## Introduction

This document presents a summary of the 2017 stock assessment update for American eel. The assessment updates the 2012 benchmark stock assessment which was peer-reviewed by an independent panel of scientific experts at an Atlantic States Marine Fisheries Commission (ASMFC) External Peer Review Workshop. This assessment update is the latest and best information available on the status of the coastwide American eel stock for use in fisheries management.

## Management Overview

American eels are managed by the ASMFC in territorial seas and inland waters along the Atlantic coast from Maine to Florida. The American Eel Fishery Management Plan (FMP) was approved in November 1999. 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 required all states and jurisdictions to implement an annual young-of-year (YOY) abundance survey in order to monitor annual recruitment. In addition, the FMP requires all states and jurisdictions to establish a minimum recreational size limit of nine inches and a recreational possession limit of no more than 50 eels per person per day. Recreational fishermen are not allowed to sell eels without a state license. Commercial regulations vary by state but also include a nine-inch minimum size limit with the exception of Maine and South Carolina which maintain glass eel fisheries. A coastwide quota of 907,671 pounds of yellow eel and a reduction in Maine's glass eel quota to 9,688 pounds was established beginning with the 2015 fishing year. The yellow eel quota has two management triggers that would require the implementation of state-specific allocations if met.

## What Data Were Used?

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

### *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 and reproduce, the American eel population is considered a panmictic (single) stock. American eels found along the eastern coast of Mexico are from the same population as eels found in the St. Lawrence River in Canada.

American eels have a multitude of life stages: leptocephali, 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 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. 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.

### *Commercial Data*

The American eel fishery primarily targets yellow stage eel. Eel pots and traps are the most typical gear used; however, weirs, fyke nets, and other fishing methods are also used. Glass eel fisheries along the Atlantic coast are prohibited in all states except Maine and South Carolina. In recent years, Maine is the only state reporting significant glass eel and elver harvest. Harvest has increased in recent years as the average market price has risen to over $1,000 per pound with peaks exceeding $2,000 per pound. Although yellow eels were harvested for food historically, today's fishery sells yellow eels primarily as bait for recreational fisheries. Glass eels are exported to Asia to serve as seed stock for aquaculture facilities.

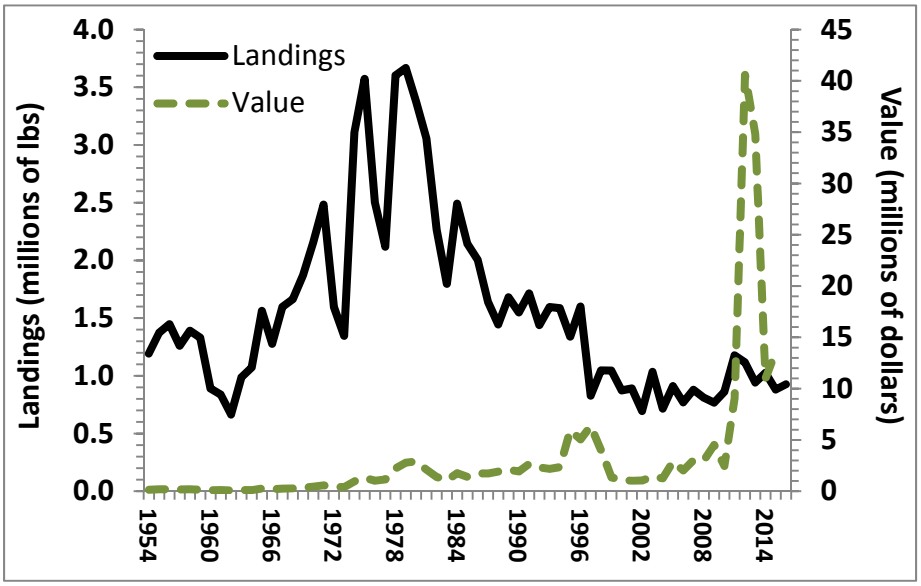



**Figure 1. Total commercial landings of American eels and value along the U.S. Atlantic Coast, 1950–2016.**

From 1950 to 2016, U.S. Atlantic coast landings of American eel ranged between approximately 664,000 pounds in 1962 to 3.67 million pounds in 1979 (Figure 1). After an initial decline in the 1950s, landings increased to a peak in the 1970s and 1980s before declining again in the 2000s. The value of U.S. commercial American eel landings as estimated by NOAA Fisheries has varied between a few hundred thousand dollars (prior to the 1980s) and a peak of $40.6 million in 2012 (Figure 1). Total landings value declined again in 2014 from the large values in the previous two years but still remained high compared to the rest of the time series.

### *Fishery-Independent Surveys*

The 2017 stock assessment update included 22 young-of-year surveys and 15 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 as determined by the 2012 benchmark stock assessment. 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., moon phase, season, flow rates). Survey data were analyzed separately and then combined to create young-of-the-year and yellow eel indices at the regional and coast-wide level to look for trends at different spatial scales.

## How Were the Data Analyzed?

Despite the large number of surveys and studies available for use in this assessment, the American eel stock is still considered data-poor because very few surveys target eels and collect information on length, age, and sex of the animals caught. Also, eels have an extremely complex life history that is difficult to describe using traditional stock assessment models. For the 2012 benchmark stock assessment, data-poor methods were used to assess the American eel resource. The first set of analyses (trend analyses) aimed at determining if there was

a statistically significant trend in the fishery-independent survey data and whether or not there was evidence for significant trends at the regional and coastwide scales. The second approach involved a model called Depletion-Based Stock Reduction Analysis (DB-SRA) which uses trends in historical catch to estimate biomass trends and maximum sustainable yield. The DB-SRA was not accepted for management use by the Peer Review Panel so it was not updated because the Panel recommended it be further developed which was outside the guidelines of a stock assessment update. The trend analyses were completed for the stock assessment update.

### *Trend Analyses*

Three trend analysis approaches were used in the benchmark assessment and update: Mann-Kendall test, Manly meta-analysis, and Autoregressive Integrated Moving Average (ARIMA) model. All three trend analysis methods detected significant downward trends in some indices over the time period examined. While results varied among individual abundance indices and analyses, the 40-year-plus trend of yellow eels showed large declines in abundance during the 1980s through the early 1990s, with primarily neutral or stable abundance from the mid-1990s through 2016. While not a comprehensive list of indices evaluated or analyses performed, a table below compares the regional trends between 2012 and the 2017 update using the Mann-Kendall analysis.

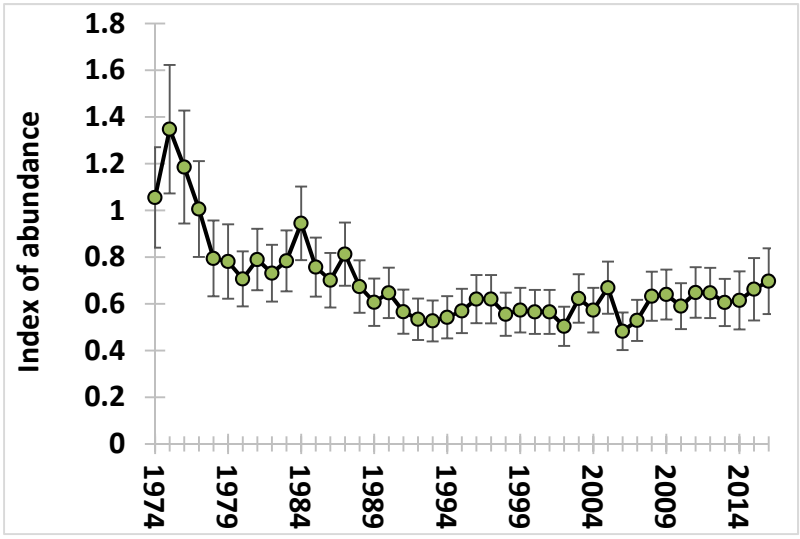



**Figure 2. Index of abundance of yellow American eels along the Atlantic Coast, 1974-2016 (40-plus-year-index). The error bars represent the standard errors about the estimates.**

## What is the Status of the Stock?

For the 2012 benchmark stock assessment, both trend analyses and DB-SRA results indicated the American eel stock has declined in recent decades and the prevalence of significant downward trends in multiple surveys across the coast is cause for concern. Therefore, the stock status was depleted and no overfishing determination could be made at that time based solely on the trend analyses performed.

The trend analysis results in this stock assessment update are consistent with the 2012 results, with few exceptions. Despite downward trends in the indices, commercial yellow American eel landings have been stable in the recent decades along the Atlantic coast (U.S. and Canada) although landings still remain much lower than historical landings. The trend analysis and stable low landings support the update conclusion that the American eel population in the assessment range is similar to five years ago and remains depleted. Therefore, ***the stock status is depleted and no overfishing determination can be made*** based on the trend analyses performed.

## Data and Research Needs

Direct and detailed monitoring of the American eel population and fisheries trends is needed to improve the stock assessment. Accuracy of commercial catch and effort data should be improved through better compliance with landings and effort reporting requirements as outlined in the FMP. Targeted fishery-independent surveys for yellow and silver eels would greatly improve the assessment. In the absence of such surveys, the collection and processing of length, age, and sex information for yellow and silver eels caught in already existing surveys would be useful, especially in the South Atlantic where few surveys are conducted that catch American eels. The

collection of age structure data outside the range of the fishery would provide much needed information about animals not typically caught by the fishery that may be contributing to stock productivity. Quantification of mortality rates due to dam turbines, disease, and other environmental stressors would be helpful. Also, a comprehensive map of coastwide habitat loss would aid in quantifying the potential magnitude of reduced productivity. Given the panmictic nature of the American eel stock, the next assessment should be a cooperative effort between U.S. and Canada.

**Results of the Mann-Kendall trend analysis applied to regional and coastwide indices of American eel abundance by young-of-the-year (YOY) and yellow eel life stages. The arrows indicate the direction of the trend if a statistically significant trend was detected (P-value < α; α = 0.05). NS = no significant trend detected. A dash (-) = indices that data were not updated.**

| Region | Life Stage | Time Period | 2012 Trend | 2017 Trend |
|---|---|---|---|---|
| Gulf of Maine | YOY | 2001–2016 | NS | NS |
| Southern New England | YOY | 2000–2016 | NS | NS |
| | Yellow | 2001–2010 | NS | - |
| Hudson River | YOY | 1974–2009 | ↓ | - |
| | Yellow | 1980–2016 | ↓ | ↓ |
| Delaware Bay/ Mid-Atlantic Coastal Bays | YOY | 2000–2016 | NS | NS |
| | Yellow | 1999–2016 | NS | NS |
| Chesapeake Bay | YOY | 2000–2016 | NS | NS |
| | Yellow | 1990–2009 | ↑ | ↑ |
| South Atlantic | YOY | 2001–2015 | NS | ↓ |
| | Yellow | 2001–2016 | ↓ | ↓ |
| Atlantic Coast | YOY (short-term) | 2000–2016 | NS | NS |
| | YOY (long-term) | 1987–2013 | NS | NS |
| | Yellow (40+ year) | 1974–2016 | NS | ↓ |
| | Yellow (30-year) | 1987–2016 | ↓ | ↓ |
| | Yellow (20-year) | 1997–2016 | NS | NS |

## Glossary

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

**Leptocephali:** larval American eels

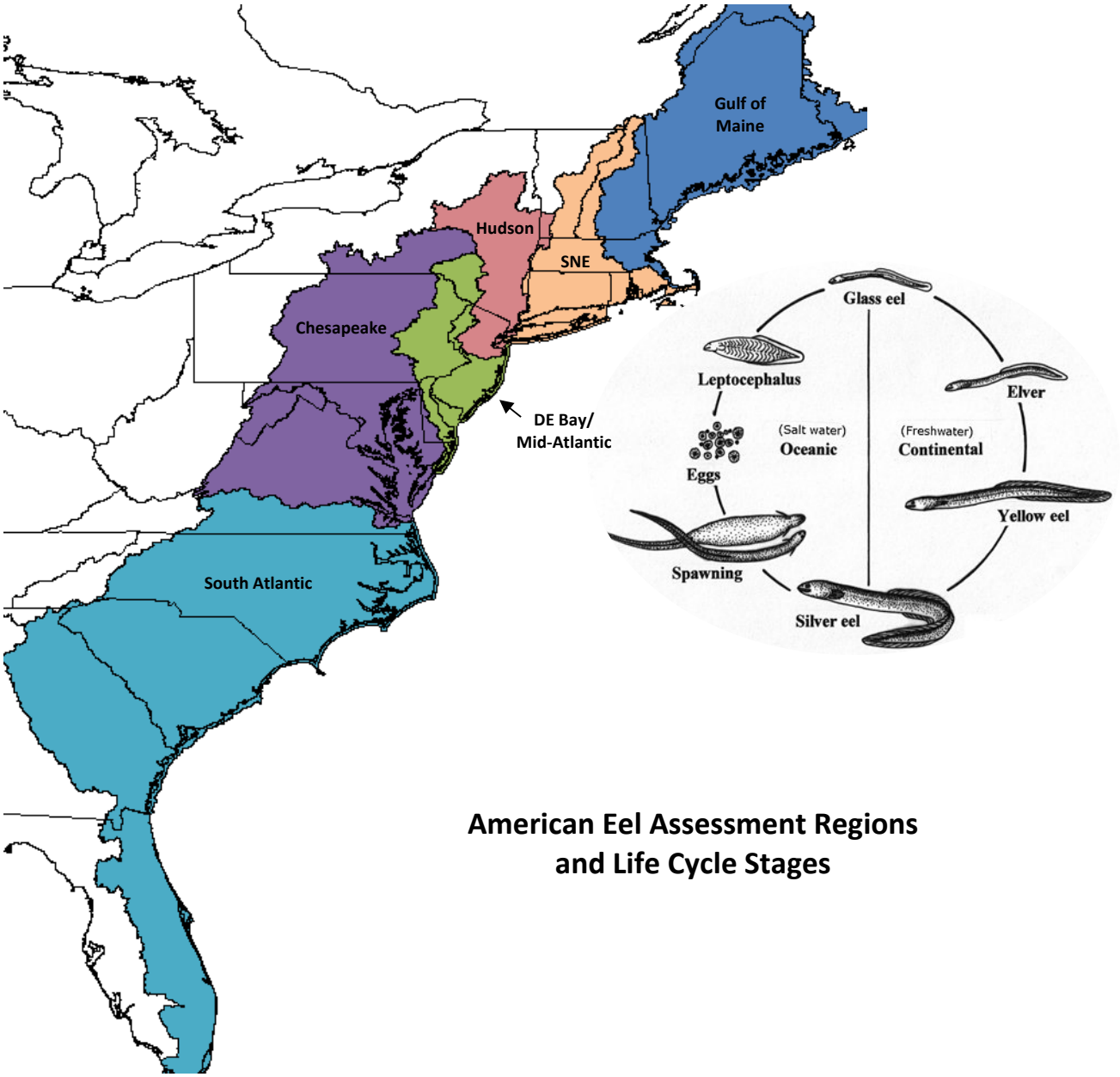
**Panmictic:** referring to a fish whose mature individuals migrate to the same place to spawn from across the fish's entire geographic range

**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

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

## References

ASMFC. 2012. American Eel Benchmark Stock Assessment. Stock Assessment Report 12- 01 of the Atlantic States Marine Fisheries Commission. 342 pp.




**American Eel Assessment Regions and Life Cycle Stages**