ASMFC Stock Assessment Overview: American Eel

Introduction

This document presents a summary of the 2012 benchmark stock assessment for American eel. The assessment was peer-reviewed by an independent panel of scientific experts at an Atlantic States Marine Fisheries Commission (ASMFC) External Peer Review Workshop in March 2012. This assessment 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.

The FMP requires that all states and jurisdictions implement an annual young-of-year abundance survey by 2001 in order to monitor annual recruitment. In addition, the FMP requires all states and jurisdictions to establish a minimum recreational size limit of six 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 six-inch minimum size limit with the exception of Maine and South Carolina which maintain glass eel fisheries. Commercial fisheries management measures stipulate that states and jurisdictions shall maintain existing (as of 2000) or more conservative regulations for all life stages. States with commercial minimum size limits must retain those minimum size limits, unless otherwise approved by the American Eel Management Board.

Addendum I, approved February 2006, established a mandatory catch and effort monitoring program for American eels. At this time, however, not all states are able to provide this level of detailed reporting. Addendum II, approved in October 2008, placed increased emphasis on improving the upstream and downstream passage of American eels.

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 eight 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. Silver eels are caught during their fall migration as well. Eel pots are the most typical gear used; however, weirs, fyke nets, and other fishing methods are also employed. 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 the last few years as the market price has risen to over $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.

From 1950 to 2010, U.S. Atlantic coast landings ranged from 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 Service has varied from less than a $100,000 (prior to the 1980s) to a peak of $6.4 million in 1997 (Figure 1). Total landings value increased through the 1980s and 1990s, dropped in the late 1990s, and increased again in the 2000s.

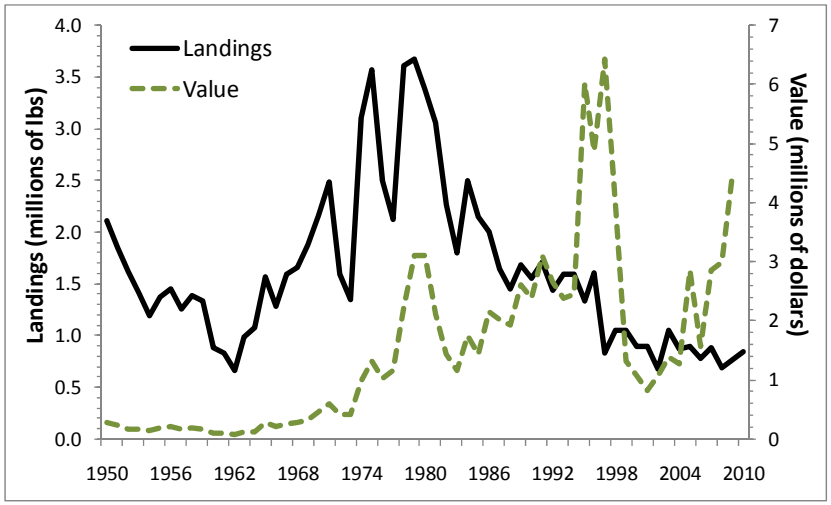


Figure 1. Total commercial landings of American eels and value in 2010 dollars along the U.S. Atlantic Coast, 1950–2010.

Fishery-Independent Surveys

After reviewing over 100 surveys and studies that catch eel, 19 young-of-year surveys and 15 yellow eel surveys were selected for use as indices of abundance in the assessment 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., moon phase, season, flow rates). Survey data were analyzed separately and then combined 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. Therefore, several 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 coast-wide 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.

Trend Analyses

Three trend analysis approaches were used in the assessment, namely the Mann-Kendall test, the Manly meta-analysis, and the Autoregressive Integrated Moving Average (ARIMA) model. Mann-Kendall is a statistical test used to identify a significant unidirectional trend in time series data. The Manly meta-analysis is a statistical approach that combines the results from multiple datasets to determine if the datasets are showing the same trends. ARIMA estimates the probability that an index in the final year of the assessment is below a specified percentile with an assumed level of confidence.

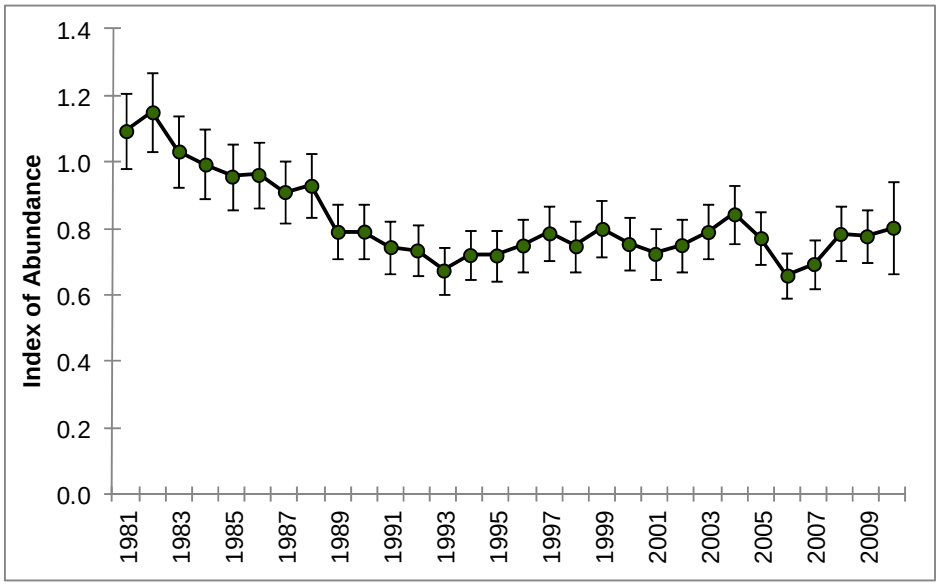


Figure 2. Index of abundance for yellow-phase American eels along the Atlantic Coast, 1981–2010 (30-year index). The error bars represent the standard errors about the estimates.

Trend analyses found evidence of declining or, at least, neutral abundance of American eels in the U.S in recent decades. All three trend analysis methods (Mann-Kendall, Manly, and ARIMA) detected significant downward trends in numerous indices over the time period examined. For example, the Mann-Kendall test detected a significant trend in the 30-year yellow-phase abundance index (Figure 2). The Manly meta-analysis found consensus for a decline in YOY and yellow eels through time.

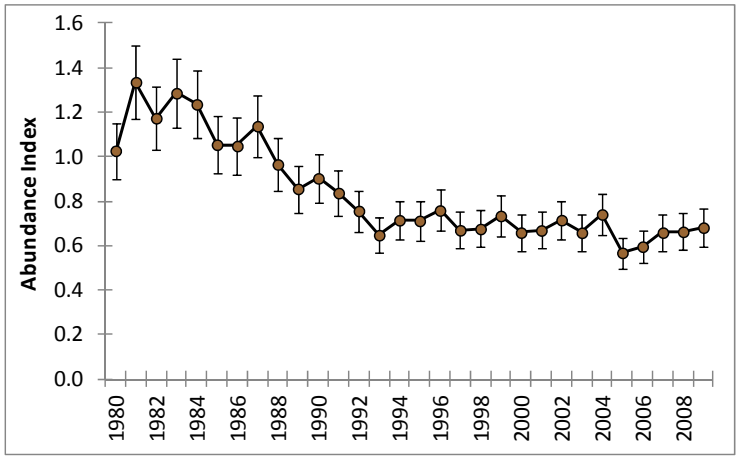


Figure 3. Index of abundance for yellow-stage American eels in the Hudson region, 1980–2009. The error bars represent the standard errors about the estimates.

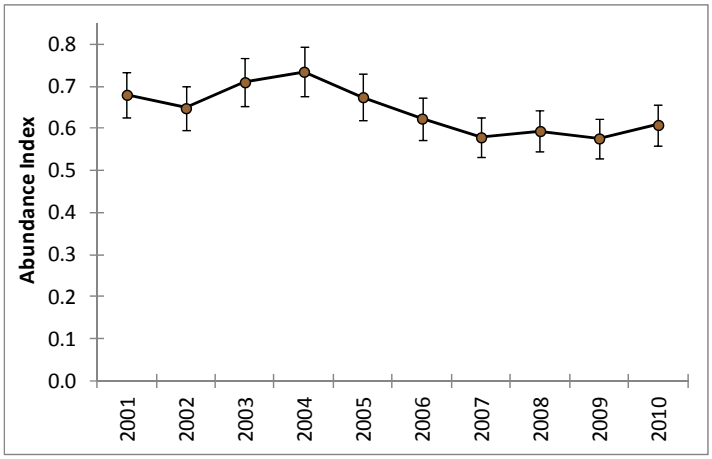


Figure 4. Index of abundance for yellow-stage American eels in the South Atlantic region, 2001–2010. The error bars represent the standard errors about the estimates.

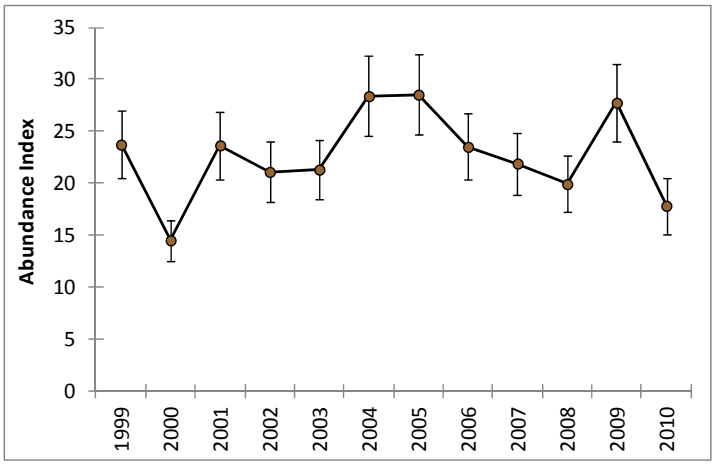


Figure 5. Index of abundance for yellow-stage American eels in the Delaware/Mid-Atlantic Coastal Bays region, 1989–2010. The error bars represent the standard errors about the estimates.

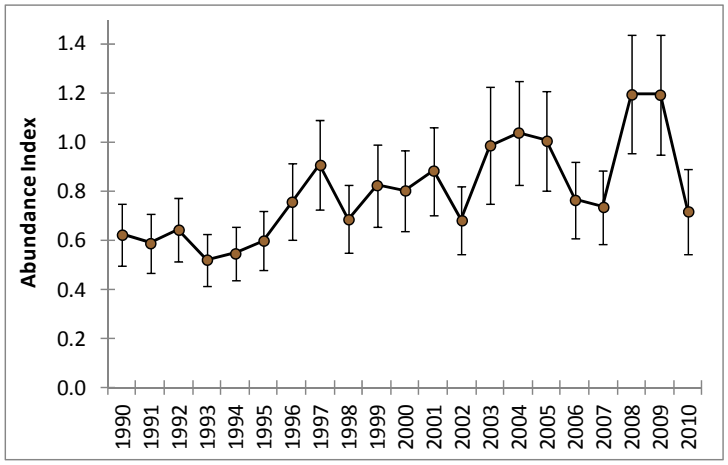


Figure 6. Index of abundance for yellow-stage American eels in the Chesapeake Bay region, 1989–2010. The error bars represent the standard errors about the estimates.

Both the ARIMA and Mann-Kendall analyses identified decreasing trends in the Hudson River and South Atlantic regions (Figures 3 and 4). In contrast, survey indices from the Chesapeake Bay and Delaware Bay/Mid-Atlantic Coastal Bays regions showed no consistent increasing or decreasing trends (Figures 5 and 6).

Depletion-Based Stock Reduction Analysis

Depletion-Based Stock Reduction Analysis (DB-SRA) is a stock assessment model designed for data-poor fisheries. The model requires a long time series of historical catch records extending back to the beginning of the modern fishery, information about the life history of the species (e.g., age at maturity), and a set of assumptions about the productivity of the stock and current stock biomass relative to unfished biomass. For this assessment, the DB-SRA was modified to include two periods of natural mortality that account for an increase over time in natural mortality due to dam construction. Dam construction in the U.S. peaked in the 1960s, so the two time periods of the model were split in 1970.

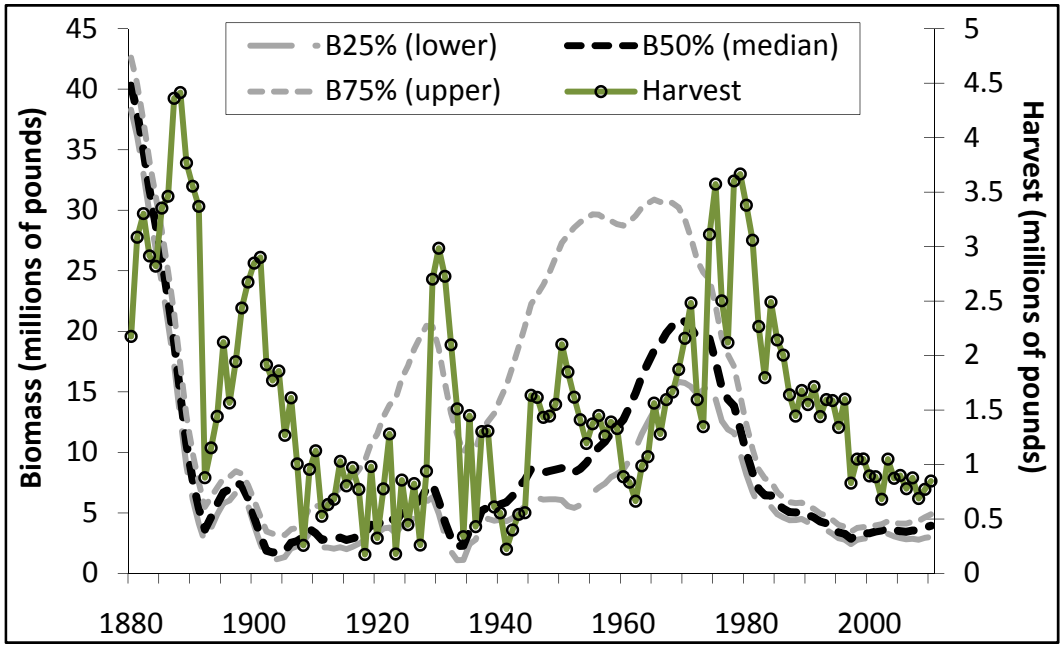


Figure 8. Estimated exploitable eel biomass from the DB-SRA model.

The DB-SRA produces a distribution of biomass and maximum sustainable yield estimates to account for uncertainty in input assumptions. The median (middle) estimate of the biomass distribution, B50%, is thought to be the most likely estimate, but 25th (lower) and 75th (upper) percentiles were calculated as well to better represent the breadth of potential uncertainty in model results.

The DB-SRA estimated that median biomass increased from a low of approximately 2.26 million pounds in 1933 to a relative peak of 21 million pounds in 1969. This was reduced to a low of 2.88 million pounds by 1997, but has since recovered to approximately 4.07 million pounds in 2011. The model estimated a recent peak biomass in the late 1960s/early 1970s which corresponds with peaks observed in fishery-independent surveys from the Chesapeake Bay region during the same time period. Due to the sensitivity of this model to the input assumptions, the External Peer Review Panel suggested improvements be made to the model and additional testing be performed before maximum sustainable yield estimates and reference points from this model are used for management.

What is the Status of the Stock?

Both trend analyses and DB-SRA results indicate that 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 is depleted***. ***No overfishing determination can be made at this time*** based solely on the trend analyses performed. However, the ASMFC American Eel Technical Committee and Stock Assessment Subcommittee caution that although commercial fishery landings and effort in recent times have declined in most regions (with the possible exception of the glass eel fishery), current levels of fishing effort may still be too high given the additional stressors affecting the stock such as habitat loss, passage mortality, and disease as well as potentially shifting oceanographic conditions. Fishing on all life stages of eels, particularly young-of-the-year and in-river silver eels migrating to the spawning grounds, could be particularly detrimental to the stock, especially if other sources of mortality (e.g., turbine mortality, changing oceanographic conditions) cannot be readily controlled. Management efforts to reduce mortality on American eels in the U.S. are warranted.

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 coast-wide 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.

Glossary

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

Leptocephali: larval American eels

Natural mortality (M): the instantaneous (not discrete) rate at which fish die because of natural causes (predation, disease, starvation, etc)

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

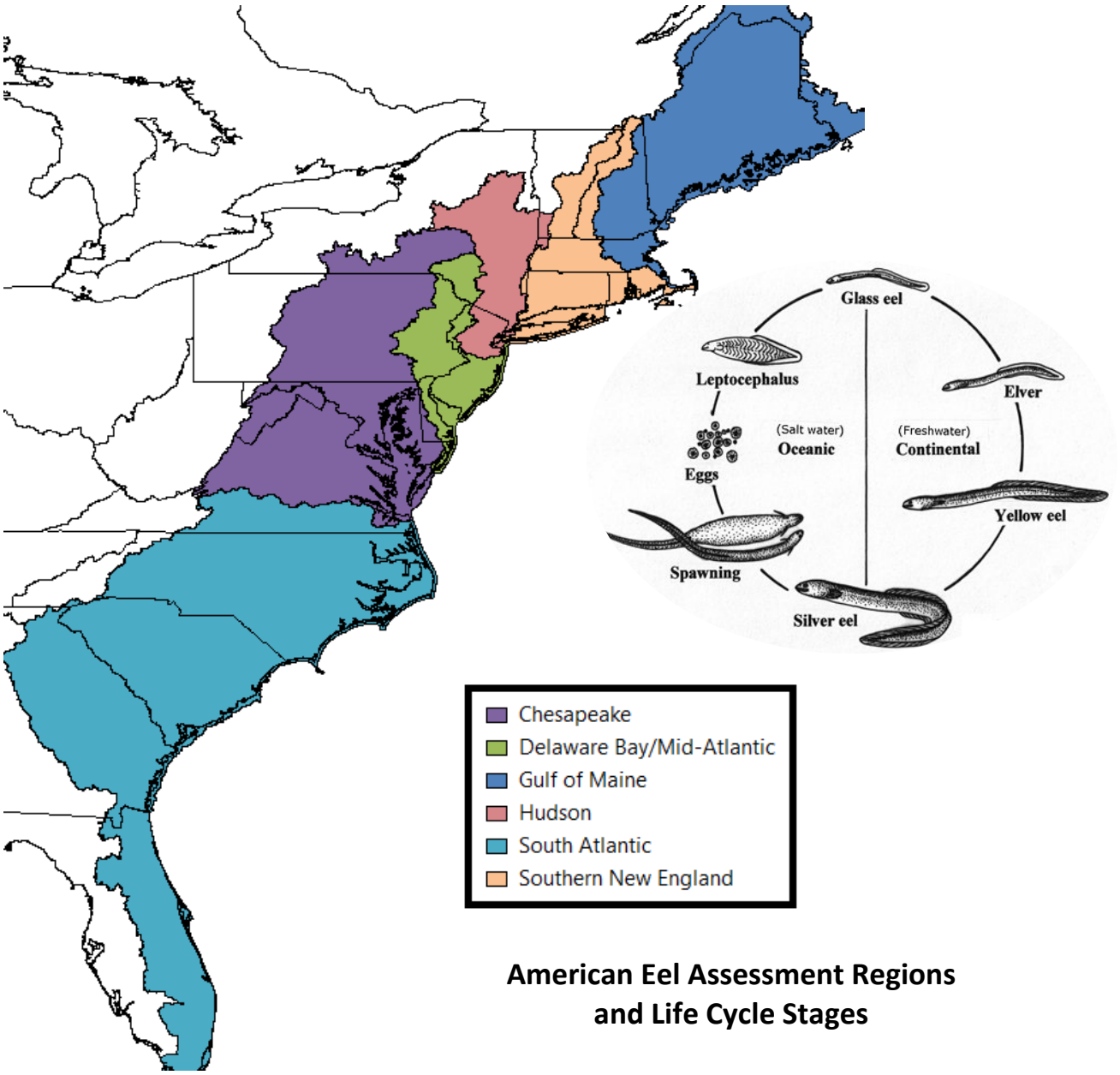
Recruitment: a measure of the weight or number of fish that enter a defined portion of the stock, such as the spawning stock or fishable stock

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 Stock Assessment Report for Peer Review. Atlantic States Marine Fisheries Commission, Stock Assessment Report No. 12-1 (supplement), Washington, DC. 303 p.

ASMFC. 2009. Guide to Fisheries Science and Stock Assessments. Washington, DC. Available (May 2012): http://www.asmfc.org/publications/GuideToFisheriesScienceAndStockAssessments.pdf



American Eel Assessment Regions and Life Cycle Stages