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HEARING ON
Atlantic Menhaden Conservation and Harvesting: H.R. 3840 and H.R. 3841
BEFORE THE
COMMITTEE ON NATURAL RESOURCES
SUBCOMMITTEE ON FISHERIES, WILDLIFE AND OCEANS
U.S. HOUSE OF REPRESENTATIVES
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Menhaden: Considerations for Resource Management*

Madam Chairwoman and Members of the Committee, thank you for inviting me. I am John Everett. My statement runs counter to general beliefs, so it is more formal and referenced.

The analysis in this report is derived from a dozen years of personal inquiry on “forage fish” species that are closely related to menhaden in both biology and ecological role. That work is nearing publication. Nevertheless, the science supporting this report is mostly specific to menhaden or is common to clupeid forage species. It is being further developed with additional statistical analyses and ideas, and with co-authors, for journal publication. Meanwhile, this information is from the scientific literature – except the ideas that pull it all together.

Disclaimers: Omega Protein, Inc., the leading menhaden fishing firm, learned of my interest from my NMFS colleagues and has funded me to develop an exposition of my ideas as they apply to regulatory actions and the various menhaden studies that are being pursued by Federal and state authorities. The foundational idea of forage fish as predators was informally provided by a Russian scientist. It took a dozen years of inquiry to validate it and to learn the mechanisms and the enormous implications. These integrating concepts and their impacts are my own and predate any involvement with industry. They are not necessarily endorsed by anyone else affiliated with Ocean Associates, Inc., or any of its clients.

Introduction

Menhaden are an important part of coastal ecosystems and have a role whose importance we are only beginning to understand. Menhaden, like other clupeids, are omnivores (eat everything), and are not just consumers of phytoplankton (plants).

Menhaden cannot and do not discriminate among the species they eat, except by size. It is particularly important to know what a fish eats when it is abundant, as is menhaden, because it can exert a controlling influence on other fish stocks that are less fortunate. Scientists who work with live menhaden have known they are omnivores for over a century. However, there has been a disconnect between this knowledge and its application by the people to whom it is vital, including ecosystem modelers, stock assessment scientists, fisheries managers, and the public.

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This analysis will show:

- Menhaden are omnivores, and there is strong evidence of food deprivation;
- Menhaden eat fish eggs and larvae of ALL species that are in the areas they frequent,
- Menhaden compete with all other larvae and young juveniles for zooplankton,
- Menhaden eat some smaller phytoplankton, at least as juveniles, and adults eat some larger phytoplankton, but all stages eat all the animals they can catch,
- Menhaden mostly eat the animals that eat plants, excreting them as plant fertilizer thus worsening water quality, and probably leading to harmful algal blooms and fish kills,
- Menhaden fishing bycatch is among the lowest in the world, and
- “How many menhaden are enough” has more than one dimension.

Population Status and Ecological Role

Menhaden stocks are at a healthy level, lying well within definitions of “sustainable”. They are not overfished and overfishing is not occurring (NMFS 2006). Menhaden are not the only prey fish. Knapp (1950) conducted stomach analyses on 5,946 fish of 34 species of “all the important game and food fish on the Texas coast. Menhaden were found in 165 stomachs with a frequency of 2.8 percent. Only 11 of the 34 species had eaten menhaden and in these the frequency of occurrence never exceeded 10.0 percent. The frequency of food items in the diet of these fishes was shrimp 61.8 percent, fishes exclusive of the menhaden 34.2 percent, crabs 12.0 percent, squids 4.0 percent, and miscellaneous invertebrates 4.4 percent.” Menhaden were less than 3% of the diet and the author stated that this may be an overrepresentation because their distinctive gizzards were slow to digest and more identifiable.

In the Chesapeake Bay, Smith and Jones (2007) found that while menhaden were an important part of the diet of some striped bass, “it is clear some individual striped bass were not consuming menhaden.” Oviatt (1977) evaluated the fear of sport fishermen in Narragansett Bay that such a large portion of the biomass of menhaden was being taken by the industry that there was insufficient food for predator species. Her calculations showed “that even when menhaden abundances are so low that it is not commercially feasible to catch them, they are still sufficiently abundant to be a primary food source for predator fish.”

Many people are concerned about reports that fish stocks around the world are overfished and that society has been “fishing down the food chain”, taking fish from lower trophic levels. This results from some very bad science that based analyses on landings data. Under fisheries management, if a stock of cod or red snapper is overfished, landings are restricted during rebuilding and fall by design. The authors did not appreciate this simple concept. Thus, regions like the Gulf of Mexico, which have sustainable fisheries for lower trophic level species such as shrimp and menhaden, were reported to be in danger because the ratio of high to low trophic level species had fallen. Since shrimp and menhaden landings have remained unchanged (within natural variability) for decades, while predator landings are restricted, it wrongly seems that more of the bottom trophic levels are being taken. In actuality we are just taking fewer of the high level fish, so they can rebuild. This is good -- not the crisis relayed around the world. De Mutsert et al. (2008) show that landings cannot be used to make these overfishing determinations because many “reductions in fishery catches were attributable to changes in regulations, market forces, or fishing effort”, and not the lack of fish.

Lastly, there are assertions that menhaden are in danger because of reports of fewer eggs and very young menhaden. This is not the case. Menhaden have the characteristics of a self-regulating population. They eat their own eggs and larvae when they cross paths with them. They are unable to discriminate. The adults and late juveniles also compete for the same food. The more adults there are in the system, once sufficient capacity is reached to overcome natural predation and other losses, the fewer will be the numbers of menhaden making it through the early juvenile stage. Further, in the average annual coastwide survey of juvenile menhaden abundance, the index in the latest 20 years (1984-2004) is 4.3, and it was also 4.3 in the first 20 years of data (1958-78). Vaughan and Smith (1988) found a relationship between recruitment and population size, albeit not strong enough to allow a predictive capacity. Cannibalism and competition with their young may be important in explaining this, as is the environment. These authors also state “it appears that managing the fishery to maintain large numbers of spawners would prove fruitless and that environmental conditions may outweigh the availability of spawners in controlling subsequent recruitment” but that it is prudent to maintain a stock of older fish to guard against stock collapse.

The impact of menhaden on water quality.

Menhaden are omnivores, with a focus on zooplankton as larvae and as adults, and perhaps a higher proportion of phytoplankton during some part of the relatively short period they are juveniles. With such a diet, they will contribute to poor water quality, not improve it.

The view of menhaden as exclusive phytoplanktivores blindly swimming through and filtering algae (and only the algae) persists despite overwhelming evidence that they are omnivores, with little energy derived from plant life. Ecological and water quality modeling too often assumes they are only algae-eaters, even when it is acknowledged they do eat zooplankton (e.g., Lynch et al. 2006). Some even show menhaden production is linked to nutrient enrichment fostering more phytoplankton (e.g., Luo et al. 2001). These and other studies have ignored the science that shows zooplankton, not menhaden, are the first level algae consumers. It has become such pervasive “common knowledge” that some feeding studies have assumed menhaden are plant eaters and have only tested various phytoplankton, which they will eat if of the appropriate size. It is analogous to having humans served lettuce and broccoli. We will eat it, but many of us would prefer to have it with steak, particularly if it comes in the same grocery bag. Scientists who actually work with menhaden (as opposed to modelers and mathematicians) have known since at least the 1800s that they are omnivores, with the observation by James Peck (1893) that adult menhaden are indiscriminate in their filter feeding and eat materials in the proportion to which they occur. Somehow, an increasing chasm has developed in what is known by the field biologists and what is known by everyone else working with, or interested in, menhaden.

Filter feeding is too-often misunderstood and this is at the root of some inappropriate research, regulations, and legislation. Filter feeding is a way of catching food. It does not mean that this food is necessarily plants, or exclusively plants, or small, nor that there is not targeting of individual items, nor that if something other than a plant or a copepod is filtered, it is spit out. The largest whales are filter feeders, and some focus on large fish, but plants are not in their diet. None of the zooplankton community are immune from an always hungry menhaden with a large mouth that swims rapidly, or millions of its closest friends swimming together in a school. Durbin and Durbin found that adult menhaden gill rakers are optimized for the size of adult copepods, which they can filter at about 70% efficiency versus 25% for large phytoplankton, while swimming nearly 2 ft/sec. They also showed that menhaden eat large phytoplankton and zooplankton, excreting them as ammonia-N, which fertilizes the water and makes more algae, and that the stock of menhaden in Narragansett Bay contributes 56 % of the total stock of ammonia when they are present during May-November (Durbin and Durbin 1998). Oviatt et al. (1972) measured ammonia concentrations (from excretion) inside menhaden schools (small juveniles-100 mm, which can filter both algae and zooplankton) that were five times higher than ambient levels. They stated, "It is possible that fish excretion makes a significant contribution of NH_3 - N [ammonia-N] to fall phytoplankton blooms." The degradation in water quality extended 2.8 miles (4.5 km) downstream of the school. As she observed, the fertilizing effect is important, but it also needs to be weighed with the knowledge that the menhaden have removed the algae grazers, leaving algae free to rapidly expand to the limits of the nutrients.

Menhaden feed mostly on zooplankton at their youngest and at their mature stages, and perhaps all stages. For most of their lives they are optimized for eating zooplankton, animals that feed directly on phytoplankton or on even smaller animals that do. By eating zooplankton, and excreting their waste as fertilizer, algae density is increased, particularly of the problematic small sizes. For example Dagg (1995) showed that in a Gulf of Mexico estuary, "95% of the grazing [on algae] was by the microzooplankton community. The grazing contribution from the mesozooplankton [larger] community, comprised primarily of *Acartia tonsa,* is believed to be small because populations were kept low by predation and advective losses. Livingston (1981) in a study of zooplankton predators in a Texas lagoon, states "Juvenile menhaden and silversides were found to be visually obligate predators". Ted Durbin, noted menhaden scientist, said last November, "the role of menhaden in filtering plankton from the [Narragansett] Bay is more complicated than many people realize. By filter-feeding, menhaden reduce zooplankton populations, but such reductions allow phytoplankton to bloom. Also, he said wastes excreted by menhaden support phytoplankton growth" (Lord 2007). Durbin's (2007) presentation stated:

- The effect of menhaden grazing on small phytoplankton is negligible because of low filtration efficiency on small particles
- Large populations of menhaden will reduce zooplankton abundance, allowing phytoplankton blooms to occur
- Nutrient release by menhaden will enhance local phytoplankton growth
- The effect of menhaden grazing on larger phytoplankton and zooplankton, and their nutrient release, will favor smaller phytoplankton.

Stoecker and Govoni (1984) offered both phyto and zooplankton to menhaden larvae, and demonstrated that larval menhaden are selective feeders and will consume the largest zooplankton they can catch. They will eat some phytoplankton at first, but also eat tintinnids and copepods and other organisms that eat plants. Friedland (1984) and others have examined the physical attributes of menhaden gill-rakers at different life stages and estimated their selectivity for different food items and their filtration efficiencies, showing that as they grow, they shift to larger planktonic organisms. Friedland et al. (2006) suggest that as menhaden near the time for leaving the estuary and becoming migratory adults, their filtering apparatus becomes coarser and they lessen their ability to catch the smaller phytoplankton (but not the larger) because the fine spacing would be a hydrodynamic burden. June and Carlson (1971) found that larval menhaden are strict zooplanktivores, with a high preference for copepods, changing to a diet that includes phytoplankton as they lose their teeth during the juvenile stage, and that juveniles can filter smaller zooplankton than are eaten by the larval stage. Kjelson et al. (1975) found that the diet of post larval juveniles was ~99% copepods of several species. Further developmental changes occur as menhaden pass into adulthood, enabling them to filter copepod-sized articles most efficiently, such that each adult can clear 24.8 liters/min of copepods (Durbin and Durbin 1975).

Menhaden remove both the zooplankton and the large sizes of phytoplankton needed by many young fish and larger zooplankton, creating a food void for many organisms in their critical path to development. Menhaden are most numerous when they are larvae, have teeth, and cannot filter feed. As adults, they have minimal capability to filter algae. In between, as juveniles, they can eat mostly (99%) detritus and algae when in creeks and marshes (Lewis and Peters 1994), or mostly (99%) zooplankton when away from the marsh areas (Kjelson et al. 1975), which is most of the time. By analyzing fatty acids in juvenile menhaden. Jeffries (1973, found that 70% of stomach contents were zooplankton. *Brevoortia patronus*, Gulf menhaden, when compared to *B. gunteri*, finescale menhaden, have a finer mesh, "which enables it to select both small and large food items", whether plant or animal. In Mexican estuaries, 91.9% of *B. patronus* stomachs had some zooplankton with 28% of their diet consisting of zooplankton (Castillo-Rivera 1996), likely reflecting its proportion of the plankton assemblage at that location.

In the last few years has there been increased awareness that clupeid species digest food so rapidly that the "amorphous mass" found in stomachs in many early studies may well be the remains of zooplankton or larger animals. Recent research shows quite definitively that menhaden are predominately zooplanktivores as adults, or at all life stages (Smith and Jones 2007, Brush et al. 2007).

Maranger et al. (2008) show that global inputs of nitrogen have greatly increased over the years while its removal by fisheries (in transport to shore) has important controlling impacts but has not risen as fast. They conclude, "Given its impact, present and historic fishery harvest should be considered in regional budgeting of anthropogenic nitrogen in coastal ecosystems throughout the world." Thus, when filter feeders are protected, while predators are below virgin levels, zooplankton levels will be abnormally low. Reduced grazing pressure by zooplankton, combined with fish waste, will increase nitrogen and algae, degrading water quality.

We often hear how poor water quality has caused a fish kill. Often it is blamed on too much algae, but why is it that it is usually filter feeders that die in massive numbers? It is likely that fish are attracted to and eat zooplankton that are feeding on the algae in our well fertilized bays. With the ability to clear the zooplankton rapidly, the fish start excreting their waste as ammonia N within minutes and digestion is complete in a few hours. In the absence of grazing by the zooplankton, and in the presence of a several fold increase in fertilizer from the menhaden, the algae bloom, perhaps doubling every few hours (NOAA 2008), quickly exhaust their nutrients, and die. Decomposition bacteria, doubling every quarter hour, consume all the oxygen and cause the menhaden to die. This can all happen quickly in warm water and could be why fish in die offs are often filter feeders such as menhaden in bays and herring in the Great lakes.

Menhaden Populations are Limited by Food Availability

On its FAQ page, the GSMFC states that "The total gulf menhaden population is limited by available food, space, and habitat. Elimination of the reduction fishery will probably not result in a substantial population increase in the Gulf". The ASMFC (2001) also states that there is evidence of density dependence and cites studies including Vaughan and Smith (1988) who document a dramatic weight reduction in age 3 fish of 60% from 1976 to 1978, lasting through 1984, during a period of high menhaden abundance. Using the Atlantic menhaden database maintained by NMFS-Beaufort, this author performed additional standard statistical tests of differences and of relationships to test if the data still support this conclusion. Comparing the menhaden biomass with the weight-at-age for age 1, 2, and 3 menhaden, with all available data back to 1955, weights are clearly lower when population is high (P=0.00003 for age 3 fish).

Also, taking the latest 20 years (1985-2005) of the average weight of age 1 fish (112 grams) and comparing it to the first 20 years (1955-1975 - 149 grams) in the database, we see that the fish used to weigh 32% more. This is also very statistically significant (P=0.0002). This is an indicator of less density dependence in the Atlantic menhaden stock 50 years ago. Thus menhaden are like all other fish and animals and can become measurably density-dependent - they are thinner for their age when there are more mouths to share the food.

During the first 20 years, the fishery was relatively unfettered by state fishing prohibitions and caps (ASMFC 2006) and in that era of presumably healthy predatory fish (1955-1975), the individual young menhaden were relatively heavy, compared to now. Even then, however, they were constrained by food availability. As an analogy, we can change grams to pounds. Thus, it is as if a person weighing 149 pounds on a restricted diet is then further deprived of food so that they come to weigh 112 pounds. This is a powerful indicator that zooplankton, the basic engine of fish and shellfish production, and of algae consumption, are being over-harvested in the estuaries. If age 1 menhaden only weigh about 2/3 of what they should, they are probably always hungry and always feeding. As target feeders at first, numbering in the trillions, and then as filter feeders, they can out-compete most other larvae and young juvenile fish and shellfish for zooplankton. Their schooling behavior makes it nearly impossible for any to escape.

Since we know that the estuaries are full of algae, it is clear that algae provides very little of the sustenance of these Age 1 menhaden, and of the menhaden, only this age group is capable of eating it along with the zooplankton. The fact that oysters have normal growth rates (Maryland DNR 2007), provides confirmation that menhaden do not rely on algae for nutrition.

All the larval and juvenile fish that eat the same things in the estuaries where these young menhaden live are likewise probably starving. With high metabolic rates and lacking mobility and fat reserves, larvae must have nearly continuous access to food. The egg and larval stages are the most vulnerable for any fish. Predation is high and constant nutrition is mandatory for larvae. This is particularly important when menhaden themselves are food constrained. Menhaden are among the few fish that can, at some point in their lives, feed on all sizes of zooplankton, from the nearly bacteria-sized animals when they are young juveniles to nearly all larger zooplankton, at all menhaden life stages. They can create a bottleneck in the ability of many species to find food. The fact that correlations have not been built between the size of adult menhaden populations and the amount of young menhaden is likely due in part to their self regulating nature. Poor recruitment may not be a sign that there are too few spawning adults, but rather, all things being equal, that there are too many late juveniles and adults. When adults are numerous they prey on and compete with their own young – as well as those of all other suitably sized animals. Poor recruitment is not a sign of impending trouble if stocks of spawning adults are high. More is not always better.

Menhaden Impact on Zooplankton

Durbin and Durbin (1975) in analyses of the filtering ability of adult menhaden in a laboratory found a minimum-size as low as 0.013 mm, a maximum of 10 mm, and that each adult can clear 24.8 liters/min of copepods (Durbin and Durbin 1975). This size range covers all the species of concern in the estuaries, including fish and shellfish eggs and larvae, most of which are vulnerable to menhaden for days or weeks. Since menhaden mouths are much larger than the zooplankton offered in the laboratory, it is likely that larger animals that are in the path of menhaden and are also feeding on the zooplankton and each other, will also be consumed as they exhaust themselves from escape attempts during passage of the school.

Menhaden adults swim in schools, not only to reduce predatory attacks and increase hydrodynamic efficiency (e.g., Pitcher 1986) but also to exhaust their own prey, so that fish further back in the school can catch them, if they don't (Kils 1989). No laboratory feeding studies are known to have considered this, yet copepods, the primary zooplankton, can nearly always escape a one-on-one encounter with a planktivore, but not a school of them. Planktivores select food based on visual factors such as size, visibility, color, shape and motion. When prey is dense enough, selection is based on size, due to the higher energy content and visibility. Copepods can sense an oncoming predator and accelerate in a few milliseconds to 500-1,000 body lengths /sec. for a few seconds, leaving it with only a 7-24% chance of capture, per encounter. Their reaction time to avoid predation is very similar to the capabilities of planktivorous fish to capture copepods (Strickler et al. 2005).

Since menhaden are abundant, well within their natural variability levels, they can suppress zooplankton populations dramatically, depriving fish larvae, including sportfish and their own, of the ability to find food. Zooplankton is the primary food source of most fish larvae and also adult menhaden. Menhaden adults have been shown to reduce zooplankton populations, and in other areas, younger stages of other clupeids have been shown to consume much of the available zooplankton supply. In the coastal Baltic Sea, for example, young-of-year herring alone account for 35-60% of the zooplankton consumption (Springer and Peckman 1997). Rapidly consuming all the food available, menhaden can become measurably density-dependent - they are smaller and thinner for their age.

Bycatch Considerations

From time to time, concern is raised about bycatch. Many studies have been done in response. In all the menhaden bycatch studies, bycatch has never exceeded a few % and is most commonly at or below 1% (Austin, Kirkley and Lucy (1994) for Mid-Atlantic bight - 0.041%, Condrey (1994) for Alabama-Louisiana -1%; Guillory and Hutton (1982) for W. Louisiana - 1.3%; and Knapp (1950) for W. Louisiana – 0.07%.

The menhaden fishery is one of the most selective in the world, with a small bycatch, of which croaker is the principal species (about half of all) and most others are not charismatic species. The menhaden fishery bycatch should be put in perspective. Juvenile Atlantic herring, a close cousin of menhaden, have been observed to find dense zooplankton patches of very evasive copepods in turbid water within 30 minutes of formation, consuming the school in 30 minutes, with individual fish eating 2.4 zooplankton/sec (Kils 1992). In that 30 minutes, the average menhaden, among thousands in a small school would have eaten dozens or hundreds of organisms. The school together would have eaten millions, including countless fish eggs, larvae and very young juveniles that are included in the zooplankton.

Two US fishery management bodies deal with menhaden at the interstate level: the Atlantic States and the Gulf of Mexico Marine Fisheries Commissions. The ASMFC states in their latest stock assessment report: "*Bycatch (or incidental catch) of other fishes in menhaden purse seines has been examined since the late 1800s. Taking of non-target species is a relatively rare event, and the overall bycatch is insignificant.*" Among their references are menhaden bycatch studies in the Gulf of Mexico (ASMFC 2004). The GSMFC (2002) states "*While bycatch reduction is a major issue in many U.S. fisheries, the U.S. Gulf of Mexico menhaden industry has used bycatch reduction devices since the 1950s. Large non-target species which are netted during the menhaden fishing operation can slow the pumping and damage pumping gear; therefore, attempts are made to remove large bycatch organisms from the net prior to this process. Currently the industry employs a hose cage designed to prevent the larger fish from being drawn up into the pump system and a large fish excluder which serves to prevent the passage of larger, non-target species from entering the hold*". The Plan cites 6 studies of menhaden bycatch.

An EPA-funded report on Gulf fisheries states *"Due to the way the gear is operated, the menhaden purse seine fishery is considered to be a relatively "clean" fishery with little incidental harvest of non-target species."(Burrage et al. 1997).* This report has a good review of the various menhaden bycatch studies.

There is at least one voluntary agreement (Texas) whereby menhaden boats remove themselves from waters when state fisheries officials find abundant sportfish and notify the owners.

What is the value of menhaden to the recreational and commercial fisheries?

The science of valuing ecosystem components is at the discussion stage. There are no definitive assessments and no published attempts to value menhaden's "ecosystem services". However, Dr. James Kirkley of VIMS is leading a study to "Estimate and assess social and economic importance and value of menhaden to Chesapeake Bay stakeholders and region." Earlier studies failed to treat recreational and commercial fishing equally and have other analytical problems (Kirkley 2007). Considering that there are no community level studies, it is understandable that valuations that would also consider interspecies and environmental relationships do not exist.

The fact that there are no hard numbers does not mean we cannot use economic theory to better understand the system. In economic analysis, we normally would look at a situation from a micro (a firm or entity) and/or from a macro (the economy) perspective. From a micro view, we can look at an individual fish in terms of its value. We know that menhaden are food-limited, and from field and laboratory research we know that menhaden can clear the water of food as they pass through. If one fish is removed from a school, the food it would have eaten is then used by some other fish in the school. The future energy is not lost and flows to other fish in the school. Fewer fish die of starvation or weakness (in a realm of predators), and each becomes a little bigger with somewhat more food value to those who eat it. Thus, one fish, or some reasonable number of fish, has little or no economic value to the ecology after removal because its nutritional worth is assumed by others and future food or harvest is undiminished. Its instantaneous value to the fisher or a predator is its only value. Since there are alternative food sources for predators, including other menhaden, the predator populations will be unaffected, as will be those who harvest them. The primary value of these fish above the point where food starts to become a constraint on productivity lies in their value to the human users. Below that level, they have value to all.

Maximum productivity in virtually any population occurs at a level substantially below the carrying capacity of the ecosystem. When populations are reduced, fish, just as mammals, reach maturity faster, have more and healthier young, are resistant to disease, are better able to defend themselves, and, very importantly in warm estuaries, are less able to transmit crowding-dependent diseases to each other. Whether deer in a residential community or a menhaden in a Texas bay, each population will quickly out eat its food supply as soon as its predators are reduced. We do not want to re-introduce wolves into our back yards nor do we wish to stop our commercial and recreational fisheries. We are left with little choice but to thin the stocks ourselves. It is particularly important with menhaden because their food is not just our ornamental plants, but it is the food of the young fish everyone cares about, and the fish themselves, as well as the small animals that eat the algae turning our waters green.

Thus, there is more value in removing a fish, or even 20% of the population, because the overall biomass of menhaden (forage base) will stay the same, while the number of predatory mouths will be reduced. Maximum production in fish stocks generally occurs when the population is markedly lower (up to half) than its virgin level or carrying capacity (Caddy and Csirke 1983). Just as is shown here for menhaden, Atlantic herring (a menhaden cousin) have been found to be 30-50% reduced in weight-at-age due to food constraints when at high population levels (Cardinale and Arrhenius 2000). The menhaden population is out of balance with its ecosystem when it approaches carrying capacity levels. With reduced natural predators, menhaden will expand beyond its natural level, making it difficult for any species with reduced spawning ability (such as from overfishing, disease, or reduced habitat) to overcome predation and competition by menhaden and other filter feeders. Recreational and commercial fishing are both very important contributors to coastal economies. The true value is difficult to obtain because statistics are imperfect and can be manipulated to underwrite virtually any policy objective. Clearly, menhaden are an important food resource for coastal birds, predatory fish and marine mammals. They are also an important input for our meat, manufacturing, and health industries. Both sectors provide economic, food, aesthetic, and health benefits but the important aspects are seldom treated similarly during comparisons. Menhaden have a value and they have a cost.

Impact on Other Fisheries

Since Atlantic menhaden are within their range of natural variation while Maryland Chesapeake Bay oyster “abundance remains at approximately 1% of historic levels” (Maryland DNR 2007) the ratio of menhaden stocks to oyster stocks has changed by a factor of about 100. This is far more than sufficient to consider that the impacts of menhaden predation on oyster larvae may be part of the oyster problem in the Chesapeake and elsewhere. Further clues from the same Maryland DNR (2007) report that menhaden may be behind this problem include: oyster growth rates are unchanged (their food is not limiting); and natural mortality rates have risen from 10% to as much as 90%. With respect to blue crabs, their population remains depressed and recruitment is poor (NOAA, 2007). Consideration should also be given to the possibility of menhaden predation and food competition with crabs (larvae (zoeae) up to crab stage 4 (9mm)), given their several weeks of exposure to menhaden. There are likely relationships with other problematic species that also bear scrutiny. Note that oysters are not food-deprived, while menhaden are very food-limited. This verifies they have different diets: algae vs. animals.

Localized Depletion

Recently, the concept of localized depletion has been brought before fisheries managers. Some fear that if a menhaden school or several schools are removed, there will be insufficient prey for some species. There are several reasons this is an unfounded fear. An extensive tagging study resolved this issue, while addressing the parent issue of whether there are separate stocks of Atlantic menhaden. Through recapture of nearly 70,000 tags, Nicholson (1972) reported that the fish move north (spring) and south (fall) along the coast, spawning along each way, and intermix during the winter, off the Carolinas, where most of the spawning occurs. Further "all menhaden do not return to the same area they occupied the previous year".

Fish that prey on menhaden of the size in the fishery are very large and mobile. As predators, they are capable of searching for and discerning their prey over great distances. Even small predators, such as juvenile herring, can find zooplankton aggregations within minutes of formation. Since menhaden are one of several forage fish it is hard to argue that there could be any important depletion of just one portion of an animal's diet. Further, not all menhaden are in schools, as is indicated by the records from fish traps. If there were localized depletion, it would be a good thing. The algae eaters would quickly recover (in a couple weeks) and the oyster larvae and young crabs would have a chance to reach settlement age, while the youngest striped bass would have something to eat.

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