Introduction

This document presents a summary of the 2017 Stock Assessment Update for Atlantic menhaden. The assessment is an update to the 2015 Benchmark Stock Assessment that was peer-reviewed by an independent panel of scientific experts through the 40th SouthEast, Data, Assessment, and Review (SEDAR) workshop. This assessment is the latest and best information available on the status of the coast-wide Atlantic menhaden stock for use in fisheries management.

Management Overview

The Atlantic menhaden stock is currently managed under Amendment 2 (2012) to the Fishery Management Plan. Amendment 2 instituted a 170,800 metric ton (mt) total allowable catch (TAC) beginning in 2013 and established state-by-state allocations based on landings history from 2009-2011. States are required to close their fisheries when their portion of the TAC has been reached and any overages must be paid back the following year. Under Amendment 2, the Atlantic Menhaden Management Board (Board) also sets aside 1% of the overall TAC for episodic events and allows a 6,000 pound bycatch limit per trip for non-directed fisheries that operate after a jurisdiction's quota has been landed.

In 2015, the Board established an 187,880 mt TAC for the 2015 and 2016 fishing years. This represented a 10% increase from the 2013 and 2014 TAC. In October 2016, the Board approved a TAC of 200,000 mt for the 2017 fishing year, representing a 6.45% increase from the 2015 and 2016 fishing years. Both increases stemmed from results of the 2015 Stock Assessment as well as projection analysis.

Amendment 3 to the Atlantic Menhaden FMP was initiated in 2015 to consider the development of ecological reference points (ERPs) and revisit allocation methods. Given the role of menhaden as forage fish, ERPs are intended to account for changes in the abundance of prey and predator species when setting overfished/overfishing thresholds and targets for menhaden. The Board is also investigating various allocation scenarios given concern that the current method does not provide equitable access to all gear types, jurisdictions, and regions. Draft Amendment 3 is slated for public hearings this fall, and the Board is scheduled to take final action on the Amendment in November 2017. In additional, the Board will be selecting a TAC for 2018.

What Data Were Used?

The Atlantic menhaden assessment used both fishery-dependent and -independent data as well as information about Atlantic menhaden biology and life history. Fishery-dependent data come from the commercial reduction and bait fisheries, while fishery-independent data are collected through scientific research and surveys.

Life History

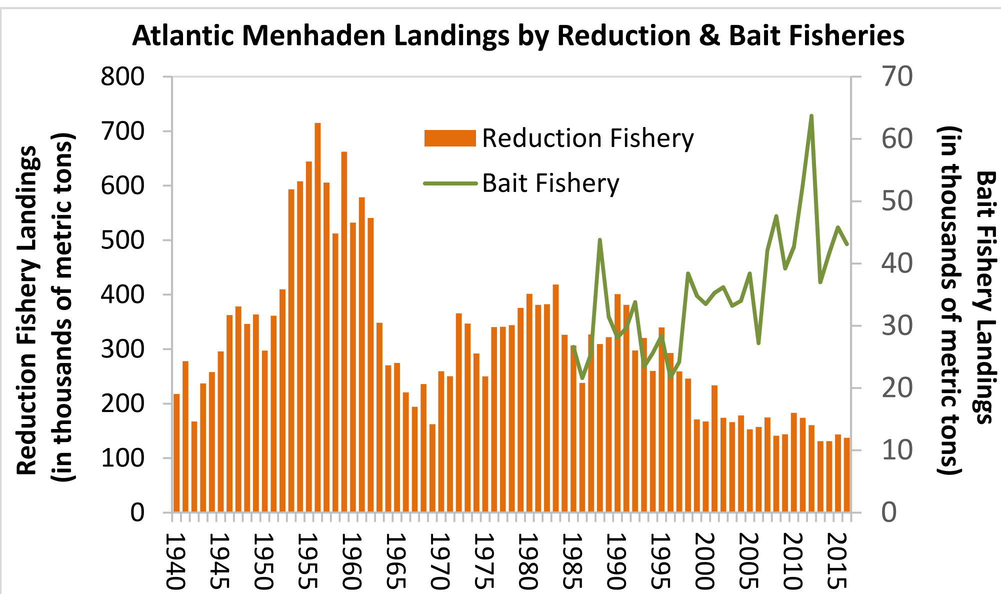
Atlantic menhaden undergo extensive north-south migratory movements and are believed to consist of a single population. Adults move inshore and northward in the spring, grouping by age and size along the Atlantic coast. During the summer, older and larger menhaden are typically found in northerly habitats whereas immature menhaden are typically found in estuarine and inshore areas from the Chesapeake Bay southward. The population extends as far north as the Gulf of Maine though menhaden abundance in the northern extent of its range can significantly fluctuate from year to year. Spawning occurs along the continental shelf as well as in sounds and bays. Eggs hatch at sea and larvae are carried by inshore currents to estuaries where they grow to the juvenile stage. Adults typically overwinter off the coast of North Carolina. Menhaden start reaching sexual maturity at age-1 and can live up to 10 years; however, fish older than age-6 have been uncommon in the fishery-dependent data since the mid-1960s. Natural mortality is modeled as age-varying with the highest mortality on the youngest fish.

Commercial Data

The Reduction Fishery

Atlantic menhaden are harvested primarily for reduction to fish meal, oil, and solubles. The reduction fishery grew with the advent of purse seine gear in the mid-1800s. Purse seine landings peaked in 1956 at 712,500 mt. At the time, over 20 menhaden reduction factories were in operation from southern Maine to northern Florida. In the 1960s, the Atlantic menhaden stock contracted geographically, and many of the fish factories north of the Chesapeake Bay closed because of a scarcity of fish. Reduction landings dropped to a low of 162,300 mt in 1969.

In the 1970s and 1980s, the menhaden population began to expand (primarily because of a series of large year classes entering the fishery), and reduction landings rose to around 300,000-400,000 mt. Adult menhaden were again abundant in the northern half of their range and as a result reduction factories in New England and Canada began processing menhaden again. However, by 1989 all shore-side reduction plants in New England had closed, mainly because of odor abatement regulations.



During the 1990s, the Atlantic menhaden stock contracted again, mostly due to a series of poor year classes. Over the next decade, several reduction plants consolidated or closed, resulting in a significant decrease in fleet size and fishing capacity. Since 2005, there has been one operational reduction factory processing Atlantic menhaden on the Atlantic coast. From 2010-2012, landings averaged 172,600 mt. Following the implementation of the coastwide TAC, landings in 2013 were 131,000 mt. In 2016, reduction landings were 137,400 mt and accounted for approximately 76% of coastwide landings. Numerous portside samples are taken to obtain information about the weight, length, and age distribution of the fished population.

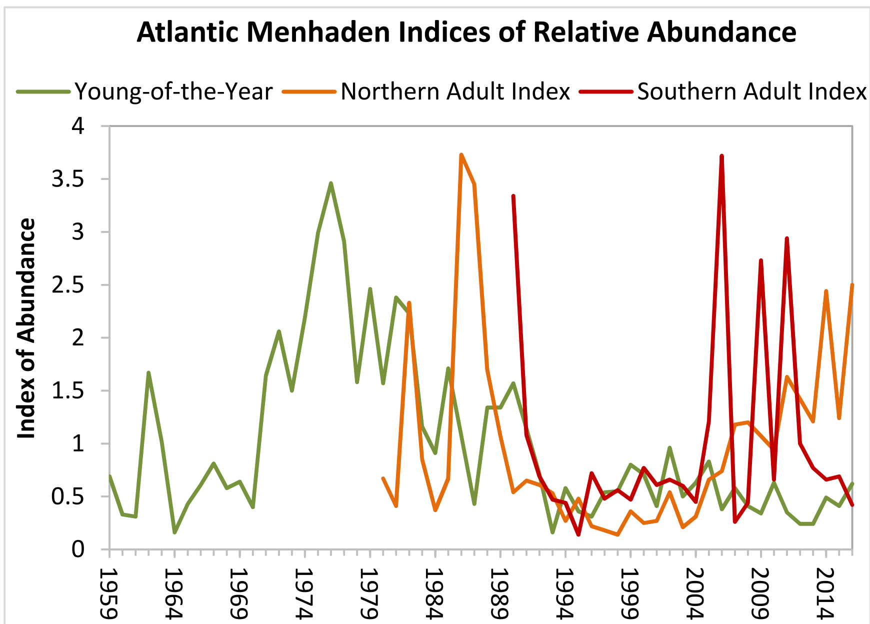
The Bait Fishery

While reduction landings have declined since the mid-2000s, menhaden landings for bait have become increasingly important to the total coastwide landings of menhaden. Commercial bait landings occur in almost every Atlantic coast state. A majority of the menhaden-for-bait landings are used commercially in crab, lobster, and hook-and-line fisheries. Recreational fishermen also catch Atlantic menhaden as bait for various game fish.

Total landings of menhaden for bait along the Atlantic Coast averaged 53,000 mt annually in 2010-2012. Following the implementation of the coastwide TAC, landings in 2013 were 37,000 mt. In 2016, bait landings were 43,100 mtons and comprised 24% of coastwide landings. Since the mid-1980s, portside samples have been taken to obtain information about the weight, length, and age distribution of the fished population.

Fishery-Independent Surveys

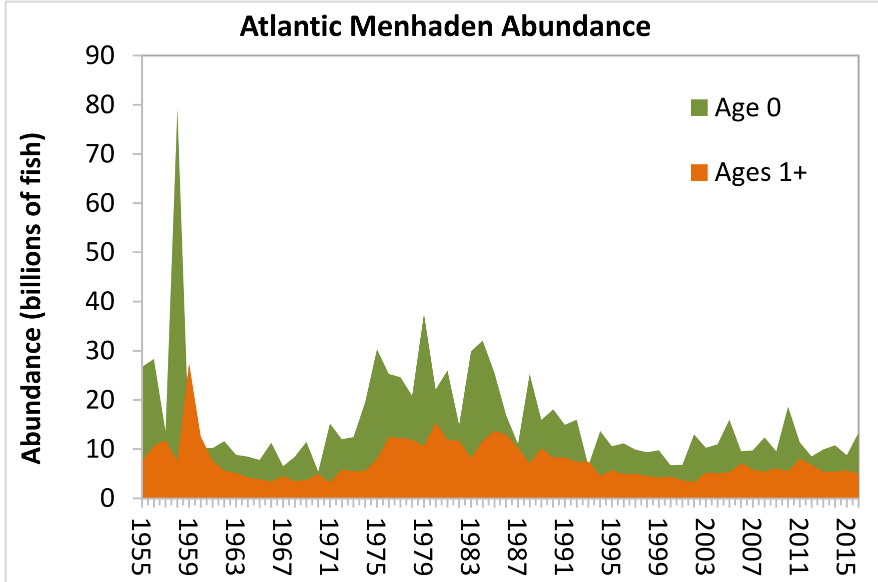
Data collected from several different surveys were used in the 2015 stock assessment and 2017 update. These data were used to inform both juvenile and adult abundance within the model. Data used to develop an index of relative abundance for juvenile menhaden (young-of-the-year) were collected from seine surveys conducted in Connecticut, New York, New Jersey, Virginia, and Maryland; from trawl surveys in Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and Georgia; and from an electrofishing survey in South Carolina. Data from these 16 surveys were statistically combined into one coastwide index. The index increased from historic lows in the 1960s to highs in the 1970s and 1980s, with a decline through the mid-1990s. Young-of-year abundance has since been lower with notable year classes in 2005, 2010, and 2016.

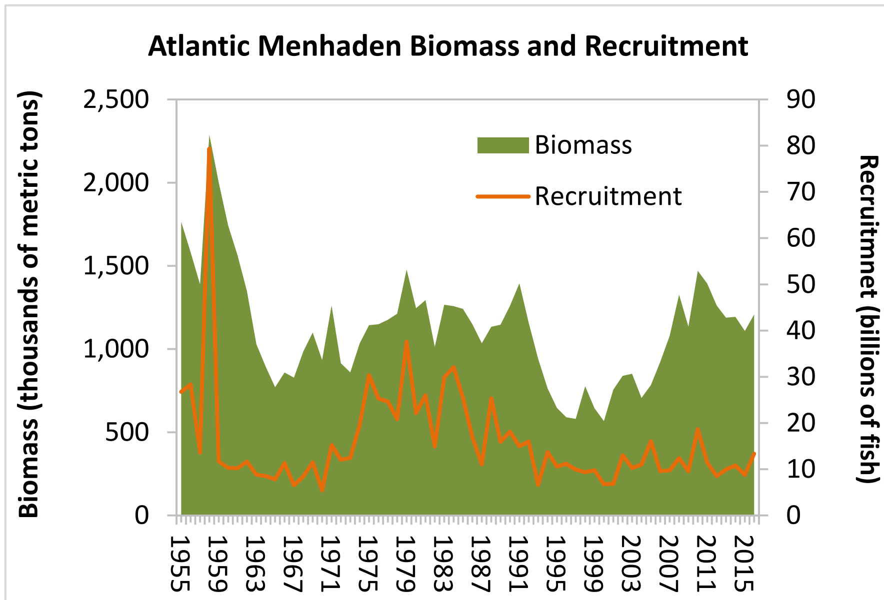


Two adult abundance indices were developed using state survey data. The first was the southern adult index (SAD), which included trawl survey data from Georgia and the Southeast Area Monitoring and Assessment Program. The second was the northern adult index (NAD), which included trawl survey data from Connecticut, New Jersey, Delaware, Virginia, Chesapeake Bay Multispecies Monitoring and Assessment Program, and Chesapeake Bay Fishery-independent Multispecies Survey. Data from each of the surveys were statistically combined into the two coastwide indices of adult abundance.

The SAD index was low through the 1990s and early 2000s. Throughout the mid-2000s and early-2010s it was highly variable and has been on a decline since 2012. The NAD index was high during the 1980s, declined to a low around 2000, and has been increasing since then. 2014 and 2016 represented two of the largest values in the NAD index, second only to 1987 and 1988. In the most recent years, the NAD index indicated an increase in abundance for ages-2+, while the SAD index indicated a slightly decreasing abundance for age-1.

What Models Were Used?



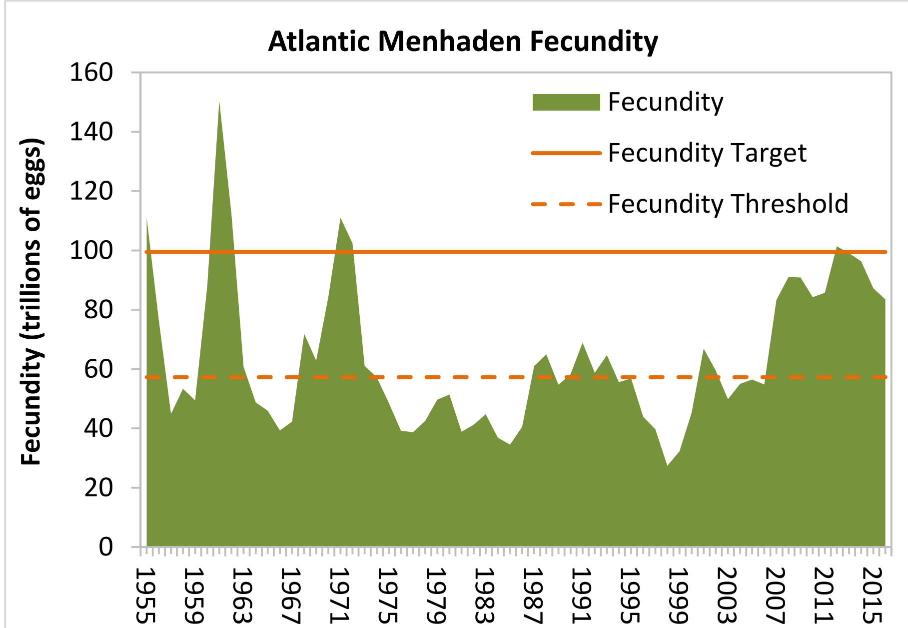


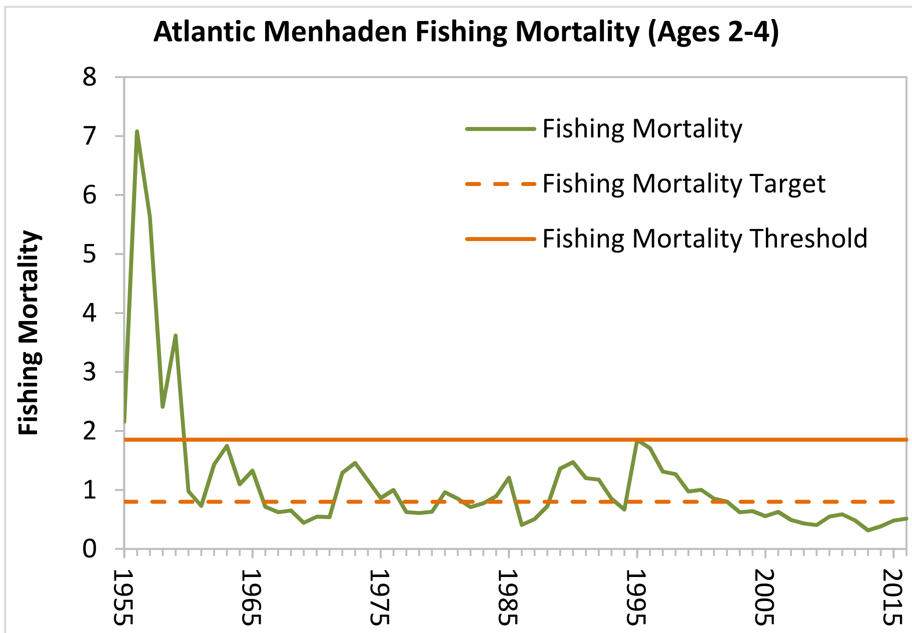
The Beaufort Assessment Model (BAM), which was used for providing management advice during the 2015 benchmark stock assessment. Using the same model, additional years of data (2013-2016) were incorporated into the 2017 update. BAM is a statistical catch-at-age model that estimates population size-at-age and recruitment, using 1955 as the based year, and then projects the population forward in time. The model estimates trends in the population, including abundance-at-age, recruitment, spawning stock biomass, egg production, and fishing mortality rates. BAM was configured to be a fleets-as-areas model with each of the fleets broken into areas to reflect differences along the coast. This means that both reduction and bait fleets were split into north and south regions because the fisheries operated differently along the coast and through time.

Model results indicate the population has undergone several periods of both high and low abundance. Following a peak in the late 1950s, abundance was high in the 1970s and 1980s, with a decline in the 1990s and a subsequent increase in the 2000s. Juvenile abundance follows a similar pattern with highs in the 1970s and 1980s, a decline in the 1990s, and a slight increase during the 2000s. Population fecundity (measured as number of maturing ova, or eggs) is variable in the beginning of the time series, with many highs and lows. After a period of low fecundity in the 1990s, fecundity has been increasing since the mid-2000s.

Fishing mortality rates were highly variable throughout the entire time series, with a decline in fishing mortality from the 1950s to the 1960s. Since the early 2000s, fishing mortality rates have declined to some of the lowest values in the entire time series. The model suggests a high degree of variability, but in general the reduction fishery has experienced declining fishing mortality rates since the 1950s in the north and since 2000 in the south. The bait fishery has expanded since the 1980s causing some increase in fishing mortality in the north and south.

What is the Status of the Stock?





Based on the assessment update, Atlantic menhaden are neither overfished nor experiencing overfishing. Stock status was evaluated against the assessment's reference points, which used historical performance of the population during the 1960-2012 time frame, a period during which the Technical Committee considers the population to have been sustainably fished. Fishing mortality rates have remained below the overfishing threshold (1.85) since the 1960s, and hovered around the overfishing target (0.8) through the 1990s. In 2003, fishing mortality dropped below the target and was estimated to be 0.51 in 2016 (the latest year in the assessment update). Generally, fishing mortality has been decreasing throughout the history of the fishery, has been below the threshold since the early 1960s, and has been below the target since the early 2000s.

The biological reference point used to determine the fecundity target is defined as the mature egg production one would expect when the population is being fished at the threshold fishing mortality rate. Population fecundity, a measure of reproductive capacity, has been well above the threshold (57,295 billion eggs) and at or near the target (99,467 billion eggs) in recent years. In 2016, fecundity is estimated to be 83,486 billion eggs, still well above the threshold but below the target.

Why are the Reference Points for the Update Different from the 2015 Benchmark Assessment?

The stock status stemming from the 2017 update assessment is assessed in the same way as the status from the 2015 benchmark assessment, although the reference point values have changed. The threshold and target are calculated as the maximum and median geometric mean fishing mortality rate for ages-2 to -4 during 1960-2012 using the same methods as the benchmark assessment. Adding the additional years (2013-2016) of data results in generally higher fishing mortality values throughout the time series. This is primarily an effect of the NAD which shows significant increases in menhaden abundance in the Mid-Atlantic and New England states, thus affecting the scaling of the reference points. This trend supports the higher landings values reported by the northern states in recent years. Since the estimated maximum and median fishing morality values associated with the update are higher than the 2015 benchmark, the resulting reference points are $F_{36\%MSP}$, $F_{21\%MSP}$, $FEC_{36\%MSP}$, and $FEC_{21\%MSP}$ which differ from the 2015 reference points of $F_{57\%MSP}$, $F_{38\%MSP}$, $FEC_{57\%MSP}$, and $FEC_{38\%MSP}$. While the scale is different and the trend differs in some years, the stock status for both fishing mortality rate (F) and fecundity (FEC) has been similar over the past decade. For reference, MSP is the estimated egg production from the female reproductive population that would occur if there was no fishing. %MSP can be used to measure the health of a stock, with a higher %MSP indicating that egg production is closer to that of an unfished stock. The use of MSP was adopted in 2012 under Amendment 2 as an interim reference point with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species while the Commission's develops ecological-based reference points for the resource.

Reference Points	*Update Values*
$F_{21\%MSP\ (THRESHOLD)} = 1.85$ $F_{36\%MSP\ (TARGET)} = 0.80$	$F_{48\%MSP}$ (F in 2016) = 0.51
$FEC_{21\%MSP\ (THRESHOLD)}$ = 57,295 billion eggs $FEC_{36\%MSP\ (TARGET)}$ = 99,467 billion eggs	FEC_{2016} = 83,486 billion eggs

Research Needs & Next Steps

Both the 2015 benchmark assessment and the 2017 update identified a number of data and research needs for future Atlantic menhaden stock assessments. In particular, the Atlantic menhaden stock assessment would be substantially improved by the development of a coastwide fishery-independent survey to replace or supplement the existing indices. Also, development of a spatially-explicit (e.g., regional) stock assessment model would be beneficial once sufficient age-specific data on movement rates of menhaden are available.

Currently, the Biological Ecological Reference Point Workgroup is developing menhaden-specific ERPs based on multi-species models. The purpose of this analysis is to consider the ecological role of menhaden as prey when determining an overfished and overfishing status. This work was noted as a high priority by the 2015 Peer Review Panel and is expected to be complete in 2019 in conjunction with the 2019 benchmark stock assessment.

Glossary

Age class – All of the individuals in a stock that were spawned or hatched in the same year. This is also known as the year class or cohort.

Biological reference point (BRP) – A particular value of stock size, catch, fishing effort, or fishing mortality that may be used as a measure of stock status or management plan effectiveness. BRPs can be categorized as limits, targets, or thresholds depending on their intended use.

Fecundity (FEC) – The number of eggs produced per female per unit time (e.g., per spawning season).

Fishing mortality (F) – The instantaneous (not annual) rate at which fish are killed by fishing

Maximum spawning potential (MSP) – The estimated egg production from female spawning stock biomass that would occur in the absence of fishing. A percentage of this value (%MSP) can be used as a measure of the health of a fish stock.

Recruitment – A measure of the weight or number of fish that enter a defined portion of the stock, such as the spawning stock or fishable stock.

Overfishing – A condition in which the rate of removal of fish by the fishery exceeds to the ability of the stock to replenish itself.

Overfished – A condition in which there is insufficient mature female biomass or egg production to replenish the stock.

Statistical catch-at-age (SCAA) model – An age-structured stock assessment model that works forward in time to estimate population size and fishing mortality in each year. It assumes some the catch-at-age data have a known level of error.

Young-of-the-year (YOY) – An individual fish in its first year of life; for most species, YOY are juveniles.

References

ASMFC. 2017. Atlantic Menhaden Stock Assessment Update. ASMFC, Arlington, VA. 183pp.

SEDAR. 2015. SEDAR 40 – Atlantic Menhaden Stock Assessment Report. SEDAR, North Charleston SC. 643 pp. http://www.asmfc.org/uploads/file/55089931S40_AtlMenhadenSAR_CombinedFINAL_1.15.2015-reduced.pdf