



MENHADEN MATTER

**Proactive Conservation
Measures Are Needed
Now To Protect the
Ecological Role of
Atlantic Menhaden and
the Chesapeake Bay**



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EXECUTIVE SUMMARY

Atlantic Menhaden are small, oily fish that play a major role in the health of marine ecosystems up and down the Atlantic Coast. Although petite in stature, menhaden are a vital source of food for a wide variety of fish, seabirds and marine mammals from the Gulf of Maine to Florida.

Menhaden are especially important to the overall health of Chesapeake Bay, the biggest estuary in North America and the third largest in the world. As principal filter feeders of the bay's waters—second only to oysters, which are already grossly depleted—menhaden feed on plankton and decaying plant matter. They are also the primary source of food for many popular sport and commercial fish, including striped bass, which spawn in the bay and rely on juvenile menhaden for the bulk of their diet.

Despite the critical role that menhaden play in the ocean food web, currently no conservation measures—including fishing limits—are in place to ensure that menhaden remain at healthy levels within the Chesapeake Bay, an ecosystem critical to the survival of fish and wildlife all along the Atlantic Coast.

The Chesapeake Bay is bounded by two states. Maryland, like most others along the Atlantic coast, has closed its waters to the industrialized harvest of menhaden with purse seines and



spotter planes. But Virginia has not. Consequently, one Virginia-based fishing fleet currently takes about three-quarters of the entire East Coast catch of menhaden—or more than 100,000 metric tons of fish—annually from the bay and surrounding coastal waters.

Menhaden Matter—a unique cooperative effort of concerned conservation and recreation organizations, including the Chesapeake Bay Foundation, Coastal Conservation Association, Environmental Defense and the National Coalition for Marine Conservation, has reviewed the available science, including data from the National Marine Fisheries Service and leading universities. Based on these findings, *Menhaden Matter* concludes that the important role menhaden play in the marine ecosystem is at risk. Common sense conservation measures should be taken immediately by the appropriate management bodies, including the Atlantic States Marine Fisheries Commission (ASMFC), the 15-state regulatory body that has responsibility for conservation of the stock.

Recent studies raise a number of red flags about the diminishing ecological role of menhaden:

- The overall number of Atlantic menhaden is near historic lows.
- The population of young menhaden has been at an all-time low for more than a decade. Indices are lowest in Chesapeake Bay for juvenile abundance—the age and size most important as forage for predators, especially resident striped bass.
- The industrial-scale menhaden fishery is concentrated in the Virginia waters of the Chesapeake Bay, taking 75 percent of the coastwide catch from within the bay and nearby waters.



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- Predators that depend on menhaden as a food source, most notably striped bass, are showing signs of ecological stress.
 - A high proportion of striped bass in the Chesapeake Bay are suffering malnutrition and poor body condition.
 - More than half of the striped bass sampled in the bay are infected with mycobacteriosis, a sometimes fatal disease, which typically appears in fish under stress.
 - The survival rate of striped bass in the bay has been declining due to natural causes.
 - The lack of menhaden also could affect sea birds, including loons and ospreys.

Any one of these indicators taken alone may not be compelling enough to demand action by fishery managers. But collectively, they signal a potentially serious threat and point to the need for proactive measures to be taken now to protect not only menhaden and the fish that depend upon them, such as striped bass, but also the waters in which they spawn and swim—especially the Chesapeake Bay.

While initial efforts are underway to study the problem, remedial action based on these studies is likely to be years away. In the meantime, the ASMFC does not regulate the number, size or location of menhaden caught in the industrial fishery, despite the fact that nearly every other species they manage have measures in place to protect the stock.

The *Menhaden Matter* effort wants to be clear. It is not looking to shut down the industrial menhaden industry. To the contrary, it believes that the proactive management of menhaden now will improve the future health of the industry and the Chesapeake Bay.



Menhaden Matter! They matter to the health of oceans and estuaries. They matter to the viability of recovering stocks of striped bass, bluefish and other species. They matter to other predators, such as loons and osprey. They matter to commercial watermen and recreational anglers who fish for stocks that depend on menhaden. And they matter to businesses and local economies that these fisheries support.

That is why it is critical that the ASMFC:

- Implement proactive measures to protect menhaden now.
- Lay the foundation for an ecosystem-based approach to fisheries management in the future.

In that way, the most important fish in the sea can be protected.



MENHADEN MATTER!

Proactive Conservation Measures Are Needed Now To Protect the Ecological Role of Atlantic Menhaden and the Chesapeake Bay

Atlantic Menhaden (*Brevoortia tyrannus*) are small, oily fish that inhabit coastal waters of the Atlantic Ocean. While the average adult is only a foot long and weighs about a pound, menhaden are a vital source of food for a wide range of fish, seabirds and marine mammals from the Gulf of Maine to Florida. Also known as pogies or bunker, menhaden generally aggregate off the coasts of North and South Carolina in the winter where peak spawning occurs. In the spring and summer, the older, larger fish migrate north along the coast and into New England. The coastal bays and estuaries of the mid-Atlantic, especially the Chesapeake Bay, provide essential habitat for the growth and development of the stock.

“THE MOST IMPORTANT FISH IN THE SEA”

Menhaden have been called “the most important fish in the sea.” Not only is the little fish valuable to the commercial fishing industry—more menhaden are landed on the East Coast than any other species—but it also plays a critical role



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Menhaden provide a vital and unique link between primary production and higher organisms. Adult and juvenile menhaden feed by straining plankton from the water, their gill rakers forming a specialized basket to efficiently capture tiny food. This ecological function is especially important in the major estuaries of the Atlantic Coast, including the Chesapeake Bay and North Carolina's Pamlico Sound, where water quality is compromised because of excess nutrients, mainly from agricultural and storm drain runoff and sewage disposal. Both of

these estuarine ecosystems lost the majority of their filtering capacity when oyster populations collapsed, increasing the potential importance of menhaden's role as filter feeders.

Menhaden also provide a critical forage base for the rest of the ecosystem, converting plankton—tiny floating plants and animals—into a usable form of energy for animals higher in the food web. Based on diet studies, many valuable and highly prized fish species—such as striped bass, bluefish and weakfish—as well as marine mammals, sea turtles, ospreys and loons depend on menhaden as a food source. Because each species occupies a crucial niche in the ecosystem, excessive removal of prey species, like menhaden, may disrupt its natural balance and sustainability. The ocean is a complex and highly interlinked environment, sustained by key predator-prey relation-



ships. What impacts one species can produce multiple impacts on other species in the food web.¹

CONCENTRATION OF THE COMMERCIAL FISHERY IN THE CHESAPEAKE BAY

The commercial menhaden reduction fishery in the United States has been around since the early 19th century. It began in New England and over time expanded along the entire Atlantic coastline. In the 1950s, 25 processing plants dotted the coast from Maine to Florida.² But one by one, states—including Maryland—began closing their waters to the industrialized reduction fishery for various reasons, including concern that the fishery was depleting the local forage base.³ At the same time, fleet size decreased as the resource declined due to overfishing in the 1960s, and because of industry consolidation for economic reasons.⁴ Today, the only East Coast states that permit industrialized menhaden harvesting are Virginia and North Carolina.

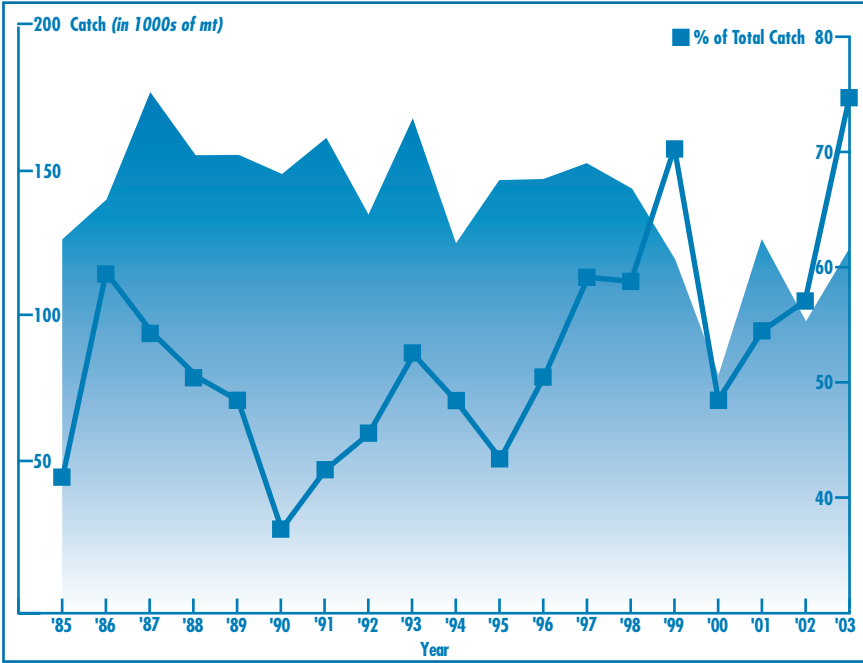
Today, the only East Coast states that permit industrialized menhaden harvesting are Virginia and North Carolina.

As a result, the industrial fishery now concentrates its effort primarily in the Chesapeake Bay and surrounding coastal waters, with 75 percent of the catch coming from this small area alone in 2003 (Figure 1).⁵ The remainder of the Atlantic menhaden catch is harvested along the mid-Atlantic coast and off the shores of North Carolina.

While the bony nature of the fish makes it inedible for humans, menhaden have been put to a variety of industrial uses. The fish were used as fertilizer for crops by early North American



FIGURE 1-ATLANTIC MENHADEN CATCH FROM THE CHESAPEAKE BAY



The menhaden catch from the Chesapeake Bay has remained relatively stable over the past three decades, however the fishery is removing an increasing amount of the catch from the Chesapeake Bay.

settlers. Today, fish meal made from menhaden is a major component of feed for cattle, swine, poultry and other fish raised through aquaculture. Its oil, which contains Omega-3 fatty acids, was recently approved by the Food and Drug Administration as a health food additive. According to the industry's trade association, the market for menhaden products is "diverse and growing."⁶

LIKE SHOOTING FISH IN A BARREL

Menhaden's behavior has always made them easy to catch in large numbers. Because the silvery fish generally travel in tight schools near the water's surface, they are easy to spot and



vulnerable to being caught even by the simplest of fishing gear. Indeed, these schooling fish are no match for the sophisticated methods employed by the commercial reduction fishery, which employs airplanes, boats and giant nets in battle-like precision to locate, trap and pump schools of menhaden out of the water.

The industrial fishery, such as the one operating in Chesapeake Bay, employs “spotter planes,” small aircraft that scout coastal estuaries for schools of menhaden. When a school is located, vessels encircle the fish with a giant net called a purse seine. A string at the bottom is pulled to “purse” the catch. Once trapped, the fish are literally vacuumed into a refrigerated hold on the main vessel, which then delivers them to a processing plant for reduction into fish meal and fish oils. A single Houston-based company, Omega Protein, which operates a newly enhanced facility in Reedville, Virginia, harvests 90 percent of the entire industrial fishery catch on the East Coast.⁷ Omega Protein also has a substantial facility in the Gulf of Mexico, which harvests and processes a related species, Gulf menhaden.

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MENHADEN POPULATION AT HISTORIC LOWS, PROBLEM WORST IN THE CHESAPEAKE BAY

Although fishery managers have not declared Atlantic menhaden to be overfished on a coastwide basis, there are strong indications of decline in the stock that raise serious concerns about the health of the population and its ability to fulfill its ecological role, particularly as a forage fish in the Chesapeake Bay.

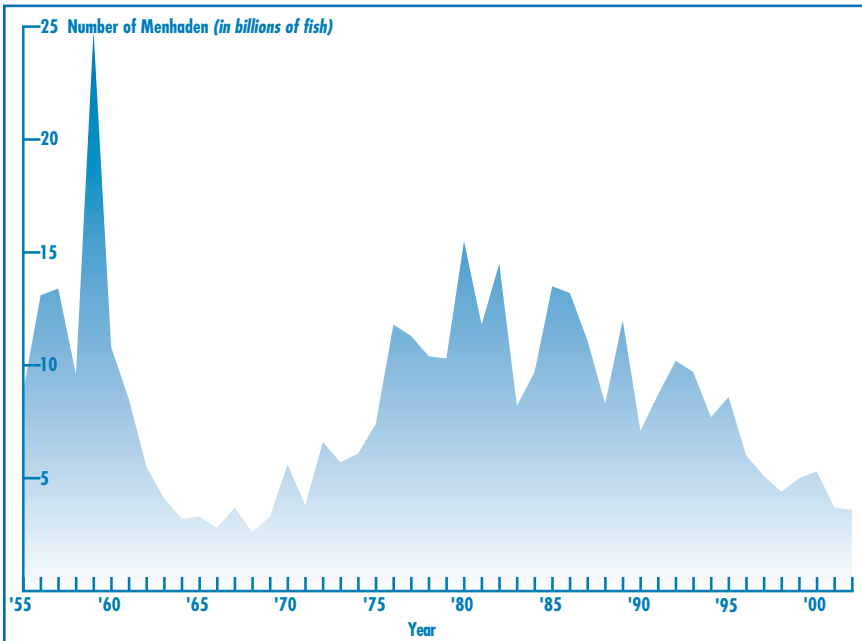


The total stock of menhaden has declined in terms of numbers of fish (as opposed to total biomass) to levels associated with

Recruitment failure—not enough young fish surviving to enter the population—has existed for over a decade.

the overfished condition of the 1960s and 1970s (Figure 2).⁸ Recruitment failure—not enough young fish surviving to enter the population—has existed for over a decade.⁹ Fishing mortality may be underestimated and the stock declining at a faster rate than the stock assessment indicates, because the relationship of catchability to abundance is not significant in a purse-seine fishery for a pelagic schooling fish like menhaden.¹⁰

FIGURE 2-ATLANTIC MENHADEN ABUNDANCE



The abundance of menhaden, in numbers of fish age one and older, has declined to nearly historic lows, and similar to levels found in the 1960s and 1970s when the stock was considered overfished.

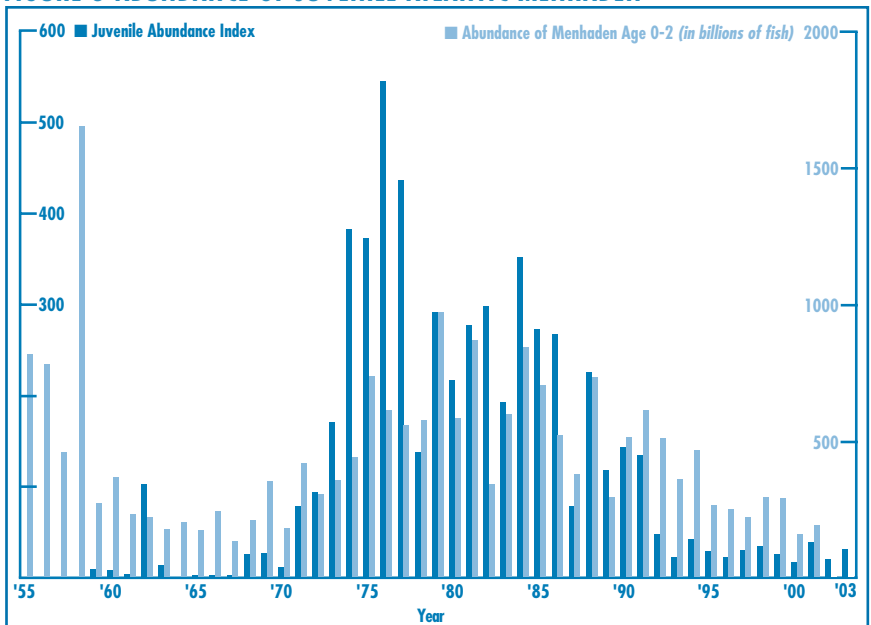


Abundance indices are lowest for Chesapeake Bay, particularly for juvenile fish, suggesting the possibility of localized depletion.¹¹

Evidence of a declining menhaden population is centered primarily in Chesapeake Bay. Since the mid-1990s, the number of young menhaden—fish in their first two years of life—entering the fish population has reached historic lows (Figure 3).¹² This analysis is based on data collected from the commercial fishery.

Indications of recruitment failure also can be found in independent sources of information collected by the states.

FIGURE 3-ABUNDANCE OF JUVENILE ATLANTIC MENHADEN



The abundance of juvenile menhaden has reached historic low levels. This trend is evident from both fishery dependent data, and state surveys collected independently from the fishery. The index of juvenile abundance is a weighted combination of state seine surveys.



Surveys conducted by Virginia and Maryland to measure the abundance of young fish in the Chesapeake Bay show extremely low levels of juvenile menhaden as well. A survey conducted by North Carolina yielded similar findings.¹³

fewer new fish joining the population, combined with a fishery that has no limits on the amount of menhaden it can catch, means overall abundance declines.

Recruitment is not the only measure of stock health that is down. Not surprisingly, fewer new fish joining the population, combined with a fishery that has no limits on the amount of menhaden it can catch, means overall abundance declines. The relatively high overall abundance of the 1980s dropped steadily throughout the 1990s and remains at low levels today.¹⁴

In a recent assessment of the menhaden population by the Atlantic States Marine Fisheries Commission (ASMFC)—the regulatory body responsible for managing menhaden—scientists used information from the Potomac River pound net fishery to gauge adult population abundance. The pound net is a fixed gear that remains in one place in the water and fishes passively, meaning that fish are caught as they swim into the netting rather than the net chasing the fish. Because the purse seine actively pursues menhaden—a schooling fish that is easily located with spotter planes and highly vulnerable to encircling nets—catchability in this fishery is a poor measure of abundance.¹⁵ Passive gear like the pound net can better provide relative estimates of abundance. The data from this gear indicate a declining population in the Chesapeake Bay.¹⁶



LARGE CATCH OF JUVENILES

Menhaden generally live to be eight years old and spawn for the first time around the age of three.¹⁷ However, a significant percentage of menhaden are being caught prior to reaching the age of reproductive maturity. Fishery data from 2003, for example, indicate 90 percent of the menhaden were immature fish, caught before their third birthday.¹⁸ That means that nine out of ten fish taken by the fishery never live to reproduce and replenish the population.

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The increased predatory demand for juvenile menhaden (age zero to two), which are considered of prime forage size for adult striped bass and other large predators, combined with concentration of the commercial reduction fishery in Chesapeake Bay, where most of the catch is juvenile menhaden, is placing unprecedented demand on a stock of young menhaden that has been at historic lows for over a decade. These changes in the fishery coincide with alarming changes in the bay's striped bass population, which include reduced growth, an outbreak of disease and decreased amounts of menhaden in their diets.¹⁹

DECLINING HEALTH OF PREDATORY POPULATIONS - SKINNY STRIPERS, WIDESPREAD DISEASE AND INCREASING NATURAL MORTALITY

Menhaden are a high energy, nutrient rich source of forage for a variety of commercially and recreationally important fish, including striped bass, bluefish and weakfish. For striped bass, also



known as rockfish or stripers, menhaden are preferred because they provide far greater sustenance than alternative prey because of their high fat content. In a healthy ecosystem, juvenile menhaden account for 70 percent to 80 percent of the diet of a mature striped bass.²⁰

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There are indications, however, that an apparent decline of available forage in Chesapeake Bay may be impacting the diet and health of striped bass and other fish and wildlife. Because up to 90 percent of the Atlantic coast striper stock originates from the Chesapeake spawning ground, the impact of a lack of forage in the bay could have profound implications for the entire population.²¹

The menhaden fishery started concentrating in the Chesapeake Bay in the early 1970s, around the same time the striped bass population began its well-publicized decline. A decade long government-enforced recovery program reversed this trend and resulted in the emergence of a resurging striper population in the early 1990s. However, since the mid-1990s, striped bass in the bay have shown signs of malnutrition and disease. Both watermen and scientists speculate that an inadequate supply of menhaden may be the cause.

A recent analysis found that wild striped bass in the Chesapeake Bay have the same low level of body fat as those that were starved for one month in a controlled environment.²² According to another recent study, the average striped bass in the bay now has 10 percent to 25 percent of the fat found in a



healthy fish.²³ Still another study concluded that adult rockfish consumed four times less menhaden in 2000 than they did 50 years ago. Moreover, juvenile stripers consumed almost nine times *less* menhaden over the same time period.²⁴

In addition, recent scientific studies have shown that 50 percent to 70 percent of the Chesapeake Bay's striped bass are currently infected with a disease called mycobacteriosis.²⁵ This becomes more alarming when one realizes possibly as much as 90 percent of all coastal migratory striped bass population on the East Coast breed in the bay's waters.²⁶ Mycobacteriosis is a bacterial infection that is common in fish species that are under stress due to malnourishment, overcrowding or poor water quality. The disease is often characterized by skin ulcers and internal lesions, which over time can destroy the internal organs and lead to death.²⁷

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A number of factors could be behind this alarming rate of infections. One is the coincidence of an explosion in the striped bass population that began in the 1990s and the significant decrease in the numbers of menhaden—a vital food source for stripers—beginning around the same time. In fact, an analysis of rockfish in the upper Chesapeake Bay found the outbreak of bacterial infections coincided with reductions in weight and decreased presence of menhaden in the diet.²⁸

Finally, a new study of striped bass survival in Chesapeake Bay concludes that, in recent years, there has been a significant



decline in survival due to natural mortality.²⁹ In other words, for the first time since the rockfish recovery began in the early 1990s, their numbers are declining. The reason is not excessive fishing mortality but natural causes, unknown at this time but possibly malnutrition or disease or both.

SEABIRDS AT RISK

Striped bass and other recovering predatory fish, such as weakfish and bluefish, are not alone in their reliance on small fish as forage. Seabirds, such as loons and osprey, which have made a strong comeback after nearly succumbing to toxics such as PCBs and DDT in the 1960s and 1970s, also demand high energy, nutrient rich prey, making menhaden an important part of their diet.

However, the return of these birds could be threatened by a reduction in available prey. Some scientists theorize that the decline of menhaden also could be affecting the population of seabirds, including loons and ospreys.³⁰ Loons stopping over in the Chesapeake Bay to feed in the fall of 1998, for example, were at 15 percent of the level observed a decade earlier.³¹ Experts speculate that the sharp drop in the population of small menhaden is affecting fish-eating birds.³²

CURRENT MENHADEN MANAGEMENT DOES NOT ADDRESS ECOSYSTEM CONCERNS

The present management plan for the Atlantic menhaden fishery includes protection of the ecological role of menhaden as one of its primary objectives.³³ However, it does *not* contain any rules regulating the number, size, and location of the har-



vest. This, despite the fact that almost every other fish caught in the Chesapeake Bay for commercial or recreational purposes—except menhaden—has catch limits. Gear restrictions, time and area closures, and limits on size and harvest are frequently used conservation tools with a proven track record that are familiar to every recreational angler and waterman alike.

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But why have the government regulators, responsible for managing the stock, not done more? The major reason is because marine fisheries are managed through a myriad of federal and regional governing councils, multi-state commissions and federal and state laws and regulations that, for the most part, address fisheries on a species-by-species basis. The management of menhaden, for instance, which is the responsibility of the ASMFC, does not address the impact of the menhaden fishery on other species or fisheries or the ecosystem as a whole.

The ASMFC's most recent menhaden stock assessment concluded that overfishing is not occurring. However, this conclusion was based on an analysis of the total coastwide population, without consideration for where the fish are caught or the possibility of localized depletion. The ASMFC made this determination even though 75 percent of all menhaden caught off the Atlantic Coast are taken from the Chesapeake Bay and surrounding waters.³⁴

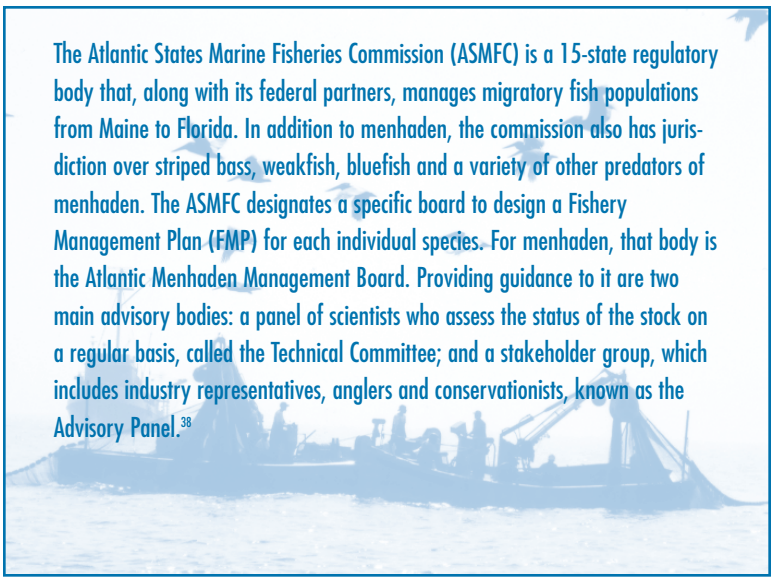
The ASMFC's own group of scientific experts, the Technical Committee, noted this flaw in the process.³⁵ In a recent report to the commission, the committee declared that localized depletion is an important issue for any species, particularly for forage species such as menhaden. They acknowledged that the current methods used to assess the stock would not and cannot detect localized depletion, nor would they detect reduced ecological function that could occur when the fishery is concentrated in Chesapeake Bay, or for that matter, anywhere else. They also concluded that current reference points or benchmarks for stock status contained in the ASMFC management plan are not sufficient to take a broader, ecosystem-based approach to conserving the stock.

Each of these shortcomings in current menhaden conservation and management were previously highlighted by an external panel of scientific experts brought together by the ASMFC to review the 2003 stock assessment. The review panel, noting previous requests by reviewers for new information on the role of menhaden as a forage fish and filter feeder, expressed frustration with the lack of ecosystem-based information in the latest assessment.³⁶

CHARTING A COURSE FOR REFORM

Recently, two major national commissions—the U.S. Commission on Ocean Policy and Pew Oceans Commission—both strongly recommended that healthy oceans depend on fisheries management moving beyond single species assessment and management to an ecosystem-based approach.³⁷ The importance of ecosystem-based fishery management has been reinforced by a number of recent studies, including one that





The Atlantic States Marine Fisheries Commission (ASMFC) is a 15-state regulatory body that, along with its federal partners, manages migratory fish populations from Maine to Florida. In addition to menhaden, the commission also has jurisdiction over striped bass, weakfish, bluefish and a variety of other predators of menhaden. The ASMFC designates a specific board to design a Fishery Management Plan (FMP) for each individual species. For menhaden, that body is the Atlantic Menhaden Management Board. Providing guidance to it are two main advisory bodies: a panel of scientists who assess the status of the stock on a regular basis, called the Technical Committee; and a stakeholder group, which includes industry representatives, anglers and conservationists, known as the Advisory Panel.³⁸

appeared in the journal *Science*, which found that “it is entirely possible that overfishing can occur on an ecosystem level when it is not overfished in a single species context. This can occur when a forage fishery that serves as a prey resource for marine predators is also the target of a fishery.”³⁹ Menhaden is a prime candidate for this type of ecosystem overfishing.⁴⁰

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Data on the diminishing ecological role of Atlantic menhaden, including depletion in Chesapeake Bay and the impact on both the future of the menhaden stock as well as on the fish and other marine life that depend on it, is not complete. More data, more research, more analyses and more analytical tools are necessary

to understand fully the intricate and delicate balance of menhaden within its environment. But much is already known. A growing body of scientific evidence raises red flags of

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concern about the amount of menhaden available as prey, especially in the Chesapeake Bay, and the declining health of predators. The situation forecasts trouble if these issues are not addressed promptly.

Achieving a menhaden population in the Chesapeake Bay robust enough to fulfill its critical role in the ecosystem requires a two-prong approach. First, research efforts must be intensified to better understand how the stock can be managed in a way that benefits both menhaden and the overall ecosystem. Second, in the interim, conservation measures must be adopted to ensure that, *at the very least*, the current situation does not deteriorate, jeopardizing the effectiveness of any future ecosystem-based planning for menhaden and the Chesapeake Bay.

Fortunately, the first step in this process is gaining traction. The ASMFC recently recognized limitations on the available data regarding the condition of menhaden in the Chesapeake Bay relative to its coastwide status and initiated the development of a new research plan for menhaden contingent on securing the necessary funding. To address technical limitations, both the ASMFC and the National Oceanic and Atmospheric Administration (NOAA) are developing working models of species interaction that will facilitate the management of inter-related species, like menhaden and striped bass.⁴¹

Realistically, however, it will be years before the new data and models can be formally incorporated into the management process.

In the meantime, prudent management dictates that short-term measures be employed to increase the margin of safety and reduce risks to the resource. The ASMFC's own scientists acknowledge that they lack methods to detect localized depletion and reduced ecological function, as forage and filter feeders, which could occur when the fishery is concentrated in the Chesapeake Bay. This uncertainty regarding the status of menhaden in the bay, as many scientists advocate, should lead to more conservative management measures.⁴² As previously stated, no management measures are currently in place to fully protect the menhaden population in the Chesapeake Bay. There are no limits on how many fish may be taken, how many may be of small, forage-size and where or when they may be caught. This must change.





RECOMMENDATIONS FOR ACTION

The coastal ecosystem, and in this case the Chesapeake Bay, cannot support the demands of increased populations of predatory fish and seabirds without increasing the supply of prey. Simply put, striped bass and a number of other predators are competing with the industrial-scale menhaden fishery for food, and they are losing the fight.

Accordingly, *Menhaden Matter*—a unique cooperative effort of concerned conservation and recreation organizations, including the Chesapeake Bay Foundation, Coastal Conservation Association, Environmental Defense and National Coalition for Marine Conservation—recommends that the Atlantic States Marine Fisheries Commission immediately take the following steps.

Adopt Proactive Measures on an Interim Basis: The ASMFC has begun a process to determine whether interim management measures should be taken to prevent what could be the ecologically harmful depletion of menhaden, particularly in the Chesapeake Bay.⁴³ Implementing such proactive management measures as soon as possible is critical. Interim measures to consider include:

- Set limits on the amount of menhaden that can be harvested in the Chesapeake Bay.

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- Delay the start of the fishing season to June 1st.
 - Implement time and area closures within the Virginia waters of the Chesapeake Bay.
 - Establish regional quotas through an area-based approach to management
 - Employ other management tools to minimize the risk of localized depletion.

Advance Long-term Ecosystem-based Management: In addition, the ASMFC also is considering new, longer-term management changes that include shifting the focus of its fisheries management process to an ecosystem-based approach. *Moving forward with this approach is important, but it does not—and should not—supplant the need to take interim management action now.*

Any long-term ecosystem-based planning should:

- Identify and apply management measures to achieve the existing plan objective to protect and maintain menhaden's ecological role along the coast.
- Develop new biological reference points to address and protect menhaden's role as forage and filter feeder.

In conclusion - *Menhaden Matter!* They matter to the health of estuaries and oceans and all marine life that these ecosystems support. They matter to the viability of resurging fish stocks such as striped bass and bluefish, whose survival depends on menhaden as a food source. They matter to other predators, seabirds such as loons and osprey, and marine mammals. They matter to the commercial and recreational fishing industries and to the watermen and anglers whose livelihoods and recreation depend on healthy fish stocks. And they matter to businesses and local economies that healthy fisheries support.



That is why it is critical that conservative action be taken now, while the foundation for future ecosystem-based management is laid. Otherwise, “the most important fish in the sea” will not be protected.



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- ³⁴ ASMFC 2004a.
- ³⁵ ASMFC Atlantic Menhaden Technical Committee report, February 2-3, 2004.
- ³⁶ ASMFC 2004b.
- ³⁷ Pew Oceans Commission. 2003. *America's Living Oceans: Charting a Course for Sea Change*. A Report to the Nation. May 2003. Pew Oceans Commission, Arlington, Virginia.
- ³⁸ When the Board is considering changes to its management program, both of these advisory groups are consulted. An opportunity for public input also is provided. Once a plan has been approved, each state is responsible for implementing fishery management measures consistent with it.
- ³⁹ Pikitch et al. 2004. Ecosystem-Based Fishery Management. *Science* 305:346-347.
- ⁴⁰ A recently completed "fishery ecosystem plan" for Chesapeake Bay singles out the Atlantic menhaden fishery management plan as "an appropriate candidate" for revision to incorporate ecosystem principles.
- ⁴¹ Ecosim with Ecopath under development through the Chesapeake Bay Office and the multi-species and spatial models under development at ASMFC.
- ⁴² Pikitch et al. 2004. NMFS 1999.
- ⁴³ ASMFC Atlantic Menhaden Board meeting minutes, May 2004.



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