
Image courtesy of Brian Gratwicke

Introduction

This document presents a summary of the 2022 Atlantic Menhaden Single-Species Stock Assessment Update. The assessment is an update to the 2019 Atlantic Menhaden Single-Species Benchmark Stock Assessment that was peer-reviewed by an independent panel of scientific experts through the 69th SouthEast, Data, Assessment, and Review (SEDAR) workshop along with the Ecological Reference Points Stock Assessment.

The stock assessment update added data through 2021, reran the peer-reviewed Beaufort Assessment Model (BAM), and determined stock status of Atlantic menhaden using the ecological reference points (ERPs) that were accepted for management use in 2020. The ERP assessment was not updated at this time. This assessment update is the latest and best information available on the status of the coastwide Atlantic menhaden stock for use in fisheries management. Both the Atlantic menhaden single-species and ERP reports are scheduled for benchmark assessments together in 2025.

Management Overview

Atlantic menhaden is currently managed under Amendment 3 (2017) to the Interstate Fishery Management Plan (FMP). Amendment 3 changed fishery allocations from Amendment 2 (2012) in order to strike a better balance between gear types and jurisdictions. The Amendment allocates a 0.5% baseline quota to each jurisdiction and then allocates the rest of the annual total allowable catch (TAC) based on landings between 2009 and 2011. The Amendment also maintains the quota transfer process, prohibits the rollover of unused quota, maintains the 6,000-pound trip limit for non-directed and small-scale gears following the closure of a directed fishery, and sets aside 1% of the TAC for episodic events in the states of New York through Maine.

The ERP assessment evaluated the health of the stock in an ecosystem context, and indicated that the fishing mortality reference points for menhaden should be lower to account for menhaden's role as a forage fish. Following the approval of ERPs for use in the management of Atlantic menhaden, the Atlantic Menhaden Management Board (Board) set the 2021-2022 TAC at 194,400 metric tons which represented a 10% reduction from the previous TAC. Additionally, the Board initiated a draft addendum to consider changes to commercial allocations, episodic events, and the incidental catch and small-scale fisheries provision, which is currently out for public comment (see here).

What Data Were Used?

The assessment update 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.

COVID-19 did impact data collection for fishery-dependent and fishery-independent sources, which resulted in some additional uncertainty in the results. However, the models used in the assessment can accommodate missing data, so the assessment was able to use a terminal year of 2021 despite the pandemic disruptions.

Single-Species Assessment Overview

Life History

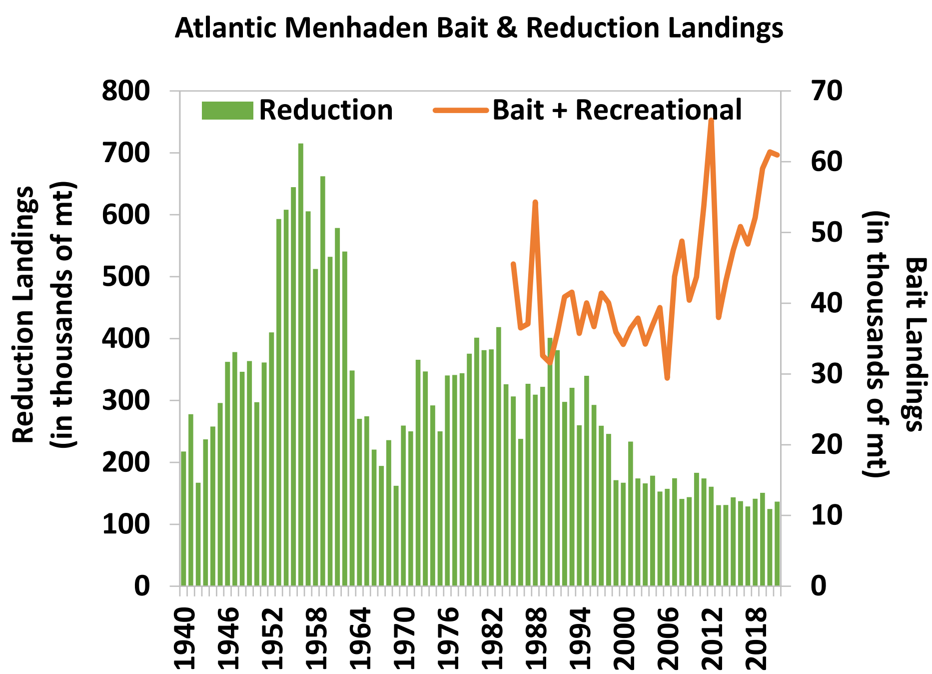
Atlantic menhaden undergo extensive north-south migratory movements and are believed to consist of a single population. Adults move inshore and northward in the spring, grouping by age and size along the Atlantic coast. During the summer, older and larger menhaden are typically found in northerly habitats, whereas immature menhaden are typically found in estuarine and inshore areas from Chesapeake Bay southward. The population extends as far north as the Gulf of Maine, although 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 coastal 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. Atlantic 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 varies by age with the highest mortality on the youngest fish.

Commercial Data

The Reduction Fishery

The majority of Atlantic menhaden harvest is reduced to fish meal, oil, and solubles (which is used in animal feed, fertilizer, health supplements for human consumption), and other products. The reduction fishery grew with the advent of purse seine gear in the mid-1800s. Purse seine landings peaked in 1956 at 715,200 mt. At the time, over 20 menhaden reduction factories were in operation from southern Maine to northern Florida. In the 1960s, the 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 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 portion of its 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 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, reduction landings averaged 172,600 mt. The first coastwide TAC for Atlantic menhaden commercial landings was implemented in 2013. Reduction landings have been steady since the implementation of the TAC. For 2021, reduction landings were approximately 136,700 mt and comprised about 70% of the coastwide landings. Numerous portside samples are taken to obtain information about the weight, length, and age distribution of the fished population.

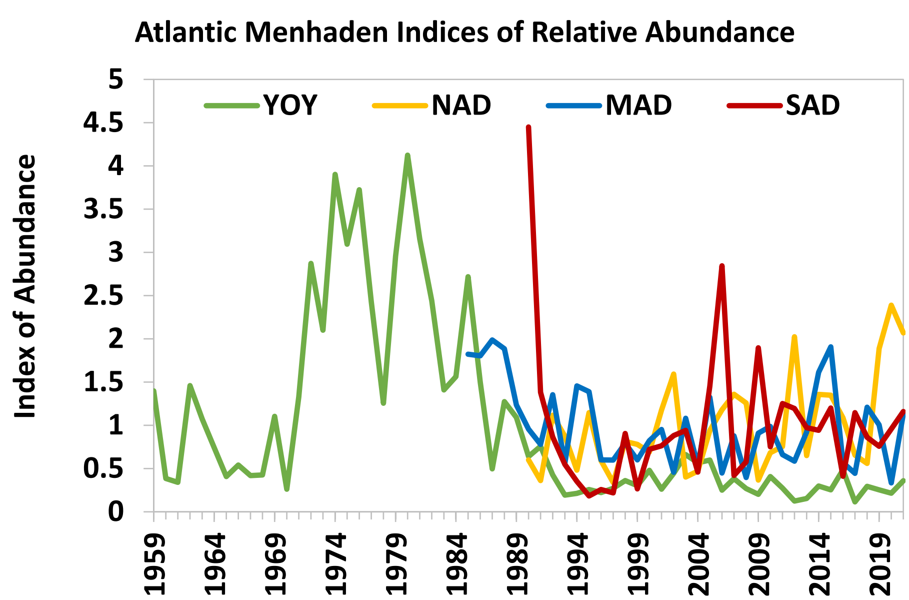
The Bait Fishery

While reduction landings have declined since the mid-2000s, Atlantic menhaden bait landings have increased due to higher demand and increased availability in the northern part of the species' range. Commercial bait landings occur in almost every Atlantic coast state. A majority of bait landings are used commercially in crab, lobster, and hook-and-line fisheries. Recreational anglers also catch Atlantic menhaden as bait for various game fish. In 2021, bait and recreational landings, which are grouped together in the model, were approximately 61,000 mt and comprised 30% of coastwide landings. Recreational landings (menhaden caught by recreational anglers and used as bait on a single trip) typically only comprise 1% of the coastwide landings annually.

Fishery-Independent Surveys

Data collected from several different surveys were used to develop indices of relative abundance for juvenile and adult Atlantic menhaden. Data used to develop an index for juvenile menhaden (young-of-the-year or YOY) were collected from 16 surveys conducted in Rhode Island to South Carolina. Data from the surveys were statistically combined into one coastwide index. The YOY index increased from historic lows in the 1960s to highs in the 1970s and 1980s. Abundance has been lower since the 1990s with some moderate increases in the mid-2000s and 2016.

Three coastwide indices of adult abundance were developed from eight fishery-independent survey data sets: northern (NAD; age-2+), Mid-Atlantic (MAD; age-1+), and southern (SAD; age-1) adult indices. The NAD was developed from surveys from Connecticut to Delaware and indicated that age-2+ abundance has been variable, with peaks in 2012 and 2019-2021. The MAD was developed from surveys in the Chesapeake Bay and showed high abundance in the late 1980s and then variable abundance with peaks in 2014 and 2015. The SAD was developed from surveys from North Carolina to Georgia and indicated that age-1 abundance was high in 1990 and then declined through the 1990s. Abundance peaked again in 2006 and then remained variable through 2021.

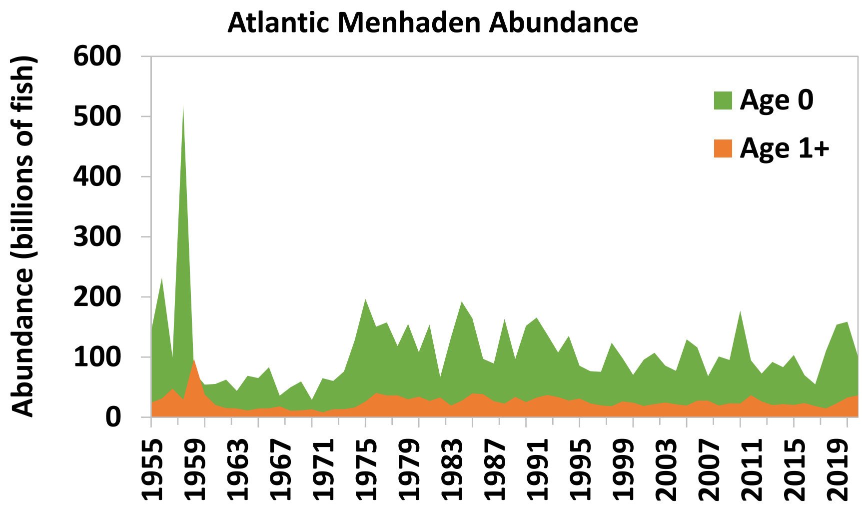


What Models Were Used?

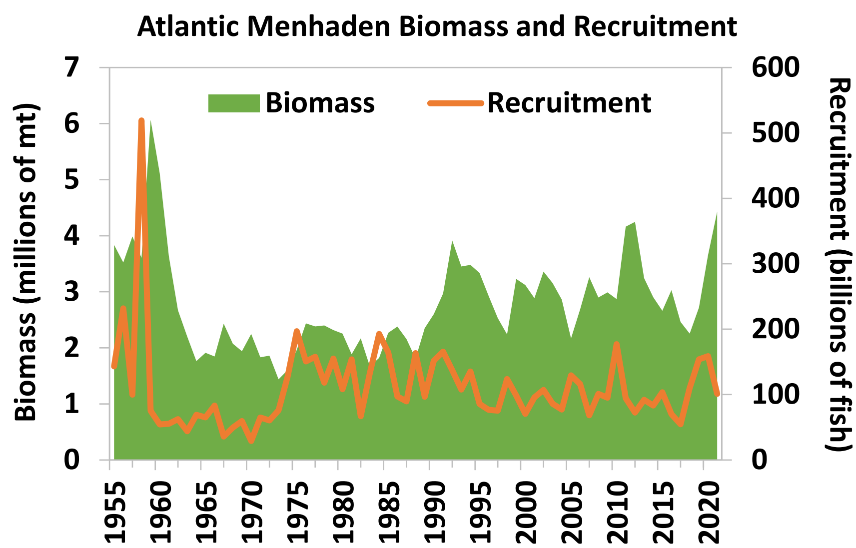
Single-Species Model

The BAM has been used for providing management advice since 2015 and was used again in this update. The BAM is a statistical catch-at-age model that estimates population size-at-age and recruitment, using 1955 as the first 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. The BAM was configured to be a fleets-as-areas model with the bait and reduction fleets broken into northern and southern regions to reflect differences in the way the fisheries operate 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, adult abundance declined through the 1960s. Adult abundance increased in the 1970s, was high until the mid-1990s, and then was lower in the 2000s. Adult abundance in 2019 was relatively high and decreased through 2021. Juvenile abundance follows a similar pattern with highs in the 1950s, 1970s, and 1980s, a decline in the 1990s, and a slight increase through 2021.



Similarly, model results indicate recruitment was highest in the late 1950s and has been variable over time. Biomass of age-1+ Atlantic menhaden also indicated biomass was high in the 1950s, with lower values through the 1960s, 1970s, and 1980s. Biomass increased in the 1990s and was variable through the 2000s. Biomass was relatively high in 2021.



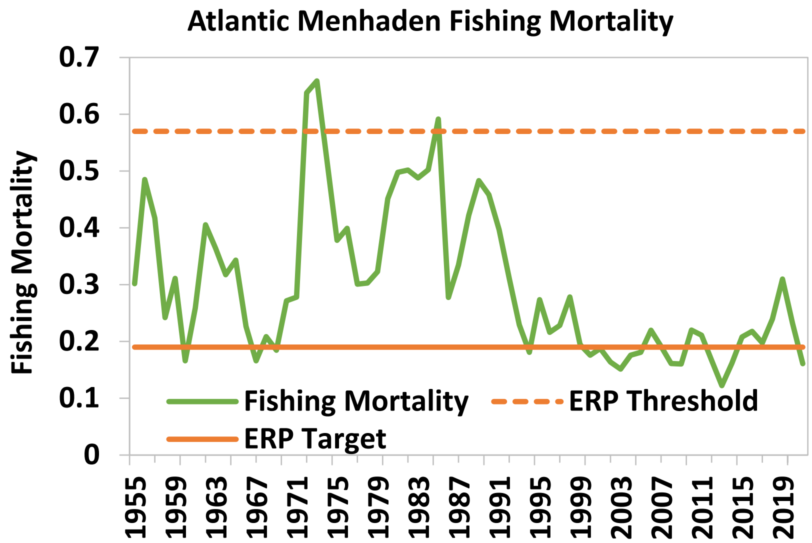
ERP Model

During the 2019 benchmark assessment, the ERP Workgroup chose the Northwest Atlantic Coastal Shelf Model of Intermediate Complexity for Ecosystems (NWACS-MICE) to develop Atlantic menhaden ERPs because it was the only model that could explore both the impacts of predators on menhaden biomass and the effects of menhaden harvest on predator populations, while being updateable in the management timeframe. The NWACS-MICE focused on four key predator species, striped bass, bluefish, weakfish, and spiny dogfish, and three key prey species, Atlantic menhaden, Atlantic herring, and bay anchovy. These species were chosen because diet data indicated they were top predators of Atlantic menhaden and there were many available datasets to describe their population dynamics. The NCWACS-MICE model provided ERPs for Atlantic menhaden that account for Atlantic menhaden's role as a forage fish. The NCWACS-

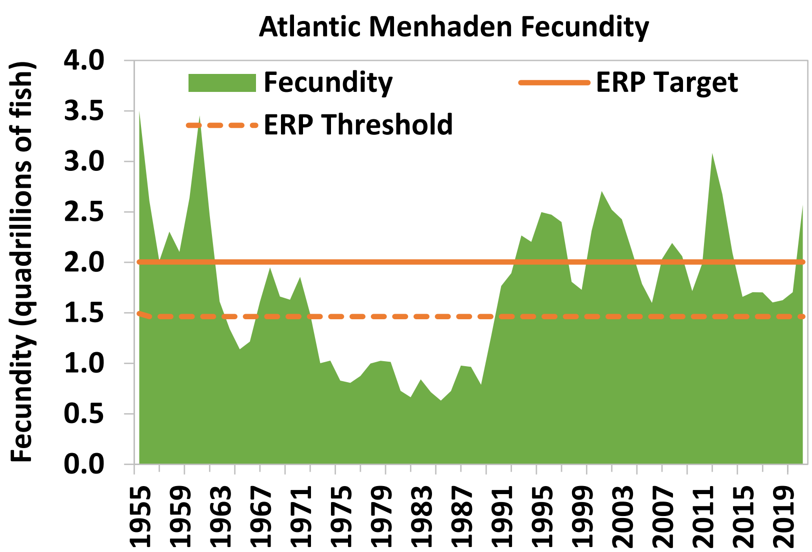
MICE model was not updated along with the single-species assessment, so the target and threshold ERPs from the ERP benchmark assessment were used to evaluate stock status of Atlantic menhaden in this update. .

What is the Status of the Stock?

In August 2020, the Board adopted ERPs for the management of Atlantic menhaden. The ERP target is the maximum fishing mortality rate (*F*) on Atlantic menhaden that sustains Atlantic striped bass at their biomass target when striped bass are fished at their *F* target. The ERP threshold is defined as the maximum *F* on Atlantic menhaden that keeps Atlantic striped bass at their biomass threshold when striped bass are fished at their *F* target. The ERP fecundity target and threshold is defined as the long-term equilibrium fecundity that results when the population is fished at the ERP *F* target and threshold, respectively.



Atlantic striped bass was the focal species for the ERP definitions because it was the most sensitive predator fish species to Atlantic menhaden harvest in the model, so an ERP target and threshold that sustained striped bass would likely provide sufficient forage for other predators under current ecosystem conditions.



Stock status for the 2022 update was determined using the ERP benchmarks. The *F* for 2021 is below the ERP threshold and target, and the fecundity for 2021 is above the ERP threshold and target. Therefore, overfishing is not occurring and the stock is not overfished.

Highly variable fishing mortalities were noted throughout the entire time series and are dependent upon fishing and management policies, as well as stock status. *F* was highest in the 1970s and 1980s and has been declining since approximately 1990. Since the mid-1990s *F* has been relatively stable and decreased in 2020 and 2021. Fishing effort in 2020 and 2021 was impacted by the COVID-19 pandemic with several vessels not operating due to restrictions.

Population fecundity (i.e., number of maturing ova) was highest in the early 1960s, low in the 1970s and 1980s, and high again from the 1990s to the present. The largest values of population fecundity were in 1955, 1961, and 2012. In the past decade, fecundity estimates were mostly between the ERP target and threshold with some years exceeding the target.

Research Needs

The single-species assessment 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. There are several research recommendations specific to model diagnostics and data inputs to the existing model.

The ERP Workgroup identified a number of research recommendations dealing with data collection and modeling. The ERP Workgroup recommended expanding the collection of diet and condition data along the Atlantic coast to provide annual, seasonally- and regionally-stratified year-round monitoring of key predator diets, as well as improving the collection of diet data and monitoring of population trends for non-finfish predators (e.g., birds, marine mammals) and data-poor prey species (e.g., bay anchovies, sand eels, benthic invertebrates) to better parameterize the full ecosystem models. In addition, the ERP Workgroup recommended further development of the multispecies statistical catch-at-age and the NWACS models to improve the spatial and seasonal dynamics of the models and to incorporate additional predator feedback and environmental recruitment drivers.

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.

Beaufort Assessment Model (BAM) – BAM is a statistical catch-at-age model that estimates population size-at-age and recruitment, using 1955 as the base 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.

Ecological reference points (ERPs) – As it is used for Atlantic menhaden, ERPs provide a method to assess the status of menhaden not only with regard to its own sustainability, but also with regard to its interactions with predators and the status of other prey species. This method accounts for changes in the abundance of several species when setting an overfished and overfishing threshold for menhaden. The benefit of this approach is that it allows fishery managers to consider the harvest of menhaden within a broad ecosystem context.

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

MAD – Mid-Atlantic adult abundance index

Northwest Atlantic Continental Shelf Model of Intermediate Complexity for Ecosystem (NWACS-MICE) – NWACS-MICE is an intermediate complexity ecosystem model that focuses on four key predator species, striped bass, bluefish, weakfish, and spiny dogfish, and three key prey species, Atlantic menhaden, Atlantic herring, and bay anchovy. The model was used to develop Atlantic menhaden ERPs because it was the only model that could explore both the impacts of predators on menhaden biomass and the effects of menhaden harvest on predator populations, while being updateable in the management timeframe.

NAD – Northern adult abundance index

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.

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.

SAD – Southern adult abundance index

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.

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