24 October 2017

Ms. Megan Ware
Fishery Management Plan Coordinator
Atlantic States Marine Fisheries Commission
1050 N. Highland Street, Suite 200 A-N
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Dear Ms. Ware:

On 3 August 2017, the Atlantic States Marine Fisheries Commission (ASMFC) requested comments from the public on Draft Amendment 3 to its Interstate Fishery Management Plan (FMP) for Atlantic Menhaden. The amendment proposes the use of 'ecological reference points' (ERPs) for the setting of catch targets and limits for the Atlantic menhaden fishery, and options for the allocation of catch among fishing sectors and states. The Marine Mammal Commission (the Commission), in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the draft amendment and offers comments on the proposed use of ERPs.

In 2010, the ASMFC initiated the development of ERPs, which could be used to set fishing mortality and fecundity (biomass) targets and thresholds that would explicitly and dynamically account for the needs of predators of Atlantic menhaden. The ASMFC recognized the importance of forage species such as menhaden in converting phytoplankton biomass and energy into a food source for a large number of marine fish, bird, and mammal predators throughout the inshore and nearshore waters of the eastern U.S. (Curry et al. 2000, Smith et al. 2011). It further recognized that excessive depletion of menhaden could have negative consequences for predators that rely on menhaden as a source of energy and nutrients, and for the structure and dynamics of the nearshore ecosystem.

The use of ERPs would allow for the sustainable harvesting of menhaden, while leaving enough for the needs of the other predators. Since 2015, the Biological Ecological Reference Points Workgroup (BERP) has been meeting and working to develop ERPs and a suite of multispecies assessment models for the Atlantic menhaden fishery. The implementation of Atlantic menhaden-specific ERPs as part of the stock's FMP is not expected to occur until 2020 at the earliest. Therefore, the ASMFC is proposing the use of generic, 'rule-of-thumb' ERPs for forage species as part of the management of Atlantic menhaden under Amendment 3.

Draft Amendment 3 proposes five alternative 'rule-of-thumb' ERPs. These reference points define the target and threshold fishing mortality rates and biomass levels (respectively, F_{target}, $F_{threshold}$, B_{target}, $B_{threshold}$). Two alternatives are status quo options, and the other three are options based on the recommendations of Smith et al. (2011) and Pikitch et al. (2012) (see the Ecological Reference Points section below):

A. Indefinite use of the single-species reference points defined in the most recent amendment to the FMP.
B. Interim use of the single-species reference points, and the continued development by the BERP of menhaden-specific ERPs.
C. Continued BERP development of ERPs, and interim use of the Pikitch et al. reference points, which prohibit fishing below a biomass level that is 40 percent of the unfished biomass, B_0 ($B<B_{threshold}=B_{40\%}$); i.e., $F_{threshold}=0$), and scales the target fishing mortality rate (F_{target}) linearly from zero at $B_{40\%}$ to approximately 0.37 at B_0, which is equal to 0.5M, the natural mortality rate (see the 'hockey-stick' control rule in Figure 1 of the Draft Amendment 3 document, with its accompanying explanation).
D. Continued BERP development of ERPs, and interim use of the Smith et al. '75% rule-of-thumb' reference points, which set a fishing mortality rate (F_{target}) that at equilibrium would achieve a biomass level of $B_{75\%}$ (i.e., $B_{target}=0.75B_0$); this option does not have threshold reference points.
E. Continued BERP development of ERPs, and interim use of the Smith et al. 75% reference points, with a $B_{40\%}$ no fishing threshold (i.e., F_{target} achieves $B_{75\%}$, and $F_{threshold}$ achieves $B_{40\%}$).

Recommendations

Based on available scientific information and management experience (see the Background and Rationale Addendum below), the Commission notes that 1) forage species are critical, foundational components of marine ecosystems, 2) marine mammals are dependent on healthy, functioning ecosystems, 3) many marine mammals depend on the forage species component of such ecosystems, and 4) a single-species approach to the management of forage species is problematic and risky. Therefore, the effective management of fisheries for forage species requires an ecosystem context and precautionary approach. The Commission is aware, however, that ascertaining the magnitude and form of linkages between the effects of fishing on forage species and the population dynamics of dependent predators such as marine mammals is complex and difficult. Nonetheless, it is difficult to deny the logical conclusion that the severe depletion of stocks of forage species would have significant population consequences for their dependent predators, and particularly on those predators that have little behavioral plasticity in terms of diet and foraging strategy. Therefore, the use of ERPs tailored to each specific fishery-predator-prey system, as the ASMFC is doing, should be seriously considered as a potentially better approach than the use of traditional single-species management.

Given the uncertainty associated with ecosystem relationships and the intention to develop new, ecosystem-based, stock-assessment methods, it will be some time before the ASMFC can implement an EBFM approach to the management of menhaden that accounts for the needs of marine mammals and other predators. Therefore, the Commission recommends that the ASMFC approve the use of rule-of-thumb ERPs, based on the recommendations of Smith et al. (2011) and Pikitch et al. (2012). The chosen ERPs should meet two criteria: 1) an increase in the likelihood of maintaining a sufficient availability of menhaden to predators and 2) significantly reduce the risk of stock collapse due to overfishing and the effects of other drivers such as climate variability. Specifically, the Commission favors the use of Option C or E, both of which meet the two criteria. The Commission believes that this approach would, given the considerable uncertainty about the impacts of menhaden fishing, provide an important buffer or hedge against the risks to dependent predator populations. In addition, the use of rule-of-thumb ERPs should provide valuable experience and data on the status of menhaden, its predators, and the functioning ecosystem under a precautionary, ecosystem-based management system based on the use of ERPs. The Commission encourages the ASMFC, in keeping with the current trend to establish precautionary, ecosystem-based fisheries management (EBFM) in the U.S., continue its precedent-setting efforts to implement a system that will simultaneously help ensure the sustainability of the menhaden fishery, the conservation of predator populations, and the health of the ecosystem.

I hope these comments are helpful. Please contact me if you have questions.

Sincerely,

Rebecca J. Lent

Rebecca J. Lent, Ph.D.,
Executive Director

Background and Rationale Addendum

Atlantic menhaden (*Brevoortia tyrannus*) is a large, common, locally abundant, herring-like forage fish found from Florida to Nova Scotia. Atlantic menhaden have been recorded to live up to 10 or 12 years, although they now rarely live beyond six years (apparently due to the impacts of fishing), and adults can grow to 15 inches. They spawn offshore and the larvae are transported by currents to estuaries where the juveniles develop. Menhaden filter feed on phytoplankton and zooplankton and can form large, compact shoals of juveniles and adults in estuaries and nearshore waters, which attract numerous predators, including striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), Altlantic cod (*Gadus morhua*), bald eagles (*Haliaeetus leucocephalus*), osprey (*Pandion haliaetus*), bottlenose dolphins (*Tursiops truncatus*), humpback whales (*Megaptera novaeangliae*) and fin whales (*Balaenoptera physalus*) (Reeves et al. 2002). Because menhaden are very oily and bony they are not usually directly consumed by humans, but large purse-seine fisheries harvest them for bait and the production of fishmeal and fish oil.

The Atlantic menhaden fishery is managed by the ASMFC's Atlantic Menhaden Management Board. By landed weight, the Atlantic menhaden fishery is second in the U.S. only to the pollock fishery in Alaska. The reduction (fishmeal) fishery began in the mid-1880s and peaked in the 1950s with landings of over 700,000 metric tons, when there were 20 reduction factories on the East Coast. Total landings are dominated by the reduction fishery, which accounted for over 90 percent of the average annual landings of 250-425 thousand metric tons through the 1990s. However, since the late 1990s, the relative importance of the bait fishery has increased steadily to nearly 35% of the total in the last few years. Since 2002, total landings have averaged approximately 160-225 thousand metric tons, and since 2006, just one reduction plant has operated on the East Coast.

Based on recent stock assessments, it is apparent that the biomass harvested in the 1950s was unsustainable. Estimated population biomass was depleted from nearly 2.3 million metric tons in 1958 to just under 700,000 metric tons in 1997. Since 1960, the fishery has stayed below the current overfishing threshold and has often been near the fishing mortality target, and since around 2000, fishing mortality has been consistently below its target. However, for much of the last 60 years, the reproductive potential of the population, as measured by fecundity (number of eggs produced), has rarely approached its target, and has often been below the overfished threshold.[1] The exception has been the last ten years, with fecundity consistently high and approaching its target.

The overfishing and overfished targets and thresholds used in the current FMP were derived from a single-species stock-assessment model (ASMFC 2017), based on single-species reference points. Those reference points call for the substantial reduction of the stock to achieve an optimal yield. At equilibrium, the target fishing rate would remove roughly 70% of the population's spawning potential (a measure of stock biomass) each year and reduce equilibrium population spawning potential to 36% of its maximum. The overfishing threshold is set at a removal of roughly 81% of the spawning potential, and the overfished threshold is set at 21% of the maximum spawning potential. These reference points are based on a model that treats the population in isolation from its ecosystem, but not from fisheries, and that does not explicitly take into account consumption by various predators. Like most stock assessment models, the model includes a

[1] In this fishery, fecundity (number of eggs) is used as a more direct measure of reproductive output than spawning stock biomass, which is the more typical measure of reproductive output. Both the fishing mortality and biomass targets and thresholds are based on fecundity, and estimated from the stock recruitment relationship (fecundity per recruit in this case).

constant 'natural mortality' parameter that is meant to include the effects of predators and abiotic factors, but it is not linked to the spatial or temporal dynamics of those sources of natural mortality.

Importance of Forage Fish

Forage fish are important prey of numerous marine mammal species. One study (Kaschner et al. 2006) estimated that, worldwide, marine mammals consume roughly 20 million tons of forage fish per annum. Pauly et al. (1998) collated diet information on marine mammals, and found that forage fish made up 25 percent or more of the diet for several species, including common minke whales (*Balaenoptera acutorostrata*); Atlantic humpback (S*ousa teuszii*), and Pacific white-sided (*Lagenorhynchus obliquidens*) dolphins; harbor porpoises (*Phocoena phocoena*); California sea lions (*Zalophus californianus*); northern fur seals (*Callorhinus ursinus*); and harbor (*Phoca vitulina*), harp (*Pagophilus groenlandicus*) and gray (*Halichoerus grypus*) seals. In Newfoundland, capelin (*Mallotus villosus*) was found to be the primary prey of humpback, fin, and minke whales (Piatt et al. 1989, Whitehead and Carscadden 1985). Harp seals eat large quantities of juvenile cod (Plagányi and Butterworth 2009), and in the winter in the Barents Sea they rely on herring (*Clupea harengus*; Nilssen 1995). In addition, although killer whales (*Orcinus orca*) are well known to consume other marine mammals and large fish (e.g., salmon), eco-types in the northeastern Atlantic specialize on herring and mackerel (*Scomber scombrus*; Bloch and Lockyer 1988, Christensen 1982, Evans 1988, Sigurjónsson et al. 1988). Little has been published on the consumption of Atlantic menhaden by marine mammals, but it is known to be a component of the diet of a few species, most notably bottlenose dolphins (Gannon and Waples 2004), and fin and humpback whales.

Fisheries – Marine Mammal Competition

Demonstrating that the population dynamics of marine mammals would be affected by the depletion of their prey by fisheries is difficult (Matthiopoulos et al. 2008, Morissette et al. 2016, Read 2008). It requires 1) linking depletion in abundance of prey species to reduced availability of prey to predators, which in turn results in 2) population consequences for those predators, such as reduced health, survivorship and/or fecundity, which, in turn, eventually results in 3) a decline in the number or diversity of predators. It also requires that the predator is prey limited. Demonstrating this linkage is difficult because focal fishery-predator-prey systems 1) are complex, 2) are not easily manipulated, 3) typically function over large spatial and temporal time scales, 4) do not allow easy differentiation between the effects of anthropogenic and natural drivers (e.g., Lindegren et al. 2013), and 5) usually do not have replicates that can be used for comparative studies. Moreover, 6) the requisite data are difficult to collect (Bowen and Siniff 1999, Morrisette et al. 2012), and 7) predators adapt by switching prey, thus obscuring predator-prey dependencies. This means that one cannot expect simple, linear, proportional responses by a component of an ecosystem (e.g., a predator) to a perturbation of some other component, such as the depletion of a prey resource. Several studies have provided evidence of a correlation between the depletion of prey by fishing and changes in marine mammals, including 1) Antarctic krill (*Euphausia superba*), several fishes, southern minke whales (*Balaenoptera bonaerensis*) and several seal species in the Southern Ocean (Ainley and Blight 2008, Beddington and May 1982, Bengtson and Laws 1985, Ballance et al. 2006, Laws 1977), 2) Alaska pollock (*Gadus chalcogrammus*) and Steller sea lions (*Eumetopias jubatus*) in Alaska (e.g., Springer et al. 2003, Cornick et al. 2006, Fay and Punt 2006, Atkinson et al. 2008; see however, Dillingham et al. 2011, Trites et al. 1997), 3) capelin and fin whales in Canada (Whitehead and Carscadden 1985), 4) European anchovies (*Engraulis encrasicolus*), European pilchard (*Sardina pilchardus*) and short-beaked common dolphins (*Delphinus delphis*) in the Mediterranean Sea (Bearzi et al. 2003, Piroddi et al. 2010, 2011), and 5) northern anchovies (*Engraulis mordax*), Pacific sardines (*Sardinops sagax*), and California sea lions in California (McClatchie et al. 2016).

Precautionary Fisheries Management

Since the advent of the concept of 'maximum sustainable yield' (MSY) in the 1930s (Russell 1933, Graham 1935) and its operationalization in the 1950s (Beverton and Holt 1957), fisheries scientists have been seeking a formulation that reliably predicts, over long periods, sustainable harvest levels for marine fish stocks. However, it was quickly realized that MSY management was problematic for a variety of reasons (Larkin 1977; see references in Mangel et al. 2002, Smith and Punt 2001), and that it often led to the collapse of stocks (Larkin 1977). In subsequent decades, the science has improved and fisheries managers have learned to use better-performing 'optimum yield' approaches (Sissenwine 1978, Smith and Punt 2001), and, in the United States at least, the number of stocks that are experiencing overfishing (realized fishing rate > fishing rate threshold) or are overfished (actual biomass < biomass threshold) has declined significantly in recent years.[2] These gains have been made largely by taking a more precautionary approach to the harvesting of wild fish stocks (Mace et al. 2013, Smith and Punt 2001). NMFS's National Standard One guidelines now state that "consideration should be given to managing forage stocks for higher biomass than [the biomass needed to produce maximum sustainable yield] to enhance and protect the marine ecosystem."[3] That guideline is consistent with a central goal of the Marine Mammal Protection Act, that marine mammals "should be protected and encouraged to develop to the greatest extent feasible commensurate with sound policies of resource management and that the primary objective of their management should be to maintain the health and stability of the marine ecosystem."[4] An important manifestation of the precautionary approach to fisheries management is known as 'ecosystem-based fisheries management' (EBFM), which seeks to "sustain healthy marine ecosystems and fisheries they support" (Pikitch et al. 2004). Fisheries management bodies around the United States have, in recent years, taken steps toward EBFM (e.g., Link et al. 2011). Some prominent EBFM approaches toward the harvesting and protection of forage fish include the 1) establishment of precautionary catch limits for Antarctic krill by the Commission for the Conservation of Antarctic Living Resources (Constable et al. 2000), 2) use by the Pacific Fishery Management Council and Alaska Department of Fish and Game of control rules that effectively set aside a portion of forage fish biomass (anchovies and sardines, and herring, respectively) for predators (PFMC 2013, 2016; Carlisle 1998), and 3) the prohibition of fishing on forage species by the North Pacific and Mid-Atlantic Fishery Management Councils (MAFMC 2017).

Ecological Reference Points

Simulation studies of multiple ecosystems using several different models (Smith et al. 2011) suggested that the harvesting of forage species produced large population-level impacts on different groups of marine predators, including marine mammals, especially when multiple forage species were harvested simultaneously. Smith et al. (2011) investigated the effects of different fishing strategies on predators, and found that impacts could be substantially reduced by lowering depletion

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[2] http://www.nmfs.noaa.gov/sfa/fisheries_eco/status_of_fisheries/fssi.html
[3] 50 C.F.R. §600.305
[4] 16 U.S.C. 1361

targets from a typical value of 40 percent (60 percent of unfished biomass) to 25 percent (75 percent of unfished biomass), while reducing long-term yields of the target forage fish by only 20 percent. In a similar exercise, the Lenfest Forage Fish Task Force examined the potential effects of the depletion of forage fish on their predators (Pikitch et al. 2012). They concluded that fishing on forage fish could put dependent predator populations at risk of collapse. They recommended that forage fish be managed to maintain population sizes (biomass) well above levels typical of single-species, MSY, or optimum-sustainable-yield management. Specifically, they recommended that managers use harvest control rules that are designed to maintain biomass near 75 percent of its unfished level, and that would close fisheries when that biomass falls below 40 percent. The recommendations from these two studies can be used as generic, rule-of-thumb ERPs for the management of forage species, although they noted that stock-specific ERPs are preferable.

A recent paper by Hilborn et al. (2017) looked for relationships between fishing on forage species and population changes in dependent predators. They concluded that ecosystem modeling has generally overestimated the impact of forage fishing on dependent predators because it has not taken into account important factors such as the high level of natural variability in forage fish populations, the weak stock-recruit relationship in such populations, and size-selective predation. Further, they found little empirical evidence of a correlation between forage fish abundance and changes in predator populations. These results are however disputed by the Lenfest Task Force (Pikitch et al. *in press,* Hilborn et al. *in press*). It is clear, however, that assessing the effects of fishing on forage fish and their predators is difficult, subject to uncertainty, and best examined on a case-by-case basis.

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