ASMFC Stock Assessment Overview: American Eel

Introduction

This document presents a summary of the 2023 benchmark stock assessment for American eel. The assessment was evaluated and endorsed by an independent panel of scientific experts through the Atlantic States Marine Fisheries Commission (ASMFC) external peer review process. The 2023 assessment is the latest and best information available on the status of the coastwide American eel.

Management Overview

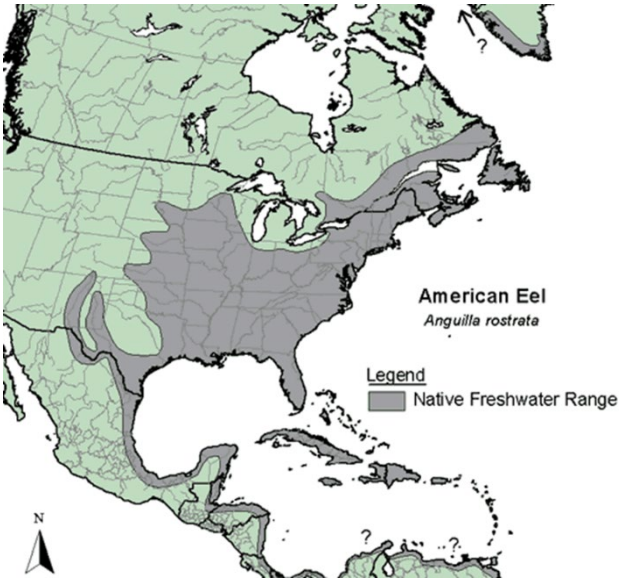
American eels are managed by ASMFC along the Atlantic coast from Maine to Florida. The American Eel Fishery Management Plan (FMP) was approved in November 1999, and has been modified through five addenda. The goal of the FMP is to conserve and protect the American eel resource to ensure ecological stability while providing for sustainable fisheries. Each state is responsible for implementing management measures within its jurisdiction to ensure the sustainability of the American eel population that resides within state boundaries.

Since 2001, the FMP has required all states and jurisdictions to implement an annual young-of-year (YOY) abundance survey with biological sampling to monitor annual recruitment. Commercial regulations vary by state but also include a 9-inch minimum size limit with the exception of Maine and South Carolina, which maintain glass eel fisheries. Currently, Maine has a glass eel quota of 9,688 pounds (through 2024) and the coastwide cap for commercial yellow eel harvest is 916,473 pounds. Management action is initiated if the yellow eel coastwide cap is exceeded by 10% in two consecutive years. If the management trigger is exceeded, only those states accounting for more than 1% of the total yellow eel landings will be responsible for adjusting their measures. In addition, all states and jurisdictions are required to establish a minimum recreational size limit of 9 inches and a recreational possession limit of 25 eels per person per day, and no more than 50 per day for party/charter employees for bait purposes. Recreational anglers are not allowed to sell eels without a state license.

What Data Were Used?

The American eel assessment used both fishery-dependent and -independent data collected through state, federal, and academic research programs.

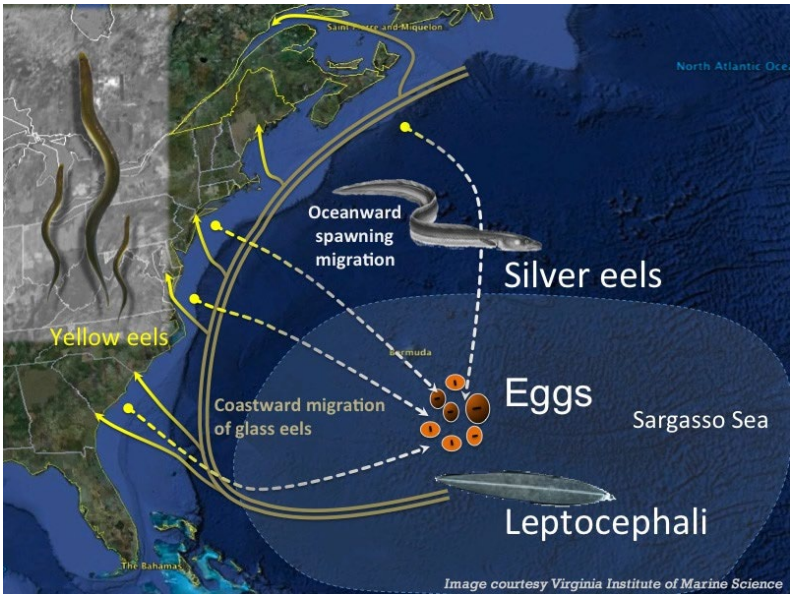
Map of the range of American eel (NatureServe 2006)



Life History

American eels are catadromous, spending most of their life in freshwater or estuarine environments, then traveling to the ocean as adults to reproduce and die. Sexually maturing eels migrate to spawning grounds located in the Sargasso Sea, an area of the western Atlantic Ocean east of the Bahamas and south of Bermuda. The Gulf Stream then transports and disperses larval eels, called leptocephali, along the eastern coast of Central and North America. Because all mature adult fish from the entire

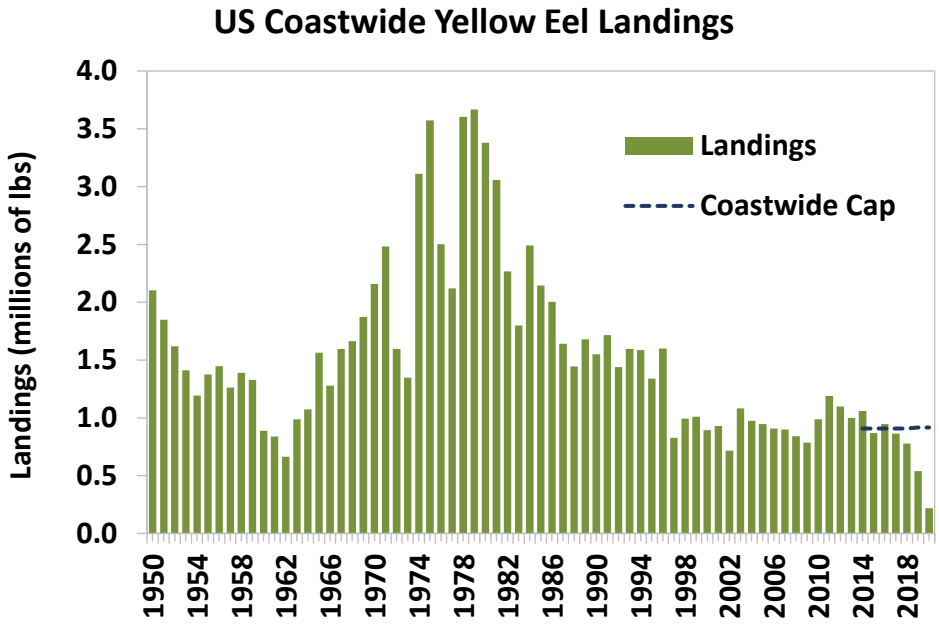
range come together in one place to reproduce, the American eel population is considered a panmictic (single) stock. American eels from Canada to Brazil comprise this single stock, although the benchmark stock assessment only includes the coastal and state waters from Maine to the Atlantic coast of Florida.



American eels have several life stages: leptocephali (larval eel), glass eel, elvers, yellow eel, and silver eel. Leptocephali metamorphose into glass eels as they migrate toward land. Glass eels develop into a pigmented stage, or elvers, as they move into brackish or freshwater. Usually by age two, small, pigmented eels make the transition into the yellow eel stage. Yellow eels inhabit fresh, brackish, and saltwater habitats where they feed primarily on invertebrates and smaller fishes. Sexual maturity can occur any time between 8 and 24 years of age depending on the location along the coast. When yellow eels start to sexually mature, they begin a downstream migration toward the Sargasso Sea spawning grounds. During this migration, yellow eels metamorphose into the adult silver eel phase, undergoing several physiological changes. Adult silver eels spawn in the Sargasso Sea during winter and early spring, after which they die.

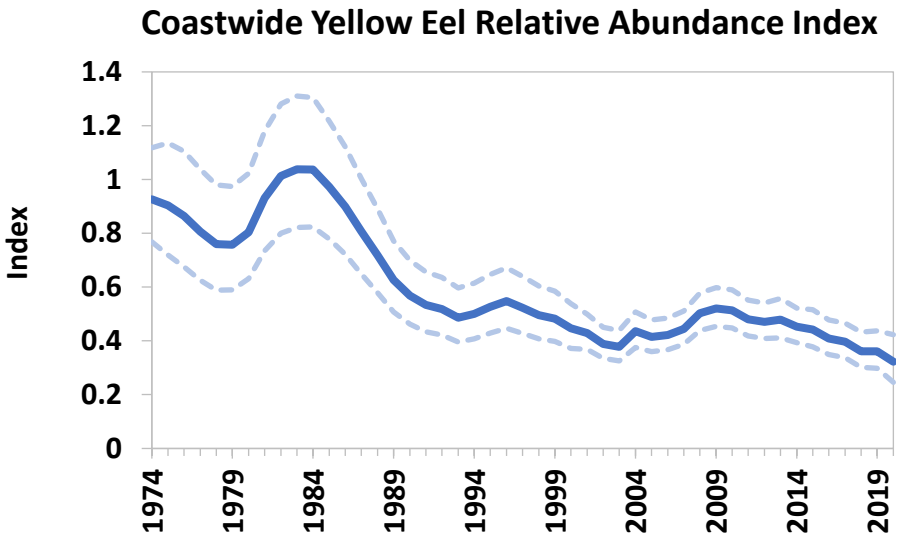
Commercial Data

Along the US Atlantic coast, all life stages are subject to fishing pressure although the degree of fishing varies. Glass eel fisheries are permitted in Maine and South Carolina. Yellow eel fisheries exist in all Atlantic coast states and jurisdictions with the exception of Pennsylvania and the District of Columbia. Yellow eel landings in the US are primarily from the Mid-Atlantic portion of the range. Eel pots and traps are the most commonly used gear; however, weirs, fyke nets, and other fishing methods are also used. American eels are harvested for food, bait, and export markets. From 1950 to 2020, American eel landings ranged from over 3 million pounds in the 1970s and early 1980s to around 1 million pounds or less since the late 1990s. In 2020, landings were at a time series low of approximately 218,000 pounds, likely due to fishing restrictions associated with the COVID-19 pandemic and possibly due to changes in market demand.



American eel recreational harvest and release data is collected by the Marine Recreational Information Program, formerly the Marine Recreational Fishery Statistics Survey. There is very high error and low precision associated with the estimates due to the limited number of American eels that have been encountered during the survey, which primarily focuses on coastal rather than inland fishing. Available information indicates that few recreational anglers directly target American eel.

American eel landings in the inland portion of the US are unquantified. There are some records of American eel landings in the Gulf of Mexico, but landings for that region have been negligible for the last two decades. Landings in Canada are well-documented, but landings in Mexico, Caribbean, and Central and South America are not.



Fishery-Independent Surveys

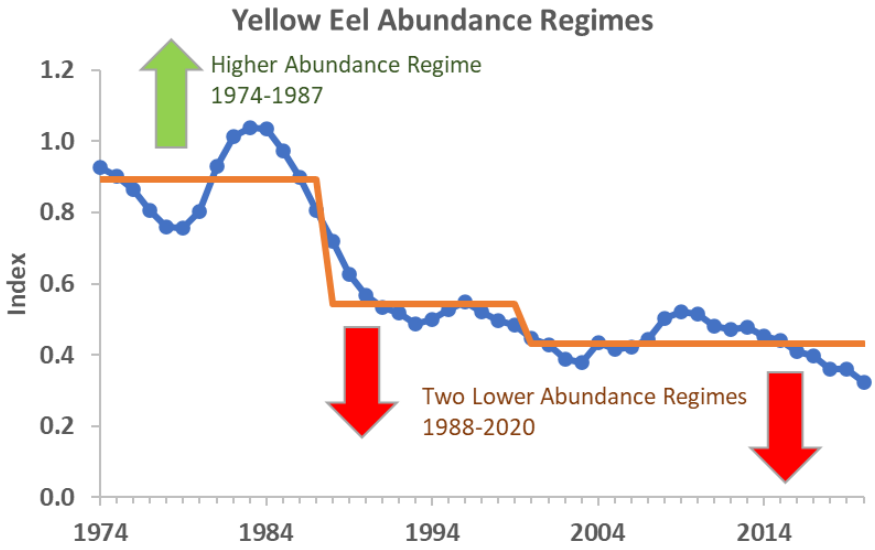
The stock assessment developed 25 YOY, 10 elver, and 14 yellow eel surveys for use as indices of abundance based on the number of years surveyed, survey design, appropriateness of gear used for catching eel, and frequency of eel catches. Several other data sources were used to characterize length-, age-, and sex-structure of the population. Survey data were statistically standardized to account for factors that affect catchability of eels (e.g., temperature, salinity, river flow rates). Survey data were analyzed separately and then combined to create coastwide YOY, elver, and yellow eel indices for potential use in trend analyses and modeling approaches.

In addition to developing YOY indices from the state-mandated surveys, the stock assessment investigated the YOY biological data (e.g., pigment stage, length, weight) for trends within or between sites. The average length of YOY eels increases from south to north along the coast, where Maine records the largest and Florida records the smallest average YOY eels. Otherwise, there was a lack of trends in the biological data within and among sites. Therefore, the stock assessment recommends not requiring the collection of biological data as part of YOY surveys going forward to relieve the sampling burden on the states.

How Were the Data Analyzed?

Despite the landings data and large number of surveys available for use in this assessment, the American eel stock is still considered data-poor. From a biological perspective, much is still unknown about the species. Information is limited about their abundance, status at all life stages, and habitat requirements. Widely varying life history traits along the coast and between freshwater and ocean habitats and American eel's large distribution from Brazil to Canada have complicated attempts to quantitatively model and assess this species over several stock assessments. No overfishing determination has been made based on the analyses performed during any of the previous stock assessments. The 2023 stock assessment has not resolved these issues despite investigating numerous new tools and methods.

Modeling approaches



The stock assessment tried several new approaches for American eel that were suggested in past stock assessments including a delay-difference model, further exploring a traffic light analysis and surplus production models, and developing an egg-per-recruit model. Numerous trend analysis approaches or tests were included in the report such as a multivariate auto-regressive state-space model, regime shift analysis, power analysis, Mann-Kendall test, and index-based methods. The most promising modeling approach was the delay-difference model and associated reference points, but the Stock Assessment Subcommittee (SAS) did not find the model appropriate for management use because of data limitations. Because comprehensive data to describe sex composition, maturity, and growth throughout its range does not exist, the delay-difference model was developed based on primarily Chesapeake Bay data. However, eel in other parts of the US range are known to have different life history parameters and thus the model should not be used for coastwide management.

The challenge of developing an analytical model for eel is not unique to the US. Increasingly, other countries such as New Zealand and Canada have explored habitat-oriented assessments for their eel species. During the development of the 2023 assessment, ASMFC partnered with the US Geological Survey to conduct a pilot assessment of the ability to use a GIS-based habitat analysis to inform eel stock assessments. The initial assessment focused on the Chesapeake and Delaware Bay watersheds because those regions have the most data. Similar to other approaches, data limitations restricted the development and use of this approach but it still may prove to be a useful tool going forward.

In the assessment, the SAS concluded that until sufficient data are available at an appropriate scale that encompasses the range inhabited by American eels to support more complex model-based assessments, abundance indices and index-based methods are the best tool for guiding management decisions.

Management Tool

Because a statistical model could not be developed for the species to determine stock status or give management advice, the SAS explored several index-based methods that were developed, simulation tested, and peer reviewed in a recent Northeast Fisheries Science Center (NEFSC) research track assessment (NEFSC 2020). At that review, 14 different index-based methods were presented for giving management advice in cases when a statistical model cannot be developed, or when there is a strong retrospective pattern in the data and model. Additionally, NEFSC provided guidance on which methods are appropriate for various scenarios, such as when a stock is thought to be in good condition or if it needs rebuilding. The SAS considered several approaches and selected one called I_{TARGET}, an index-based method that needs only catch and abundance information. I_{TARGET} compares an average index value in the last few years to a reference period. A target abundance is developed by multiplying the average index by some multiple greater than 1 to allow for rebuilding, such as 1.25 or 1.5. A threshold is also developed by multiplying the index target by a value

between 0.5-0.8 depending on the management goals. Catch advice is then based on the average catch over the reference period and adjusted by comparing the current average index to the target index.

To apply I_{TARGET} to the American eel stock, the SAS used the coastwide yellow eel index and the time series of yellow eel catch from 1974 to 2020, the terminal year of the assessment. Based on the regime shift analysis, the SAS selected a reference period of 1974-1987, a time period when yellow eels were at a higher abundance than recent years. By comparing the average catch to the reference period, the recommended catch would have been lower than the observed landings or the current coastwide cap for nearly the whole time series. The assessment and its supplemental report describe several possible configurations of I_{TARGET} that a Plan Development Team could consider when developing the tool to set catch limits and possible management actions through an addendum.

What is the Status of the Stock?

The 2023 assessment concludes that the stock is depleted, meaning it is at or near historically low levels due to a combination of historical overfishing, habitat loss, food web alterations, predation, turbine mortality, environmental changes, toxins and contaminants, and disease. Based on trend analyses, the stock was also considered depleted in the 2012 and 2017 assessments. The 2023 stock assessment found that the yellow eel population was at lower levels than the previous assessment, and yellow eel harvest should be decreased.

Determining whether a stock is overfished or overfishing is occurring means estimating one or more biological characteristics of a fishery (e.g., abundance or biomass) and comparing the estimated values to reference values that reflect a desirable condition. To do so typically requires the development of a statistical model or method to estimate biomass, fishing mortality, and biologically-based indicators or reference values which are not available for American eel at this time. A “depleted” stock status is often used by the ASMFC when a statistical model and reference points cannot be developed due to data limitations but trend analyses or other data-poor methods indicate that the stock is below historic levels.

Data and Research Needs

The American Eel SAS and Technical Committee agree that the research recommendations from the previous two assessments (ASMFC 2012, 2017) remain important. The 2023 assessment outlines several data and research needs that would improve the next benchmark assessment. Many of the recommendations are focused on data and research that would improve future efforts to apply a habitat-based model, for example, evaluating how the use and availability of inland habitats has changed through time. Other recommendations would improve all future modeling approaches such as characterizing length, weight, age, and sex along the Atlantic coast. In all assessments for American eel, it has been noted that assessing only a portion of the species range (i.e., coastal Maine through Florida) is not as meaningful for a panmictic species and the assessments recommend collaborating with scientists and agencies, inland and international, to consider a range-wide assessment in the future.

Next Steps

In response to the assessment findings, the Board initiated an addendum to consider changes to the coastwide yellow eel harvest cap. Historically, the coastwide cap of 916,473 pounds was set based on the average landings from 1998 to 2010. The addendum will consider using the I_{TARGET} tool recommended in the assessment for setting the coastwide cap based on abundance indices and catch. The Draft Addendum will include a range of potential coastwide caps and management options.

Glossary

Catadromous: adjective describing a fish that lives most of its life in freshwater then returns to saltwater to spawn

Delay-Difference Model: a variation of a biomass dynamic model that includes biological parameters, can be fitted directly to time series data, and accounts for changes in growth and recruitment over time

Management Strategy Evaluation: a process used by fisheries scientists and managers that involves using simulation modeling to compare different harvest strategies to achieve management objectives

Panmictic: referring to a fish whose mature individuals migrate to the same place to spawn from across the fish's entire geographic range

Plan Development Team: a committee appointed by the management board that is responsible for preparing all documents necessary for the development of a fishery management plan, amendment, or addendum using the best scientific information available

Regime Shift Analysis: a change in the ecosystem or time series detected by an analysis that may compare the most recent value to the mean of the time series for the current regime to identify potential change points or may use a cluster analysis to determine groups of years with similarities

Young-of-year (YOY): an individual fish in its first year of life; for most species, YOY are juveniles

References

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