

established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC), are similar to the goals of the N.C. Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015).

Management Unit

The American eel is managed as a coast-wide stock, from Maine through Florida, under the ASMFC Interstate FMP for American Eel (ASMFC 2000). The American eel's range extends beyond U.S. borders and more specifically ASMFC member states' territorial waters. However, the management unit is limited to ASMFC member states' territorial waters.

Goal and Objectives

The goals of the ASMFC American Eel FMP are to protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic states and jurisdictions and contribute to the viability of the American eel spawning population with the aim to provide sustainable commercial, subsistence, and recreational fisheries by preventing over-harvest of any eel life stage. The following objectives will be used to achieve this goal:

1. Improve knowledge of eel utilization at all life stages through mandatory reporting of harvest and effort by commercial fishers and dealers, and enhanced recreational fisheries monitoring.
2. Increase understanding of factors affecting eel population dynamics and life history through research and monitoring.
3. Protect and enhance American eel abundance in all watersheds where eel now occur.
4. Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.
5. Investigate the abundance level of eels at the various life stages necessary to provide adequate forage for natural predators to support ecosystem health and food chain structure.

DESCRIPTION OF THE STOCK

Biological Profile

The American eel is a catadromous species meaning they are born in saltwater, then migrate into freshwater as juveniles where they grow into adults before migrating back to the ocean to spawn. All American eel comprise one panmictic population meaning they are a single breeding population that exhibits random mating. For example, an American eel from the northern portion of the range could mate with an American eel from the southern portion of the range, and their offspring could inhabit any portion of the range. As a result, recruits to a particular system are likely not the offspring of the adults that migrated out of that system (ASMFC 2000). American eels require multiple habitats including the ocean, estuaries, fresh water streams, rivers and lakes. While American eels spend most their life in brackish and freshwater systems from South America to Canada, spawning occurs in the Sargasso Sea (a large portion of the western Atlantic Ocean south of Bermuda and east of the Bahamas) (Facey and

Van den Avyle 1987). Larvae develop at sea and change from glass eels (transparent post-larval stage) into elvers (pigmented young eels) in nearshore ocean waters and estuaries (ASMFC 2000). Elvers either remain in the estuary or migrate upstream. At approximately 2 years of age, they change to the yellow eel stage and resemble the adult form (Ogden 1970). Individuals can remain in the yellow phase for five to 20 years. In the yellow phase, American eels are nocturnal, feeding at night on a variety of invertebrates and smaller fish, but will also eat dead animal matter. American eels live in a variety of habitats but prefer areas where they can hide with soft bottom and vegetation. Females can grow to five feet in length, and males usually reach about three feet (ASMFC 2000). The mature silver eel life stage occurs at the time of downstream migration, when individuals leave the estuaries to spawn and die in the Sargasso Sea (Facey and Van den Avyle 1987). This spawning migration occurs annually in the late summer and fall. Information about abundance and status at all life stages, as well as habitat requirements, is very limited. The life history of the species, such as late age of maturity and a tendency for certain life stages to aggregate, can make this species particularly vulnerable to overharvest.

Stock Status

The 2017 stock assessment update found the American eel population remains depleted in U.S. waters (ASMFC 2017). The stock is at or near historically low levels due to a combination of historical overfishing, habitat loss, food web alterations, predation, hydroelectric turbine mortality, environmental changes, toxins and contaminants, and disease. The assessment updates the 2012 American Eel Stock Assessment with data from 2010-2016. Trend analyses of abundance indices indicate large declines in abundance of yellow eels during the 1980s through the early 1990s, with primarily neutral or stable abundance from the mid-1990s through 2016. Total landings remain low but stable. Based on these findings, the stock is still considered depleted. No overfishing status determination can be made based on the analyses performed.

Stock Assessment

In May 2016, the American Eel Technical Committee (TC) and Stock Assessment Subcommittee (SAS) recommended updating the 2012 stock assessment because there had not been enough new data sets or program developments to warrant an entirely new stock assessment approach. The TC and SAS also recommended continuing progress on research recommendations to support a more comprehensive stock assessment in the future.

The 2012 stock assessment was updated in 2017 with data through 2016. American eel indices of abundance were analyzed using three methods of trend analysis; Mann-Kendall, Manly, and ARIMA. The Mann-Kendall test detected significant downward trends in six of the 22 YOY indices, five of the 15 yellow eel indices, three of the nine regional YOY and yellow eel indices, and the 30-year and 40-year yellow-phase abundance indices. Only two indices had positive trends, all of the remaining survey indices tested had no trend. The Manly meta-analysis showed a decline in at least one of the indices for both yellow and YOY life stages. Results of ARIMA analysis indicated the probabilities of being less than the 25th percentile reference points in the terminal year for each survey were similar to those in the 2012 stock assessment and three of the 14 surveys had a greater than 50% probability of the terminal year being less than the 25th percentile reference point. Overall, the occurrence of some significant downward trends in

surveys across the coast remains a cause for concern, so the assessment maintained that the stock remains depleted. While it is highly likely the American eel stock is depleted, no overfishing determination can be made based solely on the trend analyses performed.

In March 2020, the American Eel TC and the American Eel SAS met to discuss the 2022 benchmark stock assessment for American eel. There were no changes recommended to the Terms of Reference, all potential data sources will be reviewed, and the terminal year will be 2019.

DESCRIPTION OF THE FISHERY

Current Regulations

New management measures for yellow eels went into effect on January 1, 2014 under North Carolina Marine Fisheries Commission (NCMFC) Rule 15A NCAC 03M .0510. These measures included a nine-inch total length (TL) minimum size limit for both the commercial and recreational fisheries, a 25 eels per person per day bag limit for the recreational fishery, and crew members involved in for-hire employment are allowed to maintain the current 50 eels per day bag limit for bait purposes. The rule also made the possession of American eels illegal from September 1 through December 31 except when taken by baited pots. NCMFC Rule 15A NCAC 03J .0301 established a ½ by ½ inch minimum mesh size requirement for the commercial eel pot fishery. Eel pots with an escape panel consisting of a 1 by ½ inch mesh are allowed until January 1, 2017.

Commercial Fishery

Average commercial landings and value from 2010 through 2019 was 49,157 pounds and \$120,107. In 2020, the commercial landings and value was 3,291 pounds and \$9,773 (Table 2). Commercial landings have fluctuated since 1974 with a peak in 1980 and significant declines beginning in the late 1980s (Figure 1). In 1979 and 1980, over 900,000 pounds were landed, however, since the late 1980s landings have averaged less than 100,000 pounds and in 2020 landings were the lowest recorded in the time-series.

Recreational Fishery

There are no recreational landings data available for American eels, which are not typically a targeted species. Since American eels are caught incidentally in the estuarine environment by recreational fishermen using hook and line, the Marine Recreational Information Program (MRIP) does not provide reliable harvest data. Also, the MRIP survey design does not provide information on the recreational harvest of American eel in inland waters. American eels are popular bait for many important recreational fisheries such as striped bass and cobia.

MONITORING PROGRAM DATA

During 2020, sampling was impacted during March through June due to the COVID pandemic. Executive Order (EO) 116, issued on March 10, 2020, declared North Carolina under a State of

Emergency and was soon followed by EO 120 which implemented a statewide Stay at Home Order for all non-essential State employees. During this time, limited sampling occurred.

Fishery-Dependent Monitoring

To comply with Addendum I to the American Eel Fisheries Management Plan, the NCDMF initiated (January 2007) mandatory reporting of harvest and effort information for American eels harvested by commercial eel pots, including eel pot soak time and number of eel pots fished. Commercial fishermen are required to participate in a monthly logbook program designed to monitor the harvest of American eels by eel pots. Soak time and number of eel pots fished are currently not reported on trip tickets.

Fishery-Independent Monitoring

The National Oceanic and Atmospheric Administration (NOAA) conducts the Beaufort Bridgenet Ichthyoplankton Sampling Program (BBISP), an ichthyoplankton survey at Beaufort Inlet, which is used to develop a North Carolina young-of-year relative abundance index for American eel. The BBISP samples once-weekly at night during flood-tide from a fixed platform on Pivers Island Bridge, Beaufort, NC during October-May. Larvae are collected using a 2 m² plankton net fitted with a flow meter. Four replicate sets (tows) are made, with each filtering about 100 m³. Between 1987 and 2019, relative abundance of American eel (glass eel) has fluctuated from a low in 1991 to a high in 2005, with a 33-year average of 0.0125 eels per cubic meter (Figure 2). In 2019, American eel relative abundance (0.0072 eels per cubic meter) remained below the time-series average. Lengths of American eels captured in the BBISP from 2001 to 2019 (n=541) ranged from 41 to 153 millimeters (1.6 to 6.0 inches; Figure 3) and averaged 52 millimeters total length (2.0 inches; note: the 60⁺ millimeter category includes pooled fish lengths of 62, 91, and 153 millimeters). The BBISP continued their long-term sampling program in 2020 (January to March); however, no samples were collected in April and May, or in November and December due to COVID-19 restrictions. Currently, there is a one-year backlog of unsorted samples (2020 to present).

The North Carolina Division of Marine Fisheries (NCDMF) has no fishery-independent monitoring programs specifically for American eel, however, the North Carolina Estuarine Trawl Survey (Program 120) collects information on American eels caught incidentally. American eel catch data from Program 120 were used in the 2012 benchmark stock assessment. From 1971 to 2020, relative abundance has fluctuated from lows in 1973 and 2000 to a peak in 2011, with a 26-year average of 0.14 per tow (Figure 4). In 2020, relative abundance (0.01 eels per tow) was the lowest recorded in the time-series and continuing a downward trend started in 2011 (Figure 4). Due to COVID restrictions all 2020 sampling was conducted in June, with 104 core stations sampled in the first half of the month and 104 core stations sampled again during the second half of the month.

RESEARCH NEEDS

The items listed below are research needs identified in the 2012 stock assessment (ASMFC 2012) and progress toward accomplishing those objectives as described in the 2017 American

Eel Stock Assessment Update (ASMFC 2017) based on input from the ASMFC American Eel TC and SAS. A single asterisk (*) denotes short-term recommendations and two asterisks (**) denote long-term recommendations.

- Compare buyer reports to reported state landings* (No Action)
- Improve compliance with landings and effort reporting requirements as outlined in the ASMFC FMP for American eel (see ASMFC 2000a for specific requirements)* (Ongoing through the NC Trip Ticket Program and the American Eel Logbook Reporting Program)
- Require standardized reporting of trip-level landings and effort data for all states in inland waters; data should be collected using the Atlantic Coastal Cooperative Statistics Program (ACCSP) standards for collection of catch and effort data (ACCSP 2004)* (Ongoing through the American Eel Logbook Reporting Program)
- Monitor catch and effort in personal-use fisheries that are not currently covered by the Marine Recreational Fishing Statistics Survey (MRFSS) or commercial fisheries monitoring programs* (No Action)
- Implement a special-use permit for use of commercial fixed gear (e.g., pots and traps) to harvest American eels for personal use; special-use permit holders should be subject to the same reporting requirements for landings and effort as the commercial fishery** (No Action)
- Improve monitoring of catch and effort in bait fisheries (commercial and personal-use)* (No Action)
- Recommend monitoring of discards in targeted and non-targeted fisheries* (No Action)
- Continue to require states to report non-harvest losses in their annual compliance reports* (Ongoing)
- Require that states collect biological information by life stage (potentially through collaborative monitoring and research programs with dealers) including length, weight, age, and sex through fishery-dependent sampling programs; biological samples should be collected from gear types that target each life stage; at a minimum, length samples should be routinely collected from commercial fisheries* (No Action)
- Finish protocol for sampling fisheries; SASC has draft protocol in development* (No Action)
- Collect site-specific information on the recreational harvest of American eels in inland waters; this could be addressed by expanding the MRIP into inland areas** (No Action)
- Improve knowledge of fisheries occurring south of the U.S. and within the species' range that may affect the U.S. portion of the stock (i.e., West Indies, Mexico, Central America, and South America)** (No Action)
- Perform economics studies to determine the value of the fishery and the impact of regulatory management** (No Action)
- Review the historic participation level of subsistence fishers and relevant issues brought forth with respect to those subsistence fishers involved with American eel** (No Action)
- Investigate American eel harvest and resource by subsistence harvesters (e.g., Native American tribes, Asian and European ethnic groups)** (No Action)
- Maintain and update the list of fisheries-independent surveys that have caught American eels and note the appropriate contact person for each survey* (No Action)
- Request that states record the number of eels caught by fishery-independent surveys; recommend states collect biological information by life stage including length, weight, age, and sex of eels caught in fishery-independent sampling programs; at a minimum, length

samples should be routinely collected from fishery-independent surveys* (Ongoing through collecting number, length, and weight of eels caught in independent sampling programs)

- Encourage states to implement surveys that directly target and measure abundance of yellow- and silver-stage American eels, especially in states where few targeted eel surveys are conducted** (No Action)
- A coast-wide sampling program for yellow and silver American eels should be developed using standardized and statistically robust methodologies** (No Action)
- Continue the ASMFC-mandated YOY surveys; these surveys could be particularly valuable as an early warning signal of recruitment failure* (In 2009, funding was cut for the NCDMF YOY survey; however, the NOAA BBISP is currently used for the YOY survey, as approved by the ASMFC American Eel Management Board)
- Develop proceedings document for the 2006 ASMFC YOY Survey Workshop; follow-up on decisions and recommendations made at the workshop* (No Action)
- Examine age at entry of glass eel into estuaries and freshwater** (No Action)
- Develop monitoring framework to provide information for future modeling on the influence of environmental factors and climate change on recruitment** (No Action)
- Improve knowledge and understanding of the portion of the American eel population occurring south of the U.S. (i.e., West Indies, Mexico, Central America, and South America)** (No Action)
- Examine the mechanisms for exit from the Sargasso Sea and transport across the continental shelf** (No Action)
- Examine the mode of nutrition for leptocephalus in the ocean** (No Action)
- Investigate the effects of environmental contaminants on fecundity, natural mortality, and overall health** (No Action)
- Research the effects of bioaccumulation with respect to impacts on survival and growth (by age) and effect on maturation and reproductive success** (No Action)
- Investigate the prevalence and incidence of infection by the nematode parasite *A. crassus* across the species range* (No Action)
- Research the effects of the swim bladder parasite *A. crassus* on the American eel's growth and maturation, migration to the Sargasso Sea, and the spawning potential* (No Action)
- Investigate the impact of the introduction of *A. crassus* into areas that are presently free of the parasite** (No Action)
- Investigate relation between fecundity and length and fecundity and weight for females throughout their range** (No Action)
- Identify triggering mechanism for metamorphosis to mature adult, silver eel life stage, with specific emphasis on the size and age of the onset of maturity, by sex; a maturity schedule (proportion mature by size or age) would be extremely useful in combination with migration rates** (No Action)
- Research mechanisms of recognition of the spawning area by silver eel, mate location in the Sargasso Sea, spawning behavior, and gonadal development in maturation** (No Action)
- Examine migratory routes and guidance mechanisms for silver eel in the ocean** (No Action)
- Improve understanding of predator-prey relationships** (No Action)
- Investigating the mechanisms driving sexual determination and the potential management implications** (No Action)

- Develop design standards for upstream passage devices for eels. The ASMFC 2011 Eel Passage Workshop (ASMFC 2013) made contributions to this goal. (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage; in particular, investigate low-cost alternatives to traditional fishway designs for passage of eel** (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Evaluate the impact, both upstream and downstream, of barriers to eel movement with respect to population and distribution effects; determine relative contribution of historic loss of habitat to potential eel population and reproductive capacity**(NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Recommend monitoring of upstream and downstream movement at migratory barriers that are efficient at passing eels (e.g., fish ladder/lift counts); data that should be collected include presence/absence, abundance, and biological information; provide standardized protocols for monitoring eels at passage facilities; coordinate compilation of these data; provide guidance on the need and purpose of site-specific monitoring** (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Use the information gained from the above evaluation and monitoring of barriers to American eel passage to develop metrics for prioritizing passage restoration projects. (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Assess characteristics and distribution of American eel habitat and value of habitat with respect to growth and sex determination; develop GIS of American eel habitat in U.S.** (No Action)
- Assess available drainage area over time to account for temporal changes in carrying capacity; develop GIS of major passage barriers** (No Action)
- Improve understanding of freshwater habitat and water quality thresholds for American eel. (No Action)
- Improve understanding of within-drainage behavior and movement and the exchange between freshwater and estuarine systems** (No Action)
- Monitor non-harvest losses such as impingement, entrainment, spill, and hydropower turbine mortality* (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group)
- Evaluate eel impingement and entrainment at facilities with NPDES authorization for large water withdrawals; quantify regional mortality and determine if indices of abundance could be established as specific facilities** (No Action)
- Investigate best methods for reintroducing eels into a watershed; examine approaches for determining optimum density* (NCDMF will continue to work with Dominion Energy and participate on the American Eel Working Group - data available from the Roanoke Rapids, NC)
- Coordinate monitoring, assessment, and management among agencies that have jurisdiction within the species' range (e.g., ASMFC, GLFC, Canada DFO)** (No Action)
- Perform a joint U.S.-Canadian stock assessment* (NC will continue to provide data for stock assessments)
- Develop new assessment models (e.g., delay-difference model) specific to eel life history and fit to available indices** (No Action)

- Conduct intensive age and growth studies at regional index sites to support development of reference points and estimates of exploitation* (No Action)
- Develop GIS-type model that incorporates habitat type, abundance, contamination, and other environmental factors** (No Action)
- Develop population targets based on habitat availability at the regional and local level** (No Action)
- Implement large-scale (coastwide or regional) tagging studies of eels at different life stages; tagging studies could address a number of issues including: Natural, fishing, and discard mortality; survival; Growth; Passage mortality; Movement, migration, and residency; Validation of ageing methods; Reporting rates; and Tag shedding or tag attrition rate** (No Action)

MANAGEMENT STRATEGY

Under Addendum V, the commercial yellow eel fishery is regulated through an annual coast wide catch cap set at 916,473 pounds. Management action is initiated if the yellow eel coast-wide cap is exceeded by 10% in two consecutive years. The management trigger has never been tripped. If the management trigger is exceeded, only those states accounting for more than 1% (9,164 pounds) of the total yellow eel landings will be responsible for adjusting their measures. In 2020, the commercial landings in North Carolina were 3,291 pounds, therefore if the coast-wide management trigger was exceeded, North Carolina would not be required to work with other states to adjust harvest. A workgroup has been formed to define the process to equitably reduce landings among the affected states when the management trigger has been met.

The ASMFC adopted Addendum IV in 2014 that contained a provision allowing states to submit an Aquaculture Plan allowing for the limited harvest of American eel glass eels for use in domestic aquaculture facilities. Specifically, states are allowed to request harvest of up to 200 pounds of glass eels under an Aquaculture Plan. NCDMF submitted an American eel Aquaculture Plan to ASMFC requesting approval to harvest up to 200 pounds of glass eels from coastal fishing waters in 2015, 2016, 2017 and 2019. The NCDMF did not submit an American Eel Aquaculture Plan to the ASMFC in 2020 and does not have an active glass eel fishery.

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TABLES

Table 1. Summary of management strategies and their implementation status from Addendum V and previous Addendums.

Management Strategy	Implementation Status
Establish a coast-wide cap (916,473 pounds)	Accomplished with Addendum V
Establish a coast-wide cap (907,671 pounds)	Accomplished with Addendum IV
Establish aquaculture plans that allows for states and jurisdictions to request harvest of a maximum of 200 pounds of glass eels annually from within their waters for use in domestic aquaculture.	Accomplished with Addendum IV
Nine (9) in minimum size limit for both commercial and recreational fisheries.	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03M .0510
Recreational possession limit of 25 eels / person / day.	
No possession of American eels from September 1 to December 31 unless they are taken with baited pots	
Minimum eel pot mesh size of one-half by one-half inch.	Accomplished by N.C. Marine Fisheries Commission Rule 15A NCAC 03J .0301
Mandatory trip level reporting by life stage, including number of units fished and unit soak time.	Accomplished by N.C.G.S. 113-170.3 and the American eel log book reporting program where fishermen are notified by letter of the monthly reporting requirement

ASMFC AND FEDERALLY-MANAGED SPECIES WITHOUT N.C. INDICES – AMERICAN EEL

Table 2. Commercial landings of American eel (in pounds) in North Carolina, 1974-2020.

Year	Pounds	Year	Pounds
1974	451,956	1998	91,084
1975	237,684	1999	99,939
1976	510,083	2000	127,099
1977	258,296	2001	107,070
1978	695,605	2002	59,820
1979	954,534	2003	172,065
1980	960,196	2004	128,875
1981	436,007	2005	49,278
1982	475,524	2006	33,581
1983	404,157	2007	37,937
1984	706,298	2008	23,833
1985	224,263	2009	65,481
1986	338,377	2010	122,104
1987	127,964	2011	61,960
1988	57,369	2012	64,110
1989	152,656	2013	33,980
1990	56,494	2014	60,755
1991	12,082	2015	57,791
1992	17,739	2016	39,991
1993	32,711	2017	24,752
1994	95,991	2018	18,058
1995	173,698	2019	8,154
1996	141,592	2020	3,291
1997	128,668		

FIGURES

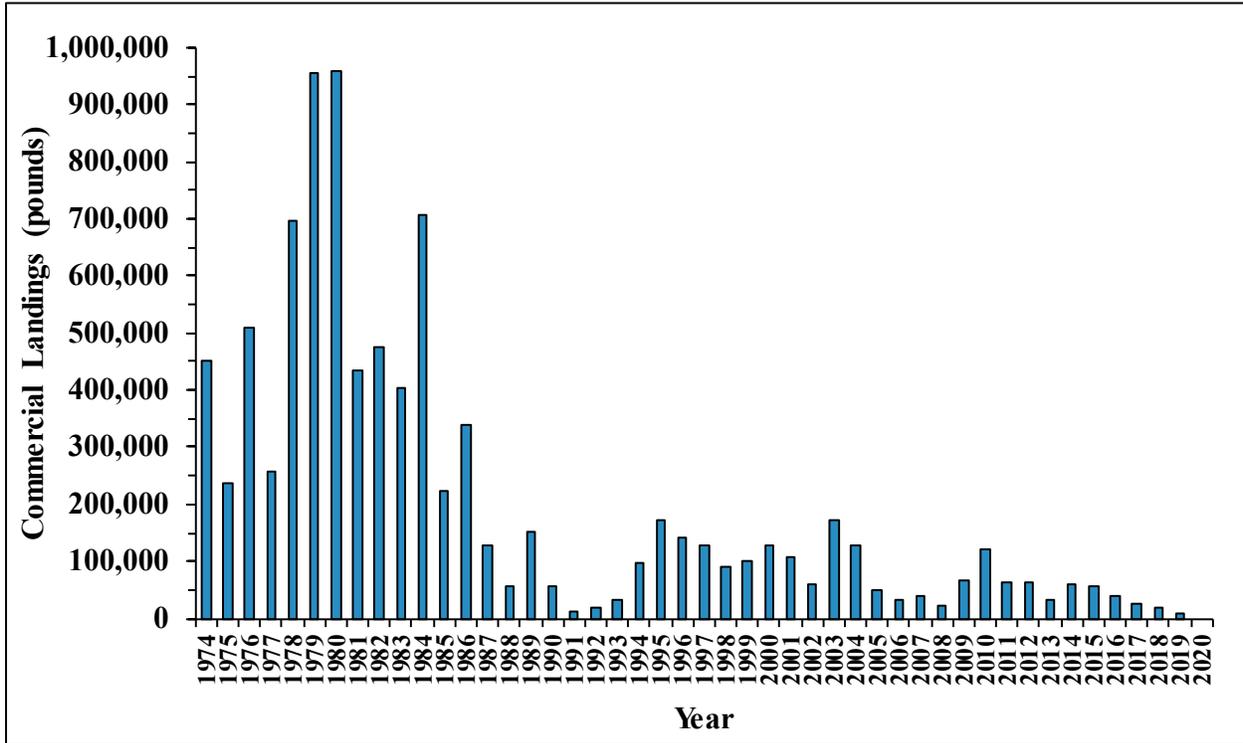


Figure 1. American eel commercial landings in N.C., 1974 – 2020.

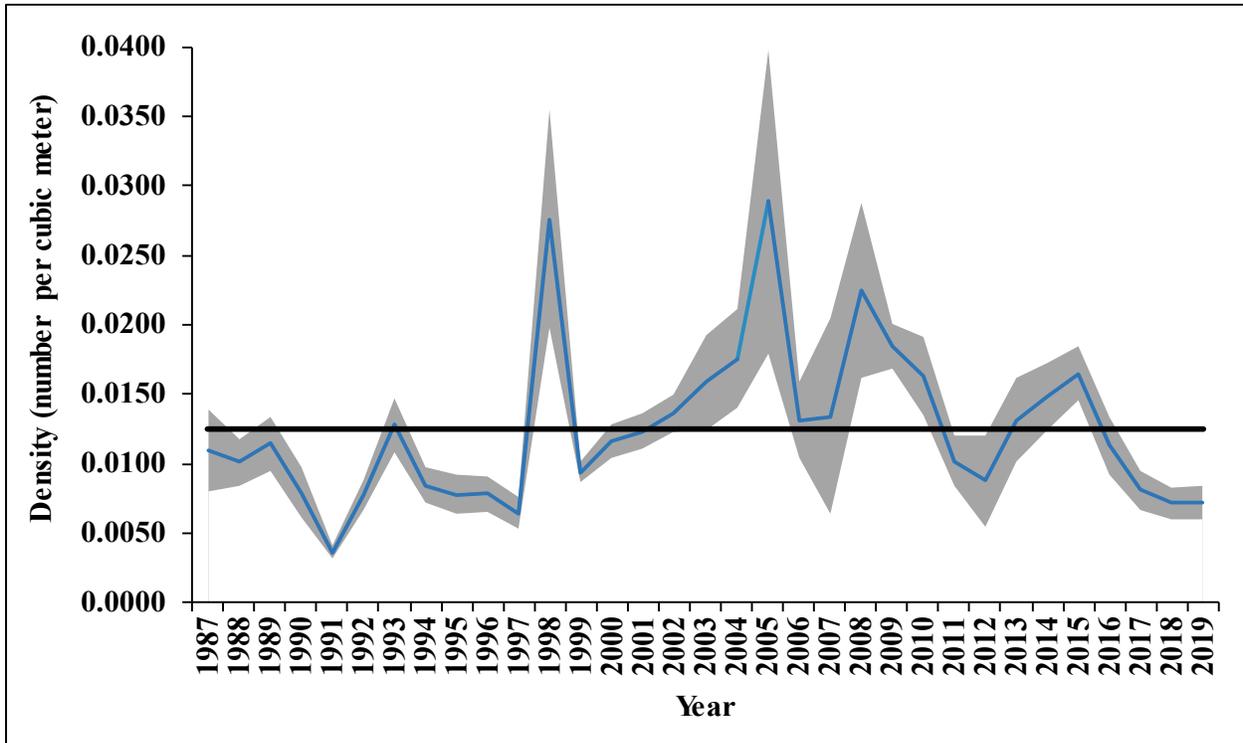


Figure 2. Average annual density (number of larvae per cubic meter) of American eel (glass eel) in the BBISP, 1987-2019. Solid black line represents time-series average. Shaded area represents standard error.

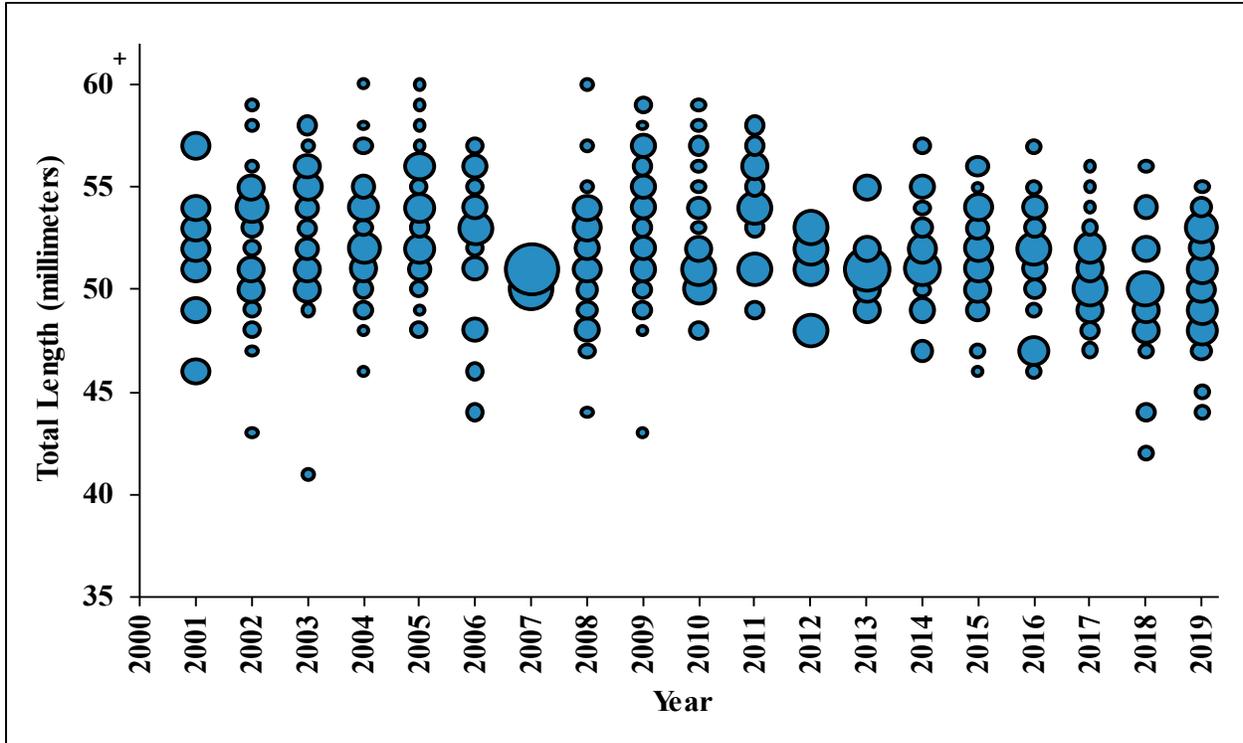


Figure 3. Average length frequency (total length, mm) of American eel collected in the BBISP, 2001-2019. Bubble represents the proportion of fish at length. (Note: the 60+ category includes three fish; 62, 91, and 153 mm).

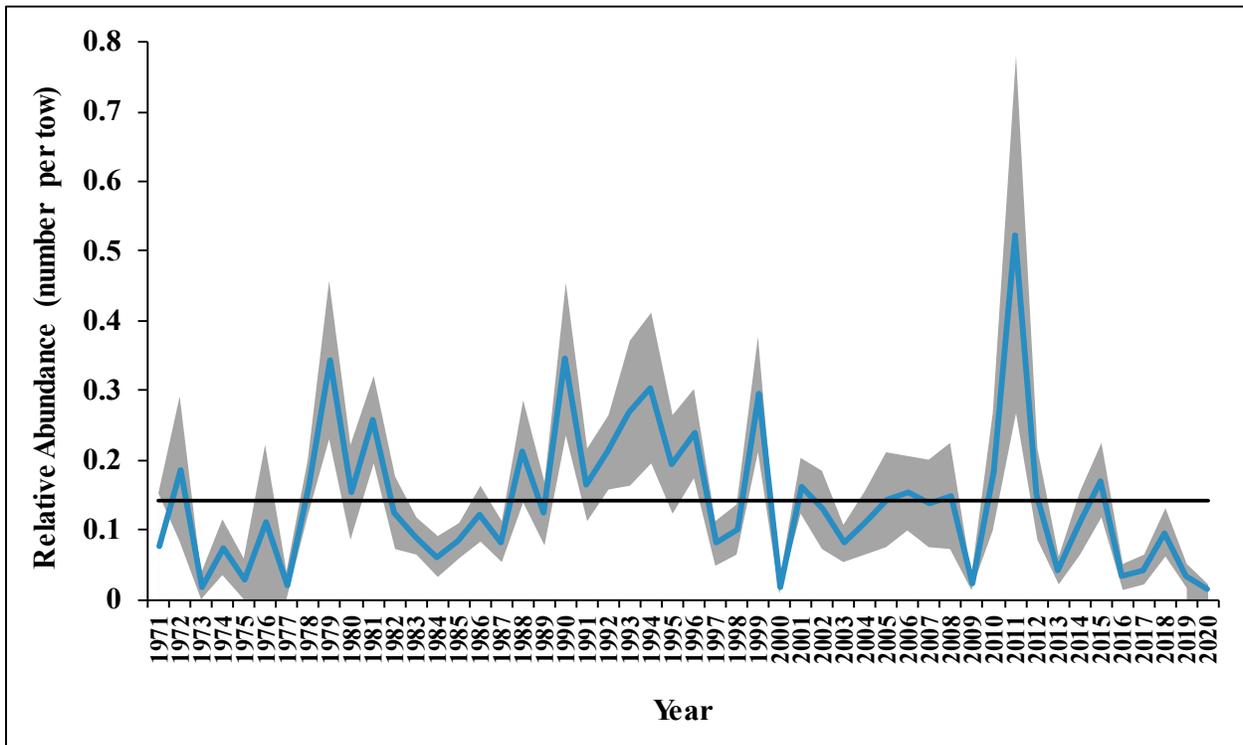


Figure 4. Relative abundance of juvenile (elver) American eel in the NCDMF Estuarine Trawl Survey, 1971-2020. Solid black line represents time-series average. Shaded area represents standard error.