Fishery Management Report No. 22
of the

ATLANTIC STATES MARINE FISHERIES COMMISSION

Fishery Management Plan for Atlantic Menhaden 1992 Revision

September 1992

FISHERY MANAGEMENT PLAN FOR ATLANTIC MENHADEN
1992 REVISION

By

Atlantic Menhaden Advisory Committee

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of the

Atlantic States Marine Fisheries Commission
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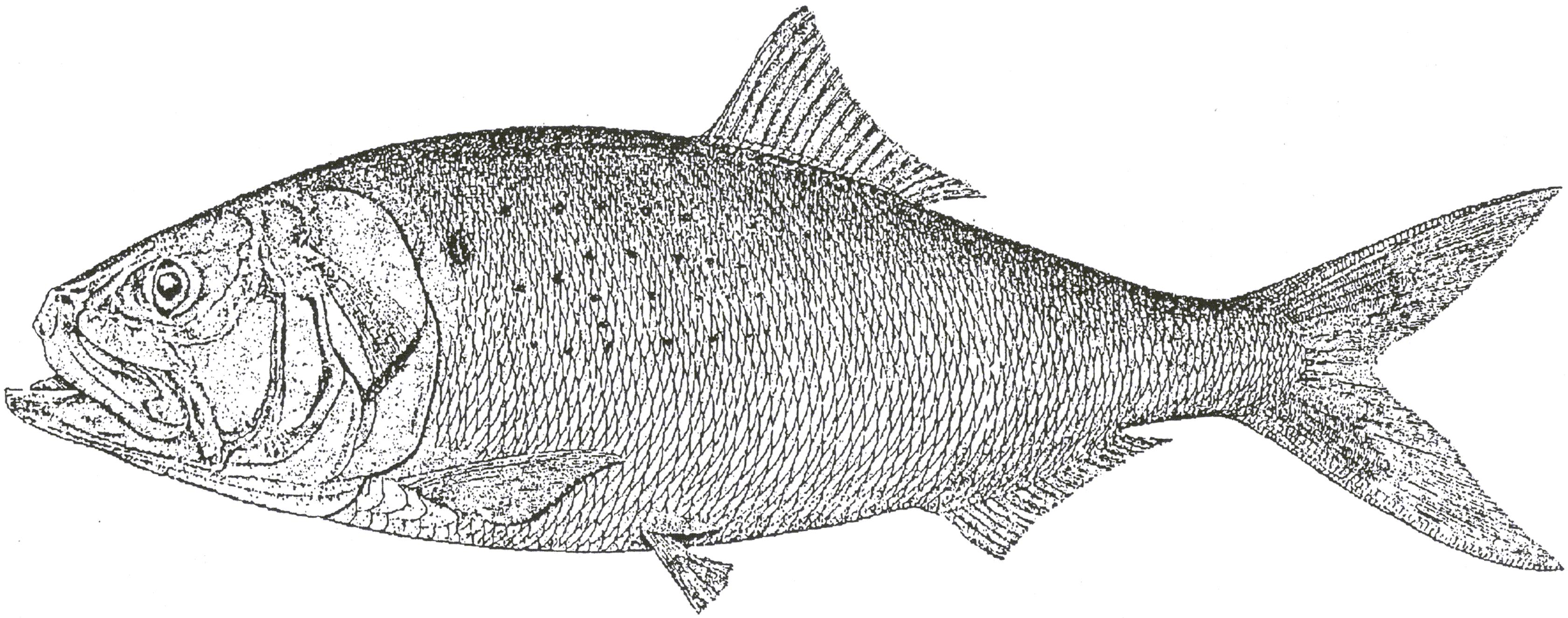

Atlantic menhaden, *Brevoortia tyrannus*

1.0 EXECUTIVE SUMMARY

The "Atlantic Menhaden Fishery Management Plan, 1992 Revision" was prepared by the Atlantic Menhaden Advisory Committee (AMAC) under the Interstate Fisheries Management Program (ISFMP) of the Atlantic States Marine Fisheries Commission (ASMFC). This revision replaces the Commission's 1981 menhaden plan, which has been rendered obsolete by significant changes in the Atlantic menhaden stock and fishery.

The goal of the 1992 plan revision is *To manage the menhaden fishery in a manner that is biologically, economically, and socially sound, while protecting the resource and its users*. Plan objectives include 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.

The menhaden program will function under the 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. The Board designates the members of AMAC, the technical committee which conducts the analytical activities for the program.

Members of this committee have expertise in menhaden life history, fishing, processing, and population dynamics. Each spring, the 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.

The menhaden stock is healthy, with total stock size and recruitment comparable to levels recorded during the late 1950s-early 1960s. The most recent estimates of maximum sustainable yield are about 480,000 metric tons. Research indicates that undefined environmental conditions probably are more important in determining reproductive success than spawning stock size, although there is a weak spawner-recruit relationship.

Atlantic menhaden are distributed along the Atlantic coast from Florida to Nova Scotia. Spawning occurs over much of the species' range, with a peak off North Carolina during late fall and winter. Menhaden are estuarine-dependent, utilizing coastal estuaries from Florida through southern New England as nursery areas. Young fish join the coastal migration late in their first year of life. After their first year, menhaden migrate along the Atlantic coast, with older, larger fish moving farthest north each spring and summer. Most fish migrate to the North Carolina area each fall and early winter.

Menhaden are primary consumers as adults, transforming phytoplankton into animal protein. They, in turn, serve as prey for many fish-eating fish, sea birds, and marine mammals, as do many other species of fish, including anchovies, herring, sardines, sand lance, and the young of most other fishes.

More Atlantic menhaden are landed annually along the Atlantic coast than any other fish species. Landings have remained fairly consistent, averaging about 341,000 metric tons during 1982-91. Landings, however, have been considerably less than during the peak years of the fishery because of changes in fishing areas (most fishing is now in Chesapeake Bay rather than the mid-Atlantic), reduced fleet size, fewer processing facilities, increased regulatory restrictions, and smaller mean weight-at-age since the mid-1970s. Bait landings have added about 30,000 metric tons annually in recent years.

Atlantic menhaden have been harvested since colonial times, when they were used for fertilizer. Oil recovery began in the early 1800s. With introduction of the purse seine in the 1850s, large-scale fisheries were established. Oil was used for industrial purposes, and "scrap" (dried fish) was used for fertilizer. By World War II, the primary product of the industry had changed from scrap to production of high protein fish meal for poultry and swine feeds, the major contemporary uses.

Bycatch (or incidental catch) of other fishes in menhaden purse seines has been examined repeatedly since the late 1800s. Taking of non-target species is a relatively rare event, and the overall bycatch is insignificant.

The number of processing plants in the fishery declined from nine to five during the 1980s, principally in response to social and economic conditions. In addition to three domestic processing plants (two in Virginia, one in North Carolina), menhaden processing for meal and oil has occurred in recent years at a Canadian plant in New Brunswick and on board a Russian factory ship operating under an internal waters processing arrangement in Maine's territorial waters.

Employment in the menhaden industry (reduction sector) includes about 500-550 fishermen and an equal number in the processing sector. Large vessels (up to 180 ft) dominate the Virginia-North Carolina fishery, while most of the Maine vessels are much smaller (less than 100 ft).

In summary, the stock is healthy, and the management system in place is adequate to meet the goal of this plan and guide the fishery for the foreseeable future. The annual AMAC review ensures that status of the stock and fishery are monitored. Should trigger values be exceeded, action will be taken by AMAC and the Board. No regulatory action beyond those rules currently in existence are recommended at the present time.

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3.0 INTRODUCTION

3.1 Development of the Plan

The original Atlantic menhaden fishery management plan (FMP) was prepared during 1976-1981 (AMMB 1981) and approved by the Atlantic States Marine Fisheries Commission (ASMFC) in October, 1981. This plan did not recommend any specific 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 ASMFC and referred to the states for implementation. Full impiementation was not achieved. Changes in operation of the ASMFC 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 FMPs in addition to menhaden.

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 can be considered healthy. There is an improved spawning stock, good recruitment, and improving age structure. Heavy fishing has 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 three are still in business. Closures have been related to international market conditions affecting 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 ASMFC 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. This document constitutes that revision and serves as a total replacement of the 1981 plan.

3.2 Problems Addressed by the Plan

3.2.1 Stock Condition

The Atlantic menhaden stock is healthy and continues to rebuild, with improved spawning stock, good levels of recruitment during the 1980s, and a broader range of ages. The stock is much improved compared to its severely depressed condition during the 1960s, when extremely heavy fishing pressure during a period of poor reproduction greatly reduced the total stock, as well as the spawning stock. The existing domestic fishery (including IWP activities) has sufficient capacity to fully utilize the available resource. If recruitment becomes poor for two or three consecutive years, existing levels of fishing pressure could negatively affect the stock. Because most of the harvest is of young, sexually immature fish which could provide a greater yield if harvested when older and larger, Atlantic menhaden are growth-overfished. This situation is not a concern for the menhaden fishery because the stock is continuing to rebuild. Many other important United States fishery resources are also growth-overfished (NMFS 1991a), and some are recruitment-overfished (harvested beyond their replacement capacity). Atlantic menhaden are not recruitment-overfished.

3.2.2 Regulation of the Fishery

Under the 1981 plan, a fishing season regulation was the only restriction proposed, with the period varying among the Atlantic coastal regions (New England, mid-Atlantic, Chesapeake Bay, south Atlantic) based on historic patterns of fishing activity. Several states implemented the recommended seasons, some imposed different seasons, and some states ignored the recommendations. During the 1980s (without support or reference to the FMP), menhaden purse seine fishing for reduction was completely prohibited in South Carolina, and a number of productive fishing areas in other states were closed. Often, biological claims were cited as justification for these closures when social conflicts were the real basis. The net result has been a significant reduction in areas available for fishing. State and federal rules concerning water and air quality have also affected the industry, especially at older processing facilities.

3.2.3 Education

As noted above, drastic actions affecting the menhaden fishery have been taken by some state and local governments. All too frequently, arguments made in support of the actions have been based on opinion, not fact. Misconceptions continue about the menhaden stock and fishery, such as the following: the stock is recruitment-overfished, purse seines take a large bycatch, and many game fish are dependent on menhaden as forage to the exclusion of other abundant forage species. The ASMFC menhaden program and the industry have prepared a number of educational products since 1990. A comprehensive positive education program aimed at the public, anglers, and government officials to present the facts concerning menhaden and the menhaden fishery should be implemented.

3.2.4 Information Needed for Management

The National Marine Fisheries Service (NMFS) menhaden program headquartered at the NMFS Beaufort Laboratory in North Carolina must continue to provide comprehensive coastwide catch-at-age, fishing effort, and processing plant data from the purse seine fishery sufficient to support the level of analytical sophistication presently used in stock assessments. The existing program is minimal and lacks the resources to address several important research areas, such as estimating juvenile abundance for forecasts, defining fishing effort, understanding ecological aspects of recruitment, and compiling and utilizing information provided in Captains Daily Fishing Reports. State management agencies and NMFS need to improve their menhaden data gathering activities, especially concerning bait landings, juvenile abundance, and mortality from kills, disease, and impingement on water intake screens.

3.2.5 Coordination of Management

As demonstrated by the uneven implementation of the fishing season recommendation in 1982, state marine fisheries management agencies have been inconsistent in their approach to managing the menhaden fishery. Some states without processing facilities have taken the approach that management of the menhaden resource is not their problem even though the stock is resident in their waters for much of the year. A coherent approach is needed to provide for optimum utilization of the resource throughout its range.

4.0 DESCRIPTION OF STOCK

4.1 Species Distribution

Atlantic menhaden are found along the Atlantic Coast from Florida to Nova Scotia, Canada. Spawning occurs in the ocean, while larvae and juveniles utilize coastal estuaries.

4.2 Abundance, MSY, and Present Condition

Although landings have generally recovered from the depressed levels of the 1970s, they have not returned to the levels attained during the late 1950s when they averaged 1,377.9 million pounds (lb) (625,000 metric tons - mt) during the 1955-1959 fishing years (Smith et al. 1987). During the 1980s, the mean population was about 7.3 billion fish, compared to less than 5.6 billion during the 1970s, and less than 3.9 billion during the 1960s (Vaughan 1990). Although the mean population for the 1980s is only slightly smaller than that for the 1950s (8.1 billion fish during 1955-58, excluding 1959), recent landings in weight have been considerably less (a mean of 381,400 mt for the 1980s -vs- 616,600 mt for 1955-58). The fact that landings (in weight) have declined since the 1950s while the population (in numbers) has nearly recovered to its previous size results from changes that have occurred in geographic and seasonal fishing patterns and smaller mean weight at age.

Recent estimates of MSY of 1,068.1 million lb ± 191.8 million lb (484,000 mt ± 87,000 mt) at a mean F of 0.54/yr (34% annual exploitation rate) were obtained from a generalized production model for the 1955-1986 period (Vaughan 1990). Levels of landings (in weight) equaling those of the 1950s are unlikely to be attained over an extended period given the present structure of the fishery. However, during the 1980s, landings averaged 753.1 million lb (342,000 mt), with a mean F averaging 1.15/yr (57% annual exploitation rate). Although this pattern of fishing might suggest that greater landings would be available with less effort, plant location and geographic restrictions on fishing limit, to a considerable degree, the ability of the fishery to attain landings comparable to those of the late 1950s.

Historical MSY estimates since the early 1970s have shown no trends, ranging between 815.7 million lb (370,000 mt) and 1,256.6 million lb (470,000 mt). Sufficient recruitment to attain MSY has been available since 1975. With considerable variation about the fitted spawner-recruit curves, it appears that managing the fishery to maintain large numbers of spawners in order to provide a large fishable stock, would prove ineffective. This situation prevails because environmental conditions appear to outweigh spawning stock size in affecting subsequent recruitment (suggested by considerable scatter in the spawner-recruit relation and both low and high recruitment concurrent with low spawning stock size). However, the Ricker spawner-recruit relationships are marginally significant, and age-3 spawners are of great importance to the spawning stock. Thus, further increasing the number of spawners (age-3 and older) may guard against a possible stock collapse brought on by heavy fishing during a period of poor recruitment.

The modern purse-seine fishery for Atlantic menhaden has a high dependency on pre-spawners (age-2 and younger fish), so large fluctuations in year-to-year availability and catches are to be expected. To enhance the stability of the resource and fishery, it is desirable that a wide range of age classes contribute significantly to the fishery. Whether landings greater than 1 billion lb (454,000 mt) are attainable is questionable because of changes in plant locations and fishing patterns. However, gains in yield per recruit are possible by increasing the age at entry to the fishery.

4.3 Life History

4.3.1 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. Small females produce less than 100,000 eggs, while large females are capable of producing nearly 400,000 eggs.

4.3.2 Eggs, Larvae, Juveniles

Atlantic menhaden produce pelagic eggs which develop and hatch within a few days. Larvae hatch offshore and are transported shoreward, entering estuaries after 1-3 months at sea. 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. Juveniles form dense schools and leave inshore estuarine waters between August and December at lengths of 75-110 mm TL. Young-of-year from the mid-Atlantic join the general southerly migration to the Carolinas in the fall. Age-1 juveniles participate in the northward migration in the spring, although most generally do not move north of Chesapeake Bay.

Larvae feed on individual zooplankton organisms, whereas juveniles rely more heavily on filter feeding. Juveniles are capable of filtering very small particles from the water, directly utilizing abundant, small phytoplankton that are not consumed by other species of fish. They also feed on plant detritus during their estuarine residency.

4.3.3 Adults

Adults are strictly filter feeders. They form large schools during feeding migrations. 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 are accelerated during the first year when juvenile population size is low and reduced when juvenile population size is high.)

Natural mortality removes an estimated 30% of the exploited population at age 1 and 20% each year thereafter. Most natural mortality is probably caused by predation and disease. Another source of natural mortality is deoxygenation of shallow inshore waters caused by the fish themselves when they form dense schools in such areas. Recently, the effects of fungal infestations and a toxic dinoflagellate have been reported to either directly cause mortality or contribute to it by weakening fish and making them more susceptible to other diseases or predation. Menhaden are preyed upon heavily by a variety of marine and estuarine fish species, marine mammals, and sea birds. 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.

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.

4.3.4 Ecology

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 and, thus, do not produce such large populations. 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 they migrate over most of the

Atlantic coast, menhaden influence the conversion and exchange of energy and organic matter within the coastal ecosystem.

4.4 Probable Future Condition

Good recruitment since the mid-1970s has supported landings generally between 661 and 881 million lb (300,000 and 400,000 mt), but there is no guarantee that recent favorable environmental conditions and good recruitment will continue. Poor recruitment during the 1960s and early 1970s supported landings generally between 441 and 661 million lb (200,000 and 300,000 mt). A precise understanding of the role of environmental conditions on menhaden recruitment is not available but would be extremely useful for predictive purposes.

5.0 DESCRIPTION OF HABITAT

5.1 Condition of Habitat

Of primary importance is the fact that Atlantic menhaden are estuarine-dependent. Following oceanic spawning, menhaden larvae enter 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.

5.2 Habitat Areas of Particular Concern

Estuaries of the mid-Atlantic and south Atlantic states provide almost all of the nursery areas utilized by Atlantic menhaden at the present time. 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.

5.3 Habitat Protection Programs

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. 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.

6.0 FISHERY MANAGEMENT JURISDICTION, LAWS, AND POLICIES

6.1 Management Institutions

Regulatory authority over the Atlantic menhaden fishery is vested in the various state management systems, not in the federal government. Thus, 15 different entities (14 states and the Potomac River Fisheries Commission) have authority over various aspects of the reduction and bait fisheries.

6.2 Treaties and International Agreements

There are no treaties or international agreements concerning the Atlantic menhaden fisheries along the east coast of the United States.

6.3 Federal Laws, Regulations, and Policies

Section 306 of the Magnuson 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. This arrangement is known as "internal waters processing" (IWP).

6.4 State Laws, Regulations, and Policies

There are open fishing seasons for the reduction fishery in Maine, New Hampshire, New York, New Jersey, Virginia, North Carolina, and Georgia. Florida has no closed seasons. There are no open seasons in Delaware, Maryland, or South Carolina. Some of the states have specific river or estuarine fishing closures. Other states have greater area closures, such as in New Jersey where fishing is restricted to not closer than 1.2 miles offshore; and in Delaware, Maryland, and South Carolina where purse seine fishing is totally prohibited. Another regulatory approach used in some states is to restrict gear in various ways; Virginia enforces a minimum mesh size for purse seines, while Massachusetts limits purse seine size, use of spotter aircraft, and net handling gear.

6.5 Other Applicable Laws, Regulations, and Policies

There are no other known applicable laws, regulations, or policies.

7.0 DESCRIPTION OF FISHING ACTIVITIES

7.1 Fishing

7.1.1 History of Exploitation

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 1970s. Since that time, the menhaden industry has experienced major changes in processing capacity, resource accessibility, and development of new product markets.

7.1.2 Fishing Vessels and Gear

The early menhaden purse seine fishery utilized sailing vessels, followed by coal-fired steamers, and finally in the 1930s, by diesel-powered vessels. The introduction of spotter aircraft in 1946, synthetic net material in 1954, and aluminum purse boats in 1958 were important improvements in the ability of the fishery to harvest menhaden.

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.

During the peak landings years (1953-1962), up to 112 vessels with a total daily carrying capacity of 76 million standard fish (one standard fish = 0.67 lb) landed their catch at 20 reduction plants from Florida to Maine. Presently (1991), 33-37 vessels with a daily carrying capacity of more than 30 million standard fish land the harvest at five processing facilities.

7.1.3 Fishing and Landing Areas

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, N.C.; Reedville, Va. (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.

7.1.4 Fishing Seasons

The directed menhaden purse seine fishery for reduction is seasonal. Two fairly distinct fishing seasons occur, the "summer fishery" and the "fall fishery." The summer fishery begins in April with the appearance of schools off the North Carolina coast. The fish migrate northward, appearing off New England by June.

In early fall, declining water temperatures trigger a southward migration to the waters between Cape Hatteras and Cape Fear, North Carolina. The fall fishery begins about 1 November with the appearance of migratory fish moving south. Fishing may continue into January or February, but is highly weather-dependent. Most menhaden leave the nearshore coastal fishing grounds by late February, probably dispersing off the coast of the southern United States.

7.1.5 Incidental Catches

The incidental catch of menhaden by other fisheries and the bycatch of other species in the menhaden fishery is of interest to the commercial and recreational fishing industries, as well as the scientific community. Numerous past studies have shown that there is little or no bycatch in the menhaden purse seine fishery.

A study of bycatch levels in the Gulf of Mexico and Atlantic Ocean menhaden fisheries is currently underway through funding from the federal Saltonstall-Kennedy grant program. The Virginia Institute of Marine Sciences (VIMS) and Louisiana State University (LSU) are conducting concurrent studies to determine the extent of bycatch in the fishery during the 1992 fishing season.

7.2 Commercial Reduction and Bait Fishing Activities

7.2.1 Reduction Fishery

In 1991, 381,400 mt of Atlantic menhaden, with an ex-vessel value of $36.4 million, were landed at five processing facilities along the Atlantic coast. In the North Atlantic, a Russian processing vessel in Maine and a shore-based processing plant located in Blacks Harbour, N.B. received 13.5% of the total landings. Two processing plants in the mid-Atlantic region handled 74% of the total, and one plant in the south Atlantic processed the remaining catch.

The annual harvest of Atlantic menhaden is completed during two fishing seasons: The "summer" fishery and the "fall" fishery. The 1990 summer fishing season (April-October) was conducted with about 33 vessels supported by 17 aircraft, which operated from North Carolina to Maine. By comparison, about 23 vessels and up to 15 aircraft were utilized during the fall season in Virginia and North Carolina. The fall season generally extends from November until the fish move offshore, usually during late December-early February.

7.2.2 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 in the south Atlantic area. The 1991 bait harvest was estimated at about 7.4% (about 30,400 mt) of the total Atlantic menhaden harvest of 411,800 mt. Value of the 1990 bait harvest was estimated at almost $3 million (ex-vessel) in 1990.

7.3. 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 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.

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. If accepted, the proposed rule 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 into the next century.

8.0 DESCRIPTION OF SOCIOECONOMIC CHARACTERISTICS OF THE FISHERY

8.1 Domestic Harvesting Sector

The purse seine reduction fishery employs about 500-550 fishermen from North Carolina to Maine, serving on about 33 vessels. Most of the crew members come from the area near the processing plants. Many fishermen are members of families with long-term involvement in the menhaden fishery, often with relatives in the harvesting and processing sectors. The large, full-time menhaden vessels utilized in Virginia and North Carolina fish with 14-16 man crews, while the small vessels which fish seasonally in Maine for the IWP have crews of about 4-6 fishermen. Almost all vessels in North Carolina and Virginia are owned by the processing companies. However, several independent vessels have fished under contracts with one of the Virginia companies in recent years. All of the Gulf of Maine vessels are independently owned.

Almost all of the purse seine vessels in North Carolina and Virginia have refrigerated holds, while most of the Gulf of Maine vessels do not. Some of the larger vessels can hold two million or more standard fish, over 600 mt. Most of the small Gulf of Maine vessels can carry 80-150 mt at a time.

Up to 17 spotter aircraft have been used to locate fish for the industry in recent years. Some of the pilots are company employees, and some aircraft are owned by the companies, while other spotter pilots and their airplanes work under contracts with the menhaden companies.

All of the Gulf of Maine fishermen are Caucasian, while about 75-80% of the crewmembers in North Carolina and Virginia are African-Americans. Menhaden fishing is the principal occupation of the Virginia and North Carolina crewmembers. In contrast, the northern fishermen participate in other fisheries, such as groundfish trawling, outside the menhaden season or when menhaden are not available.

8.2 Domestic Processing Sector

Two of the three domestic menhaden processing plants are located in Reedville, Va. The other facility is in Beaufort, N.C. Employment at these three plants in 1990 was about 300-350, including support staff (maintenance, net-mending, etc.). Similar to vessel crews, many processing employees are members of families with long-standing ties to the industry. In Virginia, about 60% of the shoreside personnel are Caucasian, and 40% are African-American. About two-thirds of North Carolina processing workers are African-American, while the remainder are Caucasian.

8.3 Foreign Processing Sector

A single shore-based plant in Blacks Harbour, New Brunswick, Canada processes approximately 20,000 mt of menhaden annually. The plant operates with two large, Maine-registered menhaden purse seine vessels and a single spotter aircraft. All of the crew is white, while the processing employees (40-50 persons) are mostly white, along with a few Asians. The fishing season extends from early June to mid-September. The meal produced is utilized domestically, while oil is exported to foreign markets.

The Russian factory processing ship participating in the IWP in Maine has a crew of about 200, all of whom are Russian. About 160 persons work in the processing sector, while the rest of the crew operates the vessel. All of the meal and oil produced is shipped back to Russia.

8.4 International Trade

The U.S. menhaden industry faces competition in the world commodity markets. At the same time, expansion of the global economy offers opportunities for new products, market expansion, and greater economic impact.

The majority of domestic meal production is marketed within the United States. Nonetheless, that market responds to international forces including commodity prices, global weather trends, currency fluctuations, and the relative strength of the domestic economy.

Currently, the menhaden industry participates internationally in three areas: export of raw material to Canada, IWP operations, and export of menhaden oil.

8.4.1 Export of Raw Material to Canada

Since 1987, the largest vessels in the New England menhaden fleet have delivered fish to a processing plant in Canada. In 1991, two boats, owned and operated by fishermen long active in the New England menhaden fishery, participated in this activity.

8.4.2 Internal Waters Processing

Since 1988, an IWP project organized by Resource Trading Company of Portland, Maine, utilizing a Russian processing ship, has provided a market opportunity for traditional Maine menhaden fishermen. Operating under an IWP permit issued by the Governor of Maine pursuant to the Magnuson Act, the M/V RIGA has annually processed 20,000-35,000 mt during the June-October menhaden season. With a capacity of 500 mt per day, the RIGA takes fish from a fleet of up to a dozen U.S. catchers and carriers and processes it into fish meal and oil for transport back to Russia.

The significance of this project is that it has maintained an American menhaden harvesting capacity in New England even though the region's domestic processing sector disappeared. As a result, those considering future investment in domestic processing will not face the difficult hurdles of refinancing the harvesting sector and recovering lost harvesting expertise.

8.4.3 Export of Menhaden Oil

Nearly all U.S. menhaden oil is exported to Europe for both food and industrial uses. This trade is vulnerable to supplies of competing fish and vegetable oils and to the standing of U.S. currency. European processing of this oil into added-value products represents an economic opportunity lost by the United States due to restrictive regulations on the domestic use of menhaden oil.

To assess the future impact of international forces on the domestic menhaden industry one can simply observe that the world's population is projected to rise from a current 5.25 billion to 6.0 billion by the year 2000 and to add another billion persons by 2010. The world economy will continue to demand every ounce of protein possible from its marine resources, not only for livestock and poultry feed, but also for the burgeoning aquaculture industry.

9.0 DESCRIPTION OF BUSINESSES, MARKETS, AND ORGANIZATIONS ASSOCIATED WITH THE FISHERY

9.1 Relationship Among Harvesting and Processing Sectors

The menhaden industry in Virginia and North Carolina is vertically integrated, with the processing companies owning the vessels, processing the catch, and selling the products. In contrast, the processing companies in the Gulf of Maine annually contract with vessel owners for the services of their vessels.

9.2 Fishery Cooperatives or Associations

The National Fish Meal and Oil Association (NFMOA) is an active division of the National Fisheries Institute, the largest fisheries trade association in the United States, which represents over 1,000 fishery-related businesses. The objectives of the NFMOA are to promote fishery products through research, education, and trade show efforts; to cooperate with state and federal agencies to ensure wise use of the fishery resource to maintain the highest continued yield; and to improve its products. Membership of NFMOA generally includes the menhaden fishing and processing companies, businesses which utilize menhaden products, and others concerned with the industry.

9.3 Labor Organizations

The Reedville Fishermen's Association is the only known labor organization formed specifically to represent menhaden fishermen. The Association was organized in 1988 among the vessel personnel of one of the two companies based in Reedville, Virginia. The Association became a local affiliate of a national labor union (United Food and Commercial Workers) during 1992.

9.4 Foreign Investment in the Domestic Fishery

There is no known foreign investment in the domestic Atlantic menhaden fishery.

10.0 ATLANTIC MENHADEN MANAGEMENT GOAL AND OBJECTIVES

10.1 GOAL: **To manage the Atlantic menhaden fishery in a manner that is biologically, economically, and socially sound while protecting the resource and its users**

10.2 OBJECTIVES:

- **To educate the public concerning the Atlantic menhaden resource and its fisheries, informing interested parties of fishery practices, products and benefits to the nation, and to promote harmonious use of the resource**

  The public is not generally aware of the menhaden industry because the final products are not eaten directly by people; there are only three domestic plants; and few vessels harvest menhaden as a target species. The high volume of catches and large size of most vessels, however, have led to many misconceptions about the fishery, its methods, and production. In recent years, several educational products have been developed, including videos, pamphlets, and a list of resource materials. These items have been provided to state management agencies, Sea Grant programs, coastal museums and aquaria, and educators. An active effort is needed to provide factual information to the public and to decision-makers. (See sections 3.2.3 and 11.8.)

- **To maintain the existing Atlantic menhaden database through monitoring of catch, effort, size, and age from the reduction fishery**

  A long-term database on Atlantic menhaden is maintained at the NMFS Beaufort Laboratory in North Carolina. Principal data elements include harvest, fishing area, nominal effort, and size and age of individual fish. These data form the basis for periodic stock assessments and annual monitoring of the stock and fishery. Long-term management of the fishery under this FMP Amendment depends on continuation and enhancement of this existing program. (See sections 3.2.4, 4.2, 10.4.1, 10.5, 11.11.2, and 11.11.3.)

- **To improve the collection of data on catch, effort, size, and age of Atlantic menhaden in the bait fisheries and the bycatch of menhaden by all other fisheries for incorporation into menhaden stock assessment analyses**

  Data on the bait harvest gathered for this document revealed that the bait catch was larger than anticipated, exceeding the reported harvest of most other Atlantic coast species. Collection of bait data is generally poor in most states, suggesting that the reported landings are probably considerably less than actual landings. To include this segment of the fishery in stock assessments, improved information on catch, effort, size, and age must be obtained from this catch. Similarly, menhaden are a significant component of the bycatch of other Atlantic coast fisheries, and size, age, and catch information are needed from these fisheries for consideration in assessments of menhaden stock status. (See sections 3.2.4, 10.5, 11.7, and 11.11.)

- **To maintain and enhance the Captains Daily Fishing Report program by adding coverage of the menhaden bait and "snapper rig"**

fisheries and to update the computerization of this database to guide management decisions

Captains of full-time menhaden vessels operating in Virginia and North Carolina complete the "Captains Daily Fishing Report" (CDFR) for each day of operation. Use of this detailed set-by-set record system by all other segments of the fishery, especially vessels in the Gulf of Maine, Chesapeake Bay "snapper rigs," and coastal bait seiners, will provide a detailed record of the fishery for analysis by managers. The National Marine Fisheries Service should provide the resources necessary to enter these data into a computerized database annually, as well as to computerize earlier records back to the late 1970s when use of the form began. (See sections 3.2.4, 7.2, 11.7, 11.9, and 11.11.)

- **To promote cooperative interstate research projects to improve biological, economic, and sociological databases needed to monitor and assess the status of the Atlantic menhaden resource, its fisheries, and its supporting habitat**

Various data collection programs, especially concerning young-of-the-year fish, are conducted by state and university researchers. However, the results are not routinely available to the NMFS menhaden staff for use in their analyses. In addition, sociological and economic studies are conducted which could produce data useful for making and evaluating management decisions affecting the menhaden fishery. Coordination among these activities would prove beneficial to the menhaden program. (See sections 3.2.4, 10.5, and 11.11.)

- **To encourage Atlantic menhaden product research which will benefit consumers and the industry**

Work on menhaden oil as an ingredient in human foods will lead to high value products. The aquaculture industry has become very interested in menhaden meal in a somewhat different form from that traditionally used for other feed formulations. These opportunities, and others, should be pursued for the long-term benefit of the industry. (See section 11.5)

- **To maintain an Atlantic menhaden stock sufficient to support viable fisheries**

The long-term health of the fisheries depends on maintenance of a healthy stock. Thus, data collection and analytical activities to determine stock status and guide management decisions must be continued. (See sections 3.2.4., 3.2.5, and 11.11.)

- **To optimize utilization of the resource within the constraints imposed by distribution of the resource, available fishing areas, and harvest capacity**

Today's menhaden industry is very different from that of 10-15 years ago. Fishing and management strategies must reflect the realities of stock size, competing uses of fishing areas, and regulations. However, state fishery managers should be aware of the facts concerning the menhaden stock and fisheries, and base their regulatory decisions on those facts. (See sections 3.2, 11.4, and 11.10.)

- **To support the maintenance and enhancement of habitat and water quality conditions which sustain healthy populations of all life history stages of Atlantic menhaden**

  Atlantic menhaden are estuarine-dependent. Thus, perturbations in estuarine conditions affect menhaden. Widespread fish kills and epidemic diseases in recent years suggest that the quality of many Atlantic coast estuaries is less than optimal. (See sections 5.0 and 10.5.)

- **To base regulatory measures upon the best available scientific information and to coordinate management efforts among the various political entities having jurisdiction over the fisheries**

  Regulatory authority over the Atlantic menhaden fishery is vested in the various state management systems, not in the federal government. Thus, 15 different entities (14 states and the Potomac River Fisheries Commission) have authority over various aspects of the reduction and bait fisheries. These jurisdictions need to coordinate their regulatory approaches to promote the long-term health of the stock and fisheries through the ASMFC menhaden program. It is important that proposed rules be fully reviewed by all affected parties to ensure they are based on the best available biological and socioeconomic information. (See sections 6.0, 10.3, and 10.4.)

10.3 Management Organization

The Atlantic Menhaden Board (AMB) and Atlantic Menhaden Advisory Committee (AMAC) will continue to function in monitoring and evaluating the condition of the stock and fishery.

Composition of the AMB will consist of an equal number of representatives of interested states and representatives of the menhaden industry, up to a maximum of five members from each sector, along with one member each from the NMFS and the NFMOA. To the extent possible, the geographic range of the fishery should be represented on the Board. The AMB provides general program oversight, policy direction, and considers management actions, as appropriate. The AMB reports to the Interstate Fishery Management Program (ISFMP) Policy Board of the ASMFC. The ISFMP Policy Board has approval authority over draft plans and amendments and the program budget because the program is a constituent of the Commission's ISFMP. The full ASMFC has approval authority over FMPs, major plan amendments (such as this document), and proposed regulations.

The AMAC will be appointed by the AMB and will include members from interested states desiring to participate in the committee, industry representatives, personnel from NMFS, and a representative from the NFMOA. This group serves as the ISFMP menhaden program's technical committee. Members of the AMAC must have technical expertise concerning Atlantic menhaden life history, population dynamics, fishing, and processing. The AMAC provides technical evaluation of stock and fishery status and IWP applications and advises the AMB, as appropriate.

The AMB and AMAC both have specific responsibilities under this amendment, as discussed below.

The AMAC will meet annually during the spring for three purposes: (1) to review fishery information from the previous season and stock assessment data in order to evaluate the condition of the stock and fishery, (2) to review and comment on allocation of Atlantic menhaden for harvest under IWP arrangements, and (3) to review implementation status of the FMP, including any state actions which may affect the menhaden fishery. The AMAC will prepare written advice on all three topics and forward its report promptly to the AMB. The AMB will convene in person or by conference call and provide timely recommendations to the ASMFC for appropriate actions.

10.4 Management Process

The management process consists of two principal activities, the annual review and the IWP review.

10.4.1 Annual Review of Stock and Fishery Conditions

Annual evaluation of the Atlantic menhaden stock and fishery will be based principally on six different variables, called "triggers," which are discussed in Section 10.4.1.2 These data types were selected for their importance as indicators of the existing condition of the stock and fishery, relative ease of measurement, and clarity of meaning within the community of those fishing industry representatives and state and federal fishery management personnel concerned with management of the Atlantic menhaden fishery. The six variables are considered as thresholds which, when met, call for specific AMB/AMAC consideration of probable causes for reaching that point and determination of whether or not regulatory action is warranted. Ancillary information will also be evaluated by AMB/AMAC in determining appropriate responses.

When AMAC meets each spring, data relative to each trigger will be evaluated, along with other available information. Should the AMAC determine that one or more triggers have been reached, but ancillary information does not indicate that significant stock or fishery problems exist, the AMAC will advise the AMB that fishing restrictions are not recommended. If, however, the AMAC analyses indicate substantive problems within the stock or fishery, the AMAC report to AMB will recommend regulatory actions to address the problems. The AMB will consider the AMAC report and forward its recommendations to the ISFMP Policy Board and the ASMFC, which has the statutory responsibility to make recommendations to the states. The ISFMP Policy Board or the ASMFC will forward specific requirements and/or recommendations to the states in time for implementation by the next fishing season. The process is illustrated in Figure 10.1.

As part of its annual review, AMAC will consider implementation status of regulatory measures which may be developed and recommended under this management process. The AMAC report will include an evaluation of state actions to implement regulations recommended by the ASMFC to the states.

Whenever a state considers implementation of rules for the menhaden fishery which do not result from the AMAC/AMB review process, those rules should be submitted to the ASMFC for review and comment. Such review should foster greater interstate cooperation and more effective management of the resource.

10.4.1.1 Options for Regulatory Actions

1. No action (Fishery would be managed under the existing rules and regulations enforced throughout the Atlantic coastal fishery.)

   No additional management restrictions are recommended at this time for the Atlantic menhaden fishery. Under current conditions of stock size and fishing, the menhaden resource has largely recovered from its severely depleted status of the 1960s. The stock is essentially fully utilized, and fishing and processing capacity (shore-based and IWP) are sufficient to catch and utilize the available stock. In some limited areas, expansion of the bait fishery could supply growing markets or replace bycatch of edible species presently used, relieving pressure on those stressed stocks. Existing rules and regulations are listed in Section 11.10.1.

2. Implement restrictions, such as effort limits, harvest limits, gear restrictions, seasonal/areal closures, size limits, or other limits, as appropriate. A range of possible actions is listed in Appendix 1.

10.4.1.2 Atlantic Menhaden Stock and Fishery Triggers

The following six triggers or warning variables were selected to represent landings and key biological aspects of the Atlantic menhaden stock that would indicate its condition (Table 10.1). All of the data for the triggers are derived from the menhaden purse seine reduction fishery. The AMAC will evaluate data relative to each trigger at its annual meeting. In the committee's discussions, all six triggers and any relevant ancillary information will be considered. The committee will forward its findings and recommendations to the AMB.

Estimates of the first variable, landings in weight, are available within a week after the end of the fishing season (end of February). Estimates of the second and third variables [proportion of age-0 and adult (age 3+) menhaden in the landings, respectively] are available from estimated catch-at-age data a few months later, after processing fish samples for size and ageing scales at Beaufort. However, these triggers are subject to the potential for "false firings" because values beyond the thresholds do not necessarily imply that something is wrong with the Atlantic menhaden stock. Ancillary information (such as weather, new rules, economic

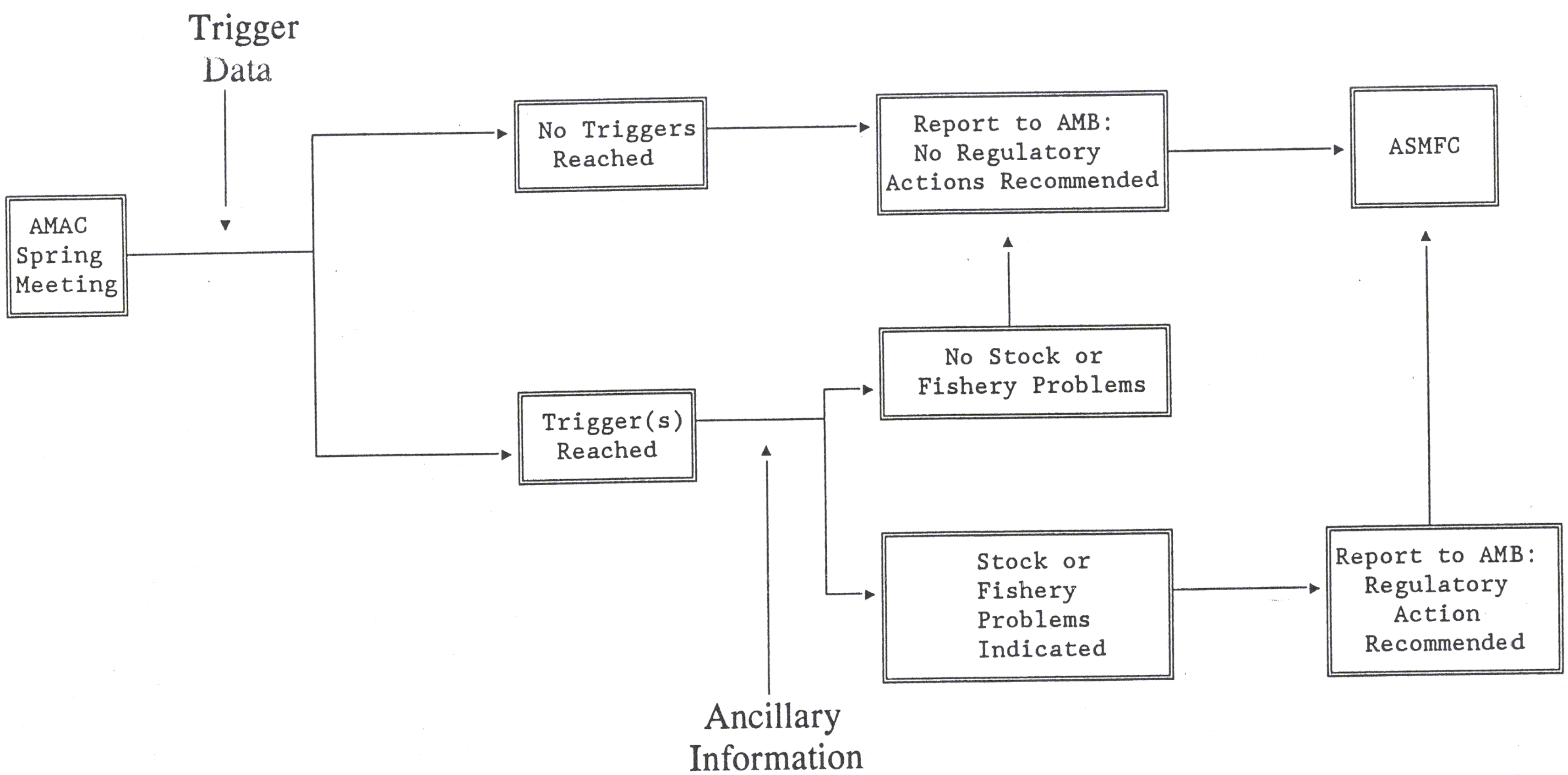


Figure 10.1 Diagram of annual review of menhaden stock and fishery condition process.

Table 10.1. Annual ... nated values of six Atlantic menhaden trig ... s. (Shading indicates years in ... ch respective trigger would have been exce ... d.)

Year	Landing	PO[b]	P3+[c]	Recruits[d]	SB[e]	MSP[f]
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	351.3	-	-	-		-
1952	423.6	-	-	-		-
1953	589.2	-	-	-		-
1954	617.9	-	-	-		-
1955	644.5	24.4	20.1	3.1	[illegible]	13.8
1956	715.4	1.0	15.5	5.7	[illegible]	6.6
1957	605.6	8.5	7.1	7.3	[illegible]	6.7
1958	512.4	3.9	4.4	3.3	[illegible]	16.1
1959	662.2	0.2	8.4	15.1	[illegible]	8.6
1960	532.2	2.6	7.7	2.2	[illegible]	24.1
1961	578.6	0.0	48.6	3.0	[illegible]	13.3
1962	541.6	2.5	33.3	2.2	[illegible]	4.9
1963	348.4	5.5	13.3	2.2	[illegible]	3.1
1964	270.4	17.5	6.8	1.7	[illegible]	2.4
1965	274.6	17.1	6.2	1.9	[illegible]	1.7
1966	220.5	26.1	2.7	1.4	[illegible]	3.3
1967	194.4	0.7	8.0	1.9	[illegible]	5.5
1968	235.9	13.4	6.7	1.2	[illegible]	2.1
1969	162.3	18.2	6.2	1.7	[illegible]	5.4
1970	259.4	1.5	2.6	2.6	[illegible]	6.6
1971	250.3	7.5	11.2	1.3	[illegible]	6.6
1972	365.9	2.9	11.3	3.4	[illegible]	2.0
1973	346.9	3.0	2.5	2.7	[illegible]	1.3
1974	292.2	15.9	2.6	3.0	[illegible]	1.5
1975	250.2	13.8	2.6	3.7	[illegible]	1.9
1976	340.5	8.4	1.7	6.8	[illegible]	2.8
1977	341.2	13.2	2.8	5.1	[illegible]	4.3
1978	344.1	14.8	9.5	4.7	[illegible]	3.7
1979	375.7	38.6	3.9	4.2	[illegible]	6.4

Table 10.1. (Continued)

Year	Landings[a]	P0[b]	P3+[c]	Recruits[d]	SSB[e]	MSP[f]
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	19.2	2.6
1986	238.0	5.2	3.5	4.6	16.9	7.7
1987	326.9	1.9	7.1	3.4	39.0	7.8
1988	309.3	18.6	16.8	3.1	60.8	4.6
1989	322.0	5.7	5.5	5.7	36.3	5.1
1990	401.2	25.5	6.1	2.3	36.0	7.8
1991	381.4	28.3	9.1	3.4	67.7	3.6
1992	297.6	18.7	5.8	7.0	40.8	11.4
Median[g]	324.1	13.6	6.9	3.5	26.7	4.1
25%	250.3	3.6	3.7	2.0	16.1	2.1
75%	365.9	21.1	10.3	4.7	43.9	6.3
Trigger	<250.0	>25.0	>25.0	<2.0	<17.0	<3.0

a Landings in thousands of metric tons.

b Percent by numbers of age 0's in landings.

c Percent by numbers of adults (ages 3+) in landings.

d Estimated numbers of recruits to age 1 in billions.

e Estimated mature female biomass (spawning stock biomass or SSB) in thousands of metric tons.

f Estimated equilibrium maximum spawning potential (MSP) based on egg production (for estimated F vs F=0) in percent (includes F at age 0).

g Median, 25th, and 75th percentiles based on fishing years from 1965 through 1990, except for P3+ which is based on fishing years 1955 through 1990.

conditions) is important to judge whether exceeding any of these triggers requires some recommendation from the committee for initiation of management actions to rectify the apparent problem.

Estimates of the last three variables are obtained from virtual population analysis (VPA) on estimated catch-at-age data, and can be completed within a few weeks of availability of such data. These triggers are also subject to false firings, but for a different reason than the first three triggers. Trigger estimates for recent years from VPA are subject to large uncertainty, while estimates more than 2 to 3 years old are more reliable. This situation exists because of the convergence properties of back-calculations. If the estimates are considered to be reliable, then firing of any of these triggers suggests a problem in the Atlantic menhaden stock, which must be addressed by the AMB and AMAC.

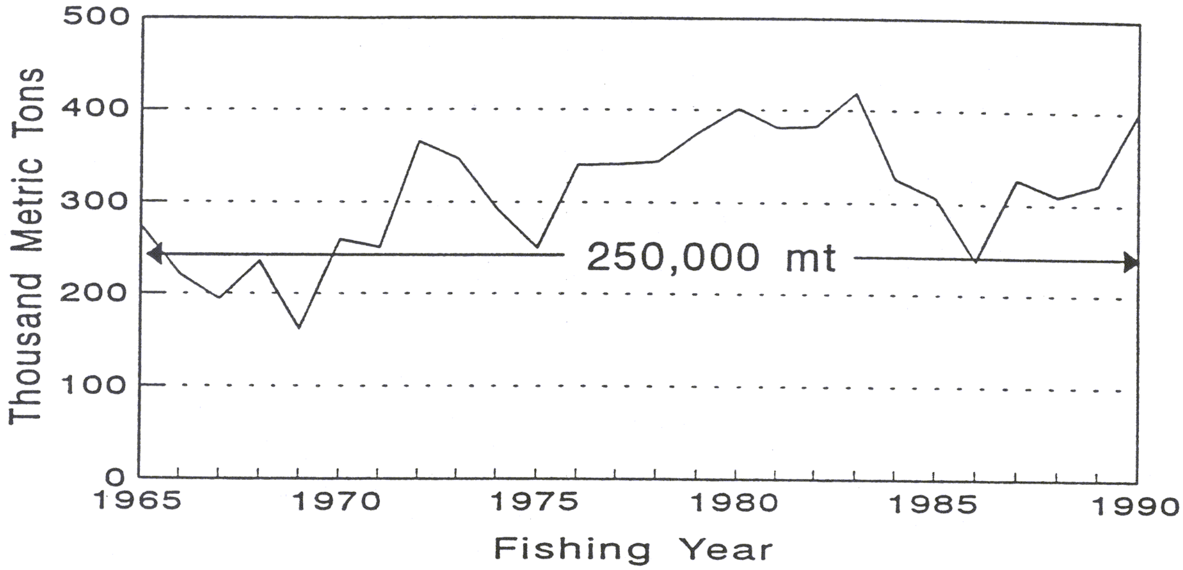
Generally, the 25th or 75th percentile of the historical data from 1965 through 1990 was used to select the particular trigger value for each variable. The value of the third trigger is based on historical data from 1955 through 1990, because the scenario of concern (recruitment overfishing) occurred in 1960-1961. The first, fourth, fifth, and sixth variables are triggered if the respective values fall below the 25th percentile (or similar value). The second variable is triggered if the respective value exceeds the 75th percentile. The third variable is triggered at about twice the 75th percentile; this trigger was last fired during the stock collapse of the early 1960s.

10.4.1.2.1 Landings in Weight (Trigger #1, Figure 10.2)

Landings were selected because they could be an indicator of a change in stock abundance. An awareness of whether economic conditions have affected fishing activity, as occurred in 1986 when a major plant closed, would be important ancillary information. Catch-per-unit effort was not selected because of the general problem of using effort from a purse seine fishery (Clark and Mangel 1979); that is, effort is not a valid measure of fishing mortality, nor is catch-per-unit effort a valid measure of stock abundance for pelagic schooling species, such as menhaden. This trigger fires if landings fall below 250,000 mt.

10.4.1.2.2 Proportion of Age-0 Menhaden in Landings (Trigger #2, Figure 10.3)

The proportion of age-0 menhaden in the landings was selected because of two concerns. First, very high harvest of the youngest fish, in general, reduces potential yields based on a yield-per-recruit or growth overfishing argument. The number of fish in a population declines with increasing age due to both natural and fishing sources of mortality, while weight of an individual fish increases with age. Initial growth is rapid and then tends to level off. Population biomass, represented by the product of numbers and weight, typically increases during the period of rapid growth, peaks, and then declines as growth levels off. Growth overfishing refers to the catching of fish at ages significantly below the age where biomass peaks. Second, very high harvest of the youngest fish in years of poor recruitment, although they may be readily available for harvest due to good weather or other factors, may reduce subsequent spawning stock biomass. This threshold is reached if more than 25% of the menhaden harvested (by number) are age-0 fish.



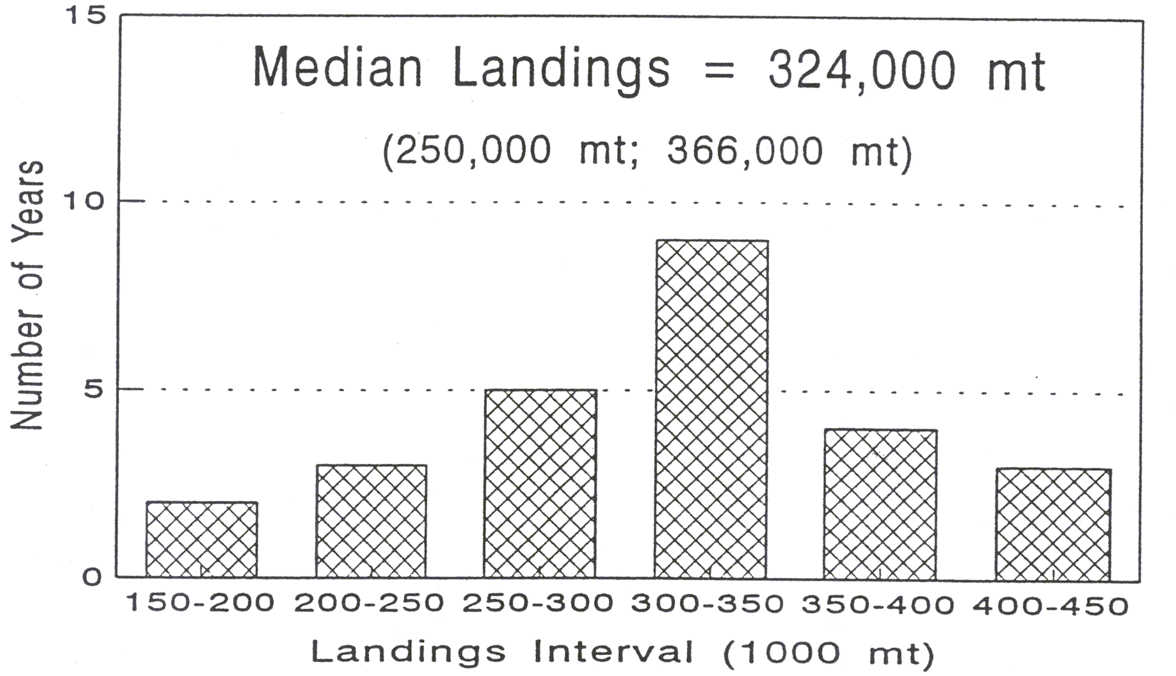


Figure 10.2 Trigger #1 <250,000 mt, Atlantic menhaden landings, temporal trend, 1965-1990.

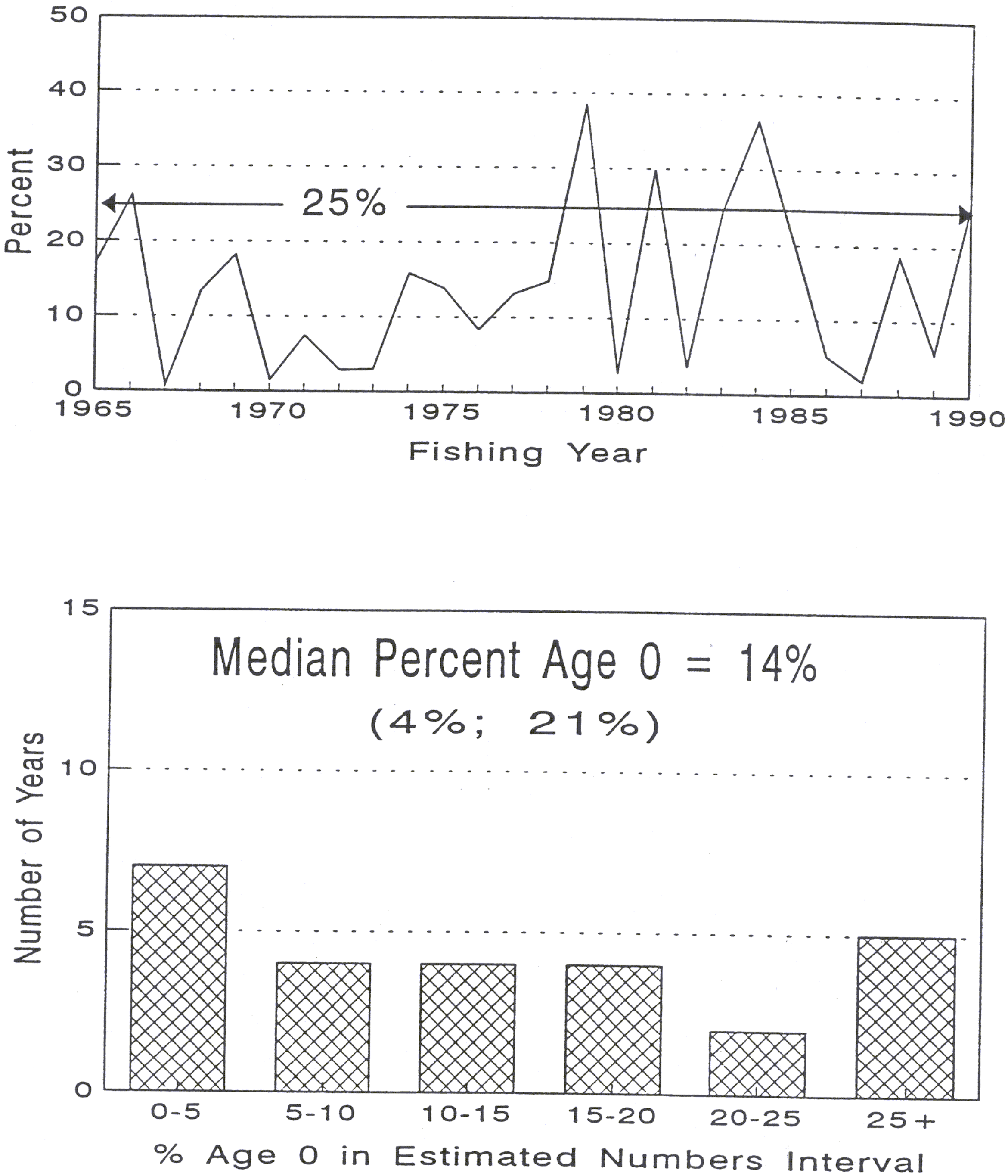


Figure 10.3 Trigger #2 >25%, Atlantic menhaden percent age 0 in landings, temporal trend, 1965-1990.

10.4.1.2.3 Proportion of Adults in Landings (Trigger #3, Figure 10.4)

The proportion of adult (age 3+) menhaden in the landings was also selected because of two concerns. First, short-term reduction in adult spawning stock may be indicated. This approach addresses the concern of recruitment overfishing, which can occur if the spawning stock is insufficient to produce adequate numbers of recruits to the stock. Although the relationship between spawning stock and subsequent recruits for menhaden is weak, as spawning stock is reduced the probability of poor recruitment increases. Second, large landings of adults relative to subadults may indicate lack of availability of subadults (i.e., recruitment failure), as occurred in 1961 and 1962. This trigger is reached if more than 25% of the menhaden in the catch (by number) are age 3 and older.

10.4.1.2.4 Recruits to Age 1 (Trigger #4, Figure 10.5)

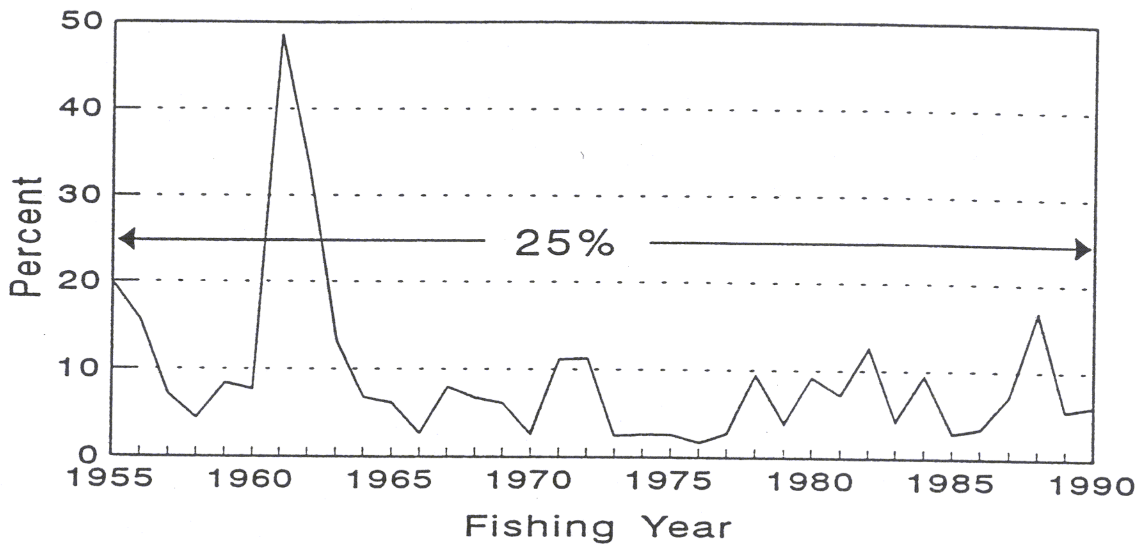
The estimates of recruits to age 1 was selected because it indicates directly what will be available to the fishery, especially one year later at age-2, the age class upon which the fishery largely depends. The problem with using this variable, as indicated above, is the great uncertainty with estimating recruitment for the most recent years. A major concern with this variable is that several poor recruitment years may occur consecutively. Such a situation, coupled with high fishing mortality, will subsequently result in reduced spawning stock biomass, and potential recruitment overfishing. An estimate of less than 2 billion age-1 menhaden will cause this trigger to fire.

10.4.1.2.5 Spawning Stock Biomass (Trigger #5, Figure 10.6)

Estimates of female spawning stock biomass were selected to represent the availability of spawners in sufficient quantity to produce adequate recruitment. Although the relationship between menhaden spawning stock biomass and subsequent recruits is poor, it is generally understood and accepted that the probability of poor recruitment will increase when spawning stock biomass falls to some low level. What that low level might be is poorly known for menhaden and generally unknown for most fish stocks. Again, the most recent estimates (1-2 yr) of spawning stock biomass must be viewed with uncertainty. A spawning stock biomass below 17,000 mt will cause this trigger to fire.

10.4.1.2.6 Percent Maximum Spawning Potential (Trigger #6, Figure 10.7)

Estimates of percent maximum spawning potential (%MSP), based on fishing mortality rates estimated in the VPA, are widely used by the regional fishery management councils to define overfishing (e.g., recruitment overfishing). This index is equal to the ratio of spawning stock biomass at the current fishing mortality rate (F), divided by the spawning stock biomass calculated when F is equal to 0 (unfished spawning stock). 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 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 cumulated. The index of egg production for Atlantic



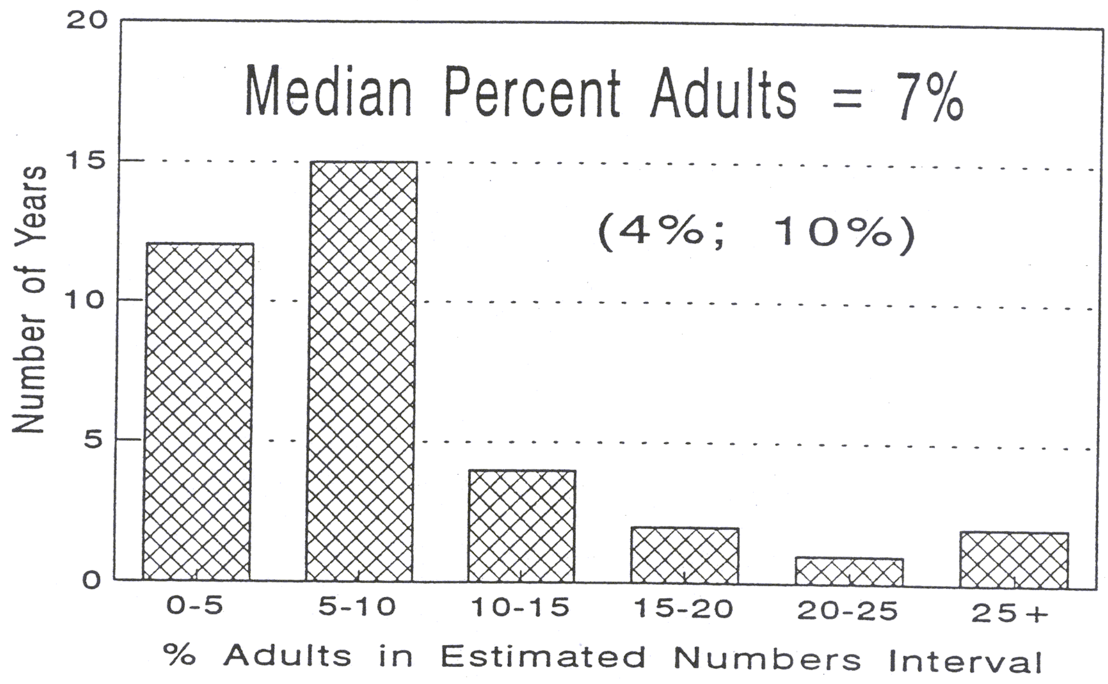
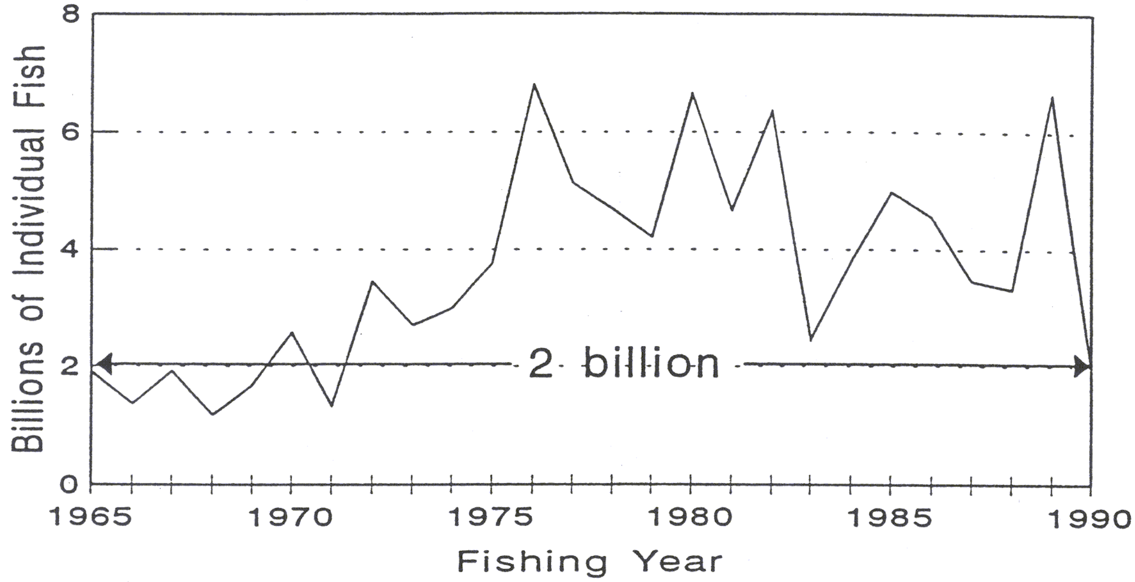


Figure 10.4 Trigger #3 >25%, Atlantic menhaden percent of adults in landings, temporal trend, 1955-1990.



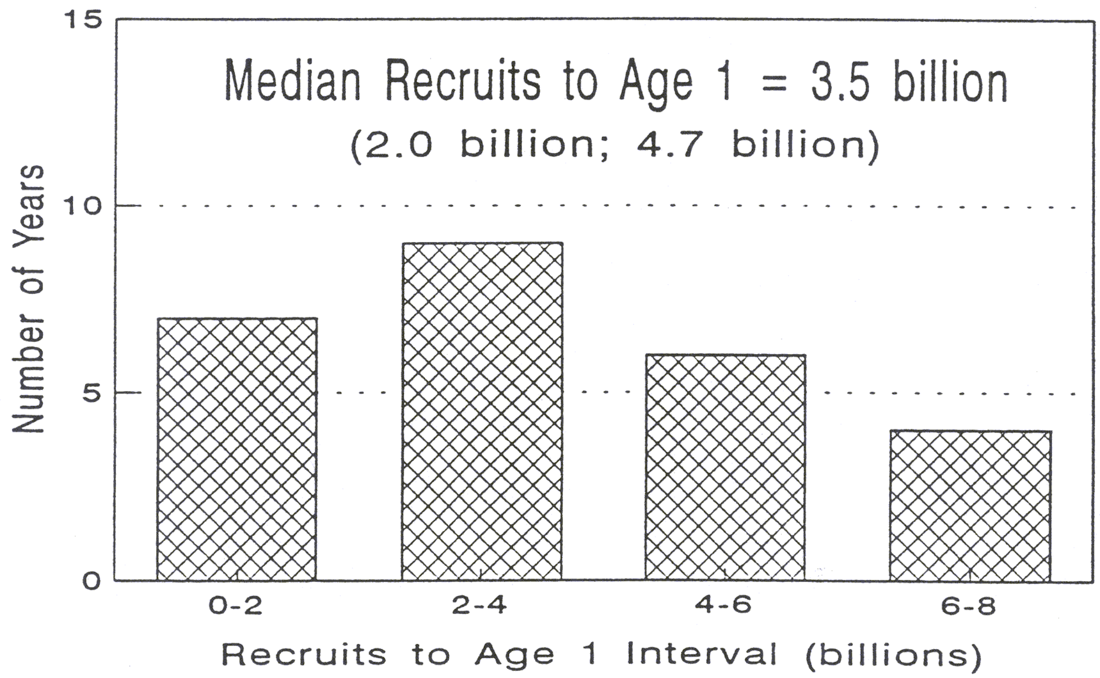


Figure 10.5 Trigger #4 <2 billion, Atlantic menhaden recruits to age 1, temporal trend, 1965-1990.

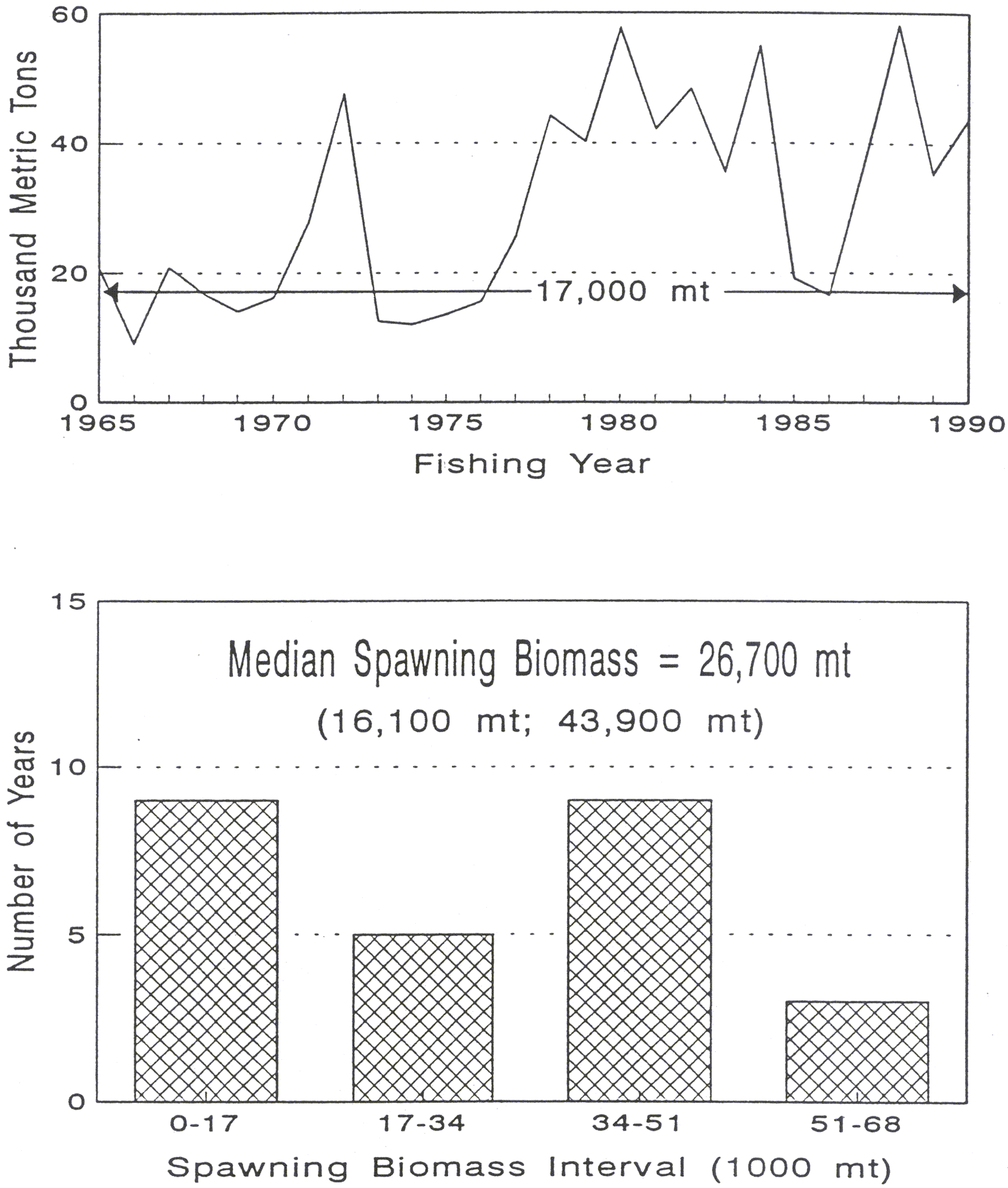
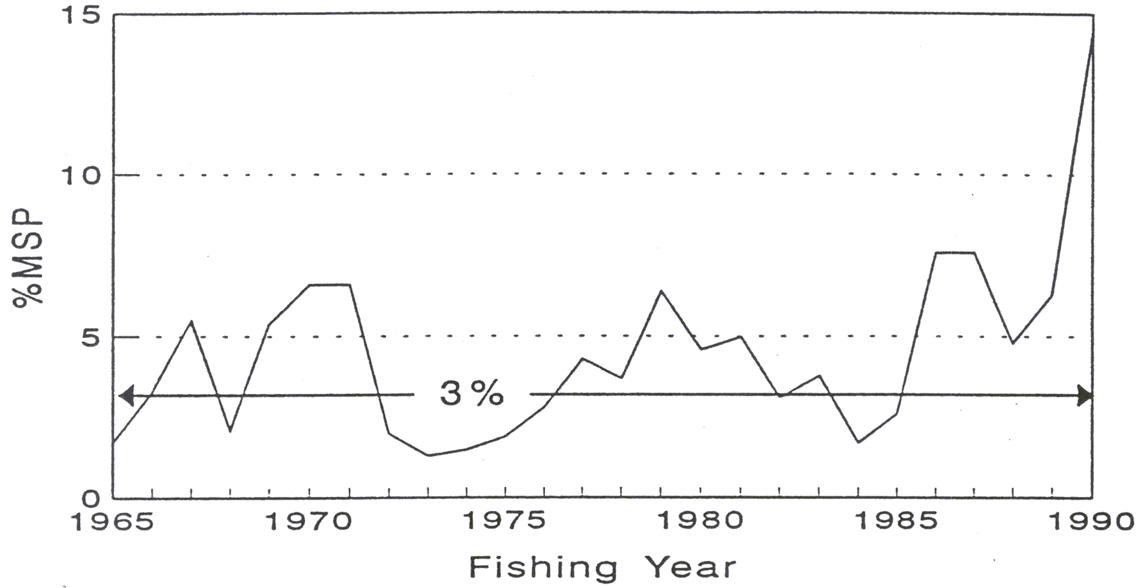


Figure 10.6 Trigger #5 <17,000 mt, Atlantic menhaden female spawning biomass, temporal trend, 1965-1990.



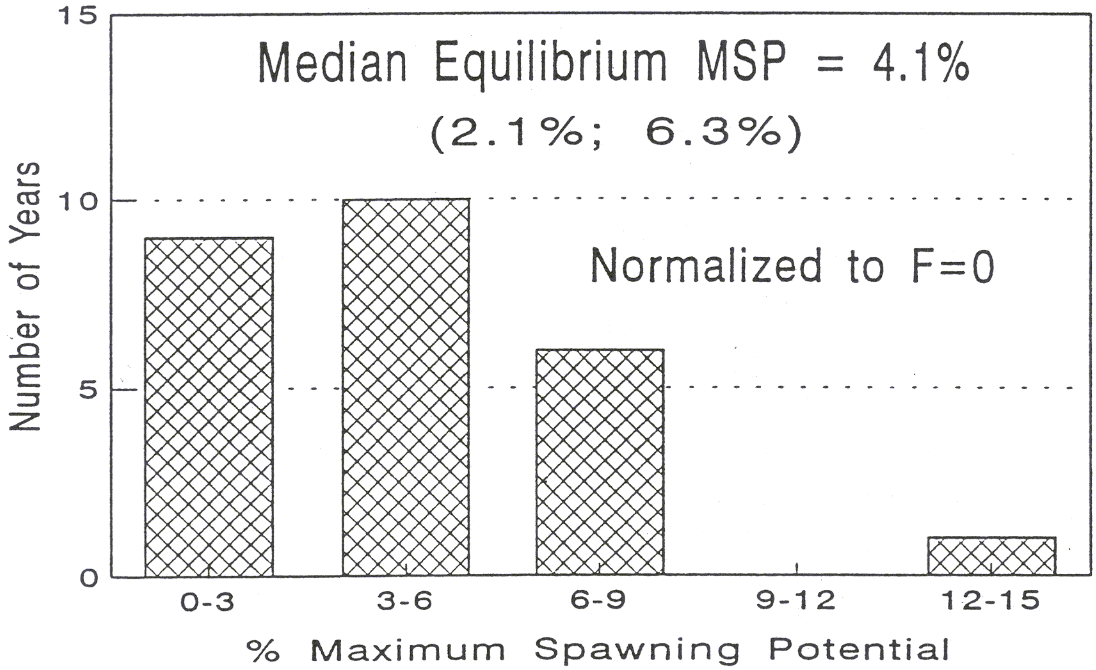


Figure 10.7 Trigger #6 <3%, Atlantic menhaden percent MSP, temporal trend, 1965-1990.

menhaden is based on the egg-length relation provided in Lewis et al. (1987). These estimates compare equilibrium female spawning stock biomass with and without fishing mortality. These estimates are useful for determining whether fishing mortality is too high to permit adequate survival of recruits to spawning age. As above, recent estimates of fishing mortality from the virtual population analysis are quite uncertain. This trigger will fire if the %MSP falls below 3%.

10.4.2 Internal Waters Processing

Section 306 of the Magnuson 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 marine fisheries commission.

An IWP for Atlantic menhaden has been conducted in Maine since the 1988 season. Through Resolution No. 1 of the 1989 Annual Meeting, the ASMFC established a general policy for evaluation of IWP applications. The annual review of IWP proposals by the AMAC/AMB will be conducted according to the specific process presented in Appendix II and illustrated in Figure 10.8.

10.5 Research and Data Collection Programs

Data needs for the Atlantic menhaden management program are complicated by the extensive migration patterns, mixing of age-classes characteristic of the species, the multiple resource users, the large number of states within the species' range, and changing economic and social factors affecting the fisheries. The current data collection program for the menhaden fisheries is carried out by the NMFS Laboratory in Beaufort, North Carolina. This program, which primarily collects fishery-dependent data from the Atlantic and gulf menhaden fisheries, is essential for the ASMFC, states, and industry to attain the goal and objectives of this management plan. For long-term management of the fishery under this plan, a more extensive, integrated fisheries-dependent and -independent database needs to be developed. This information should be incorporated into the Beaufort Laboratory program, including additional resources as described in this plan.

Improvements are necessary in several specific areas. Past data files of CDFR, which hold extensive information on catch by area, must be computerized so this information can be integrated into the analysis program for Atlantic menhaden. Effects of environmental factors, evaluations of fish kills, disease studies, and ecological studies need to be conducted so managers can more fully understand the biological and ecological interactions of Atlantic menhaden. Investigations to develop and institute a reliable juvenile recruitment index for Atlantic menhaden would greatly enhance the ability of managers to effectively manage this species. Also, studies of the economic trends in menhaden fisheries, its products, and impacts on other industries are needed to properly address the many socioeconomic factors affecting fisheries operations. Research to develop more valuable menhaden products should be conducted. Bycatch

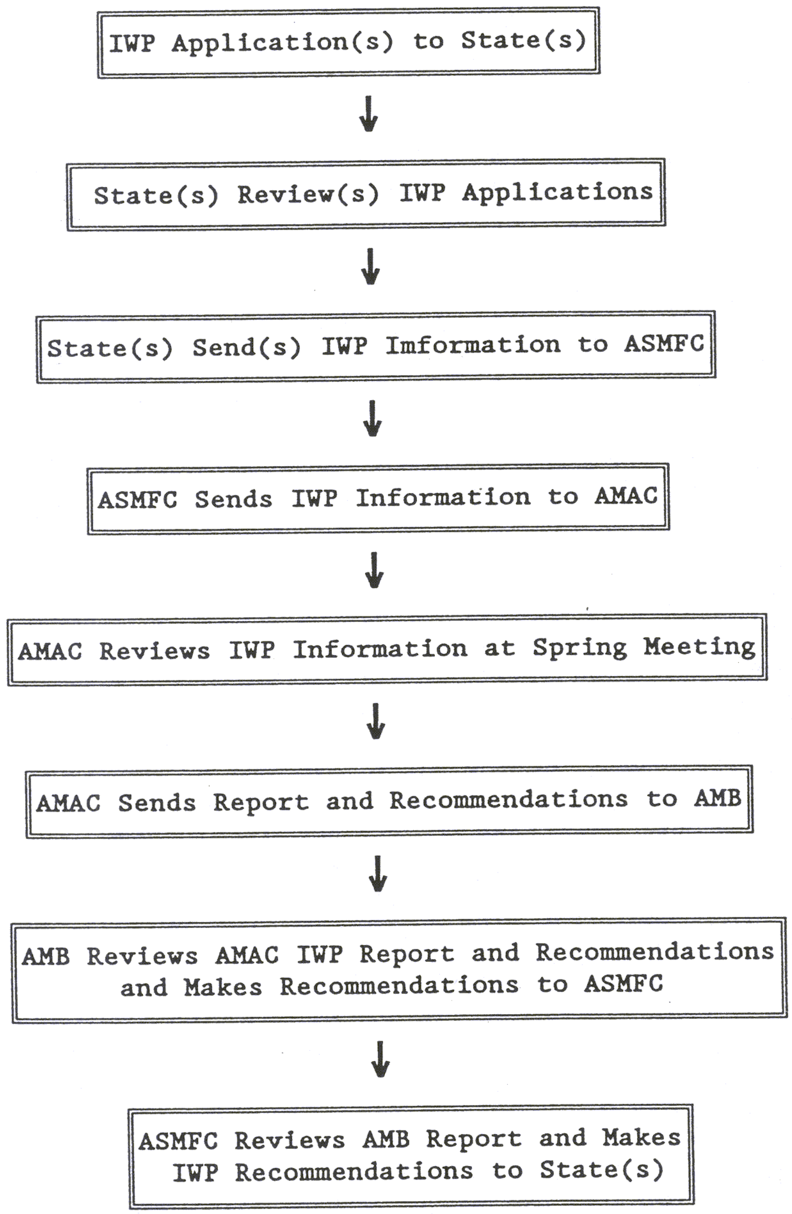


Figure 10.8 Diagram of annual menhaden IWP review process.

studies, both of species in the menhaden fisheries and of menhaden in other fisheries, are needed to address concerns which have become quite important in a number of jurisdictions.

Data collection from groups other than the purse seine fishery, such as menhaden bait fisheries and power plant operations, needs to be consolidated to build a more comprehensive data collection system which can more fully assess overall impacts on the Atlantic menhaden stock.

11.0 BIOLOGICAL AND FISHERIES PROFILE OF ATLANTIC MENHADEN

11.1 Identity

11.1.1 Nomenclature

The valid scientific name for the Atlantic menhaden is *Brevoortia tyrannus*. Other common names used include menhaden, mossbunker, bunker, fatback, shad, pogy, and bugfish. The following synonymy is after Hildebrand (1963):

Clupea tyrannus Latrobe 1802
Clupea menhaden Mitchell 1818
Clupea neglecta Rafinesque 1818
Alosa menhaden DeKay 1842
Alosa sadina DeKay 1842
Clupea carolinensis Gromow 1854
Brevoortia menhaden Gill 1873
Brevoortia tyrannus Goode 1879

11.1.2 Taxonomy

Classification:
Order: Clupeiformes
Family: Clupeidae
Genus: Brevoortia
Species: *Brevoortia tyrannus*

11.1.3 Range

Atlantic menhaden are found in the continental waters of North America from Nova Scotia to Florida. They have been taken in commercial quantities from northern Florida to eastern 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).

11.2 Biology and Life History

11.2.1 Reproduction

11.2.1.1 Age and Size at Maturity

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 11.2.1.3). 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 January 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 - Lewis et al. 1987) because of latitudinal differences in size-at-age (See 11.2.3.2) and the fact that larger fish of a given age mature earlier.

11.2.1.2 Fecundity

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 by the authors 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.

11.2.1.3 Spawning Times and Locations

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 (Ted Creaser, Maine Dept. Marine Resources, pers. comm.) 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 (Steve Young, Maine Dept. Marine Resources observer on the M/V RIGA, pers. comm.). Egg and larval surveys have been entirely 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.

11.2.2 Early Life History Stages

11.2.2.1 Eggs

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).

11.2.2.2 Larvae and Juveniles

A full morphological description of Atlantic menhaden eggs and larvae is 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).

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 salt marsh cordgrass (*Spartina alterniflora*) has also been reported as a primary food source for juveniles in North Carolina salt marshes (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 resources 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 in recent years from Massachusetts to Georgia. (There is no survey on the Atlantic coast of Florida.) As noted above, a juvenile menhaden was taken in Maine estuarine waters in October, 1990.

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).

11.2.3 Adults

11.2.3.1 Feeding

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).

11.2.3.2 Growth

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).

Due to their greater migratory range (See section 11.2.3.4), 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 (See below). 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).

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[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.*

Estimated fork lengths and weights for ages 1-6 were as follows:

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 (Virginia Institute of Marine Science, 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) indicates 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 Smith 1988).

11.2.3.3 Natural 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% (M=0.35) and, for ages 2 and older, it was 20% (M=0.22) [see section 11.3.2 and Vaughan (1990)].

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 piscivorus 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.

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. (1986) 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) is "red tide." The term refers to color of the 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. The most recent 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 (Stanley Warlen, NMFS Laboratory, Beaufort N.C., pers. comm.). A new species of toxic dinoflagellate that has recently been discovered was identified as the causative agent in a major menhaden kill in the Pamlico River, North Carolina, in May, 1991. (For more information on this particular dinoflagellate, contact Dr. JoAnn M. Burkholder, Dept. of Botany, North Carolina State University, Raleigh, N.C. 27695). 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 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 (Michael W. Street, North Carolina Division of Marine Fisheries, Morehead City, N.C. pers. comm.). Other species are not nearly as susceptible simply because they do not enter enclosed inshore waters in such large numbers.

11.2.3.4 Migrations

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 Roithmayer (1963) based on the reduction in the number of purse seine sets north of Cape Cod in September and by June and Reintjes (1959) who 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 the 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.

11.2.4 Ecology

A major reason menhaden are so plentiful is their ability to directly utilize phytoplankton, which is such an abundant food resource. 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. Menhaden are preyed upon by a large number of piscivorous fishes, birds, and marine mammals because they are so abundant in nearshore coastal and estuarine waters. Because menhaden occupy a very important link in the coastal marine food chain, they 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 consume 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 determined. Swimming speed, the duration of the daily feeding period, and the concentration of plankton in the water control the energy and nitrogen budgets for this species.

11.3 Population Dynamics

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. (1986). 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 11.1) as described most recently in Vaughan (1990).

11.3.1 Abundance and Structure

Population size (age 1 and older at the start of the fishing season) ranged from 2.0 billion Atlantic menhaden in 1968 to 17.6 billion fish in 1959 (Table 11.2). Population size averaged 9.2 billion menhaden between 1955 and 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). Since 1975 population size has averaged 7.3 billion menhaden, comparing favorably to population sizes between 1955 and 1961, but landings have 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 (Figure 11.1), 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

Table 11.1. Estimated Atlantic menhaden landings in numbers by age (in millions) and weight of total landings (in thousands of metric tons), 1955-1991.

	Numbers at age								
Year	0	1	2	3	4	5	6-8	Total numbers	Total weight
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	100.3	225.0	1527.5	48.7	10.2	6.4	1.1	1919.2	238.0
1987	44.9	541.8	1652.0	143.9	25.5	2.2	0.8	2411.1	327.0
1988	429.2	314.1	1180.6	309.3	70.7	6.8	0.8	2311.4	309.3
1989	161.1	1358.0	1166.0	98.5	46.3	11.6	0.2	2841.7	322.0
1990	643.6	152.2	1576.6	104.5	37.9	10.1	0.4	2525.3	401.2
1991[a]	906.5	1069.4	939.8	240.7	37.5	10.6	2.0	3206.4	381.4

a Preliminary estimate.

Table 11.2. 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 (yr1, weighted mean of F for ages 1-8 from VPA), for fishing years, 1955-1990.

Fishing year	Population size (millions)	Numbers landed (millions)	u	F
1955	6967.6	2357.4	0.34	0.63
1956	8298.0	3528.5	0.43	0.83
1957	9823.3	3212.1	0.33	0.89
1958	7123.0	2613.1	0.37	0.69
1959	17627.0	5342.2	0.30	0.55
1960	9309.4	2702.9	0.29	0.50
1961	6843.4	2598.1	0.38	0.71
1962	4587.1	2048.3	0.45	1.19
1963	3603.0	1667.6	0.46	1.15
1964	2770.6	1426.5	0.51	1.20
1965	2594.0	1260.4	0.49	1.23
1966	2071.7	991.2	0.48	0.98
1967	2496.8	977.2	0.39	0.79
1968	2024.7	993.7	0.49	1.39
1969	2222.7	710.0	0.32	0.82
1970	3443.4	1381.5	0.40	0.79
1971	2463.1	896.2	0.36	0.87
1972	4318.1	1663.8	0.39	1.17
1973	4179.4	1787.4	0.43	1.81
1974	4325.7	1675.1	0.39	1.54
1975	5243.6	1863.7	0.36	1.43
1976	8738.5	3009.3	0.34	1.06
1977	8399.8	3189.1	0.38	1.15
1978	7622.6	2627.8	0.34	1.21
1979	7080.5	2377.7	0.34	1.07
1980	9350.3	3244.1	0.35	0.95
1981	8152.4	2796.4	0.34	1.02
1982	9419.3	3061.6	0.33	1.27
1983	6134.8	2977.7	0.49	1.37
1984	5449.6	2253.8	0.41	1.28
1985	6744.6	2388.1	0.35	1.26
1986	7051.8	1818.9	0.26	1.28
1987	6574.6	2366.1	0.36	0.99
1988	5695.6	1882.3	0.33	1.27
1989	8854.3	2680.6	0.30	0.79
1990	5541.5	1881.7	0.34	0.82

this decline 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. 1987). These factors, however, do not account for all of the decline in mean weight-at-age. Part simply cannot be explained.

The number of Atlantic menhaden spawners (age 3 and older at the start of the fishing year) ranged between 28 million in 1966 and 1,321 million in 1961 (Table 11.3). High spawning stock size (averaging 506 million menhaden) was the rule between 1955 and 1962, while low spawning stock size predominated from 1963 to 1974 (averaging 67 million menhaden). Improvement in spawning stock size has occurred since 1975 (averaging 176 million menhaden). Between 1955 and 1961, high spawning stock size produced excellent recruitment to age 1 (averaging 5.5 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 size present since 1975 has produced excellent recruitment (averaging 4.4 billion menhaden), comparable to that produced during the high spawning stock years (1955-61).

11.3.2 Fishing Mortality

Short-term losses to the Atlantic menhaden stock due to the fishery can be assessed by considering the exploitation rate (Figure 11.2), 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 11.2). 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). Since 1975 when population size and landings have improved significantly, the population exploitation rate has averaged 35%. 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 essentially 0% to 26%.

11.3.3 Dynamics

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 were such as to create 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

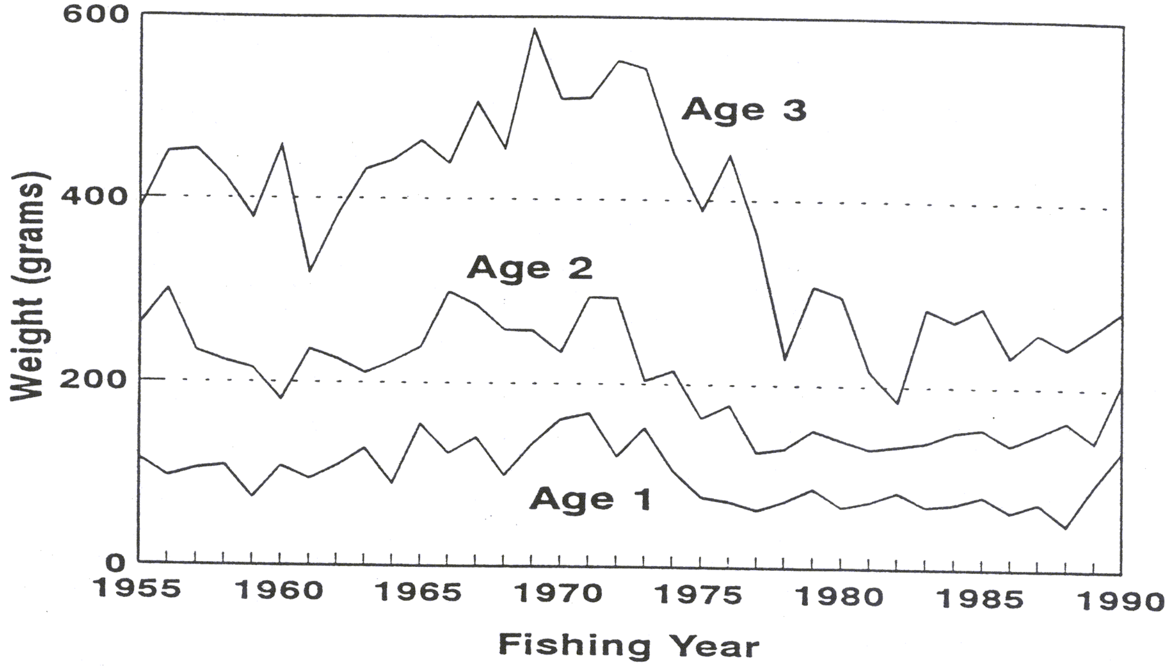

Figure 11.1 Weighted mean weight (grams) of Atlantic menhaden for ages 1, 2, and 3, for fishing years 1955-1990.

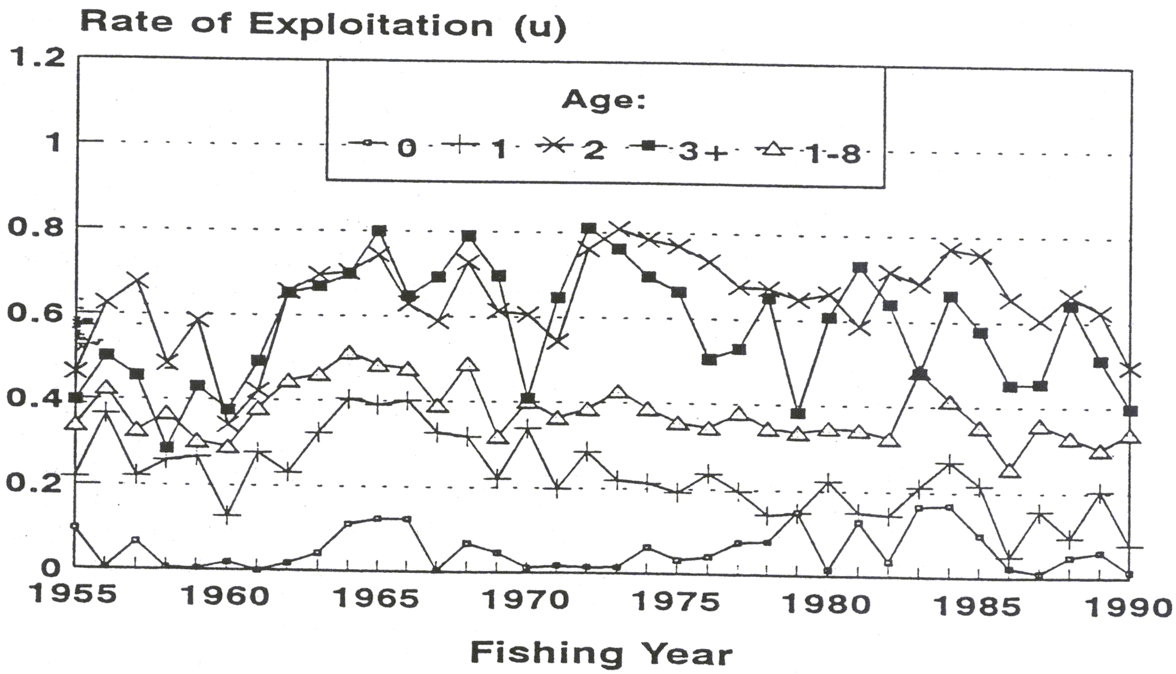

Figure 11.2 Estimates of annual rates of exploitation of Atlantic menhaden [ages 0 through 3+ and total population (ages 1+)], for fishing years 1955-1990.

Table 11.3. Estimated number of spawning Atlantic menhaden (age 3-8 females) that produced the given year class, estimated egg production from the spawning stock, and estimated numbers of recruits to age-1 by year class, 1955-1989.

	Spawners			
Year class	Number (millions)	Weight (100 mt)	Eggs (trillions)	Recruits to age 1 (millions)
1955	795.40	325.36	152.59	5680.4
1956	587.20	257.34	124.11	7243.8
1957	282.25	132.59	65.88	3324.1
1958	215.75	88.30	42.50	15103.1
1959	537.40	172.82	77.18	2216.1
1960	306.95	122.69	57.48	3008.7
1961	1321.35	358.56	152.88	2228.3
1962	544.75	199.03	91.15	2232.9
1963	175.60	64.93	30.31	1741.2
1964	84.25	30.68	14.09	1910.1
1965	58.75	20.70	9.32	1373.6
1966	28.15	9.05	3.99	1933.5
1967	56.45	20.84	9.43	1184.8
1968	49.60	16.70	7.42	1681.7
1969	39.45	14.03	6.29	2572.3
1970	45.15	16.16	7.28	1330.5
1971	84.30	27.93	12.57	3435.1
1972	120.40	47.75	22.13	2691.5
1973	31.00	12.46	5.88	2994.4
1974	37.95	12.03	5.33	3745.2
1975	43.80	13.57	5.91	6801.3
1976	56.75	15.49	6.54	5125.1
1977	99.35	25.50	10.68	4691.0
1978	225.60	44.31	18.09	4213.8
1979	198.80	40.23	16.33	6648.1
1980	252.60	57.67	23.80	4674.4
1981	198.00	42.23	17.49	6356.1
1982	316.00	48.51	19.62	2448.4
1983	178.10	35.59	14.43	3785.1
1984	254.25	54.99	22.43	4977.7
1985	76.20	19.17	8.06	4562.7
1986	78.70	16.53	6.85	3454.5
1987	194.25	36.66	14.86	3311.7
1988	303.40	58.17	23.55	6647.9
1989	171.15	35.45	14.48	1959.7

longer significant with the addition of more recent data (W. Schaaf, pers. comm.), and is not useful for predictive purposes.

11.3.3.1 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 (Figure 11.3). These values were exceptionally high during the 1970s (87% and 78%, respectively), but have 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 (Figure 11.4). 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.

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 (Figure 11.5) 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 cumulated. The index of egg production for Atlantic menhaden is based on the egg-length relation provided in Lewis et al. (1987).

Since 1962, the percent maximum spawning potential has remained below 10% (except for a tentative estimate of 14% in 1990). Periods of both poor recruitment and excellent recruitment 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 raise concern among some persons. On average, however, the Atlantic menhaden stock has been able to replace itself at these low %MSP values. Thus, a value much lower than 20% - 40% of MSP appears to apply to Atlantic menhaden.

11.3.3.2 Potential Yields

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 (Figure 11.6). Overall YPR for the age at entry of 0.5 yr and F-

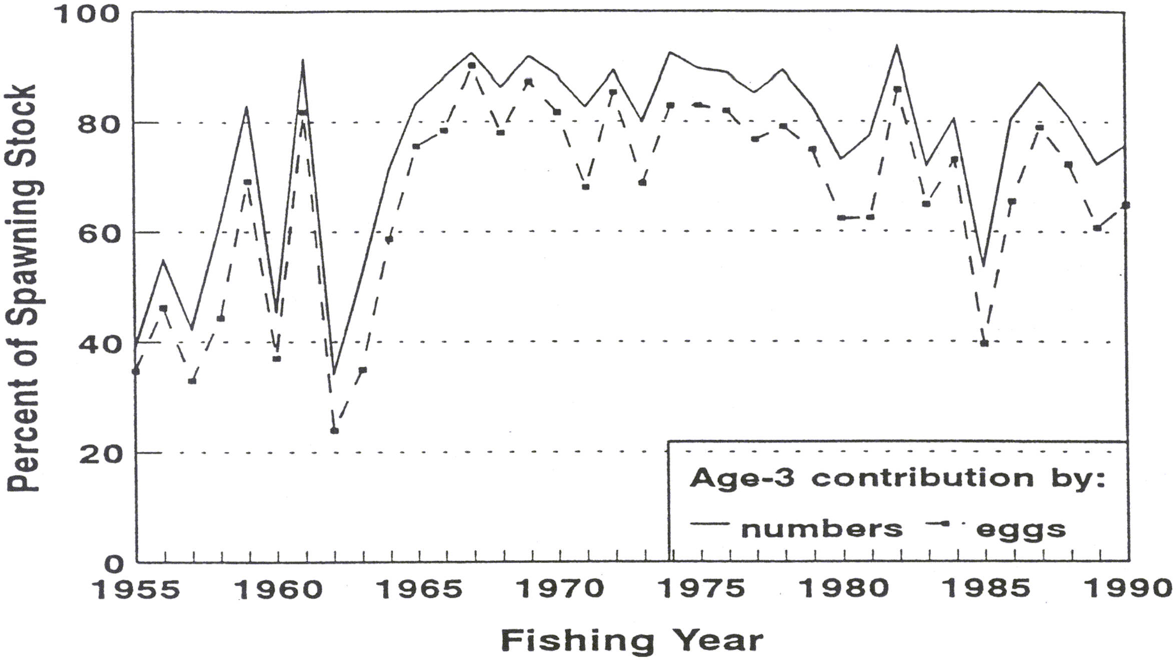

Figure 11.3 Contribution of age-3 spawners to total spawning stock (numbers) and to total egg production (eggs) of Atlantic menhaden for fishing years 1955-1990.

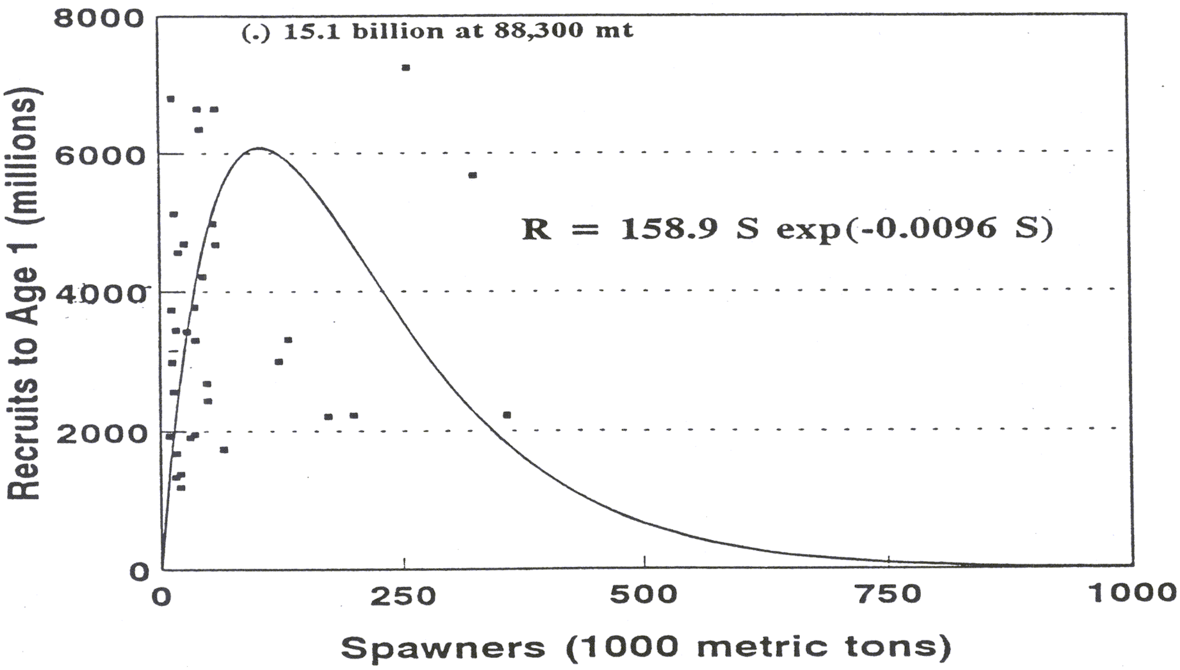

Figure 11.4 Numbers of Atlantic menhaden recruits (R) plotted against numbers of spawners (S) for year classes, 1955-1989. Curve represents the fitted Ricker function [R = αS exp (-ßS)].

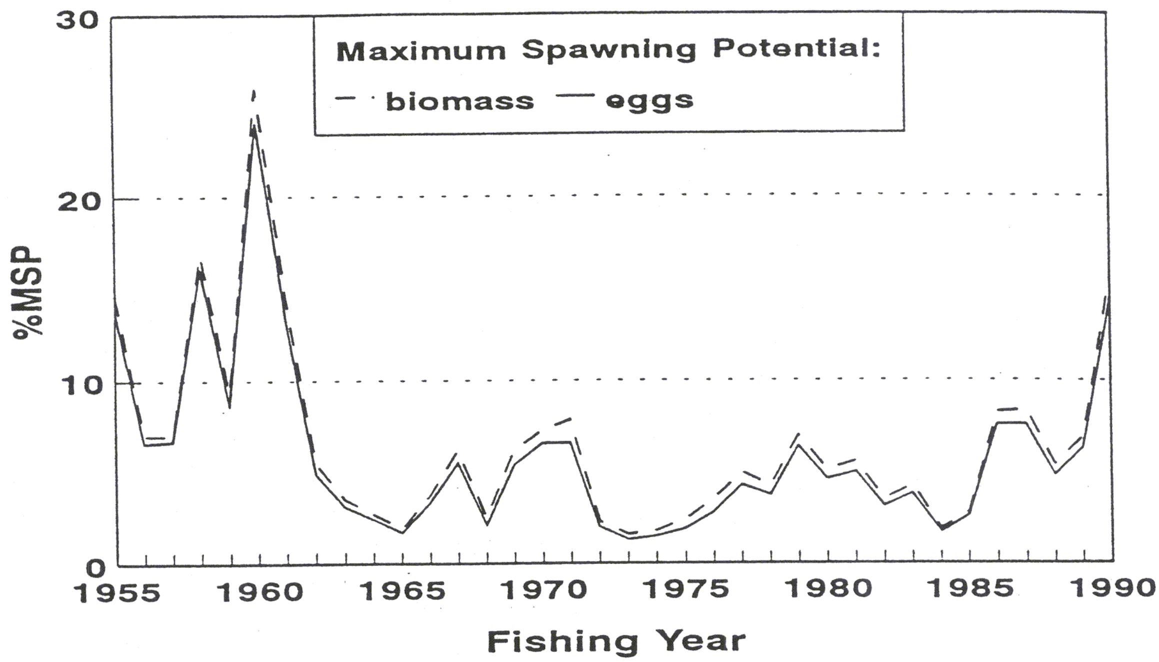

Figure 11.5 Equilibrium spawning stock ratio in biomass and index of egg production for Atlantic menhaden for fishing years, 1955-1990.

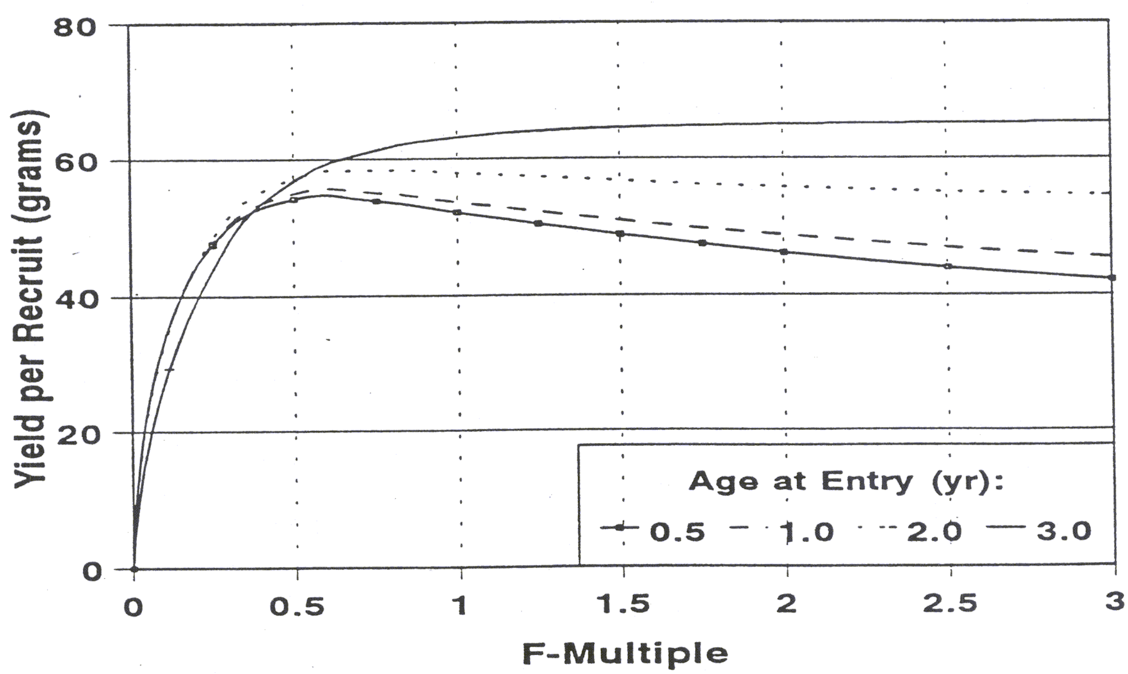

Figure 11.6 Yield-per-recruit analysis for Atlantic menhaden using average growth and fishing mortality values for the 1980-1990 fishing years.

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 11.4). 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 menhaden in certain fishing years (e.g., 1979, 1981, 1983, 1984, and 1985, as noted in Vaughan and Smith 1991). 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 11.4). 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.

In general, increasing the age at entry causes an increase in YPR, except for small F-multiples; e.g., F-multiple = 0.2 (Figure 11.6). 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 and fishing regulations greatly restrict the ability to obtain optimal yield per recruit.

11.3.3.3 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 depends heavily on recruitment success, which has been favorable since 1975. The level of uncertainty precludes the direct use of MSY for determining quotas for 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, suggests 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). Generally high recruitment during 1975-1986 indicates 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 ranged from 524.7 million lb (238,000 mt) to 922.9 million lb (418,600 mt) since 1980, with 1991 fishing year landings of about 840.9 million lb (381,400 mt).

Table 11.4 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

11.4 Exploitation

11.4.1 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 species in terms of quantity. Total menhaden landings (Gulf of Mexico and Atlantic) in calendar year 1991 were 2,091 million lb (948,255 mt) valued at $79.7 million (NMFS 1992). Atlantic menhaden landings in 1991 (calendar year) totaled 876 million lb (397,533 mt) with an estimated ex-vessel value of $ 38.3 million (NMFS 1992). 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 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 1978). 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.

Menhaden's primary use 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 (Tables 11.5 and 11.6). 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 has operated in Maine state waters since 1988. Menhaden are also 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 11.10.1).

11.4.1.1 Fishing Vessels and Gear

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 introduction of refrigerated fish holds in the 1960s enabled the fleet to range over a larger area and stay out longer, greatly improving the ability to catch fish when and where they were available.

Currently, commercial menhaden 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 (still called "steamer" by some) 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.

Table 11.5. Atlantic menhaden reduction plants active during the 1980s.

Company	Location	Year*
Inactive		
Seacoast Products Co.	Port Monmouth, N.J.	1981
Pt. Judith By Products	Pt. Judith, R.I.	1982
Pine State Products	South Portland, Me.	1983
Standard Products	Southport, N.C.	1983
Standard Products	Beaufort, N.C.	1984
Lipman Marine Products Co.	Gloucester, Ma.	1984
Sea and Sound Processing Co.	Beaufort, N.C.	1986
Nassau Oil and Fertilizer	Fernandina Beach, Fla.	1987
Sea Pro Inc.	Rockland, Me.	1988
Currently Active (1990):		
Beaufort Fisheries	Beaufort, N.C.	1980
AMPRO Fisheries Inc.**	Reedville, Va.	1980
Zapata Haynie Corp.	Reedville, Va.	1980
Connors Brothers Inc.	Blacks Harbour, N.B.	1987
Resource Trading Co. (IWP)	Maine	1988

* For inactive plants, the year listed is the last fishing year the plant was in operation. For currently active plants, the year given is the first year the plant was in operation

** AMPRO Fisheries Inc., formerly Standard Products, did not operate during the 1986 fishing season.

Table 11.6. Distribution of menhaden reduction plants along the Atlantic Coast in selected years, 1875-1991.

	YEAR																
State	1875	1912	1929	1955	1967	1970	1971	1972	1973	1974	1979-81	1982-83	1984	1985	1986	1987[2]	1988	1989-1991
ME[1]	22	1	-	2	-	-	-	-	-	-	2	2	1	1	1	2	3	2
MA[1]	4	-	-	2	-	1	1	1	1	1	1	1	1	-	-	-	-	-
RI[1]	13	-	-	1	-	1	1	1	1	-	-	-	-	-	-	-	-	-
CT	5	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NY	26	5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NJ	5	5	3	3	2	1	1	1	1	1	1	-	-	-	-	-	-	-
DE	-	2	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
VA	4	19	12	6	7	4	3	3	2	2	2	2	2	2	1	2	2	2
NC	2	12	12	6	7	7	7	4	4	4	4	4	3	3	2	1	1	1
SC	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GA	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FL	-	1	2	3	2	1	1	1	1	1	1	1	1	1	1	1	-	-
TOTAL	81	45	36	28	18	15	14	11	10	9	11	10	8	7	5	6	6	5

1 Reduction plants located in Maine, Massachusetts, and Rhode Island during 1970-1988 were not solely dependent on menhaden for raw materials.

2 Data for Maine since 1987 include a plant in Blacks Harbour, New Brunswick, Canada, and the Internal Waters Processing vessel located in Maine waters since 1988.

The small vessels used in the Gulf of Maine are not refrigerated and utilize only one purse boat.

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, menhaden vessels range from about 50 ft (15 m) to 220 ft (67 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 very small fraction of the total) are often sold for bait (sport fishery, crab pots, etc.) as well as being processed into meal, oil, and solubles.

The typical purse seine net has a stretched mesh of 1½ in (3.8 cm) to 2⅜ in (6.3 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).

The commercial menhaden fleet operating in the North Atlantic region has undergone considerable changes in recent years, including the introduction of two conventional menhaden steamers, 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 a Russian processing ship. In 1987, two New England-based menhaden steamers began to fish the Gulf of Maine area, landing the catch at a Canadian processing plant.

An IWP venture has been operating within Maine's coastal waters since 1988. Under state jurisdiction, a foreign vessel was permitted to process menhaden caught by United States vessels into fish meal and oil during the 1988-92 fishing seasons. Throughout this period, approximately eight catcher boats and four carrier boats were active in the IWP. Several of the catchers boats can hold their catch for direct transfer to the foreign processing vessel. Smaller catcher boats normally pump the fish from the seine onto a carrier vessel for later transfer to the processing vessel.

Presently (1990), the Gulf of Maine Atlantic menhaden fleet includes about 20 purse seine vessels and carriers serving the reduction and lobster bait markets. These vessels include some that are 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 are based in Maine, but some operate out of the Boston area.

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.

The total number of vessels fishing for menhaden is 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 11.7).

Changes in fleet size over the years are attributable to a number of factors. Reductions in effort during the early-to-mid-1980s were related largely to world commodity markets and economic considerations. Addition of vessels participating in the Gulf of Maine IWP venture reflected resource and vessel 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.

All of the large vessels in the menhaden fleet currently utilize refrigerated fish holds, compared to only 60% of the fleet in 1980 (Table 11.7). 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 went 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 11.7). Although the total hold capacity of the menhaden fleet is well below that in the late 1950s, it is still adequate to handle production at current, and even, expanded levels.

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 current (1990) fleet of 33 vessels, which operates within a more restrictive and regulated environment, lands their catch at five plants, including the foreign processing vessel.

11.4.1.2 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 11.8. and Figure 11.7.). Plants in the north and south Atlantic areas, including one plant active during the fall fishery, generally handled about 27% of the annual landings. Three processing plants located in Virginia and North Carolina normally process about 90% of the harvest (Figure 11.7). The data in Table 11.8 illustrate the recent year-to-year variations in regional landings.

11.4.1.3 Fishing Seasons

The menhaden purse seine fishery is seasonal. The presence of menhaden schools is dependent on the temperature of coastal waters. Two fairly distinct fishing seasons

Table 11.7. 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

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.

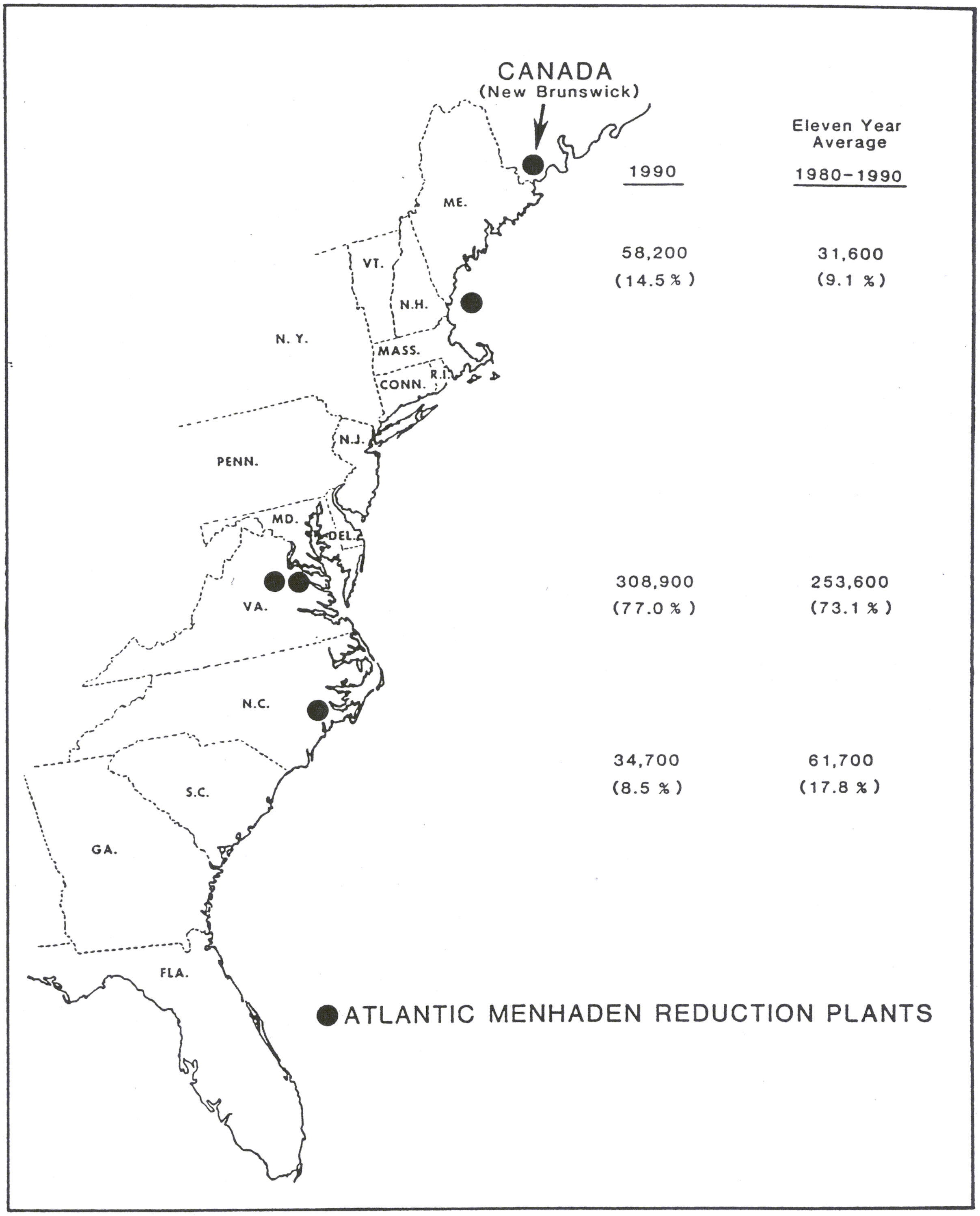

Figure 11.7. Locations of Atlantic menhaden processing plants and purse seine landings (mt) for reduction, 1990.

Table 11.8. Atlantic menhaden catch (1,000 metric tons) and percent contribution of total landings by region for 1980-1990.

Year	North Atlantic	%	Chesapeake Bay	%	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
Mean	31.6		253.6		61.7		346.8

occur, the "summer fishery" and the "fall fishery". The summer fishery begins in April with the appearance of schools of menhaden off North Carolina. The fish migrate northward, appearing off New England in May-June. The fishery in the Gulf of Maine may extend into early October. 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 11.9).

In early fall, a 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 often continues into January (and sometimes February), but is highly weather-dependent. Menhaden leave the coastal fishing grounds, probably dispersing in ocean waters off the south Atlantic states by late February.

11.4.1.4 Incidental Catches

Incidental bycatch of other finfish species in menhaden purse seines has been a topic of interest for many years to the commercial and recreational fishing industry, as well as the scientific community (Smith 1896; Christmas et al. 1960; Oviatt 1977). The fishery has a history of low levels of bycatch. Some states restrict bycatch to 1% or less of the total catch on a vessel by regulation (See Section 11.10.1).

A study of bycatch of other species in the menhaden fishery is currently (1992) underway through funding provided by the Federal Saltonstall-Kennedy grant program. The Virginia Institute of Marine Science and Louisiana State University have received funding to complete concurrent studies on bycatch levels of finfish, turtles, and marine mammals in the Atlantic and Gulf of Mexico menhaden fisheries. The research is funded for one year starting in March 1992.

The most recent data available are from the Gulf of Maine IWP fishery. Every catch unloaded onto the processing vessel is inspected by a state observer. In 1991, a total of 93 fish was taken as bycatch along with about 60,000,000 menhaden (David Stevenson, Maine Department of Marine Resources, pers. comm.).

11.4.2 Bait Fishery

Annual landings of Atlantic menhaden for bait along the Atlantic coast average about 65.5 million lb (about 29,700 mt). Bait landings in 1991 (30,400 mt) accounted for 7.4% of the total Atlantic menhaden landings.

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. The appearance of growth in the Atlantic coast bait fishery (Table 11.10) 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

Table 11.9. Atlantic menhaden landings by month (metric tons) for fishing seasons 1980-1990.

	Year										
Month	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Mar	0	0	0	0	0	0	713	0	0	0	0
Apr	173	2,223	795	554	7	0	1,060	751	0	0	0
May	37,220	19,681	34,151	23,487	12,436	24,608	17,616	12,822	13,318	24,779	34,848
Jun	59,785	61,551	76,315	62,627	38,590	60,690	35,384	46,139	32,507	48,372	51,345
Jul	77,666	90,029	76,220	74,646	56,487	58,213	48,306	68,636	43,381	54,182	64,612
Aug	82,954	61,299	69,010	82,705	65,820	57,377	42,229	53,336	63,711	71,862	72,314
Sep	66,588	45,601	59,164	62,212	45,254	41,907	46,235	61,532	69,471	49,544	65,574
Oct	34,213	28,151	34,072	20,979	30,079	35,319	34,052	35,248	23,215	29,728	47,749
Nov	15,630	41,679	4,953	26,288	14,623	6,363	5,404	34,506	23,588	14,274	29,108
Dec	30,092	31,097	27,755	49,405	34,031	20,345	6,538	12,588	37,045	27,336	30,206
Jan	3,287	0	25	15,732	26,397	1,017	465	1,317	3,057	1,938	5,402
Feb	0	0	0	0	2,571	824	0	21	0	0	0
Total*	409,588	383,291	382,460	418,634	326,296	306,662	239,633	326,894	309,293	322,014	401,159

* Total may not agree with data in other tables due to rounding.

Table 11.10. Atlantic coast menhaden bait landings (pounds) by region*, 1985-91.

	Region				
Year	New England	Mid-Atlantic	Chesapeake Bay	South Atlantic	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	225,418,928	17,519,449	18,399,037	5,465,646	66,803,060

* Regions are defined as follows:

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

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 (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. Average bait landings by region for the principal gears are shown in Table 11.11. This plan represents the first coast-wide presentation of menhaden bait data.

11.4.2.1 New England

In the New England region, Maine and Rhode Island purse seine vessels account for the majority of the recorded landings. Ocean trap nets are also used in Rhode Island and Maine, while stop seines are used only in Maine. 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 coastal lobster fishery.

11.4.2.2 Mid-Atlantic

New Jersey dominates current mid-Atlantic landings. Reports of catch by fishing area are required by New Jersey under its recently implemented licensing of bait purse seine vessels. Pound 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.

11.4.2.3 Chesapeake Bay

In the Chesapeake Bay region, pound nets account for the majority of menhaden landings in Maryland and the Potomac River. Virginia snapper rigs (small purse seiners) provide landings records, but menhaden taken in other fisheries are combined with other finfish bait species in landings reports. Therefore, only total landings data are available. Most of the catch is used in the blue crab pot fishery.

11.4.2.4 South Atlantic

Part of North Carolina's landings are reported directly, while the rest are estimated from fishery-dependent sampling. The principal use 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 has substantial menhaden landings for bait from gill nets and purse seines.

Table 11.11. Average annual Atlantic menhaden bait landings (pounds), by gear, 1985-1991.

	Gear					Total landings	
Region[a]	Purse seine	Haul seine	Pound net	Gill net	Other[b]	lb	mt
New England	13,458,565	-	-	139,432	873,253	14,471,250	6,564
Mid-Atlantic	3,891,899	143,906	1,343,839	544,046	145,849	6,069,539	2,753
Chesapeake Bay area	[c]	27	12,729,062	84,454	13,463,474	26,277,017	11,919
South Atlantic	3,431,623	723,261	730,482	1,048,777	391,176	6,325,319	2,869

[a] Regions are defined in Table 11.10.

[b] The "other" category may include gears specifically listed to maintain confidentiality of landings. Also, state landings not separated by gear are collectively reported in this category.

[c] Purse seine (snapper rig) landings in Virginia have not been recorded separately, but compose the vast majority of the "other" category.

Appendix 3 contains each state's menhaden bait landings by gear for each year recorded since 1985. Also included is an overview of each state's bait fisheries.

11.5 Domestic Processing Sector

11.5.1 General

From a few cast iron pots on the Rhode Island shore (Frye 1978), the processing of menhaden has become a highly mechanized operation. As companies have consolidated operations, the remaining plants have been upgraded so that each can handle peak catches that formerly might have been distributed among several plants. As is the case with the vessels, plants must have the capacity to process peak catches when they occur to compensate for the general trend in reduced volume of day-to-day landings. Consequently, modern plants have the capability to process far more menhaden than the fleet can supply in a fishing year (Table 11.12).

All of the plants currently processing menhaden have made significant investments in recent years to meet federal, state, and local pollution control requirements.

The distribution of processing plants at various times during the last 115^+ years is shown in Table 11.6. In 1990, five reduction plants processed Atlantic menhaden for fish meal and oil (Figure 11.7). These sites included land-based plants in Beaufort, North Carolina, and Reedville, Virginia, an IWP venture in Maine state waters using a Russian processing ship, and a land-based plant in Blacks Harbour, New Brunswick, Canada that processed menhaden caught off the coast of Maine.

11.5.2 Processing of Atlantic Menhaden

The menhaden reduction industry produces three major products: fish meal, fish oil, and condensed fish solubles. In addition, a few specialized products are produced by some processors. The process used to produce fish meal and oil is the wet reduction process (Figure 11.8). As the name implies, the procedure separates liquid from solid by use of water or steam. The major steps in the process are cooking, pressing, drying, separating, and evaporating, and purifying or polishing of the oil. The wet reduction process is universal in meal and oil fisheries and is employed in Scandinavia, Africa, the Far East, Australia, and North and South America.

After the refrigerated fish are unloaded at the plant, they are cooked in a continuous steam-heated cooker. The cooker is cylindrical, with a steam-heated jacket and hollow steam-heated auger in the center. Cooking denatures the protein and promotes a mechanical separation of liquids and solids. The mixture is then transferred to a press which separates the water and oil from the solids, resulting in two intermediate products, press liquor and press cake.

Press cake is dried to produce fish meal. Drying reduces moisture content and inhibits microbial decomposition. There are two types of dryers in commercial use, direct and indirect. The direct or flame dryer utilizes heat from a furnace (or other direct heating source) to evaporate water from the press cake. Indirect dryers rely on an intermediate material to convey the heat from the furnace to the dryer (Sand and Burt 1987). Initially, this method used steam, but major advancements in drying technology have taken

Table 11.12. Maximum processing capacity (in metric tons) of four Atlantic menhaden reduction plants during the 1990 menhaden fishery.

Hourly rate*	Weekly rate**	Season***
363	42,270	1,724,580

* Includes foreign processing vessel operating under an IWP agreement. Data do not include Blacks Harbour, Canada processing plant.

** Weekly rate = 24 hours per day x 6 days.

*** Season = 33 weeks.

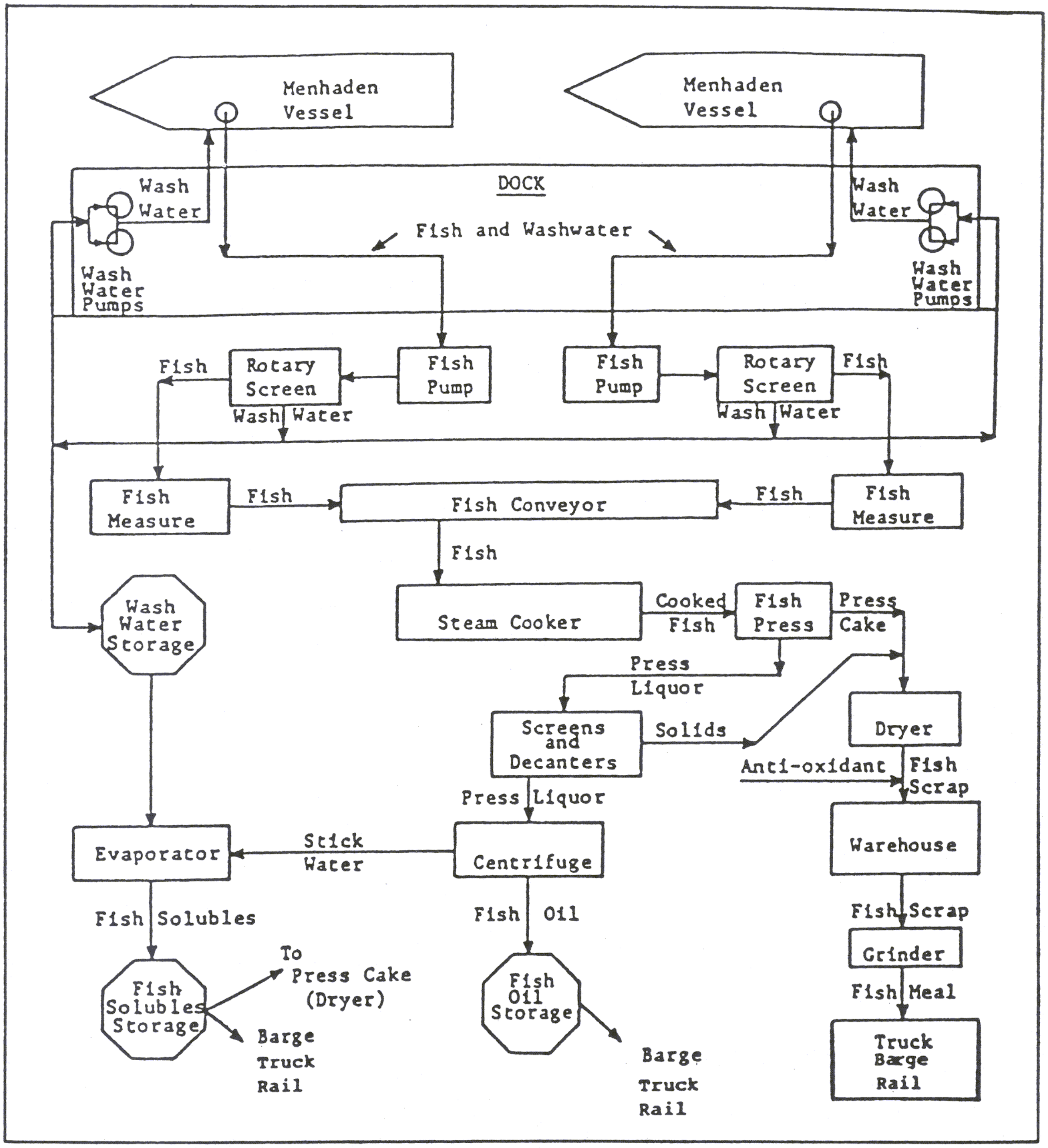

Figure 11.8. Schematic diagram illustrating the wet reduction process utilized in menhaden processing.

place during the last five years. Low temperature and minimal mechanical agitation drying is now replacing previous methods (Bimbo 1989). These improvements have led to increased utilization of indirect hot air, steam, vacuum, and fluid bed dryers, although direct hot air drying is predominant.

Upon leaving the dryer, fish meal is stabilized by means of an antioxidant to retard oxidation of residual fat. The amount of antioxidant required to avoid undue heating depends upon the degree of unsaturation of the residual fat in the meal and is determined through laboratory analyses. The fish meal is then bulk-stored in weatherproof, well ventilated buildings and may be shipped as soon as the meal is properly cooled.

Press liquor contains large particles of fish and bone which must be removed before the liquid can be separated. In most processing plants, the press liquor is passed through decanters (centrifugal separators) to remove suspended solids. In modern fish reduction plants, treatment of the press liquor is carried out in three steps:

1) Decanters - remove suspended solids from the press liquor to obtain a liquor suitable for the separation step;

2) Separators - remove as much oil as possible from the press liquor. The result is a stickwater with the least amount of fat; and

3) Polishers or purifiers - remove the final traces of moisture and impurities from the oil prior to storage.

Decanters are cylindrical bowls housing a cylindrical conveyor. The press liquor is pumped into the bowl where the solids are forced to the outer periphery and removed by the conveyor. Through a combination of variable conveyor speed and controlling liquid depth, the desired clarification can be achieved. Solids removed from the decanters are mixed with the press cake and dried.

Press liquor discharged from the decanters is pumped into a holding tank and then to the separators. The separators make a three phase separation (oil, water, sludge) of the press liquor. The sludge phase is pumped away either to the cookers or to the press cake where it is added to the fish meal. The water phase, which is rich in water soluble proteins and vitamins is vacuum-pumped to large holding tanks and continuously fed to evaporators. This process concentrates the solid content from 6% to 35%. The solid concentrate is termed "fish solubles" or "stickwater concentrate." The liquid component is called "stickwater."

Stickwater contains about 92% water and 8% solids composed of residual fat, hydrolyzed protein, and minerals leached from the bones of the fish during processing. The fish solubles have a viscous consistency and contain 50% water, approximately 30% protein, 10% fat and 10% minerals. The solubles can be sold separately as a liquid feed ingredient, although almost all is presently added to the press cake and dried to produce "full meal."

The fish oil recovered from the separators is pumped into storage tanks where it is tested and either sold as crude oil or further refined. The process of refining fish oil is quite costly. There are very few industrial products that can be produced from the oil in the crude stage because of the presence of color bodies, free fatty acids, and the solid stearin fraction. In the early stages of preparation for food use, oils and fats generally contain minor amounts of non-triglyceride substances. These compounds may detract from acceptability because of the flavors and odors they impart or to reduced stability and shortened shelf life. Fats and oils intended for edible purposes are therefore refined to remove these substances while retaining their desirable omega-3 and low cholesterol properties.

A number of processing steps are necessary to refine crude fish oil. These steps include (1) winterization to remove low melting point triglycerides for clarity at refrigerator temperature; (2) degumming to remove phosphates and proteinaceous materials; (3) neutralization to remove free fatty acids; (4) bleaching to remove pigmentation, oxidation products, trace metals and soaps; and (5) deodorization or steam stripping to remove volatile components and environmental organics. In cases where the final product is margarine or shortening, a partial hydrogenation step is performed prior to deodorization (Bimbo 1987).

11.5.3 Description and Utilization of Products

11.5.3.1 Reduction Fishery

11.5.3.1.1 Menhaden Meal

Menhaden meal is a valuable ingredient in poultry and livestock feeds. It contains high levels of lysine and methionine, essential amino acids required for rapid growth and development of poultry and swine. Aquaculture has recently shown an increased demand for fish meal. The fat content contributes to the caloric content of the feed ration. The calcium, phosphorous, selenium, sulfur, and trace minerals contribute to the nutritional requirements of the designed feed formula.

Menhaden meal, according to the American Feed Industries Association, contains a minimum of 60% protein, approximately 10% fat, 20% minerals and 10% moisture. Besides being a rich source of protein, essential amino acids, minerals, and vitamins, fish meal is also a rich source of omega-3 fatty acids.

The National Fish Meal and Oil Association's publication "Fish Meal Notes" (NFMOA 1990) provides menhaden meal composition data over a ten year span (1980-1989) (See Table 11.13). The pamphlet summarizes data from annual studies conducted by the NFMOA and its member companies. During each fishing season, data from daily meal samples are compiled from each plant and combined to represent commercially available menhaden fish meal for that year.

Feed formulations are determined by computer programs designed to meet the specific nutritional requirements for the particular animal to be fed. For example, in the broiler industry, a "starter feed" is designed to meet the trophic requirements of a chick for the first three weeks of life. A "grower feed" is designed to supply the nutritional requirements for the bird from three to six weeks of age. Finally, a "finisher feed" is then utilized until the bird reaches market weight or age. Some formulators within the aquaculture industry design feed rations containing up to 40% fish meal.

Table 11.13. Menhaden meal composition, 1980-1989 [in percent or parts per million (ppm)].

Meal component	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Average
Crude protein	62.10	60.70	61.70	61.80	61.10	61.20	60.11	61.02	61.62	61.29	61.27
Fat	9.50	7.90	10.20	9.70	9.60	9.80	9.56	10.50	8.72	7.64	9.31
Moisture	7.20	8.50	7.70	7.90	7.60	6.50	8.16	7.93	6.98	9.19	7.87
Ash	19.10	19.50	19.20	18.00	18.60	19.20	18.54	18.87	19.05	18.51	18.86
Amino Acids											
Lysine	4.60	4.20	4.62	4.51	4.63	4.49	4.49	4.48	4.57	4.50	4.51
Histidine	1.38	1.27	1.62	1.38	1.43	1.41	1.45	1.51	1.41	1.37	1.42
Arginine	3.79	3.56	3.83	3.76	4.04	3.60	3.85	3.43	3.46	3.44	3.68
Threonine	2.59	2.25	2.51	2.47	2.42	2.37	2.60	2.41	2.43	2.52	2.46
Serine	2.50	2.09	2.30	2.46	2.40	2.35	2.46	2.39	2.35	2.43	2.37
Proline	2.97	2.88	2.91	2.89	3.10	2.77	3.18	2.87	2.38	2.95	2.89
Glycine	4.62	4.44	4.45	4.30	4.44	4.51	5.73	4.42	4.31	4.36	4.46
Valine	2.71	2.59	2.78	2.67	2.94	3.03	2.92	2.69	2.69	2.71	2.77
Methonine	1.78	1.48	1.69	1.58	1.72	1.67	1.31	1.82	1.64	1.56	1.63
Isoleucine	2.43	2.00	2.36	2.14	2.64	2.14	2.32	2.25	2.26	2.27	2.28
Leucine	4.31	3.63	4.21	4.09	4.41	4.18	4.20	4.16	4.17	4.22	4.16
Tyrosine	1.83	1.65	1.77	1.69	1.94	1.81	1.77	1.81	1.83	1.85	1.80
Phenylalanine	2.26	2.11	2.24	2.02	2.31	2.29	2.10	2.24	2.26	2.27	2.21
Tryptophan	0.65	0.47	0.55	0.49	0.51	0.39	0.28	0.49	0.55	0.49	0.49
Cystine	0.69	0.82	0.76	0.51	0.47	0.52	0.44	0.55	0.47	0.49	0.57
Taurine		0.37	0.41	0.41	0.33	0.40	0.45	0.46	0.49	0.40	0.42
Aspartic acid	5.68	5.13	5.60	5.35	5.46	5.40	5.75	5.33	5.27	5.32	5.43
Glutamic acid	8.28	7.45	8.59	7.85	8.00	8.26	8.39	7.95	7.93	0.02	7.27
Alanine	3.94	3.57	3.90	3.72	3.87	3.69	3.88	3.76	3.7	3.79	3.78

Table 11.13. (Continued).

Meal component	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	Average
Minerals											
Calcium	4.78	4.86	5.12	4.90	4.71	4.79	4.59	4.73	4.83	5.00	4.83
Phosphorus	2.85	2.89	3.03	2.99	2.82	3.06	2.80	2.74	2.89	2.98	2.91
Potassium	0.81	0.81	0.81	0.83	0.89	0.89	0.94	0.91	0.84	1.04	0.88
Magnesium	0.18	0.22	0.20	0.20	0.19	0.22	0.21	0.21	0.21	0.23	0.21
Sodium	0.55	0.62	0.54	0.54	0.60	0.66	0.71	0.71	0.7	0.70	0.63
Manganese (ppm)	37.60	50.11	43.33	42.10	39.60	44.41	43.65	50.12	21.45	48.00	42.04
Iron (ppm)	881.50	1135.50	1026.80	1069.00	906.00	1126.29	898.75	992.67	1175.00	946.00	1015.75
Boron (ppm)	2.82	3.71	3.58	2.80	3.00	2.00	4.60	4.60	-	-	3.39
Copper (ppm)	3.92	6.96	4.57	4.50	5.90	5.83	6.25	6.33	6.76	6.80	5.88
Zinc (ppm)	87.91	92.30	86.91	83.50	86.70	75.90	77.53	77.80	85.33	110.00	87.39
Chromium (ppm)	3.06	3.77	3.49	1.94	2.60	2.00	1.64	2.38	2.37	3.70	2.70
Selenium (ppm)	2.23	2.40	2.52	1.10	2.16	2.00	2.44	2.26	2.06	1.80	2.10
Strontium (ppm)	74.73	88.88	75.20	75.40	65.00	69.52	58.79	60.63	58.05	64.90	69.11
Barium (ppm)	16.99	18.63	20.30	21.20	18.70	20.00	14.20	15.03	16.47	15.00	17.65
Aluminum (ppm)	730.60	937.00	907.20	767.20	774.60	939.00	837.13	929.50	857.67	730.00	840.99

Animal nutritionists do not uniformly agree on the preferred feed matrix for a specific ration or on the nutritional qualities of the various ingredients. Additionally, some feed ingredients are more available or less expensive in certain areas of the country. Hence, ingredient composition of a specific feed may vary from company to company as well as regionally.

Ingredients commonly used in feeds for poultry and swine include corn, soybean meal, fish meal, meat and bone meal, poultry by-product meal, bakery by-product meal, corn gluten meal, fat, phosphate, lime, and synthetic amino acids. Only two of these ingredients, corn and soybean meal, are traded as "futures options" on the Chicago Board of Trade. The market value of the remaining items is determined daily, depending on the level of supply and demand.

In 1992, *Feedstuffs* magazine estimated that United States feed manufacturers distributed primary formulated feeds during 1990-1991 in the following categories (in millions of short tons):

Type of feed	1990	1991
Starter, grower, layer, breeder	13.7	13.8
Broiler	27.7	28.9
Turkey	8.5	8.7
Dairy	17.4	17.2
Beef and Sheep	18.5	18.7
Hog	14.5	15.1
All other	7.3	7.4

(Data from *Feedstuffs*, July 16, 1992 (64)29:5-23).

Since fish meal is used in a majority of these feeds, it is possible to conservatively estimate that at least 1.04 million short tons (about 1% of the total annually) of fish meal was required to produce the tonnages listed above. The United States' production of menhaden fish meal in the Gulf and Atlantic areas in 1990 was 929,000 mt (1,024,037 short tons). Hence, the potential demand for fish meal in the United States exceeds the domestic supply. Menhaden fish meal accounted for about 77-80% of the total domestic fish meal production in 1990 and 1991 (NMFS 1992).

11.5.3.1.2 Menhaden Oil

The production of menhaden oil in the United States during 1990 was about 35.4 million gallons and about 33.9 million gallons in 1991 (NMFS 1992), representing about 98% of the entire marine oil production in the United States.

Menhaden fish oil has, for many years, been used as an edible oil in Europe. The oil is refined, deodorized, and hydrogenated to blend with other fats for cooking oils and margarine. Menhaden oil competes on the European market with palm oil, soybean oil, and other vegetable and marine oils.

On September 15, 1989 the United States Food and Drug Administration (FDA) approved both partially hydrogenated and fully hydrogenated menhaden oils as being "Generally Recognized as Safe" (GRAS) for human consumption. The GRAS affirmation allows processed menhaden oils to be utilized domestically in such foods as margarine, butter, salad dressings, salad oils, shortenings, and cooking oils. In 1990, the FDA issued a proposed rule amending the standard of identity for margarine to permit the use of marine oils. If accepted, the proposed rule would provide a significant new market for omega-3 rich menhaden oils.

The oil from Atlantic menhaden contains greater proportions of highly unsaturated fatty acids than does the oil from the gulf menhaden from the Gulf of Mexico. ("Saturation" is a measurement of the number of double bonds contained within the fatty acid chain molecule.) The position of these bonds on the chain are indicated by nomenclature (eg. omega-3 and omega-6). Omega-3 fatty acids have recently been identified as having possible human health benefits. Research has linked omega-3 fatty acids to reduced risk of heart disease and reduced blood serum cholesterol levels (Conner 1991).

Other domestic uses of menhaden oil include the production of paints, varnishes, and marine lubricants. In addition, some companies produce fractionated fatty acids for use as plasticizers in the plastic and rubber industries. These ancillary applications do not utilize a significant quantity of oil. In fact, over 90% of the fish oil produced in the United States is exported to western Europe for use in food preparations (Bimbo 1989).

11.5.3.1.3 Menhaden Solubles

In general, producers of menhaden meal utilize most of their solubles by adding it back to their fish meal in the drying process to produce a product termed "full meal." Fish solubles have also been exported to Europe where they were used as a liquid ingredient for poultry and swine feeds. However, the ingredients in domestic feed industry rations are generally dry materials like corn, soybean, and fish meal which can easily be handled by conveyors and bin storage. The majority of feed facilities do not have storage tanks, pumps, and meters to handle liquid products, such as solubles. Hence, the use of solubles as a product for market is restricted. Additionally, the high moisture content reduces the nutritional concentration and further reduces the desirability of solubles as a separate product.

11.5.3.1.4 Recovery of Products

The yields of fish meal, oil, and solubles vary by company, region, season, age, and size of fish. Fish of varying length and weight have been analyzed for moisture, lipid, protein, and ash content (Dubrow et al. 1976). The data indicate that regardless of size or season, the fish were composed of 80% moisture and lipid and 20% protein and ash. Hence, the yield of a full fish meal containing 10% moisture and 10% fat should be 25% of the weight of the raw fish. The yield of fish oil, according to the data, could range from 0 to 15% of the raw fish weight.

The design of menhaden processing plants and levels of process control are not identical for all companies. Therefore, some companies can produce more tons of product from the same quantity and "class" of fish than other companies because of differences in plant efficiency.

11.5.3.2 Bait Fishery

Landings of menhaden for bait are utilized in a variety of forms. Commercial fishermen in the lobster pot fishery in New England and the Chesapeake Bay and North Carolina blue crab pot fishery buy considerable, but unknown, quantities of fresh dead bait directly from small purse seiners, pound netters, and long haul seiners on the fishing grounds ("over the side sales").

Most of the bait catch is frozen in bulk and sold for lobster pot and blue crab pot bait, often through the lobster and crab dealers rather than through a bait dealer. Considerable quantities are sold in interstate commerce throughout New England and the Southeast.

Sport fishermen utilize whole or cut fresh or frozen menhaden for bait. Some bait and tackle stores grind menhaden and freeze it for anglers who use it as chum to attract game fish. A specialized use for menhaden as live bait has developed in the south Atlantic area in recent years. A number of entrepreneurs spend much of the summer and early fall harvesting menhaden with cast nets in estuarine nurseries. The fish are kept alive and sold by the dozen from "bait barges" operating in inlet areas near oceanic fishing grounds for king mackerel and other coastal pelagic fishes.

11.6 Economic Characteristics of the Fishery

The NMFS publishes annual summaries of the quantities and wholesale value of menhaden products, but data are not published separately for the Atlantic and Gulf of Mexico fisheries (Table 11.14). The proportion of menhaden landed along the United States Atlantic coast is an inexact indicator of the contribution of the Atlantic fishery to total production and value of the menhaden products. Production rates per ton of raw fish vary geographically due to biologically related differences in product content of the Atlantic and gulf menhaden, as well as to differences among reduction plants in processing efficiency.

Until the early 1960s, the Atlantic fishery was the dominant fishery. Growth in total production during the mid 1970s-early 1980s is attributed to a general recovery of the Atlantic fishery and to rapid growth in the dominant Gulf fishery. The relative importance of the Atlantic fishery has increased since the mid-1980s due to continued improvement in the Atlantic population, and a decline in landings in the Gulf of Mexico. In 1991, vessels fishing in the Atlantic fishery accounted for approximately 39% of the total catch and about 47% of the value (Table 11.15).

Soybean meal is the principal substitute for fish meal in mixed livestock feeds. As a consequence, fish meal prices are determined largely by prices in the market for soybean meal. Prices for both commodities fell dramatically during the mid-1980s. In real terms, after adjusting for inflation, fish meal and soybean meal prices fell in 1985 to their lowest levels in the last 35 years. Prices recovered somewhat in 1990, but in

Table 11.14. Production and value of menhaden products in the United States, (except bait), 1980-1990.

Year	Meal (100 short tons)	Meal Value (millions)	Oil (1000 short tons)	Oil Value (millions)	Solubles (1000 short tons)	Solubles Value (millions)	Total value
1980	271.2	$102.1	145.7	$54.2	99.4	$10.2	$166.5
1981	230.8	89.4	85.0	30.89	99.7	11.4	131.6
1982	301.9	100.0	169.0	52.2	129.3	13.0	165.2
1983	315.9	111.6	192.9	64.3	127.0	12.4	188.3
1984	314.9	97.9	182.9	60.0	14.7	13.8	171.7
1985	307.5	73.4	139.2	41.2	161.5	19.0	133.5
1986	296.3	73.1	166.0	43.3	97.6	11.6	128.0
1987	334.4	105.3	147.5	35.1	124.6	17.1	157.5
1988	252.3	114.0	108.7	42.8	111.7	14.6	171.4
1989	232.0	89.1	109.3	23.2	116.4	17.7	130.0
1990	224.0	77.5	137.0	28.2	92.8	14.1	119.8

Source: U.S. Department of Commerce, 1981-1991. Fisheries of the United States. National Marine Fisheries Service, Current Fishery Statistics 8200, 8300, 8320, 8360, 8380, 8385, 8700, 8800, 8900, 9000.

Table 11.15. Reported landings (metric tons) and value (thousands) of menhaden for reduction in the Atlantic coast and Gulf of Mexico purse seine fisheries, 1970-1991. (Data are for calendar years, not fishing seasons.)

	Atlantic		Gulf		Total	
Year	Landings	Value	Landings	Value	Landings	Value
1970	263,228	$ 9,315	548,331	$23,722	811,559	$33,037
1971	252,721	8,880	729,556	25,888	982,277	34,768
1972	367,691	12,811	501,956	18,197	869,647	31,008
1973	346,409	27,676	486,739	46,019	833,148	73,695
1974	309,888	18,045	587,806	48,327	897,694	66,372
1975	274,775	13,801	542,945	35,521	817,721	49,322
1976	363,648	23,212	561,453	43,967	925,101	67,179
1977	367,251	28,974	447,462	39,155	814,712	68,129
1978	356,739	20,233	820,352	78,039	1,177,090	98,272
1979	401,995	36,004	779,390	73,426	1,181,385	109,430
1980	430,400	42,883	702,073	69,129	1,132,473	112,012
1981	402,440	33,576	552,567	47,734	954,907	81,310
1982	400,342	35,013	854,335	72,728	1,254,677	107,741
1983	420,343	36,889	923,579	82,445	1,393,922	119,334
1984	328,501	32,054	982,883	85,243	1,311,383	117,297
1985	359,057	33,227	883,528	67,453	1,242,584	100,680
1986	256,199	26,260	828,516	67,502	1,084,715	93,762
1987	323,167	33,901	907,117	70,524	1,230,284	104,425
1988	307,506	32,445	638,728	73,259	946,234	105,708
1989	318,737	32,129	583,343	52,333	902,080	84,462
1990	370,439	39,534	519,591	54,362	890,030	93,896
1991	346,065	36,386	550,723	41,308	896,788	77,694

real terms, were still lower than prices in the early 1980s [(Inflation was measured by the producer price index for finished goods, which is an index of prices received by producers of commodities that are sold to their final users. Menhaden companies are the final users of the input (such as energy and materials) which they purchase. The producer price index is expressed with 1982 as the base period (=100)]. The value of the index was 69.8 in 1978 and 119.2 in 1990. These values imply that producer prices were approximately 71% higher in 1990 than in 1978 (Table 11.16).

Some menhaden oil is used domestically for industrial purposes, but the bulk of the United States' production is exported to European markets for use in margarine and cooking oil. Increased world-wide production and use of vegetable oils and tropical palm oils have driven the price of menhaden oil down since the early 1980s. By 1990, the average annual price of menhaden oil had fallen to levels found in the early 1970s. In real terms, menhaden oil prices have fallen to their lowest levels in the past 30 years. Prices have recovered some since 1990 (Table 11.16).

The average annual price of condensed menhaden solubles remained relatively stable through the mid-1980s and then rose at the end of the decade (Table 11.16).

11.6.1 Reduction Fishery Costs

A confidential questionnaire was completed by four firms which harvest and process Atlantic menhaden. AMPRO Fisheries, Inc. (Reedville, Va.), Beaufort Fisheries, Inc. (Beaufort, N.C.), Resource Trading Company (Portland, Me.), and Zapata Haynie Corp. (Reedville, Va.) harvest Atlantic menhaden for reduction into fish meal, oil, and solubles. One plant, located in New Brunswick, Canada, was not represented in the survey. The purpose of the questionnaire was to provide a better understanding of harvesting activities and the types and magnitudes of costs incurred by the menhaden purse-seine industry during the twelve month period ending 31 December 1990. Data are compared whenever possible with data from a similar questionnaire pertaining to the 1978 calendar year (AMMB 1981)[2]. The following discussion (Sections 11.6.1.1 and 11.6.1.2) of reduction fishery costs is based on a report prepared by Dr. James Waters, Fisheries Economist, National Marine Fisheries Service, Southeast Fisheries Science Center, Beaufort Laboratory (Waters 1992).

11.6.1.1 Fishing Effort and Employment

The four firms which participated in the 1990 survey deployed a total of 35 vessels accompanied by 20 spotter aircraft and fished a total of 798 vessel-weeks[3] in 1990 (Table 11.17). Their combined production represented over 90% of the total purse-seine catch of Atlantic menhaden in 1990. On average, there were fewer weeks

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[2] *The 1978 questionnaire was completed by three firms (Seacoast Products, Inc., Standard Products Company, Inc., and Zapata Haynie Corp.) which operated five processing plants and landed approximately 86% of the total purse-seine catch in 1978. Six other plants, not included in the 1978 survey, processed the remainder of the catch that year.*

[3] *A vessel-week is a nominal unit of effort in the Atlantic menhaden fishery. If a reduction fishery vessel lands menhaden one or more times in a week, it has fished one vessel-week.*

Table 11.16. Annual unit values and unit values adjusted for inflation for menhaden products in the United States, 1980-1990.

	Meal		Oil		Solubles	
Year	Mean price[1] per short ton	Adjusted price[2] per short ton	Mean price[1] per pound	Adjusted price[2] per pound	Mean price[1] per short ton	Adjusted price[2] per short ton
1980	$376	$428	$0.19	$0.21	$103	$117
1981	387	403	0.18	0.19	114	119
1982	331	331	0.15	0.15	10	100
1983	353	348	0.17	0.16	98	96
1984	311	300	0.16	0.16	120	116
1985	239	228	0.15	0.14	117	112
1986	247	239	0.13	0.13	118	115
1987	315	299	0.12	0.11	137	130
1988	452	418	0.20	0.18	130	121
1989	384	338	0.11	0.09	153	134
1990	346	290	0.10	0.09	152	127

Source: U.S. Department of Commerce. 1981-1991. Fisheries of the United States. National Marine Fisheries Service. Current Fishery Statistics 8200, 8300, 8320, 8360, 8380, 8385, 8700, 8800, 8900, 9000.

[1] Mean prices were calcualted as total value divided by total production. Prices are FOB processing plant.

[2] Prices were adjusted for inflation by dividing average prices by the Producer Price Index for finished goods (base year = 1982).

fished per vessel than in 1978 when 31 vessels were deployed for a total of 1,004 vessel-weeks.

Total employment in the Atlantic menhaden fishery declined between 1978 and 1990 (Table 11.18) due to reductions in the number of processing facilities (See Tables 11.5 and 11.6) that occurred during the mid-1980s when fish meal and oil prices declined to historically low levels. A total of 657 people was employed by the four plants that participated in the 1990 survey compared with 1,010 persons who were employed by five plants that participated in the 1978 survey. Employees earned nearly $12.9 million in gross wages during the 1990 fishing season and $1.4 million during the off-season. Most of those laid-off during the off-season were vessel and plant employees (Table 11.19). Some employees were hired for the off-season only; thus, the difference between season and off-season employment does not equal the number of employees laid-off at the end of the fishing season. One firm surveyed in 1990, Resource Trading Company, supplied Atlantic menhaden to the Soviet factory ship M/V RIGA; hence it did not hire employees to staff a processing facility.

11.6.1.2 Industry Costs

Harvesting, processing, and administrative costs were aggregated for two plants in Reedville, Virginia, and one plant in Beaufort, North Carolina (Table 11.20). Total costs for 1990 were $34.6 million compared with $32.6 million for three firms which operated five processing facilities in 1978. Although total costs appear to be marginally higher in 1990 than in 1978, the actual cost in real terms, after adjusting for inflation, was significantly lower than in 1978. (Total costs in 1978 would have been approximately $55.7 million in 1990 if they had kept pace with inflation, as measured by the producer price index for finished goods.) Costs were reduced, in real terms, through reductions in the number of processing facilities. The average cost per plant was approximately 77% higher in 1990 ($11.5 million) than in 1978 ($6.5 million). However, average total cost per plant in real terms was approximately the same in 1990 as in 1978. Average cost per plant would have been $11.2 million in 1990 if 1978 expenditures had kept pace with inflation.

Four general cost categories and their relative shares of total costs during the 1978 and 1990 calendar years are identified in Table 11.20. The relative shares of energy and repair and maintenance in 1990 changed significantly when compared with costs incurred in 1978 (Table 11.16). The cost of energy increased from 14.9% to 23.3% of total costs, which was offset by a decline in repair and maintenance costs from 18.6% to 11.3% of total costs. Labor and other costs (benefits, depreciation, and miscellaneous expenses) represented approximately the same fraction of total costs as in 1978.

The reductions in real costs that were achieved through reductions in the number of processing facilities is consistent with the general downsizing of the industry that occurred during the mid-1980s when fish meal and oil prices declined to historically low levels. The Atlantic menhaden industry has become economically more efficient over time as manifested by approximately the same or greater levels of production with lower total cost (in real terms) for all plants combined.

Table 11.17. General data for Atlantic menhaden companies surveyed, 1978 and 1990.

Data type	1978	1990
Number of landing sites in survey	5	4
Total number of fishing vessels	31	35
Total vessel-weeks fished	1,004	798
Total number of spotter aircraft	n.a.	20
Calendar weeks fished this season	n.a.	113
Calendar weeks off this season	n.a.	95
Combined catch (million standard fish)	960	1,235

Table 11.18. Atlantic menhaden processing employment and gross wages paid in 1978 and 1990.

	1978 (5 plants)		1990 (4 plants)	
Time period	Number of employees	Gross wages (millions)	Number of employees	Gross wages (millions)
Season	1,010	$11.004	657	$12.881
Off-season	461	2.185	201	1.415

Table 11.19. Numbers of Atlantic menhaden industry employees laid off at the end of the 1978 and 1990 fishing seasons.

Employment category	1978 (5 plants)	1990 (4 plants)
Vessel employees	453	359
Aircraft employees	20	19
Shore, marine maintenance	0	30
Plant employees	114	104
Administrative	4	23
Other	0	2
Total	591	537

Table 11.20. Total harvesting, processing, and administrative costs for Atlantic menhaden firms during 1978 and 1990.

	1978 (5 plants)		1990 (3 plants)	
Cost component	Millions	Percent	Millions	Percent
Labor (gross wages)	$13.352	40.9%	$13.202	38.1%
Energy	4.863	14.9%	8.065	23.3%
Repair and maintenance	6.602	18.6%	3.929	11.3%
Other	8.372	25.6%	9.466	27.3%
Total costs	$32.649	100.0%	$34.642	100.0%

11.6.1.3 Volume of Products

During the 5-year period ending in 1990, the three plants in Virginia and North Carolina produced an average of 79,711 short tons of fish meal and 1.98 million gallons of solubles, all of which was sold domestically (Table 11.21). Approximately 70% of the fish meal and 67% of the solubles were shipped to destinations in North Carolina, Virginia and Georgia. The remaining fish meal was shipped to destinations in the mid-Atlantic states (21% to Maryland, Delaware and Pennsylvania) or the Midwest (9% to Ohio, Iowa, Indiana, Wisconsin and Illinois). The remaining solubles were shipped to the mid-Atlantic area (11% to Maryland and Pennsylvania), Midwest (14% to Iowa and Indiana) and the Southwest (8% to Arkansas). An average of 3.15 million gallons of menhaden oil was also produced annually, of which 76% was exported. The remaining menhaden oil was delivered to Iowa (8.3%), Utah (5.0%), Pennsylvania (4.5%), North Carolina (4.0%), Delaware (0.9%) and Florida (0.9%).

Table 11.21 excludes production of meal, oil and solubles by the Maine-Soviet IWP venture and the processing plant in New Brunswick, Canada. The entire production of fish meal and oil from the IWP operation in Maine was shipped to the Soviet Union. Reported as sale of fresh menhaden, this production did not appear in United States export statistics as finished product. Some fish meal produced from Atlantic menhaden at the Canadian plant may have been exported to United States buyers. This fish meal would appear in United States import statistics, but cannot be identified from the summary data available.

11.6.2 Value of Menhaden Products

11.6.2.1 Domestic Value

The National Marine Fisheries Service publishes annual summaries of the quantities and wholesale value of menhaden products, but data are not published separately for the Atlantic and Gulf of Mexico fisheries. Tables 11.14 and 11.16 present production and value data for the Atlantic and gulf menhaden fisheries combined. The total value for all products in 1990 was $119.8 million (NMFS 1992).

Other fisheries (such as tunas and Alaska pollock) also provide fish meal, oil, and solubles for domestic and export markets. Tables 11.22-11.24 show the supply and utilization of these products in the United States during 1980-1990. It is apparent that menhaden products dominated the domestic fish meal, fish oil, and fish solubles markets, accounting for 82% of the average fish meal produced in the United States and 61% of the average fish meal used annually in this country. Similarly, the menhaden industry provided almost 97% of the fish oil produced in the United States during 1980-1990, and about 82% of the fish solubles produced during 1980-1984 (the last period for which data are available to separate menhaden from other solubles).

11.6.2.2 International Trade

Menhaden oil and fish meal contribute to the United States' export of fishery products. During 1989 and 1990, an average of $22 million worth of fish oil was exported from the United States, of which 97% was menhaden oil, with an average value of about $21.4 million (NMFS 1991a). An average of $31.2 million worth of fishmeal was

Table 11.21. Average production and distribution of Atlantic menhaden fish meal, oil, and condensed solubles by three firms during 1986-1990.

	Fish meal (short tons)	Fish oil (million gallons)	Solubles (million gallons)
Production	79,711	3.155	1.981
Distribution (%)[1]			
Export	0%	76.3%	0.0%
North Carolina	41	4.0	56.5
Georgia	18	*	0.4
Virginia	11	*	9.9
South Carolina	*	*	*
Florida	*	0.9	*
Maryland	11	*	6.7
Delaware	7	0.9	*
Pennsylvania	3	4.5	4.7
Ohio	4	*	*
Iowa	2	8.3	8.1
Indiana	1	*	5.6
Illinois	1	*	*
Wisconsin	1	*	*
Minnesota	*	*	*
Utah	*	5.0	*
Arkansas	*	*	8.1
Total	100.012	99.9	100.0

[1] Asterisks indicate minor shipments of less than 0.5% of total production.

Table 11.22. Supply and utilization of fishmeal in the United States, 1980-1990 (thousands of short tons)

Year	Menhaden fishmeal	Other fishmeal	Total domestic production	Imports	Total supply	Exports	Apparent[1] utilization
1980	271.2	84.1	355.3	49.5	404.9	85.3	319.6
1981	230.8	79.3	310.1	59.4	369.6	47.0	322.5
1982	301.9	62.3	364.2	84.3	448.5	17.9	430.6
1983	315.9	57.7	373.7	67.9	441.6	77.4	364.2
1984	314.9	54.0	368.9	83.4	452.3	20.2	432.1
1985	307.5	44.8	352.3	255.3	607.6	34.6	573.0
1986	296.3	43.3	339.6	185.3	524.8	38.5	486.3
1987	334.4	51.0	385.4	196.9	582.3	51.7	530.6
1988	252.3	60.2	312.5	132.7	445.1	75.1	370.0
1989	232.0	64.5	296.5	85.6	382.1	51.9	330.2
1990	224.0	53.6	277.6	119.7	397.3	64.3	333.0

Source: U.S. Department of Commerce. 1981-1991. Fisheries of the United States. National Marine Fisheries Service, Current Fishery Statistics 8200, 8300, 8320, 8360, 8380, 8385, 8700, 8800, 8900, 9000.

[1] Apparent utilization includes year-to-year changes in inventories and does not necessarily estimate actual domestic consumption.

Table 11.23. Supply and utilization of fish oil in the United States, 1980-1990 (Thousands of short tons).

Year	Menhaden oil	Other fish oil	Domestic production	Imports	Total supply	Exports	Apparent[1] utilization
1980	145.7	10.5	156.3	13.0	169.2	142.0	27.2
1981	85.0	7.1	92.2	11.0	103.1	119.2	-16.0
1982	169.0	4.7	173.8	8.1	181.9	101.2	80.7
1983	192.9	6.8	199.7	9.4	209.1	202.0	7.1
1984	182.9	3.5	186.4	8.3	194.7	199.7	-5.0
1985	139.2	3.4	142.5	10.3	152.8	139.5	13.3
1986	166.0	2.3	168.4	11.4	169.8	96.1	83.7
1987	147.5	1.8	149.2	15.3	164.5	124.6	39.9
1988	108.7	3.6	112.4	13.8	126.2	74.6	51.6
1989	109.3	3.5	112.7	12.7	125.5	97.4	28.1
1990	137.0	4.0	141.0	18.4	159.3	111.2	48.2

Source: U.S. Department of Commerce. 1981-1991. Fisheries of the United States. National Marine Fisheries Service, Current Fishery Statistics 8200, 8300, 8320, 8360, 8380, 8385, 8700, 8800, 8900, 9000.

[1] Apparent utilization includes year-to-year changes in inventories and does not necessarily estimate actual domestic consumption.

Table 11.24. Supply and utilization of condensed fish solubles in the United States, 1980-1990 (thousands of short tons).

Year	Menhaden solubles	Other[1] solubles	Domestic production	Imports	Total supply	Exports	Apparent[2] utilization
1980	99.4	34.3	133.7	0.0	133.7	0.0	133.7
1981	99.7	28.9	128.6	0.0	128.6	0.0	128.6
1982	129.3	23.2	152.5	0.0	152.5	0.0	152.5
1983	127.0	31.5	158.5	0.0	158.5	0.0	158.5
1984	114.7	11.3	126.0	0.0	126.0	0.0	126.0
1985	161.5	0.0	161.5	0.0	161.5	0.0	161.5
1986	97.6	0.0	97.6	0.0	97.6	0.0	97.6
1987	124.6	0.0	124.6	0.0	124.6	0.0	124.6
1988	111.7	0.0	111.7	0.0	111.7	0.0	111.7
1989	116.4	0.0	116.4	0.0	116.4	0.0	116.4
1990	92.8	0.0	92.8	0.0	92.8	0.0	92.8

Source: U.S. Department of Commerce. 1981-1991. Fisheries of the United States. National Marine Fisheries Service, Current Fishery Statistics 8200, 8300, 8320, 8360, 8380, 8385, 8700, 8800, 8900, 9000.

[1] Production of menhaden solubles after 1984 includes solubles from other sources.

[2] Apparent utilization includes year-to-year changes in inventories and does not necessarily estimate actual domestic consumption.

exported during 1989-90, of which about 76% was menhaden meal, valued at about $23.7 million (NMFS 1991a).

11.6.3 Value of Bait Landings

11.6.3.1 Reported Value of Bait Landings

Data on the value of bait are difficult to obtain. During 1987-91, the ex-vessel value of menhaden harvested specifically for bait in North Carolina ranged from $180,000 to $252,000 annually, with an average value of $211,318 for average landings of 4.5 million lb, or $0.0465 per pound. Menhaden bait landings in Maine in 1991 (13.9 million lb) had a total value of $1,166,000 for an average ex-vessel value of $0.084/lb. The NMFS has reported that menhaden landings in Massachusetts during 1986-91, which were sold entirely as bait, were valued at $0.0418 per pound. However, fresh bait sold "over the side" in Boston Harbor and not sampled by NMFS, has sold for as much as $0.20 per pound (Steven Cadrin, Massachusetts Division of Marine Fisheries, pers. comm.)

Twelve states and the Potomac River Fisheries Commission reported menhaden landed in other fisheries besides the purse seine reduction fishery during 1980-1991, presumably for use as bait in both commercial and recreational fisheries. Using 1990 data, the total ex-vessel value of bait menhaden reported landed along the Atlantic coast was $2,948,000.

11.6.3.2 Unreported Bait Landings

Historically, menhaden have been an important source of bait for recreational fishermen. Until recently, however, the resource had been used solely as cut bait (or whole, but dead) along the Atlantic coast for the capture of a variety of fish, such as bluefish and cobia. During the 1980s, live menhaden became a popular bait for king and Spanish mackerel, cobia, dolphin, bluefish, and others. Live menhaden is the principal bait used in the popular "slow-trolling" method of fishing in the south Atlantic area.

The bait are made available in two ways. First, recreational fishermen often catch the fish themselves, using cast nets. This method is limited to boats of about 24 feet or less with engines that can be raised in order to chase the menhaden in shallow water. In cases where the small vessel fishermen prefer not to catch their own bait, or for larger vessels with inboard engines, live menhaden are often available for purchase at marinas or from floating "bait barges." The latter approach is most typical along the central North Carolina coast. The fish are purchased normally for $8.00 or more per dozen. In addition, some recreational fishermen sell excess bait to other anglers. There are dozens of marinas in North Carolina alone which provide live bait to anglers, averaging 70 to 80 dozen fish sold on a typical weekend from May through November. During the popular king mackerel tournaments, which are increasing in number, participation, and size of purses, the marina operators sell all they can catch. In 1992, there were 21 king mackerel tournaments in North Carolina and 22 in South Carolina. On a normal recreational trip, a fisherman may carry four dozen or more menhaden in the live bait well. During a tournament, where up to $50,000 in prize money is at stake, that same fisherman may have as many as eight dozen live baits on board. For a king mackerel season of 24 weekends, a marina selling 70 dozen live menhaden per weekend at $8.00 per dozen may gross over $13,000, so the total value is probably quite significant.

As noted in the previous section (11.6.3.1), "over the side" sale of bait by purse seiners to commercial lobster and blue crab fishermen is very common. The value is unknown.

11.6.4 Employment and Pay in the Reduction Fishery

Prior to vertical integration of the industry in the mid-1950s, some individuals and companies owned and operated menhaden vessels independently of the processing plants. Independent vessel owners sold menhaden to processing companies, augmenting the catch of the processing companies' vessels. This practice has continued in New England. Independent operators there work in conjunction with the Russian factory ship and the Canadian company. In Virginia, the independent snapper rigs sometimes sell menhaden to one of the processing companies. All other vessels operating in the fishery (up to 24 in the mid-and south Atlantic) fish exclusively for the companies that own them.

All vessel workers earn money according to a share system. Each is paid a fee per a specified quantity of fish (thousands of standard fish). Captains are paid the most, followed by first mate and pilot, engineers, cook, and then the crew. Bonuses and incentives are added, and are grounded in the presence or absence of the pre-sale of fish (i.e., known price in advance), price swings in the marketplace, quotas, and the willingness to stay with the company for the season. Some captains may pay a particular crewman more than the established rate, but the additional monies may have to come out of the captains' own pockets.

Some of the companies have offered guaranteed minimum payments for certain quantities of fish every two weeks (1.4 million fish, for example) in order to keep crews together. Some companies also offer retirement plans (e.g., 401 k), and/or savings and profit sharing programs to the fishermen.

All vessel workers, including captains, are eligible for state unemployment benefits for the 4-6 month period of off-season inactivity. The majority of workers reportedly opt for unemployment pay.

The number of vessels operating in the Atlantic in 1990 totalled 35, along with 17 spotter aircraft (NMFS 1991b, Waters 1992). Vessel employees numbered 500 to 550 fishermen. In 1990, deckhand income ranged from $15,000 to $20,000 per year; mid-range officer incomes (engineer, mate, pilot, spotter pilot) ranged from $25,000 to $35,000 annually. The incomes of captains ranged from $60,000 to $100,000 or more in some cases.

11.7 Sociological Characteristics of the Fishery[4]

11.7.1 Reduction Fleet Characteristics

The fishing season for the Gulf of Maine runs from May through August or early September. For Virginia and North Carolina, the fishing season normally extends from late April or early May to late December. Virginia vessels harvest fish during the summer as far north as southern New England, as well as in Chesapeake Bay and off North Carolina. Fall fishing activities from Chesapeake Bay plants may range as far south as Cape Lookout, N.C. The North Carolina fall fishery usually lasts at least until late December, sometimes well into January, although state waters out to one mile offshore are closed to purse seine fishing from January 16 until May 15 [unless opened by "proclamation" (administrative order) during April 1 - May 14].

The Atlantic menhaden fleet can be divided into two components: the New England and mid-Atlantic/south Atlantic, with additions from the Gulf coast during the fall. All but two of the New England vessels were multiple species craft which also participated in other fisheries. These two large conventional menhaden vessels, based in Maine, harvested menhaden in U.S. waters for a Canadian processing plant, while about eight other vessels worked in the IWP venture.

Mid-and south Atlantic vessels were mobile within those regions, and some vessels have historically moved to the south Atlantic fall fishery after the end of the Gulf of Mexico season. Previous fleet movements to the Northeast ended when the number of processing plants was reduced from 3-4 plants to one plant and one factory ship in 1990.

11.7.2 Bait Fishery Characteristics

Bait fishermen in New England utilize small vessels (30-ft range, crew of up to five) and participate in a variety of other fisheries. When fishing for menhaden, they prefer to sell their catches as bait first, with the lobster fishery being the favored outlet. Excess menhaden taken in southern Maine may also be sold to the IWP venture, according to industry spokesmen. Twenty or more vessels (mostly 40-50 ft, but up to 121 ft) participate in the New England purse seine bait fishery from Rhode Island to Maine. In addition to purse seines, gears used by bait fishermen in New England include pound nets, gill nets, trawls, and common seines.

In the mid-Atlantic, several small purse seine vessels (up to about 60 ft long) fish for bait. At least two vessels work in New Jersey waters, along with pound netters, gill netters, and others. Three small purse seiners fish in Virginia waters of Chesapeake Bay. These Virginia boats, with crews of 4-6, are known locally as "snapper rigs." They fish for menhaden along with the large industry-owned vessels. The catch of the Chesapeake Bay vessels may be sold to one of the reduction plants or to a pet food

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[4]Section 11.7 is based principally on a report prepared under contract to the ASMFC by Dr. John R. Maiolo (Maiolo 1991), with the assistance of Dr. Barbara Garrity-Blake. Two reports prepared by Dr. Garrity-Blake for Dr. Maiolo, but not provided to the ASMFC, are cited as Garrity-Blake (1991a and 1991b).

facility, in addition to utilization as bait. Other gears taking menhaden include pound nets, gill nets, and seines. Menhaden harvested for bait in the Chesapeake area are a key ingredient in the Bay's very important blue crab fishery.

Purse seines, pound nets, and long haul seines are the primary gears in North Carolina's commercial bait fishery, while Florida's fishery is characterized by purse seines and gill nets, and common seines are used in South Carolina. Throughout the south Atlantic, cast nets are the popular choice of recreational fishermen and marina operators who capture live menhaden for recreational live bait fishing.

11.7.3 Vessel Crew Organization in the Reduction Fishery

The personnel hierarchy on menhaden purse seine vessels is very structured, based on authority, responsibility, and skill. Each conventional vessel is manned by 14-16 people in the mid-Atlantic and southern regions: five officers (captain, first mate, vessel pilot, chief engineer, and second engineer) and 8-10 regular crewmen or "net handlers," and one cook. The small vessels operating in New England, the mid-Atlantic, and Chesapeake Bay carry crews of 4-6 persons.

The captain is the primary decision-maker in regard to day-to-day harvesting operations, although company owners and managers have the ultimate authority concerning when and where vessels will fish. Captains supervise shipboard labor and hire and fire vessel crewmembers. During fishing operations, the captain also runs one of the two purse boats used in conventional menhaden purse seine fishing.

Spotter pilots are employed by the companies, even in cases where the aircraft are leased rather than owned by a company. The aviators are dispatched to find schools of menhaden and maintain radio communications with the vessels. The pilots are skilled, not only in discovering schools of fish, but in the identification of them as menhaden or other species. Spotter pilots estimate the size of menhaden under certain conditions, as well as the volume of fish in a school. Spotters may work for more than one menhaden vessel in a company's fleet.

The first mate coordinates the duties and activities of crewmen and is responsible for keeping the fishing gear in good working order. Second in command on the steamer, the mate also navigates one of the two purse boats in harvesting operations.

The pilot is in charge of operating the menhaden vessel, remaining on board while the captain and mate run the purse boats during fishing operations. The chief engineer is responsible for engine room and deck machinery operation, maintenance, and repair, and is assisted in these duties by the second engineer. The cook stocks the boat with provisions and prepares all meals.

The 8-10 crewmen who handle the net during harvesting operations have slightly differentiated tasks, e.g., ringsetter, bunt puller, etc. Most crewmen and officers are also adept at mending nets. Once loaded and brought to the dock, the crew's work is finished until the next trip. Fish are unloaded by factory employees.

During the 8-9 month season, vessel workers may be absent from home from Sunday evening to Friday afternoon.

11.7.4 Labor Force Recruitment

The labor force for the Atlantic menhaden fishery is overwhelmingly community and kinship based. Virtually all captains and crewmen in Virginia and North Carolina come from the rural coastal areas known as the "Northern Neck" of Virginia (Northumberland, Westmoreland, Lancaster, and Richmond counties), and "Downeast" North Carolina (Carteret and Craven counties). Menhaden fishing in these areas began after the Civil War, and contemporary captains and crewmen tend to be second, third, or even fourth generation family members who have worked in the menhaden industry.

No systematic recruitment data specific to menhaden fishermen are available for the communities in New England. However, the smaller purse seine vessels which fish in the Gulf of Maine work full-time in that area, pursuing other species outside the menhaden fishery. Thus, recruitment of New England fishermen to the local menhaden fishery probably follows the same patterns exhibited by traditional New England fisheries.

11.7.5 Employment in Processing and Other Sectors

In 1990,the number of shoreside (and Soviet factory ship) personnel in the United States Atlantic menhaden reduction industry totalled between 500 and 550, including processing and support services (net making and mending, shipyard duties, spotter pilots, etc.) Adding the 500 to 550 fishermen, 1990 total employment was about 1,100 persons in the United States, compared to approximately 1,700 in 1978 (AMMB 1981). As with fishermen, processing and support personnel were recruited locally. The Canadian operation added another 40-50 processing workers.

The division of labor in processing plants is divided as follows: there are 4-6 "bailers," workers who transfer ("bail") fish from vessel holds via a suction pump to the plant. If not automated, one laborer operates the counter or "dump" house, a mechanism for measuring the quantity of fish unloaded per vessel. One to four employees maneuver fish to and from the temporary storage container ("raw box"). Companies employ one boiler operator and one evaporator operator. One or two employees direct the fish "cooker" and press decanters. Oil is separated from the press liquor and processed by two workers. Three or four people are employed drying fish solids. Four to seven persons work in the "scrap house," moving and loading dried solids or "fish scrap" into tractor trailers for delivery. Factory processing is directed by a superintendent. Companies also employ three to eight welders, an electrician, and a "shore engineer." Factory laborers are paid hourly wages. Except for the smaller North Carolina factory, companies operate on two 12-hour shifts during peak season and two eight-hour shifts otherwise. Manpower is reduced about 70% during the off-season (Table 11.19).

11.7.6 Description of Businesses, Markets, and Organizations Associated with the Atlantic Menhaden Industry

11.7.6.1 Relationships Among the Harvesting and Processing Sectors

By 1990, there was only one small land-based processing plant remaining in the Northeast (located in Blacks Harbour, New Brunswick, Canada). Two conventional menhaden vessels supplied this plant with fish taken in the Gulf of Maine. The IWP venture between Resource Trading Company (Portland, Maine) and the Soviet Union, which began in 1988, also received fish from these vessels. As of mid-July 1990, seven United States vessels (including the two large vessels) had offloaded menhaden onto the 504-ft Soviet factory ship, M/V RIGA, with two reduction plants on board. The United States vessels were multiple species craft (except for the two large vessels) which participate in other fisheries when not fishing for menhaden. Some of the small purse seine vessels also sold their catch as lobster bait, depending on market conditions. Larger vessels transferred menhaden directly to the Soviet factory ship, while smaller ones transferred fish to carriers (vessels up to 100 ft in length) which, in turn, offloaded the fish to the M/V RIGA. All products processed by the M/V RIGA were returned to the Soviet Union (NMFS 1990).

The current menhaden industry in New England is quite different from that existing ten years earlier. There were three small processing plants in 1983, two in Maine and one in Massachusetts, with five harvesting vessels. The plants operated primarily on cuttings from foodfish processors and other industrial fish; menhaden contributed a minor part of their raw material. Less than 10% of the Atlantic menhaden catch was landed in New England. Social and economic problems during the 1980s resulted in closing of all three plants. These facilities were located in areas formerly separated from residential neighborhoods, but coastal zone development led to conflicts which contributed greatly to plant closures.

Three companies operate in the mid-and south Atlantic areas. The plants are located in Virginia (2) and North Carolina (1) and depend entirely on menhaden (and some Atlantic thread herring in North Carolina) taken by purse seine. In contrast, there were six companies with eight processing plants in 1980 extending from New Jersey to Florida. The three remaining companies (three plants) now operate 22 to 24 menhaden purse seine vessels each season. In 1980, the six companies utilized 46 vessels and accounted for 90% of all Atlantic menhaden taken for reduction purposes. Although fewer vessels and plants were operating in 1990, both processing and harvest capacity are adequate for the available stock. Regulatory restrictions on fishing enacted over the last 15-20 years probably limit the industry's ability to return to the harvest levels of the 1950s-early 1960s.

Harvesting and processing menhaden remains an integrated operation as practiced by the existing companies, except for the IWP. Garrity-Blake (1991a) noted that the United States menhaden industry "is characterized by a highly organized and efficient...system...." Referring to the Southeast, she stated that the harvesting and processing facilities "...are manned by a tight network of mobile North Carolina and Virginia laborers. The efficiency of such a system sets the...industry apart from other commercial fisheries." She argued, too, that it was "one of the most capital intensive, highly productive, and bureaucratically organized..." fisheries in this country. Maiolo (1991) suggested that, in this respect, the fishery is more similar to those found in European industrial fisheries than in other commercial fisheries in the United States.

11.7.6.2 Labor Organizations

The only known labor organization created specifically for menhaden fishermen formed in 1988 after a 21 day strike by Zapata Haynie crewmen. The "Reedville Fisherman's Association" was certified as a collective bargaining unit by the National Labor

Relations Board. In the winter of 1991-92, the Reedville Fisherman's Association was absorbed into the Landover, Maryland-based United Food and Commercial Workers Union, Local 400. Efforts are underway to organize factory workers in Virginia. Fishing industry organizations in other states are generic in nature, generally covering all fisheries in a geographic area, such as the North Carolina Fisheries Association.

11.7.6.3 Industry Organization

Established in 1949, the National Fish Meal and Oil Association (NFMOA) is an active division of the National Fisheries Institute, the largest fisheries trade association in the United States, representing over 1,000 fishery-related businesses. The objectives of the NFMOA are to promote menhaden fishery products through research, education and trade show efforts; to cooperate with state and federal agencies to ensure wise use and conservation of the fishery resource in order to maintain product at the highest continued yield; and to improve the industry's products. All U.S. Atlantic menhaden companies are members of NFMOA.

11.7.7 Foreign Participation

From a sociological perspective, the most important international component of the menhaden industry is the IWP venture in Maine. Socio-political benefits have been derived from this operation. The United States, through Resource Trading Corp., has provided the Soviet Union (now Russia) with the opportunity to buy and process much-needed protein from U.S. state territorial and federal jurisdictional waters. The processing ship also provides employment for hundreds of workers at a time when Russia and the Eastern European nations are undergoing severe economic stress.

Some of the Maine communities involved in the menhaden fishery may be playing a more important role in U.S.-Russian relations than anyone realized when the IWP venture began. Viewed with skepticism and fear at first, local communities have extended the welcome mat to the Russian workers. Interviews conducted with industry representatives indicate that processors on leave stay in local homes, one community involved the Russians in a local lobster festival, and local educational facilities are offering Russian language courses.

Within the business community, the IWP venture can be used as a reference point by other entrepreneurs for business opportunities with the former Soviet republics. Interviews with industry representatives show that doing business with the Soviets involves different practices and relationships than those generally conducted in the United States.

The IWP has also kept about 7-12 U.S. vessels busy for a significant part of each year. These vessels do not have to join the fleet working on depressed New England groundfish stocks during the summer. Some relief is thus provided to those stocks by the IWP.

The other significant foreign involvement as of 1990 was the Black's Harbour plant in New Brunswick, Canada. A fish meal plant originally designed for sardine offal was used to process menhaden on an increasing scale. Two U.S.-flag vessels continue to supply menhaden for the Canadian plant.

11.7.8 Social and Cultural Framework of Domestic Fishermen and Their Communities[5]

11.7.8.1 Ethnicity and Kinship

11.7.8.1.1 Ethnicity and Kinship in The Harvesting Sector

In the early to mid-1800s, the lure of the profitable New England-based menhaden fishery drew people from other occupations and fisheries. The early labor force consisted largely of Portuguese crews and Yankee managers. Following the Civil War, menhaden harvesting and processing operations began in the South, shifting the base of the industry in the 1870s to a labor force dominated by southern black crews and southern native-born white managers. The ethnic makeup of the labor force still varies regionally. The geographic and ethnic factors inherent to the U.S. menhaden fishery result in a sociologically diverse occupational work force that stretches from Maine to the Gulf of Mexico, and included over 1,700 people in 1978 in the harvesting and processing of Atlantic menhaden alone (AMMB 1981). In New England, where the menhaden vessels are independently owned and separate from the processing sector, the labor force from the crew level through management is Caucasian. The vertically integrated firms which operate in Virginia and North Carolina are supported by a fishing labor force of whites and blacks in approximately a 1:4 ratio. Some minority members hold officer positions, such as first mate, pilot, or vessel captain, but rural whites tend to dominate those higher status positions. The crew of the processing vessel M/V RIGA is made up entirely of Russian citizens. About 160 people work directly in processing on the vessel, while another 44 have other duties.

Southern blacks, as the dominant ethnic group constituting the menhaden crew labor force in the mid- and south Atlantic, have established a kinship-oriented recruitment pattern. Given the need for crews with the experience, willingness, and ability, along with few other employment options in rural coastal areas, African-Americans have supplied this portion of the labor force. Southern blacks have established themselves as a dependable source of labor for the difficult work associated with harvesting and processing menhaden. The share system of pay has been an important work incentive providing the potential for high income in limited time periods. Whites in the southern fishing areas traditionally have not participated to any great extent in purse seine crews, although certain white families have tended to produce generations of captains (Ligouri 1967).

The recruitment pattern for African-Americans is a combination of kinship/community structure and opportunism. A rural black crewman has probably had relatives and ancestors in the menhaden business since after the Civil War. Menhaden fishing is also valued because it is the best local source of income for poorly educated and unskilled coastal North Carolina and Virginia African-Americans who have few or no attractive

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[5] *This summary is based on the early work of Ligouri (1967), interviews conducted by Orbach (1978), research by Orbach (1989), personal communication by John Maiolo with state and federal fishery scientists, research by Barbara Garrity-Blake (1991a, b, and c), demographic analysis by Paul Tschetter (East Carolina University, pers. comm.) and research conducted by Maiolo (1991).*

alternatives within their communities. These laborers emphasize that work aboard menhaden vessels provides the opportunity to make, from their perspective, large sums of money, especially given the educational and skill levels involved. Such work is preferable to hourly wage work (mostly minimum wage) in the service sector because of the periodic "booms" of good fishing weeks where, compared to other possibilities, a great deal of money can be made. African-American crew members often have at least one child in college, and further, their wages allow them to assist kinsmen in need (Garrity-Blake 1991b). The presence of such support networks among fishermen, in general, is widely documented (See, for example, Maiolo and Johnson 1989).

Those who have not fished for menhaden are typically forced to migrate to distant cities in order to find employment (Garrity-Blake 1991b).

African-Americans value employment on the local level because it allows them to maintain and support their coastal black communities of origin (Garrity-Blake 1991a). North Carolina and Virginia rural African-Americans tend to be land and homeowners, residing on coastal land acquired or purchased by their ancestors in the late 19th century. Rural blacks fear that the loss of substantial local employment will lead, eventually, to the dismantling of their coastal communities.

Anecdotal data and other research (Acheson 1981) indicate that the menhaden industry in the North also draws its labor force from traditional fishing communities. Current crews in New England come from families which have participated in the fishery for generations.

11.7.8.1.2 Ethnicity in the Processing and Support Sectors

Processing and support personnel in the menhaden industry traditionally have been drawn from the same local communities as those of vessel personnel. This pattern still holds in Black's Harbour, Canada, Virginia, and North Carolina, where all of the workers live in communities near the reduction facilities, and family participation in the fishery dates back to the nineteenth century. In the Gulf of Maine, all processing personnel were Soviet citizens aboard the M/V RIGA, as of 1990.

Some support personnel are former fishermen, who have changed, for reasons of health or age, from the lucrative, but grueling, harvest side to the less lucrative, but comparatively easier shoreside activities. Earlier discussions of kinship and community among vessel personnel apply to processing personnel, as well.

The racial composition of processing plant personnel in Virginia is approximately 60% Caucasian and 40% African-American. Support personnel are about equally divided between the races. In North Carolina, two-thirds of the processing personnel are African-American. In Canada, workers are predominately of English heritage, with some French-Canadians. During the past few years, some Vietnamese and Cambodian immigrants have worked for the Canadian operation.

11.7.8.2 Demographic Characteristics of Communities

Data were examined for four selected coastal counties each in Maine, Virginia, and North Carolina. These counties are generally important to the fishing industry and specifically important to the menhaden industry. With the exception of Cumberland County, Maine, all of the counties were non-metropolitan, nor were they adjacent to metropolitan counties. Lincoln County, Maine; Dare and Hyde counties, North Carolina; and Northumberland, Richmond, and Westmoreland counties, Virginia, were entirely rural in 1980 (Table 11.25).

The populations for each of the four counties in Maine grew by more than 10% during the 1980s; most was attributable to immigration. The rate of growth in each county was slightly less than that in the 1970s. In North Carolina, three of the four counties grew during the 1980s (Table 11.25), with Dare County showing the fastest growth rate among all North Carolina counties. Carteret County grew by more than 20% during the 1980s. Similar to the case in Maine, growth rates for the North Carolina counties were less in the 1980s than in the 1970s. Three of the four counties in Virginia involved in the menhaden industry grew by less than 10% in the past decade. Westmoreland County grew by an even 10% (Table 11.25). All four grew at slower rates than in the 1970s.

The trend seen in all three states is consistent with the view that United States coastal communities will contain the bulk of the nation's population in the near future. Population growth in these coastal counties was due largely to immigration, typically of persons unrelated to commercial fishing. Especially in rural areas, considerable growth is related to retirees. Specific impacts of growth on coastal community organization are currently the topics of sociological research (See, for example, Ellis 1988; Smith 1982; Maiolo and Tripp 1990). The entire way of life in a given community can change, as the forces of housing patterns and development take their toll on local economies, work force structure, and the socio-political environment (See, for example, Ellis 1988).

Specific comments on the employment structure in the coastal communities illustrate the impacts relative to the fishing industry. The employment picture for the coastal counties is limited because the data come from the 1980 census (1990 data were not yet available). The primary industry employment group includes agriculture, forestry, fisheries, and mining. For 1980, county level reports distinguished between two categories: (1) agriculture, and (2) forestry and fisheries. Data for 1980 (Table 11.26) revealed that employment in agriculture, forestry, and fisheries as a percentage of total employment declined in 10 of the 12 counties examined. This pattern is consistent with the national trend for the same period. Only in Carteret and Hyde counties, North Carolina, did natural resources employment increase as a fraction of the total employment. Contrary to the national trend for a parallel decline in the absolute number of workers employed in these categories, three of the Maine counties, all of the North Carolina counties, and one of the Virginia counties experienced increases in the actual number of people employed in agriculture, forestry, and fisheries. In fact, in two North Carolina counties (Carteret and Hyde), the size of the agriculture, forestry, and fishery labor force grew faster than the total labor force. In a third North Carolina county, Dare, the natural resources labor force grew by 132%, but the total labor force grew by 133.5%. This growth was normally associated with growth in the general fisheries labor force, rather than the menhaden labor force, which experienced a decline. Research in the Southeast has shown that such general fisheries worker growth is often the result of the so-called "gentrification of fisheries": entry of people who have retired from other communities and occupations to coastal communities and

Table 11.25. Total population, percent population changes, percent urban, percent working outside county of residence, for selected coastal counties in Maine, Virginia, and North Carolina, 1980 and 1990. (Data for 1990 are projections.)

	County			
State	Cumberland	Knox	Lincoln	Sagadahoc
MAINE				
Total population				
1980	215,789	32,941	25,691	28,795
1990	243,135	36,310	30,357	33,535
Percent population change				
1970-1980	12.1	13.5	25.1	22.8
1980-1990	12.7	10.2	18.2	16.5
Percent urban, 1980	60.5	35.4	0.0	51.8
Journey to work, 1980				
Percent working outside county of residence	7.9	10.3	30.1	36.5

	County			
State	Lancaster	Northumberland	Richmond	Westmoreland
VIRGINIA				
Total population				
1980	10,129	9,828	6,925	14,041
1990	10,896	10,524	7,273	15,480
Percent population change				
1970-1980	11.0	6.4	6.9	15.6
1980-1990	7.5	7.1	5.0	10.2
Percent urban, 1980	53.5	0.0	0.0	0.0
Journey to work, 1980				
Percent working outside of county of residence	14.6	35.3	41.04	41.9

	County			
State	Carteret	Craven	Dare	Hyde
NORTH CAROLINA				
Total population				
1980	41,092	71,043	13,377	5,873
1990	52,556	81,613	22,746	5,411
Percent population change				
1970-1980	30.0	13.6	91.2	5.4
1980-1990	25.5	14.9	70.0	-7.9
Percent urban, 1980	19.9	49.6	0.0	0.0
Journey to work, 1980				
Percent working outside of county of residence	26.9	11.5	3.6	14.2

Table 11.26. Labor force data for selected counties in Maine, Virginia, and North Carolina, 1970 and 1980.

State	County: Cumberland	Knox	Lincoln	Sagadahoc
MAINE	1980			
Total labor force	95,856	12,447	9,898	11,182
Agriculture (number)	876	318	338	167
Percent	0.9	2.6	3.4	1.5
Forestry and fisheries (number)	615	628	466	144
Percent	0.6	5.0	4.7	1.3
Total agriculture, forestry, fisheries	1,491	946	804	311
Percent	1.5	7.6	8.1	2.8
	1970			
Total labor force	75,105	10,352	7,526	8,575
Agriculture, forestry, and fisheries	1,717	848	739	261
Percent	1.6	8.2	9.8	3.0
Percent change 1970-1980				
Total labor force	27.6	20.2	31.5	30.4
Agriculture, forestry, and fisheries labor force	-13.2	11.6	8.8	19.2
	Lancaster	Northumberland	Richmond	Westmoreland
VIRGINIA	1980			
Total labor force	3,924	3,555	2,946	5,243
Agriculture (number)	85	187	191	265
Percent	2.2	5.3	6.5	5.0
Forestry and fisheries (number)	230	243	76	139
Percent	5.9	6.8	2.6	2.7
Total agriculture, forestry, fisheries	315	430	267	404
Percent	8.0	12.1	9.1	7.7
	1970			
Total labor force	3,219	3,077	2,126	4,072
Agriculture, forestry, and fisheries	453	516	248	407
Percent	1.6	8.2	9.8	3.0
Percent change 1970-1980				
Total labor force	21.9	15.5	38.6	28.8
Agriculture, forestry, and fisheries labor force	-30.5	-16.7	-7.7	-0.1

Table 11.26. (Continued)

State	County: Carteret	Craven	Dare	Hyde
NORTH CAROLINA		1980		
Total labor force	15,563	23,523	5,448	2,215
Agriculture (number)	323	897	48	346
Percent	2.1	3.8	0.9	15.6
Forestry and fisheries (number)	904	196	372	233
Percent	5.8	.8	6.8	10.5
Total agriculture, forestry, fisheries	1,227	1,093	420	579
Percent	7.9	4.6	7.7	26.1
		1970		
Total labor force	11,225	17,395	2,333	1,699
Agriculture, forestry, and fisheries	731	1,045	181	433
Percent	6.5	6.0	7.8	25.5
Percent change				
1970-1980				
Total labor force	38.6	26.1	133.5	30.4
Agriculture, forestry, and fisheries labor force	67.8	4.66	132.0	33.7

Sources: U.S. Census of the Population, 1980, Table 178. U.S. Census of the Population, 1970, Table 123.

occupations. These are normally middle class whites (J. Johnson, East Carolina University, pers. comm.). The type of growth pattern noted for some of the communities in which menhaden workers reside is consistent with the findings of that research.

Information indicating in which of the three categories (agriculture, forestry, fisheries) employment changes occurred is gathered by a knowledge of local conditions. In North Carolina, there is no evidence of increased agricultural activity in the coastal counties during the 1980s, which suggests the growth in that state probably occurred in fisheries (probably gentrification) or forestry. Similar information is not available for Maine or Virginia.

11.7.8.3 Labor Force Profiles

There were about 1,100 employees in the fishery in 1990 (distributed about equally between vessel and shoreside workers), compared with approximately 1,700 in 1978 (AMMB 1981). Processing personnel are wage earners, not "shareholders" like the fishermen, except the spotter pilots, who receive a base salary and incentives based on catch levels. All of these personnel are active in the menhaden industry as the seasonal availability of menhaden permits. Considerable reduction in force occurs during slow periods and the off-season (Table 11.19), but as many as possible are kept on in order to retain a stable labor force for the next season.

Labor force stability has become a problem for the menhaden industry in the Southeast because of great variations in menhaden production during the 1980s and consequent changes in personnel needs. In addition, other employment opportunities have developed, especially in the Virginia segment of the fishery. With a dwindling labor pool from which to draw, training programs for captains have emerged, along with the hiring of otherwise marginally qualified support personnel who receive work and training in order to be available when vessel crew replacements are needed. The training of captains includes rotation schemes for tutelage under successful and experienced captains in order to increase the potential for success and, therefore, retention/commitment.

This pattern of expanding the labor pool from a tightly controlled kinship/community recruitment network to one which incorporates otherwise ineligible workers, is not uncommon in commercial fisheries around the world. (The terms "fission" and "fusion" have been utilized to address the issue sociologically--M. Hepburn, East Carolina University pers. comm.) In steady-state fisheries, kinship and community networks operate to provide an adequate labor force, fusing the network parameters, and locking them in, so to speak, thus preventing "outsiders" from entering. As a fishery changes (as in a new, expanding fishery), historic networks break down because they cannot provide an adequate supply of labor, and outsiders can enter. This scenario occurred in the Florida oyster fishery examined by Hepburn and the calico scallop fishery studied by Maiolo (1984). In the menhaden fishery, other forces (recombination, fluctuations in menhaden catches and employment, other work opportunities) are having the same effect.

The work force profile and educational/skill levels of menhaden fishermen, in general, and African-American fishermen, in particular, are mixed in a number of ways.

Research by Blomo, et al. (1988) in the Southeast indicated that most of the fishermen have relatively low levels of educational achievement and skills for alternative employment. However, "there are historical patterns of occupational and residential stability primarily due to their participation in the menhaden industry" (Blomo, et al. 1988:58). In a study of menhaden fishermen in three coastal counties in North Carolina, Blomo, et al. (1988) found that 47% of the 102 fishermen studied had been in school for 6 to 10 years, and that 93% had no earned income other than from menhaden fishing. Yet, 68% owned their own homes. In addition, it is common for black menhaden fishermen to send at least one child to college (Garrity-Blake 1991b).

Data on work force age composition are available only for vessel personnel. Information from the late 1970s indicated that the average age of these fishermen was in the low forties (AMMB 1981). Data gathered by Garrity-Blake (1991a) indicated that this profile had not changed, and that the range was 18 to 65 years of age.

11.7.8.4 Community Organization

Menhaden employees in the New England fishery live primarily in the Portland, Maine area (Cumberland County), as well as in the nearby counties of Lincoln, Knox, and Sagadahoc. They come from traditional fishing families and communities. With the advent of the IWP venture, according to industry spokesmen, several important aspects of community organization have emerged. The arrangement has been described as a "win-win" situation: 1) a large factory ship is kept busy; 2) the foreigners have been given access to much needed protein; 3) fishing families and communities in Maine benefit economically because the fishing fleet infrastructure has been kept intact in spite of the loss of shoreside operations (Should shoreside plants open for business in the future, the fleet still exists to provide fish.); 4) the fleet continues to provide bait for lobster fishermen, which according to one informant, would not have been sufficient by itself, from an economic standpoint, to keep the fleet intact; and 5) menhaden industry spokesmen argue that continuation of the menhaden fishery may have kept some fishing pressure off the distressed New England groundfish stocks.

Except for some company executives, industry personnel who work in the mid- and south Atlantic menhaden fishery are from two counties in North Carolina (Carteret and Craven) and four in Virginia (Northumberland, Westmoreland, Lancaster, and Richmond). Most white menhaden workers in North Carolina live in Beaufort, neighboring Morehead City or "Downeast" communities such as Harkers Island, Marshallberg, and Atlantic (all in Carteret County). Most African-Americans in the fishery live in the more distant "black" communities of North River, South River, and Merrimon (Carteret), Harlowe (Craven), and historically segregated black sections of Morehead City and Beaufort (Garrity-Blake, 1991b).

In Virginia, most white vessel workers who fish in Atlantic waters are from Reedville or neighboring Fairport (Northumberland County), while a few are scattered in the more distant towns of White Stone or Kilmarnock (Lancaster County). The black communities of the Northern Neck of Virginia tend to be on the periphery of towns, unlike Beaufort and Morehead City, which have some predominantly African-American neighborhoods. In Virginia, African-American fishermen and support personnel are from small rural settlements of thirty to fifty houses. These settlements (composed primarily of kinsmen) are smaller and more widely scattered throughout the four counties than the North Carolina black communities. The six counties in North Carolina and Virginia are mostly rural, with waterfront settlements founded in the mid- to late 1800s (and much earlier in the case of Beaufort, North Carolina). Several communities have seen the immigration in recent years of white retirees, part-time summer residents, military personnel (in North Carolina), and others who have moved into the areas as part of the Sun Belt/coastal zone migration pattern of the 1980s. (Maiolo 1991, East Carolina University 1990, and Ellis 1988).

11.7.8.5 Economic Dependence on Commercial Fishing and Related Activities

Money appears to be the main impetus attracting labor to menhaden fishing and processing/support activities. Although family tradition has been a factor, participation at the crew level appears to be based on the fact that one can make relatively large sums of money in a shorter time in menhaden fishing than in alternative fisheries and shoreside occupations.

During the off-season, the New England harvesters generally engage in other fishing activities. In the mid- and south Atlantic, menhaden firms operate seasonally, and much of the labor force depends on government unemployment payments during the off-season. A substantial portion of the shoreside personnel are kept on throughout the year for two reasons: maintenance work is needed in the factories and on the vessels, and there is a need to maintain labor force stability. Some of those persons not retained by the companies choose not to go on the unemployment rolls and find work in forestry, farming, crabbing, oyster shucking, or other fisheries.

These off-season activities may contribute to a long-term commitment to menhaden-related activities for some individuals. Monetary incentives, such as bonuses for completion of a fishing season, are held in higher regard by older fishermen. However, when many fishermen find a more profitable alternative to menhaden fishing and related activities, they are apt to leave the industry. This situation has become a problem of increasing concern to the Virginia-based companies and has provided those companies with the incentive to keep many personnel on for the entire year, to initiate personnel training and maintenance programs, and to improve health and retirement benefits. Still, the Virginia companies find it problematical to compete with developing work opportunities in Richmond, Norfolk, and Washington, D.C.

11.8 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 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). There is strong competition within the menhaden purse seine reduction industry, but no conflict. However, 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 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 occupy 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. An abundant supply of menhaden in the estuary makes capture of bait less laborious for this group of anglers.

A misconception 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 1989:18). 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). A study is planned for the 1992 season by Virginia Institute of Marine Science. Bycatches are 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 (by number) is allowed in Virginia and North Carolina.

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 is principally for space rather than for menhaden.

In an effort to reduce conflicts, the menhaden industry has instituted an education program for other fishermen, management agencies, and the general public. These efforts include taking interested persons on their vessels to observe fishing activities. Individual menhaden companies follow internal codes of conduct for their fishing operations which clearly demonstrate 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.

11.9 Habitat

11.9.1 Physical Description of Habitat

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

11.9.1.1 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.

11.9.1.2 Middle Atlantic Region (Cape Cod, Mass. to Cape Hatteras, N.C.)

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) (the largest estuary in the U.S.), 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 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 (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 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.

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.

11.9.1.3 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, Fla., with mean minimums ranging from 2° to 20°C and maximums ranging from 17° to 26°C. In the summer, the increases are more gradual, ranging north to south from minimums of 21° to 27°C to maximums of 28° to 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.

11.9.2 Habitat Areas of Particular Concern

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). As juvenile menhaden grow and develop, they form dense schools and range throughout the lower salinity portions of the estuary; eventually migrating to the ocean in late fall-winter.

Pollution and habitat degradation threaten the coastal 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 industrialization 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.

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.

11.9.3 Habitat Protection

Every state on the Atlantic coast has a coastal habitat protection system in place (Table 11.27). Most states' programs are federally approved under the Coastal Zone Management Act. 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.

Table 11.27. Summary of Atlantic coast states' coastal habitat regulatory programs.

State	Administrative organization	Legislative authority	General requirements
Maine	Department of Environmental Protection	Natural Resources Protection Act; Mandatory Shoreland Zoning Act	Permits are required for development in, on, or adjacent to wetlands; local government or state zoning ordinances apply to coastal shorelands.
New Hampshire	Wetlands Board	New Hampshire Statute RSA 482-A	Permits are required for any alterations of wetlands or submerged bottoms.
Massachusetts	Department of Environmental Protection	Wetlands Protection Act; Wetlands Conservancy Program; Public Waterfront Act	Permits are required for dredging, filling, and other actions which affect coastal habitats.
Rhode Island	Department of Environmental Management, Coastal Resources Management Council	Chapter 279, Public Laws of 1971, Sect. 1, Title 46, General Laws of Water and Navigation. Chapter 23 Coastal Resources Management Council	Permits are required for coastal zone development, aquaculture, and dredge and fill operations.
Connecticut	Department of Environmental Protection	The Coastal Management Act, Section 22-a-90 to 22-a-96	Permits are required to dredge, fill, or build structures in both fresh and saltwater. Permits required to work in regulated wetland areas
New York	Department of Environmental Conservation, Bureau of Tidal Wetlands	Environmental Conservation Law Article 25; Tidal Wetlands Act, Part 661. Land use regulations for tidal wetlands	Activities in and adjacent to tidal wetlands are regulated, and permits are required for such activities

Table 11.27. (Continued)

State	Administrative organization	Legislative authority	General requirements
New Jersey	Department of Environmental Protection, Division of Coastal Resources	Wetlands Act of 1970 NJSA 13:9A-1 et seq., Coastal Area Facilities Review Act NJSA 13:19-1 et seq., Waterfront Development Law, NJSA 12:5-3, Beaches and Harbors Bond Act of 1977 PL 77-208, Shore Protection legislation NJSA 12:6A-1	Regulates activities in the coastal zone and requires permits for such activities.
Delaware	Department of Natural Resources and Environmental Control, Division of Environmental Control, Wetlands Section	Sect. 1, Title 7, Delaware Code, chapter 66. Wetlands	Regulates use of wetlands and their upland border and provides penalties for violations.
Maryland	Department of Natural Resources, Tidewater Administration; Department of Health and Mental Hygiene, Office of Environmental Programs	Natural Resources Article, Code of Maryland	Regulates activities in tidal wetlands areas.
Virginia	Marine Resources Commission; county wetlands boards	The Wetlands Act Section 62.1-13.20, Code of Virginia	Regulates alterations to tidal marshes, sand and mud flats, subaqueous bottoms, and sand dunes.
North Carolina	Department of Environment, Health, and Natural Resources, Division of Coastal Management; Coastal Resources Commission	Dredge and Fill Law (GS 113-229), Coastal Area Management Act (CAMA) (GS 113A-100 et. seq.)	Permits are required to dredge, fill, or otherwise alter coastal wetlands or submerged bottoms, and other areas of environmental concern.
	Marine Fisheries Commission, Division of Marine Fisheries	NC Administrative Code Title 15A, Chapter 3	Use of most bottom-disturbing fishing gears is prohibited in designated nursery areas for young finfish and crustaceans.
South Carolina	Coastal Zone Management Council	Coastal Zone Management and Planning Act	Permits are required for alteration of wetlands, beaches, and dunes.

Table 11.27. (Continued)

State	Administrative organization	Legislative authority	General requirements
Georgia	Department of Natural Resources, Coastal Resources Division, Coastal Protection Section	Coastal marshlands Protection Act of 1970 (Gs L. 1970, p. 939, 1.)	Permits are required to dredge, fill, remove, drain, or otherwise alter any marshlands.
		Shore Assistance Act of 1979 (Gs L. 1979, 1.)	Permits are required for a structure, shoreline engineering activity, or land alteration in beaches, sand bars, and sand dunes in Georgia.
Florida	Department of Natural Resources	Chapter 253, Florida Statutes	Regulates dredge, fill, and structures on state submerged lands (below mean high water). Provides for acquisition of conservation lands and tidally influenced areas.
		Chapter 258, F.S.	Establishes aquatic preserves and regulates activities within preserves.
	Department of Environmental Regulation	Chapter 403, F.S.	Permits are required for activities (including dredge and fill) which affect water quality.
	Department of Community Affairs	Chapter 380, F.S.	Administer and set standards for "Development of Regional Impact." Protects regional or statewide resources from poorly conceived development activities

11.10 Management

11.10.1 Regulatory Measures

Major changes have occurred in the Atlantic menhaden industry since the completion of the 1981 menhaden FMP (AMMB 1981). The Atlantic fishery has become relatively more important, due in part, to the continued improvement of the Atlantic menhaden population and the overall 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 11.5). During the mid-1980s, historical low prices occurred for fish meal, while oil prices fell to lows during 1987 and 1989-90 (Table 11.16). Menhaden companies have either gone out of business or have adapted with internal restructuring, as well as adopting new organizational procedures and technology. An IWP fishery has operated in Maine waters since 1988, maintaining 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. A summary of current state laws and regulations pertaining to the Atlantic menhaden fishery is presented in Table 11.28. The summary includes information on licensing, closed seasons and areas, special conditions, and penalties for violations.

11.10.2 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 biological condition of the stock. Combined with national and international economic factors, the closures have affected the viability of the Atlantic menhaden industry in spite of improved stock conditions. 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 sound biological or economic data. A regulatory summary (Table 11.28) is followed by a series of maps (Figure 11.10) which show the areas in each state that were closed to menhaden purse seine fishing as of September, 1992.

11.11 Data Needed for Atlantic Menhaden Resource Management

11.11.1 General Needs

Management of the Atlantic menhaden resource will require long-term continuation of several ongoing research and monitoring programs based at the NMFS Beaufort Laboratory. Special projects of a shorter duration may be needed from time to time to

Table 11.28. State statutes and rules governing the Atlantic menhaden fishery, as of September 1992.

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
MAINE Department of Marine Resources	12 M.R.S.A. Sections 6171, 6171-A, 6191 and 6192	Commissioner may adopt or amend regulations upon advice and consent of the Advisory Council. Limitations: method, time, number, weight, length or location. When a condition endangering marine species exists, Commissioner may adopt emergency rules with no public hearing or Council approval required. An emergency rule may be in effect no more than 90 days.	None specifically for menhaden NRC - $334 RC - $89	June 1 to December 31 in certain areas; otherwise, no season.	1) No setting of purse seine within 1500 ft. of any stop seine. 2) No setting of seine within 2000 ft. of the mouth of any weir. Chapter 34 special permit Damariscotta and St. George rivers--in certain areas. No purse seining in Kennebec and upper Sheepscot rivers. Boats transporting are limited to 30,590 lb, must be measured, plainly marked and sealed by State sealer.	Possible suspension of permit or where specific penalties are not provided. Fine up to $1000 and/or imprisonment for one year.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penaltiesp2796Y
NEW HAMPSHIRE Fish and Game Department	R.S.A. 211.65 Division of Marine Fisheries created R.S.A. 206.1 Commission created R.S.A. 206.10. Powers and Duties of Director R.S.A. 211.62. Authority to regulate taking, inspections, and processing of marine species.	The Director may make rules and regulations. Methods: size, number, quantity, areas, and manner of their taking.	None specifically for menhaden. NRC - $200.50 (or equal to non-resident fee in operators' home state) RC - $25.50 Inland Netter Permit-free (required to take finfish by net or trap in Great Bay and Hampton/ Seabrook estuaries.)	May 15 to October 10.	State waters closed to mobile gear April 16-December 14. Gill nets in Great Bay estuary system 2-7/8" maximum mesh size.	General penalty misdemeanor.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
MASSACHUSETTS Division of Marine Fisheries Marine Fisheries Advisory Commission	Mass. Ann. Laws 2.5, SA; Chapter 130	The Division may promulgate regulations with approval of Marine Advisory Commission. Method: taking fish, size, seasons and hours, and opening and closing of areas.	Boats: 100'--$260; 60'-99'--$195; up to 59'--$130. This permit is valid for taking, landing, and selling finfish, and may be endorsed for shellfish. A special permit ($20) is required for regulated fisheries.	No season.	Special permits are issued for areas designated as a regulated fishery area or as an inshore permit area. Specific regulations may apply by individual area.	Violators are subject to fines from $10 to $5000, imprisonment not more than 1 year, or both.
RHODE ISLAND Division of Fish and Wildlife	Title 20-3-1 General Laws of Rhode Island Title 42 Chapter 17	Marine Fisheries Council may promulgate regulations: Manner of taking fish, size of fish, seasons and hours, numbers and quantities and opening and closing of areas. 1)Required to make monthly reports to Department. 2) Equipment must be registered.	Vessels to 50'-$100; 50' to 99'-$125; 99' or more $10 per linear foot.	May 1 to October 1.	Numerous areas within Narragansett Bay and Mt. Hope Bay are restricted if landings exceed 1,000,000 pounds per day.	Fine up to $500 and one year suspension of license. Fine from $500 to $700, imprisonment not more than 30 days, or both.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
CONNECTICUT Department of Environmental Protection	C.G.S. Section 26.3	Promulgate regulations for the management and protection of fishery resources.	Purse seine--$500.	Third Monday in May through third Friday of October.	Closed area: Buoy to buoy line from Byram River to Stonington. Sec. 26-154a.	Fine up to and not exceeding $500 or imprisonment not more than 50 days, or both.
NEW YORK Department of Environmental Conservation	N.Y.E.C.L. Sections 13-0333, 13-0343	None specifically for menhaden; all rules are statutory.	Vessel-30 gross tons (gt) or less--$25; 30-100 gt--$200; 100-150 gt--$500; 150-200 gt--$750; over 200 gt--$1000. Licenses expire Dec. 31 following date of issue.	Third Monday in May to third Friday in October. Purse seine fishing is not allowed on weekends or legal holidays May 1 through September 15.	Buoy to buoy line in western half of Long Island Sound. All waters of New York Harbor and tributaries closed to all net fishing. Menhaden fishing prohibited within 1/2 mile of ocean beach from Rockaway Pt. to East Rockaway Inlet.	General civil penalty of $60 plus $25 per fish. Specific civil penalties from $250 to $1000 for each offense of Section 13-0333. General criminal penalty of fine up to $250 and/or up to 15 days imprisonment.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
NEW JERSEY Division of Fish, Game and Wildlife	New Jersey Stat. Ann. Title 23:3-51, 3.52.	Division cooperates with other states, interstate and Federal departments and agencies to develop programs and policies for the conservation and protection of natural resources.	R - Vessels: 30-100 gt--$125; 100-150 gt--$250; 150-175 gt--$400; 175-200 gt--$550; 200 + gt--$900; 20 tons or less used for taking menhaden for bait purposes only--$20. NR - Vessels: 30-100 gt--$ 450; 100-150 gt--$ 700; 150-175 gt--$1000; 175-200 gt--$1150; 200 + gt--$1500. Residents who lease vessels from out of state shall pay fees same as NR. License applications for bait purposes will only be accepted between January 1 and March 1 of any year.	Third Monday in May through third Friday in October.	Purse seine fishing for purposes other than bait restricted to the Atlantic Ocean not closer than 1.2 nautical miles of the shore, jetties or fishing piers. Purse seine fishing for bait purposes only restricted to the Atlantic Ocean and Delaware Bay not closer than 0.6 nautical miles and in Raritan Bay and Sandy Hook Bay not closer than 0.3 nautical miles of the shore, jetties or fishing piers. No fishing on Saturdays, Sundays or legal holidays. Fishing allowed only between sunrise and sunset. Fishing for bait purposes requires monthly reporting of fish harvested.	Violations are misdemeanors--$1000 for each offense.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
DELAWARE Division of Fish and Wildlife	Title 7, Section 903	Division has authority to protect, conserve and propagate the fisheries resources of State.	None.	No open season.	Purse seine fishing not allowed in state waters.	Violations are regarded as misdemeanors. $2500-fine for first offense; $5000 each offense thereafter.
MARYLAND Tidewater Administration	M.D.N.R. Section 1-101, 4-202	Regulations may include, but are not limited to, provisions enlarging, extending, restricting, or prohibiting the taking or catching of these resources.	None issued for purse seines; gill nets and pound nets used in Bay, up to 200 yards of gill nets--$50.	No open season.	Commercial menhaden fishery prohibited from use of purse seines in Maryland waters. Pound net locations are regulated laterally.	Violations are misdemeanors. Fine from $100 to $1000; violators shall be imprisoned until such fines and costs are paid.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
VIRGINIA Marine Resources Commission	Code of Virginia, Chapter 4. Use of purse nets for taking menhaden, Sections 28.2-400 to 28.2-411.	Commission has authority to protect, conserve and promote the seafood and marine resources of the Commonwealth.	R - Vessels: A) Sail vessel: purse nets of not more than 400 meshes deep--$21.50; B) Sail vessel: more than 400 meshes--$75; C) Power boat or steam vessel: under 70 gt--$3 per gt, max. $150; over 70 gt--$5 per gt, max. $600; and D) Power boat or steam vessel less than 20hp--$37.50. NR - applicants required to submit affidavit.	First Monday of May through third Friday of November in the Chesapeake Bay and tributaries. In waters east of the Chesapeake Bay Bridge Tunnel within 3 miles, season is first Monday of May to Friday before Christmas. For vessels under 70 gt taking only bait--season is first Monday of March through third Friday of November.	Selected smaller tributaries to Chesapeake Bay and major rivers are closed above designated lines. Mesh size not less than 1-3/4" stretched. Unlawful for purse seines to take food fish in excess of 1 percent of the total catch.	All violations are misdemeanors. Upon conviction, violators shall be fined up to $1000 and/or imprisonment up to 12 months.

Table 11.28. (Continued)

State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
NORTH CAROLINA Marine Fisheries Commission Division of Marine Fisheries	North Carolina General Statutes. See G.S. 113-152 113-156 113-163 113-182 113-185 113-186 143B-289.3 143B-289.4	Marine Fisheries Commission power specifically includes the promulgation of rules and regulations implementing the provisions of Chapter 113 of the General Statutes. Commission can restrict gear, area, season, size and quantity and can delegate authority for management by Proclamation (Administrative order).	License must have name of man in command. Mother ship: $2 per ton, gt, customhouse measurements and no license is required for a purse boat used in connection with a licensed mothership. NR License fee--$200.	May 15-January 15 within 1 mile of shore. Year 'round beyond 1 mile. Director may open season by proclamation during April 1-May 14 with restrictions. No purse seine fishing between sunrise and sunset on Memorial Day, Fourth of July, Labor Day or weekends from Memorial Day through Labor Day.	Various estuarine and ocean areas restricted. Buying or selling menhaden for reduction must be done by a measure of 22,000 cubic inches for every 1000 fish. Specific regulation prohibiting fishing applies to Wrightsville Beach. No fishing in the ocean within 750 ft. of a marked ocean pier. Unlawful for purse seines to take foodfish in excess of 1 percent of the total amount of fish on board.	Violations of marine fisheries regulations are misdemeanors punishable by fine of $50 to $250 for the first offense and $100 to $500 for any offense thereafter, and/or imprisonment for up to 30 days.

Table 11.28. (Continued).

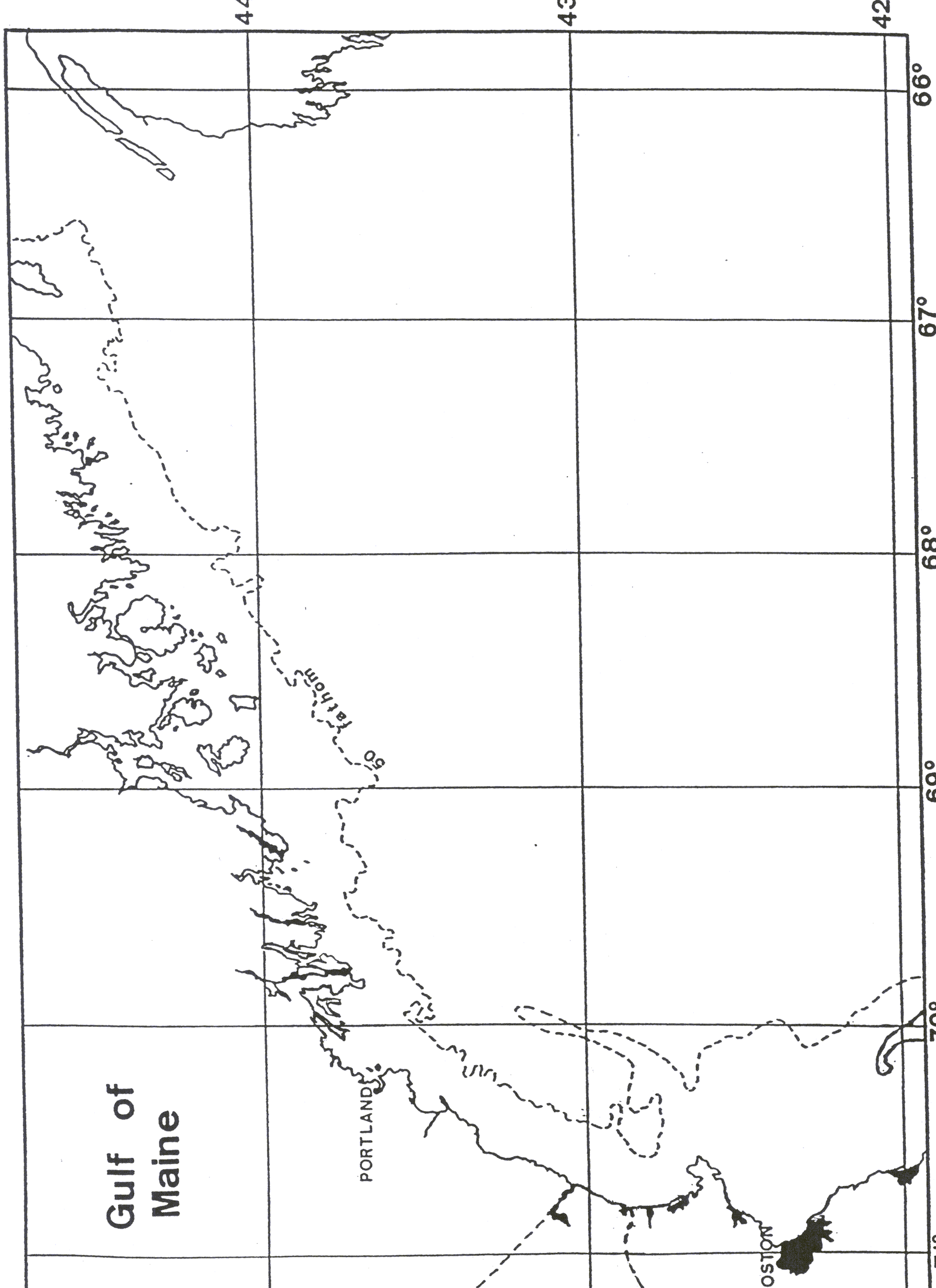
State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
SOUTH CAROLINA Wildlife and Marine Resources Commission	S.C. Code Section 50-17-440	Statutory authority only.	None.	No open season.	Purse seine fishing not allowed in state waters.	Violations are misdemeanors punishable by fine up to $200 or imprisonment for up to 30 days. Any nets and catch are subject to confiscation.
GEORGIA Department of Natural Resources	Official Code of Georgia, Section 27-4-114; 27-4-130.	Commissioner of Natural Resources may open and close the saltwaters to allow or disallow the use of certain equipment in accordance with sound principles of wildlife research and management (O.C.G.A. 27-4-130).	Personal-RC - $10 NRC - $100.25 Purse boats: 18′ or less--$50; over 18′--$50 plus $3 per foot. Other boats: 18′ or less--$5; over 18′--$5 plus $.50 per foot or fraction thereof; NRC-License fee--$25.	Set administratively by Commissioner of Department of Natural Resources.	1000 ft. restricted area from shore for Jekyll Island, St. Simons Island, Sea Island, Tybee Island. No purse seines inside rivers, creeks and sounds.	Variable, civil or misdemeanor criminal prosecutions.

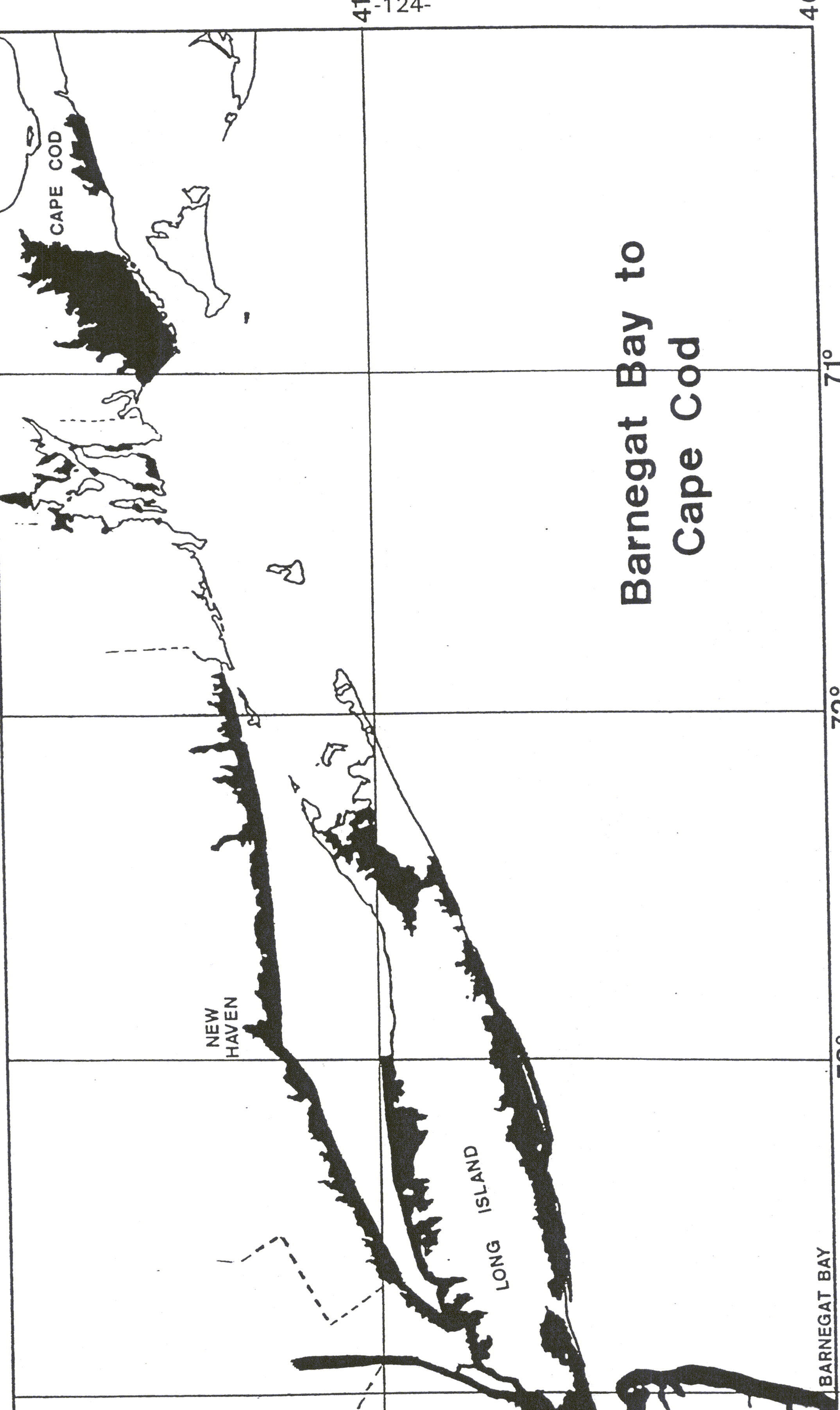
Table 11.28. (Continued).

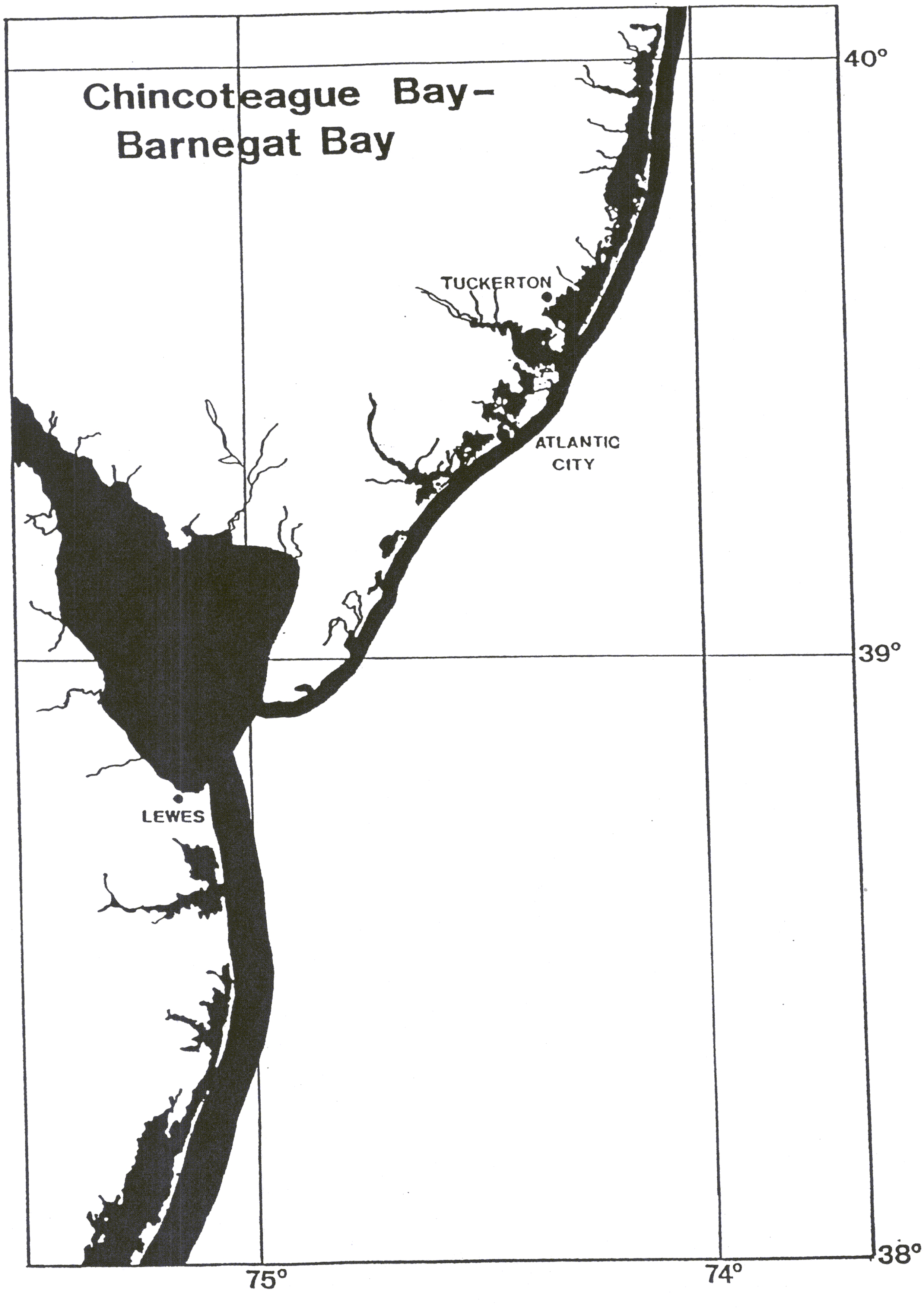
State delegation of authority	Legislative authority	Regulatory/ administrative authority	Licenses*	Open season	Special areas and conditions	Penalties
FLORIDA Marine Fisheries Commission	Title 46	All rules and regulations under the Florida Marine Fisheries Commission.	Purse seine--$25 NR--$25 Purse boat--$31 Carrier vessel--$76 Dealer classification--$10 Wholesale dealer: R--$100 NR--$150 Alien--$500	No closed season.	No menhaden by purse seine along designated areas of west coast. All fishing by nets (except small cast nets) prohibited in Broward County.	Violations of Chapter 370-up to $500 fine and/or imprisonment of 1 year. Other sections specify seizure of fishing gear, vessels, catch and vehicles.

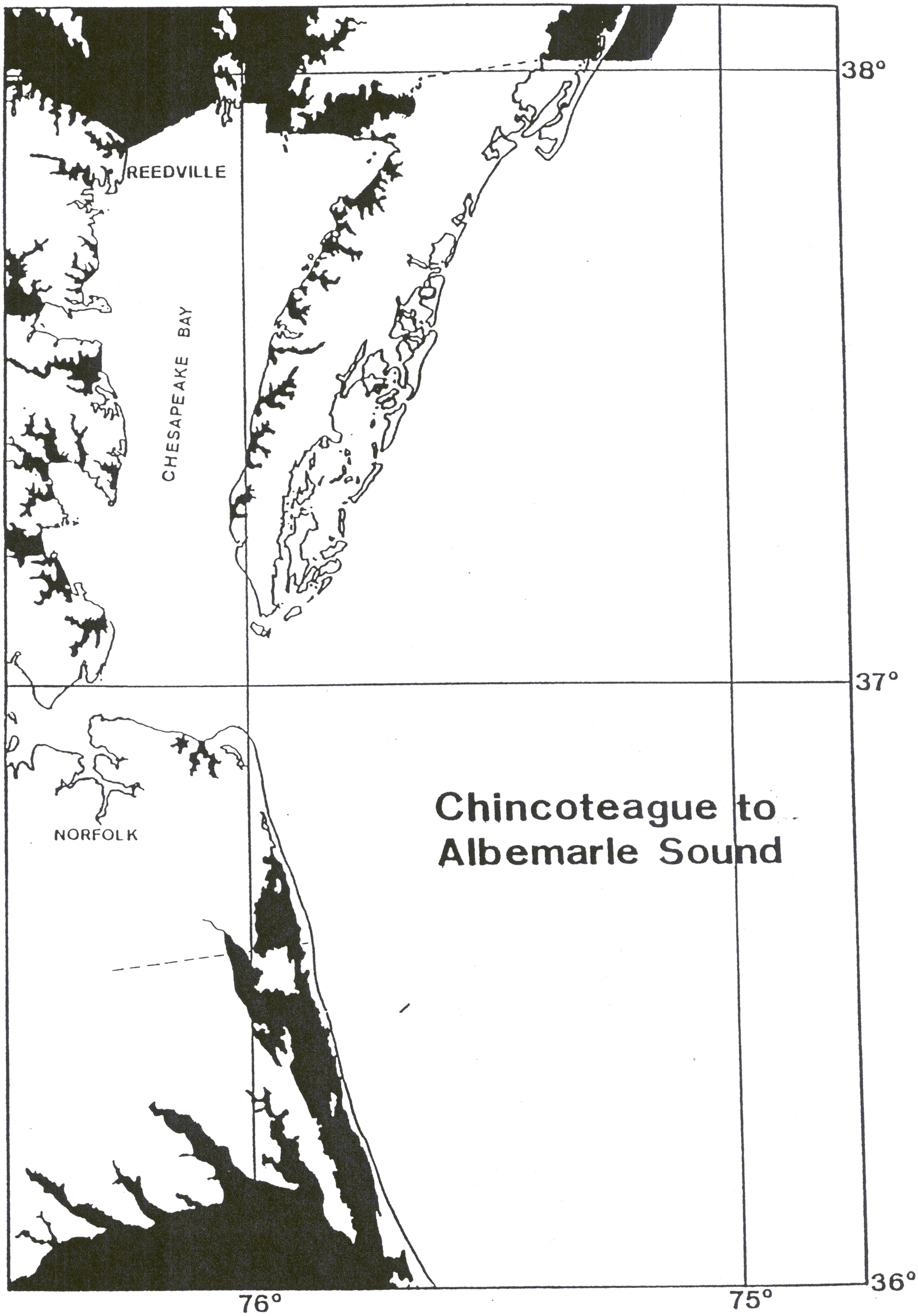
* Terms used: NR = non resident
R = resident
NRC = non resident commercial
RC = resident commercial

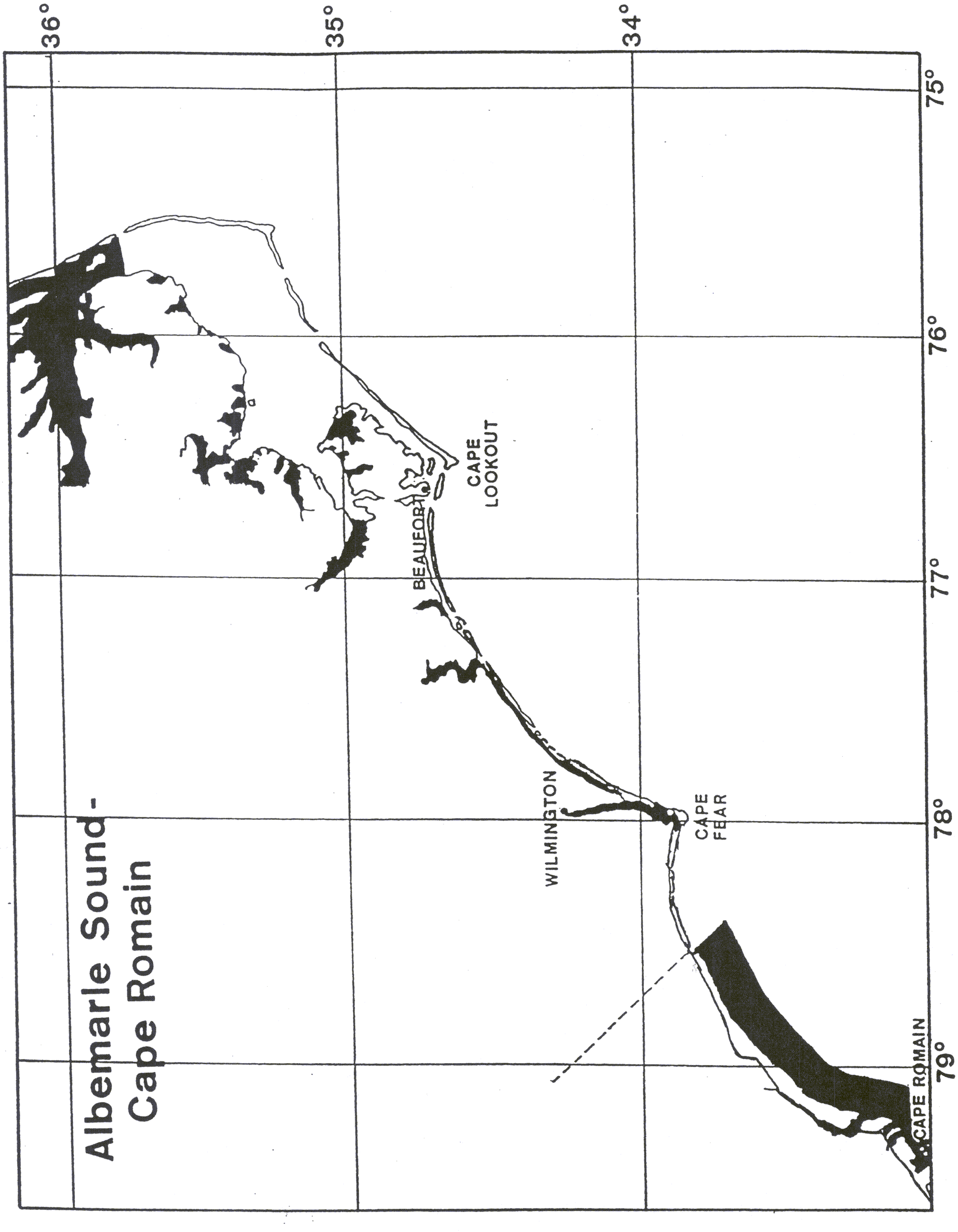
Figure 11.10. Maps of prohibited areas. (Darkened areas on the following maps indicate those areas in which menhaden purse seine fishing is prohibited.)

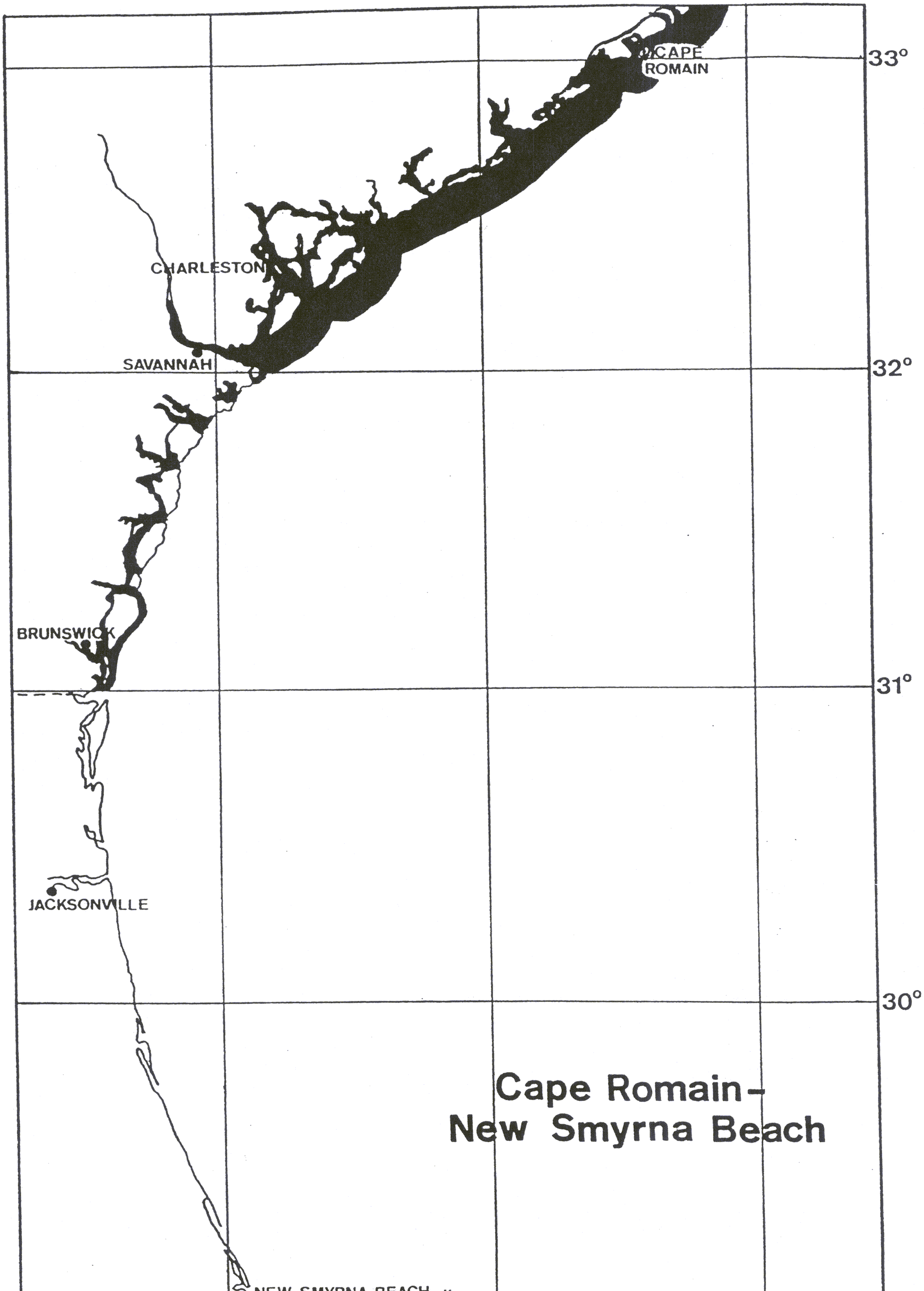

Gulf of Maine
PORTLAND
BOSTON
60 fathom
44°
43°
42°
66°
67°
68°
69°
70°
71°


Barnegat Bay to Cape Cod
CAPE COD
NEW HAVEN
LONG ISLAND
BARNEGAT BAY
41°
40°
71°
72°
73°
74°


Chincoteague Bay-
Barnegat Bay
TUCKERTON
ATLANTIC
CITY
LEWES
40°
39°
38°
75°
74°


38°
REEDVILLE
CHESAPEAKE BAY
37°
Chincoteague to
Albemarle Sound
NORFOLK
36°
76°
75°


Albemarle Sound -
Cape Romain
36°
35°
34°
75°
76°
77°
78°
79°
CAPE
LOOKOUT
BEAUFORT
WILMINGTON
CAPE
FEAR
CAPE ROMAIN


CAPE
ROMAIN
33°
CHARLESTON
SAVANNAH
32°
BRUNSWICK
31°
JACKSONVILLE
30°
Cape Romain-
New Smyrna Beach
NEW SMYRNA BEACH
vii
81°
80°
79°

answer specific questions posed by the ASMFC or others concerned with management of Atlantic menhaden.

11.11.2 Existing NMFS Program

The ongoing research program of the NMFS Beaufort Laboratory began in 1952, while coastwide sampling began in 1955. Menhaden program activities at the NMFS Beaufort Laboratory are primarily fishery monitoring and resource assessment in nature. The Beaufort Laboratory receives and processes daily information on catch and nominal fishing effort from the Atlantic menhaden reduction fishery, as well as set-specific information contained in the Captain's Daily Fishing Reports (CDFRs). In addition, NMFS menhaden port samplers collect biological information (fish length and weight and scales for ageing) from samples of the purse seine catch. Approximately 5,000-7,000 fish are sampled each year from the Atlantic coast. Data from these samples comprise the biostatistical data set. The landings and subsequent biostatistical data are necessary for estimating landings in numbers-at-age, which in turn are used in virtual population analysis (estimation of fishing mortality, recruitment, and spawning stock size), the fundamental stock assessment process.

The above information forms the basis for NMFS Beaufort Laboratory's regular reports to ASMFC, the states, industry, and others on the status of the Atlantic menhaden stock and fishery. Reports include updated landings, estimated nominal fishing effort, forecasts of landings, and stock assessments. New data are not being collected by tagging juveniles or conducting juvenile abundance surveys. Historical data sets are being analyzed to improve/evaluate alternative juvenile abundance survey methodologies and to support studies relating environmental factors to menhaden recruitment. In-depth analysis of various biological attributes of the Atlantic menhaden resource throughout its range is needed by ASMFC in a timely fashion. Data presently available through NMFS at its Beaufort Laboratory are considered adequate for initial recommendations to meet the short-term objectives of this plan. The long-term objectives involve the development of additional data through NMFS, the states, industry, and other sources.

Continuation of the NMFS Beaufort Laboratory menhaden program as the primary data collection, processing, storage, and analysis institution for Atlantic menhaden is essential for the states and ASMFC to manage the fishery. Present staffing at the NMFS Beaufort Laboratory for biostatistical sampling, fishery monitoring, and routine analyses of the Atlantic menhaden is approximately three "Full Time Equivalent" employees (FTE). If Atlantic coast CDFR data analyses are to be incorporated into monitoring, assessment and management, an additional 1.5 FTE are needed. Fishery-independent data collections and analyses are not currently funded. Research efforts under the NOAA-Coastal Ocean Program (SABRE) are addressing the generic question of historical regional contributions of recruitment to the stock. These efforts are not designed for resource monitoring purposes. Table 11.29 summarizes ongoing and needed research for Atlantic menhaden.

11.11.3 Harvest Data

Most companies in the purse seine reduction fishery continue to voluntarily provide daily catch records, plant production data, and a daily CDFR (set-by-set data) for each

Table 11.29. Long-term monitoring and research needs for management of the Atlantic menhaden fishery.

	Ongoing	Needs improvement	Need
Monitor landing size, age, gear, and area harvest in the:			
Reduction fishery	X		
Bait fishery	X	X	
Monitor effects of fishery on the Atlantic menhaden stock	X		
Make annual predictions of atlantic coast fishery	X	X	
Effects of selected environmental factors on Atlantic menhaden stock			X
Develop catch-per-unit-effort index for juveniles			X
Analysis of vessel catch records	X		
Analysis of Captains Daily Fishing Reports			X
New approaches to monitor recruitment			X
Programs to monitor fish kills	X	X	
Ulcerative mycosis studies	X		
Toxic dinoflagellate and other fish disease studies	X	X	
Studies on the magnitude and value of fisheries	X		
Evaluation of the effects of regulations			X
Studies of bycatch in the menhaden purse seine fishery	X		
Bycatch studies of menhaden by other fisheries			X
Studies of the ecological role of menhaden (predator/prey relationship)	X	X	
Relation of habitat loss/degradation and Atlantic menhaden abundance			X

vessel (Figure 11.11). These reports provide data for accurate and timely assessment of the fishery, monitoring of fleet activity, and periodic summary of landings in the fishery by time period and area. Landings data for other gear types (eg. gill nets, pound nets) are obtained by state agencies and NMFS personnel through commercial statistics programs and other state reporting systems. However, these data do not provide the same level of detail provided in the purse seine data, nor are such data of consistent quality. Data on the harvest of menhaden for bait are of special concern (See Section 11.4.2).

11.11.3.1 Recommended Minimum Catch Reporting Requirements

11.11.3.1.1 Purse Seine Reduction Fishery

The Captain's Daily Fishing Report program must be continued, including collection of completed forms. In addition, historic and current CDFR data must be coded and key-entered for analysis to provide guidance for management decisions by government agencies and industry.

11.11.3.1.2 Other Commercial Fishing Gear

Purse seine "snapper rigs," haul seines, pound nets, gill nets, etc. take menhaden in their normal operations, principally for use as bait (whether directed or bycatch). Landings information for menhaden used as bait should also be incorporated into a data management system. Daily, weekly, or monthly catch reports should be implemented by the states to provide data parallel to that of the purse seine fishery. Samples of these catches should be processed for biological data, such as age, weight, and length of fish. This information will provide a characterization of this segment of the catch which parallels that for the purse seine fishery.

11.11.3.2 Management of Harvest and Biological Data

The NMFS Beaufort Laboratory should continue to provide the centralized data management system for Atlantic coast menhaden landings and biological data. The system should be expanded to incorporate new data into the current NMFS monitoring program for the species. Data access and confidentiality can be directly controlled through user codes. Landings for menhaden used as bait should be incorporated.

The NMFS Beaufort Laboratory should continue to provide primary data summaries and analyses for the ASMFC, industry, and states.

11.11.3.3 Research Needs

11.11.3.3.1 Mortality Other Than Directed Fishing

A great number of menhaden may be killed and discarded as bycatch in other fisheries. The impacts of this loss to the menhaden population, currently included in natural mortality, should be investigated. High volume water users, such as electric power generating facilities, impinge menhaden on their intake screens. At present, these data are dispersed among the various industries and states and are not generally immediately available to the fisheries management agencies. Each permittee should

CAPTAIN'S DAILY FISHING REPORT

NAME OF VESSEL 1	PLANT 2	DATE OF SETS 3	4

LEFT DOCK / ANCHORAGE 5
DATE
TIME : ☐AM ☐PM

IF DID NOT LEAVE DOCK (CHECK ONE) 6
☐ WEATHER UNFIT FOR FISHING ☐ UNLOADING
☐ LACKING SUFFICIENT CREW ☐ RADIO
☐ MECHANICAL ☐ OTHER________
☐ NET

IF NO SETS WERE MADE (CHECK ONE) 7
☐ ROUGH SEAS ☐ OTHER________
☐ FOGGY
☐ NO FISH SHOWING
☐ NO PLANES
☐ CHANGING LOCATION

SET NO. 8	TIME 9		FISH (000) 10	PLANE NO. 11	LOCATION 12		MILES AND DIRECTION TO SHORE 13		WEATHER CONDITIONS AND REMARKS 14	15
	START	END								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

16 REMARKS & COMMENTS 17

DATE/TIME RETURN TO DOCK: ________________

____
CAPTAIN'S SIGNATURE 18

This form is required by State Law

Figure 11.11. Captain's Daily Fishing Report form.

provide the appropriate permitting agency with regular (monthly, quarterly) reports of fish killed during the water intake phase of their operations. Data could include daily estimates (counts) by species and length frequencies. The state water use permitting agency should forward regular data reports to the Atlantic menhaden program at the NMFS Beaufort Laboratory directly or through the ASMFC.

Each state should develop a program for the assessment of fish kills (natural, thermal, or toxic-substance related). The designated state agency should report a summary of findings and estimated numbers killed to the Atlantic menhaden program at the Beaufort Laboratory at regular intervals. The procedure developed by the Pollution Committee of the Southern Division of the American Fisheries Society (American Fisheries Society 1982) could be used as the model for investigation and reporting of fish kills in Atlantic coastal waters.

During the 1980s, Atlantic menhaden and several other estuarine fishes at multiple sites along the Atlantic coast suffered from ulcerative mycosis disease (Noga and Dykstra 1986). This disease, which causes lesions and can result in significant mortalities of fish in local areas, is believed to be associated with oomycete fungi (genus *Aphanomyce*) (Dykstra et al. 1986). It is not known whether these outbreaks of lesions are rare events, epidemic cases of disease, or symptoms of environmentally stressed estuaries. Dinoflagellate algae (similar to the red tide organism) have recently been associated with major menhaden kills in North Carolina (J. Burkholder, N.C. State University, pers. comm.). Further studies are needed to understand how disease and fish kills affect the Atlantic menhaden stock.

11.11.3.3.2 Resource Assessment and Monitoring

Biological health and response of the resource to management should be ascertained by analysis of data from the total stock. Landings data alone do not suffice as a measure of the resource's condition under management actions which may result from this plan. This situation exists because harvest effort is greatly affected by weather, market conditions, plant capacity, and other factors. Data needs essential to the management program are listed in Table 11.29.

11.11.3.3.3 Composition of the Harvest

It is essential that the existing NMFS port sampling program be maintained to assess the biological health of the resource. States should also develop a parallel port sampling program for menhaden taken in other fisheries (bait, pound nets, etc.) in coordination with the NMFS program. Data obtained from individual fish in a sample of the catch (be it purse seine, pound net, power plant intake screen, fish kill, etc.) should include weight, length, and scales for age. Additionally, periodic intensive sampling should be undertaken to examine sex ratio, maturity, fecundity, and other measures. These data should be integrated with those from other sources for analysis and assessment of the resource.

11.11.3.3.4 Juvenile Survey and Forecasts

Past attempts to develop indices of juvenile abundance as measures of recruitment have been unsuccessful. Development of indices which are quantitative and predictive would greatly improve ASMFC's ability to accurately monitor the status of the menhaden stock, particularly the magnitude of recruiting year classes. Analysis of power plant intake screen impingement data or other novel approaches for measuring menhaden juvenile abundance should be investigated. This information should allow more accurate forecasting of the purse seine harvest. Sampling programs should be devised which will allow a more active involvement of the individual states in the monitoring of the resource. Data management should be through the NMFS Beaufort Laboratory menhaden program, and annual assessments should be provided to the Atlantic menhaden management program of the ASMFC.

11.11.3.3.5 Socioeconomic Information

Major changes in the nature of the menhaden fishery occurred during the 1980s. Regulatory restrictions and changing economic conditions resulted in plant closures in the Northeast and South, shifting the fishery more to the mid-Atlantic area. Development of the IWP fishery in Maine has also changed the focus of how the menhaden fishery is integrated with other Maine fisheries. Competition by alternate products has affected the world markets for fish meal and oil. Furthermore, new products from the menhaden fisheries, such as surimi and/or oil products which can be used for human consumption, may alter the markets for menhaden. Socioeconomic studies to help understand the changing menhaden fishery should focus on ascertaining the value of menhaden fisheries and processing and their importance to the nation and local communities. Additionally, studies should be carried out to determine the extent and effects of regulations governing harvesting and processing and factors affecting the use and distribution of menhaden products.

11.11.3.3.6 Bycatch Studies

The menhaden reduction fishery is the nation's second largest fishery, with Atlantic and Gulf coast landings accounting for over 20% of the total United States marine finfish and shellfish landings. The fishery is characterized by relatively large and highly efficient vessels operating close to shore, which some coastal residents find objectionable. Much controversy occurs when these vessels operate in the vicinity of sport fishing grounds, with some anglers claiming that large numbers of gamefish are taken incidentally during menhaden purse seine operations. Purse seine bycatch studies conducted from the late 1800s to the early 1970s (See Section 11.8) demonstrated that very few saltwater gamefish were taken by menhaden purse seines. Controversy over operation of menhaden boats in state waters is currently at a high level. Since fishing areas and technology have changed, new bycatch studies on the fishery were conducted during 1992 by Virginia Institute of Marine Science to facilitate knowledgeable and informed decisions on bycatch. Findings from these studies will be made available to the ASMFC's menhaden management program.

11.11.3.3.7 Forage Base Study

Menhaden occupy an important level in the food chain, serving to transfer energy from plankton to higher level organisms. As a coastal schooling species, they constitute a large part of the diet of fish, sea birds, and marine mammals. Predator-prey relationships should be studied to assess the ecological role of menhaden throughout its range and the potential effects of the fishery on the availability o menhaden relative to its ecological role.

11.11.3.3.8 Evaluation of Habitat Loss

No information is presented in this plan concerning the degree of coastal habitat loss and degradation or the impact of specific factors on the survival or production of different menhaden life history stages or on planktonic food resources available to menhaden. Some of this information may exist in the literature. It is recommenced that this information be compiled and summarized in a separate report to the ASMFC in support of this management plan. This report should focus on major estuarine habitats for juvenile menhaden in the middle Atlantic region such as Delaware Bay, Chesapeake Bay, and the estuarine system behind the Outer Banks of North Carolina. This task could be accomplished by a contractor or by graduate students as theses.

11.11.3.3.9 Special Projects

This document contains several references to special research projects needed to support the management program or to provide background data for evaluation of the proposed long-term management approach. Also, considerable data on Atlantic menhaden may exist in many state finfish monitoring programs in which substantial incidental menhaden catches occur. These data may provide useful information for Atlantic menhaden management. Long-term data needs and special projects needed for management are listed in Table 11.29. Several problems are exacerbated along the Atlantic coast by the extensive migration pattern, age-class mixing, multiple resource users, large number of states within the range of the fishery, and economic factors arising from the distribution of landing ports within the range of the fishery. The ASMFC, AMB, and NMFS will use these and other sources for guidance in the formulation of the research program, assignment of research priorities, and response to management questions.

ACKNOWLEDGEMENTS

Preparation of the revised Atlantic menhaden FMP has been a rather laborious and drawn-out exercise. Actual writing was shared by most members of AMAC, with editorial responsibility delegated to AMAC Chair Michael W. Street. Drafts of various sections were consolidated by the editor with all subsequent typing by Diana D. Willis of the North Carolina Division of Marine Fisheries. Consistency and appearance of the document are the result of Ms. Willis' dedication. Dr. James Waters of the NMFS Southeast Fisheries Science Center, Beaufort (N.C.) Laboratory conducted the fishing and processing costs survey and wrote the initial report on which much of the economics section of the FMP is based. Dr. John R. Maiolo (East Carolina University, Department of Sociology and Anthropology) conducted original research on sociological aspects of menhaden workers under contract to the ASMFC. Dr. Maiolo's report provided the basis for much of the sociological section of the FMP. Dr. Barbara Garrity-Blake, an independent social scientist, assisted Dr. Maiolo and also provided follow-up information at the request of the AMAC Chair. The ASMFC staff, especially Paul Perra, has been extremely helpful in completing and publishing this document. The members of the Atlantic Menhaden Board have shown great support and patience in providing their staff personnel who serve on AMAC and have spent many hours in preparation of this plan. Special gratitude is extended to the menhaden industry members of AMAC and AMB whose special insights and historical perspectives have ensured that the ASMFC menhaden plan is realistic and will meet the needs of the stock and fishery. Finally, the Menhaden Team based at the NMFS Beaufort (N.C.) Laboratory has provided all requested information, analysis, and literature quickly, often repeatedly, contributing immeasurably to completion of the FMP.

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APPENDIX 1

POSSIBLE MANAGEMENT ACTIONS FOR THE ATLANTIC MENHADEN FISHERY

1. No Action
2. Limit Number Of Vessels And Capacity
3. Effort Quota
4. Harvest Quota
5. Mesh Regulation To Permit Selective Fishing
6. Season Or Area Closure To Protect A Portion Of The Resource Each Year
7. Size Limit

APPENDIX 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 processes, 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 fish 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 AMAC and AMB for 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 AMAC/AMB review of the six defined triggers (Section 10.4.1.2 of the FMP) and relevant ancillary information;

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

5. Following review of IWP information at its spring meeting, AMAC will prepare a report of its findings and recommendations and send that report to the AMB. The AMB will promptly consider the AMAC report,

and the Chairman of the AMB will forward the recommendations of the AMB 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

APPENDIX 3

ATLANTIC MENHADEN BAIT LANDINGS

Menhaden bait landings (pounds) in Maine, by gear, 1985-91.

Year	Stop seine	Purse seine	Pots & traps	Total (lb)	Total (mt)
1985		1,891,383		1,891,383	875.8
1986		16,250,100		16,250,100	7,369.6
1987		14,361,840		14,361,840	6,513.3
1988		19,685,728		19,685,728	8,927.8
1989		380,000	619	380,619	172.6
1990	852,000	4,892,597		5,744,597	2,605.2
1991		13,893,963		13,893,963	6,301.1

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. A 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).

Menhaden bait landings (pounds) in New Hampshire, by gear, 1987-91.

Year	Gill net	Other	Total (lb)	Total (mt)
1987	2,650		2,650	1.2
1988	4,814		4,814	2.2
1989	5,424		5,424	2.5
1990	6,044		6,044	2.7
1991	11,849	141	11,990	5.4

Atlantic menhaden landings from New Hampshire coastal inland gill netting have been recorded 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 ranges 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 ("other").

Menhaden bait landings (pounds) in Massachusetts, by gear, 1985-91.

Year	Gill net	Purse seine	Trawl	Total (lb)	Total (mt)
1985	3,625	3,036,000		3,039,625	1,378.5
1986		3,411,600	7,425	3,419,025	1,550.8
1987	1,775	1,213,400		1,215,175	551.1
1988	1,125	8,039,195	125	8,040,445	3,646.5
1989		1,454,350		1,454,350	659.6
1990		1,361,900		1,361,900	617.6
1991		6,326,300		6,326,300	2,869.6

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.

Menhaden bait landings (pounds) in Rhode Island, by gear, 1985-91.

Year	Trap	Other	Total (lb)	Total (mt)
1985	840,020	7,548,026	8,388 046	3,804.1
1986	619,187	9,770,000	10,389,187	4,711.6
1987	609,294	12,999,930	13,609,224	6,172.0
1988	409,437	15,174,000	15,583,437	7,067.3
1989	285,975	18,747,198	19,033,173	8,631.8
1990	372,155	16,730,495	17,102,650	7,756.3
1991	80,375	5,010,000	5,090,375	2,309.0

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. The "other" category includes small purse seines and miscellaneous gears. Most of the bait catch is used in the lobster pot fishery.

Menhaden bait landings (pounds) in Connecticut, by gear, 1981-91.

Year	Hook & line	Gill net	Trawl	Other	Total (lb)	Total (mt)
1981	3,059	136,864	11,426		151,349	68.6
1982	426	167,570	3,090		171,086	77.6
1983		125,400	2,400	1,500	129,300	58.6
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	79.4
1989	1,300	128,700	500	18,000	148,500	67.3
1990	1,615	86,621	470	8,000	96,706	43.8
1991	1,600	86,700	-	8,000	96,300	43.7

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 confidentially of landings.

Menhaden bait landings (pounds) in New York, by gear, 1981-91.

Year	Pound net	Common seine	Gill net	Trawl	Total (lb)	Total (mt)
1981					533,200	241.8
1982					394,300	178.8
1983					216,300	98.1
1984					692,500	314.0
1985					901,800	409.0
1986	307,385		58,500		365,885	165.9
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	132.5
1990	86,960	221,400	92,150		400,510	181.6
1991	86,620	117,775	430,805	3,550	638,750	289.7

Atlantic menhaden are taken as bait in New York for the recreational finfish and crab fisheries and for the commercial lobster and crab fisheries. How reported catches are divided for use by each of those fisheries is not known. A restricted gill net fishery for menhaden is conducted by commercial lobster fishermen in Long Island Sound. Catches in this fishery were probably under-reported from 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. Purse seiners 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.

Menhaden bait landings (pounds) in New Jersey, by gear, 1982-91.

					Total	
Year	Pound net	Gill net	Purse seine	Trawl	(lb)	(mt)
1982	1,112,351	199,526	325,480		1,637,357	742.6
1983	588,433	129,091	863,930		1,581,454	717.2
1984	1,194,037	327,555	719,440	1,080	2,242,112	1,016.8
1985	1,561,771	314,923	969,800	33,272	2,879,766	1,306.0
1986	1,380,707	259,990	797,388	15,508	2,453,593	1,112.7
1987	1,510,028	363,979	663,350	25,806	2,563,163	1,162.4
1988	889,967	419,863	667,934	6,281	1,984,045	899.8
1989	1,581,755	297,865	956,231	18,510	2,854,361	1,294.5
1990	1,098,126	176,347	7,761,439	5,547	9,041,459	4,100.4
1991	828,615	335,208	15,427,136	6,443	16,597,402	7,528.5

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 by area fished). 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. Much of the bait catch is shipped out of state for use in the blue crab pot fishery. The principal uses in New Jersey are for the commercial and recreational blue crab fisheries and for sport fishing (chum and cut bait).

Menhaden bait landings (pounds) in Delaware, by gear, 1982-91.

			Total	
Year	Gill net	Other	(lb)	(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	90,451		90,451	41.0
1990	140,525	3	140,528	63.7
1991	282,447	850	283,297	128.5

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; 1986, 0.08; 1987, 0.10' 1988, 0.63; 1989, 0.56; 1990, 0.60; and 1991, 1.01). Landings in April and May account for the majority of the catch.

Menhaden bait landings (pounds) in Maryland, by gear, 1981-91.

Year	Pound net	Long haul seine	Gill net	Fish Pot	Fyke net	Other	Total (lb)	Total (mt)
1981	5,261,549	8,970	78,132	300	104		5,349,055	2,425.9
1982	5,199,839		69,561	57	1,359		5,190,816	2,354.1
1983	3,369,791	50	162,307		2,576		5,534,724	1,603.0
1984	1,650,623	59,440	271,822	100	20,420		2,002,405	908.1
1985	2,034,749		84,272	30,870	7,515		2,157,406	978.4
1986	2,198,060	12	61,612		3,185	22	2,262,891	1,026.2
1987	2,243,887		44,766	7,080	16,448	55,197	2,367,378	1,073.6
1988	2,059,701		128,329	30	15,626	38,794	2,242,480	1,017.0
1989	3,715,820		55,086		2,630	5,080	3,778,616	1,713.6
1990	1,602,438		59,182		655		1,662,275	753.9
1991	2,949,000		130,990	20,000	595	25,760	3,126,345	1,418.1

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 from fishermen. Landings data include Maryland tributaries of the Potomac River, but not the Potomac main stem. Other gear types include trawl and hook and line.

Menhaden bait landings (pounds) in Virginia, 1984-91.

Year	Total (lb)	Total (mt)
1984	14,011,404	6,355.5
1985	16,224,307	7,359.3
1986	9,087,237	4,121.9
1987	14,318,627	6,494.9
1988	11,976,740	5,432.6
1989	19,955,260	9,051.6
1990	12,660,826	5,742.9
1991	9,896,469	4,489.0

Menhaden bait landings come from three gear types, however, small purse seine vessels (snapper rigs) account for the majority of the poundage. Menhaden landed for bait taken with other gear (pound net and gill net) are often recorded only 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.

Menhaden bait landings (pounds) for Potomac River Fisheries Commission, by gear, 1981-91.

Year	Pound net	Gill net	Haul seine	Landed in MD	Landed in VA	Total (lb)	Total (mt)
1981	20,364,817	7,048		4,150,488	16,216,377	20,366,865	9,236.7
1982	17,988,067	1,367		3,764,705	14,224,729	17,989,434	8,158.5
1983	20,820,224	721		2,857,187	17,963,758	20,820,945	9,442.6
1984	13,111,057	840	9,700	3,244,254	9,877,343	13,121,597	5,950.8
1985	16,768,303	586		3,213,502	13,555,387	16,768,889	7,604.9
1986	10,946,547	25,426		2,548,105	8,423,868	10,971,973	4,976.0
1987	13,119,905	590		3,381,323	9,739,172	13,120,495	5,950.3
1988	13,231,030	338		4,342,213	8,889,155	13,231,368	6,000.6
1989	8,333,994		180	2,072,144	6,262,030	8,334,174	3,779.7
1990	4,523,776			903,355	3,620,421	4,523,776	2,051.6
1991	5,376,223			1,431,142	3,945,081	5,376,223	2,438.2

Commercial menhaden landings come from three 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. The Maryland landings are used in the blue crab fishery and for sport fishing.

Menhaden bait landings (pounds) in North Carolina, by gear, 1981-91.

Year	Pound net	Long haul seine	Gill net	Purse seine	Trawl	Other	Total (lb)	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	2,420.2
1989	1,443,546	990,838	59,370	3,613,493	48,568		6,155,815	2,770.1
1990	584,540	1,744,304	14,989	3,989,610	400		6,333,843	2,850.2
1991	320,600	814,134	269,920	3,258,084	308,940		4,969,678	2,236.4

Menhaden are taken as bait in North Carolina in a directed small vessel purse seine fishery and as bycatch in othe fisheries, principally with pound nets and long haul seines. Purse seine data are collected from participating dealer through the North Carolina Division of Marine Fisheries/NMFS Cooperative Statistics Program. Data for all othe gears are derived from a combination of data from the statistics program and bycatch calculated from biologica sampling of unculled catches from various commercial gears.

Menhaden bait landings (pounds) in South Carolina, by gear, 1983-91.

		Total	
Year	Trawl	(lb)	(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

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 (pounds) in Georgia, by gear, 1981-91.

While there are no commercial landings data for menhaden in Georgia, the demand for menhaden for bait, especially live menhaden for king mackerel tournaments over the last 5-6 years, has been steadily increasing. Many fishermen use cast nets (12' diameter, 1-1/2 - 1-3/4" mesh) to catch and sell bait for sportfishing tournaments; however, cast nets are not licensed, and the number of nets used yearly is unknown. Menhaden meal is also used in the formation of "baitballs" (i.e., meal and mud) in some sport fisheries. Menhaden taken as bycatch in the shrimp trawl fishery, while not substantial, goes unrecorded at dockside and is probably sold as bait for the crab pot fishery.

Menhaden bait landings (pounds) in Florida, by gear, 1982-91.

					Total	
Year	Long haul seine	Gill net	Purse seine	Cast net	(lb)	(mt)
1982		413,299			413,299	187.4
1983		1,150,426			1,150,426	521.7
1984	947	1,036,021			1,036,968	470.3
1985	23,859	1,067,826			1,091,685	495.1
1986	30,298	842,607			872,905	395.9
1987	11,849	1,297,636			1,309,485	593.9
1988		1,017,904	53		1,017,957	461.6
1989	8,026	1,248,275	116,179		1,372,480	622.4
1990		1,498,152	1,134,328	956	2,633,436	1,194.3
1991					495,968*	225.0

Historically, gill netting accounted for the majority of Florida east coast 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.

*Total landings available, though not completely edited. 1991 total landings preliminary and not broken down by gear.

APPENDIX 4

ATLANTIC MENHADEN BOARD MEMBERSHIP (1992)

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North Carolina Division of Marine Fisheries
Morehead City, NC

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Maine Department of Marine Resources
Augusta, ME

Mr. William A. Pruitt
Virginia Marine Resources Commission
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Mr. John C. Barnes, III
AMPRO Fisheries, Inc.
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Mr. Spencer Fuller
Resource Trading Company
Portland, ME

Mr. Rick E. Marks
National Fish Meal and Oil Association
Arlington, VA

Dr. John V. Merriner
National Marine Fisheries Service
Beaufort, NC

APPENDIX 5

ATLANTIC MENHADEN ADVISORY COMMITTEE MEMBERSHIP (1992)

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Maine Dept. of Marine Resources
West Boothbay Harbor, ME

Mr. Peter Himchak
New Jersey Bureau of Marine Fisheries
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