menhaden Management Board. One of the reasons the Commission initiated this amendment was to examine the structure of the menhaden management process. Concerns were raised over the mixed composition of both the management board and the joint technical/advisory committee because they differed from the traditional board/technical committee structure in all other Commission fishery management programs.

Concern over declines in the Atlantic menhaden population led the Menhaden Board to recommend that the Commission conduct an external peer review of the menhaden stock assessment which is conducted annually through AMAC. This peer review was completed in November 1998 and provided recommendations for improving the assessment and management of menhaden (ASMFC 1999b). Upon receiving the report of the Peer Review Panel in January 1999, the Board recommended that a full amendment to the 1992 FMP be developed and that the recommendations of the Peer Review Panel be addressed through the development of the amendment. Concerns over apparent reductions in the forage fish base in Chesapeake Bay and northeastern Florida have also been expressed by members of the public and state fisheries personnel.

In 1998, AMAC also suggested that changes to the menhaden management process be addressed through an addendum to the current FMP (AMAC 1998). The addendum would address: 1) updating the FMP in accordance with changes to the Commission’s ISFMP FMP outline; 2) updating the data with particular attention to the 1998 reduction of the Virginia fleet; 3) strengthening the Habitat section of the FMP; and 4) examining the biological reference points (trigger levels) based on recent data and analyses.

The Atlantic menhaden spawning stock is currently considered to be healthy, although there has been a decline in recruitment over the last ten years (Fig. 1) (AMAC 2000). The overall spawning stock biomass is currently high, but is expected to decline over the next few years unless the trend in recruitment is reversed. There has also been a general decline in the stock size (numbers and biomass), concurrent with the decline in recruitment.

The primary concern over management of the stock appears to be the allocation of fish between fisheries and ecological functions. Recreational fishing and environmental groups have emphasized the forage role of menhaden for piscivorous fishes and its ecological role in filtering phytoplankton. Commercial fisheries interests advocate maintenance of the traditional reduction and bait fisheries. In recent years there have been allegations that sport fishing may be negatively affected by menhaden purse seine fishing in the same general areas; data are not presently available to evaluate this issue.

2.2 GOAL

The goal of Amendment 1 to the Interstate Fishery Management Plan for Atlantic Menhaden is:

> “To manage the Atlantic menhaden fishery in a manner that is biologically, economically, socially and ecologically sound, while protecting the resource and those who benefit from it.”

2.3 OBJECTIVES

In support of this goal, the following objectives are recommended for Amendment 1:

<u>Biological Objectives</u>

< Protect and maintain the Atlantic menhaden stock at levels to maintain viable fisheries and the forage base with sufficient spawning stock biomass to prevent stock depletion and guard against recruitment failure.

< Maintain a uniform data collection system for the reduction fishery and develop new protocols for other harvesting sectors, including biological, economic, and sociological data (ACCSP protocols as a minimum; NMFS reduction fishery monitoring system should be continued).

< Evaluate, develop, and improve approaches or methodologies for stock assessment including fishery-independent surveys and variable natural mortality at age or by area.

< Optimize utilization of the resource within the constraints imposed by distribution of the resource, available fishing areas, and harvest capacity.

<u>Social/Economic Objectives</u>

< Maintain existing social and cultural features of the fishery to the extent possible.

< Develop a public information program for Atlantic menhaden, including the fishery, biology, estuarine ecology and role of menhaden in the ecosystem.

<u>Ecological Objectives</u>

< Protect fishery habitats and water quality in the nursery grounds to insure recruitment levels are adequate to support and maintain a healthy menhaden population.

< Improve understanding of menhaden biology, food web ecology and multispecies interactions that may bear upon predator-prey and recruitment dynamics.

< Protect and maintain the important ecological role Atlantic menhaden play along the coast.

Management Objectives

< Insure adequate accessibility to fishing grounds.

< Develop options or programs to control or limit effort, and regulate fishing mortality by time or area.

< Base regulatory measures upon the best available scientific information and coordinate management efforts among the various political entities having jurisdiction over the fisheries.

2.4 SPECIFICATION OF THE MANAGEMENT UNIT

The management unit for Amendment 1 is defined as the Atlantic menhaden resource throughout the range of the species within U.S. waters of the northwest Atlantic Ocean from the estuaries eastward to the offshore boundary of the EEZ. This definition is consistent with recent stock assessments which treat the entire resource in U.S. waters of the northwest Atlantic as a single stock. It is also recognized that the menhaden resource, as defined here, is interstate and state-federal in nature, and that effective assessment and management can be enhanced through cooperative efforts with all Atlantic coast state and federal scientists and fisheries managers.

2.4.1 Management Area

The management area for Amendment 1 shall be the entire coastwide distribution of the resource.

2.5 DEFINITION OF OVERFISHING

There are two broad strategies for defining overfishing in practice today: 1) fishing mortality rate (F) strategies, and 2) (spawning) stock biomass (SB) strategies. Fishing mortality-based reference points are designed to prevent F from getting too high which could result in a subsequent decline in the population because individuals are being removed at too fast of a rate. Spawning stock biomass (SSB) based reference points are designed to prevent SSB from getting too low and compromising the ability of the stock to replenish itself. To accurately categorize the status of a stock one should look at both fishing mortality and biomass, simultaneously (Figure 10).

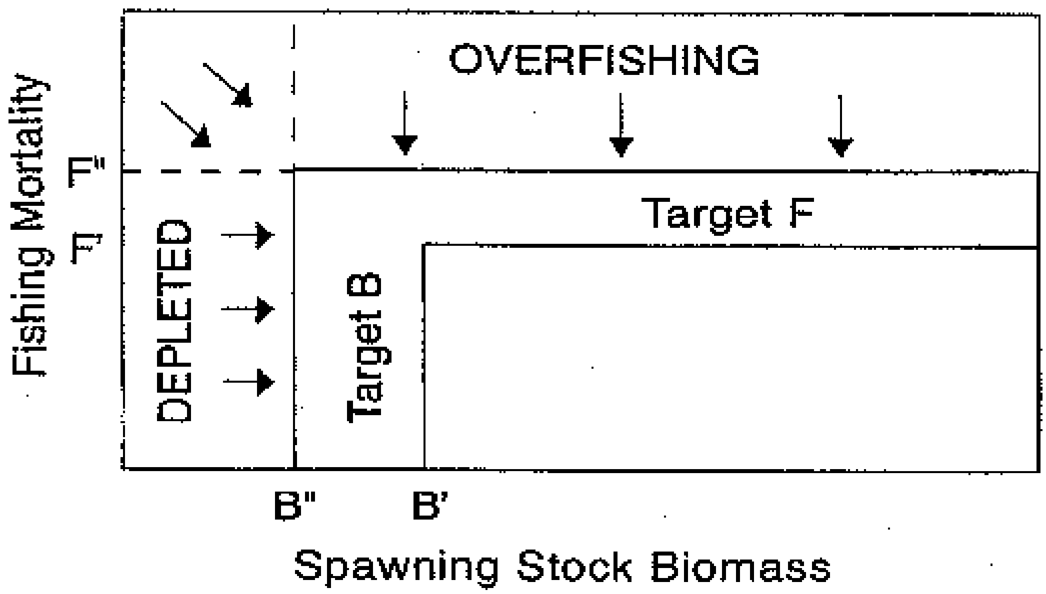

Figure 10. Generalized representation of overfishing definition utilizing both spawning stock biomass (B', B") and fishing mortality (F', F") targets and thresholds (modified from Mace et al. 1996).

A target and threshold approach will be used to define stock status of Atlantic menhaden incorporating both fishing mortality and spawning stock biomass reference points. The Management Board has adopted F_{max} (F = 1.04) and F_{rep} (F = 1.33) as the fishing mortality target and threshold, respectively, for the Atlantic menhaden overfishing definition (Figures 11 & 12). Furthermore, the Board has adopted a spawning stock biomass target of 37,400 mt (as a proxy for B_{MSY}) and a spawning stock biomass of 20,570 mt as the threshold level, or Minimum Spawning Stock Threshold (MSST), where:

$$[MSST = (1 - M) \times B_{MSY} = (1 - 0.45) \times 37{,}400 = 20{,}570].$$

These biological reference points are based on widely accepted analytical models and seem to also track the historical database for menhaden. The proposed target (F=1.04) and threshold (F=1.33) levels for fishing mortality are similar to the 25^{th} and 50^{th} percentiles for 1955-99 (F=1.13 and F=1.39) (Table 12). The proposed target (37,400 mt) and threshold (20,570 mt) levels of spawning stock biomass are also similar to the 25^{th} and 50^{th} percentiles (20,900 and 40,400 mt respectively).

The Management Board will evaluate both sets of reference points before proposing any additional management measures. In general, if the current F exceeds the threshold level of 1.33, the Board should take steps to reduce F to the target level; if current F exceeds the target (1.04), but is below the threshold, the Board should consider steps to reduce F to the target level. If current F is below the target F, then no action would be necessary to reduce F. Likewise, if the SSB falls below its threshold level of 20,570 mt, action would have to be taken to allow the stock to rebuild. If SSB is above the threshold but below the

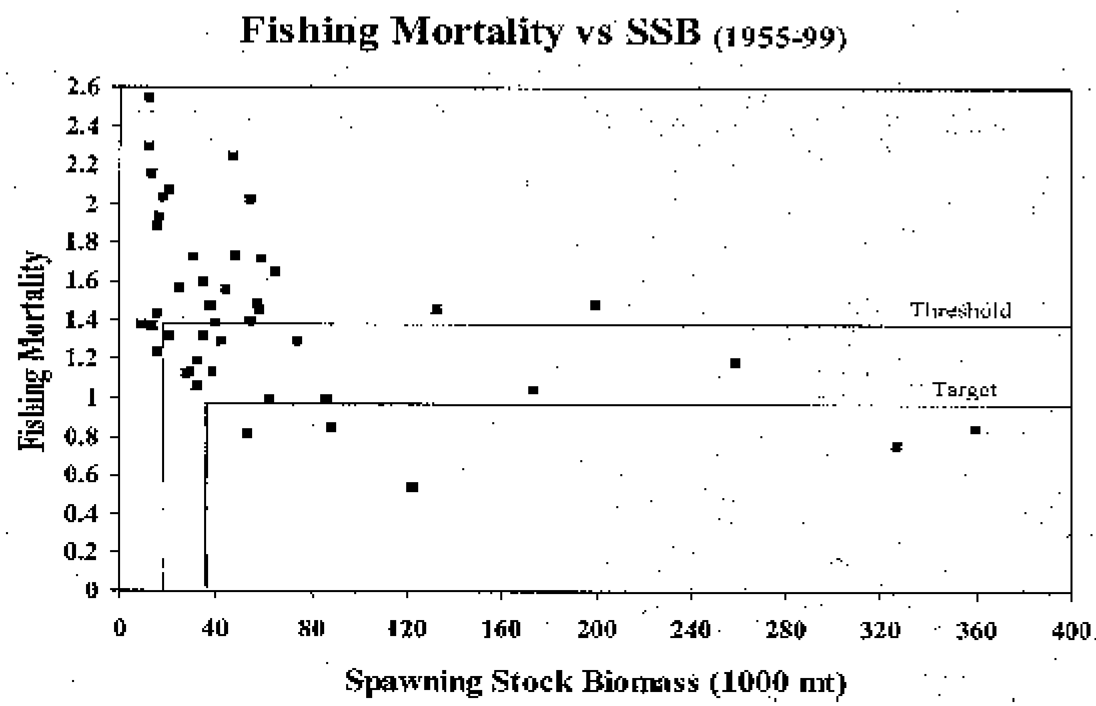

Figure 11. Graphic representation of Atlantic menhaden overfishing definition including historical data points, 1955-99.

target, the Board should consider taking steps to encourage stock rebuilding. If SSB is above the target of 37,400 mt no action would be required. There may be times when one of the reference points is exceeded but not the other. In those cases the Board will consider the relative risk of the situation to stock status before proposing or taking any new action.

Preliminary projections of Atlantic menhaden spawning stock biomass based on F = 1.0 and historical recruitment levels observed from 1955-99, result in an estimated mean SSB of 75,000 mt over the next 25 years (Vaughan et al. in press). These analyses have also demonstrated that varying fishing mortality has virtually no effect on future recruitment of Atlantic menhaden.

Future SSB targets and thresholds could change based on a new choice for the fishing mortality target and threshold, i.e. SSB could be higher given a choice of a lower fishing mortality. This could address concerns that the targets and thresholds should be more conservative to alleviate concerns over the ecological role of menhaden (to provide more forage and filtering capacity). More conservative reference points would also allow the Board more time to react in a timely fashion to changes in stock status and fishing pressure if the proposed reference points in Amendment 1 are not adequate.

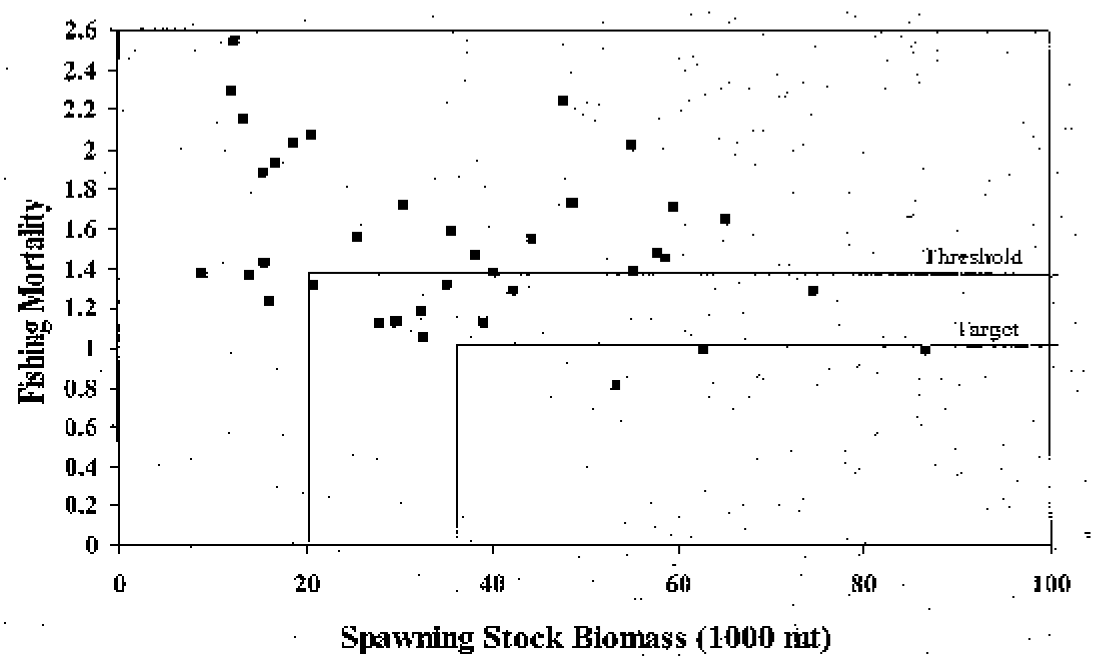

**Figure 12. Graphic representation of Atlantic menhaden overfishing definition including historical
data points, 1963-99.**

2.6 STOCK REBUILDING PROGRAM

Should the stock be defined as overfished or depleted, the Management Board will take action to recover the stock to the desired target level (in terms of spawning stock biomass). The SSB target level, based on the proposed overfishing definition, is 37,400 mt. Should it be determined that overfishing is occurring (F greater than 1.04), the Management Board will take action to reduce the fishing mortality on the stock to at least the desired target level. If fishing mortality exceeds the threshold level and SSB is less than the proposed threshold level, the Management Board must act immediately to reduce fishing mortality to the desired target level or lower.

2.6.1 Stock Rebuilding Targets

When the Atlantic menhaden stock is defined as depleted or overfished (i.e. falls below the biomass target of 37,400 mt), the Management Board shall take action to rebuild the spawning stock biomass (SSB) to the target level in a time-frame consistent with *Section 2.6.2.*

2.6.2 Stock Rebuilding Schedules

The Board shall take action to rebuild the Atlantic menhaden stock to at least the target biomass level in a time frame that shall be no longer than 10 years.

2.6.3 Maintenance of Age Structure

The Technical Committee will monitor the age structure through the current VPA methodology and report to the Board the results, as provided in *Section 3.1* (Assessment of Annual Age/Size Structure).

It would prove difficult to manage this stock to ensure that a certain percentage of the population is made up of a certain number of age-classes since it is currently difficult, if not impossible, to get an accurate picture of the younger age-classes without a fishery-independent survey. It may become increasingly difficult to accurately sample the overall population due to the consolidation of the fishery and its limited geographic range. Changes in reduction fishery practices have also resulted in a reduced harvest of juvenile fish since the late 1980s-early 1990s.

Table 12. Potential biological reference points based on: a) historical performance (as percentiles); b) yield per recruit ($F_{0.1}$ and F_{max}); and c) static spawning stock per recruit (SPR for 5, 10 and 20%, and replacement, F_{med}). Selectivity for YPR, static SPR, and replacement based on 1995-1999 pattern (**3 of the 4 reference points chosen for Amendment 1 are shown in bold type, the 4th is calculated from the SSB target**).

Approach	Biological Reference Points		
Historical Performance (1955-1999)	**F (1/yr)**	**SSB/R (t/million)**	**SSB (mt)** [a]
25^{th} %	1.13	6.38	20,900
50^{th} %	1.39	12.48	40,400
75^{th} %	1.72	26.40	62,900
Yield per Recruit			
$F_{0.1}$	0.50	47.10	141,300
F_{max}	**1.04**	15.90	47,700
Static SPR (biomass)			
5%	1.65	8.20	24,600
10%	1.14	16.40	49,200
20%	0.69	32.81	98,300
Replacement (SSB/R)			
50^{th} %	**1.33**	12.48	**37,400**

[a] multiply SSB/R by median recruits to age-1 (3.0 billion) to obtain SSB, except for historical performance approach

(The reference points in this table are based only on data from the reduction fishery. Preliminary analyses including the data from bait fisheries has shown little effect on the estimates of F or SSB. Efforts to further quantify bait landings and incorporate these into the statistical data sets are ongoing.)

2.7 RESOURCE COMMUNITY CONSIDERATIONS

Due to the unique and important role that menhaden play in the ecosystem, management considerations should be broader than just traditional fisheries management. Menhaden serve not only as an important prey species for fish, birds and marine mammals (see *Sections 1.2.10* and *1.2.11*), but also as a consumer of phyto- and zooplankton. Menhaden's role as a consumer organism has been studied on a local basis for Narragansett Bay (Durbin and Durbin 1975, 1981a, 1981b, 1983, 1998; Oviatt et al. 1972; Jeffries 1975), Chesapeake Bay (Gottlieb 1998), and to a lesser extent, for the Atlantic coast (Peters and Schaaf 1981; Lewis and Peters 1984; Friedland et al. 1984, 1996). Menhaden have been shown to alter the size, species composition and abundance of plankton as a result of their ability to filter large quantities of water and their own abundance.

Concerns have been raised recently regarding the health of those fish which feed on menhaden, such as striped bass. These concerns have been voiced primarily in the Chesapeake Bay region and have led to recent studies of the interactions between menhaden abundance and the health of striped bass, bluefish and weakfish (Hartman and Brandt 1995a, 1995b; Austin and Walter 1998).

What has been lacking is a synthesis of all the major roles menhaden play in ecosystem dynamics and what impacts various management measures might have. To begin to address this need, the Commission through independent researchers, is developing a multispecies model to examine the interaction between various levels of abundance of menhaden and three of its main fish predators: striped bass, bluefish and weakfish. Once complete, the model should allow the technical committee to estimate how much of the resource should be available for predator-prey interactions and the role menhaden play as filtering organisms. Actual data will be evaluated and modeled before any real estimates of how much annual production (of menhaden) could be allocated for its various ecological roles. Once these quantities are determined an estimate of how much production is available for fisheries can be justified. The model will also allow managers to evaluate the effect of changing predator abundance on the menhaden population and vice versa. This work is scheduled to be completed by the end of 2001 and at that time, the Board may re-examine provisions contained in Amendment 1.

2.8 IMPLEMENTATION SCHEDULE

Since no new management measures are being adopted through this amendment, future addenda prepared under Adaptive Management (*Section 4.6*) will provide an implementation schedule for the states/jurisdictions to follow. Those states/jurisdictions which need to implement the reporting requirements of Amendment 1 shall follow the compliance schedule in *Section 5.1.2.*

3. MONITORING PROGRAM SPECIFICATIONS/ELEMENTS

An Atlantic menhaden stock assessment will be performed on an annual basis by the stock assessment subcommittee. The technical committee and advisory panel will meet to review the stock assessment and all other relevant data sources. An annual report will be presented to the Management Board in a timely fashion (usually May or June depending on Commission meeting week scheduling) in order to make annual adjustments to the management program as necessary. The stock assessment report shall follow the general outline as approved by the ISFMP Policy Board for all Commission-managed species. In addition to the general content of the report as specified in the outline, the stock assessment report will also address the specific topics detailed in the following sections.

3.1 ASSESSMENT OF ANNUAL AGE/SIZE STRUCTURE

Annual estimates of Atlantic menhaden age and size structure will be monitored based on results of the stock assessment. These estimates are available from the annual VPA and are based on the reduction fishery. Efforts to include data from the bait fishery and other sources as available should be continued in order to provide an overall picture of the status of the menhaden population.

The Technical Committee will monitor the age structure through the current VPA methodology and report to the Board the results. The old "trigger" estimates, from the 1992 FMP, will be retained as part of a long-term monitoring program and renamed as "Biological and Fishery Status Reference Points". These data will be used only for the evaluation of current stock status with the caveats identified by the Menhaden Peer Review Panel (i.e. landings based reference points reflect conditions of the fishery and not the actual population, subject to sampling coverage; ASMFC 1999b). In particular, the percent age-0 and percent age-3+ fish in the reduction landings may serve to indicate the status of the population age structure and incoming year-class strength. Another indicator could be the number and relative size of age-classes in the population as estimated through the annual VPA.

3.2 ASSESSMENT OF ANNUAL RECRUITMENT

Annual recruitment of Atlantic menhaden will be estimated by examination of a variety of data sources. The first is the estimate of recruitment to age-1from the VPA as currently conducted. Secondly will be the examination of various fishery-independent data sources. Although many of these surveys are not designed to specifically target menhaden, continued examination of these surveys in the future may prove worthwhile (see *Section 3.6.7*). In addition, surveys designed to specifically monitor menhaden abundance are needed. Current efforts to examine power plant impingement data for their utility in estimating young-of-year menhaden abundance should be continued.

3.3 ASSESSMENT OF SPAWNING STOCK BIOMASS

Spawning stock biomass (SSB) will be estimated from the VPA on an annual basis. The terminal year estimates will be used for evaluating stock status versus the chosen reference points. Because of the retrospective problems observed in the menhaden stock assessment (VPA), a three-year running average of SSB will also be developed (Table 13). Terminal year estimates generated by a VPA tend to be subject to some fluctuation as additional data are added each year. Therefore, terminal year estimates may not accurately depict current conditions. A three-year running average may be more reflective of overall trends in the population and might reduce the risk of implementing management measures based on a false reading of the population status. However, three-year running averages may lessen the chance of detecting a decline in SSB or an increase in F over the short term. The running average approach may be fine so long as the menhaden population does not undergo wide variations or fluctuations from year to year.

Table 13. Comparison of Atlantic menhaden biological reference points and observed values.

	Reference Points		Observed Values	
	Target	**Threshold**	**1999 Estimate**	**1997-99**
Fishing Mortality (F)	1.04	1.33	1.06	1.15
Spawning Stock Biomass (SSB) (in metric tons)	37,400	20,570	32,800	58,300

3.4 ASSESSMENT OF FISHING MORTALITY

Fishing mortality rates will be estimated on an annual basis. Fishing mortality will be estimated for each age-class as well as on a coastwide or total stock basis. Currently, fishing mortality rates are estimated for the reduction fishery and efforts are underway to include other sources of fishing mortality. These efforts should continue and will result in a comprehensive estimation of fishing mortality.

3.5 FORECAST METHODOLOGY

The Stock Assessment Subcommittee provided a preliminary estimate of fishing mortality and the remaining spawning stock biomass for the 2000 fishing season during the development of Amendment 1. The estimates were based on the forecasted effort in the reduction fishery and the historical landings record. The forecasted landings for the reduction fishery in 2000 was 185,000 mt with an 80% CI of 112-257,000 mt. This level of landings translated into an estimated fishing mortality (F) of 0.84 which was below the proposed fishing mortality target. The range of fishing mortality that corresponds to the 80% CI of forecasted landings was approximately 0.4 to 1.4, which was below or slightly above the proposed threshold level (1.33). The preliminary estimate for the 2000 reduction fishery landings was 167,253 mt and the estimate of fishing mortality was F = 1.1.

If this forecasting methodology proves to be valid, the Board could consider the following for future use: 1) if the forecasted F is below the target F, the Board would take no action; or 2) if the forecasted F exceeds the target F, the Board would then consider options to restrict harvest so that the F target is not exceeded in the following year.

3.6 SUMMARY OF MONITORING PROGRAMS

The Atlantic Menhaden Management Board encourages all state fishery management agencies to pursue full implementation of the Atlantic Coastal Cooperative Statistics Program (ACCSP), which will meet the monitoring and reporting requirements of this amendment. The Board recommends a transition or phased-in approach be adopted for full implementation of the ACCSP. Until such time as the ACCSP is implemented, the Board encourages state fishery management agencies to initiate implementation of specific ACCSP modules, 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 harvest/monitoring reports to the Commission as may be required under this Amendment.

Atlantic menhaden landings have been reported from processing plants since 1940. They have been sampled for length, weight, and age since 1955 according to a two-stage cluster sampling design in which fish were sampled weekly from each port where menhaden were processed (Nicholson 1975, Chester 1984, Smith et al. 1987). The frequency of fishery samples and the consolidated nature of the fishery provide an extremely reliable 45-year series of catch at age, ages 0-6+, for estimation of abundance and mortality through VPA (Cadrin and Vaughan 1997). Unfortunately, no independent indices of relative abundance are available to calibrate abundance estimates for the last year of catch. Commercial catch-per-unit-of-effort is a biased index because commercial catchability of Atlantic menhaden is inversely related to abundance (Schaaf 1975; Ahrenholz et al. 1987a; Vaughan and Smith 1988; Atran and Loesch 1995), and fishery-independent survey indices are not correlated with abundance (Ahrenholz et al. 1989). In the absence of reliable abundance indices, and therefore of a formal statistical estimator for year-class abundance in the last year of the VPA, ad hoc estimation rules have been used to approximate abundance (Cadrin and Vaughan 1997).

The commercial fishery for menhaden consists primarily of a purse seine reduction fishery, which has accounted for approximately 90% of the landings since the mid-1980s. There is also a bait fishery which is primarily a directed small purse seine fishery. In addition, there is a mixed species aggregate bycatch from pound nets, gill nets, and trawl nets, as well as a live bait market. Data used in the stock assessment are from the Atlantic menhaden reduction fishery and include landings information from 1940 through 1999, nominal fishing effort from 1941 through 1999, and estimated landings in numbers by age (from NMFS biostatistical port sampling) from 1955 through 1999. Data from the bait fishery is limited; therefore, landings by the bait fishery have been conservatively estimated at 10% of the total Atlantic menhaden harvest for the period 1985-1999. Bait landings of menhaden during 1998 accounted for approximately 14% of the coastwide landings, and preliminary estimates for 1999 indicate that this share increased to 17.3% (Table 9). The increase can be attributed to more accurate reporting from the bait fishery, as well as the decrease in the reduction fishery landings.

3.6.1 Catch and Landings Data (Fishery-dependent)
As noted in Ahrenholz et al. (1987a), some fishing on Atlantic menhaden has occurred since colonial times, but the purse seine fishery for reduction began in New England about 1850. Landings and nominal effort (measured as number of weeks a vessel unloaded during the fishing year, vessel-weeks) are available since 1940 (Fig. 12). Landings rose during the 1940s (from 167,000 to 376,000 mt), peaking during the 1950s (high of 712,000 mt in 1956), and then declined to low levels during the 1960s (from 576,000 mt in 1961 to 162,000 mt in 1969). During the 1970s the stock rebuilt (landings rose from 250,000 mt in 1971 to 376,000 mt in 1979), and then maintained intermediate levels during the 1980s (varying between 238,000 mt in 1986 when meal prices were very low to 402,000 mt in 1981). Landings during the 1990s have varied between 171,200 mt in 1999 and 401,000 mt in 1990. It has been demonstrated for purse seine fisheries, in general, that catch-per-unit-of-effort and nominal fishing effort are poor measures of population abundance and fishing mortality, respectively (Clark and Mangel 1979). However, there was an approximate linear relationship between landings and fishing effort during this time period (Fig. 12). Thus, at a rough level, reduction in nominal effort does equate approximately with a reduction in landings.

The number of processing plants declined from more than twenty during the late 1950s to two during the last two years (1998-99), located in Reedville, Virginia, and Beaufort, North Carolina (Table 8). Similarly, the number of purse seine vessels in the reduction fishery has declined from more than 130 vessels during the 1950s, to 20-23 vessels during most of the 1990s. In 1998, fifteen vessels were active (Smith et al. 1998), and by the end of 1999, only thirteen vessels remained in the Atlantic fleet. Only twelve vessels are active in 2000.

Detailed information on various aspects of the commercial catch included in the Stock Assessment Report for Peer Review (ASMFC 1999a) will be updated on an annual basis and reported to the Board. Information on catch rates, mean weight and size-at-age, catch-at-age and catch-at-age by area will be provided as available. Unfortunately, no programs currently provide bycatch or discard data. Upon implementation of the Atlantic Coastal Cooperative Statistics Program (ACCSP), more detailed data on the menhaden catch from directed fisheries and bycatch of menhaden in other fisheries should be available.

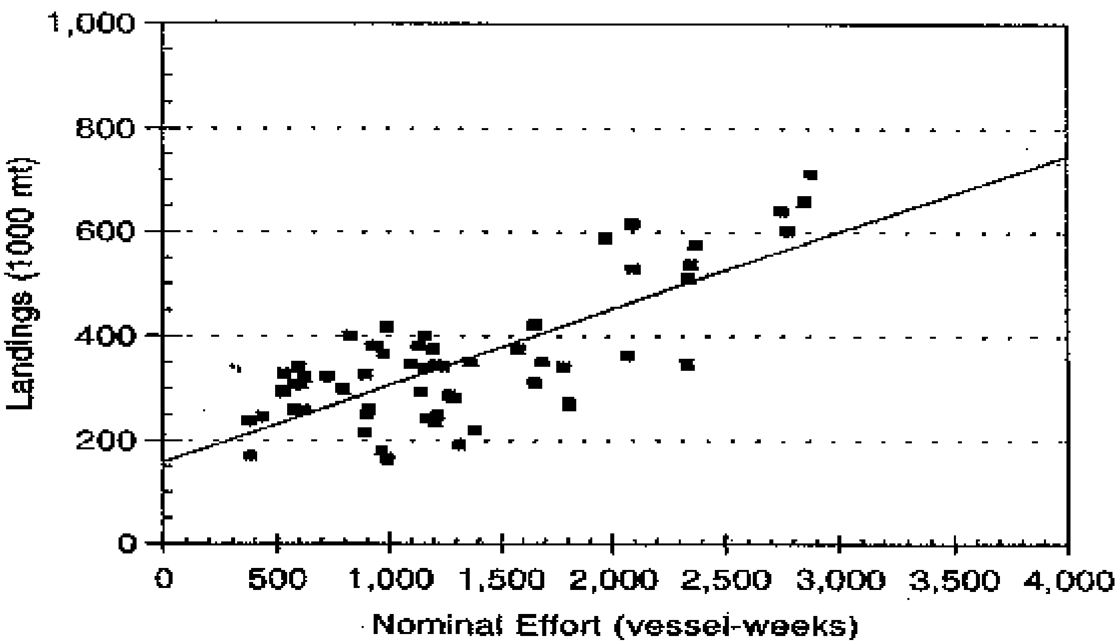

Figure 12. Atlantic menhaden landings versus nominal effort (vessel-weeks).

3.6.2 Recreational Fishery Data

A recreational bait fishery exists, but no data are currently available to quantify the amount of menhaden removed by this fishery. This issue is addressed in *Section 6.1* (Stock Assessment and Population Dynamics Research Needs).

3.6.3 Biological Data

The Beaufort Laboratory of the Southeast Fisheries Science Center (NMFS) conducts biostatistical sampling of the Atlantic coast menhaden reduction fishery (Smith 1991). The program began preliminary sampling in the Mid-Atlantic and Chesapeake Bay areas in 1952 and 1954 and has continued uninterrupted since 1955, sampling the entire range of the Atlantic fishery. Detailed descriptions of the sampling procedures and estimates gathered through the program are cited in Smith (1991).

Throughout the development of the 1992 Atlantic Menhaden FMP, the AMAC compiled reported menhaden landings in bait fisheries along the east coast. AMAC continues to develop and update the reported coastal bait landings for all gear types. Since the 1992 FMP management “triggers” and the annual stock assessment are based on data obtained solely from the reduction fishery, the AMAC designed and implemented a pilot study to sample menhaden from bait fisheries in 1994, with continued sampling through 1999. As bycatch of other fish species is being reduced through implementation of ASMFC and state FMPs and regulations, menhaden are becoming increasingly more important as bait for a wide variety of commercial and recreational fisheries. This trend is expected to continue.

Incorporating coastwide bait landings into the stock assessment requires better port sampling and landing information for the bait fishery. In its annual report for 2000, AMAC recommended continuing the bait sampling program, incorporating changes in the sampling allocation of required samples which would more effectively sample the bait fisheries and make subsequent comparison with reduction fishery age and size composition more valid. Upon adoption of this amendment, the Menhaden Technical Committee will continue the work started by AMAC in incorporating this data into the stock assessment.

3.6.4 Social Data
Currently there are no programs designed specifically to collect social data pertaining to the Atlantic menhaden fishery. The Atlantic Coastal Cooperative Statistics Program (ACCSP) is currently developing a comprehensive coastwide data collection program that will include social data.

3.6.5 Economic Data
Currently there are no programs designed specifically to collect economic data pertaining to the Atlantic menhaden fishery. The Atlantic Coastal Cooperative Statistics Program (ACCSP) is currently developing a comprehensive coastwide data collection program that will include economic data.

3.6.6 Observer Programs
Currently there are no dedicated observer programs for the menhaden fishery. As part of its overall program, the ACCSP will implement a comprehensive at-sea observer program (see *Section 4.2.4.2*).

3.6.7 Fishery-Independent Survey Data
Current fishery-independent monitoring is inadequate at best for Atlantic menhaden. Sampling for juvenile Atlantic menhaden began in 1955, and in the 1970's sampling activities culminated in extensive coastwide trawl surveys conducted through 1978 (Ahrenholz et al. 1989). A four-stream survey (two streams in North Carolina and two streams in Virginia) was continued through 1986. Ahrenholz et al. (1989) found no significant correlations between the relative juvenile abundance estimates and fishery-dependent estimates of year class strength. However, recent investigations with extant data sets suggest there may be some hope. Several potential indices include striped bass seine surveys conducted by the states of Virginia and Maryland, the Beaufort Bridge Larval Index (part of the SABRE Project), and SEAMAP indices. A discussion and evaluation of the applicability of these indices can be found in the Annual AMAC Report (AMAC 2000).

3.7 STOCKING PROGRAM
Given the current technology, stocking of menhaden is not cost-effective and should not be considered as

a management tool.

3.8 BYCATCH MONITORING PROGRAM

When the ACCSP is implemented, quantifiable data should be available to evaluate the extent of bycatch in menhaden fisheries, as well as the bycatch of menhaden in other fisheries. Independent studies of these two aspects of the bycatch question are encouraged and identified as a research need (see *Section 6.2.1*). Bycatch of menhaden in other fisheries is probably an important component of the overall bait market.

3.9 HABITAT MONITORING PROGRAM

Periodic review of various programs to monitor habitat and water quality would play an important role in understanding menhaden population dynamics. The following topics should be examined: nutrient loading; long-term water quality monitoring; hypoxia events; incidence of red tides, harmful dinoflagellates and *Pfiesteria*; habitat modification permits; and wetlands protection.

4. MANAGEMENT PROGRAM IMPLEMENTATION

4.1 RECREATIONAL FISHERIES MANAGEMENT MEASURES

No recreational fisheries management measures are included in this amendment. Recreational landings of Atlantic menhaden (for bait) are currently believed to be very small; therefore, regulation of this fishery is unnecessary at this time. However, evaluation of the extent of this harvest is needed.

4.2 COMMERCIAL FISHERIES MANAGEMENT MEASURES

4.2.1 Spawning Area Restrictions

No fishing activity on offshore spawning grounds has been identified at this time. In the future, federal action may be requested if fishing activities in federal waters (EEZ) become evident and they can be identified as having a detrimental effect on the Atlantic menhaden population.

4.2.2 Specification of Maximum Sustainable Yield (MSY) and Optimum Yield (OY)

The Technical Committee and Stock Assessment Subcommittee cannot specify Maximum Sustainable Yield (MSY) for Atlantic menhaden at this time due to the technical difficulties encountered in applying current model methodologies (surplus production, yield per recruit) to the historical data. The weak spawner-recruit relationship observed for Atlantic menhaden has lead to inconsistent estimates of MSY in the range of 350-450,000 mt, levels which cannot be supported at this time due to stock status, fishery infrastructure and existing regulations. Therefore, specifying MSY for Atlantic menhaden is not feasible at this time due to the current inability to provide realistic estimates of MSY and a subsequent definition for Optimum Yield (OY).

4.2.2.1 Initial Specifications

Due to the technical difficulties with estimating both MSY and the strength of incoming year-classes of Atlantic menhaden, the Management Board will determine annual specifications based on the status of the stock in relation to the proposed targets as outlined in the overfishing definition (*Section 2.5*). The Board may recommend new management measures based on this review and implement them through the adaptive management process (*Section 4.6*).

4.2.3 Internal Waters Processing (IWP) Recommendations

Section 306 of the Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265, as amended) allows foreign fish processing vessels to operate within the internal waters of a state with the permission of the Governor of that state. Before granting such permission, the Governor must (1) determine that the harvest of the target species of the proposed IWP operation exceeds the processing capacity for that species within the state, and 2) consult with the Governors of other states within which the fishery occurs, as well as with the appropriate regional fishery management council and interstate marine fisheries commission. Through Resolution No. 1 of the 1989 ASMFC Annual Meeting, the Commission established a general policy for evaluation of IWP applications. An annual review of the IWP proposals will be conducted by the Menhaden Technical Committee and forwarded to the Atlantic Menhaden Management Board for action. The Menhaden Board will then forward its recommendations to the Commission for adoption and subsequent transmittal as recommendations to the states. The review will be conducted according to the specific process presented in Appendix A.2 and illustrated in Fig. A.2.1

4.2.4 General Administrative Provisions

Presently there are individual state and federal permits and reporting requirements that may affect the Atlantic menhaden fishery. A comprehensive reporting and permitting system, the Atlantic Coastal Cooperative Statistics Program (ACCSP) is in the process of being developed and implemented.

4.2.4.1 Permits

This amendment does not implement a separate permitting system for menhaden fishermen or vessels. However, the ACCSP is designing an integrated and comprehensive permit system for all commercial dealers and fishermen.

4.2.4.2 Observers/Sea Samplers

The ACCSP at-sea observer program will be a mandatory program. As a condition of state and/or federal permitting, vessels will 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 will be determined by the Discard/Release Prioritization Committee of the ACCSP.

4.2.5 Data Collection and Reporting Requirements

The reporting requirements for the Atlantic menhaden fishery will be based in part on the existing Captains Daily Fishing Reports (CDFRs). The ASMFC, NMFS, US Fish & Wildlife Service, the New England, Mid-Atlantic, and South Atlantic Fishery Management Councils, and all the Atlantic coastal states are currently developing a coastwide fisheries statistics program (Atlantic Coastal Cooperative Statistics Program). A minimum set of reporting requirements based on a trip-level for fishermen and dealers is being developed and once adopted by each state/agency, will become the minimum standard for data collection on the Atlantic coast. Nothing in the proposed program would prohibit a state/agency from requiring more detailed information on a trip basis if so desired. As the ACCSP provisions are adopted they will be incorporated into the reporting requirements for the menhaden fishery.

4.2.5.1 Commercial Catch and Effort Data Collection Program(s)

The ACCSP commercial data collection program will be a mandatory, trip-based system with all fishermen and dealers required to report a minimum set of standard data elements (refer to the ACCSP Program Design document for details).

Until the development and implementation of a comprehensive, coastwide data collection program, all menhaden purse seine and bait seine vessels (or snapper rigs) shall be required to submit the Captain's Daily Fishing Reports (CDFRs) which are currently in use. States may implement this measure through alternative reporting requirements already in place. Implementation of this measure shall be a compliance criterion.

4.2.5.2 Recreational Catch and Effort Data Collection Program(s)

The ACCSP recreational data collection program for private/rental and shore modes of fishing will be conducted through a combination telephone and intercept survey. Recreational effort data will be collected through a telephone survey with random sampling of households until such time as a more comprehensive universal sampling frame is established. Recreational catch data will be collected through an access-site intercept survey. A minimum set of standard data elements will be collected in both the telephone and intercept surveys (refer to the ACCSP Program Design document for details). The ACCSP will implement research and evaluation studies to expand sampling and improve the estimates of recreational catch and effort. This amendment does not institute a separate data collection program for recreational menhaden fisheries.

4.2.5.3 For-Hire Catch/Effort Data Collection Programs

The ACCSP is conducting an evaluation study to determine the best method(s) of data collection for for-hire fisheries. A minimum set of standard data elements will be collected in all for-hire catch/effort surveys (refer to the ACCSP Program Design document for details). This amendment does not institute a separate data collection program for for-hire menhaden fisheries.

4.2.5.4 Social and Economic Information

The ACCSP will require the collection of baseline social and economic data on all commercial fisheries (refer to the ACCSP Program Design document for details). A minimum set of standard data elements will be collected by all social and economic surveys (refer to the ACCSP Program Design document for details).

The ACCSP will require the collection of baseline social and economic data on all recreational fisheries through add-ons to existing recreational catch/effort surveys (refer to the ACCSP Program Design document for details). A minimum set of standard data elements will be collected by all social and economic surveys (refer to the ACCSP Program Design document for details). This amendment does not institute a separate data collection program for socio-economic data for menhaden fisheries.

4.2.5.5 Vessel Registration System

The ACCSP has recommended the development of a standardized national fishing vessel registration system (VRS) through upgrades and expansions of the current Vessel Identification System (VIS). The VIS is an integration of the Coast Guard documentation and individual state registration systems. A minimum set of standard data elements will be collected through the VIS (refer to the ACCSP Program Design document for details). This amendment does not institute a separate vessel registration system for menhaden fisheries.

4.2.5.6 Quota Monitoring

The ACCSP will require tracking of all commercial fishing quotas through an Interactive Voice Response (IVR) system. A minimum set of standard data elements will be collected through all IVR systems (refer to the ACCSP Program Design document for details). Under the ACCSP quota monitoring program, any ACCSP partner could authorize another partner to act as agents for collection of specific data elements. Any IVR system implemented by an ACCSP partner must collect complete quota management information for all species managed under a quota type system if there is a realistic possibility that the quota or TAC for that species could be taken during an allocation period. Any ACCSP partner monitoring commercial quotas must submit weekly reports to the responsible partner by the end of the reporting week. Any ACCSP partner monitoring quotas must electronically submit detailed data to the responsible partner as required in this Amendment, or using the minimum standards required by the ACCSP (refer to the ACCSP Program Design document for details).

4.2.6 FMP Monitoring

The Atlantic Menhaden Technical Committee will meet at least once each year to review the stock assessment and all other relevant data pertaining to stock status. The Technical Committee will report on all required monitoring elements outlined in *Section 3* and forward any recommendations to the Atlantic Menhaden Board. The Technical Committee shall also report to the Management Board the results of any other monitoring efforts or assessment activities not included in *Section 3* that may be relative to the stock status of Atlantic menhaden or indicative of ecosystem health and interactions.

The Atlantic Menhaden Advisory Panel will meet at least once each year to review the stock assessment and all other relevant data pertaining to stock status. The Advisory Panel will forward its report and any recommendations to the Menhaden Board.

The Atlantic Menhaden Plan Review Team will annually review implementation of Amendment 1 and any subsequent adjustments (addenda), and report to the Menhaden Board on any compliance issues that may arise. The PRT will also prepare the annual Atlantic Menhaden FMP Review and coordinate the annual update and prioritization of research needs (see *Section 6.0*).

4.2.7 Catch Control Options

The Management Board considered a number of options for controlling catches in the menhaden fishery during the development of Amendment 1 but chose not to implement any new measures at this time. However, should the Board determine that action is required to control menhaden catches, the preferred option shall be controlling catch through the imposition of a Total Allowable Catch (TAC) by area of catch, with some additional restriction on small or juvenile fish. Imposition of a catch control will be considered under Adaptive Management, *Section 4.6*, if future action is necessary once overfishing or an overfished/depleted condition is identified.

4.2.8 Effort Control Options

The Management Board considered a number of options for controlling effort in the menhaden fishery during the development of Amendment 1 but chose not to implement any new measures at this time. Effort could be indirectly limited in the menhaden fishery through the imposition of closed seasons. Currently there are seasonal closures in a number of states, but none coastwide. Effort could also be directly limited by imposing days at sea restrictions or limits on the number of vessel weeks (the current effort measurement in the reduction fishery). These options could be implemented in the future under

Adaptive Management, *Section 4.6,* if future action is necessary once overfishing or an overfished/depleted condition is identified..

4.2.9 Measures to Regulate Gear

The Management Board may consider implementing a minimum mesh size regulation for menhaden purse seine fisheries in the future under Adaptive Management (*Section 4.6*), if the population becomes overfished or depleted. The chosen mesh size should correspond to that which would be most effective in limiting the harvest of under-sized (juvenile) menhaden. One option the Board may consider is implementing the mesh size regulations in place in Virginia (7/8" bar, 1.75" stretch mesh, knitted and knotted twine), which are designed to minimize the harvest of age-0 menhaden. Further technical information should be gathered and evaluated prior to the Board implementing a minimum mesh regulation for this fishery. Gear regulations for other fisheries which harvest Atlantic menhaden may be considered in the future as well.

4.2.10 Season or Area Closures

Seasonal closure options were discussed in *Section 4.2.8*, under effort limitations. Area closures could be implemented to protect juvenile nursery areas, or they could be implemented to reduce potential social conflicts such as a minimum fishing distance from shore/structures. No additional closures are implemented through this amendment but they may be considered in the future under Adaptive Management, *Section 4.6*.

4.2.11 Fixed Gear Fishery

No management measures for fixed gear fisheries are implemented through this amendment. It may be possible to implement future management measures for this fishery through Adaptive Management, *Section 6*, if necessary.

4.2.12 Measures to Reduce/Monitor Bycatch

No bycatch management or monitoring measures are implemented through this amendment. It may be possible to limit menhaden fishing in areas or by season where a significant bycatch may occur, but observer data are necessary to document areas of concern before any measures could be developed.

4.2.13 Other Management Alternatives

The Management Board reviewed a number of other measures during the development of this amendment, including a recommendation from AMAC to open state waters one mile from shore to reduction fishing, and modifications to fishing practices such as eliminating spotter pilots. The Board recommended against including any of these for consideration in Amendment 1.

4.3 FOR-HIRE FISHERIES MANAGEMENT MEASURES

No management measures for for-hire fisheries are proposed in this amendment.

4.4 HABITAT CONSERVATION AND RESTORATION RECOMMENDATIONS

In order to ensure the productivity of populations, each state should implement identification and protection of critical nursery areas within its boundaries for estuarine dependent, marine migratory species in general and Atlantic menhaden in particular. Such efforts should inventory historical habitats, identify habitats presently used and specify those that are targeted for recovery, and impose or encourage measures to retain or increase the quantity and quality of Atlantic menhaden essential habitats.

4.4.1 Preservation of Existing Habitat
States should provide inventories and locations of critical Atlantic menhaden habitat to other state and federal regulatory agencies. Regulatory agencies should be advised of the types of threats to Atlantic menhaden populations and recommended measures that should be employed to avoid, minimize or eliminate any threat to current habitat extent or quality.

4.4.2 Habitat Restoration, Improvement and Enhancement
While Atlantic menhaden appear to be utilizing the bulk of their historic nursery areas, water quality in these areas should be maintained or improved (if impaired), to prevent hypoxic fish kills and minimize the threat of increased mortality due to disease and parasitism. Modern trends toward the protection of wetlands will protect and improve menhaden habitat.

4.4.3 Avoidance of Incompatible Activities
Federal and state fishery management agencies should take steps to limit the introduction of compounds which are known or suspected to accumulate in any animal species' tissue and which pose a threat to human health or any animals' health.

Each state should establish windows of compatibility for activities known or suspected to adversely affect Atlantic menhaden life stages and their habitats, such as navigational dredging, inlet modifications, and dredged material disposal, and notify the appropriate construction or regulatory agencies in writing.

Projects involving water withdrawal from nursery habitats (e.g. power plants, irrigation, water supply projects) should be scrutinized to ensure that adverse impacts resulting from larval/juvenile impingement, entrainment, and/or modification of flow, temperature and salinity regimes due to water removal, will not adversely impact estuarine dependent species, including Atlantic menhaden, especially early life stages.

Each state which contains Atlantic menhaden nursery areas within its jurisdiction should develop water use and flow regime guidelines which are protective of these nursery areas and which will ensure to the extent possible, the long-term health and sustainability of the stock.

4.4.4 Fishery Practices
The use of any fishing gear or practice which is documented by management agencies to have an unacceptable impact on Atlantic menhaden (e.g. habitat damage, bycatch mortality) should be prohibited within the effected essential habitats (e.g. trawling in primary nursery areas should be prohibited).

4.5 ALTERNATIVE STATE MANAGEMENT REGIMES
Once approved by the Atlantic Menhaden Management Board, states are required to obtain prior approval from the Board of any changes to their management program for which a compliance requirement is in effect. Other measures must be reported to the Board but may be implemented without prior Board approval A state can request permission to implement an alternative to any mandatory compliance measure only if that state can show to the Board's satisfaction that its alternative proposal will have the same conservation value as the measure contained in this amendment or any addenda prepared under Adaptive Management (*Section 4.6*). States submitting alternative proposals must demonstrate that the proposed action will not contribute to overfishing of the resource. All changes in state plans must

be submitted in writing to the Board and to the Commission either as part of the annual FMP Review process or the Annual Compliance Reports.

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 to the Commission, including a proposal for *de minimis* status. Such changes shall be submitted to the Chair of the Plan Review Team, who shall distribute the proposal to the Management Board, 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 Management Board for decision.

The Atlantic Menhaden Management Board 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 applicable", and the goals and objectives of this amendment.

In order to maintain fishing seasons similar to those currently in place, new rules should be implemented prior to the start of the fishing season and be effective on March 1 each year. Given the time for the annual assessment to be prepared and presented to the Technical Committee, Advisory Panel and the Management Board, and the time for individual states to promulgate new regulations, it may not be possible to implement new regulations for the current fishing season. Therefore new regulations should be effective at the start of the following season after a determination to do so has been made.

4.5.2 Management Program Equivalency
The Atlantic Menhaden Technical Committee (and/or Plan Review Team) will review any alternative state proposals under this section and provide to the Atlantic Menhaden Management Board its evaluation of the adequacy of such proposals.

4.5.3 *De minimis* Fishery Guidelines
The ASMFC Interstate Fisheries Management Program Charter defines *de minimis* as "a situation in which, under existing condition of the stock and scope of the fishery, conservation, and enforcement actions taken by an individual state would be expected to contribute insignificantly to a coastwide conservation program required by a Fishery Management Plan or amendment" (ASMFC 2000).

As future management measures are implemented through addenda prepared subsequent to Amendment 1, a state may be granted *de minimis* status if, the Management Board determines that action by the state with respect to a particular management measure would not contribute significantly to the overall management program. States may petition the Atlantic Menhaden Management Board at any time for *de minimis* status. Once *de minimis* status is granted, designated states must submit annual reports to the Management Board justifying the continuance of *de minimis* status. States must include *de minimis* requests as part of their annual compliance reports.

4.6 ADAPTIVE MANAGEMENT
The Atlantic Menhaden Management Board may vary the requirements specified in this amendment as a

part of adaptive management in order to conserve the Atlantic menhaden resource. Specifically, the Management Board may change target fishing mortality rates and harvest specifications, other measures designed to prevent overfishing of the stock complex or any spawning component. Such changes will be instituted to be effective on the first fishing day of the following year, but may be put in place at an alternative time when deemed necessary by the Management Board. These changes should be discussed with the appropriate federal representatives and Councils prior to implementation in order to be complementary to the regulations for the EEZ.

4.6.1 General Procedures

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

The Atlantic Menhaden Management Board will review the report of the Plan Review Team, and may consult further with Technical Committee, the Stock Assessment Committee or the Advisory Panel. The Management Board may direct the PRT to prepare an addendum to make any changes it deems necessary. The addendum shall contain a schedule for the states to implement its provisions.

The Plan Review Team will prepare a draft addendum as directed by the Management Board, and shall distribute it to all states for review and comment. A public hearing will be held in any state that requests one. The Plan Review Team will also request comment from federal agencies and the public at large. After a 30-day review period, the Plan Review Team will summarize the comments and prepare a final version of the addendum for the Management Board.

The Management Board shall review the final version of the addendum prepared by the Plan Review Team, and shall also consider the public comments received and the recommendations of the Technical Committee, the Stock Assessment Committee 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 Management Board, states shall prepare plans to carry out the addendum, and submit them to the Management Board for approval according to the schedule contained in the addendum.

4.6.2 Measures Subject to Change

The following measures are subject to change under adaptive management upon approval by the Atlantic Menhaden Management Board:

(1) Fishing seasons;
(2) Area closures;
(3) Annual specifications, including maximum sustainable yield (MSY), allowable biological catch (ABC), optimum yield (OY), internal waters processing (IWP) allocations, etc.;
(4) Overfishing definition;
(5) Rebuilding targets and schedules;
(6) Catch controls;

(7) Effort controls;
(8) Reporting requirements;
(9) Gear limitations including mesh sizes;
(10) Measures to reduce or monitor bycatch;
(11) Observer requirements;
(12) Management areas;
(13) Recommendations to the Secretaries for complementary actions in federal jurisdictions;
(14) Research or monitoring requirements; and
(15) Any other management measures currently included in Amendment 1.

4.7 EMERGENCY PROCEDURES

Emergency procedures may be used by the Atlantic Menhaden Management Board 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 Interstate Fisheries Management Program Charter, Section Six (c)(10) (ASMFC 2000).

4.8 MANAGEMENT INSTITUTIONS

The management institutions for Atlantic menhaden shall be subject to the provisions of the ISFMP Charter (ASMFC 2000). The following is not intended to replace any or all of the provisions of the ISFMP Charter. All committee roles and responsibilities are included in detail in the ISFMP Charter and are only summarized here.

4.8.1 ASMFC and the ISFMP Policy Board

The ASMFC (Commission) and the ISFMP Policy Board are generally responsible for the oversight and management of the Commission's fisheries management activities. The Commission must approve all fishery management plans, and amendments, including this Amendment 1; 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 Atlantic Menhaden Management Board

The Atlantic Menhaden Management Board is hereby established under the provisions of the Commission's ISFMP Charter (Section Four [b]) and is generally responsible for carrying out all activities under this Amendment (ASMFC 2000).

The Atlantic Menhaden Management Board (Board) establishes and oversees the activities of the Plan Development or Plan Review Team, the Technical Committee and the Stock Assessment Subcommittee; and requests the establishment of the Commission's Atlantic Menhaden Advisory Panel. Among other things, the Board makes changes to the management program under adaptive management and approves state programs implementing the Amendment and alternative state programs under *Sections 4.5* and *4.6.* The Board reviews the status of state compliance with the FMP or Amendment 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 Atlantic Menhaden Plan Development / Plan Review Team

The Plan Development Team (PDT) and the Plan Review Team (PRT) will be composed of a small group of scientists and/or managers whose responsibility is to provide all of the technical support necessary to carry out and document the decisions of the Atlantic Menhaden Management Board. Both are chaired by an ASMFC FMP Coordinator. The Atlantic Menhaden PDT/PRT is directly responsible to the Board for providing information and documentation concerning the implementation, review, monitoring and enforcement of Amendment 1. The Atlantic Menhaden PDT/PRT shall be comprised of personnel from state and federal agencies who have scientific and management ability and knowledge of Atlantic menhaden. The PDT will be responsible for preparing all documentation necessary for the development of Amendment 1, using the best scientific information available and the most current stock assessment information. The PDT will either disband or assume inactive status upon completion of Amendment 1. Alternatively, the Board may elect to retain PDT members as members of the PRT or appoint new members. The PRT will provide annual advice concerning the implementation, review, monitoring, and enforcement of Amendment 1 once it has been adopted by the Commission.

4.8.4 Atlantic Menhaden Technical Committee

The Atlantic Menhaden Technical Committee will consist of representatives from state or federal agencies, Regional Fishery Management Councils, Commission, university or other specialized personnel with scientific and technical expertise and knowledge of the Atlantic menhaden fishery. The Board will appoint the members of the Technical Committee and may authorize additional seats as it sees fit. Its role is to act as a liaison to the individual state and federal agencies, provide information to the management process, and review and develop options concerning the management program. The Technical Committee will provide scientific and technical advice to the Management Board, PDT, and PRT in the development and monitoring of a fishery management plan or amendment.

4.8.5 Atlantic Menhaden Stock Assessment Subcommittee

The Atlantic Menhaden Stock Assessment Subcommittee shall be appointed by the Technical Committee at the request of the Management Board, and will consist of scientists with expertise in the assessment of the Atlantic menhaden population. Its role is to assess the Atlantic menhaden population and provide scientific advice concerning the implications of proposed or potential management alternatives, or to respond to other scientific questions from the Board, Technical Committee, PDT or PRT. The Stock Assessment Subcommittee will report to the Technical Committee.

4.8.6 Atlantic Menhaden Advisory Panel

The Atlantic Menhaden Advisory Panel will be established according to the Commission's Advisory Committee Charter. Members of the Advisory Panel will be citizens who represent a cross-section of commercial and recreational fishing interests and others who are concerned about Atlantic menhaden conservation and management. The Advisory Panel provides the Board with advice directly concerning the Commission's Atlantic menhaden management program. Normally, the Advisory Panel meetings will be held in conjunction with Board meetings insofar as possible.

4.8.7 Federal Agencies

4.8.7.1 Management in the Exclusive Economic Zone (EEZ)

Management of Atlantic menhaden in the EEZ is within the jurisdiction of the three Regional Fishery Management Councils under the Magnuson-Stevens Act (16 U.S.C. 1801 et seq.). In the absence of a Council Fishery Management Plan, management is the responsibility of the NMFS as mandated by the Atlantic Coastal Fishery Conservation and Management Act (16 U.S.C. 5105 et seq.)

4.8.7.2 Federal Agency Participation in the Management Process

The Commission has accorded the United States Fish and Wildlife Service (USFWS) and the NMFS voting status on the ISFMP Policy Board and the Atlantic Menhaden Management Board in accordance with the Commission's ISFMP Charter. The NMFS also participates on the Atlantic Menhaden Plan Development Team, Plan Review Team, Technical Committee and Stock Assessment Subcommittee.

4.8.7.3 Consultation with Fishery Management Councils

At the time of adoption of Amendment 1, none of the Regional Fishery Management Councils had implemented a management plan for Atlantic menhaden nor had they indicated an intent to develop a plan.

4.9 RECOMMENDATIONS TO THE SECRETARIES FOR COMPLEMENTARY ACTIONS IN FEDERAL JURISDICTIONS

The Atlantic States Marine Fisheries Commission believes that the measures contained in Amendment 1 are necessary to prevent the overfishing of the Atlantic menhaden resource. Due to the preponderance of the Atlantic menhaden resource occurring in state waters, the Commission through Amendment 1, recommends to the Secretary of Commerce that no additional management measures be implemented in federal waters at this time. In addition, Amendment 1 calls for the Atlantic Menhaden Management Board to make additional changes to Amendment 1 via adaptive management, and as such changes are made, the Management Board may recommend additional measures to the Secretary. The Commission recognizes that such action may be taken under the Atlantic Coastal Fisheries Cooperative Management Act or the Magnuson-Stevens Fishery Conservation and Management Act.

4.10 COOPERATION WITH CANADA

The Plan Review Team, Technical Committee and Management Board shall regularly communicate with fishery managers in Canadian agencies to help ensure the sustainability of the Atlantic menhaden resource. Canadian fishery managers and their officials shall be invited to ASMFC discussions on Atlantic menhaden conservation as needed, especially when discussing transshipment issues, and cross-border trade.

5. 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 the Atlantic States Marine Fisheries Commission does not have authority to directly compel state 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. This section sets forth the specific elements states must implement in order to be in 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 Fisheries Management Program Charter (ASMFC 2000).

5.1 MANDATORY COMPLIANCE ELEMENTS FOR STATES

A state will be determined to be out of compliance with the provisions of this fishery management plan, according to the terms of Section Seven of the ISFMP charter if:

- its regulatory and management programs to implement *Section 4* have not been approved by the Atlantic Menhaden Management Board; or

- 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 Atlantic Menhaden Management Board; or

- it makes a change to its regulations required under *Section 4* or any addendum prepared under adaptive management (*Section 4.6*), without prior approval of the Atlantic Menhaden Management Board.

5.1.1 Mandatory Elements of State Programs

To be considered in compliance with this fishery management plan, all state programs must include a regime of restrictions on Atlantic menhaden fisheries consistent with the requirements of *Sections 4.1* and *4.2*; except that a state may propose an alternative management program under *Section 4.5*, which, if approved by the Management Board, may be implemented as an alternative regulatory requirement for compliance.

In addition, the Atlantic Menhaden Management Board (through its Technical Committee and Advisory Panel), will monitor bycatch of Atlantic menhaden in other fisheries and report excessive bycatch problems to the management authority for the fishery causing the bycatch.

5.1.1.1 Regulatory Requirements

States may begin to implement Amendment 1 after final approval by the Commission. Each state must submit its required Atlantic menhaden regulatory program to the Commission through the ASMFC staff for approval by the Atlantic Menhaden Management Board. During the period from submission, until the Management Board makes a decision on a state's program, a state may not adopt a less protective management program than contained in this Amendment or contained in current state law. The following lists the specific compliance criteria that a state/jurisdiction must implement in order to be in compliance with Amendment 1:

1. All states shall implement the reporting requirement contained in *Section 4.2.5.1*, that all menhaden purse seine and bait seine vessels (or snapper rigs) be required to submit the Captain's Daily Fishing Reports (CDFRs). Existing reporting requirements may serve as an alternative to implementing this measure.

Once approved by the Atlantic Menhaden Management Board, states are required to obtain prior approval from the Board of any changes to their management program for which a compliance requirement is in effect. Other measures must be reported to the Board but may be implemented without prior Board approval A state can request permission to implement an alternative to any mandatory compliance measure only if that state can show to the Board's satisfaction that its alternative proposal will have the same conservation value as the measure contained in this amendment or any addenda prepared under Adaptive Management (*Section 4.6*). States submitting alternative proposals must demonstrate that the proposed action will not contribute to overfishing of the resource. All changes in state plans must be submitted in writing to the Board and to the Commission either as part of the annual FMP Review process or the Annual Compliance Reports.

5.1.1.2 Monitoring Requirements *(fishery-dependent measures)*

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

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

States are encouraged to assist the NMFS in the collection of biological data from their respective menhaden fisheries. In particular, states that have significant menhaden bait fisheries should work closely with NMFS personnel to ensure adequate sampling of those fisheries.

5.1.1.3 Research Requirements *(fishery-independent measures)*

No mandatory research requirements have been identified at this time. However, mandatory research requirements may be added in the future under Adaptive Management, *Section 4.6*.

5.1.1.4 Law Enforcement Requirements

All state programs must include law enforcement capabilities adequate for successfully implementing that state's Atlantic menhaden regulations. The adequacy of a state's enforcement activity will be monitored annually by reports of the ASMFC Law Enforcement Committee to the Atlantic Menhaden Plan Review Team. The first reporting period will cover the period from May 1, 2001 to April 30, 2002.

5.1.1.5 Habitat Requirements

There are no mandatory habitat requirements in Amendment 1. See *Section 4.4* for Habitat Recommendations.

5.1.2 Compliance Schedule

States must implement this Amendment according to the following schedule:

August 1st, 2001:	Submission of state programs to implement Amendment 1 for approval by the Atlantic Menhaden Management Board. Programs must be implemented upon approval by the Management Board.
January 1st, 2002:	States with approved management programs must implement Amendment 1. States may begin implementing management programs prior to this deadline if approved by the Management Board.

Reports on compliance should be submitted to the Commission by each jurisdiction annually, no later than

April 1st, each year, beginning in 2002.

5.1.3 Compliance Report Content

Each state must submit an annual report concerning its Atlantic menhaden fisheries and management program for the previous year. A standard compliance report format has been prepared and adopted by the ISFMP Policy Board. States should follow this format in completing the annual compliance report.

5.2 PROCEDURES FOR DETERMINING COMPLIANCE

Detailed procedures regarding compliance determinations are contained in the ISFMP Charter, Section Seven (ASMFC 2000). The following summary is not meant in any way to replace the language found in the ISFMP Charter.

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 Atlantic Menhaden Management Board, ISFMP Policy Board or the Commission, may request the Plan Review Team to conduct a review of plan implementation and compliance at any time.

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

The ISFMP Policy Board shall, within thirty days of receiving a recommendation of noncompliance from the Atlantic Menhaden Management Board, review that recommendation of noncompliance. If it concurs in the recommendation, it shall recommend at that time to the Commission that a state be found out of compliance.

The Commission shall consider any Amendment 1 noncompliance recommendation from the Policy Board within 30 days. Any state which 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 Policy Board, it may determine that a state is not in compliance with 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 Atlantic menhaden conservation measures.

5.3 RECOMMENDED (NON-MANDATORY) MANAGEMENT MEASURES

The NMFS is encouraged to at least maintain its current Atlantic menhaden sampling program. This includes the monitoring of catch and effort data, Captains Daily Fishing Reports (CDFRs), and the biostatistical sampling program.

5.4 ANALYSIS OF ENFORCEABILITY OF PROPOSED MEASURES

The Law Enforcement Committee will, during the implementation of this amendment, analyze the enforceability of conservation and management measures as they are proposed.

6. RESEARCH AND MANAGEMENT NEEDS

The following list of research needs have been identified in order to enhance the state of knowledge of the Atlantic menhaden resource, population dynamics, ecology and the various fisheries for menhaden. This list will be reviewed annually by the technical committee, advisory panel, and the management board and an updated, prioritized list will be included in the Annual Menhaden FMP Review.

6.1 STOCK ASSESSMENT AND POPULATION DYNAMICS NEEDS

Monte Carlo simulations should be conducted to evaluate precision of VPA (need resources).

Alternative measures of effort, including spotter pilot logbooks, trip length, or other variables, should be evaluated. Spotter pilot logbooks should be evaluated for spotter plane search time, GPS coordinates, and estimates of school sizes observed by pilots.

Re-evaluate menhaden natural mortality, by age and response to changing predator population sizes.

Develop and test methods for estimating size of recruiting year-classes of juveniles using fishery-independent survey techniques (ongoing research).

Evaluate extent of recreational netting of menhaden for bait purposes.

6.2 RESEARCH AND DATA NEEDS

6.2.1 Biological

Study the ecological role of menhaden (predator/prey relationships, nutrient enrichment, oxygen depletion, etc.) in major Atlantic coast embayments and estuaries.

Evaluate use of coastal power plant impingement data as a possible means to estimate young-of-the-year menhaden abundance.

Evaluate effects of selected environmental factors on growth, survival and abundance of juvenile and adult menhaden.

Monitor landings, size, age, gear, and harvest area in the reduction and bait fisheries, and determine age composition by area. Enhance biostatistical sampling of bait samples in purse seine fisheries for Virginia and New Jersey to improve stock assessment.

Develop bycatch studies of menhaden by other fisheries.

Determine the effects of fish diseases (such as ulcerative mycosis and toxic dinoflagellates) on the menhaden stock (ongoing research).

Monitor fish kills along the Atlantic coast and use the NMFS Beaufort Laboratory as a repository for these reports.

The feasibility of estimating yearclass strength using biologically stratified sampling design should be evaluated. The efforts could be supported by process studies linking plankton production to abundance of young menhaden (need resources).

Growth back-calculation studies should be pursued to investigate historical trends in growth rate. The NMFS has an extensive data base on scale growth increments which should be utilized for this purpose.

Investigate the amount or extent of bycatch in the menhaden fishery when it operates in nearshore waters of North Carolina.

6.2.2 Social

Determine the effects of regulations on the fishery, the participants and the stock.

Periodically monitor the economic structure and sociological characteristics of the menhaden reduction industry.

6.2.3 Economic

Determine the effects of regulations on the fishery, the participants and the stock.

Periodically monitor the economic structure and sociological characteristics of the menhaden reduction industry.

6.2.4 Habitat

Determine how loss/degradation of critical estuarine and nearshore habitat affects growth, survival and abundance of juvenile and adult menhaden abundance.

6.2.5 General

(No general research needs have been identified at this time)

6.2.6 Management

Make annual predictions for the Atlantic coast fishery.

Analyze vessel catch records.

6.2.7 Protected Species

Evaluate whether a statistically valid observer program is needed to document possible sea turtle interactions with the various gear types.

7. 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 Six (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 Marine Mammal Protection Act (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. Under 1994 Amendments, the Act requires the National Marine Fisheries Service (NMFS) 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. Specifically, a strategic stock is defined as a stock: (1) for which the level of direct human-caused mortality exceeds the potential biological removal (PBR)[2] level; (2) which is declining and is likely to be listed under the Endangered Species Act (ESA) in the foreseeable future; or (2) which is listed as a threatened or endangered species under the ESA or as a depleted species under the MMPA. Category I and II fisheries are those that have frequent or occasional incidental mortality and serious injury of marine mammals, respectively, whereas Category III fisheries have a remote likelihood of incidental mortality and serious injury of marine mammals.

Under 1994 mandates, the MMPA also requires fishermen in Category I and II to register under the Marine Mammal Authorization Program (MMAP), the purpose of which is to provide an exception for commercial fishers from the general taking prohibitions of the MMPA. All fishermen, regardless of the category of fishery they participate in, must report all incidental injuries and mortalities caused by commercial fishing operations.

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

[2] PBR is the number of human-caused deaths per year each stock can withstand and still reach an optimum population level. This is calculated by multiplying “the minimum population estimate” by “½ stock’s net productivity rate” by “a recovery factor ranging from 0.1 for endangered species to 1.0 for healthy stocks.”

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. Permits are not required for Category III fisheries, however, any serious injury or mortality of a marine mammal must be reported.

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

A number of protected species inhabit the management unit, which includes inshore and nearshore waters, as addressed in Amendment 1 to the Fishery Management Plan for Atlantic Menhaden. Nine are classified as endangered or threatened under the ESA; the remainder are protected under provisions of the MMPA. The species found in coastal Northwest Atlantic waters are listed below.

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*)
Shortnose sturgeon	(*Acipenser brevirostrum*)

Threatened

Loggerhead turtle	(*Caretta caretta*)

Species Proposed for ESA Listing

Harbor porpoise	(*Phocoena phocoena*)

MMPA
Includes all marine mammals above in addition to:

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. For several stocks of marine mammals, including humpback whales, menhaden are an important prey species. 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

There have been marine mammal interactions in the primary fisheries that target menhaden- including the purse seine, pound net and gill net- in addition to those gear types for which menhaden is a bycatch, including trawl, haul seine, cast net, as well as the pound net and gill net already mentioned. The bycatch reports included below do not represent a complete list but rather available records. It should be noted that without an observer program for many of these fisheries, actual numbers of interactions are difficult to obtain.

7.4.1.1 Purse seine

The Gulf of Maine and U.S. mid-Atlantic menhaden purse seine fisheries are currently classified as Category III fisheries (under the MMPA). In the 2000 MMPA List of Fisheries (65 FR 24448, April 26, 2000), the Gulf of Maine menhaden purse seine fishery is listed as having no incidental bycatch of marine mammals, and the U.S. mid-Atlantic menhaden purse seine fishery is listed with reported incidental bycatch of the coastal stock of bottlenose dolphin. However, in 1999, a mid-Atlantic menhaden purse seine fisherman reported through the MMAP that a humpback whale became entangled after bumping into the net; upon release from the gear, the animal was reported as showing an inability to swim or dive and equilibrium imbalance. NMFS will be updating the List of Fisheries to include the humpback whale as a marine mammal species/stocks incidentally injured/killed in the mid-Atlantic menhaden purse seine listing.

The Atlantic purse seine fishery reported the lethal incidental take of one minke whale in 1990 (NMFS 1993); however, the target species of the purse seine (i.e. tuna or menhaden) is unknown.

Historically, Atlantic menhaden purse seine fishermen have reported an annual incidental take of one to five coastal bottlenose dolphins (NMFS 1991). This information comes from reports required under a small take exemption issued under the then Section 101(a)(4) of the MMPA. Atlantic purse seine fishermen (target species unknown) also reported the lethal take of four coastal bottlenose dolphins in 1990 (NMFS 1993). Other than the humpback whale above, however, no other marine mammal interactions have been reported by the Atlantic purse seine fishery since 1990. Yet, the proposed 1999 MMPA List of Fisheries (63 FR 42803, August 11, 1998) summarizes the results of the analysis which re-categorized the Gulf of Mexico menhaden purse seine fishery based on interactions with coastal bottlenose dolphin. In brief, an observer program conducted by Louisiana State University in 1992, 1994, and 1995 recorded nine captures of coastal bottlenose dolphin, three of which were reported as mortalities. The Gulf of Mexico menhaden purse seine was subsequently re-categorized from Category III to Category II in the final 1999 MMPA List of Fisheries (64 FR 9067, February 24, 1999) as estimated mortality, based on observer data, exceeded the combined PBR level for the three Gulf coastal stocks of bottlenose dolphins. Similar observer programs of the menhaden purse seine fisheries have been conducted in the Atlantic. From September 1978 through early 1980, approximately 40 sea days were observed for fish sampling aboard menhaden purse seine vessels fishing from Maine south to North Carolina. No marine mammals were recorded as bycatch (S. Epperly, NMFS SEFSC, pers. comm.). Additionally, observations of the Atlantic menhaden fishery between June and November 1992 observed no incidental takes of marine mammals during the at-sea sampling of 43 sets (Austin et al. 1994). However, Austin et al. (1994) recommended an extended sampling scheme for a more precise assessment of bycatch as their study only occurred for one year and the sampling size was limited. Due to the reports and based on the analogy with the Gulf of Mexico menhaden purse seine fishery, additional observations are needed of the Atlantic fishery to determine interaction levels.

7.4.1.2 Atlantic Trap Nets/Stop Seines/Pound Nets

The Gulf of Maine herring and Atlantic mackerel stop seine/weir fisheries are classified in the 2000 MMPA List of Fisheries as Category III fisheries with reported species incidentally injured/killed including the North Atlantic right, humpback and minke whale, as well as harbor porpoise, harbor seal and gray seal. The U.S. mid-Atlantic mixed species stop/seine/weir is also a Category III fishery with no documented marine mammal interactions. However, the mid-Atlantic stranding network has documented interactions between coastal bottlenose dolphin and pound nets in the mouth of Chesapeake Bay during the summer. Therefore, this fishery may be elevated from its current category III status in a future MMPA List of Fisheries.

7.4.1.3 Gillnet

In the 2000 MMPA List of Fisheries, the following gillnet fisheries are classified with the marine mammal species that have been reported incidentally injured or killed.

Category	Gillnet fishery	Marine mammal species incidentally injured/killed
I	Northeast sink	North Atlantic right whale
		Humpback whale
		Minke whale
		Killer whale
		White-sided dolphin
		Bottlenose dolphin (offshore stock)
		Harbor porpoise
		Harbor seal
		Gray seal
		Common dolphin
		Fin whale
		Spotted dolphin
		False killer whale
		Harp seal
II	U.S. mid-Atlantic coastal	Humpback whale
		Minke whale
		Bottlenose dolphin (coastal and offshore stock)
		Harbor porpoise
III	Rhode Island, southern Massachusetts and New York Bight inshore	Humpback whale
		Bottlenose dolphin (coastal stock)
		Harbor porpoise
	Long Island Sound inshore	Humpback whale
		Bottlenose dolphin (coastal stock)
		Harbor porpoise
	Delaware Bay inshore	Humpback whale
		Bottlenose dolphin (coastal stock)
		Harbor porpoise
	Chesapeake Bay inshore	None documented
	North Carolina inshore	Bottlenose dolphin (coastal stock)

NMFS has documented observed takes of harbor porpoise in the menhaden gillnet fishery. There were 3 observed takes in the mid-Atlantic menhaden gillnet fishery (a component of the coastal gillnet fishery complex under the MMPA List of Fisheries) in mesh sizes of 5 inches (12.7 cm) or less during 1997 (63 FR 66464, December 2, 1998). The observed bycatch rate of harbor porpoise in the menhaden drift gillnet fishery is lower than in other net fisheries (see Mid-Atlantic Take Reduction Team meeting handouts[3]). Although takes of harbor porpoise have not been documented in the mid–Atlantic sink gillnet fishery for menhaden, NMFS observer coverage has been low in comparison to the menhaden driftnet or other mid-Atlantic coastal gillnet fisheries (see Mid-Atlantic Take Reduction Team meeting handouts).

7.4.1.4 Haul Seine

The Mid-Atlantic haul seine fishery is listed as a Category II fishery in the 2000 MMPA List of Fisheries due to interactions with coastal bottlenose dolphin and possibly harbor porpoise. NMFS has recorded one observed take of a bottlenose dolphin in this fishery in 1998 (Waring and Quintal 2000).

7.4.1.5 Trawl

The Atlantic shrimp trawl fishery is currently a Category III fishery in the 2000 MMPA List of Fisheries, although some interactions have been reported to occur with coastal bottlenose dolphin. Some states have identified a menhaden trawl fishery occurring in their states, with no bycatch of marine mammals (ASMFC, Atlantic Coastal Fisheries Characterization Database, unpubl. data). This fishery falls under the umbrella of the mid-Atlantic mixed species trawl fisheries and has no reports of marine mammal species/stocks incidentally injured/killed according to the 2000 MMPA List of Fisheries.

7.4.1.6 Cast Net

Currently, cast net is not listed in the 2000 MMPA List of Fisheries. NMFS is presently evaluating this fishery to determine whether there have been any records of marine mammal interactions. Any such information obtained will be reflected in a future MMPA List of Fisheries.

7.4.2 Sea Turtles

All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the Endangered Species Act of 1973 (ESA). Five species occur along the U.S. Atlantic coast, namely, loggerhead (*Caretta caretta*), Kemp's Ridley (*Lepidochelys kempi*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*).

The Atlantic seaboard is considered to provide important developmental habitat for post-pelagic juveniles, as well as foraging and nesting habitat for adult sea turtles. 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. Turtle abundance in estuarine and nearshore waters is generally seasonal north of Canaveral, Florida. Sea turtles do not usually appear on the summer foraging grounds in the Gulf of Maine until June, but are found in Virginia as early as April. As water temperatures decline, turtles typically move from cold inshore waters in the late fall to move offshore to the warmer waters in the Gulf stream.

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[3] Mid-Atlantic Take Reduction Team. January 14-15, 2000. Alexandria, VA. Harbor porpoise bycatch data provided by NMFS Northeast Fisheries Science Center, Woods Hole, MA.

The effect water temperature has on sea turtle presence is important in assessing possible interactions with the menhaden fishery. Menhaden are also affected by water temperatures and similarily migrate north in the spring and south in the fall. Thus, the menhaden purse seine fishery exhibits a 'summer' season beginning in April off North Carolina and appearing off New England in June, and a 'fall' season beginning in early November between Cape Hatteras and Cape Fear, North Carolina.

The main gear used in the directed menhaden fishery is a small mesh purse seine, however other gear is deployed, including trawls, fixed net, gillnet, haul beach seine, pound net, and cast net. From September 1978 through early 1980, approximately 40 sea days were observed for fish sampling aboard menhaden purse seiners fishing from Maine south to North Carolina. No sea turtles were recorded as bycatch (S. Epperly, NMFS SEFSC, pers. comm.). Several states have indicated that sea turtles have been incidentally captured in menhaden fixed nets and trawls, but not for seine nets (ASMFC, Atlantic Coastal Fisheries Characterization Database, unpubl. data). An observer program for protected species has not been established for this fishery.

7.4.3 Seabirds

Like marine mammals, seabirds are vulnerable to entanglement in commercial fishing gear. The interaction has not been quantified in the Atlantic menhaden 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 menhaden fishery.

7.5 POPULATION STATUS REVIEW OF RELEVANT PROTECTED SPECIES

7.5.1 Marine Mammals

Five marine mammal species known to co-occur with or become entangled in gear used by the Atlantic menhaden fishery - namely, Atlantic right whale, humpback whale, fin whale, coastal bottlenose dolphin and harbor porpoise - are classified as strategic stocks under the MMPA. Additionally, the right, humpback and fin whales are listed as endangered, and the harbor porpoise is classified as a candidate species under the ESA. Above all, the species of greatest concern is the right whale, which is one of the most endangered species in the world, numbering only around 300 animals (Waring et al. 1999).

The status of these and other marine mammal populations inhabiting the Northwest Atlantic has been discussed in great detail in the U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments. Initial assessments were presented in Blaylock et al. (1995) and were updated in Waring et al. (1999). The report presents information on stock definition, geographic range, population size, productivity rates, PBR, fishery specific mortality estimates, and compares the PBR to estimated human-caused mortality for each stock.

7.5.2 Sea Turtles

All sea turtles that occur in U.S. waters are listed as either endangered or threatened under the ESA. Five species occur along the U.S. Atlantic coast, namely, loggerhead (*Caretta caretta*), Kemp's Ridley (*Lepidochelys kempii*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), and hawksbill (*Eretmochelys imbricata*).

7.5.2.1 <u>Biological Synopsis</u>: Loggerhead Sea Turtle

The threatened loggerhead turtle is the most abundant species of sea turtle in U.S. waters, commonly occurring throughout the inner continental shelf from Florida through Cape Cod, Massachusetts. This species is found in a wide range of habitats throughout the temperate and tropical regions of the globe. These include open ocean, continental shelves, bays, lagoons, and estuaries (NMFS and USFWS 1995).

The activity of the loggerhead is limited by temperature. Keinath *et al*. (1987) observed sea turtle emigration from the Chesapeake Bay when water temperatures cooled to below 18º C, generally in November. Sea turtles emigrate from the estuarine rivers, coastal bays and sounds when water temperatures cool to below 18º C (Keinath *et al*. 1987) and conversely immigrate when temperatures warm to 20º C (Burke *et al.* 1989; Musick *et al*. 1984). Work in North Carolina showed a significant movement of sea turtles into more northern waters at 11º C (Chester *et al.* 1994). Scientists studying movements of turtles in New York waters have seen loggerheads remain in that area for extended periods at temperatures as low as 8º C. Surveys conducted offshore and sea turtle strandings during November and December off North Carolina suggest that sea turtles emigrating from northern waters in fall and winter months may concentrate in nearshore and southerly areas influenced by warmer Gulf stream waters (Epperly et al. 1995). This is supported by the collected work of Morreale and Standora (1998) who tracked 12 loggerheads and 3 Kemp's ridleys by satellite. All of the turtles tracked similar spatial and temporal corridors, migrating south from Long Island Sound, NY, in a time period of October through December. The turtles traveled within a narrow band along the continental shelf and became sedentary for one to two months south of Cape Hatteras. Some of the turtles lingered between Cape Lookout Shoals and Frying Pan Shoals offshore of Wilmington, NC prior to moving south or into the Gulf Stream.

Since they are limited by water temperatures, sea turtles do not usually appear on the summer foraging grounds in the Gulf of Maine until June, but are found in Virginia as early as April. They remain in these areas until as late as November and December in some cases, but the large majority are leaving the Gulf of Maine by mid-September. Aerial surveys of loggerhead turtles at sea north of Cape Hatteras indicate that they are most common in waters from 22 to 49 m deep, although they range from the beach to waters beyond the continental shelf (Shoop and Kenney 1992). There is no information regarding the activity of these offshore turtles.

Loggerhead sea turtles are primarily benthic feeders, opportunistically foraging on crustaceans and mollusks. Under certain conditions they also feed on finfish, particularly if they are easy to catch (*e.g.*, caught in gillnets or inside pound nets where the fish are accessible to turtles).

During 1996, a Turtle Expert Working Group (TEWG) met on several occasions and produced a report assessing the status of the loggerhead sea turtle population in the Western North Atlantic (WNA). Of significance is the conclusion that in the WNA, there are at least 4 loggerhead subpopulations separated at the nesting beach (TEWG 1998). This finding was based on analysis of mitochondrial DNA, which the turtle inherits from its mother. It is theorized that nesting assemblages represent distinct genetic entities, but further research is necessary to address the stock definition question. These nesting subpopulations include the following areas: northern North Carolina to northeast Florida, south Florida, the Florida Panhandle, and the Yucatan Peninsula. Genetic evidence has shown that loggerheads from Chesapeake Bay southward to Georgia are nearly equally divided in origin between South Florida and northern subpopulations. Work is currently ongoing in the Northwestern North Atlantic to collect samples which will provide information relative to turtles north of the Chesapeake, which is most of the action area for this consultation.

The loggerhead turtle was listed as threatened under the ESA on July 28, 1978, but is considered endangered by the World Conservation Union (IUCN) and under the Convention on International Trade in Endangered Species of Flora and Fauna (CITES). The significance of the results of the TEWG analysis is that the northern subpopulation may be experiencing a significant decline (2.5 percent - 3.2 percent for various beaches). A recovery goal of 12,800 nests has been assumed for the Northern Subpopulation, but current nests number around 6,200 (TEWG 1998). Since the number of nests declined in the 1980's, the TEWG concluded that it is unlikely that this subpopulation will reach this goal given current stresses on population performance. Considering this apparent decline and the current lack of information on the stock definition of the northern subpopulation, a conservative approach must be implemented and adverse effects from fisheries minimized as a priority for recovery.

The most recent 5-year ESA sea turtle status review (NMFS and USFWS 1995) reiterates the difficulty of obtaining detailed information on sea turtle population sizes and trends. Most long-term data is from the nesting beaches, and this is often complicated by the fact that they occupy extensive areas outside U.S. waters. The TEWG was unable to determine acceptable levels of mortality. This status review supports the conclusion of the TEWG that the northern subpopulation may be experiencing a decline and that inadequate information is available to assess whether its status has changed since the initial listing as threatened in 1978. The current recommendation from the 5-year review is to retain the threatened designation but note that further study is needed before the next status review is conducted.

7.5.2.2 Biological Synopsis: Leatherback Sea Turtle

The leatherback is the largest living turtle and ranges farther than any other sea turtle species, exhibiting broad thermal tolerances (NMFS and USFWS 1995). Leatherback turtles are often found in association with jellyfish. The turtles feed primarily on the Cnidarians (medusae, siphonophores) and tunicates (salps, pyrosomas). These turtles are found throughout the action area of this consultation and, while predominantly pelagic, they occur annually in places such as Cape Cod Bay and Narragansett Bay during certain times of the year, particularly the Fall. Of the turtle species common to the action area, leatherback turtles seem to be the most susceptible to entanglement in pot gear and pelagic trawl gear. The susceptibility to entanglement in pot gear may be the result of attraction to gelatinous organisms and algae that collect on buoys and buoy lines at or near the surface.

Nest counts are the only reliable population information available for leatherback turtles. Recent declines have been seen in the number of leatherbacks nesting worldwide (NMFS and USFWS 1995). The status review notes that it is unclear whether this observation is due to natural fluctuations or whether the population is at serious risk. With regard to repercussions of these observations for the U.S. leatherback populations in general, it is unknown whether they are stable, increasing, or declining, but it is certain that some nesting populations (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated.

7.5.2.3 Biological Synopsis: Kemp's Ridley Sea Turtle

The Kemp's ridley is the most endangered of the world's sea turtle species. The only major nesting site for ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963). Estimates on the adult population reached a low of 1,050 in 1985, and increased to 3,000 individuals in 1997. First-time nesting adults increased from 6 percent to 28 percent from 1981 to 1989, and from 23 percent to 41 percent from 1990 to 1994, indicating that the ridley population may be in the early stages of exponential growth (TEWG 1998).

Juvenile Kemp's ridleys use northeastern and mid-Atlantic coastal waters of the U.S. Atlantic coastline as primary developmental habitat during summer months, with shallow coastal embayments serving as important foraging grounds. Post-pelagic ridleys feed primarily on crabs, consuming a variety of species, including *Callinectes* sp., *Ovalipes* sp., *Libinia* sp., and *Cancer* sp. Mollusks, shrimp, and fish are consumed less frequently (Bjorndal 1997). Juvenile ridleys migrate south as water temperatures cool in fall, and are predominantly found in shallow coastal embayments along the Gulf Coast during fall and winter months. Although the natural tendency of sea turtles is to migrate south to warmer waters, they may be susceptible to rapid drops in water temperatures in the enclosed, shallow bays of the mid-Atlatntic. In November and early December, 1999, 184 sea turtles, including 178 Kemp's ridleys, stranded along the Massachusetts coast as a result of cold-stunning.

Ridleys found in mid-Atlantic waters are primarily post-pelagic juveniles averaging 40 centimeters in carapace length, and weighing less than 20 kilograms (Terwilliger and Musick 1995). Next to loggerheads, they are the second most abundant sea turtle in Virginia and Maryland waters, arriving in these areas during May and June, and migrating to more southerly waters from September to November (Keinath *et al.* 1987; Musick and Limpus 1997). In the Chesapeake Bay, ridleys frequently forage in shallow embayments, particularly in areas supporting submerged aquatic vegetation (Lutcavage and Musick 1985; Bellmund *et al.* 1987; Keinath *et al.* 1987; Musick and Limpus 1997). The juvenile population in Chesapeake Bay is estimated to be 211 to 1,083 turtles (Musick and Limpus 1997).

Juvenile ridleys follow regular coastal routes during spring and fall migrations to and from developmental foraging grounds along the mid-Atlantic and northeastern coastlines. Consequently, many ridleys occurring in coastal waters off Virginia and Maryland are transients involved in seasonal migrations. However, Maryland's and Virginia's coastal embayments - which contain an abundance of crabs, shrimp, and other prey as well as preferred foraging habitat such as shallow subtidal flats and submerged aquatic vegetation beds - are likely used as a foraging ground by Kemp's ridley sea turtles (J. Musick, VIMS, 1998; pers. comm.; S. Epperly, NMFS SEFSC, 1998; pers. comm.; M. Lutcavage, New England Aquarium, 1998; pers. comm.). No known nesting occurs on Virginia or Maryland beaches.

7.5.2.4 Biological Synopsis: Green Sea Turtle:

Green turtles are distributed circumglobally, mainly in waters between the northern and southern 20EC isotherms (Hirth 1971). In the western Atlantic, several major nesting assemblages have been identified and studied. However, most green turtle nesting in the continental United States occurs on the Atlantic Coast of Florida. Nesting has been documented along the Gulf coast of Florida, at Southwest Florida beaches, as well as the beaches on the Florida Panhandle. On the west coast of Florida the Florida Department of Environmental Protection (FDEP) documented 35 nests in 1996, only 6 in 1997, and 45 in 1998. However, most documented green turtle nesting activity occurs on Florida index beaches, which are on the east coast and were established to standardize data collection methods and effort on key nesting beaches. The pattern of green turtle nesting shows biennial peaks in abundance, with a generally positive trend during the six years of regular monitoring since establishment of the index beaches in 1989, perhaps due to increased protective legislation throughout the Caribbean. The FDEP documented 3,061 nest in 1996, 731 in 1997, and 5,512 in 1998 on the east coast of Florida. There is evidence that green turtle nesting has been on the increase during the past decade.

While nesting activity is obviously important in determining population distributions, the remaining portion of the green turtle's life is spent on the foraging grounds. Juvenile green sea turtles occupy pelagic habitats after leaving the nesting beach. Pelagic juveniles are assumed to be omnivorous, but with a strong tendency toward carnivory during early life stages. At approximately 20 to 25 cm carapace length, juveniles leave pelagic habitats, and enter benthic foraging areas, shifting to a chiefly herbivorous diet (Bjorndal 1997). Post-pelagic green turtles feed primarily on sea grasses and benthic algae, but also consume jellyfish, salps, and sponges. Known feeding habitats along U.S. coasts of the western Atlantic include shallow lagoons and embayments in Florida, and similar shallow inshore areas elsewhere. Some of the principal feeding pastures in the western Atlantic Ocean include the upper west coast of Florida, the northwestern coast of the Yucatan Peninsula, the south coast of Cuba, the Mosquito Coast of Nicaragua, the Caribbean Coast of Panama, and scattered areas along Colombia and Brazil (Hirth 1971). The preferred food sources in these areas are *Cymodocea*, *Thalassia*, *Zostera*, *Sagittaria,* and *Vallisneria*.

Juvenile green turtles occur north to Long Island Sound, presumably foraging in coastal embayments. In North Carolina, green turtles are known from estuarine and oceanic waters. Recently, green turtle nesting occurred on Bald Head Island, just east of the mouth of the Cape Fear River, on Onslow Island, and on Cape Hatteras National Seashore. No information is available regarding the occurrence of green turtles in the Chesapeake Bay, although they are presumably present in very low numbers.

In the western Atlantic region, the summer developmental habitat encompasses estuarine and coastal waters as far north as Long Island Sound, Chesapeake Bay, and the North Carolina sounds, and south throughout the tropics (Musick and Limpus 1997). Most of the individuals reported in U.S. waters are immature (Thompson 1988). Individuals that use waters north of Florida during the summer must return to southern waters in autumn, or face the risk of cold stunning.

7.5.3 Sea Birds

No information is available at this time.

7.6 EXISTING AND PROPOSED FEDERAL REGULATIONS/ACTIONS PERTAINING TO THE RELEVANT PROTECTED SPECIES

7.7 POTENTIAL IMPACTS TO ATLANTIC COASTAL STATE AND INTERSTATE FISHERIES

The Northeast sink and Mid-Atlantic coastal gillnet fisheries are the two fisheries regulated by the Harbor Porpoise Take Reduction Plan (63 FR 66464, December 2, 1998; also refer to for defined fishery boundaries). Amongst other measures, the plan uses time area closures in combination with pingers in Northeast waters, and time area closures along with gear modifications for both small (mesh size greater than 5 inches (12.7 cm) to less than 7 inches (17.78 cm)), and large (mesh size greater than or equal to 7 inches (17.78 cm) to 18 inches (45.72 cm)) mesh gillnet in mid-Atlantic waters. Although the plan predominately impacts the dogfish and monkfish fisheries due to their higher porpoise bycatch rates, other gillnet fisheries are also affected. NMFS has documented observed takes of harbor porpoise in the mesh sizes of 5 inches or less and will be reevaluating observed data for these fisheries and stranding data to reconsider whether management measures are needed to reduce bycatch in these smaller mesh fisheries (63 FR 66464, December 2, 1998).

The Atlantic Large Whale Take Reduction Plan (64 FR 7529; February 16, 1999) 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 and Mid-Atlantic coastal gillnet. Amongst other measures, the plan closes right whale critical habitat areas to specific types of fishing gear during certain seasons and modifies fishing practices. The Atlantic Large Whale Take Reduction Team continues to identify ways to reduce possible interactions between large whales and commercial gear. Upcoming rules will address additional gear marking and modification provisions to further reduce the risk of entanglement.

The Bottlenose Dolphin Take Reduction Team is scheduled to convene in January 2001 and will include representatives from Category I and II fisheries impacting the coastal bottlenose dolphin stock. Currently, the fisheries to be represented that also participate in the Atlantic menhaden fishery include the Mid-Atlantic coastal gillnet and haul seine fisheries. These participating fisheries may change depending on any fishery re-categorizations in future MMPA Lists of Fisheries.

7.8 IDENTIFICATION OF CURRENT DATA GAPS AND RESEARCH NEEDS

A lack of sea sampling data in regards to protected species interactions in the domestic Atlantic menhaden fisheries has been identified during the course of drafting this amendment. Additional observer coverage for these fisheries is needed to understand the level of interaction in the fisheries where there is no or limited data.

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Table 2. Estimated Atlantic menhaden landings in numbers by age (in millions of fish) and weight of total landings (in thousands of metric tons), 1955-99.

Year	Number at age							Total number	Total weight
	0	1	2	3	4	5	6-8		
1955	761.0	674.1	1057.7	267.3	307.2	38.1	13.0	3118.4	641.4
1956	36.4	2073.3	902.7	319.6	44.8	150.7	37.4	3564.8	712.1
1957	299.6	1600.0	1361.8	96.7	70.8	40.5	42.3	3511.7	602.8
1958	106.1	858.2	1635.3	72.0	17.3	15.9	14.4	2719.2	510.0
1959	11.4	4038.7	851.3	388.3	33.4	11.9	18.7	5353.6	659.1
1960	72.2	281.0	2208.6	76.4	102.2	23.8	11.0	2775.1	529.8
1961	0.2	832.4	503.6	1209.6	19.2	29.4	3.9	2598.3	575.9
1962	51.6	514.1	834.5	217.3	423.4	30.8	28.3	2099.9	537.7
1963	96.9	724.2	709.2	122.5	45.0	52.4	14.3	1764.5	346.9
1964	302.6	704.0	605.0	83.5	17.9	7.8	8.3	1729.1	269.2
1965	259.1	745.2	421.4	77.8	12.2	1.8	2.0	1519.5	273.4
1966	349.5	550.8	404.1	31.7	3.9	0.4	0.3	1340.6	219.6
1967	7.0	633.2	265.7	72.8	5.1	0.5	0.0	984.2	193.5
1968	154.3	377.4	539.0	65.7	10.7	1.0	0.1	1148.0	234.8
1969	158.1	372.3	284.3	47.8	5.4	0.1	0.0	868.2	161.6
1970	21.4	870.8	473.9	32.6	4.0	0.1	0.0	1403.0	259.4
1971	72.8	263.3	524.3	88.3	17.8	2.5	0.0	969.1	250.3
1972	50.2	981.3	488.5	173.1	19.1	1.9	0.0	1713.9	365.9
1973	56.0	588.5	1152.9	38.6	7.0	0.3	0.0	1843.4	346.9
1974	315.6	636.7	986.0	48.6	2.5	1.4	0.0	1990.6	292.2
1975	298.6	720.0	1086.5	50.2	6.6	0.2	0.1	2162.3	250.2
1976	274.2	1612.0	1341.1	48.0	8.0	0.3	0.0	3283.5	340.5
1977	484.6	1004.5	2081.8	83.5	17.8	1.4	0.1	3673.7	341.1
1978	457.4	664.1	1670.9	258.1	31.2	3.5	0.0	3085.2	344.1
1979	1492.5	623.1	1603.3	127.9	21.8	1.5	0.1	3870.1	375.7
1980	88.3	1478.1	1458.2	222.7	69.2	14.4	1.4	3332.3	401.5
1981	1187.6	698.7	1811.5	222.2	47.5	15.4	1.3	3984.0	381.3
1982	114.1	919.4	1739.5	379.7	16.3	5.8	0.9	3175.7	382.4
1983	964.4	517.2	2293.1	114.3	47.4	5.0	0.7	3942.1	418.6
1984	1294.2	1024.2	892.1	271.5	50.3	15.2	0.5	3548.0	326.3
1985	637.2	1075.8	1224.6	44.1	35.6	6.2	1.7	3025.3	306.7
1986	98.4	224.2	1523.1	49.1	10.5	6.1	1.1	1912.4	238.0
1987	42.9	504.7	1587.7	151.9	25.2	2.2	0.7	2315.2	327.0
1988	338.8	282.7	1157.6	301.4	69.8	7.1	0.3	2158.0	309.3
1989	149.7	1154.6	1158.5	108.4	47.5	11.6	0.2	2630.0	322.0
1990	308.1	132.8	1553.1	109.0	42.2	12.7	0.4	2157.9	401.2
1991	881.8	1033.9	946.1	254.0	37.9	10.7	2.0	3166.6	381.4
1992	399.6	727.2	195.4	66.1	51.3	10.9	1.4	2052.5	297.6
1993	67.9	379.0	983.1	148.9	10.9	3.9	0.3	1594.0	320.6
1994	88.6	274.5	888.9	165.1	67.2	7.5	0.2	1492.1	260.0
1995	56.8	533.6	671.9	309.1	67.5	4.4	0.0	1643.3	339.9
1996	33.7	209.1	679.1	138.9	29.0	2.0	0.0	1091.9	292.9
1997	25.2	246.9	424.5	237.4	51.6	9.0	1.2	995.9	259.1
1998	72.8	185.0	540.6	126.3	73.0	9.0	0.8	1007.5	245.9
1999	194.2	300.8	449.4	83.1	24.7	3.2	0.4	1055.8	171.2

Table 3. Estimated Atlantic menhaden population size in numbers by age (in millions) from Murphy Virtual Population Analysis, 1955-99 (estimates of population size at age-0 should be interpreted with care, because natural mortality at this age is poorly understood).

Year	0	1	2	3	4	5	6	7	8
1955	7962.2	3091.4	2285.4	619.6	813.4	116.4	32.1	7.3	2.0
1956	9112.6	5680.4	1443.2	644.3	189.1	280.9	44.6	12.3	3.2
1957	4496.7	7243.4	2015.0	239.1	166.0	85.6	64.2	6.9	2.7
1958	19031.2	3324.1	3367.4	265.0	77.7	51.2	23.5	12.9	1.2
1959	2787.9	15103.1	1449.3	893.3	112.8	36.1	20.3	7.9	4.4
1960	3848.3	2216.1	6479.4	278.5	270.5	45.9	13.8	3.6	1.6
1961	2790.7	3008.7	1192.0	2417.1	118.0	93.3	11.1	2.7	0.5
1962	2853.9	2228.3	1269.3	371.7	615.0	60.2	36.7	4.8	1.1
1963	2288.8	2232.9	1018.9	182.5	72.2	75.8	14.9	5.0	0.8
1964	2729.0	1741.2	860.9	120.3	24.5	12.1	9.2	1.7	0.7
1965	1997.5	1910.1	566.4	98.0	14.4	2.3	1.8	0.9	0.1
1966	2810.5	1373.6	641.8	49.6	5.7	0.4	0.2	0.3	0.1
1967	1491.5	1933.5	450.4	104.4	7.7	0.7	0.0	0.0	0.1
1968	2278.0	1184.8	740.7	85.7	12.3	1.1	0.1	0.0	0.0
1969	3397.8	1681.7	462.1	72.4	6.3	0.2	0.0	0.0	0.0
1970	1690.1	2572.3	780.8	79.8	10.3	0.1	0.0	0.0	0.0
1971	4383.0	1330.5	964.0	139.4	25.7	3.4	0.0	0.0	0.0
1972	3426.4	3435.1	642.2	215.0	22.3	3.1	0.3	0.0	0.0
1973	3812.5	2691.5	1425.9	49.6	11.0	0.6	0.6	0.2	0.0
1974	5042.4	2994.4	1255.4	70.2	3.3	1.8	0.1	0.4	0.1
1975	8850.7	3745.2	1410.8	78.4	8.5	0.3	0.1	0.1	0.2
1976	6724.6	6801.3	1823.7	100.8	12.2	0.5	0.0	0.0	0.0
1977	6414.9	5125.1	3076.0	169.4	27.4	1.8	0.1	0.0	0.0
1978	5787.0	4691.0	2480.4	402.9	44.1	4.1	0.1	0.0	0.0
1979	9987.1	4213.8	2469.1	329.9	62.6	4.9	0.1	0.1	0.0
1980	5948.1	6648.1	2197.0	368.8	111.4	23.0	2.0	0.0	0.0
1981	9277.0	4671.0	3082.0	306.7	66.6	18.7	3.8	0.2	0.0
1982	3188.8	6352.2	2429.4	591.8	30.6	7.2	0.8	1.5	0.1
1983	5817.9	2444.5	3328.2	255.6	91.6	7.0	0.4	0.1	0.7
1984	7695.8	3788.6	1153.8	408.8	75.0	22.2	0.8	0.1	0.1
1985	6295.0	4995.5	1616.5	80.5	56.9	10.1	2.8	0.1	0.0
1986	4339.5	4459.5	2342.9	127.8	17.7	9.4	1.7	0.5	0.1
1987	3788.0	3377.2	2666.6	348.6	43.5	3.4	1.4	0.3	0.3
1988	7291.4	2985.6	1757.1	497.4	105.3	8.6	0.5	0.4	0.2
1989	2943.3	5520.6	1678.0	251.0	89.2	14.8	0.4	0.1	0.1
1990	4777.2	2217.0	2477.9	224.0	76.5	20.6	0.9	0.1	0.0
1991	5424.0	3540.1	1308.8	391.3	64.6	16.6	3.8	0.2	0.0
1992	4504.3	3547.8	1452.1	132.0	65.0	12.9	2.6	0.9	0.1
1993	2974.9	3241.1	1692.6	319.9	33.6	5.1	0.6	0.6	0.2
1994	3853.1	2314.9	1768.5	333.2	89.6	12.9	0.4	0.1	0.4
1995	2070.4	2997.7	1260.0	447.2	86.0	7.5	2.5	0.1	0.1
1996	2144.6	1602.7	1493.0	290.7	54.3	5.4	1.4	1.6	0.0
1997	1928.0	1682.3	857.3	429.6	78.7	12.5	1.8	0.9	0.0
1998	3484.0	1517.1	878.7	221.5	93.1	11.4	1.3	0.3	0.6
1999	13657.7	2717.2	821.7	151.9	45.2	5.9	0.7	0.8	0.2

Table 4. Yield-per-recruit (g) for age at entry of 0.5 yr and F-multiple of 1 for Atlantic menhaden for each fishing year from 1970 through 1990, and for mean conditions for the 1970s and 1980s. Percent gains/ losses are presented for increasing ages at entry (1.0 and 2.0 yr) and two F-multiples (0.5 and 2.0).

		Age at entry (y)		F-multiple	
		%			
Fishing year	Y/R (grams)	1.0	2.0	0.5	2.0
1970	89.7	0.4	8.7	-4.0	-6.4
1971	100.5	0.6	8.4	-2.7	-5.5
1972	99.5	0.5	15.5	6.7	-12.7
1973	90.4	0.6	14.3	8.7	-13.9
1974	85.7	2.2	13.5	7.2	-12.0
1975	79.9	1.1	10.3	7.4	-11.4
1976	69.7	1.6	14.1	1.9	-12.6
1977	58.2	2.7	15.6	9.4	-16.7
1978	53.7	2.6	9.1	7.6	-11.5
1979	52.7	6.5	12.7	-3.0	-10.4
1980	53.9	0.6	14.3	3.9	-13.2
1981	50.5	5.3	13.5	10.1	-17.4
1982	51.6	1.4	7.4	4.5	-7.4
1983	51.5	6.0	16.1	4.2	-12.9
1984	51.3	6.1	17.7	8.1	-14.1
1985	52.0	4.3	13.7	4.8	-12.7
1986	56.2	0.9	3.6	-4.1	-5.5
1987	51.5	0.4	6.9	-2.3	-8.6
1988	53.9	1.9	6.2	2.5	-7.8
1989	50.8	2.1	10.3	1.7	-10.0
1990	63.0	0.6	3.1	-12.4	+1.6
			Mean conditions		
1970s	78.5	1.8	12.6	4.7	-11.7
1980s	52.1	2.9	11.2	4.0	-11.5
1990-98	95.4	1.7	6.6	-6.8	-3.2
1990-95	106.6	0.7	6.1	-6.9	-4.2

Table 5. Numbers of menhaden processing plants, aircraft, vessels, vessel hold capacity (standard fish), and percent fleet refrigeration for the Atlantic menhaden fishery, 1972-1990 (one standard fish = 0.667 lb)[1].

	Summer fishery[2]						Fall fishery[3]				
					Hold capacity (1000)					Hold capacity (1000)	
Year	Number of plants	Number of aircraft	Number of vessels	Percent refrigerated	Total	Mean	Number of aircraft	Number of vessels	Percent refrigerated	Total	Mean
1972	7	23	35	29	29,085	831	15	15	40	14,285	952
1973	7	24	39	44	34,960	896	15	16	44	13,360	835
1974	7	26	41	49	38,160	931	16	18	39	13,710	762
1975	7	27	43	51	42,710	993	18	23	48	19,860	863
1976	7	26	41	56	40,560	989	17	20	60	18,260	913
1977	7	28	43	65	48,125	1119	17	18	67	18,275	1015
1978	7	28	38	66	44,350	1167	11	17	65	19,550	1150
1979	7	29	39	67	44,550	1142	11	18	67	21,500	1194
1980	7	29	40	60	44,020	1101	11	19	58	21,820	1148
1981	7	29	40	63	40,450	1011	13	18	61	21,150	1175
1982	6	23	30	60	31,350	1045	10	16	69	19,150	1197
1983	6	20	31	61	33,750	1089	11	17	71	19,950	1174
1984	5	20	30	63	33,150	1105	9	12	67	14,850	1238
1985	5	17	23	83	29,500	1283	2	4	25	2,850	713
1986	5	8	16	75	15,900	994	2	3	33	2,300	767
1987	6	11	19	84	21,100	1110	2	3	33	2,300	767
1988	6	15	27	74	28,400	1052	2	6	83	8,700	1450
1989	5	17	32	53	31,400	981	15	25	83	32,600	1300
1990	5	17	33	53	32,900	997	15	23	90	31,500	1432
1991	5	18[4]	35	69	38,500	1167	18	23	96	33,650	1530
1992	8	18[4]	35	74	41,900	1232	18	23	96	34,950	1520
1993	7	18[4]	29	72	35,350	1263	18	20	95	30,800	1540
1994	3	17	20	100	31,700	1585	17	20	100	31,700	1585
1995	3	17	20	100	33,300	1586	17	20	100	31,700	1585
1996	3	17	21	100	33,300	1,586	17	20	100	31,700	1585
1997	3	17	23	100	31,600	1580	17	21[5]	100	31,600	1580
1998	2	12	15	100	23,800	1587	12	15[5]	100	23,800	1587
1999	2	12	15	100	23,800	1587	12	15	100	23,800	1587

[1] In attempting to compute total number of vessels active during the fishing year, summer and fall fishing vessel tallies are not additive.

[2] Includes only vessels that fished regularly during the summer fishery; does not include vessels added to the Virginia fleet during October and November or vessels fishing exclusively for the New Brunswick, Canada plant.

[3] The fall fishery is defined through 1988, as all vessels unloading fish in North Carolina after the start of the fall fishery on 1 November. In 1989 and 1990, the fall fishery includes activities of vessels landing at Reedville, VA because those vessels fished intensively along the North Carolina coast to south of Cape Hatteras.

[4] Does not include aircraft used in the Gulf of Maine.

[5] Two small vessels (approx. 90 foot long) unloaded infrequently in 1997 and 1998, and are excluded.

Table 6. Atlantic menhaden reduction landings (1,000 metric tons) and percent contribution of total reduction landings by region, 1980-99.

Year	North Atlantic	%	Mid-Atlantic	%	South Atlantic	%	Total
1980	29.6	7.4	282.8	70.4	89.1	22.2	401.5
1981	21.8	5.7	215.9	56.6	143.6	37.7	381.3
1982	35.1	9.2	258.0	67.5	89.4	23.3	382.4
1983	39.4	9.4	279.6	66.8	99.7	23.8	418.6
1984	35.0	10.7	203.6	62.4	87.7	26.9	326.3
1985	14.3	4.7	273.4	89.2	19.0	6.1	306.7
1986	10.0	4.2	197.7	83.1	30.4	12.7	238.0
1987	25.9	7.9	276.1	84.5	24.9	7.6	326.9
1988	39.8	12.9	236.3	76.4	33.2	10.7	309.3
1989	38.2	11.9	256.9	79.8	27.0	8.3	322.0
1990	58.2	14.5	308.9	77.0	34.7	8.5	401.8
1991	51.3	13.5	282.9	74.2	47.3	12.4	381.4
1992	27.8	9.3	249.5	83.8	20.4	6.8	297.6
1993	10.3	3.2	281.9	87.9	28.4	8.8	320.6
1994	0	0	227.9	87.6	32.1	12.4	260.0
1995	0	0	313.0	92.1	26.9	7.9	339.9
1996	0	0	261.8	89.4	31.1	10.6	292.9
1997	0	0	223.6	86.3	35.6	13.7	259.1
1998	0	0	216.4	88.0[1]	29.5	12.0[1]	245.9
1999	0	0	150.7	88.0[1]	20.5	12.0[1]	171.2
Period							
1980-93	31.2	9.1	257.4	74.8	55.3	16.1	343.9
1980-98	23.0	7.0	255.1	78.0	49	15	327
1994-98	0	0	248.5	88.9	31.0	11.1	279.6

[1] average of regional landings for 1995-99

Table 7. Atlantic menhaden purse seine reduction landings by month (metric tons) for 1980-1999 (totals include Jan-Feb of following calendar year).

Year	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total[1]
1980	0	173	37,220	59,785	77,666	82,954	66,588	34,213	15,630	30,092	3,287	0	409,588
1981	0	2,223	19,681	61,551	90,029	61,299	45,601	28,151	41,679	31,097	0	0	383,291
1982	0	795	34,151	76,315	76,220	69,010	59,164	34,072	4,953	27,755	25	0	382,460
1983	0	554	23,487	62,627	74,646	82,705	62,212	20,979	26,288	49,405	15,732	0	418,634
1984	0	7	12,436	38,590	56,487	65,820	45,254	30,079	14,623	34,031	26,397	2,571	326,296
1985	0	0	24,608	60,690	58,213	57,377	41,907	35,319	6,363	20,348	1,017	824	306,665
1986	713	1,060	17,616	35,384	48,306	42,229	46,235	34,052	5,403	6,538	465	0	238,001
1987	0	751	12,822	46,157	68,636	53,336	61,532	35,248	34,506	12,588	1,317	20	326,912
1988	0	0	13,318	32,507	43,381	63,711	69,471	23,215	23,588	37,045	3,057	0	309,293
1989	0	0	24,779	48,372	54,182	71,862	49,544	29,727	14,274	27,336	1,938	0	322,014
1990	0	0	34,848	51,345	64,612	72,314	65,574	47,749	29,108	30,206	5,402	0	401,159
1991	0	0	50,387	44,913	59,042	60,436	44,197	44,713	37,835	35,403	4,271	216	381,413
1992	2,361	3,326	10,103	59,047	65,220	46,279	33,060	42,839	14,302	20,793	301	0	297,631
1993	0	0	25,437	39,156	51,683	64,686	41,180	33,164	50,020	15,241	25	0	320,592
1994	0	2,424	23,532	38,484	36,025	46,887	46,317	24,000	34,812	7,102	404	0	259,988
1995	0	35	11,224	46,969	58,162	64,338	50,390	37,714	37,318	32,791	987	0	339,927
1996	0	0	17,830	35,579	36,256	58,119	41,753	38,052	46,163	11,070	8,103	0	292,924
1997	0	0	9,972	42,237	32,708	42,238	34,057	31,421	34,802	30,779	142	784	259,140
1998	0	0	12,255	24,777	28,718	38,354	40,717	39,688	36,396	19,943	5,071	0	245,920
1999	0	0	2,456	20,755	33,753	28,137	22,080	25,546	17,300	16,627	4,536	0	171,191
Avg.	153.7	567.4	20,908.1	46,262	55,697.3	58,604.6	48,341.7	33,497.1	26,268.2	24,809.5	4,123.9	220.8	319,652

[1] Total may not agree with data in other tables due to rounding.

Table 8. Years of activity for individual Atlantic menhaden reduction plants (! indicates when plant was active).

Year/plant	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Total Plants	Number Vessels
1955	!	!	!	!	!	!		!		!	!	!	!		!	!	!	!	!	!	!	!	!	!	!	!											23	150
1956	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!												24	149
1957	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!											25	144
1958	!	!	!	!	!			!	!	!	!	!	!	!	!	!	!	!		!	!		!	!	!	!											22	130
1959	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!		!	!		!	!	!	!											23	144
1960	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!		!			!		!												20	115
1961	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!		!			!		!												20	117
1962	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!			!			!		!												19	112
1963	!	!	!	!	!			!	!	!	!	!	!	!	!	!	!	!		!																	17	112
1964	!	!	!	!	!	!		!	!	!	!	!	!	!	!	!	!	!		!																	18	111
1965	!	!		!	!			!		!	!	!	!	!		!	!	!	!	!							!	!									17	84
1966	!	!		!	!		!	!	!	!	!	!	!	!	!	!	!		!	!							!	!	!								20	76
1967		!		!			!	!	!	!	!	!	!	!	!	!	!		!	!							!	!	!								18	64
1968	!	!		!			!			!	!	!	!	!	!	!	!		!	!							!	!	!								17	59
1969	!	!		!			!			!		!	!	!	!	!	!			!							!	!	!								15	51
1970		!					!			!		!	!	!	!	!	!			!			!		!		!	!	!								15	54
1971		!					!			!		!	!	!	!	!	!			!			!		!		!	!									14	51
1972		!					!			!			!	!			!			!			!		!		!	!									11	51
1973		!					!			!			!	!			!			!		!	!		!			!									11	58
1974		!					!			!			!	!			!			!			!		!			!									10	63
1975		!					!			!			!	!			!			!		!	!		!			!		!							12	61
1976		!					!			!			!	!			!			!			!		!			!		!							11	62
1977		!					!			!			!	!			!			!		!	!		!			!		!							12	64
1978		!					!			!			!	!			!			!		!	!		!			!		!							12	53
1979		!					!			!			!	!			!			!		!	!		!			!		!							12	54
1980							!			!			!	!			!			!		!	!					!		!							11	51
1981							!			!			!	!			!			!		!	!					!		!							11	57
1982							!			!			!	!			!			!		!	!					!		!							10	47
1983							!			!			!	!			!			!			!					!		!							9	41
1984							!			!			!	!						!			!					!		!							8	38
1985							!			!			!							!								!		!							6	24
1986							!			!			!							!								!		!							6	16
1987							!			!			!							!										!		!					6	23
1988							!			!			!																	!		!	!				6	30
1989							!			!			!																			!	!				5	37
1990							!			!			!																			!	!				5	35
1991							!			!			!																			!	!				5	37
1992							!			!			!																			!	!	!	!	!	8	37
1993							!			!			!																			!	!		!	!	7	31
1994							!			!			!																								3	20
1995							!			!			!																								3	20
1996							!			!			!																								3	21
1997							!			!			!																								3	23
1998										!			!																								2	15
1999										!			!																								2	13

Table 8 (continued).

Port	Plant	Name	Location
3	1	Atlantic Processing Co.	Amagansett, NY
4	2	J. Howard Smith (Seacoast Products)	Port Monmouth, NJ
4	3	Fish Products Co.	Tuckerton, NJ
8	4	New Jersey Menhaden Products Co.	Wildwood, NJ
0	5	Fish Products Co. (Seacoast Products Co.)	Lewes, DE
0	6	Consolidated Fisheries	Lewes, DE
5	7	AMPRO (Standard Products Co.)	Reedville, VA
5	8	McNeal-Edwards (Standard Products Co.)	Reedville, VA
5	9	Menhaden Co. (Standard Products Co.)	Reedville, VA
5	10	Omega Protein (Zapata haynie Co.)	Reedville, VA
5	11	Standard Products Co.	White Stone, VA
6	12	Fish Meal Co.	Beaufort, NC
6	13	Beaufort Fisheries, Inc.	Beaufort, NC
6	14	Standard Products Co.	Beaufort, NC
6	15	Standard Products Co.	Morehead City, NC
6	16	Haynie Products, Inc.	Morehead City, NC
7	17	Standard Products Co.	Southport, NC
7	18	Southport Fisheries Menhaden	Southport, NC
9	19	Quinn Menhaden Fisheries, Inc.	Fernandina Beach, FL
9	20	Nassau Oil and Fertilizer Co.	Fernandina Beach, FL
9	21	Mayport Fisheries	Mayport, FL
1	22	Maine Marine Products (Pine State Products)	Portland, ME
2	23	Lipman Marine Products (Gloucester Marine Protien)	Glucester, MA
2	24	Gloucester Dehydration Co.	Gloucester, MA
11	25	Point Judith By Products Co.	Point Judith, RI
9	26	Quinn Fisheries	Younges Island, SC
5	27	Haynie Products (Cockerall’s Ice & Seafood)	Reedville, VA
6	28	Sea and Sound Processing Co.	Beaufort, NC
12	29	Cape Charles Processing Co.	Cape Charles, VA
13	30	Sea Pro, Inc.	Rockland, ME
	31		
15	32	Conner Bros.	New Brunswick, Cananda
14	33	Riga (IWP)	Maine
14	34	Vares (IWP)	Maine
14	35	Dauria (IWP)	Maine
15	36	Comeau	Nova Scotia, Canada

Table 9. Comparison of landings (1000 mt) by the bait and reduction fisheries for Atlantic menhaden.

Year	Reduction	Bait	(%)	Total
1985	306.7	26.7	(8.0)	333.4
1986	238.0	28.0	(10.5)	266.0
1987	326.9	60.6	(8.6)	357.5
1988	309.3	36.3	(10.5)	345.6
1989	322.0	30.9	(8.8)	352.9
1990	401.2	30.7	(7.1)	431.9
1991	381.4	36.2	(8.7)	417.6
1992	297.6	38.7	(11.5)	336.3
1993	320.6	35.1	(9.9)	355.7
1994	260.0	28.1	(9.8)	288.1
1995	339.9	31.1	(8.4)	371.0
1996	291.5	23.3	(7.4)	314.8
1997	259.1	25.6	(9.0)	284.7
1998	245.9	39.1	(13.7)	285.0
1999	171.2	35.8	(17.3)	207.0

Table 10. Atlantic coast menhaden bait landings (pounds) by region, 1985-99.

	Region				
Year	**New England[1]**	**Mid-Atlantic[2]**	**Chesapeake Bay[3]**	**South Atlantic[4]**	**Total**
1985	13,553,854	3,957,701	35,150,602	5,015,223	57,677,380
1986	30,313,112	2,839,559	22,322,101	5,379,492	60,854,264
1987	29,283,789	2,763,534	29,806,500	5,642,884	67,496,707
1988	43,498,624	2,586,956	27,450,588	6,354,442	79,881,610
1989	21,022,066	3,237,063	32,068,050	7,528,295	63,855,474
1990	24,311,897	9,582,497	18,846,877	8,967,279	61,708,550
1991	25,418,928	17,519,449	18,399,037	5,465,646	66,803,060
1992	27,430,232	28,021,724	23,072,633	6,842,281	85,366,870
1993	26,421,477	29,419,670	16,870,684	4,638,141	77,349,972
1994	946,206	39,154,289	14,920,995	6,992,881	62,014,371
1995	8,805,518	37,761,873	18,559,221	3,452,459	68,579,071
1996	92,226	35,627,924	14,417,119	1,274,399	51,411,668
1997	78,079	38,174,982	14,496,390	3,653,799	56,403,250
1998	348,556	33,375,397	49,639,790	2,931,401	86,295,144
1999	32,628	27,838,439	48,489,247	2,875,252	79,235,566

[1] New England: ME, NH, MA, RI, CT
[2] Mid-Atlantic: NY, NJ, DE
[3] Chesapeake Bay: MD, VA, Potomac River
[4] South Atlantic: NC, SC, GA, FL (east coast)

Table 10 (continued). Average annual Atlantic menhaden bait landings (pounds) by gear, 1985-99 .

Region[1]	Gear					Total (bait) landings	
	Purse seine	Haul seine	Pound net[2]	Gill net	Other[3]	Pounds	Metric tons
<u>1985-93</u>							
New England	26,813,608	0	410,169	128,833	210,721	27,563,331	12,500.4
Mid-Atlantic	8,813,304	0	1,372,294	663,520	157,809	11,006,927	4,991.8
Chesapeake Bay area	11,157,236[4]	91,008	21,487,178	53,053	43,501	32,831,976	14,890
South Atlantic	3,341,680	930,840	759,418	1,337,374	56,651	6,425,963	2,914.3
<u>1994-99</u>							
New England	1,584,854	0	29,151	37,191	66,006	1,717,202	778.8
Mid-Atlantic	34,003,540	0	272,489	816,020	229,601	35,321,650	16,018.9
Chesapeake Bay area	36,553,960[5]	16,565	14,245,373	190,135	28,322	51,034,355	23,145
South Atlantic	1,775,273	184,269	438,277	490,273	641,940	3,530,032	1600.9

[1] Regions are defined as follows: New England (ME, NH, MA, RI, CT); Mid-Atlantic (NY, NJ, DE); Chesapeake Bay (MD, VA, Potomac River); and South Atlantic (NC, SC, GA, FL east coast)

[2] Includes fish traps.

[3] "Other" may include gear specifically listed to maintain confidentiality of landings. Also, state landings not separated by gear are collectively reported in this categor

[4] Incomplete reporting for this period/fishery; average is for four years where data were available.

[5] Incomplete reporting for this period/fishery; average is for 1998-99, only years where data were available.

Table 11. Annual estimated values of six Atlantic menhaden stock and fishery status reference points (boldface indicates years in which respective value would have exceeded its warning level).

Year	Landings[1]	PO[2]	P3+[3]	Recruits[4]	SSB[5]	MSP[6]
1940	179.0	-	-	-	-	-
1941	283.1	-	-	-	-	-
1942	167.4	-	-	-	-	-
1943	215.0	-	-	-	-	-
1944	243.5	-	-	-	-	-
1945	285.6	-	-	-	-	-
1946	351.8	-	-	-	-	-
1947	376.4	-	-	-	-	-
1948	341.3	-	-	-	-	-
1949	363.4	-	-	-	-	-
			-	-	-	-
1950	311.2	-	-	-	-	-
1951	351.2	-	-	-	-	-
1952	423.6	-	-	-	-	-
1953	589.2	-	-	-	-	-
1954	617.9	-	-	-	-	-
1955	644.5	24.4	20.1	3.1	327.0	13.8
1956	715.4	1.0	15.5	5.7	258.7	6.6
1957	605.6	8.5	7.1	7.3	133.2	6.7
1958	512.4	3.9	4.4	3.3	88.7	16.1
1959	662.2	0.2	8.4	15.1	173.7	8.6
1960	532.2	2.6	7.7	2.2	123.3	24.1
1961	578.6	0.0	**48.6**	3.0	360.3	13.3
1962	541.6	2.5	**33.3**	2.2	200.0	4.9
1963	348.4	5.5	13.3	2.2	65.3	3.1
1964	270.4	17.5	6.8	**1.7**	30.8	**2.4**
1965	274.6	17.1	6.2	**1.9**	20.8	**1.7**
1966	**220.5**	**26.1**	2.7	**1.4**	**9.1**	3.3
1967	**194.4**	0.7	8.0	**1.9**	20.9	5.5
1968	**235.9**	13.4	6.7	**1.2**	**16.8**	**2.1**
1969	**162.3**	18.2	6.2	**1.7**	**14.1**	5.4
1970	259.4	1.5	2.6	2.6	**16.2**	6.6
1971	250.3	7.5	11.2	**1.3**	28.1	6.6
1972	365.9	2.9	11.3	3.4	48.0	**2.0**
1973	346.9	3.0	2.5	2.7	**12.5**	**1.3**
1974	292.2	15.9	2.6	3.0	**12.1**	**1.5**
1975	250.2	13.8	2.6	3.7	**13.6**	**1.9**
1976	340.5	8.4	1.7	6.8	**15.6**	2.8
1977	341.2	13.2	2.8	5.1	25.6	4.3
1978	344.1	14.8	9.5	4.7	44.5	3.7
1979	375.7	**38.6**	3.9	4.2	40.4	6.4

Table 11 (continued).

Year	Landings[1]	PO[2]	P3+[3]	Recruits[4]	SSB[5]	MSP[6]
1980	401.5	2.6	9.2	6.7	58.0	4.6
1981	381.3	**29.8**	7.2	4.7	42.4	5.0
1982	382.5	3.6	12.7	6.4	48.8	3.1
1983	418.6	24.5	4.2	2.5	35.8	3.8
1984	326.3	**36.5**	9.5	3.8	55.3	**1.7**
1985	306.7	21.1	2.9	5.0	18.8	**2.5**
1986	**238.0**	5.1	3.5	4.5	**15.7**	7.5
1987	326.9	1.9	7.8	3.4	37.5	7.8
1988	309.3	15.7	17.6	3.0	58.9	5.1
1989	322.0	5.7	6.4	5.5	38.3	5.2
1990	401.2	14.3	7.6	2.2	35.3	7.7
1991	381.4	**27.8**	9.6	3.5	59.6	**2.8**
1992	297.6	19.5	6.3	3.5	29.8	8.6
1993	320.6	4.3	10.3	3.2	39.3	10.1
1994	260.0	5.9	16.1	2.3	62.9	13.0
1995	339.9	3.5	23.2	3.0	74.7	8.2
1996	292.9	3.1	15.6	**1.6**	53.5	15.3
1997	259.1	2.5	**30.0**	**1.7**	86.8	11.7
1998	**245.9**	7.2	20.8	**1.5**	55.3	6.7
1999	**171.2**	18.4	10.6	2.7	32.8	9.7
Median[7]	333.5	7.5	7.8	3.0	40.4	5.4
25%	259.7	3.0	4.4	2.2	20.9	3.1
75%	381.9	17.5	12.7	4.5	62.9	8.2
Reference Level	<250.0	>25.0	>25.0	<2.0	<17.0	<3.0

1 Landings in thousands of metric tons.
2 Percent by numbers of age 0's in landings.
3 Percent by numbers of adults (ages 3+) in landings.
4 Estimated numbers of recruits to age 1 in billions.
5 Estimated mature female biomass (spawning stock biomass or SSB) in thousands of metric tons.
6 Estimated equilibrium maximum spawning potential based on egg production (for estimated F vs F=0) in percent (includes F at age 0).
7 Median, 25^{th}, and 75^{th} percentiles based on fishing years from 1965 through 1990, except for P3+ which is based on fishing years 1955 through 1990.

Table 14. Atlantic coast menhaden bait landings (metric tons [1]) by state, 1985-1999.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	PRFC	NC	SC	GA	FL
1985	857.9	0	1378.8	3804.8	106.5	409.1	1306.3	79.9	978.6	7856.5	7606.3	1776.1	3.6	0	495.2
1986	7371.0	0	1547.2	4712.5	115.4	166.0	1112.9	9.1	1026.4	4483.9	4976.9	2043.5	<1	0	396.0
1987	6514.5	1.9	551.2	6173.1	43.0	80.9	1162.6	10.0	1073.8	6494.9	5951.4	1963.8	1.8	0	594.0
1988	8929.4	2.3	3650.2	7068.6	79.5	215.5	900.0	57.9	1017.2	5432.6	6001.7	2420.6	0	0	461.7
1989	172.6	2.5	662.0	8633.4	67.4	132.6	1294.7	47.3	1714.0	11027.1	3780.4	2792.3	0	0	622.6
1990	2605.7	2.7	775.5	7757.7	43.9	181.7	4101.2	75.8	754.0	8266.4	2052.0	2873.0	0	0	1195.9
1991	6302.3	5.4	5805.3	2309.0	43.7	289.7	7528.5	126.5	1418.1	6571.4	2438.6	2254.2	0	0	1130.7
1992	4980.5	4.6	6123.3	1292.5	41.4	201.9	12460.7	48.0	806.1	7363.7	2295.9	1857.8	0	0	1245.8
1993	8664.2	1.7	549.6	2334.3	434.9	434.9	12835.3	74.4	819.5	3256.8	3576.2	931.4	0	0	1172.4
1994	0	0.5	159.3	242.1	27.3	408.0	17316.6	35.7	1168.1	2569.5	3030.5	2556.4	0	0	629.1
1995	0	0.7	1320.2	2664.1	9.1	493.5	16589.1	46.0	2450.2	2785.3	3176.5	1266.5	0	0	299.5
1996	0	0	3.9	<1	37.6	5.1	16110.3	45.4	1772.1	2448.9	2318.5	409.6	0	0	123.4
1997	0	0	0	2.6	32.8	<1	17218.9	25.3	1568.2	2395.8	2611.5	1440.5	0	0	185.3
1998	0	0	0	<1	157.9	9.0	15099.2	26.3	1261.1	19446.0	1797.5	1192.9	0	0	119.6
1999	0	0	0	1	13.7	2.9	12586.7	35.6	1992.2	17793.9	2204.4	1194	0	0	110

[1] (Multiply by 2,205 to get pounds)

Table 15. Annual estimates of Atlantic menhaden population size (age 1-8 at start of fishing year), numbers landed (age 1 to maximum age observed), exploitation rates (u, ratio of catch to population numbers for ages 1-8), and instantaneous fishing mortality rate, F_{part} (yr $^{-1}$, weighted mean of F, for ages 1-8 from VPA), and instantaneous fishing mortality rate, F_{full} (yr $^{-1}$, weighted mean of F, for ages 2-8 from VPA) for 1955-99.

Fishing year	Population size (millions)	Numbers landed (millions)	u	F_{part}	F_{full}
1955	6967.6	2357.4	0.34	0.63	0.76
1956	8298.0	3528.5	0.43	0.83	1.19
1957	9823.3	3212.1	0.33	0.89	1.46
1958	7123.0	2613.1	0.37	0.69	0.85
1959	17627.0	5342.2	0.30	0.55	1.04
1960	9309.4	2702.9	0.29	0.50	0.54
1961	6843.4	2598.1	0.38	0.71	0.85
1962	4587.1	2048.3	0.45	1.19	1.48
1963	3603.0	1667.6	0.46	1.15	1.65
1964	2770.6	1426.5	0.51	1.20	1.72
1965	2594.0	1260.4	0.49	1.23	2.07
1966	2071.7	991.2	0.48	0.98	1.34
1967	2496.8	977.2	0.39	0.79	1.32
1968	2024.7	993.7	0.49	1.39	1.94
1969	2222.7	710.0	0.32	0.82	1.37
1970	3443.4	1381.5	0.40	0.79	1.23
1971	2463.1	896.2	0.36	0.87	1.12
1972	4318.1	1663.8	0.39	1.17	2.24
1973	4179.4	1787.4	0.43	1.81	2.54
1974	4325.7	1675.1	0.39	1.54	2.29
1975	5243.6	1863.7	0.36	1.43	2.16
1976	8738.5	3009.3	0.34	1.06	1.89
1977	8399.8	3189.1	0.38	1.15	1.56
1978	7622.6	2627.8	0.34	1.21	1.55
1979	7080.5	2377.7	0.34	1.07	1.38
1980	9350.3	3244.1	0.35	0.95	1.48
1981	8149.0	2796.4	0.34	1.02	1.29
1982	9413.6	3061.6	0.33	1.27	1.73
1983	6128.1	2977.7	0.49	1.37	1.59
1984	5449.4	2253.8	0.41	1.28	2.03
1985	6752.4	2388.0	0.35	1.26	2.03
1986	6959.6	1814.1	0.26	1.28	1.43
1987	6441.3	2272.4	0.36	0.99	1.19
1988	5355.1	1818.9	0.33	1.27	1.46
1989	7554.2	2480.6	0.30	0.79	1.47

Table 15 (continued). Annual estimates of Atlantic menhaden population size (age 1-8 at start of fishing year), numbers landed (age-1 to maximum age observed), exploitation rates (u, ratio of catch to population numbers for ages 1-8), instantaneous fishing mortality rate, F_{part} (yr $^{-1}$, weighted mean of F, for ages 1-8 from VPA), and instantaneous fishing mortality rate, F_{full} (yr $^{-1}$, weighted mean of F, for ages 2-8 from VPA) for 1955-99.

Fishing year	Population size (millions)	Numbers landed (millions)	u	F_{part}	F_{full}
1990	5017.0	1849.8	0.34	0.82	1.32
1991	5325.4	2284.6	0.43	1.14	1.72
1992	5213.4	1652.3	0.32	0.76	1.13
1993	5293.7	1526.1	0.29	0.89	1.13
1994	4520.0	1403.4	0.31	0.83	0.99
1995	4801.1	1586.5	0.33	0.94	1.29
1996	3449.1	1058.1	0.31	0.69	0.81
1997	3063.1	970.6	0.32	0.79	0.99
1998	2724.0	934.7	0.34	1.15	1.39
1999	3743.6	861.6	0.23	0.74	1.06

APPENDIX A.1

ATLANTIC MENHADEN BAIT LANDINGS BY STATE AND GEAR TYPE, 1985-1999

Table A.1-1. Menhaden bait landings (pounds) in Maine, by gear, 1985-99 [1].

Year	Stop Seine	Purse Seine	Pots & Traps	Total (lbs)	Total (mt)
1985		1,891,383		1,891,383	857.9
1986		16,250,100		16,250,100	7,371.0
1987		14,361,840		14,361,840	6,514.5
1988		19,685,728		19,685,728	8,929.4
1989		380,000	619	380,619	172.6
1990	852,000	4,892,597		5,744,597	2,605.7
1991		13,893,963		13,893,963	6,302.3
1992		10,980,056		10,980,056	4,980.5
1993		19,101,041		19,101,041	8,664.2
1994	0	0		0	0
1995	0	0		0	0
1996	0	0	0	0	0
1997	0	0	0	0	0
1998	0	0	0	0	0
1999	0	0	0	0	0

[1] Concerted effort was expended by NMFS reporting specialists in 1991 to record menhaden bait landings. Thus, the 1991 estimate is given with a high level of confidence. All estimates prior to 1991 are based on incomplete information. Unique gear type in Maine within recent years is the stop seine, a long net which has traditionally been used in Maine to harvest juvenile Atlantic herring. The menhaden bait fishery takes place in the summer, with the majority of the catch in July and August (75% of the catch in 1991).

Table A.1-2. Menhaden bait landings (pounds) in New Hampshire, by gear, 1987-99 [1] .

Year	Gill Net	Cast Net	Other	Total (lbs)	Total (mt)
1987	4,099			4,099	1.9
1988	5,141		6	5,147	2.3
1989	5,424			5,424	2.5
1990	6,044			6,044	2.7
1991	11,849		141	11,990	5.4
1992	10,164		3	10,167	4.6
1993	3,710			3,710	1.7
1994	1,000	27		1,027	0.5
1995	1,538		52	1,590	0.7
1996	32	41		73	<0.1
1997				0	0
1998	9			9	<0.1
1999				0	0.0

[1] Atlantic menhaden landings from New Hampshire coastal inland gill netting have been recorded only since 1987. These data were collected from coastal inland netting reports from Great Bay and tributaries and a portion of the Piscataqua River. The bait fishery is primarily a gill net fishery using fixed position 24-hour sets, average net length from 70 to 117 feet. Gill net fishing effort is recorded in hours, ranging from 1,370 hours (13 gill nets) in 1988 to 2,518 hours (11 gill nets) in 1989. Cast nets (8" diameter x 1" mesh) and a dip net (18" diameter) were used in 1991.

Table A.1-3. Menhaden bait landings (pounds) in Massachusetts, by gear, 1985-99 [1].

Year	Gill Net	Purse Seine	Pound Net	Fish Trap	Total (lbs)	Total (mt)
1985	3,625	3,036,000			3,039,625	1,378.8
1986		3,411,000			3,411,000	1,547.2
1987	1,775	1,213,400			1,215,175	551.2
1988	1,125	8,039,195		7,000	8,047,320	3,650.2
1989		1,454,350		5,052	1,459,402	662.0
1990		1,700,200		9,405	1,709,605	775.5
1991		12,783,000		15,310	12,798,310	5,805.3
1992		13,490,990		8,460	13,499,450	6,123.3
1993		1,210,000		1,569	1,211,569	549.6
1994		348,000		3,251	351,251	159.3
1995		2,902,823		7,790	2,910,613	1,320.2
1996			8,500		8,500	3.9
1997					0	0
1998					0	0
1999					0	0

[1] Massachusetts has a small but significant menhaden purse seine fishery for bait, used primarily in the coastal lobster fishery. In 1990, the fishery was concentrated in Boston Harbor, where 12 permits were issued, five of which were actively fished. Two additional seiners worked the North Shore of Massachusetts, while a third worked from Cape Cod into Rhode Island waters. The number of active permits declined from seven in 1993 to four in 1995 due to poor availability of menhaden in Massachusetts coastal waters.

Table A.1-4. Menhaden bait landings (pounds) in Rhode Island, by gear, 1985-99 [1].

Year	Trap	Purse Seine	Other	Total (lbs)	Total (mt)
1985	840,020	7,548,026		8,388,046	3,804.8
1986	619,187	9,770,000		10,389,187	4,712.5
1987	609,294	12,999,930		13,609,224	6,173.1
1988	409,437	15,174,000		15,583,437	7,068.6
1989	285,975	18,747,198		19,033,173	8,633.4
1990	372,155	16,730,495		17,102,650	7,757.7
1991	80,375	5,010,000		5,090,375	2,309.0
1992	84,859	2,764,500		2,849,359	1,292.5
1993	342,800	4,803,480		5,146,280	2,334.3
1994	46,000	487,800		533,800	242.1
1995	102,815	5,770,500		5,873,315	2,664.1
1996	802			802	0.4
1997	5,750			5,750	2.6
1998			400	400	0.2
1999			2,330	2,330	1.1

[1] Menhaden are taken as bait in Rhode Island in a directed small vessel purse seine fishery, and as a bycatch in other fisheries, primarily with floating fish traps. These data are collected by port agents through the Department of Environmental Management/NMFS Cooperative Statistics Program. Since 1984 all menhaden landings for Rhode Island have been used for bait.

Table A.1-5. Menhaden bait landings (pounds) in Connecticut, by gear, 1981-99 [1].

Year	Hook & Line	Gill Net	Trawl	Other	Total (lbs)	Total (mt)
1981	3,059	136,864	11,426		151,349	68.7
1982	426	167,570	3,090		171,086	77.6
1983		125,400	2,400	1,500	129,300	58.7
1984	200	185,600	100	1,000	186,900	84.8
1985	1,700	231,600		1,500	234,800	106.5
1986	2,600	176,700	100	75,000	254,400	115.4
1987	800	55,500	100	38,500	94,900	43.0
1988	1,000	172,900	300	1,000	175,200	79.5
1989	1,300	128,700	500	18,000	148,500	67.4
1990	1,615	86,621	470	8,000	96,706	43.9
1991	1,600	86,700		8,000	96,300	43.7
1992	1,300	87,800		2,100	91,200	41.4
1993	71,855	80,020	807,002		958,877	434.9
1994	460	57,568		2,100	60,128	27.3
1995		15,000		5,000	20,000	9.1
1996		76,392		6,459	82,851	37.6
1997		71,609		720	72,329	32.8
1998				348,147	348,147	157.9
1999				30,298	30,298	13.7

[1] Menhaden are taken as bait in Connecticut primarily by gill net. Smaller landings come from snag hook and line, otter trawl, pound net, seine, and fyke and dip net fishermen. Landings data originate from annual reports required of holders of a Commercial Finfish License. It is estimated that at least 90% of the landings are used as lobster bait, with the remainder used for bluefish bait by hook and line fishermen. The "other" category for gear type includes pound net, seine, fyke net, and dip net to maintain confidentiality of landings.

Table A.1-6. Menhaden bait landings (pounds) in New York, by gear, 1981-99 [1].

Year	Pound Net	Common Seine	Gill Net	Trawl	Total (lbs)	Total (mt)
1981					533,200	241.9
1982					394,300	178.9
1983					216,300	98.1
1984					692,500	314.1
1985					901,800	409.1
1986	307,385		58,500		365,885	166.0
1987	57,020	3,000	118,317		178,337	80.9
1988	2,900	433,380	38,918		475,198	215.5
1989	15,020	231,790	42,330	3,110	292,250	132.6
1990	86,960	221,400	92,150		400,510	181.7
1991	86,620	117,775	430,805	3,550	638,750	289.7
1992	9,650	170,000	262,500	2,950	445,100	201.9
1993	71,855	80,020	807,002		958,877	434.9
1994	600	86,900	811,916		899,416	408.0
1995			1,087,978		1,087,978	493.5
1996	200		10,795	140	11,135	5.1
1997			670		670	0.3
1998	67	680	22,234	6,727	29,708	13.5
1999	585	10	2,671	140	6,406	2.9

[1] Atlantic menhaden are taken as bait in New York for the recreational finfish and crab fisheries and for the commercial American lobster and crab fisheries. How reported catches are divided for use by each of those fisheries is not known. A restricted gill net fishery were probably under-reported for 1981 until 1990. Best estimates indicate this fishery takes between 50,000 and 100,000 pounds annually. There are other gill net landings in which menhaden are a bycatch. Most of the haul seine catches are the result of a directed fishery supplying wholesale and retail bait dealers. All pound net menhaden landings are bycatch. Large purse seiners do sporadically take menhaden from New York waters, but, they are landed (and recorded) out of state. All reported menhaden landings in New York are for bait (including chum) purposes.

Table A.1-7. Menhaden bait landings (pounds) in New Jersey, by gear, 1982-99 [1].

Year	Pound Net	Gill Net	Purse Seine	Trawl	Other	Total (lbs)	Total (mt)
1982	1,112,351	199,526	325,480			1,637,357	742.7
1983	588,433	129,091	863,930			1,581,454	717.3
1984	1,194,037	327,555	719,440	1,080		2,242,112	1,017.0
1985	1,561,771	314,923	969,800	33,272		2,879,766	1,306.3
1986	1,380,707	259,990	797,388	15,508		2,453,593	1,112.9
1987	1,510,028	363,979	663,350	25,806		2,563,163	1,162.6
1988	889,967	419,863	667,934	6,281		1,984,045	899.96
1989	1,581,755	297,865	956,231	18,510		2,854,361	1,294.7
1990	1,098,126	176,347	7,761,439	5,547		9,041,459	4,101.2
1991	828,615	335,208	15,427,136	6,443		16,597,402	7,528.5
1992	1,773,468	334,124	25,348,814	14,500		27,470,906	12,460.7
1993	1,088,803	455,305	26,727,648	4,790	20,195	28,296,741	12,835.3
1994	365,385	273,525	37,524,924	5,375	6,992	38,176,201	17,316.6
1995	858,832	406,460	35,280,491	26,534	190	36,572,507	16,589.2
1996	118,800	708,417	33,755,346	933,938	225	35,516,726	16,110.3
1997		228,248	37,783,060	103,606	3,665	38,118,579	17,290.5
1998	177,066	420,796	32,524,543	165,236		33,287,641	15,099.2
1999	113,400	450,195	27,152,878	37,066	28	27,753,567	12,588.9

[1] Historically, menhaden bait landings came largely from Sandy Hook Bay pound nets, purse seine vessels, a variety of gill nets (set, drift and runabout) and the otter trawl fishery as bycatch. Recent regulations created a separate menhaden bait license for purse seine vessels, allowed them to come closer to shore in major bays and along the coast, and created a mandatory reporting system (daily catch area fished). Six such licenses were issued in 1990 for six purse seine vessels, 31 to 67 ft. long. Purse seine landings now dominate menhaden bait landings in New Jersey (86% in 1990 and 93% in 1991) while other gear landings remain at their historic levels.

Table A.1-8. Menhaden bait landings (pounds) in Delaware, by gear, 1982-99 [1].

Year	Gill Net	Other	Total (lbs)	Total (mt)
1982			58,300	26.4
1983			41,000	18.6
1984			208,000	94.3
1985	176,135		176,135	79.9
1986	19,821	260	20,081	9.1
1987	22,034		22,034	10.0
1988	127,713		127,713	57.9
1989	104,382		104,382	47.3
1990	167,116	3	167,119	75.8
1991	277,148	1,626	278,774	126.5
1992	105,518	200	105,718	48.0
1993	163,686	366	164,052	74.4
1994	78,672		78,672	35.7
1995	101,312	76	101,388	46.0
1996	99,983	80	100,063	45.4
1997	55,733		55,733	25.3
1998	58,048		58,048	26.3
1999	78,466		78,466	35.6

[1] Since 1985, the Delaware menhaden bait fishery has been primarily a gill net fishery (staked or anchored and drifting) with the catch used for crab bait. Prior to 1985, NMFS obtained landings data directly from the fishermen. Reporting is required of all licensed gill net fishermen. Effort data have been obtained since 1985 as pounds of menhaden landed per yard of gill net fished (1985: 0.69; ‘86: 0.08; ‘87: 0.10; ‘88: 0.63; ‘89: 0.56; ‘90: 0.60; and ‘91: 1.01). Landings in April and May account for the majority of the catch.

Table A.1-9. Menhaden bait landings (pounds) in Maryland, by gear, 1981-99 [1].

Year	Pound Net	Long Haul Seine	Gill Net	Fish Pot	Fyke Net	Other	Total (lbs)	Total (mt)
1981	5,261,549	8,970	78,132	300	104		5,349,055	2,426.3
1982	5,119,839			57	1,359		5,190,816	2,354.5
1983	3,369,791	50			2,576		3,534,724	1,603.3
1984	1,650,623	59,440		100	20,420		2,002,405	908.3
1985	2,034,749			30,870	7,515		2,157,406	978.6
1986	2,198,060	12			3,185	22	2,262,891	1,026.4
1987	2,243,887			7,080	16,448	55,197	2,367,378	1,073.8
1988	2,059,701			30	15,626	38,794	2,242,480	1,017.2
1989	3,715,820				2,630	5,080	3,778,616	1,714.0
1990	1,602,438				655		1,662,275	754.0
1991	2,949,000			20,000	595	25,760	3,126,345	1,418.1
1992	1,624,533			10	80,089	400	1,777,088	806.1
1993	1,750,114				1,475	2,300	1,806,638	819.5
1994	2,336,220				41,830	9,921	2,575,135	1,168.1
1995	5,401,700						5,401,700	2,450.2
1996	3,713,620	50		300	2,502	610	3,906,808	1,772.1
1997	3,297,418				4,170		3,457,237	1,568.2
1998	2,600,801		171,751	4,921	2,290	445	2,780,208	1,261.1
1999	4,254,730		107,558	18,891	1,840	9,783	4,392,802	1,992.6

[1] Over 90% of the commercial menhaden landings are taken by pound nets within the Maryland portion of Chesapeake Bay. Menhaden are primarily used as bait for the blue crab pot fishery and are a major source of chum for charter boat and sport fishermen. Catch statistics are collected through monthly harvest reports by the fishermen. Landings data include Maryland tributaries of the Potomac River but not the Potomac mainstem. Other gear types include trawl and hook and line.

Table A.1-10. Menhaden bait landings (pounds) in Virginia, by gear, 1981-99 [1].

Year	Gill Net	Snapper Rig	Pound Net	Haul Seine	Otter Trawl	Other [2]	Total (lbs)	Total (mt)
1981	250,589	9,710,805	21,209,653	465			31,171,512	14,139.3
1982	324		21,966,452		53,210		22,019,986	9,988.2
1983	10,809		24,471,744				24,482,553	11,105.2
1984	36,540		14,489,426		1,340		14,527,306	6,589.5
1985	50,674		17,269,831				17,320,505	7,856.5
1986	35,081		9,816,378	33,786		66	9,885,311	4,483.9
1987	14,132		14,216,087	88,408			14,318,627	6,494.9
1988	87,104		11,596,293	293,343			11,976,740	5,432.6
1989	6,210	12,738,922	11,487,918	180		77,200	24,310,430	11,027.1
1990	7,453	12,113,763	5,716,821	386,149			18,224,186	8,266.4
1991	167,455	8,610,878	5,708,905				14,487,238	6,571.4
1992	23,712	11,165,380	5,044,888				16,233,980	7,363.7
1993	58,442		7,119,652	1,471		480	7,180,045	3,256.8
1994	146,669		5,517,147	1,100		7	5,664,923	2,569.6
1995	171,447		5,977,4.76	5,850			6,154,703	2,791.8
1996	126,131		5,218,437	4,600	49,720		5,398,888	2,448.9
1997	107,734		5,163,705	3,294	6,300	750	5,281,783	2,395.8
1998	86,045	38,889,680	3,836,159	61,860		4,920	42,878,664	19,449.6
1999	217,859	34,218,240	4,790,525	373	7,125	1,440	39,235,562	17,797.1

[1] Menhaden bait landings in Virginia have been reported by the fishermen since 1993, under the mandatory reporting program. Prior to 1993, landings were collected by technicians from the buyers or processors. The snapper rigs (small purse seine boats) are not required to report their catch under the current mandatory reporting system. Menhaden landed for bait taken by other gear (pound net and gill net) are often reported as "bait" collectively with other species of fish. Consequently, the complete picture of menhaden bait landings in Virginia cannot be shown because the menhaden poundage cannot be extracted from the generic bait category.

[2] Other gear types include fyke net, crab pots and traps, eel and fish pots.

Table A.1-11. Menhaden bait landings (pounds) for Potomac River Fisheries Commission (PRFC), by gear, 1981-99[1].

Year	Pound Net	Gill Net	Haul Seine	Fyke Net	Landed in MD	Landed in VA	Total (lbs)	Total (mt)
1981	20,364,817	7,048			4,150,488	16,216,377	20,371,865	9,240.6
1982	17,988,067	1,367			3,764,705	14,224,729	17,989,434	8,160.0
1983	20,820,224	721			2,857,187	17,963,758	20,820,945	9,444.3
1984	13,111,057	840	9,700		3,244,254	9,877,343	13,121,597	5,951.9
1985	16,768,303	586			3,213,502	13,555,387	16,768,889	7,606.3
1986	10,946,547	25,426			2,548,105	8,423,868	10,971,973	4,976.9
1987	13,119,905	590			3,381,323	9,739,172	13,120,495	5,951.4
1988	13,231,030	338			4,342,213	8,889,155	13,231,368	6,001.7
1989	8,333,994		180		2,072,144	6,262,030	8,334,174	3,780.4
1990	4,523,776				903,355	3,620,421	4,523,776	2,052.0
1991	5,376,223				1,431,142	3,945,081	5,376,223	2,438.6
1992	5,061,295	270			752,796	4,308,769	5,061,565	2,295.9
1993	7,868,456	5	15,540		1,247,141	6,636,860	7,884,001	3,576.2
1994	6,680,785	26		126	1,239,923	5,441,014	6,680,937	3,030.5
1995	7,002,818				1,671,619	5,331,199	7,002,818	3,176.5
1996	5,111,370			53	1,844,756	3,266,677	5,111,423	2,318.5
1997	5,757,060	70	22	218	1,715,759	4,041,611	5,757,370	2,611.5
1998	3,956,806	3,029	20,863	220			3,980,918	1,805.7
1999	4,855,463	2,489	1,380	1,551	1,372,713	3,488,170	4,860,883	2,204.9

[1] Commercial menhaden landings come from four gear types; however, pound net catches account for the majority of the catch. Only 2-10% of the Virginia landings go for industrial use; the rest is used for bait.

Table A.1-12. Menhaden bait landings (pounds) in North Carolina, by gear, 1981-99 [1].

Year	Pound Net	Long Haul Seine	Gill Net	Purse Seine	Trawl	Other	Total (lbs)	Total (mt)
1981						8,000	8,000	3.6
1982	1,017,178	1,782,672					2,799,850	1,270.0
1983	433,817	2,167,933	1,000				2,602,750	1,180.6
1984	283,380	1,023,969		791,000			2,098,349	951.8
1985	267,814	723,123	12,833	2,911,830			3,915,600	1,776.1
1986	311,886	626,384		3,566,771			4,505,041	2,043.5
1987	412,737	728,164	1,754	3,186,810			4,329,465	1,963.8
1988	1,772,250	1,309,122	10,174	2,244,205	734		5,336,485	2,420.6
1989	1,443,546	990,838	59,370	3,613,493	48,568		6,155,815	2,792.3
1990	584,540	1,744,304	14,989	3,989,610	400		6,333,843	2,873.0
1991	320,600	812,134	269,920	3,258,084	308,940		4,969,678	2,254.2
1992	1,235,939	753,050	215,756	1,891,052			4,095,797	1,857.8
1993	485,450	603,516	32,858	931,550			2,053,374	931.4
1994[2]	777,804	219,188	37,472[3]	3,981,910	2,864[4]	586,632	5,605,870	2,542.8
1995[2]	455,765	117,736	40,458[3]	1,866,580	705[4]	310,941	2,792,185	1,266.5
1996[2]	253,186	60,462	98,927[3]	86,850		502,588	1,002,013	454.5
1997[2]	393,181	240,372	69,258[3]	1,521,757	300[4]	1,020,439	3,245,307	1,472.1
1998	473,400	247,588	400,145	1,454,940	2,960	50,802	2,629,835	1,192.9
1999	276,323	142,194	631,091	1,419,940	138,119	25,110	2,632,777	1,194.2

[1] Menhaden are taken as bait in North Carolina in a directed small vessel purse seine fishery and as bycatch in other fisheries, principally with pound nets and long haul seines. Preceding 1994, purse seine data were collected from participating dealers through the North Carolina Division of Marine Fisheries (NCDMF)/NMFS Cooperative Statistics Program. Values for other gears were derived from a combination of data from the statistics program and bycatch calculated from biological sampling of unculled catches from various commercial gears. The 1994 to present data were collected through NCDMF's Trip Ticket Program.

[2] Figures reflect trip ticket data only. Most menhaden is recorded in the "general bait" category. Biological sampling of the fishery for bait composition has not been analyzed to adjust the figures.

[3] Includes anchor, drift, and runaround gill nets.

[4] Includes shrimp and fish trawl.

Table A.1-13. Menhaden bait landings (pounds) in South Carolina, by gear, 1983-99 [1].

Year	Trawl	Total (lbs)	Total (mt)
1983	34,000	34,000	15.4
1984	CONFIDENTIAL		
1985	7,938	7,938	3.6
1986	1,546	1,546	0.7
1987	3,934	3,934	1.8
1988	CONFIDENTIAL		
1989	0	0	0
1990	0	0	0
1991	0	0	0
1992	CONFIDENTIAL		
1993		0	0
1994	0	0	0
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	0	0
1999	0	0	0

[1] There are no directed fisheries for Atlantic menhaden in South Carolina. Recorded landings of menhaden for bait represent a bycatch from the shrimp trawl fishery. These menhaden, as well as frozen menhaden obtained from North Carolina, serve as bait in the blue crab fishery.

Menhaden bait landings in Georgia, 1981-1999.

There is no directed commercial fishery for menhaden in Georgia. However, the demand for menhaden to be used for live bait in the recreational fishery, especially king mackerel tournaments, is at an all time high. These recreational anglers use large cast nets (up to 12' in diameter) to capture menhaden for their personal use. Few, if any, individuals are involved in the sale of menhaden for bait purposes. Since cast nets and saltwater anglers are unlicensed, the extent of this harvest is unknown. Menhaden are also taken as bycatch in the shrimp trawl fishery. While most are discarded at sea, a small quantity is landed and sold for bait in the crab pot fishery.

Table A.1-14. Menhaden bait landings (pounds) in Florida, by gear, 1982-99 [1].

Year	Long Haul Seine	Gill Net	Purse Seine	Cast Net	Other	Total (lbs)	Total (mt)
1982		413,299				413,299	187.5
1983		1,150,426				1,150,426	521.8
1984	947	1,036,021				1,036,968	470.4
1985	23,859	1,067,826				1,091,685	495.2
1986	30,298	842,686				872,984	396.0
1987	11,849	1,297,636				1,309,485	594.0
1988		1,017,904	53			1,017,957	461.7
1989	8,026	1,248,275	116,179			1,372,480	622.6
1990		1,499,414	1,136,116	956		2,636,486	1,195.9
1991		970,624	1,490,012	27,132	5,063	2,492,831	1,130.7
1992	8,600	2,104,951	590,441	41,825	667	2,746,484	1,245.8
1993	4,296	1,369,400	1,148,915	59,905	2,251	2,584,767	1,172.4
1994	39,739	1,074,604	248,410	16,086	8,172	1,387,011	629.1
1995	38,260	557,454	1,875	62,383	302	660,274	299.5
1996	77	5,173	20,000	245,376	1,759	272,386	123.6
1997		15,802	281	353,785	38,624	408,492	185.3
1998		8,441	49,092	192,487	51,546	301,566	136.8
1999		2,814		188,668	50,993	242,475	110.0

[1] Historically, gill netting accounted for the majority of Florida east coast (Atlantic) menhaden landings for bait. Recently, there has been an increase in purse seining for bait menhaden. All data are collected from licensed wholesale dealers and reported through a detailed trip ticket program to the Florida Department of Natural Resources' Marine Fisheries Information System.

APPENDIX A.2

ATLANTIC MENHADEN INTERNAL WATERS PROCESSING PROCEDURES AND GUIDELINES

1. Permit applications for Internal Waters Processing (IWP) operations should be submitted to the individual state no later than 90 days prior to the start of the requested fishing period.

2. The state's marine fisheries management agency should review the applications received no later than 75 days prior to the start of the fishing period. The state agency should provide appropriate information (#3 below) to the ASMFC not less than 60 days prior to the start of the fishing period.

3. To assist the ASMFC in their review process, the following information should be required of each applicant by each state and furnished to the ASMFC:

   (a) information on processing and storage capacity of the foreign processing vessel(s);

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

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

   (d) the ultimate country of sale for the product(s);

   (e) other information as needed.

4. In the review of IWP application information, the following factors will be considered by the Atlantic Menhaden Management Board of the ASMFC:

   (a) whether or not the cumulative amount requested by applicants will adversely impact the stock or the traditional fishery;

   (b) the status of the menhaden stock to be harvested by the proposed IWP relative to the biological reference points established in Amendment 1;

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

5. Following a review of IWP applications and stock status, the Menhaden Technical Committee and Advisory Panel will prepare a report of findings and recommendations and forward that to the Board. The Board will promptly consider the report of the Technical Committee and Advisory Panel and the Chair of the Board will forward the recommendations of the Board to the Chairman and Executive Director of the ASMFC, who will send the official recommendations of the ASMFC to the appropriate state Governors.

6. The ASMFC should provide recommendations to the Governors of the individual states in which IWPs are proposed not later than 30 days after receipt of requests for consultation. Such advice may include:

a) total IWP species allocation by state;
b) times and areas of operations;
c) observer coverage;
d) manner and methods of harvest;
e) catch sampling and reporting requirements.

Figure A.2.1. Diagram of annual Atlantic menhaden Internal Waters Processing (IWP) review and allocation process.