
Image courtesy of Brian Gratwicke

Introduction

This document presents a summary of the 2015 benchmark stock assessment for Atlantic menhaden. The assessment 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 coastwide Atlantic menhaden stock for use in fisheries management.

Management Overview

The first Fishery Management Plan (FMP) for Atlantic menhaden was developed in 1981, providing managers with a suite of options for managing the fishery. Soon after, a combination of state restrictions, local land use rules, and changing economic conditions resulted in the closure of all but three Atlantic coast menhaden reduction plants north of Virginia by the early 1990s. Currently, one reduction plant operates seasonally in Reedville, Virginia.

In 1988, the Atlantic States Marine Fisheries Commission (Commission) initiated a revision to the FMP. The Plan Revision included a suite of objectives to improve data collection and promote awareness of the fishery and its research needs, including six management triggers used to annually evaluate the menhaden stock and fishery. In 2001, Amendment 1 was passed, providing specific biological, social, economic, ecological, and management objectives for the fishery.

Addendum I (2004) established a new set of biological reference points. Addendum II (2005) initiated a five-year research program for Chesapeake Bay aimed at examining the possibility of localized depletion. Addendum III (2006) instituted a harvest cap of 109,020 metric tons for reduction landings from Chesapeake Bay (2006-2010) and a provision allowing under-harvest in one year to be credited only to the following year's harvest, not to exceed 122,740 metric tons. Addendum IV (2009) extended the Chesapeake Bay harvest cap three additional years (2011-2013) at the same cap levels.

Addendum V (2011) established the current F threshold and target rate (based on maximum spawning potential; MSP) with the goal of increasing abundance, spawning stock biomass, and menhaden availability as a forage species. In response to the findings of the 2010 benchmark stock assessment and 2012 assessment update, Amendment 2 (2012) established new biological reference points for biomass based on MSP and instituted a 170,800 metric ton total allowable catch (TAC) beginning in 2013. The TAC was allocated on a state-by-state basis based on landings history of the fishery from 2009-2011. States are required to close their fisheries when the state-specific portion of the TAC has been reached; any overages must be paid back the following year. Finally, Amendment 2 enabled the Atlantic Menhaden Management Board to set aside 1% of the overall TAC for episodic events. If the episodic event set aside quota is unused as of October 31, it is redistributed to all the states on November 1 based on the Amendment 2 allocation percentages.

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.

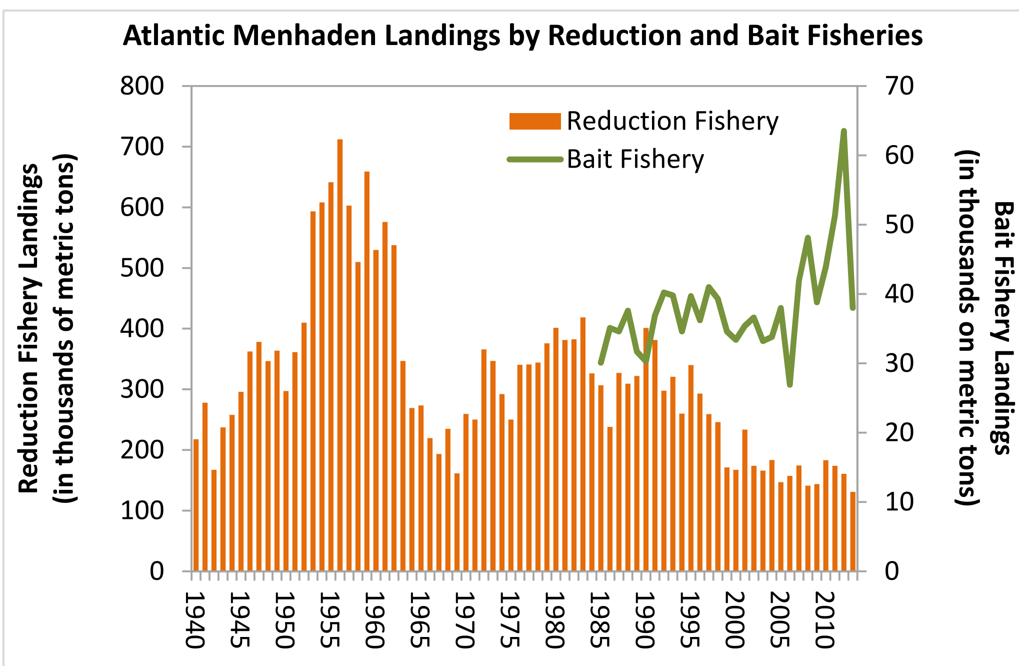
Life History

Atlantic menhaden undergo extensive north-south migratory movements and are believed to consist of a single population. Adults move inshore and northward in spring and group by age and size along the Atlantic coast. Older, larger menhaden are typically found in colder, northerly habitats during summer whereas immature menhaden are found in large numbers in estuarine and inshore areas from Chesapeake Bay southward. The population extends as far north as the Gulf of Maine though it has been recorded that since the mid-1800s its occurrence has fluctuated tremendously from year to year from periods of great abundance to periods of scarcity or compete absence. Spawning occurs in oceanic waters along the continental shelf as well as in sounds and bays in the northern extent of their range. Eggs hatch at sea and larvae are carried by inshore currents to estuaries where they transform to the juvenile stage soon upon arrival. Adults overwinter off the coast of North Carolina. Menhaden start maturing 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 was modeled as age-varying with the highest mortality on the youngest fish and was scaled to values estimated using the historical tagging data.

Commercial Data

The Reduction Fishery

Atlantic menhaden are harvested primarily for reduction to fish meal, fish oil, and fish solubles. The reduction fishery grew with the advent of purse seine gear in the mid-1800s. Purse seine landings reached a high point in the 1950s with peak landings of 712,100 metric tons in 1956. At the time, over 20 menhaden reduction factories ranged from northern Florida to southern Maine. In the 1960s, the Atlantic menhaden stock contracted geographically, and many of the fish factories north of Chesapeake Bay closed because of a scarcity of fish. Reduction landings dropped to a low of 161,000 metric tons in 1969.



In the 1970s and 1980s, the menhaden population began to expand (primarily because of a series of above average year classes entering the fishery), and reduction landings rose to around 300,000-400,000 metric tons. 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 by the mid-1970s. 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 (as in the 1960s) mostly due to a series of poor to average 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. In recent years (2010-2012), landings averaged 172,600 metric tons. Landings in 2013 were 131,031 metric tons with the implementation of Amendment 2 and the coastwide TAC. Numerous portside samples are taken to obtain information about the weight, length, and age distribution of the fished population.

The Bait Fishery

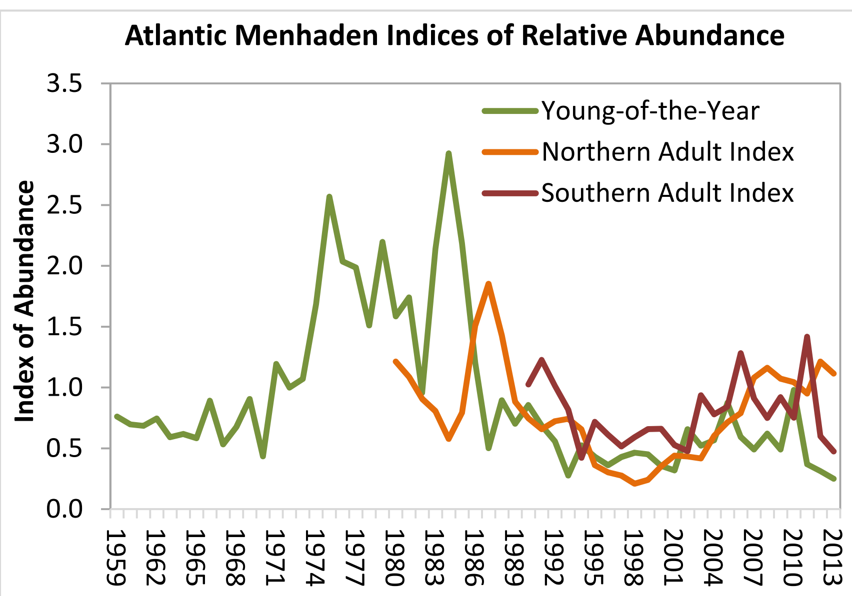
As reduction landings have declined in recent years, menhaden landings for bait have become relatively more important to the coastwide total landings of menhaden. Commercial landings of menhaden for bait occur in almost every Atlantic coast state. Recreational fishermen also catch Atlantic menhaden as bait for various game fish. A majority of the menhaden-for-bait landings are used commercially as bait for crab pots, lobster pots, and hook-and-line fisheries.

Total landings of menhaden for bait along the US East Coast have been increasing in recent years, averaging about 52,900 metric tons during 2010-2012, with peak landings of about 63,540 metric tons in 2012. Between 2001 and 2012, the percent of total menhaden landings attributed to the bait fishery rose from 13% to a high of 28% in 2012. In 2013, bait landings were approximately 22% of the total menhaden harvest.

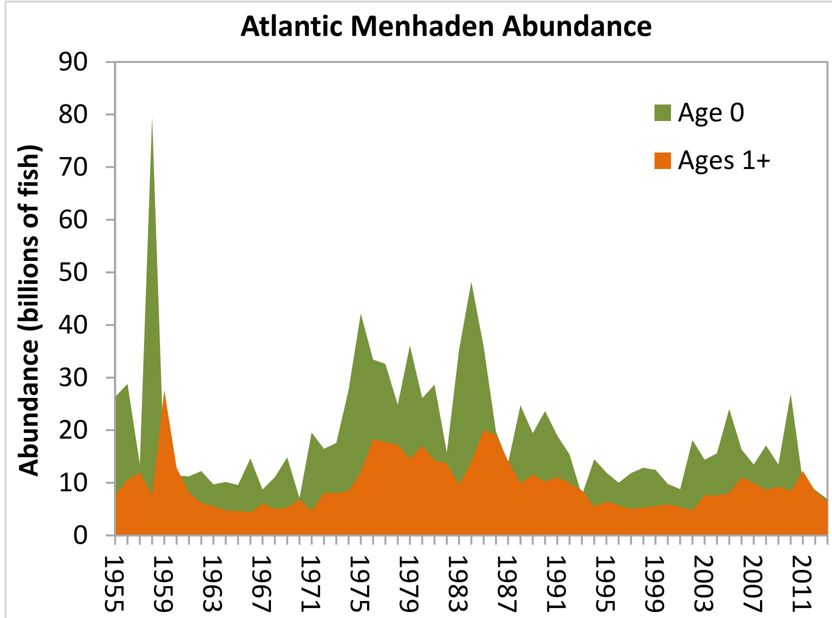
Since the mid-1980s, portside samples have been taken to obtain information about the weight, length, and age distribution of the fished population.

Fishery-Independent Surveys

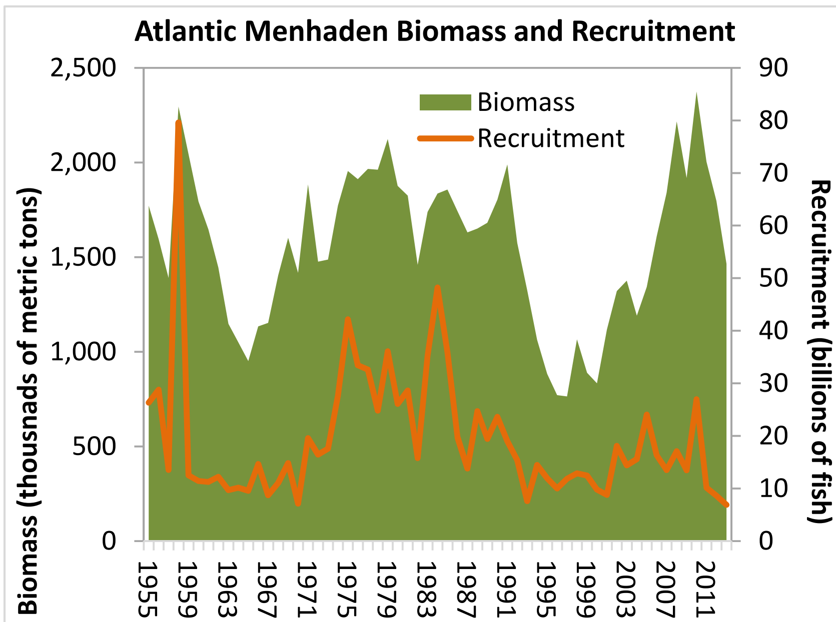
Data collected from several different types of gears were used in the 2015 stock assessment. These data were used to inform both recruitment and adult abundance within the model. Data used to develop an index of relative abundance for juvenile menhaden were collected from seine surveys conducted in Connecticut, 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. Although menhaden are a bycatch species in these surveys, the seine catch-per-effort data represent the best available information for the construction of a menhaden juvenile abundance index. Data from these 16 surveys were statistically combined into one coastwide index. Inclusion of the trawl juvenile survey data in the development of the juvenile index



represented a significant improvement from the 2010 assessment. The index increased from historic lows in the 1960s to the largest recruitments in the 1970s and 1980s with a decline through the mid-1990s and increasing thereafter with fairly stable recruitment.



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. This represents a significant improvement from the 2010 assessment that only used one pound net survey index from the Chesapeake Bay to characterize adult abundance.



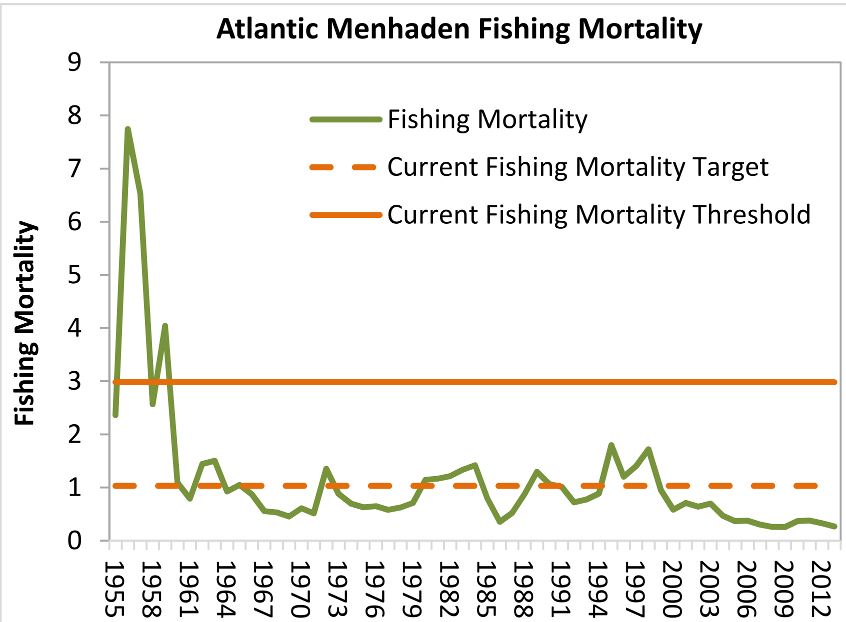
The SAD index was highest in the mid to late 2000s. The NAD index was high during the 1980s, declined to a low around 2000, and has been increasing since. For the adult indices, length composition data were available. Length data were used to estimate selectivity for each adult index. In addition, the length data provided evidence that the reduction fishery is not capturing all size classes of fish in the population, thus indicating dome-shaped selectivity.

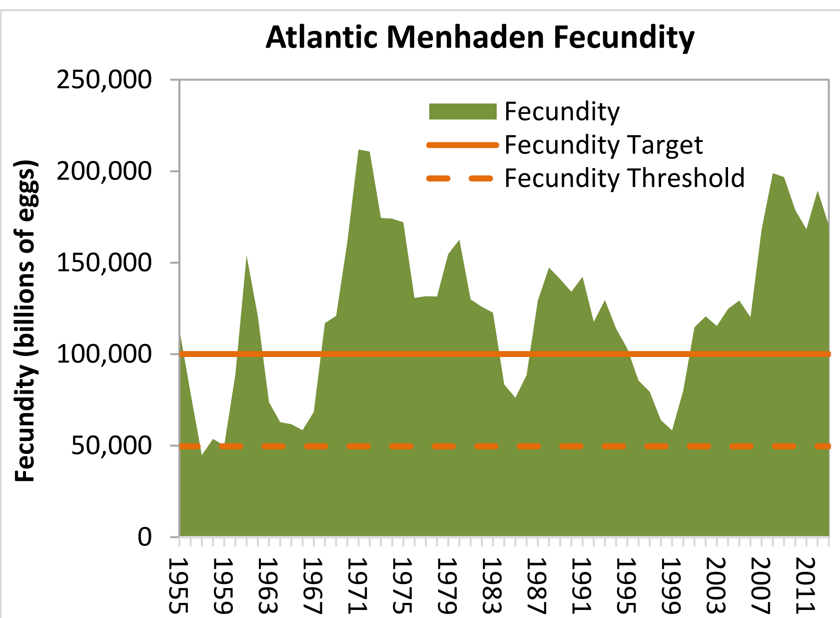
What Models Were Used?

Two alternative modeling approaches were pursued, including the Beaufort Assessment Model (BAM) and Stock Synthesis 3. After comparing model performance, reliability, flexibility, and assumption requirements among the alternatives, the BAM was chosen as the base model for providing management advice.

The BAM is a statistical catch-at-age model that estimates population size at age and recruitment in 1955 and then projects the population forward in time to 2013. The model estimates trends in population dynamics, including abundance at age, recruitment, spawning stock biomass, egg production, and fishing mortality rates. The BAM was configured to be a fleets-as-areas model with each of the fishery fleets being broken into areas to reflect difference in selectivity 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 over the time series. Abundance was highest in the 1970s and 1980s with a decline in the 1990s and an increase during the 2000s. Recruitment (age 0 fish) followed a similar pattern with highs in the 1970s and 1980s, a decline in the 1990s, and an increase during the 2000s. Population fecundity (measured as number of maturing ova, or eggs) was highest in the early 1970s and late 2000s and low in the 1950s, 1960s, and 1990s.





Fishing mortality rates were highly variable throughout the entire time series, with a decline in fishing mortality from the 1950s to the 1960s. Since 2000 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, while the bait fishery has experienced increasing fishing mortality rates since the 1980s.

What is the Status of the Stock?

In 2014, the population was not overfished and overfishing was not occurring, relative to the current MSP-based biological reference points. The overfishing threshold for menhaden is $F_{15\%MSP}$=2.98. The fishing mortality rates over time have been below the overfishing threshold except during the 1950s. For most of the time series, the fishing mortality rate has hovered around the target of $F_{30\%MSP}$ =1.03 and more recently has been below the target. Full fishing mortality in 2013 (the latest year in the assessment) is estimated at F_{2013}=0.27, which was below both the target and threshold, hence overfishing is not occurring.

The biological reference point that determines the fecundity target for Atlantic menhaden is defined as the mature egg production one would expect when the population is being fished at the threshold fishing mortality rate. Population fecundity was estimated to be well above the threshold and above the target in recent years as well. This means that the spawning stock in 2013 appears to be adequate to produce the target number of eggs, and thus the population is deemed not overfished.

Why are the Findings so Different from those of the 2010 Benchmark Assessment?

Through the consideration of new and existing datasets and the exploration of alternative model configurations, significant changes were made during the 2015 assessment to address the issues identified with the 2010 assessment. Below are a few of the major changes that led to significantly different assessment results.

1. Using new datasets, maturity at age was corrected, resulting in a higher estimated proportion of mature fish at ages 1, 2, and 3. This higher proportion of mature fish at the earlier ages resulted in a stock that had higher reproductive potential (i.e., increased fecundity) than previously estimated.
2. Two composite adult indices of relative abundance were created using nine new standardized fishery-independent indices that spanned a much broader spatial scale. This was a significant improvement from the 2010 benchmark assessment that used one Chesapeake Bay fishery-dependent pound net index to characterize adult abundance for the entire stock.
3. Dome-shaped selectivity for all fishery fleets was used to account for the fact that larger sized individuals were observed in multiple fishery-independent surveys than captured by the bait and reduction fisheries during the entire history of sampling. This ultimately results in more fish at older ages because the larger fish are not being captured by the fisheries.

Data and Research Needs

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. Accurate information on trends in abundance over time is critical for determining stock status and population trajectory in stock assessments. 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. Spatially explicit modeling would help to better characterize the movements of both the population and fishery allowing for better management practices on a regional basis.

Whom Do I Contact For More Information?

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