ENDANGERED SPECIES ACT SECTION 7 CONSULTATION
BIOLOGICAL OPINION

Action Agency: U.S. Fish and Wildlife Service, Region 5

Activity: Issuance of Funds to 11 Northeast States and the District of Columbia through the Wildlife and Sport Fish Restoration Program from 2018-2022
PCTS ID: NER-2018-14763
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Consulting Agency: National Marine Fisheries Service, Greater Atlantic Regional Office, Protected Resources Division

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1.0 INTRODUCTION

Section 7(a)(2) of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*), requires each Federal agency to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of the designated critical habitat of such species. When the action of a Federal agency "may affect" a species or critical habitat that is protected under the ESA, that agency is required to consult with either the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (U.S. FWS), depending upon the species and critical habitats that may be affected. On occasion, NMFS or U.S. FWS must consult internally or with each other on proposed actions their agencies are authorizing, funding, or carrying out. In this instance, U.S. FWS must consult with us at NMFS on impacts to listed species under our jurisdiction.

The U.S. FWS, the lead Federal action agency for the proposed action assessed in this biological opinion, provides funds to several states through the Dingell-Johnson Sport Fish Restoration Program and State Wildlife Grant programs. These grant programs are collectively managed under the U.S. FWS Wildlife and Sport Fish Restoration (WSFR) program. Once dispersed, the states use these funds to carry out activities to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. A detailed list of activities considered in this opinion is included in Section 3.0. This opinion is based on information provided by U.S. FWS Region 5, state resource agencies being funded, and other available information cited herein. A complete administrative record of this consultation will be kept on file at the NMFS Greater Atlantic Regional Fisheries Office (GARFO).

2.0 CONSULTATION HISTORY

We, the NMFS GARFO Protected Resources Division (PRD), completed consultation on a previous five-year funding period of WSFR grant programs in 2013. We issued a biological opinion on January 23, 2013, which analyzed the state fisheries surveys funded by those grant programs from 2013-2017. This new opinion will consider future grants and funding of research activities under these programs for another five-year period from 2018-2022.

As the U.S. FWS-funded actions carried out by the states are similar in scope and design, take place in similar geographic areas (i.e., rivers, bays, estuaries, and nearshore ocean waters), and affect the same sets of ESA-listed species in similar manners, we have determined that it is most efficient to combine the analysis of effects of these activities into one consultation, similar to our approach in 2013. As such, while there are 12 independent actions considered here (i.e., U.S. FWS providing funds to 11 states and the District of Columbia), we are again completing one biological opinion to comprehensively address the effects of these 12 actions programmatically. This type of "multi-action" consultation is discussed in Chapter 5.3 of the ESA Section 7 Consultation Handbook (Regional or Ecosystem Consultations; U.S. FWS and NMFS 1998). Once in effect, this opinion replaces the opinion issued in 2013 on the effects of U.S. FWS-funded state fisheries surveys carried out over the previous five-year period from 2013-2017.

On September 13, 2017, U.S. FWS requested that we initiate formal consultation on their continued funding of surveys in marine, estuarine, and riverine waters of 11 Northeast states and the District of Columbia under the Dingell-Johnson Sport Fish Restoration and State Wildlife Grants programs. Along with their memorandum requesting formal consultation, U.S. FWS also provided us with an updated list of WSFR-funded state fisheries surveys to be assessed in the new opinion. On October 31, 2017, U.S. FWS requested that we include an additional electrofishing survey to be carried out by the state of Virginia in this opinion. On that date, we received all of the information necessary to initiate consultation. Given the complex action and need to consider the effects of over 100 studies on several ESA-listed species and designated critical habitat, we mutually agreed to complete a new opinion by the summer of 2018.

3.0 DESCRIPTION OF THE PROPOSED ACTIONS

U.S. FWS Region 5 provides an annual apportionment of funds to 13 Northeast states and the District of Columbia under the Dingell-Johnson Sport Fish Restoration Grant program and State Wildlife Grant programs. The states then decide which research projects to fund. Typically, states ask for annual grants, but on occasion will ask for multiple year grants. Even with multi-year grants, funds are usually disbursed on an annual basis. In regards to timing, the states choose the start and end times for grants, be it by calendar year, state fiscal year, federal fiscal year, or any other annual time period. Vermont and West Virginia are the only two Northeast states that do not use these funds to conduct surveys in marine, estuarine, or riverine waters where ESA listed species under our (i.e., NMFS) jurisdiction are present. The 11 other states (Maine, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia) and the District of Columbia are anticipated to carry out a total of 113 studies under these grant programs, mostly on an annual basis.

The list of activities considered in this opinion is outlined in Table 1. Complete project descriptions and maps illustrating project locations are included in Appendix A. There are several broad categories of fisheries surveys including: hook and line; long line; beach seine; haul seine; bottom trawl; surface trawl; fishway trap; fish lift; boat, backpack, and/or barge electrofishing; fyke net; dip net; gill net; push net; hoop net; trap net; cast net; plankton net; pound net; and fish and/or eel pot/trap. These surveys occur in rivers, bays, estuaries, and nearshore ocean waters of those 11 states and the District of Columbia. Some of these recurring surveys, such as the Virginia juvenile fish trawl survey, date back as far as the 1950s. Of the 113 surveys proposed for funding, ESA listed species (including sea turtles, shortnose sturgeon, and Atlantic sturgeon) have been incidentally captured in 24 of them. Records of sea turtle and sturgeon captures in these surveys date back as far as the 1960s, even before Congress enacted the ESA into law. Over time, reporting of listed species interactions with these surveys has increased due to heightened awareness and legal requirements. We have provided details on past interactions between these state fisheries surveys and NMFS listed species in Section 7.0.

Table 1. U.S. FWS-funded state fisheries surveys considered in this opinion.

State	Grant	Survey	Location	Gear
ME	F-41-R	Striped Bass Acoustic Telemetry Study	Kennebec and Androscoggin estuaries	Hook and line
ME	F-41-R	Juvenile Striped Bass and Alosine Beach Seine Survey	Kennebec, Androscoggin and Penobscot estuaries	Beach seine (17 m)
ME	F-43-R	Maine-New Hampshire Inshore Trawl Survey	Coastal Maine and New Hampshire	Bottom trawl (17.3 m)
NH	F-61-R	Anadromous Alosid Restoration and Evaluation	Coastal rivers systems of New Hampshire	Fishway trap
NH	F-61-R	Estuarine Survey of Juvenile Finfish	Great Bay and Hampton Harbor estuaries	Beach seine (30.5 m)
NH	F-61-R	Rainbow Smelt Survey	Oyster, Squamscott, and Winnicut Rivers	Fyke net
MA	T-3	Fish Community Assessments	Small rivers and streams statewide	Boat, backpack, and barge electrofishing; gill net; beach seine (100 ft)
MA	T-3	Holyoke Dam Fish Passage Facility Evaluation	Connecticut River	Fish lift
MA	T-3	Westfield River Fish Passage Facility Evaluation	Westfield River	Fishway trap
MA	T-3	Essex Dam Fish Passage Facility Evaluation	Merrimack River	Fishway trap
MA	T-3	Pawtucket Dam Fish Passage Facility Evaluation	Merrimack River	Fish lift
MA	F-56-R	Fishery Resource Assessment	Coastal Massachusetts	Bottom trawl (11.8 m)
MA	F-56-R	Winter Founder Year Class Strength Survey	Cape Cod southern shore estuaries	Beach seine (6 m)
MA	F-57-R	Cooperative Striped Bass Tagging Study	Cape Cod Bay, Nantucket Sound	Hook and line
MA	F-57-R	Massachusetts Large Pelagics Research Project	Massachusetts Bay, Cape Cod Bay, Nantucket Sound, Buzzards Bay	Hook and line

State	Grant	Survey	Location	Gear
MA	F-57-R	Striped Bass Acoustic Telemetry Study	Massachusetts Bay	Hook and line
MA	F-57-R	Monitoring Spawning Behavior and Movement of Atlantic Cod - Hook and line	Massachusetts Bay	Hook and line
MA	F-57-R	Monitoring Spawning Behavior and Movement of Atlantic Cod - Long line	Massachusetts Bay	Long line
MA	F-67-R	Population and Spawning Habitat Monitoring for Rainbow Smelt	Parker, Crane, North, Saugus, Fore, Jones, Weweantic , Westport rivers	Fyke net
MA	F-67-R	Monitoring of Biological Parameters and Habitat Characteristics for River Herring and American Shad	Nemasket and Monument rivers, Town Brook	Dip net
MA	F-67-R	Restoration of American Shad in the Charles River	Charles River	Boat electrofishing
MA	F-67-R	River Herring Trap and Transfer	Nemasket, Agawam, Charles and Monument rivers	Beach seine
RI	F-61-R	Seasonal Fishery Assessment in Rhode Island and Block Island Sound	Rhode Island and Block Island sounds	Bottom trawl (12.1 m)
RI	F-61-R	Narragansett Bay Monthly Fish Assessment	Narragansett Bay	Bottom trawl (12.1 m)
RI	F-61-R	Young-of-the-Year Survey of Selected Rhode Island Coastal Ponds and Embayments	Rhode Island coastal ponds and embayments	Beach seine
RI	F-61-R	Juvenile Marine Finfish Survey	Narragansett Bay	Beach seine
RI	F-61-R	Block Island Juvenile Finfish Survey	Great Salt Pond and Old Harbor, Block Island	Beach seine
RI	F-61-R	Assessment of Marine Fish Habitat	Providence-Seekonk Tidal Estuaries	Beach seine
RI	F-61-R	Enhancing Degraded Marine Habitats	Rhode Island coastal ponds and embayments	Gill net; eel pot

State	Grant	Survey	Location	Gear
RI	F-61-R	Winter Flounder Spawning Stock Biomass	Rhode Island coastal ponds and embayments	Fyke net
RI	F-61-R	Ventless Pot Multi-species Monitoring	Rhode Island coastal ponds and embayments	Fish pot
RI	F-61-R	University of Rhode Island Weekly Fish Trawl Survey	Narragansett Bay	Bottom trawl
RI	F-26-R	American Shad and River Herring Restoration and Enhancement - Fishway Trap	Pawcatuck River	Fishway trap (Potter Hill Dam)
RI	F-26-R	American Shad and River Herring Restoration and Enhancement - Beach Seine	Pawcatuck River	Beach seine
CT	F-54-R	Long Island Sound Trawl Survey	Long Island Sound	Bottom trawl (9.1 m)
CT	F-54-R	Estuarine Seine Survey	Connecticut shoreline	Beach seine (7.6 m)
CT	F-57-R	Monitor Warmwater Fish Populations in Lakes and Large Rivers	Connecticut River	Boat electrofishing
CT	F-57-R	Channel Catfish Management	Connecticut River	Boat electrofishing; trap net; hoop net
CT	T-18-R	Survey of Diadromous Fishes in the Connecticut River	Connecticut River	Beach seine
NY	F-49-R	New York Small Mesh Survey	Peconic Bay	Bottom trawl (4.9 m)
NY	F-49-R	Long Island Sound Trap Survey	Long Island Sound	Fish trap
NY	F-49-R	Western Long Island Sound Seine Survey	Little Neck, Manhasset and Jamaica bays	Beach seine (61 m, 152 m)
NY	F-49-R	Young-of-the-Year American Eel Survey	Carmans River	Fyke net
NY	F-49-R	Artificial Reef Monitoring	Hempstead, Fire Island, Kismet and Moriches reefs	Fish trap
NY	F-49-R	Spawning Stock Survey of American Shad, River Herring and Striped Bass	Hudson River	Haul seine (152 m, 305 m)
NY	F-49-R	Striped Bass Electrofishing	Hudson River	Boat electrofishing
NY	F-49-R	Alosine Juvenile Abundance Survey	Hudson River	Beach seine (30.5 m)
NY	F-49-R	Striped Bass Juvenile Abundance Survey	Hudson River	Beach seine (71 m)
NY	F-49-R	American Shad Spawning Habitat Studies	Hudson River	Gill net
NJ	F-48-R	Protection and Restoration of Inland Fisheries and Aquatic Habitats - Invasive Species Assessments	Delaware River	Boat electrofishing

State	Grant	Survey	Location	Gear
NJ	F-48-R	Assessment of the Biological Integrity of Inland Fisheries - Warmwater Species Assessments	Delaware River	Boat electrofishing
NJ	F-48-R	Assessment of the Biological Integrity of Inland Fisheries - Anadromous Species Assessments	Delaware River tributaries	Boat and backpack electrofishing; gill net; trap net; cast net; dip net; fyke net; seine
NJ	F-15-R	New Jersey Ocean Trawl Survey	Coastal New Jersey	Bottom trawl (25 m)
NJ	F-15-R	Cooperative Striped Bass Tagging in Delaware Bay	Delaware Bay	Gill net
NJ	F-15-R	Delaware River Juvenile Striped Bass Seine Survey	Delaware River	Beach seine (30.5 m)
NJ	F-15-R	Relative Abundance of Selected Finfish Species in Delaware Bay	Delaware Bay	Bottom trawl (4.9 m)
NJ	F-15-R	River Herring Survey	Maurice and Great Egg Harbor Rivers	Gill net; beach seine
PA	F-57-R	Estimate of Black Bass Population Density	Delaware River	Boat electrofishing
PA	F-57-R	Long Term Fish Population Monitoring and Management Technique Evaluations (Striped Bass)	Delaware River and Estuary	Boat electrofishing
DE	F-75-R	Delaware Tidal Largemouth Bass Monitoring Program	Nanticoke River, Broadkill River, St. Jones River, Marshyhope Creek, Mispillion River	Boat electrofishing
DE	F-47-R	Delaware River Striped Bass Spawning Stock Assessment	Delaware River	Boat electrofishing
DE	F-47-R	Nanticoke River Juvenile Shad Seine Survey	Nanticoke River	Beach seine
DE	F-47-R	Nanticoke River Adult Shad Boat Electrofishing	Nanticoke River	Boat electrofishing
DE	F-47-R	Christina River Juvenile Alosid Survey	Christina River	Beach seine
DE	F-37-R	Stream and Tidal Tributary Fish Survey	Streams and tidal tributaries in coastal plain of Delaware	Bottom trawl; beach seine; electrofishing
DE	F-42-R	Bottom Trawl Sampling of Adult Groundfish in Delaware Bay	Coastal waters of Delaware	Bottom trawl (9.3 m)
DE	F-42-R	Bottom Trawl Sampling of Juvenile Fishes in Delaware's Estuaries	Delaware estuaries	Bottom trawl (4.9 m)
DE	F-84-R	Structure Oriented Fish Assessment Program	Delaware artificial reefs	Fish trap

State	Grant	Survey	Location	Gear
MD	F-48-R	Tidal Largemouth Bass Survey	Potomac River, upper Chesapeake Bay and its tributaries	Boat electrofishing
MD	F-48-R	Invasive Species Studies	Potomac River and tributaries, Susquehanna River	Boat electrofishing
MD	F-50-R	Coastal Bays Fisheries Investigations - Trawl Survey	Coastal bays of Maryland	Bottom trawl (4.9 m)
MD	F-50-R	Coastal Bays Fisheries Investigations - Beach Seine Survey	Coastal bays of Maryland	Beach seine (15.2 m, 30 m)
MD	F-50-R	Submerged Aquatic Vegetation Beach Seining Program	Coastal bays of Maryland	Beach seine (15.2 m)
MD	F-57-R	Summer Juvenile American and Hickory Shad Seine Survey	Patuxent and Choptank rivers, Marshyhope Creek	Beach seine (61 m)
MD	F-57-R	Spring Adult American and Hickory Shad Electrofishing Survey	Patuxent and Choptank rivers, Marshyhope Creek	Boat electrofishing
MD	F-57-R	Spring American Shad Gill Net Brood Stock Collection	Potomac River	Gill net
MD	F-57-R	Spring Hickory Shad Electrofishing Brood Stock Collection	Susquehanna River	Boat electrofishing
MD	F-57-R	American Shad Larval Survey	Choptank River	Plankton net
MD	F-57-R	American Shad Adult Gillnet Survey	Choptank River	Gill net
MD	F-61-R	Upper Chesapeake Bay Winter Trawl Survey	Upper Chesapeake Bay	Bottom trawl (7.6 m)
MD	F-61-R	Fishery Independent Choptank River Fyke Net Survey	Choptank River	Fyke net
MD	F-61-R	Juvenile Alosid Trawl and Seine Survey	Chester River	Bottom trawl (4.9 m); Beach seine (30.5 m)
MD	F-61-R	American Shad Hook and Line Survey	Susquehanna River	Hook and line
MD	F-61-R	River Herring Gill Net Survey	Northeast River	Gill net
MD	F-61-R	Alosid Ichthyoplankton Survey	Nanticoke River	Towed plankton net
MD	F-61-R	Migratory Fish Gill Net Survey	Lower Choptank River	Gill net
MD	F-61-R	Spring Striped Bass Experimental Drift Gill Net Survey	Potomac River and Upper Chesapeake Bay	Gill net
MD	F-61-R	Juvenile Striped Bass Seine Survey	Chesapeake Bay	Beach seine (30.5 m)

State	Grant	Survey	Location	Gear
MD	F-63-R	Marine and Estuarine Finfish Ecological and Habitat Investigations	Chesapeake Bay	Bottom trawl (4.9 m); Beach seine (30.5 m)
MD	F-63-R	Ichthyoplankton Surveys	Chesapeake Bay subestuaries	Towed plankton net (0.5 m)
MD	F-110-R	Mycobacteriosis in Striped Bass Resident to Chesapeake Bay	Chesapeake Bay	Hook and line; Pound net; Beach seine
DC	F-2-R	Fish Population Surveys - Electrofishing	Potomac and Annacostia rivers	Boat electrofishing
DC	F-2-R	Fish Population Surveys - Seining	Potomac and Annacostia rivers	Beach seine (30.5 m)
DC	F-2-R	Fish Tagging Surveys	Potomac and Annacostia rivers	Boat electrofishing
DC	F-2-R	Push Net Survey	Potomac and Annacostia rivers	Push net
DC	F-2-R	American Eel Studies (Adult)	Potomac and Annacostia rivers	Eel pot
DC	F-2-R	American Shad Stock Enhancement	Potomac River	Gill net
DC	F-2-R	Blue Catfish Diet Study	Potomac and Annacostia rivers	Low frequency electrofishing
VA	F-111-R	Tidal River Fish Community Monitoring	James, Chickahominy, York and Rappahannock rivers	Boat electrofishing
VA	F-111-R	Tidal River Fish Catfish Surveys	James, Pamunkey, Piankatank, Mattaponi and Rappahannock rivers	Boat electrofishing
VA	F-111-R	American Shad Restoration - Gill Netting	James, Pamunkey, Potomac and Rappahannock rivers	Gill net

State	Grant	Survey	Location	Gear
VA	F-111-R	American Shad Restoration - Electrofishing	James, Pamunkey, Potomac and Rappahannock rivers	Boat electrofishing
VA	F-111-R	Northern Snakehead Monitoring in Virginia	Potomac, Wicomico, Rappahannock and Piankatank rivers	Boat electrofishing
VA	F-116-R	American Shad Monitoring Program – Gill Netting	York, James and Rappahannock rivers	Staked gill net
VA	F-116-R	Striped Bass Spawning Stock Assessment - Fyke Netting	York, James and Rappahannock rivers	Fyke net
VA	F-116-R	Adult Spawning River Herring Monitoring - Rappahannock	Rappahannock River	Staked gill net
VA	F-116-R	Adult Spawning River Herring Monitoring - Chickahominy	Chickahominy River	Staked and drift gill nets
VA	F-116-R	Juvenile Alosid Monitoring	Chickahominy River	Surface trawl
VA	F-104-R	Juvenile Fish Trawl Survey	Chesapeake Bay	Bottom trawl (9.1 m)
VA	F-87-R	Juvenile Striped Bass Beach Seine Survey	Chesapeake Bay	Beach seine (30.5 m)
VA	F-130-R	Chesapeake Bay Multispecies Monitoring and Assessment Program	Chesapeake Bay	Bottom trawl (13.7 m)
VA	F-77-R	Striped Bass Spawning Stock Assessment - Gill Netting	James and Rappahannock rivers	Gill net
VA	F-77-R	Striped Bass Spawning Stock Assessment - Electrofishing	James and Rappahannock rivers	Electrofishing

3.1 Action Area

The action area is defined as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 CFR 402.02). We anticipate that the effects on ESA-listed species and their habitats as a result of the state fisheries surveys funded under the proposed action include: (1) the direct effects of interactions between listed species and the fishing/sampling gear that will be used for these studies and (2) the effects on other marine organisms (i.e., prey) on the sea floor or within the water column that may result from direct capture in the gear. In addition, indirect effects from the operation of research and fishing vessels on ESA-listed species, their prey, and habitats are possible. Therefore, for the purpose of this consultation, the action area is defined by the area in which various research and fishing vessels/platforms will be conducting study activities and the areas they will be sited at and/or transiting through. The action area includes U.S. state and territorial waters where fisheries surveys and sampling will occur as described in Section 3.0 and Table 1 above, and generally consists of riverine, estuarine, and marine waters of the U.S. Northeast and Mid-Atlantic from Maine through Virginia out to approximately 12 nautical miles from shore.

4.0 STATUS OF LISTED SPECIES AND CRITICAL HABITATS

This section presents biological and ecological information relevant to formulating the opinion. Information on species' life history, habitat and distribution, and other factors necessary for their survival are included to provide background for analyses in later sections of this opinion.

4.1 Species and Critical Habitat Not Affected or Not Likely to be Adversely Affected by the Proposed Actions

In consultation with U.S. FWS, we have determined that the actions being considered in this opinion will not affect endangered sei whales (*Balaenoptera borealis*), blue whales (*Balaenoptera musculus*), sperm whales (*Physeter macrocephalus*), and hawksbill sea turtles (*Eretmochelys imbricata*) because these ESA-listed species are not expected to be present in the action area. We have also determined that the proposed actions are not likely to adversely affect endangered North Atlantic right whales (*Eubalaena glacialis*) and fin whales (*Balaenoptera physalus*). Additionally, we have determined that the proposed actions will not adversely affect critical habitat that has been designated in the action area for right whales, the Gulf of Maine distinct population segment (DPS) of Atlantic salmon, and three of the five listed DPSs of Atlantic sturgeon (Gulf of Maine, New York Bight, and Chesapeake Bay). Below, we present the rationale behind these "no effect" and "not likely to adversely affect" determinations.

Sei, sperm, and blue whales

Federally endangered sei, sperm, and blue whales are not expected to occur in the action area, which is limited to state and territorial waters of the U.S. Northeast and Mid-Atlantic. Sei whales are generally restricted to continental shelf edge-slope waters greater than 200 meters in depth (Horwood 2002; Hayes *et al*. 2017). During surveys for the Cetacean and Turtle Assessment Program (CeTAP), sperm whales were observed along the continental shelf edge, centered around the 1,000 meter depth contour but extending seaward out to the 2,000 meter depth contour (CeTAP 1982; Whitehead 2002). The blue whale is best considered as an occasional visitor to U.S. Atlantic Exclusive Economic Zone (EEZ) waters, which may represent the current southern limit of its feeding range (CeTAP 1982; Wenzel *et al.* 1988; Sears 2002). Although blue whales are have been sighted in offshore U.S. waters beyond the continental shelf break, they are more commonly found in Canadian waters and are extremely rare in continental shelf waters of the eastern U.S. (Waring *et al.* 2011). Given the highly offshore distribution of these three large whale species, and the fact that none has ever been captured or sighted during the state fisheries surveys being considered in this opinion, we do not expect them to occur in the action area. The range maps and species presence tables for ESA listed Atlantic large whales, currently available on our website at https://www.greateratlantic.fisheries.noaa.gov/protected/section7/listing/index.html, further confirm that there is no overlap between these three whale species and the proposed actions. As a result, they will not be affected by the proposed actions.

Hawksbill sea turtles

The hawksbill sea turtle is listed as endangered. This species is uncommon in the waters of the continental U.S. Hawksbills prefer coral reef habitats, such as those found in the Caribbean and Central America. Mona Island (Puerto Rico) and Buck Island (St. Croix, U.S. Virgin Islands) contain especially important foraging and nesting habitat for hawksbills. Within the continental U.S., nesting is restricted to the southeast coast of Florida and the Florida Keys, but even in these areas nesting is rare. Hawksbills have been recorded from all Gulf of Mexico states and along the U.S. east coast as far north as Massachusetts, but sightings north of Florida are extremely rare. Many of the sightings and strandings of hawksbills in states north of Florida have been observed after hurricanes or offshore storms. Aside from Florida, Texas is the only other U.S. state where hawksbills are sighted with any regularity (NMFS and U.S. FWS 1993, 2013a). Over the approximately 70 years of state fisheries surveys conducted in the action area, not a single hawksbill sea turtle observation has been reported. As a result, we do not expect hawksbill sea turtles to be present in the action area, and thus do not anticipate any effects to this species due to the proposed actions.

Right and fin whales
Federally endangered North Atlantic right whales and fin whales are expected to occur year round in nearshore and offshore waters of the action area where several state fisheries surveys considered in this opinion will occur (Aguilar 2002; Kenney 2002; Hayes *et al*. 2017). State fisheries surveys overlapping with the range of right and fin whales in the action area are trawl surveys that will occur in nearshore and offshore waters, and gillnet, pot/trap, seine, longline, and hook and line studies that will only occur in nearshore, inshore, and riverine waters.

Trawl surveys, because they will occur in both nearshore and offshore waters, have the greatest overlap with right and fin whale distribution. Even though trawl surveys have a high degree of overlap with right and fin whale distribution, this gear type is not likely to adversely affect these species because large whales have the speed and maneuverability to get out of the way of oncoming mobile gear, which is generally towed at slow speeds of less than three knots. The short tow times involved in the trawl studies (usually around 20 minutes or less) further reduce the potential for entanglement. We also made this determination based upon the lack of any documented large whale interactions during prior state and Federally operated ocean trawl surveys in the action area dating back to their inception (e.g., the 1950s for U.S. FWS funded state fisheries surveys, 1963 for the NMFS Northeast Fisheries Science Center [NEFSC] spring and fall bottom trawl surveys, and 2006 for the Northeast Area Monitoring and Assessment Program [NEAMAP] Near Shore Trawl Program surveys). Although there have been reports of fin whales feeding behind the codend of trawl nets during fishing activities (Fertl and Leatherwood 1997), there have been no records of right or fin whale entanglements in trawl gear in U.S. Atlantic waters in any recent marine mammal stock assessment reports or the NMFS List of Fisheries (Hayes *et al.* 2018; 83 FR 5349, February 7, 2018).

Gillnet, pot/trap, seine, longline, and hook and line studies will be conducted in nearshore, inshore, and riverine waters at depths where right and fin whales are either much less common or not expected at all, so although there is some overlap between these studies and known right and fin whale distributions, it is unlikely that these gears will adversely affect these species. That is because these studies will be conducted in shallow waters (nearly all less than 50 feet in depth) and for limited set durations. Sets in nearshore waters where some overlap with right and fin whales may occur are often only a few hours in duration, as compared to sets in inshore and riverine areas, where right and fin whales are not expected, which could last a couple days.

Therefore, it is extremely unlikely that right and fin whales will be present during the study periods when these gears are being deployed. Monitoring reports and summaries from past state and Federally operated fisheries surveys using these gear types, at similar times of year, in similar habitats, and for similar durations, provide no evidence of right or fin whale interactions with gillnet, pot/trap, seine, longline, and hook and line studies since the 1950s and 1960s.

We also considered the impact of study vessels on right whales and fin whales. Large whales, particularly right whales, are vulnerable to injury and mortality from vessel strikes. Vessel strike injuries to whales take two forms: (1) propeller wounds characterized by external gashes or severed tail stocks; and (2) blunt trauma injuries indicated by fractured skulls, jaws, and vertebrae, and massive bruises that sometimes lack external expression (Laist *et al.* 2001). Collisions with smaller vessels may result in propeller wounds or no apparent injury, depending on the severity of the incident. Laist *et al.* (2001) reports that of 41 vessel strike accounts that reported vessel speed, no lethal or severe injuries occurred at speeds below ten knots, and no collisions have been reported for vessels traveling less than six knots. A majority of whale vessel strikes seem to occur over or near the continental shelf, probably reflecting the concentration of vessel traffic and whales in these areas (Laist *et al.* 2001).

Most vessel strikes have occurred at vessel speeds of 13-15 knots or greater (Laist *et al*. 2001; Jensen and Silber 2003). An analysis by Vanderlaan and Taggart (2006) showed that at speeds greater than 15 knots, the probability of a vessel strike resulting in death increases asymptotically to 100%. At speeds below 11.8 knots, the probability decreases to less than 50%, and at ten knots or less, the probability is further reduced to approximately 30%. The speed of fisheries survey vessels is not expected to exceed three knots while surveying and ten knots while transiting to and from ports and survey sites. In addition, all vessels will have lookouts on board and operators will receive training on prudent vessel operating procedures to avoid vessel strikes with protected species. All fisheries survey vessels will slow down or alter course if whales are sighted and no vessel will approach within 500 meters of a whale. With these measures in place, interactions between the fisheries survey vessels and any listed whales are extremely unlikely. Therefore, the effects of research vessel strikes on right and fin whales are discountable.

We have also determined that the proposed action is not likely to have any adverse effects on the availability of prey for fin whales. Fin whales feed on pelagic krill as well as small schooling fish (e.g., sand lance, herring, mackerel) (Aguilar 2002). Most survey gear deployed under the proposed action will be set on or near the bottom in shallow waters. Fish species caught in these gears are typically shallow water species that live in benthic habitat (on or very near the bottom) versus schooling fish and invertebrates that occur within the water column in deeper waters. As a result, the proposed action is extremely unlikely to affect the availability of the pelagic prey of foraging fin whales. Since effects of the proposed action on fin whales and their prey are extremely unlikely, and therefore discountable, we will not assess them further in this opinion.

Critical habitats

We have determined that the actions considered in the opinion are not likely to adversely affect designated critical habitat for North Atlantic right whales. This determination is based on the actions' effects on the conservation value of the habitat that has been designated. Specifically, we considered whether the actions were likely to affect the physical or biological features (PBFs) that afford the designated area value for the conservation of North Atlantic right whales. On January 27, 2016, NMFS published a final rule (81 FR 4838) to replace the critical habitat for right whales in the North Atlantic originally designated in 1994 with two new areas. The final rule became effective on February 26, 2016. The areas designated as critical habitat contain approximately 29,763 square nautical miles of marine habitat in the Gulf of Maine and Georges Bank region (Unit 1, Northeastern U.S. Foraging Area) and off the Southeast U.S. coast (Unit 2, Southeastern U.S. Calving Area).

The Northeastern U.S. foraging habitat, which is located within the action area and overlaps with the study areas for the Maine-New Hampshire and Massachusetts trawl surveys as well as Massachusetts hook and line and longline surveys, has been designated as critical habitat for right whales due to its importance as a spring/summer foraging ground for the species. What makes this area so critical is the presence of dense concentrations of copepods upon which right whales primarily feed. The final rule identifies the following four PBFs of the Northeastern U.S. foraging habitat that are essential to the conservation of the species: (1) the physical oceanographic conditions and structures of the Gulf of Maine and Georges Bank region that combine to distribute and aggregate *Calanus finmarchicus* for right whale foraging, namely prevailing currents and circulation patterns, bathymetric features (basins, banks, and channels), oceanic fronts, density gradients, and temperature regimes; (2) low flow velocities in Jordan, Wilkinson, and Georges Basins that allow diapausing *C. finmarchicus* to aggregate passively below the convective layer so that the copepods are retained in the basins; (3) late stage *C. finmarchicus* in dense aggregations in the Gulf of Maine and Georges Bank region; and (4) diapausing *C. finmarchicus* in aggregations in the Gulf of Maine and Georges Bank region.

Based on information contained in the NMFS (2014) 4(b)(2) listing report and the 2016 listing rule (81 FR 4838; January 27, 2016), we have determined that the effects of the fishing gears and vessels to be used during the proposed actions on the availability of copepods for foraging right whales are likely so small that they cannot be meaningfully measured, detected, or evaluated, and are therefore insignificant. That is because copepods (*i.e.*, the biological features) are extremely small organisms that will pass through or around the fishing gears and vessels rather than being captured on or in them. In addition, it is extremely unlikely that the operation of fishing gears and vessels in small, localized areas off Maine, New Hampshire, and Massachusetts during the proposed actions will affect the large-scale oceanographic conditions, structures, and low flow velocities, which serve to concentrate copepods throughout the much larger Gulf of Maine. As a result, the effects of the proposed actions on those three types of physical features are discountable. Since the effects of the proposed actions on the PBFs that characterize the feeding habitat for North Atlantic right whales are all insignificant or discountable, the proposed actions are not likely to adversely affect this critical habitat.

We have also determined that the actions being considered in this opinion are not likely to adversely affect critical habitat that was designated for the Gulf of Maine DPS of Atlantic salmon on June 19, 2009 (74 FR 29300), and revised on August 10, 2009, to exclude trust and fee holdings of the Penobscot Indian Nation (74 FR 39003; August 10, 2009). There is no Atlantic salmon critical habitat in the marine environment where a number of the state fisheries research activities will occur. For inshore and estuarine areas where these surveys will operate, a discussion of effects on critical habitat is included below.

The critical habitat designation for the Gulf of Maine DPS of Atlantic salmon consists of 45 specific areas that include approximately 19,571 kilometers of perennial river, stream, and estuary habitat and 799 square kilometers of lake habitat within the geographic area occupied by the Gulf of Maine DPS at the time of listing, and in which are found those physical and biological features essential to the conservation of the species. The entire occupied range of the Gulf of Maine DPS in which critical habitat is designated is within the State of Maine. Some of the estuarine research activities proposed to be funded by the U.S. FWS occur within designated critical habitat for listed Atlantic salmon.

Portions of the action area in Maine contain known migratory corridors for both juvenile and adult Atlantic salmon. A migratory corridor free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds or prevent emigration of smolts to the marine environment is identified in the critical habitat designation as essential for the conservation of Atlantic salmon. Similar to PBFs, the primary constituent elements (PCEs) that comprise the designated critical habitat of listed Atlantic salmon in the action area are: (1) freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations; (2) freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation; and (3) freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.

We have analyzed the potential impacts of the state fisheries surveys on the PCEs of designated critical habitat for Atlantic salmon in the action area. We have determined that the effects to these PCEs will be insignificant or discountable for several reasons. First, the research activities are extremely unlikely to result in a migration barrier for salmon, as they will utilize small vessels and only deploy fishing gears within very small portions of specific rivers and estuaries at any given time. The use of small vessels and limited amounts of gear during the state fisheries surveys over limited time periods means that only a portion of a given critical habitat river will be used at any one time, leaving more than enough room for fish passage. As a result, it is extremely unlikely that salmon adults or smolts will be prevented from passing through the action area while the fisheries surveys are being conducted. In addition, the research activities are extremely unlikely to alter the habitat in any way that would increase the risk of predation, as fisheries research activities in Maine rivers and estuaries will primarily involve low impact surface and mid-water trawls, hook and line gear, pot/trap gear, and possibly beach seines and fyke nets. Since the proposed actions involve the use of only a small number of vessels and involve gears that produce only small amounts of turbidity and will be hauled back aboard the vessel shortly after being set, water quality impacts to salmon during migrations in the action area are also extremely unlikely. The research activities are also extremely unlikely to affect the forage of juvenile or adult Atlantic salmon, as their prey are not normally the target of the fisheries research activities being undertaken (and if they are, they will be collected in small numbers with most being returned to the water soon after capture). Finally, the proposed actions are extremely unlikely to affect the natural structure of the nearshore habitat, since the gears and vessels to be used will only affect very small areas of rivers and estuaries (and their bottom habitats) at any one time and will only be there temporarily. Therefore, any reduction in the capacity of the substrate, food resources, and natural cover to meet the conservation needs of Atlantic salmon resulting from the proposed actions will be too small to meaningfully measure, detect, or evaluate. Based upon this reasoning, we have determined that all effects to designated critical habitat for Atlantic salmon in the action area will be insignificant or discountable.

Finally, we have also determined that the actions being considered in this opinion are not likely to adversely affect designated critical habitat for Atlantic sturgeon. On August 17, 2017, NMFS issued a final rule designating critical habitat for the five listed DPSs of Atlantic sturgeon found in U.S. waters (82 FR 39160). The action area for this consultation overlaps with the downstream (*i.e.*, saline) portions and mouths of a number of rivers designated as critical habitat for three of the five DPSs of Atlantic sturgeon (Gulf of Maine, New York Bight, and Chesapeake Bay). We have analyzed the potential impacts of the proposed actions on these designated critical habitats, inclusive of the four PBFs described in the final rule and presented in Table 2. We have determined that the effects to these PBFs from the state fisheries surveys to be funded by the U.S. FWS will be insignificant or discountable as described below.

The state fisheries surveys do not overlap with and thus will not affect hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 parts per thousand [ppt]) that is used for settlement of fertilized eggs, refuge, growth, and development of early life stages (PBF 1). These features occur far upstream of the areas where state fisheries survey gear to be used in the projects covered under this opinion is placed in Northeast and Mid-Atlantic coastal rivers. As there is no overlap between PBF 1 in any of the critical habitat units and the action area, there will be no effects to PBF 1.

Table 2. PBFs for Atlantic sturgeon critical habitat (Gulf of Maine, New York Bight, and Chesapeake Bay).

1.	Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages.
2.	Aquatic habitat with a gradual downstream salinity gradient of 0.5 up to as high as 30 parts per thousand and soft substrate (e.g., sand, mud) between the river mouth and spawning sites for juvenile foraging and physiological development.
3.	Water of appropriate depth absent physical barriers to passage (e.g., locks, dams, thermal plumes, turbidity, sound, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) unimpeded movement of adults to and from spawning sites; (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., at least 1.2 meters) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
4.	Water, between the river mouth and spawning sites, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (1) spawning; (2) annual and interannual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment (e.g., 13°C to 26°C for spawning habitat and no more than 30°C for juvenile rearing habitat, and 6 milligrams per liter dissolved oxygen or greater for juvenile rearing habitat).

The state fisheries surveys may affect aquatic habitats downstream from the spawning sites that are used for juvenile foraging and physiological development (PBF 2), but those effects are expected to be extremely minor and temporary in nature. These waters are characterized by a gradual downstream salinity gradient of 0.5 up to as high as 30 ppt and soft substrate (e.g., sand, mud). As the surveys only involve the deployment and hauling of net, line, pot/trap, and electrofishing gear and occasional vessel transits to fish the gear, the salinity gradient will not be affected, and the natural structure of the soft bottom habitat at the river mouth locations will only incur temporary negative effects as a result of occasional bottom trawling and the deployment and hauling of pot/trap gear that rests on the river bottom. However, the scale at which these minor and temporary negative effects on soft bottom habitat will occur is likely too small to be meaningfully measured, detected, or evaluated when compared to the overall extent and conservation value of the rest of PBF 2 within Atlantic sturgeon critical habitat in the action area. In addition, the surveys are extremely unlikely to affect the forage base of juveniles, as their prey are not the target of the surveys and all gear will be deployed for only brief periods along or above the benthos of the estuary where preferred prey of juvenile sturgeon reside. As such, any reduction in the capacity of the soft bottom substrate, food resources, and natural cover to meet the conservation needs of juvenile Atlantic sturgeon would also be too small to be meaningfully measured, detected, or evaluated, and therefore insignificant. Therefore, all effects from the proposed actions on the distribution and conservation value of PBF 2 throughout the action area are insignificant.

Similar to the above analysis for Atlantic salmon critical habitat, the state fisheries surveys are extremely unlikely to result in a physical barrier to Atlantic sturgeon passage, as the gear placement and transit of vessels will only affect very small portions of specific rivers and estuaries at any given time. As was described above, the use of small vessels and limited amounts of gear during the state fisheries surveys over limited time periods means that only a portion of a given critical habitat river will be used at any one time, leaving more than enough room for fish passage through the action area. In addition, the proposed actions will not affect the depth or flow of water. As such, effects to PBF 3 are extremely unlikely and discountable.

Finally, as the state surveys only involve the temporary deployment and hauling of net, line, pot/trap, and electrofishing gear and occasional vessel transits to fish the gear, they will not affect water quality parameters (temperature, salinity, and dissolved oxygen) that support spawning, survival, growth, development, and recruitment (PBF 4). Based upon this analysis, as all effects to designated critical habitat in the action area will be insignificant or discountable, the action is not likely to adversely affect critical habitat for the Gulf of Maine, New York Bight, or Chesapeake Bay DPSs of Atlantic sturgeon.

4.2 Species Likely to be Adversely Affected by the Proposed Actions

This section will focus on the status of the various species within the action area, summarizing information necessary to establish the environmental baseline and to assess the effects of the proposed action. We have determined that the actions we consider in this opinion may adversely affect the following listed species:

Common name	Scientific name	ESA Status
Atlantic salmon - Gulf of Maine DPS	*Salmo salar*	Endangered
Loggerhead sea turtle - Northwest Atlantic DPS	*Caretta caretta*	Threatened
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Green sea turtle - North Atlantic DPS	*Chelonia mydas*	Threatened
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Atlantic sturgeon (five listed DPSs)	*Acipenser oxyrinchus oxyrinchus*	
Gulf of Maine DPS		Threatened
New York Bight DPS		Endangered
Chesapeake Bay DPS		Endangered
Carolina DPS		Endangered
South Atlantic DPS		Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered

4.2.1 Gulf of Maine DPS of Atlantic salmon

The only research activities considered here that may result in the capture of ESA-listed Atlantic salmon are surveys that take place in Maine. NMFS holds an ESA section 10(a)(l)(A) research permit (ESA permit 697823) issued by U.S. FWS. This section 10 research permit allows NMFS and any designated subpermittee to engage in research, recovery, management, and assessment activities involving listed Atlantic salmon in Maine. Maine Department of Marine Resources (DMR) is a subpermittee on this permit. As all effects to Atlantic salmon resulting from the proposed action are considered and authorized under the existing section 10 permit and accompanying section 7 consultation, any effects to Atlantic salmon will not be further considered in this opinion.

4.2.2 Status of Sea Turtles

With the exception of loggerheads and greens, sea turtles are listed under the ESA at the species level rather than as subspecies or DPSs. Therefore, information on the range-wide status of Kemp's ridley and leatherback sea turtles is included to provide the status of each species overall. Information on the status of loggerhead and green sea turtles will only be presented for the DPS affected by this action. Additional background information on the range-wide status of these species can be found in a number of published documents, including sea turtle status reviews and biological reports (NMFS and U.S. FWS 1995, 2007a, 2007b, 2013; 2015; Hirth 1997; Marine Turtle Expert Working Group [TEWG] 1998, 2000, 2007, 2009; Conant *et al.* 2009; Seminoff *et al.* 2015), and recovery plans for the loggerhead sea turtle (NMFS and U.S. FWS 2008), Kemp's ridley sea turtle (NMFS *et al.* 2011), green sea turtle (NMFS and U.S. FWS 1991), and leatherback sea turtle (NMFS and U.S. FWS 1992, 1998).

2010 BP Deepwater Horizon Oil Spill
The April 20, 2010, explosion of the Deepwater Horizon oil rig affected sea turtles in the Gulf of Mexico. This extensive oiling event contaminated important sea turtle foraging, migratory, and breeding habitats at the surface, in the water column, on the ocean bottom, and on beaches

throughout the northern Gulf of Mexico in areas used by different life stages. Sea turtles were exposed to oil when in contaminated water or habitats; breathing oil droplets, oil vapors, and smoke; ingesting oil-contaminated water and prey; and potentially by maternal transfer of oil compounds to embryos (DWH NRDA Trustees 2016). Response activities and shoreline oiling also directly injured sea turtles and disrupted or deterred sea turtle nesting in the Gulf.

During direct at-sea capture events, more than 900 turtles were sighted, 574 of which were captured and examined for oiling (Stacy 2012). Of the turtles captured during these operations, greater than 80% were visibly oiled (DWH NRDA Trustees 2016). Most of the rescued turtles were taken to rehabilitation facilities; more than 90% of the turtles admitted to rehabilitation centers eventually recovered and were released (Stacy 2012; Stacy and Innis 2012). Recovery efforts also included relocating nearly 300 sea turtle nests from the northern Gulf to the east coast of Florida in 2010, with the goal of preventing hatchlings from entering the oiled waters of the northern Gulf. Approximately 14,000 hatchlings were released off the Atlantic coast of Florida, 95% of which were loggerheads (http://www.nmfs.noaa.gov/pr/health/oilspill/gulf2010.htm).

Direct observations of the effects of oil on turtles obtained by at-sea captures, sightings, and strandings only represent a fraction of the scope of the injury. As such, the DWH NRDA Trustees used expert opinion, surface oiling maps, and statistical approaches to apply the directly observed adverse effects of oil exposure to turtles in areas and at times that could not be surveyed. The Trustees estimated that between 4,900 and up to 7,600 large juvenile and adult sea turtles (Kemp’s ridleys, loggerheads, and hard-shelled sea turtles not identified to species), and between 55,000 and 160,000 small juvenile sea turtles (Kemp’s ridleys, green turtles, loggerheads, hawksbills, and hard-shelled sea turtles not identified to species) were killed by the DWH oil spill (DWH NRDA Trustees 2016). Nearly 35,000 hatchling sea turtles (loggerheads, Kemp’s ridleys, and green turtles) were also injured by response activities. Despite uncertainties and some unquantified injuries to sea turtles (e.g., injury to leatherbacks, unrealized reproduction), the Trustees conclude that this assessment adequately quantifies the nature and magnitude of injuries to sea turtles caused by the DWH oil spill and related activities.

Based on this quantification of sea turtle injuries caused by the DWH oil spill, sea turtles from all life stages and all geographic areas were lost from the northern Gulf of Mexico ecosystem. The DWH NRDA Trustees (2016) conclude that the recovery of sea turtles in the northern Gulf of Mexico from injuries caused by the DWH oil spill will require decades of sustained efforts to reduce the most critical threats and enhance survival of turtles at multiple life stages. The ultimate population level effects of the spill and impacts of the associated response activities are likely to remain unknown for some period into the future.

4.2.2.1 Status of Loggerhead Sea Turtles – Northwest Atlantic DPS

Species Description

Loggerhead sea turtles are circumglobal, and are found in the temperate and tropical regions of the Indian, Pacific and Atlantic Oceans. Northwest Atlantic Ocean DPS loggerheads are found along eastern North America, Central America, and northern South America (Figure 1).

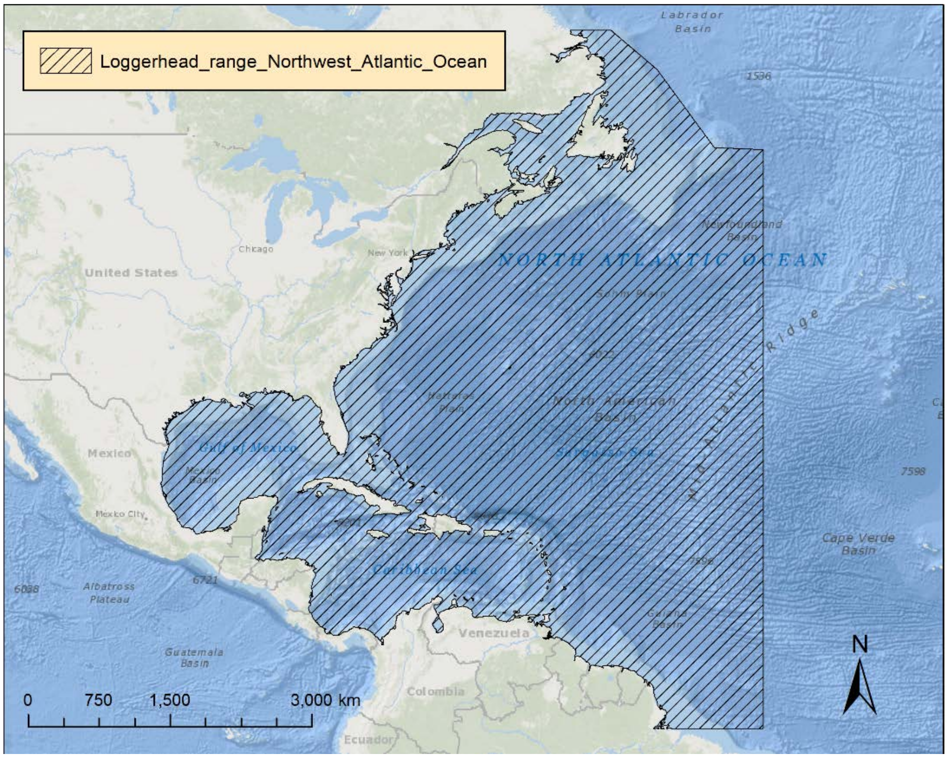

Figure 1. Map identifying the range of the Northwest Atlantic Ocean DPS of loggerhead sea turtles.

The loggerhead sea turtle is distinguished from other turtles by its reddish-brown carapace, large head and powerful jaws (Figure 2). The species was first listed as threatened under the Endangered Species Act in 1978 (43 FR 32800). On September 22, 2011, the NMFS designated nine distinct population segments of loggerhead sea turtles, with the Northwest Atlantic Ocean DPS listed as threatened (75 FR 12598) (Table 3).

Figure 2. Loggerhead turtle. Photo: NOAA

Table 3. Northwest Atlantic Ocean DPS loggerhead sea turtle information bar provides species Latin name, common name and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Caretta caretta	Loggerhead sea turtle	Northwest Atlantic	Threatened	2009	76 FR 58868	2009	79 FR 39855

We used information available in the 2009 Status Review (Conant *et al*. 2009) and the final listing rule (76 FR 58868) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Mean age at first reproduction for female loggerhead sea turtles is thirty years. Females lay an average of three clutches per season. The annual average clutch size is 112 eggs per nest. The average remigration interval is 2.7 years. Nesting occurs on beaches, where warm, humid sand temperatures incubate the eggs. Temperature determines the sex of the turtle during the middle of the incubation period. Turtles spend the post-hatchling stage in pelagic waters. The juvenile stage is spent first in the oceanic zone and later in the neritic zone (*i.e.*, coastal waters). Coastal waters provide important foraging habitat, inter-nesting habitat, and migratory habitat for adult loggerheads.

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Northwest Atlantic Ocean DPS loggerhead sea turtle.

There is general agreement that the number of nesting females provides a useful index of the species' population size and stability at this life stage, even though there are doubts about the ability to estimate the overall population size. Adult nesting females often account for less than 1% of total population numbers (Bjorndal *et al*. 2005).

Using a stage/age demographic model, the adult female population size of the DPS is estimated at 20,000 to 40,000 females, and 53,000 to 92,000 nests annually (NMFS SEFSC 2009). Based on genetic information, the Northwest Atlantic Ocean DPS is further categorized into five recovery units corresponding to nesting beaches. These are Northern Recovery Unit, Peninsular Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit.

The Northern Recovery Unit, from North Carolina to northeastern Florida, and is the second largest nesting aggregation in the DPS, with an average of 5,215 nests from 1989 to 2008, and approximately 1,272 nesting females (NMFS and U.S. FWS 2008).

The Peninsular Florida Recovery Unit hosts more than 10,000 females nesting annually, which constitutes 87% of all nesting effort in the DPS (Ehrhart *et al*. 2003).

The Greater Caribbean Recovery Unit encompasses nesting subpopulations in Mexico to French Guiana, the Bahamas, and the Lesser and Greater Antilles. The majority of nesting for this recovery unit occurs on the Yucatán peninsula, in Quintana Roo, Mexico, with 903 to 2,331 nests annually (Zurita *et al*. 2003). Other significant nesting sites are found throughout the Caribbean, and including Cuba, with approximately 250 to 300 nests annually (Ehrhart *et al*. 2003), and over one hundred nests annually in Cay Sal in the Bahamas (NMFS and U.S. FWS 2008).

The Dry Tortugas Recovery Unit includes all islands west of Key West, Florida. The only available data for the nesting subpopulation on Key West comes from a census conducted from 1995 to 2004 (excluding 2002), which provided a mean of 246 nests per year, or about sixty nesting females (NMFS and U.S. FWS 2007a).

The Gulf of Mexico Recovery Unit has between one hundred to 999 nesting females annually, and a mean of 910 nests per year.

The population growth rate for each of the four of the recovery units for the Northwest Atlantic DPS (Peninsular Florida, Northern, Northern Gulf of Mexico, and Greater Caribbean) all exhibit negative growth rates (Conant *et al.* 2009).

Nest counts taken at index beaches in Peninsular Florida show a significant decline in loggerhead nesting from 1989 to 2006, most likely attributed to mortality of oceanic-stage loggerheads caused by fisheries bycatch (Witherington *et al.* 2009). Loggerhead nesting on the Archie Carr National Wildlife Refuge (representing individuals of the Peninsular Florida subpopulation) has fluctuated over the past few decades. There was an average of 9,300 nests throughout the 1980s, with the number of nests increasing into the 1990s until it reached an all-time high in 1998, with 17,629 nests. From that point, the number of loggerhead nests at the Refuge have declined steeply to a low of 6,405 in 2007, increasing again to 15,539, still a lower number of nests than in 1998 (Bagley *et al.* 2013).

For the Northern recovery unit, nest counts at loggerhead nesting beaches in North Carolina, South Carolina and Georgia declined at 1.9% annually from 1983 to 2005 (NMFS and U.S. FWS 2007a).

The nesting subpopulation in the Florida panhandle has exhibited a significant declining trend from 1995 to 2005 (NMFS and U.S. FWS 2007a; Conant *et al.* 2009). Recent model estimates predict an overall population decline of 17% for the St. Joseph Peninsula, Florida subpopulation of the Northern Gulf of Mexico recovery unit (Lamont *et al.* 2014).

Based on genetic analysis of nesting subpopulations, the Northwest Atlantic Ocean DPS is further divided into five recovery units: Northern, Peninsular Florida, Dry Tortugas, Northern Gulf of Mexico, and Greater Caribbean (Conant *et al.* 2009). A more recent analysis using expanded mitochondrial DNA sequences revealed that rookeries from the Gulf and Atlantic coasts of Florida are genetically distinct, and that rookeries from Mexico's Caribbean coast express high haplotype diversity (Shamblin *et al.* 2014). Furthermore, the results suggest that the Northwest Atlantic Ocean DPS should be considered as ten management units: (1) South Carolina and Georgia, (2) central eastern Florida, (3) southeastern Florida, (4) Cay Sal, Bahamas, (5) Dry Tortugas, Florida, (6) southwestern Cuba, (7) Quintana Roo, Mexico, (8) southwestern Florida, (9) central western Florida, and (10) northwestern Florida (Shamblin *et al.* 2012).

Loggerhead hatchlings from the western Atlantic disperse widely, most likely using the Gulf Stream to drift throughout the Atlantic Ocean. Mitochondrial DNA evidence demonstrates that juvenile loggerheads from southern Florida nesting beaches comprise the vast majority (71%-88%) of individuals found in foraging grounds throughout the western and eastern Atlantic: Nicaragua, Panama, Azores and Madeira, Canary Islands and Andalusia, Gulf of Mexico and Brazil (Masuda 2010).

Status
Due to declines in nest counts at index beaches in the United States and Mexico, and continued mortality of juveniles and adults from fishery bycatch, the Northwest Atlantic Ocean DPS is at risk and likely to decline in the foreseeable future (Conant *et al*. 2009).

Recovery Goals
See the 2009 Final Recovery Plan for the Northwest Atlantic Population of Loggerheads for complete down listing/delisting criteria for each of the following recovery objectives.

1. Ensure that the number of nests in each recovery unit is increasing and that this increase corresponds to an increase in the number of nesting females.
2. Ensure the in-water abundance of juveniles in both neritic and oceanic habitats is increasing and is increasing at a greater rate than strandings of similar age classes.
3. Manage sufficient nesting beach habitat to ensure successful nesting.
4. Manage sufficient feeding, migratory and internesting marine habitats to ensure successful growth and reproduction.
5. Eliminate legal harvest.
6. Implement scientifically based nest management plans.
7. Minimize nest predation.
8. Recognize and respond to mass/unusual mortality or disease events appropriately.
9. Develop and implement local, state, Federal and international legislation to ensure long-term protection of loggerheads and their terrestrial and marine habitats.
10. Minimize bycatch in domestic and international commercial and artisanal fisheries.
11. Minimize trophic changes from fishery harvest and habitat alteration.
12. Minimize marine debris ingestion and entanglement.
13. Minimize vessel strike mortality.

4.2.2.2 Status of Kemp's Ridley Sea Turtles

Species Description
The Kemp's ridley turtle is considered to be the most endangered sea turtle, internationally (Zwinenberg 1977; Groombridge and Wright 1982). Its range extends from the Gulf of Mexico to the Atlantic coast, with nesting beaches limited to a few sites in Mexico and Texas (Figure 3).

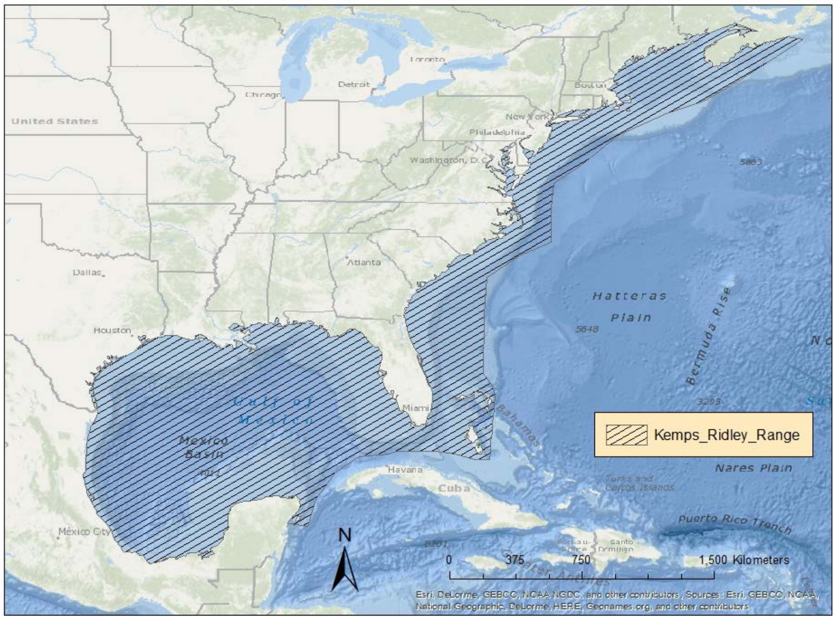

Figure 3. Map identifying the range of the endangered Kemp's ridley sea turtle.

Kemp's ridley sea turtles the smallest of all sea turtle species, with a nearly circular top shell and a pale yellowish bottom shell (Figure 4). The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973 (Table 4).

We used information available in the revised recovery plan (NMFS *et al*. 2011) and the Five-Year Review (NMFS and U.S. FWS 2015) to summarize the life history, population dynamics and status of the species, as follows.

Figure 4. Kemp's ridley turtle. Photo: NOAA

Table 4. Kemp's ridley turtle information bar provides species Latin name, common name and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment/Evolutionary Significant Unit, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Lepidochelys kempii	Kemp's ridley sea turtle	None Designated	Endangered range wide	2015	35 FR 18319	2011	None Designated

Life History

Females mature at 12 years of age. The average remigration is two years. Nesting occurs from April to July in large arribadas, primarily at Rancho Nuevo, Mexico. Females lay an average of 2.5 clutches per season. The annual average clutch size is ninety-seven to one hundred eggs per nest. The nesting location may be particularly important because hatchlings can more easily migrate to foraging grounds in deeper oceanic waters, where they remain for approximately two years before returning to nearshore coastal habitats. Juvenile Kemp's ridley sea turtles use these nearshore coastal habitats from April through November, but move towards more suitable overwintering habitat in deeper offshore waters (or more southern waters along the Atlantic coast) as water temperature drops. Adult habitat largely consists of sandy and muddy areas in shallow, nearshore waters less than 120 feet (37 meters) deep, although they can also be found in deeper offshore waters. As adults, Kemp's ridleys forage on swimming crabs, fish, jellyfish, mollusks, and tunicates (NMFS *et al*. 2011).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Kemp's ridley sea turtle.

Of the sea turtles species in the world, the Kemp's ridley has declined to the lowest population level. Nesting aggregations at a single location (Rancho Nuevo, Mexico) were estimated at 40,000 females in 1947. By the mid-1980s, the population had declined to an estimated 300 nesting females. In 2014, there were an estimated 10,987 nests and 519,000 hatchlings released from three primary nesting beaches in Mexico (NMFS and U.S. FWS 2015). The number of nests in Padre Island, Texas has increased over the past two decades, with one nest observed in 1985, four in 1995, fifty in 2005, 197 in 2009, and 119 in 2014 (NMFS and U.S. FWS 2015).

From 1980 to 2003, the number of nests at three primary nesting beaches (Rancho Nuevo, Tepehuajes, and Playa Dos) increased 15% annually (Heppell *et al*. 2005); however, due to recent declines in nest counts, decreased survival at other life stages, and updated population modeling, this rate is not expected to continue (NMFS and U.S. FWS 2015).

Genetic variability in Kemp's ridley turtles is considered to be high, as measured by heterozygosis at microsatellite loci (NMFS *et al*. 2011). Additional analysis of the mitochondrial DNA taken from samples of Kemp's ridley turtles at Padre Island, Texas, showed six distinct haplotypes, with one found at both Padre Island and Rancho Nuevo (Dutton *et al.* 2006).

The Kemp's ridley occurs from the Gulf of Mexico and along the Atlantic coast of the U.S. (TEWG 2000). Kemp's ridley sea turtles have occasionally been found in the Mediterranean Sea, which may be due to migration expansion or increased hatchling production (Tomas and Raga 2008). The vast majority of individuals stem from breeding beaches at Rancho Nuevo on the Gulf of Mexico coast of Mexico. During spring and summer, juvenile Kemp's ridleys occur in the shallow coastal waters of the northern Gulf of Mexico from south Texas to north Florida. In the fall, most Kemp's ridleys migrate to deeper or more southern, warmer waters and remain there through the winter (Schmid 1998). As adults, many turtles remain in the Gulf of Mexico, with only occasional occurrence in the Atlantic Ocean (NMFS *et al*. 2011).

Status

The Kemp's ridley was listed as endangered in response to a severe population decline, primarily the result of egg collection. In 1973, legal ordinances prohibited the harvest of sea turtles from May to August, and in 1990, the harvest of all sea turtles was prohibited by presidential decree. In 2002, Rancho Nuevo was declared a Sanctuary. A successful head-start program has resulted in the re-establishment of nesting at Texan beaches. While fisheries bycatch remains a threat, the use of turtle excluder devices mitigates take. Fishery interactions and strandings, possibly due to forced submergence, appear to be the main threats to the species. It is clear that the species is steadily increasing; however, the species' limited range and low global abundance make it vulnerable to new sources of mortality as well as demographic and environmental randomness, all of which are often difficult to predict with any certainty. Therefore, its resilience to future perturbation is low.

Recovery Goals

See the 2011 Final Bi-National (U.S. and Mexico) Revised Recovery Plan for Kemp's ridley sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were identified as priorities to recover Kemp's ridley sea turtles:

1. Protect and manage nesting and marine habitats.
2. Protect and manage populations on the nesting beaches and in the marine environment.
3. Maintain a stranding network.
4. Manage captive stocks.
5. Sustain education and partnership programs.
6. Maintain, promote awareness of and expand U.S. and Mexican laws.
7. Implement international agreements.
8. Enforce laws.

4.2.2.3 Status of Green Sea Turtles – North Atlantic DPS

Species description

The green sea turtle is globally distributed and commonly inhabits nearshore and inshore waters. The North Atlantic DPS green turtle is found in the North Atlantic Ocean and Gulf of Mexico (Figure 5).

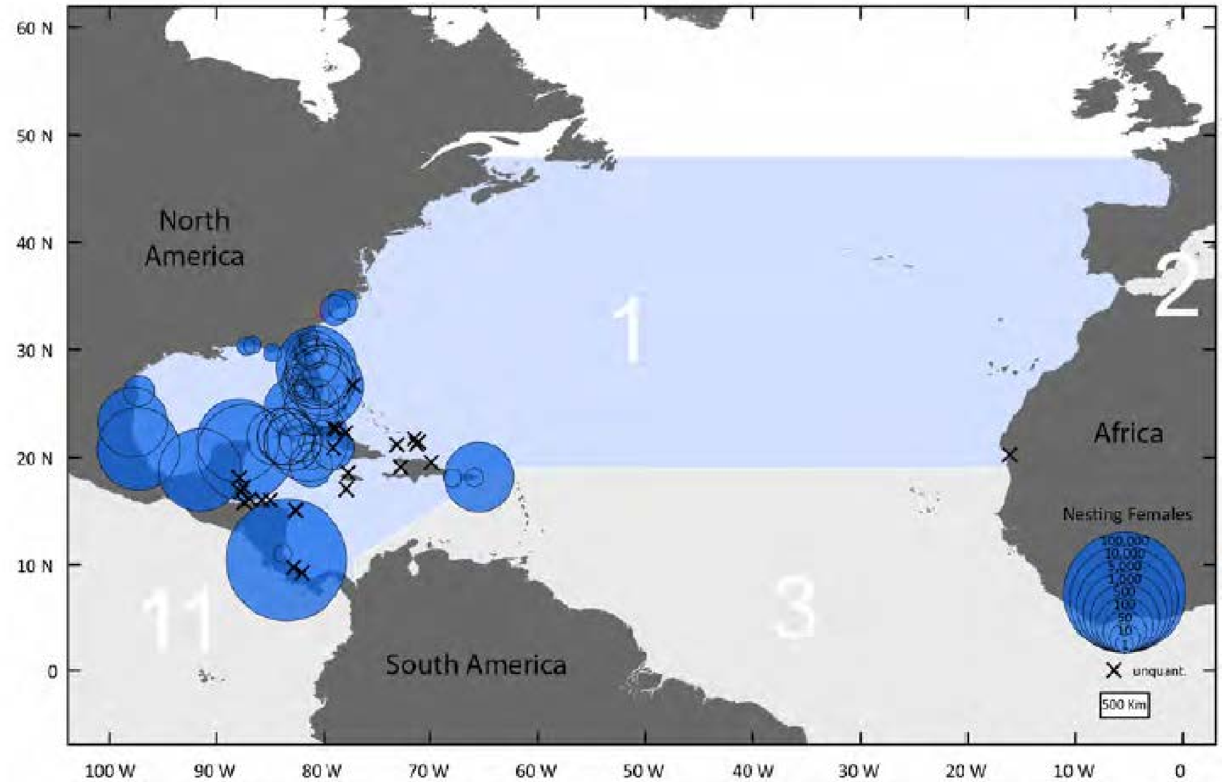

Figure 5. Geographic range of the North Atlantic distinct population segment green turtle, with location and abundance of nesting females. From Seminoff *et al.* (2015).

The green sea turtle is the largest of the hardshell marine turtles, growing to a weight of 350 pounds (159 kilograms) and a straight carapace length of greater than 3.3 feet (one meter) (Figure 6). The species was listed under the ESA on July 28, 1978 (43 FR 32800). The species was separated into two listing designations: endangered for breeding populations in Florida and the Pacific coast of Mexico and threatened in all other areas throughout its range. On April 6, 2016, NMFS listed 11 DPSs of green sea turtles as threatened or endangered under the ESA (81 FR 20057) (Table 5). The North Atlantic DPS is listed as threatened.

Figure 6. Green turtle. Photo: Mark Sullivan, NOAA.

Table 5. North Atlantic DPS green sea turtle information bar provides species Latin name, common name and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recover y Plan	Critical Habitat
Chelonia mydas	Green sea turtle	North Atlantic (4 sub-populations)	Threatened	2015	81 FR 20057	1991	63 FR 46693

We used information available in the 2007 Five Year Review (NMFS and U.S. FWS 2007b) and 2015 Status Review (Seminoff *et al*. 2015) to summarize the life history, population dynamics and status of the species, as follows.

Life history

Age at first reproduction for females is twenty to forty years. Green sea turtles lay an average of three nests per season with an average of one hundred eggs per nest. The remigration interval (i.e., return to natal beaches) is two to five years. Nesting occurs primarily on beaches with intact dune structure, native vegetation and appropriate incubation temperatures during summer months. After emerging from the nest, hatchlings swim to offshore areas and go through a post-hatchling pelagic stage where they are believed to live for several years. During this life stage, green sea turtles feed close to the surface on a variety of marine algae and other life associated with drift lines and debris. Adult turtles exhibit site fidelity and migrate hundreds to thousands of kilometers from nesting beaches to foraging areas. Green sea turtles spend the majority of their lives in coastal foraging grounds, which include open coastlines and protected bays and lagoons. Adult green turtles feed primarily on seagrasses and algae, although they also eat jellyfish, sponges and other invertebrate prey.

Population dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the North Atlantic DPS green sea turtle.

Worldwide, nesting data at 464 sites indicate that 563,826 to 564,464 females nest each year (Seminoff *et al*. 2015). Compared to other DPSs, the North Atlantic DPS exhibits the highest nester abundance, with approximately 167,424 females at seventy-three nesting sites, and available data indicate an increasing trend in nesting. The largest nesting site in the North Atlantic DPS is in Tortuguero, Costa Rica, which hosts 79% of nesting females for the DPS (Seminoff *et al*. 2015).

For the North Atlantic DPS, the available data indicate an increasing trend in nesting. There are no reliable estimates of population growth rate for the DPS as a whole, but estimates have been developed at a localized level. Modeling by Chaloupka *et al*. (2008) using data sets of twenty-five years or more show the Florida nesting stock at the Archie Carr National Wildlife Refuge growing at an annual rate of 13.9%, and the Tortuguero, Costa Rica, population growing at 4.9%.

The North Atlantic DPS has a globally unique haplotype, which was a factor in defining the discreteness of the population for the DPS. Evidence from mitochondrial DNA studies indicates that there are at least four independent nesting subpopulations in Florida, Cuba, Mexico and Costa Rica (Seminoff *et al*. 2015). More recent genetic analysis indicates that designating a new western Gulf of Mexico management unit might be appropriate (Shamblin *et al*. 2017).

The green turtle has a circumglobal distribution, occurring throughout nearshore tropical, subtropical and, to a lesser extent, temperate waters. Green turtles from the North Atlantic DPS range from the boundary of South and Central America (7.5°N, 77°W) in the south, throughout the Caribbean, the Gulf of Mexico, and the U.S. Atlantic coast to New Brunswick, Canada (48°N, 77°W) in the north. The range of the DPS then extends due east along latitudes 48°N and 19°N to the western coasts of Europe and Africa (Figure 5). Nesting occurs primarily in Costa Rica, Mexico, Florida and Cuba.

Status

Historically, green sea turtles in the North Atlantic DPS were hunted for food, which was the principle cause of the population’s decline. Apparent increases in nester abundance for the North Atlantic DPS in recent years are encouraging but must be viewed cautiously, as the datasets represent a fraction of a green sea turtle generation, up to fifty years. While the threats of pollution, habitat loss through coastal development, beachfront lighting, and fisheries bycatch continue, the North Atlantic DPS appears to be somewhat resilient to future perturbations.

Recovery Goals

See the 1998 and 1991 recovery plans for the Pacific, East Pacific and Atlantic populations of green turtles for complete down-listing/delisting criteria for recovery goals for the species. Broadly, recovery plan goals emphasize the need to protect and manage nesting and marine habitat, protect and manage populations on nesting beaches and in the marine environment, increase public education, and promote international cooperation on sea turtle conservation topics.

4.2.2.4 Status of Leatherback Sea Turtles

Species Description

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 7).

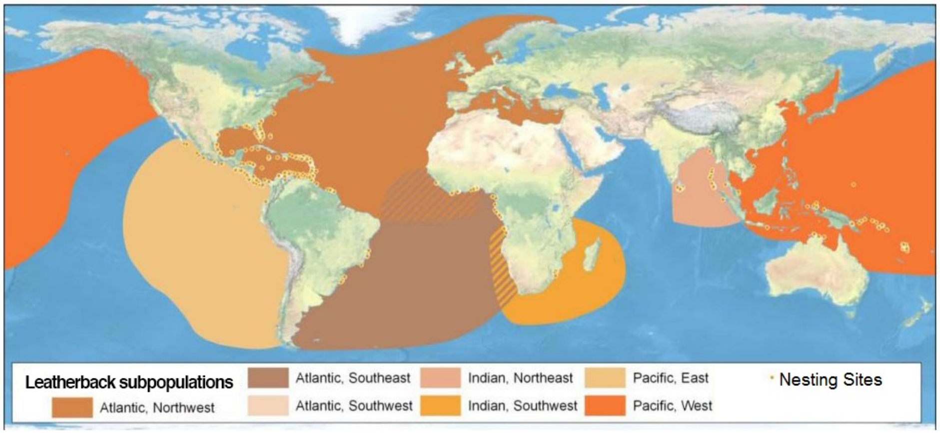

Figure 7. Map identifying the range of the endangered leatherback sea turtle. From NMFS http://www.nmfs.noaa.gov/pr/species/turtles/leatherback.html, adapted from Wallace *et al*. (2010).

Leatherbacks are the largest living turtle, reaching lengths of six feet long, and weighing up to one ton. Leatherback sea turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly (Figure 8). The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973 (Table 6).

Figure 8. Leatherback turtle. Photo: R.Tapilatu

Table 6. Leatherback turtle information bar provides species Latin name, common name and current Federal Register notifications for notice of listing status, designated critical habitat, Distinct Population Segment/Evolutionary Significant Unit, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Dermochelys coriacea	Leatherback sea turtle	None Designated	Endangered range wide	2013	35 FR 8491	1991 (U.S. Caribbean, Atlantic, and Gulf of Mexico); 1998 (Pacific)	44 FR 17710 and 77 FR 4170

We used information available in the five year review (NMFS and U.S. FWS 2013b) and the critical habitat designation (44 FR 17710) to summarize the life history, population dynamics and status of the species, as follows.

Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to twenty-nine years (Spotila *et al*. 1996; Avens *et al*. 2009). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (Reina *et al*. 2002; Wallace *et al*. 2007). The number of leatherback hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50% worldwide (Eckert *et al*. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback sea turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherbacks must consume large quantities to support their body weight. Leatherbacks weigh about 33% more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James *et al*. 2005; Wallace *et al*. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price *et al*. 2006).

Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the leatherback sea turtle.

Leatherbacks are globally distributed, with nesting beaches in the Pacific, Atlantic, and Indian oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherbacks in the North Atlantic (TEWG 2007). In contrast, leatherback populations in the Pacific are much lower. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila *et al*. 2000). Population abundance in the Indian Ocean is difficult to assess due to lack of data and inconsistent reporting. Available data from southern Mozambique show that approximately ten females nest per year from 1994 to 2004, and about 296 nests per year counted in South Africa (NMFS and U.S. FWS 2013b).

Population growth rates for leatherback sea turtles vary by ocean basin. Counts of leatherbacks at nesting beaches in the western Pacific indicate that the subpopulation has been declining at a rate of almost 6% per year since 1984 (Tapilatu *et al*. 2013). Leatherback subpopulations in the Atlantic Ocean, however, are showing signs of improvement. Nesting females in South Africa are increasing at an annual rate of 4%-5.6%, and from 9%-13% in Florida and the U.S. Virgin Islands (TEWG 2007), believed to be a result of conservation efforts.

Analyses of mitochondrial DNA from leatherback sea turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton *et al*. 1999). Further analysis of samples taken from individuals from rookeries in the

Atlantic and Indian oceans suggest that each of the rookeries represent demographically independent populations (NMFS and U.S. FWS 2013b).

Leatherback sea turtles are distributed in oceans throughout the world. Leatherbacks occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson *et al*. 2011).

Status

The leatherback sea turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback sea turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherbacks and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise. The species' resilience to additional perturbation is low.

Recovery Goals

See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S Caribbean, Gulf of Mexico and Atlantic leatherback sea turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified to support in the Leatherback Five Year Action Plan:

1. Reduce fisheries interactions
2. Improve nesting beach protection and increase reproductive output
3. International cooperation
4. Monitoring and research
5. Public engagement

4.2.3 Status of Atlantic Sturgeon

Species description

Atlantic sturgeon occupy ocean waters and associated bays, estuaries, and coastal river systems from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida (Stein *et al*. 2004a) (Figure 9). Atlantic sturgeon are listed as five DPSs under the ESA.

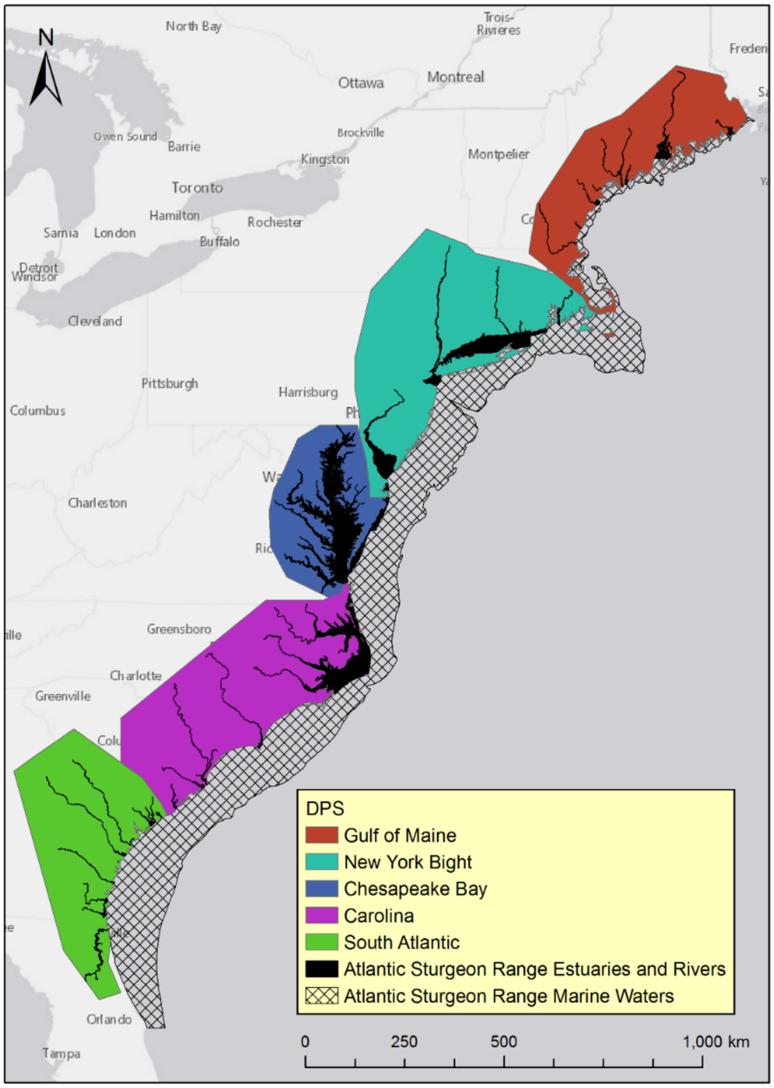

Figure 9. Geographic range for all five Atlantic sturgeon DPSs.

The Atlantic sturgeon is a long-lived, late maturing, anadromous species. Atlantic sturgeon attain lengths of up to approximately 14 feet, and weights of more than 800 pounds (Figure 10). They are bluish black or olive brown dorsally with paler sides and a white ventral surface and have five major rows of dermal scutes (Colette and Klein-MacPhee 2002). Five DPSs were listed under the ESA on February 6, 2012. The Gulf of Maine DPS was listed as threatened, and the New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered (Table 7).

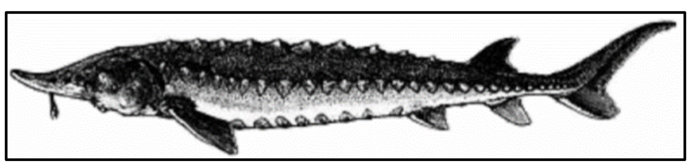

Figure 10. Adult Atlantic Sturgeon.

Table 7. Atlantic sturgeon information bar provides species' Latin name, common name and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	Gulf of Maine (GOM)	Threatened	2007	77 FR 5880	No	82 FR 39160
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	New York Bight (NYB)	Endangered	2007	77 FR 5880	No	82 FR 39160
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	Chesapeake Bay (CB)	Endangered	2007	77 FR 5880	No	82 FR 39160
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	Carolina	Endangered	2007	77 FR 5914	No	82 FR 39160
Acipenser oxyrinchus oxyrinchus	Atlantic Sturgeon	South Atlantic (SA)	Endangered	2007	77 FR 5914	No	82 FR 39160

Life history

Atlantic sturgeon size at sexual maturity varies with latitude with individuals reaching maturity in the Saint Lawrence River at 22 to 34 years (Scott and Crossman 1973). Atlantic sturgeon spawn in freshwater, but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in May through July in Canadian systems (Murawski and Pacheco 1977; Smith 1985; Bain 1997; Smith and Clugston 1997; Caron *et al*. 2002). Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers at depths of three to 27 meters (Borodin 1925; Leland 1968; Scott and Crossman 1973; Crance 1987; Bain *et al*. 2000). Atlantic sturgeon likely do not spawn every year; spawning intervals range from one to five years for males (Smith 1985; Collins *et al*. 2000; Caron *et al*. 2002) and two to five years for females (Vladykov and Greeley 1963; Van Eenennaam *et al*. 1996; Stevenson and Secor 2000).

Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces (Gilbert 1989; Smith and Clugston 1997) between the salt front and fall line of large rivers (Borodin 1925; Scott and Crossman 1973; Crance 1987; Bain *et al*. 2000). Following spawning in northern rivers, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks (Savoy and Pacileo 2003). Hatching occurs approximately 94 to 140 hours after egg deposition at temperatures of 20 and 18 degrees Celsius, respectively (Theodore *et al*. 1980). The yolk sac larval stage is completed in about eight to 12 days, during which time larvae move downstream to rearing grounds over a six to 12 day period (Kynard and Horgan 2002). Juvenile sturgeon continue to move further downstream into waters ranging from zero to up to ten parts per thousand salinity. Older juveniles are more tolerant of higher salinities as juveniles typically spend two to five years in freshwater before eventually becoming coastal residents as sub-adults (Smith 1985; Boreman 1997; Schueller and Peterson 2010).

Upon reaching the subadult phase, individuals may move to coastal and estuarine habitats (Murawski and Pacheco 1977; Dovel and Berggren 1983; Smith 1985; Stevenson 1997). Tagging and genetic data indicate that subadult and adult Atlantic sturgeon may travel widely once they emigrate from rivers. Despite extensive mixing in coastal waters, Atlantic sturgeon exhibit high fidelity to their natal rivers (King *et al*. 2001; Waldman *et al*. 2002; Grunwald *et al*. 2008). Because of high natal river fidelity, it appears that most rivers support independent populations (Waldman and Wirgin 1998; Wirgin *et al*. 2000, 2002; King *et al*. 2001; Grunwald *et al*. 2008). Atlantic sturgeon feed primarily on polychaetes, isopods, American sand lances and amphipods in the marine environment, while in fresh water they feed on oligochaetes, gammarids, mollusks, insects, and chironomids (Moser and Ross 1995; Johnson *et al*. 1997; Guilbard *et al*. 2007; Savoy 2007; Novak *et al*. 2017).

Population dynamics
The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and distribution as it relates to Atlantic sturgeon.

Abundance
Historically, the Gulf of Maine DPS likely supported more than 10,000 spawning adults. The current abundance is estimated to be one to two orders of magnitude smaller than historical levels (Secor *et* al. 2002; ASSRT 2007).

The New York Bight, ranging from the Delmarva Peninsula to Cape Cod, historically supported four or more spawning populations. Currently, this DPS only supports two spawning populations, the Delaware and Hudson River. Numbers of Atlantic sturgeon in the New York Bight DPS are extremely low compared to historical levels and have remained so for the past 100 years. The spawning populations of this DPS are thought to be one to two orders of magnitude below historical levels.

Historically the Delaware River is believed to have supported around 180,000 individuals (Secor 2002). In 2007, NMFS status review estimated that the population had declined to fewer than 300 individuals. In 2014, Hale *et al*. (2016) estimated that 3,656 (95% CI = 1,935-33,041) early juveniles (age zero to one) utilized the Delaware River estuary as a nursery. Based on commercial fishery landings from the mid-1980s to the mid-1990s, the total abundance of adult Hudson River Atlantic sturgeon was estimated to be 870 individuals (Kahnle *et* al. 2007). Based on the juvenile assessments from (Peterson 2000), the Hudson River suffered a series of recruitment failures, which triggered the ASMFC fishing moratorium to allow the populations to recover.

There are no current abundance estimates for the Chesapeake Bay DPS. Historically, Atlantic sturgeon were common throughout the Chesapeake Bay and its tributaries (Kahnle *et al*. 1998; Bushnoe *et al.* 2005). At the time of listing, the James River was the only known spawning river for the Chesapeake Bay DPS (ASSRT 2007; Balazik *et al*. 2012a). Since the listing, spawning has been confirmed to occur in the Pamunkey River, a tributary of the York River (Hager *et al*. 2014; Kahn *et al*. 2014) and is suspected to be occurring in Marshyhope Creek, a tributary of the Nanticoke River. The historical and contemporary accounts of Atlantic sturgeon in the York, Rappahannock, Susquehanna, and Potomac Rivers (ASSRT 2007), as well as the presence of the features necessary to support reproduction and recruitment in this river indicate that there is the potential for spawning to occur.

The Carolina DPS spawning populations are estimated to be at less than 3% of their historic levels. Prior to 1890, there were estimated to be 7,000 to 10,500 adult female Atlantic sturgeon in North Carolina and approximately 8,000 adult females in South Carolina. Currently, the existing spawning populations in each of the rivers in the Carolina DPS are thought to have less than 300 adults spawning each year.

The South Atlantic DPS historically supported eight spawning populations ranging from the St. Johns River, Florida to the Ashepoo, Combahee, and Edisto Rivers Basin in South Carolina. Currently, this DPS supports five extant spawning populations. Of these populations, the Altamaha is believed to support the largest number of spawning adults. The current abundance of the Altamaha population is suspected to be less than 6% of historical abundance, extrapolated from the 1890s commercial landings (Secor 2002). Few captures have been documented in other populations within this DPS and are suspected to be less than 1% of their historic abundance (less than 300 spawning adults).

Lacking complete estimates of population abundance across the distribution of Atlantic sturgeon, the NMFS Northeast Fisheries Science Center (NEFSC) developed a virtual population analysis model with the goal of estimating bounds of Atlantic sturgeon ocean abundance. The NEFSC suggested that cumulative annual estimates of surviving fishery discards could provide a minimum estimate of abundance. The objectives of producing the Atlantic Sturgeon Production Index (ASPI) were to characterize uncertainty in abundance estimates arising from multiple sources of observation and process error and to complement future efforts to conduct a more comprehensive stock assessment (Table 8). The ASPI provides a general abundance metric to assess risk for actions that may affect Atlantic sturgeon in the ocean; however, it is not a comprehensive stock assessment. In general, the model uses empirical estimates of post-capture survivors and natural survival, as well as probability estimates of recapture using tagging data from the U.S. FWS sturgeon tagging database, and federal fishery discard estimates from 2006 to 2010 to produce a virtual population. The U.S. FWS sturgeon tagging database is a repository for sturgeon tagging information on the Atlantic coast. The database contains tag release and recapture information from state and federal researchers. The database records recaptures by the fishing fleet, researchers, and researchers on fishery vessels.

Table 8. Description of the ASPI model and NEAMAP survey based area estimate method.

Model Name	Model Description
A. ASPI	Uses tag-based estimates of recapture probabilities from 1999 to 2009. Natural mortality based on Kahnle *et al.* (2007) rather than estimates derived from tagging model. Tag recaptures from commercial fisheries are adjusted for non-reporting based on recaptures from observers and researchers. Tag loss assumed to be zero.
B. NEAMAP Swept Area	Uses NEAMAP survey-based swept area estimates of abundance and assumed estimates of gear efficiency. Estimates based on average of ten surveys from fall 2007 to spring 2012.

In additional to the ASPI, a population estimate was derived from the NEAMAP trawl surveys (Table 9). The NEAMAP trawl surveys are conducted from Cape Cod, Massachusetts to Cape Hatteras, North Carolina in nearshore waters at depths up to 18.3 meters (60 feet) during the fall since 2007 and spring since 2008. Each survey employs a spatially stratified random design with a total of 35 strata and 150 stations.

Table 9. Annual minimum swept area estimates for Atlantic sturgeon during the spring and fall NEAMAP surveys. Estimates provided by Dr. Chris Bonzek (VIMS) and assume 100% net efficiencies.

Year	Fall Number	CV	Spring Number	CV
2007	6,981	0.015		
2008	33,949	0.322	25,541	0.391
2009	32,227	0.316	41,196	0.353
2010	42,164	0.566	52,992	0.265
2011	22,932	0.399	52,840	0.480
2012			28,060	0.652

Atlantic sturgeon are frequently encountered during the NEAMAP surveys. The information from these surveys can be used to calculate minimum swept area population estimates within the strata swept by the surveys. The estimate from fall surveys ranges from 6,980 to 42,160 with coefficients of variation between 0.02 and 0.57, and the estimates from spring surveys ranges from 25,540 to 52,990 with coefficients of variation between 0.27 and 0.65 (Table 9). These are considered minimum estimates because the calculation makes the assumption that the gear will capture (i.e., net efficiency) 100% of the sturgeon in the water column along the tow path and that all sturgeon are with the sampling domain of the survey. We define catchability as: 1) the product of the probability of capture given encounter (i.e., net efficiency), and 2) the fraction of the population within the sampling domain. Catchabilities less than 100% will result in estimates greater than the minimum. The true catchability depends on many factors including the availability of the species to the survey and the behavior of the species with respect to the gear. True catchabilities much less than 100% are common for most species. The average ASPI estimate of 417,934 fish implies a catchability of between 6% and 13% for the spring NEAMAP surveys, and a catchability of between 2% and 10% for the fall NEAMAP surveys. If the availability of Atlantic sturgeon in the areas sampled by the spring NEAMAP surveys were say 50%, then the implied range of net efficiencies for this survey would double to 12% and 26%. The ratio of total sturgeon habitat to area sampled by the NEAMAP surveys is unknown, but is certainly greater than one.

The NEAMAP-based estimates do not include young-of-the-year (YOY) fish and juveniles in the rivers; however, those segments of the Atlantic sturgeon populations are at minimal risk from the proposed action since they are rare to absent within the action area. The NEAMAP surveys are conducted in waters that include the preferred depth ranges of subadult and adult Atlantic sturgeon and take place during seasons that coincide with known Atlantic sturgeon coastal migration patterns in the ocean. Therefore, the NEAMAP estimates are minimum estimates of the ocean population of Atlantic sturgeon but are based on sampling throughout the action area, in known sturgeon coastal migration areas during times that sturgeon are expected to be migrating north and south.

Available data do not support estimation of true catchability (i.e., net efficiency x availability) of the NEAMAP trawl survey for Atlantic sturgeon. Thus, the NEAMAP swept area biomass estimates were produced and presented for catchabilities from 5% to 100%. Assuming the NEAMAP surveys have been 100% efficient would require the unlikely assumption that the survey gear captures all Atlantic sturgeon within the path of the trawl and all sturgeon are within the sampling area of the NEAMAP survey. The 50% efficiency assumption seems to reasonably account for the robust, yet not complete sampling of the Atlantic sturgeon oceanic temporal and spatial ranges and the documented high rates of encounter with NEAMAP survey gear and Atlantic sturgeon. For this opinion, we have determined that the best available data at this time are the population estimates derived from NEAMAP swept area biomass resulting from the 50% catchability rate (Table 10). The estimates are derived directly from empirical data with fewer assumptions than have been required to model Atlantic sturgeon populations to date.

The ocean population abundance of 67,776 fish estimated from the NEAMAP surveys assuming 50% efficiency (based on net efficiency and the fraction of the total population exposed to the survey) was subsequently partitioned by DPS based on genetic frequencies of occurrence in the sampled area (Table 11). Given the proportion of adults to subadults in the observer database (approximate ratio of 1:3), we have also estimated a number of subadults originating from each DPS. However, this cannot be considered an estimate of the total number of subadults because it only considers those subadults that are of a size vulnerable to capture in commercial sink gillnet and otter trawl gear in the marine environment and are present in the marine environment, which is only a fraction of the total number of subadults.

Table 10. Modeled results from the ASPI and NEAMAP Atlantic sturgeon estimation methods.

Model Run	Model Years	95% low	Mean	95% high
A. ASPI	1999-2009	165,381	417,934	744,597
B.1 NEAMAP Survey, swept area assuming 100% efficiency	2007-2012	8,921	33,888	58,856
B.2 NEAMAP Survey, swept area assuming 50% efficiency	2007-2012	13,962	67,776	105,984
B.3 NEAMAP Survey, swept area assuming 10% efficiency	2007-2012	89,206	338,882	588,558

Table 11. Summary of calculated population estimates based upon the NEAMAP survey swept area model assuming 50% efficiency.

DPS	Estimated Ocean Population Abundance	Estimated Ocean Population of Adults	Estimated Ocean Population of Subadults (of size vulnerable to capture in fisheries)
GOM	7,455	1,864	5,591
NYB	34,566	8,642	25,925
CB	8,811	2,203	6,608
Carolina	1,356	339	1,017
SA	14,911	3,728	11,183
Canada	678	170	509

Population Growth Rate

There are some positive signs for the Gulf of Maine DPS, which include observations of Atlantic sturgeon in rivers from which sturgeon observations have not been reported for many years (Saco, Presumpscot, and Charles rivers) and potentially higher catch-per-unit-effort levels than in the past (Kennebec) (ASSRT 2007). Precise estimates of population growth rate (intrinsic rates) are unknown due to lack of long-term abundance data.

Precise estimates of population growth rate (intrinsic rates) for the New York Bight DPS are unknown due to lack of long-term abundance data. Long-term juvenile surveys indicate that the Hudson River population supports successful annual year classes since 2000 and the annual production has been stable and/or slightly increasing in abundance (ASSRT 2007). Recently, juvenile Atlantic sturgeon collected in the Connecticut River suggest at least one successful colonizing spawning event may have occurred (Savoy *et al*. 2017). Around the same time, a dead 213-centimeter Atlantic sturgeon was recovered on the banks of the Connecticut River[1].

The Chesapeake Bay once supported at least six historical spawning populations; however, today the Bay is believed to support at the most, four to five spawning populations. Precise estimates

[1] (http://www.wfsb.com/story/25392783/rare-sturgeon-found-along-connecticut-riverin-lyme)

of population growth rate (intrinsic rates) for the Chesapeake Bay DPS are unknown due to lack of long-term abundance data. The status review team (ASSRT 2007) concluded that the populations in the James and York Rivers are at a moderate and moderately high risk of extinction.

Precise estimates of population growth rate (intrinsic rates) for the Carolina DPS are unknown due to lack of long-term abundance data. The status review team (ASSRT 2007) concluded that the populations in the Roanoke, Tar/Pamlico, Neuse, Waccamaw, and Pee Dee river systems are at a moderate extinction risk and the populations in the Cape Fear and Santee-Cooper river systems are at a moderately high risk of extinction.

Precise estimates of population growth rate (intrinsic rates) for the South Atlantic DPS are unknown due to lack of long-term abundance data. During the last two decades, Atlantic sturgeon have been observed in most South Carolina coastal rivers, although it is not known if all rivers support a spawning population (Collins and Smith 1997). The Altamaha River supports the healthiest Atlantic sturgeon populations in the South Atlantic DPS. In a telemetry study by Peterson *et al*. (2008), most tagged adult Atlantic sturgeon were found between river kilometer 215 and 420 in October and November when water temperatures were appropriate for spawning. The status review team (ASSRT 2007) found that, overall, the South Atlantic DPS had a moderate risk (<50% chance) of becoming endangered over the next 20 years.

Stock Assessments

The ASMFC released a new benchmark stock assessment for Atlantic sturgeon in October 2017 (ASMFC 2017a). The assessment used both fishery-dependent and fishery-independent data, as well as biological and life history information. Fishery-dependent data came from commercial fisheries that formerly targeted Atlantic sturgeon (before the moratorium), as well as fisheries that catch sturgeon incidentally. Fishery-independent data were collected from scientific research and survey programs.

At the coastwide and DPS levels, the stock assessment concluded that Atlantic sturgeon are depleted relative to historical levels. The low abundance of Atlantic sturgeon is not due solely to effects of historic commercial fishing, so the ‘depleted’ status was used instead of ‘overfished.’ This status reflects the array of variables preventing Atlantic sturgeon recovery (e.g., bycatch, habitat loss, and ship strikes).

As described in the Assessment Overview, Table 12 shows “the stock status determination for the coastwide stock and DPSs based on mortality estimates and biomass/abundance status relative to historic levels, and the terminal year (i.e., the last year of available data) of indices relative to the start of the moratorium as determined by the ARIMA[2] analysis.”

[2] “The ARIMA (Auto-Regressive Integrated Moving Average) model uses fishery-independent indices of abundance to estimate how likely an index value is above or below a reference value” (ASMFC 2017a).

Table 12. Stock status determination for the coastwide stock and DPSs (from the ASMFC's Atlantic Sturgeon Stock Assessment Overview, October 2017)

	Mortality Status	Biomass/Abundance Status	
Population	Probability that $Z > Z_{50\%EPR}$ 80%	Relative to Historical Levels	Average probability of terminal year of indices > 1998* value
Coastwide	7%	Depleted	95%
Gulf of Maine	74%	Depleted	51%
New York Bight	31%	Depleted	75%
Chesapeake Bay	30%	Depleted	36%
Carolina	75%	Depleted	67%
South Atlantic	40%	Depleted	Unknown (no suitable indices)

* For indices that started after 1998, the first year of the index was used as the reference value.

Despite the depleted status, the assessment did include signs that the coastwide index is above the 1998 value (95% chance). The Gulf of Maine, New York Bight, and Carolina DPS indices also all had a greater than 50% chance of being above their 1998 value; however, the index from the Chesapeake Bay DPS (highlighted red) only had a 36% chance of being above the 1998 value. There were no representative indices for the South Atlantic DPS. Total mortality from the tagging model was very low at the coastwide level. Small sample sizes made mortality estimates at the DPS level more difficult. The New York Bight, Chesapeake Bay, and South Atlantic DPSs all had a less than 50% chance of having a mortality rate higher than the threshold. The Gulf of Maine and Carolina DPSs (highlighted red) had 74%-75% probability of being above the mortality threshold (ASMFC 2017a).

Genetic Diversity

The genetic diversity of Atlantic sturgeon throughout its range has been well documented (Bowen and Avise 1990; Ong *et al*. 1996; Waldman *et al*. 1996; Waldman and Wirgin 1998). Overall, these studies have consistently found populations to be genetically diverse and the majority can be readily differentiated. Relatively low rates of gene flow reported in population genetic studies (King *et al*. 2001; Waldman *et al*. 2002) indicate that Atlantic sturgeon return to their natal river to spawn, despite extensive mixing in coastal waters.

Determination of DPS Composition in the Action Area

As explained above, the range of all five DPSs overlaps and extends from Canada through Cape Canaveral, Florida. The action area is known to be used by Atlantic sturgeon originating from all five DPSs. We have considered the best available information from a recent mixed stock analysis done by Wirgin *et al*. (2015) to determine from which DPSs individuals in the action area are likely to have originated. We have determined that when looking at the entire action area, Atlantic sturgeon throughout likely originate from the five DPSs at the following frequencies: NYB 51.7%; SA 21.9%; CB 11.8%; GOM 10.1%; and Carolina 2.4%. Approximately 2.2% of the Atlantic sturgeon throughout the action area originate from Canadian rivers or management units. These percentages are based on genetic sampling of all individuals (n=173) captured during observed fishing trips along the U.S. Atlantic coast from Maine through

North Carolina between March 2009 and February 2012, and the results of the genetic analyses for these 173 fish were compared against a reference population of 411 fish and results for an additional 790 fish from other sampling efforts. Therefore, they represent the best available information on the likely genetic makeup of individuals occurring throughout the action area. The genetic assignments have corresponding 95% confidence intervals. However, for purposes of section 7 consultation, we have selected the reported values without their associated confidence intervals. The reported values, which approximate the mid-point of the range, are a reasonable indication of the likely genetic makeup of Atlantic sturgeon in the action area. These assignments and the data from which they are derived are described in detail in Wirgin *et al.* (2015).

For state fisheries surveys occurring specifically in the Hudson River, Long Island Sound, and Delaware Bay, we have also considered mixed stock information from studies by Dunton *et al.* (2012) and Damon-Randall *et al*. (2013), which are more accurate depictions of the DPS percentage breakdowns in those areas. The mixed stock analysis by Dunton *et al*. (2012) for the Hudson River indicates that the majority of Atlantic sturgeon in the river are likely to originate from the NYB DPS (92%), with 6% originating from the GOM DPS and 2% from the CB DPS. These percentages are based on genetic sampling of 39 individuals captured within the Hudson River during the study and, therefore, represent the best available information on the likely genetic makeup of individuals occurring in that area. Based on the mixed stock analysis available for Long Island Sound referenced in Damon-Randall *et al*. (2013), we expect that 79% of captured Atlantic sturgeon will originate from the NYB DPS, 10% from the SA DPS, 7% from the CB DPS, 4% from the GOM DPS, and 0.5% from the Carolina DPS. Finally, based on the mixed stock analysis for Atlantic sturgeon in Delaware Bay referenced in Damon-Randall *et al*. (2013), we have determined that Atlantic sturgeon likely originate from the five DPSs at the following frequencies: NYB 58%; CB 18%; SA 17%; GOM 7%; and Carolina 0.5%.

Distribution

The Gulf of Maine DPS includes all anadromous Atlantic sturgeons that are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, Massachusetts (Figure 9). The geomorphology of most small coastal rivers in Maine is not sufficient to support Atlantic sturgeon spawning populations, except for the Penobscot and the estuarial complex of the Kennebec, Androscoggin, and Sheepscot rivers. Spawning still occurs in the Kennebec and Androscoggin Rivers, and may occur in the Penobscot River. Atlantic sturgeon have more recently been observed in the Saco, Presumpscot, and Charles rivers.

The natal river systems of the New York Bight DPS span from the Connecticut River south to the Delaware River (Figure 9). The Connecticut River has long been known as a seasonal aggregation area for subadult Atlantic sturgeon, and both historical and contemporary records document presence of Atlantic sturgeon in the river as far upstream as Hadley, Massachusetts (Savoy and Shake 1992; Savoy and Pacileo 2003). The upstream limit for Atlantic sturgeon on the Hudson River is the Federal Dam at the fall line, approximately river kilometer 246 (Dovel and Berggren 1983; Kahnle *et* al. 1998). In the Delaware River, there is evidence of Atlantic sturgeon presence from the mouth of the Delaware Bay to the head-of-tide at the fall line near

Trenton on the New Jersey side and Morrisville on the Pennsylvania side of the River, a distance of 220 river kilometers (Breece *et al*. 2013).

The natal river systems of the Chesapeake Bay DPS span from the Susquehanna River south to the James River (Figure 9).

The natal river systems of the Carolina DPS span from the Roanoke River, North Carolina south to the Santee-Cooper system in South Carolina (Figure 9). The Carolina DPS ranges from the Santee-Cooper River to the Albemarle Sound and consists of seven extant populations; one population (the Sampit River) is believed to be extirpated.

The natal river systems of the South Atlantic DPS span from Edisto south to the St. Mary's River (Figure 9). Seventy-six Atlantic sturgeon were tagged in the Edisto River during a 2011 to 2014 telemetry study (Post *et al*. 2014). Fish entered the river between April and June and were detected in the saltwater tidal zone until water temperature decreased below 25 degrees Celcius. They then moved into the freshwater tidal area, and some fish made presumed spawning migrations in the fall around September to October. Atlantic sturgeon in the Savannah River were documented displaying similar behavior three years in a row—migrating upstream during the fall and then being absent from the system during spring and summer. Forty three Atlantic sturgeon larvae were collected in upstream locations (river kilometer 113 to 283) near presumed spawning locations (Collins and Smith 1997).

Hearing

Information available about the hearing abilities of Atlantic sturgeon come from studies of other species of sturgeon.

Meyer *et al*. (2003) investigated shortnose sturgeon (*Acipenser brevirostrum*) hearing abilities by using physiological methods to measure responses to pure tones. The authors presented shortnose sturgeon with pure tone stimuli from 50 to 1000 hertz with intensities ranging from of 120 to 160 dB re 1 µpa. Shortnose sturgeon were most sensitive to tones presented at 100 and 400 hertz although thresholds were not determined. Based on the limited data, sturgeon were able to detect sounds below 100 hertz to about 1,000 hertz and that sturgeon should be able to determine the direction of sounds (Popper 2005). Pallid sturgeon (*Scaphirhynchus albus*) and the shovelnose sturgeon (*S. platorynchus*) produce sounds like squeaks, chirps, knocks, and moans during the breeding season, and are thought to help individuals locate other sturgeon (Johnston and Phillips 2003).

Meyer (2010) recorded auditory evoked potentials to pure tone stimuli of varying frequency and intensity in lake sturgeon (*Acipenser fulvescens*) have best sensitivity from 50 to 400 hertz. Lovell (2005) also studied sound reception in and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon in pressure dominated and particle motion dominated sound fields. They concluded that both species were responsive to sounds ranging in frequency from 100 to 500 hertz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 hertz and higher thresholds at 100 and 500 hertz. The results showed that both species were not sensitive to sound pressure, and would have a significantly higher hearing threshold in a pressure dominated sound field. Based on the above we assume that the hearing sensitivity of shortnose sturgeon is best between 100 to 500 hertz with sensitivity falling up to 1,000 hertz.

BOEM (2012) categorized sturgeon in general as fishes that detect sounds from below 50 hertz to perhaps 800 to 1,000 hertz (though several probably only detect sounds to 600 to 800 hertz). These fishes have a swim bladder but no known structures in the auditory system that would enhance hearing, and sensitivity (lowest sound detectable at any frequency) is not very great. Sounds would have to be more intense to be detected compared to fishes with swim bladders that enhance hearing. Sturgeon can detect both particle motion and pressure.

Status

Atlantic sturgeon were once present in 38 river systems and, of these, spawned in 35 of them. Individuals are currently present in 36 rivers, and spawning occurs in at least 20 of these (ASSRT 2007). The decline in abundance of Atlantic sturgeon has been attributed primarily to the large U.S. commercial fishery which existed for the Atlantic sturgeon from the 1870s through the mid 1990s. The fishery collapsed in 1901 and landings remained at between 1%-5% of the pre-collapse peak until ASMFC placed a two generation moratorium on the fishery in 1998 (ASMFC 1998a, 1998b). The majority of the populations show no signs of recovery, and new information suggests that stressors such as bycatch, ship strikes, and low DO can and do have substantial impacts on populations (ASSRT 2007). Additional threats to Atlantic sturgeon include habitat degradation from dredging, damming, and poor water quality (ASSRT 2007). Climate change related impacts on water quality (e.g., temperature, salinity, dissolved oxygen, contaminants) have the potential to impact Atlantic sturgeon populations using impacted river systems. These effects are expected to be more severe for southern portions of the U.S. range of Atlantic sturgeon (Carolina and South Atlantic DPSs). None of the spawning populations are currently large or stable enough to provide any level of certainty for continued existence of any of the DPSs.

Critical Habitat

On August 17, 2017, NMFS designated critical habitat for all five Atlantic sturgeon DPSs in 31 rivers from Maine through Florida (82 FR 39160; Figure 11).

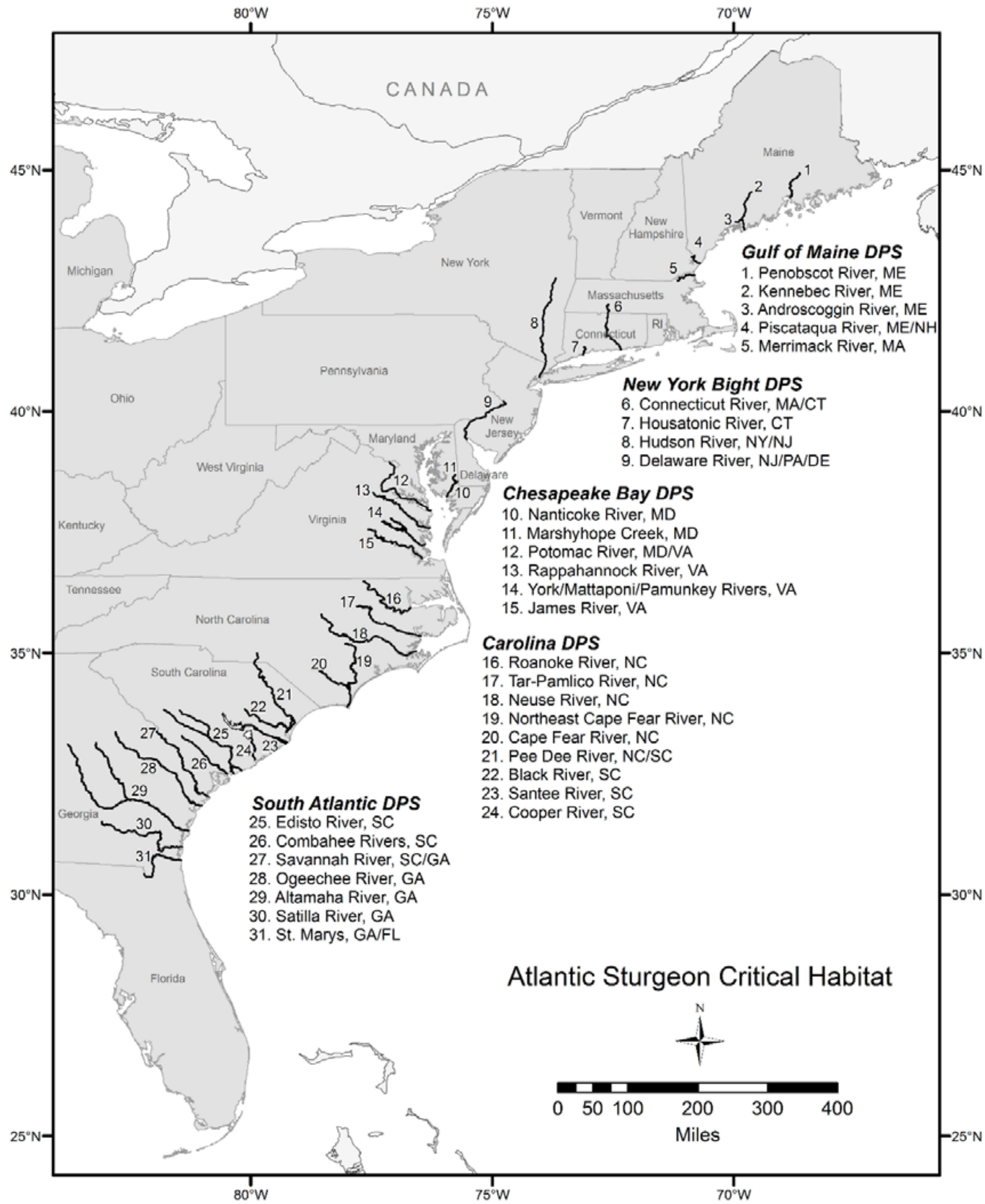

Figure 11. Map of designated critical habitat for Atlantic sturgeon distinct population segments.

The essential physical or biological features identified for Atlantic sturgeon critical habitat pertain to the features that promote larval, juvenile, and sub-adult growth and development, foraging habitat, water conditions suitable for adult spawning, and an absence of physical barriers (e.g., dams) (Table 13).

Table 13. Physical or biological features for Atlantic sturgeon critical habitat.

Atlantic Sturgeon Distinct Population Segment	Physical or Biological Features
Gulf of Maine New York Bight Chesapeake Bay	Hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0 to 0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages.
Gulf of Maine New York Bight Chesapeake Bay	Aquatic habitat with a gradual downstream salinity gradient of 0.5 to 30 parts per thousand and soft substrate (e.g., sand, mud) downstream of spawning sites for juvenile foraging and physiological development.
Gulf of Maine New York Bight Chesapeake Bay	Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) Unimpeded movement of adults to and from spawning sites; (2) Seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) Staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (e.g., ≥1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river.
Gulf of Maine New York Bight Chesapeake Bay	Water, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (1) Spawning; (2) Annual and interannual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 °C to 26 °C for spawning habitat and no more than 30° C for juvenile rearing habitat, and 6 mg/L dissolved oxygen for juvenile rearing habitat).
Carolina South Atlantic	Suitable hard bottom substrate (e.g., rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (i.e., 0.0-0.5 ppt range) for settlement of fertilized eggs and refuge, growth, and development of early life stages.
Carolina South Atlantic	Transitional salinity zones inclusive of waters with a gradual downstream gradient of 0.5-30 ppt and soft substrate (e.g., sand, mud) downstream of spawning sites for juvenile foraging and physiological development.

Atlantic Sturgeon Distinct Population Segment	Physical or Biological Features
Carolina South Atlantic	Water of appropriate depth and absent physical barriers to passage (e.g., locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) Unimpeded movement of adults to and from spawning sites; (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) staging, resting, or holding of subadults and spawning condition adults. Water depths in main river channels must be deep enough to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Water depths of at least 1.2 m are generally deep enough to facilitate effective adult migration and spawning behavior.
Carolina South Atlantic	Water quality conditions, especially in the bottom meter of the water column, with temperature and oxygen values that support: (1) Spawning; (2) Annual and inter-annual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L D.O. for juvenile rearing habitat is considered optimal, whereas D.O. less than 5.0 mg/L for longer than 30 days is considered suboptimal when water temperature is greater than 25 °C. In temperatures greater than 26 °C, D.O. greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 °C to 26 °C for spawning habitat are considered optimal.

Federal activities that were identified as potentially altering the physical or biological features of Atlantic sturgeon critical habitat are: in-water construction, dredging for navigation, harbor expansion or sand and gravel mining, flood control projects, bridge repair and replacement, hydropower licensing, natural gas facility and pipeline construction, ESA research and incidental take permits, and Clean Water Act Total Maximum Daily Load program management.

Recovery Goals

Recovery Plans have not yet been drafted for any of the Atlantic sturgeon DPSs.

4.2.3.1 Gulf of Maine DPS of Atlantic sturgeon

The Gulf of Maine (GOM) DPS includes the following: all anadromous Atlantic sturgeon that spawn or are spawned in the watersheds from the Maine/Canadian border and, extending southward, all watersheds draining into the Gulf of Maine as far south as Chatham, Massachusetts. The marine range of Atlantic sturgeon from the GOM DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the GOM DPS and the adjacent portion of the marine range are shown in Figure 9. Within this range, Atlantic sturgeon historically spawned in the Androscoggin, Kennebec, Merrimack, Penobscot, and Sheepscot Rivers (ASSRT 2007). Spawning still occurs in the Kennebec and Androscoggin Rivers, and it is possible that it still occurs in the Penobscot River as well. Spawning in the Androscoggin River was just recently confirmed by the Maine DMR when they captured a larval Atlantic sturgeon during the 2011 spawning season below the Brunswick Dam. There is no evidence of recent spawning in the remaining rivers. In the 1800s, construction of the Essex Dam on the Merrimack River at river kilometer (rkm) 49 blocked access to 58% of Atlantic sturgeon habitat in the river (Oakley 2003; ASSRT 2007). However, the accessible portions of the Merrimack seem to be suitable habitat for Atlantic sturgeon spawning and rearing (i.e., nursery habitat) (Kieffer and Kynard 1993). Therefore, the availability of spawning habitat does not appear to be the reason for the lack of observed spawning in the Merrimack River. Studies are on-going to determine whether Atlantic sturgeon are spawning in the Penobscot and Saco Rivers. Atlantic sturgeon that are spawned elsewhere continue to use habitats within all of these rivers as part of their overall marine range (ASSRT 2007).

At its mouth, the Kennebec River drains an area of 24,667 square kilometers, and is part of a large estuarine system that includes the Androscoggin and Sheepscot Rivers (ASMFC 1998a; ASSRT 1998; Squiers 1998). The Kennebec and Androscoggin Rivers flow into Merrymeeting Bay, a tidal freshwater bay, and exit as a combined river system through a narrow channel, flowing approximately 32 kilometers (20 miles) to the Atlantic Ocean as the tidal segment of the Kennebec River (Squiers 1998). This lower tidal segment of the Kennebec River forms a complex with the Sheepscot River estuary (ASMFC 1998a; Squiers 1998).

Substrate type in the Kennebec estuary is largely sand and bedrock (Fenster and FitzGerald 1996; Moore and Reblin 2010). Main channel depths at low tide typically range from 17 meters (58 feet) near the mouth to less than 10 meters (33 feet) in the Kennebec River above Merrymeeting Bay (Moore and Reblin 2010). Salinities range from 31 parts per thousand at Parker Head (five kilometers from the mouth) to 18 parts per thousand at Doubling Point during summer low flows (ASMFC 1998a). The 14-kilometer river segment above Doubling Point to Chops Point (the outlet of Merrymeeting Bay) is an area of transition (mid estuary) (ASMFC 1998a). The salinities in this section vary both seasonally and over a tidal cycle. During spring freshets this section is entirely fresh water but during summer low flows, salinities can range from two to three parts per thousand at Chops Point to 18 ppt at Doubling Point (ASMFC 1998a). The river is essentially tidal freshwater from the outlet of Merrymeeting Bay upriver to the site of the former Edwards Dam (ASMFC 1998a). Mean tidal amplitude ranges from 2.56 meters at the mouth of the Kennebec River estuary to 1.25 meters in Augusta near the head of tide on the Kennebec River (in the vicinity of the former Edwards Dam) and 1.16 meters at Brunswick on the Androscoggin River (ASMFC 1998a).

Bigelow and Schroeder (1953) surmised that Atlantic sturgeon likely spawned in Gulf of Maine Rivers in May-July. More recent captures of Atlantic sturgeon in spawning condition within the Kennebec River suggest that spawning more likely occurs in June-July (Squiers *et al.* 1981; ASMFC 1998a; ASSRT 1998). Evidence for the timing and location of Atlantic sturgeon spawning in the Kennebec River includes: (1) the capture of five adult male Atlantic sturgeon in spawning condition (i.e., expressing milt) in July 1994 below the (former) Edwards Dam; (2) the capture of 31 adult Atlantic sturgeon from June 15 through July 26, 1980, in a small commercial fishery directed at Atlantic sturgeon from the South Gardiner area (above Merrymeeting Bay) that included at least four ripe males and one ripe female captured on July 26, 1980; and, (3) the capture of nine adults during a gillnet survey conducted from 1977-1981, the majority of which were captured in July in the area from Merrymeeting Bay and upriver as far as Gardiner, Maine (ASSRT 1998; ASMFC TC 2007). The low salinity values for waters above Merrymeeting Bay are consistent with values found in other rivers where successful Atlantic sturgeon spawning is known to occur.

Age to maturity for GOM DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is 11 to 21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.* 1998), and 22 to 34 years for Atlantic sturgeon that originate from the Saint Lawrence River (Scott and Crossman 1973). Therefore, age at maturity for Atlantic sturgeon of the GOM DPS likely falls within these values. Of the 18 sturgeon examined from the commercial fishery that occurred in the Kennebec River in 1980, all of which were considered mature, age estimates for the 15 males ranged from 17-40 years, and from 25-40 years old for the three females (Squiers *et al.* 1981).

Several threats play a role in shaping the current status of GOM DPS Atlantic sturgeon. Historical records provide evidence of commercial fisheries for Atlantic sturgeon in the Kennebec and Androscoggin Rivers dating back to the 17th century (Squiers *et al.* 1979). In 1849, 160 tons of sturgeon was caught in the Kennebec River by local fishermen (Squiers *et al.* 1979). After the collapse of sturgeon stock in the 1880s, the sturgeon fishery was almost non-existent. All directed Atlantic sturgeon fishing as well as retention of Atlantic sturgeon bycatch has been prohibited since 1998. Nevertheless, mortalities associated with bycatch in fisheries in state and Federal waters still occurs. In the marine range, GOM DPS Atlantic sturgeon are incidentally captured in Federal and state-managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.* 2004b; ASMFC TC 2007). As explained above, we have estimates of the number of subadults and adults that are killed as a result of bycatch in fisheries authorized under Northeast fishery management plans. At this time, we are not able to quantify the impacts from other threats or estimate the number of individuals killed as a result of other anthropogenic threats. Habitat disturbance and direct mortality from anthropogenic sources are the primary concerns.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Many rivers in the GOM DPS have navigation channels that are maintained by dredging. Dredging outside of Federal channels and in-water construction occurs throughout the GOM DPS. While some dredging projects operate with observers present to document fish mortalities, many do not. To date we have not received any reports of Atlantic sturgeon killed during dredging projects in the Gulf of Maine region. At this time, we do not have any information to quantify the number of Atlantic sturgeon killed or disturbed during dredging or in-water construction projects are also not able to quantify any effects to habitat.

Connectivity is disrupted by the presence of dams on several rivers in the Gulf of Maine region, including the Penobscot and Merrimack Rivers. While there are also dams on the Kennebec, Androscoggin, and Saco Rivers, these dams are near the site of historical natural falls and likely represent the maximum upstream extent of sturgeon occurrence even if the dams were not present. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the Gulf of Maine region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent that Atlantic sturgeon are affected by operations of dams in the Gulf of Maine region is currently unknown; however, the documentation of an Atlantic sturgeon larvae downstream of the Brunswick Dam in the Androscoggin River suggests that Atlantic sturgeon spawning may be occurring in the vicinity of at least that project and therefore, may be affected by project operations. The range of Atlantic sturgeon in the Penobscot River is limited by the presence of the Milford Dam, at the base of which is the presumed historical spawning habitat. Atlantic sturgeon are known to occur in the Penobscot River, but it is unknown if spawning is currently occurring in this river. The Essex Dam on the Merrimack River blocks access to approximately 58% of historically accessible habitat in this river. Atlantic sturgeon occur in the Merrimack River but spawning has not been documented. As with the Penobscot, it is unknown how the Essex Dam affects the likelihood of spawning in this river.

GOM DPS Atlantic sturgeon may also be affected by degraded water quality. In general, water quality has improved in the Gulf of Maine over the past decades (Lichter *et al.* 2006; EPA 2008). Many rivers in Maine, including the Androscoggin River, were heavily polluted in the past from pulp and paper mill industrial discharges. While water quality has improved and most discharges are limited through regulations, many pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds, as developing eggs and larvae are particularly susceptible to exposure to contaminants.

There are no direct in-river abundance estimates for the GOM DPS. The Atlantic Sturgeon Status Review Team (ASSRT 2007) presumed that the GOM DPS was comprised of less than 300 spawning adults per year, based on extrapolated abundance estimates from the Hudson and Altamaha riverine populations of Atlantic sturgeon. Surveys of the Kennebec River over two time periods, 1977-1981 and 1998-2000, resulted in the capture of nine adult Atlantic sturgeon (Squiers 2004). However, since the surveys were primarily directed at capture of shortnose sturgeon, the capture gear used may not have been selective for the larger-sized, adult Atlantic sturgeon; several hundred subadult Atlantic sturgeon were caught in the Kennebec River during these studies. We have estimated that there are a minimum of 7,455 GOM DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters. We note further that this estimate is predicated on the assumption that fish in the GOM DPS would be available for capture in the NEAMAP surveys which extend from Block Island Sound, Rhode Island southward. Recoveries of tagged sturgeon do not support this migration pattern.

Summary of the Gulf of Maine DPS

Spawning for the GOM DPS is known to occur in two rivers (Kennebec and Androscoggin). Spawning may be occurring in other rivers, such as the Sheepscot, Merrimack, and Penobscot, but has not been confirmed. There are indications of potential increasing abundance of Atlantic sturgeon belonging to the GOM DPS. Atlantic sturgeon continue to be present in the Kennebec River; in addition, they are captured in directed research projects in the Penobscot River, and are observed in rivers where they were unknown to occur or had not been observed to occur for many years (e.g., Saco, Presumpscot, and Charles Rivers). These observations suggest that abundance of the GOM DPS of Atlantic sturgeon is sufficient such that recolonization to rivers historically suitable for spawning may be occurring. However, despite some positive signs, there is not enough information to establish a trend for this DPS.

Some of the impacts from the threats that contributed to the decline of the GOM DPS have been removed (e.g., directed fishing), or reduced as a result of improvements in water quality and removal of dams (e.g., the Edwards Dam on the Kennebec River in 1999 and the Veazie Dam on the Penobscot River in 2013). In Maine state waters, there are strict regulations on the use of fishing gear that incidentally catches sturgeon. In addition, in the last several years there have been reductions in fishing effort in state and Federal waters, which most likely would result in a reduction in bycatch mortality of Atlantic sturgeon. A significant amount of fishing in the Gulf of Maine is conducted using trawl gear, which is known to have a much lower mortality rate for Atlantic sturgeon caught in the gear compared to sink gillnet gear (ASMFC TC 2007). Atlantic sturgeon from the GOM DPS are not commonly taken as bycatch in areas south of Chatham, Massachusetts, with only 8% (e.g., 7 of 84 fish) of interactions observed south of Chatham being assigned to the GOM DPS (Wirgin and King 2011). Tagging results also indicate that GOM DPS fish tend to remain within the waters of the Gulf of Maine and only occasionally venture to points south.

Data on Atlantic sturgeon incidentally caught in trawls and intertidal fish weirs fished in the Minas Basin area of the Bay of Fundy (Canada) indicate that approximately 35% originated from the GOM DPS (Wirgin *et al.* 2012). Thus, a significant number of the GOM DPS fish appear to migrate north into Canadian waters where they may be subjected to a variety of threats including bycatch.

As noted previously, studies have shown that in order to rebuild, Atlantic sturgeon can only sustain low levels of bycatch and other anthropogenic mortality (Boreman 1997; ASMFC TC 2007; Kahnle *et al*. 2007; Brown and Murphy 2010). We have determined that the GOM DPS is at risk of becoming endangered in the foreseeable future throughout all of its range (i.e., is a threatened species) based on the following: (1) significant declines in population sizes and the protracted period during which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect recovery.

4.2.3.2 New York Bight DPS of Atlantic sturgeon

The New York Bight (NYB) DPS includes the following: all anadromous Atlantic sturgeon that spawn or are spawned in the watersheds that drain into coastal waters from Chatham, Massachusetts to the Delaware-Maryland border on Fenwick Island. The marine range of Atlantic sturgeon from the NYB DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the NYB DPS and the adjacent portion of the marine range are shown in Figure 9. Within this range, Atlantic sturgeon historically spawned in the Connecticut, Delaware, Hudson, and Taunton Rivers (Murawski and Pacheco 1977; Secor 2002; ASSRT 2007). Spawning still occurs in the Delaware and Hudson Rivers, but there is no recent evidence (within the last 15 years) of spawning in the Connecticut and Taunton Rivers (ASSRT 2007). Atlantic sturgeon that are spawned elsewhere continue to use habitats within the Connecticut and Taunton Rivers as part of their overall marine range (ASSRT 2007; Savoy 2007; Wirgin and King 2011).

The abundance of the Hudson River Atlantic sturgeon riverine population before the over-exploitation of the 1800s is unknown, but has been conservatively estimated at 6,000 adult females (Secor 2002). Current abundance is likely at least one order of magnitude smaller than historical levels (Secor 2002; ASSRT 2007; Kahnle *et al.* 2007). As described above, an estimate of the mean annual number of mature adults (863 total; 596 males and 267 females) was calculated for the Hudson riverine population based on fishery-dependent data collected from 1985-1995 (Kahnle *et al.* 2007). Kahnle *et al.* (1998, 2007) also showed that the level of fishing mortality from the Hudson River Atlantic sturgeon fishery during the period of 1985-1995 exceeded the estimated sustainable level of fishing mortality for the riverine population and may have led to reduced recruitment. All available data on abundance of juvenile Atlantic sturgeon in the Hudson River Estuary indicate a substantial drop in production of young since the mid-1970s (Kahnle *et al.* 1998). A decline appeared to occur in the mid to late 1970s followed by a secondary drop in the late 1980s (Kahnle *et al.* 1998; Sweka *et al.* 2007; ASMFC 2010). Catch-per-unit-effort (CPUE) data suggests that recruitment has remained depressed relative to catches of juvenile Atlantic sturgeon in the estuary during the mid-late 1980s (Sweka *et al.* 2007; ASMFC 2010). The CPUE data from 1985-2011 show significant fluctuations. There appears to be a decline in the number of juveniles between the late 1980s and early 1990s and then a slight increase in the 2000s, but, given the significant annual fluctuation, it is difficult to discern any trend. Despite the CPUEs from 2000-2011 being slightly higher than those from 1990-1999, they are low compared to the late 1980s (Figure 12). There is currently not enough information regarding any life stage to establish a trend for the Hudson River population.

There is no overall, empirical abundance estimate for the Delaware River population of Atlantic sturgeon. Harvest records from the 1800s indicate that this was historically a large population with an estimated 180,000 adult females prior to 1890 (Secor and Waldman 1999; Secor 2002). Sampling in 2009 to target YOY Atlantic sturgeon in the Delaware River (i.e., natal sturgeon) resulted in the capture of 34 YOY, ranging in size from 178 to 349 millimeters TL (Fisher 2009), and the collection of 32 YOY Atlantic sturgeon in a separate study (Brundage and O'Herron 2009 in Calvo *et al.* 2010). Genetics information collected from 33 of these YOY indicates that at least three females successfully contributed to the 2009 year class (Fisher 2011). Therefore, while the capture of YOY in 2009 provides evidence that successful spawning still occurs in the Delaware River, the relatively low numbers suggest the existing riverine population is small.

Several threats play a role in shaping the current status and trends observed in the Delaware River and estuary. In-river threats include habitat disturbance from dredging, and impacts from historical pollution and impaired water quality. A dredged navigation channel extends from Trenton seaward through the tidal river (Brundage and O'Herron 2009), and the river receives significant shipping traffic. Vessel strikes have been identified as a threat in the Delaware River and may be detrimental to the long-term viability of the NYB DPS, as well as other DPSs (Brown and Murphy 2010).

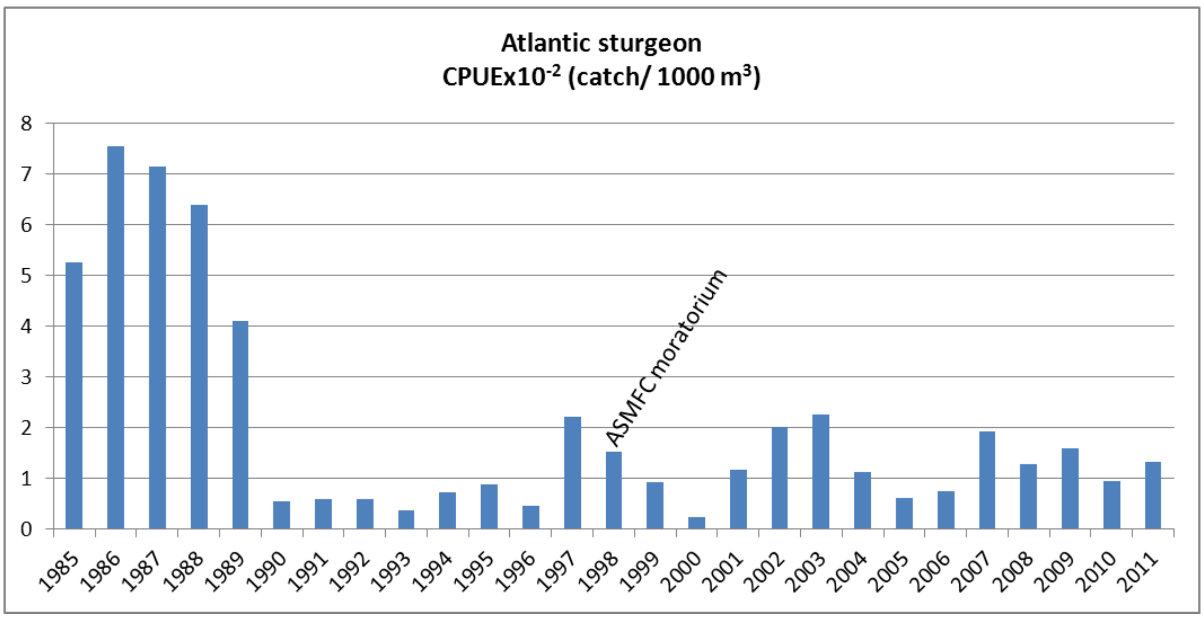

Figure 12. Hudson River Atlantic sturgeon CPUE juvenile index (1985-2011).

Summary of the New York Bight DPS

Atlantic sturgeon originating from the NYB DPS have been documented to spawn in the Hudson and Delaware Rivers and may spawn in the Connecticut and Housatonic Rivers, although that has not been confirmed. While genetic testing can differentiate between individuals originating from the Hudson or Delaware River, the available information suggests that the straying rate is relatively high between these rivers. Some of the impact from the threats that contributed to the decline of the NYB DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the Clean Water Act. In addition, there have been reductions in fishing effort in state and Federal waters, which may result in a reduction in bycatch mortality of Atlantic sturgeon. Nevertheless, areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in state and federally-managed fisheries, and vessel strikes remain significant threats to the NYB DPS.

In its marine range, NYB DPS Atlantic sturgeon are incidentally captured in Federal and state-managed fisheries, reducing survivorship of subadult and adult Atlantic sturgeon (Stein *et al.* 2004a; ASMFC TC 2007). Based on mixed stock analysis results presented by Wirgin and King (2011), more than 40% of the Atlantic sturgeon bycatch interactions in the Mid-Atlantic Bight region were sturgeon from the NYB DPS. Individual-based assignment and mixed stock analysis of samples collected from sturgeon captured in Canadian fisheries in the Bay of Fundy indicated that approximately 1%-2% were from the NYB DPS (Wirgin *et al.* 2012). At this time, we are not able to quantify the impacts from threats other than fisheries or estimate the number of individuals killed as a result of other anthropogenic threats.

Riverine habitat may be impacted by dredging and other in-water activities, disturbing spawning habitat and also altering the benthic forage base. Both the Hudson and Delaware Rivers have navigation channels that are maintained by dredging. Dredging is also used to maintain channels in the nearshore marine environment. Dredging outside of Federal channels and in-water construction occurs throughout the New York Bight region. While some dredging projects operate with observers present to document fish mortalities, many do not. We have reports of Atlantic sturgeon entrained during hopper dredging operations in Ambrose Channel, New Jersey, and in the Delaware River.

In the Hudson and Delaware Rivers, dams do not block access to historical habitat. The Holyoke Dam on the Connecticut River blocks passage past the dam at Holyoke; however, the extent that Atlantic sturgeon would historically have used habitat upstream of Holyoke is unknown. The first dam on the Taunton River may block access to historical spawning habitat. Connectivity also may be disrupted by the presence of dams on several smaller rivers in the New York Bight region. Because no Atlantic sturgeon occur upstream of any hydroelectric projects in the New York Bight region, passage over hydroelectric dams or through hydroelectric turbines is not a source of injury or mortality in this area. The extent to which Atlantic sturgeon are affected by operations of dams in the New York Bight region is currently unknown. Atlantic sturgeon may also be impinged or entrained at power plants in the Hudson and Delaware Rivers, and may be adversely affected by the operation of the power plants, but the power plants have not been found to jeopardize their continued existence.

NYB DPS Atlantic sturgeon may also be affected by degraded water quality. Rivers in the New York Bight region, including the Hudson and Delaware, have been heavily polluted by industrial and sewer discharges. In general, water quality has improved in the Hudson and Delaware over the past several decades (Lichter *et al.* 2006; EPA 2008). While water quality has improved and most discharges are limited through regulations, it is likely that pollutants persist in the benthic environment. This can be particularly problematic if pollutants are present on spawning and nursery grounds, where developing eggs and larvae are particularly susceptible to exposure to contaminants.

Vessel strikes are known to occur in the Delaware River and may also be occurring in the Hudson and other New York Bight rivers. Twenty-nine mortalities believed to be the result of vessel strikes were documented in the Delaware River from 2004-2008, and at least 13 of these fish were large adults. Given the time of year in which the fish were observed (predominantly May through July, with two in August), it is likely that many of the adults were migrating through the river to the spawning grounds. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the NYB DPS.

Studies have shown that to rebuild, Atlantic sturgeon can only sustain low levels of anthropogenic mortality (Boreman 1997; ASMFC TC 2007; Kahnle *et al.* 2007; Brown and Murphy 2010). There are no empirical abundance estimates of the number of Atlantic sturgeon in the NYB DPS. We have estimated that there are a minimum of 34,566 NYB DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters. We have determined that the NYB DPS is currently at risk of extinction due to: (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and (3) the impacts and threats that have and will continue to affect population recovery.

4.2.3.3 Chesapeake Bay DPS of Atlantic sturgeon

The Chesapeake Bay (CB) DPS includes the following: all anadromous Atlantic sturgeon that spawn or are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, Virginia. The marine range of Atlantic sturgeon from the CB DPS extends from Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the CB DPS and the adjacent portion of the marine range are shown in Figure 9. Within this range, Atlantic sturgeon historically spawned in the Susquehanna, Potomac, James, York, Rappahannock, and Nottoway Rivers (ASSRT 2007). Based on the review by Oakley (2003), 100% of Atlantic sturgeon habitat is currently accessible in these rivers since most of the barriers to passage (i.e., dams) are located upriver of where spawning is expected to have historically occurred (ASSRT 2007). Spawning still occurs in the James River, and the presence of juvenile and adult sturgeon in the York River suggests that spawning may occur there as well (Musick *et al.* 1994; ASSRT 2007; Greene *et al.* 2009). However, conclusive evidence of current spawning is only available for the James River, where a recent study found evidence of Atlantic sturgeon spawning in the fall (Balazik *et al.* 2012a). Atlantic sturgeon that are spawned elsewhere are known to use the Chesapeake Bay for other life functions, such as foraging and as juvenile nursery habitat (Vladykov and Greeley 1963; Wirgin *et al.* 2000; ASSRT 2007; Grunwald *et al.* 2008).

Age to maturity for CB DPS Atlantic sturgeon is unknown. However, Atlantic sturgeon riverine populations exhibit clinal variation with faster growth and earlier age to maturity for those that originate from southern waters, and slower growth and later age to maturity for those that originate from northern waters (75 FR 61872; October 6, 2010). Age at maturity is five to 19 years for Atlantic sturgeon originating from South Carolina rivers (Smith *et al.* 1982) and 11 to

21 years for Atlantic sturgeon originating from the Hudson River (Young *et al.* 1998). Therefore, age at maturity for Atlantic sturgeon of the CB DPS likely falls within these values.

Several threats play a role in shaping the current status of CB DPS Atlantic sturgeon. Historical records provide evidence of the large-scale commercial exploitation of Atlantic sturgeon from the James River and Chesapeake Bay in the 19th century (Hildebrand and Schroeder 1928; Vladykov and Greeley 1963; ASMFC 1998b; Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007) as well as subsistence fishing and attempts at commercial fisheries as early as the 17th century (Secor 2002; Bushnoe *et al.* 2005; ASSRT 2007; Balazik *et al.* 2010). Habitat disturbance caused by in-river work, such as dredging for navigational purposes, is thought to have reduced available spawning habitat in the James River (Holton and Walsh 1995; Bushnoe *et al.* 2005; ASSRT 2007). At this time, we do not have information to quantify this loss of spawning habitat.

Decreased water quality also threatens Atlantic sturgeon of the CB DPS, especially since the Chesapeake Bay system is vulnerable to the effects of nutrient enrichment due to a relatively low tidal exchange and flushing rate, large surface-to-volume ratio, and strong stratification during the spring and summer months (Pyzik *et al.* 2004; ASMFC 1998a; ASSRT 2007; EPA 2008). These conditions contribute to reductions in dissolved oxygen levels throughout the Bay. The availability of nursery habitat, in particular, may be limited given the recurrent hypoxia (low dissolved oxygen) conditions within the Bay (Niklitschek and Secor 2005, 2010). Heavy industrial development during the 20th century in rivers inhabited by sturgeon impaired water quality and impeded these species' recovery.

Although there have been improvements in the some areas of the Bay's health, the ecosystem remains in poor condition. The EPA gave the overall health of the Bay a grade of 45% based on goals for water quality, habitats, lower food web productivity, and fish and shellfish abundance (EPA CBP 2010). This was a 6% increase from 2008. According to the EPA, the modest gain in the health score was due to a large increase in the adult blue crab population, expansion of underwater grass beds growing in the Bay's shallows, and improvements in water clarity and bottom habitat health as highlighted below:

- 12% of the Bay and its tidal tributaries met CWA standards for dissolved oxygen between 2007 and 2009, a decrease of 5% from 2006 to 2008,
- 26% of the tidal waters met or exceeded guidelines for water clarity, a 12% increase from 2008,
- Underwater bay grasses covered 9,039 more acres of the Bay's shallow waters for a total of 85,899 acres, 46% of the Bay-wide goal,
- The health of the Bay's bottom dwelling species reached a record high of 56% of the goal, improving by approximately 15% Bay-wide, and
- The adult blue crab population increased to 223 million, its highest level since 1993.

At this time we do not have sufficient information to quantify the extent that degraded water quality effects habitat or individuals in the James River or throughout the Chesapeake Bay.

Vessel strikes have been observed in the James River (ASSRT 2007). Eleven Atlantic sturgeon were reported to have been struck by vessels from 2005-2007. Several of these were mature individuals. Because we do not know the percent of total vessel strikes that the observed mortalities represent, we are not able to quantify the number of individuals likely killed as a result of vessel strikes in the CB DPS.

In the marine and coastal range of the CB DPS from Canada to Florida, fisheries bycatch in federally and state-managed fisheries poses a threat to the DPS, reducing survivorship of subadults and adults and potentially causing an overall reduction in the spawning population (Stein *et al.* 2004b; ASMFC TC 2007; ASSRT 2007).

Summary of the Chesapeake Bay DPS

Spawning for the CB DPS is known to occur in only the James and Pamunkey Rivers. Spawning may be occurring in other rivers, such as the York, Rappahannock, Potomac, Nanticoke, and Susquehanna, but has not been confirmed for any of those. There are anecdotal reports of increased sightings and captures of Atlantic sturgeon in the James River. However, this information has not been comprehensive enough to develop a population estimate for the James River or to provide sufficient evidence to confirm increased abundance. Some of the impact from the threats that facilitated the decline of the CB DPS have been removed (e.g., directed fishing) or reduced as a result of improvements in water quality since passage of the CWA. We have estimated that there are a minimum of 8,811 CB DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters.

Areas with persistent, degraded water quality, habitat impacts from dredging, continued bycatch in U.S. state and federally-managed fisheries, Canadian fisheries, and vessel strikes remain significant threats to the CB DPS of Atlantic sturgeon. Of the 35% of Atlantic sturgeon incidentally caught in the Bay of Fundy, about 1% were CB DPS fish (Wirgin *et al.* 2012). Studies have shown that Atlantic sturgeon can only sustain low levels of bycatch mortality (Boreman 1997; ASMFC TC 2007; Kahnle *et al.* 2007). The CB DPS is currently at risk of extinction given (1) precipitous declines in population sizes and the protracted period in which sturgeon populations have been depressed; (2) the limited amount of current spawning; and, (3) the impacts and threats that have and will continue to affect the potential for population recovery.

4.2.3.4 Carolina DPS of Atlantic sturgeon

The Carolina DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the Carolina DPS and the adjacent portion of the marine range are shown in Figure 9. Sturgeon are commonly captured 40 miles offshore (D. Fox, Delaware State University, pers. comm.). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 meters deep (Stein *et al*. 2004b, ASMFC TC 2007), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms.

Rivers known to have current spawning populations within the range of the Carolina DPS include the Roanoke, Tar-Pamlico, Cape Fear, Waccamaw, and Pee Dee Rivers. We determined spawning was occurring if YOY were observed or mature adults were present in freshwater portions of a system (Table 14). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. There may also be spawning populations in the Neuse, Santee, and Cooper Rivers, though it is uncertain. Historically, both the Sampit and Ashley Rivers were documented to have spawning populations at one time. However, the spawning population in the Sampit River is believed to be extirpated, and the current status of the spawning population in the Ashley River is unknown. Both rivers may be used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. Fish from the Carolina DPS likely use other river systems than those listed here for their specific life functions.

Table 14. Major rivers, tributaries, and sounds within the range of the Carolina DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

River/Estuary	Spawning Population	Data
Roanoke River, VA/NC; Albemarle Sound, NC	Yes	collection of 15 YOY (1997-1998); single YOY (2005)
Tar-Pamlico River, NC; Pamlico Sound	Yes	one YOY (2005)
Neuse River, NC; Pamlico Sound	Unknown	
Cape Fear River, NC	Yes	upstream migration of adults in the fall, carcass of a ripe female upstream in mid-September (2006)
Waccamaw River, SC; Winyah Bay	Yes	age-1, potentially YOY (1980s)
Pee Dee River, SC; Winyah Bay	Yes	running ripe male in Great Pee Dee River (2003)
Sampit, SC; Winyah Bay	Extirpated	
Santee River, SC	Unknown	
Cooper River, SC	Unknown	
Ashley River, SC	Unknown	

Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002; Secor 2002). Secor (2002) estimates that 8,000 adult females were present in South Carolina during that same time frame. Prior reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS. Currently, the Atlantic sturgeon spawning population in at least one river system within the Carolina DPS has been extirpated, with potential extirpation in an additional system. The abundances of the remaining river populations within the DPS, each estimated to have fewer than 300 spawning adults, are estimated to be less than 3% of what they were historically (ASSRT 2007). We have estimated that there are a minimum of 1,356 Carolina DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters.

Threats

The Carolina DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overutilization (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dams, dredging, and degraded water quality is contributing to the status of the Carolina DPS. Dams have curtailed Atlantic sturgeon spawning and juvenile developmental habitat by blocking more than 60% of the historical sturgeon habitat upstream of the dams in the Cape Fear and Santee-Cooper River systems. Water quality (velocity, temperature, and dissolved oxygen) downstream of these dams, as well as on the Roanoke River, has been reduced, which modifies and curtails the extent of spawning and nursery habitat for the Carolina DPS. Dredging in spawning and nursery grounds modifies the quality of the habitat and is further curtailing the extent of available habitat in the Cape Fear and Cooper Rivers, where Atlantic sturgeon habitat has already been modified and curtailed by the presence of dams. Reductions in water quality from terrestrial activities have modified habitat used by the Carolina DPS. In the Pamlico and Neuse systems, nutrient-loading and seasonal anoxia are occurring, associated in part with concentrated animal feeding operations (CAFOs). Heavy industrial development and CAFOs have also degraded water quality in the Cape Fear River. Water quality in the Waccamaw and Pee Dee Rivers has been affected by industrialization and riverine sediment samples contain high levels of various toxins, including dioxins. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the Carolina DPS. Twenty interbasin water transfers in existence prior to 1993, averaging 66.5 million gallons per day (mgd), were authorized at their maximum levels without being subjected to an evaluation for certification by the North Carolina Department of Environmental and Natural Resources and other resource agencies. Since the 1993 legislation requiring certificates for transfers took effect, almost 170 mgd of interbasin water withdrawals have been authorized, with an additional 60 mgd pending certification. The removal of large amounts of water from the system will alter flows, temperature, and dissolved oxygen. Existing water allocation issues will likely be compounded by population growth and potentially climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower dissolved oxygen, all of which are current stressors to the Carolina DPS.

Overutilization of Atlantic sturgeon from directed fishing caused initial severe declines in Atlantic sturgeon populations in the Southeast in the mid- to late 19th century, from which they have never rebounded. Continued bycatch of Atlantic sturgeon in commercial fisheries is an ongoing impact to the Carolina DPS. More robust fishery independent data on bycatch are available for the Northeast and Mid-Atlantic than in the Southeast where high levels of bycatch underreporting are suspected.

Though there are statutory and regulatory regulations that authorize reducing the impact of dams on riverine and anadromous species, these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Water quality continues to be a problem in the Carolina DPS, even with existing controls on some pollution sources. Current regulatory regimes are not effective in controlling water allocation issues (e.g., no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution, etc.).

The recovery of Atlantic sturgeon along the Atlantic coast, especially in areas where habitat is limited and water quality is severely degraded, will require improvements in the following areas: (1) elimination of barriers to spawning habitat either through dam removal, breaching, or installation of successful fish passage facilities; (2) operation of water control structures to provide appropriate flows, especially during spawning season; (3) imposition of dredging restrictions including seasonal moratoriums and avoidance of spawning/nursery habitat; and (4) mitigation of water quality parameters that are restricting sturgeon use of a river (i.e., dissolved oxygen). Additional data regarding sturgeon use of riverine and estuarine environments are needed.

The concept of a viable population able to adapt to changing environmental conditions is critical to Atlantic sturgeon, and the low population numbers of every river population in the Carolina DPS put them in danger of extinction throughout their range; none of the populations are large or stable enough to provide with any level of certainty for the continued existence of Atlantic sturgeon in this part of its range. Although the largest impact that caused the precipitous decline of the species has been curtailed (directed fishing), the population sizes within the Carolina DPS have remained relatively constant at greatly reduced levels (approximately 3% of historical population sizes) for 100 years. Small numbers of individuals resulting from drastic reductions in populations, such as that which occurred due to the commercial fishery, can remove the buffer against natural demographic and environmental variability provided by large populations (Berry 1971; Soulé 1980; Shaffer 1981). Recovery of depleted populations is an inherently slow process for late-maturing species such as Atlantic sturgeon, and they continue to face a variety of other threats that contribute to their risk of extinction. Their late age at maturity provides more opportunities for individual Atlantic sturgeon to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, it also increases the timeframe over which exposure to the multitude of threats facing the Carolina DPS can occur. The viability of the Carolina DPS depends on having multiple self-sustaining riverine spawning populations and maintaining suitable habitat to support the various life functions (spawning, feeding, growth) of Atlantic sturgeon populations.

Summary of the Status of the Carolina DPS of Atlantic Sturgeon

Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the Carolina DPS by habitat alteration and bycatch. This DPS was severely depleted by past directed commercial fishing, and faces ongoing impacts and threats from habitat alteration or inaccessibility, bycatch, and the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch that have prevented river populations from rebounding and will prevent their recovery.

The presence of dams has resulted in the loss of more than 60% of the historical sturgeon habitat on the Cape Fear River and in the Santee-Cooper system. Dams are contributing to the status of the Carolina DPS by curtailing the extent of available spawning habitat and further modifying the remaining habitat downstream by affecting water quality parameters (such as depth, temperature, velocity, and dissolved oxygen) that are important to sturgeon. Dredging is also contributing to the status of the Carolina DPS by modifying Atlantic sturgeon spawning and nursery habitat. Habitat modifications through reductions in water quality are contributing to the status of the Carolina DPS due to nutrient-loading, seasonal anoxia, and contaminated sediments. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch is also a current threat to the Carolina DPS that is contributing to its status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may use multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in either reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality. While many of the threats to the Carolina DPS have been ameliorated or reduced due to existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch and habitat alterations are currently not being addressed through existing mechanisms. Further, despite NMFS's authority under the Federal Power Act to prescribe fish passage and existing controls on some pollution sources, access to habitat and improved water quality continues to be a problem. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the Carolina DPS.

4.2.3.5 South Atlantic DPS of Atlantic sturgeon

The South Atlantic (SA) DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto Rivers (ACE) Basin southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida. The marine range of Atlantic sturgeon from the SA DPS extends from the Hamilton Inlet, Labrador, Canada, to Cape Canaveral, Florida. The riverine range of the SA DPS and the adjacent portion of the marine range are shown in Figure 9. Sturgeon are commonly captured 40 miles offshore (D. Fox, Delaware State University, pers. comm.). Records providing fishery bycatch data by depth show the vast majority of Atlantic sturgeon bycatch via gillnets is observed in waters less than 50 meters deep (Stein *et al.* 2004b, ASMFC TC 2007), but Atlantic sturgeon are recorded as bycatch out to 500 fathoms (900 meters).

Rivers known to have current spawning populations within the range of the South Atlantic DPS include the Combahee, Edisto, Savannah, Ogeechee, Altamaha, and Satilla Rivers. We determined spawning was occurring if YOY were observed, or mature adults were present, in freshwater portions of a system (Table 15). However, in some rivers, spawning by Atlantic sturgeon may not be contributing to population growth because of lack of suitable habitat and the presence of other stressors on juvenile survival and development. Historically, both the Broad-Coosawatchie and St. Marys Rivers were documented to have spawning populations at one time; there is also evidence that spawning may have occurred in the St. Johns River or one of its tributaries. However, the spawning population in the St. Marys River, as well as any historical spawning population present in the St. Johns, is believed to be extirpated, and the status of the spawning population in the Broad-Coosawatchie is unknown. Both the St. Marys and St. Johns Rivers are used as nursery habitat by young Atlantic sturgeon originating from other spawning populations. The use of the Broad-Coosawatchie by sturgeon from other spawning populations is unknown at this time. The presence of historical and current spawning populations in the Ashepoo River has not been documented; however, this river may currently be used for nursery habitat by young Atlantic sturgeon originating from other spawning populations. Fish from the SA DPS likely use other river systems than those listed here for their specific life functions.

Table 15. Major rivers, tributaries, and sounds within the range of the SA DPS and currently available data on the presence of an Atlantic sturgeon spawning population in each system.

River/Estuary	Spawning Population	Data
ACE (Ashepoo, Combahee, and Edisto Rivers) Basin, SC; St. Helena Sound	Yes	1,331 YOY (1994-2001); gravid female and running ripe male in the Edisto (1997); 39 spawning adults (1998)
Broad-Coosawhatchie Rivers, SC; Port Royal Sound	Unknown	
Savannah River, SC/GA	Yes	22 YOY (1999-2006); running ripe male (1997)
Ogeechee River, GA	Yes	age-1 captures, but high inter-annual variability (1991-1998); 17 YOY (2003); 9 YOY (2004)
Altamaha River, GA	Yes	74 captured/308 estimated spawning adults (2004); 139 captured/378 estimated spawning adults (2005)
Satilla River, GA	Yes	4 YOY and spawning adults (1995-1996)
St. Marys River, GA/FL	Extirpated	
St. Johns River, FL	Extirpated	

Secor (2002) estimates that 8,000 adult females were present in South Carolina before the collapse of the fishery in 1890. However, because fish from South Carolina are included in both the Carolina and SA DPSs, it is likely that some of the historical 8,000 fish would be attributed to both the Carolina DPS and SA DPS. The sturgeon fishery had been the third largest fishery in Georgia. Reductions from the commercial fishery and ongoing threats have drastically reduced the numbers of Atlantic sturgeon within the South Atlantic DPS. Currently, the Atlantic sturgeon population in at least two river systems within the SA DPS has been extirpated. We have estimated that there are a minimum of 14,911 SA DPS adult and subadult Atlantic sturgeon of size vulnerable to capture in U.S. Atlantic waters.

Threats
The SA DPS was listed as endangered under the ESA as a result of a combination of habitat curtailment and modification, overuse (i.e., being taken as bycatch) in commercial fisheries, and the inadequacy of regulatory mechanisms in ameliorating these impacts and threats.

The modification and curtailment of Atlantic sturgeon habitat resulting from dredging and degraded water quality is contributing to the status of the SA DPS. Dredging is a present threat to the SA DPS and is contributing to its status by modifying the quality and availability of Atlantic sturgeon habitat. Maintenance dredging is currently modifying Atlantic sturgeon nursery habitat in the Savannah River and modeling indicates that the proposed deepening of the navigation channel will result in reduced dissolved oxygen and upriver movement of the salt wedge, curtailing spawning habitat. Dredging is also modifying nursery and foraging habitat in the St. Johns Rivers. Reductions in water quality from terrestrial activities have modified habitat used by the SA DPS. Low dissolved oxygen is modifying sturgeon habitat in the Savannah due to dredging, and non-point source inputs are causing low dissolved oxygen in the Ogeechee River and in the St. Marys River, which completely eliminates juvenile nursery habitat in summer. Low dissolved oxygen has also been observed in the St. Johns River in the summer. Sturgeon are more sensitive to low dissolved oxygen and the negative (metabolic, growth, and feeding) effects caused by it increase when water temperatures are concurrently high, as they are within the range of the SA DPS. Additional stressors arising from water allocation and climate change threaten to exacerbate water quality problems that are already present throughout the range of the SA DPS. Large withdrawals of over 240 million gallons per day mgd of water occur in the Savannah River for power generation and municipal uses. However, permits for users withdrawing less than 100,000 gallons per day (gpd) are not required to get permits, so actual water withdrawals from the Savannah and other rivers within the range of the SA DPS are unknown, but likely much higher. The removal of large amounts of water from the system will alter flows, temperature, and dissolved oxygen. Water shortages and “water wars” are already occurring in the rivers occupied by the SA DPS and will likely be compounded in the future by population growth and, potentially, by climate change. Climate change is also predicted to elevate water temperatures and exacerbate nutrient-loading, pollution inputs, and lower dissolved oxygen, all of which are current stressors to the SA DPS.

The directed Atlantic sturgeon fishery caused initial severe declines in southeast Atlantic sturgeon populations. Although the directed fishery is closed, bycatch in other commercial fisheries continues to impact the SA DPS. Statutory and regulatory mechanisms exist that authorize reducing the impact of dams on riverine and anadromous species such as Atlantic sturgeon, but these mechanisms have proven inadequate for preventing dams from blocking access to habitat upstream and degrading habitat downstream. Further, water quality continues to be a problem in the SA DPS, even with existing controls on some pollution sources. Current regulatory regimes are not effective in controlling water allocation issues (e.g., no permit requirements for water withdrawals under 100,000 gpd in Georgia, no restrictions on interbasin water transfers in South Carolina, the lack of ability to regulate non-point source pollution.)

The recovery of Atlantic sturgeon along the Atlantic coast, especially in areas where habitat is limited and water quality is severely degraded, will require improvements in the following areas: (1) elimination of barriers to spawning habitat either through dam removal, breaching, or installation of successful fish passage facilities; (2) operation of water control structures to provide appropriate flows, especially during spawning season; (3) imposition of dredging restrictions including seasonal moratoriums and avoidance of spawning/nursery habitat; and (4) mitigation of water quality parameters that are restricting sturgeon use of a river (i.e., dissolved oxygen). Additional data regarding sturgeon use of riverine and estuarine environments is needed.

Summary of the Status of the South Atlantic DPS of Atlantic Sturgeon

Recovery of depleted populations is an inherently slow process for a late-maturing species such as Atlantic sturgeon. Their late age at maturity provides more opportunities for individuals to be removed from the population before reproducing. While a long life-span also allows multiple opportunities to contribute to future generations, this is hampered within the SA DPS by habitat alteration, bycatch, and from the inadequacy of existing regulatory mechanisms to address and reduce habitat alterations and bycatch.

Dredging is contributing to the status of the SA DPS by modifying spawning, nursery, and foraging habitat. Habitat modifications through reductions in water quality and dissolved oxygen are also contributing to the status of the SA DPS, particularly during times of high water temperatures, which increase the detrimental effects on Atlantic sturgeon habitat. Interbasin water transfers and climate change threaten to exacerbate existing water quality issues. Bycatch also contributes to the SA DPS's status. Fisheries known to incidentally catch Atlantic sturgeon occur throughout the marine range of the species and in some riverine waters as well. Because Atlantic sturgeon mix extensively in marine waters and may use multiple river systems for nursery and foraging habitat in addition to their natal spawning river, they are subject to being caught in multiple fisheries throughout their range. In addition to direct mortality, stress or injury to Atlantic sturgeon taken as bycatch but released alive may result in increased susceptibility to other threats, such as poor water quality (e.g., exposure to toxins). This may result in reduced ability to perform major life functions, such as foraging and spawning, or even post-capture mortality. While many of the threats to the SA DPS have been ameliorated or reduced due to the existing regulatory mechanisms, such as the moratorium on directed fisheries for Atlantic sturgeon, bycatch and habitat alteration are currently not being addressed through existing mechanisms. Further, access to habitat and good water quality continues to be a problem even with NMFS's authority under the Federal Power Act to prescribe fish passage and existing controls on some pollution sources. There is a lack of regulation for some large water withdrawals, which threatens sturgeon habitat. Current regulatory regimes do not require a permit for water withdrawals under 100,000 gpd in Georgia and there are no restrictions on interbasin water transfers in South Carolina. Data required to evaluate water allocation issues are either very weak, in terms of determining the precise amounts of water currently being used, or non-existent, in terms of our knowledge of water supplies available for use under historical hydrologic conditions in the region. Existing water allocation issues will likely be compounded by population growth, drought, and, potentially, climate change. The inadequacy of regulatory mechanisms to control bycatch and habitat alterations is contributing to the status of the SA DPS.

4.2.4 Status of Shortnose Sturgeon

Species description

Shortnose sturgeon occur in estuaries and rivers along the east coast of North America (Vladykov and Greeley 1963). Their northerly distribution extends to the Saint John River, New Brunswick, Canada, and their southerly distribution historically extended to the Indian River, Florida (Evermann and Bean 1898; Scott and Scott 1988) (Figure 13).

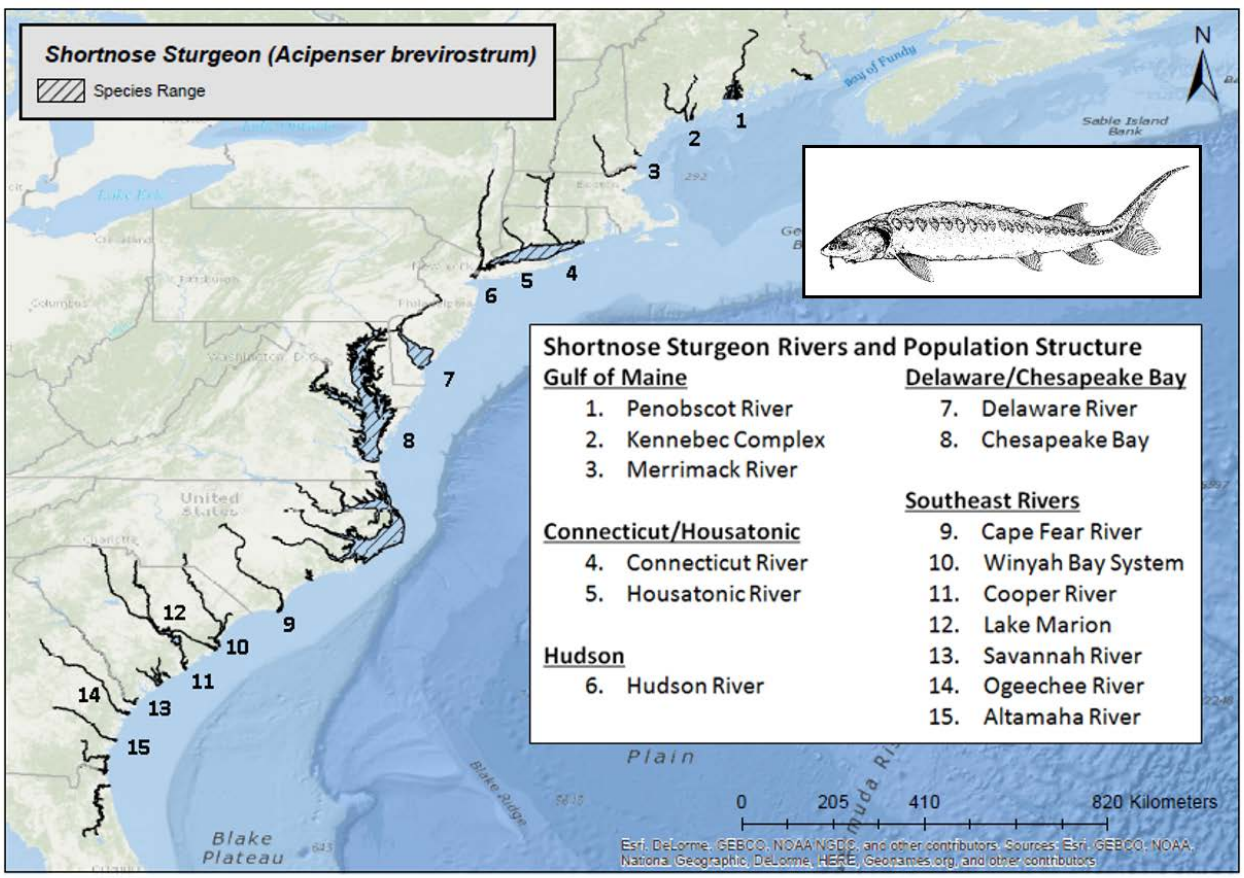

Figure 13. Geographic range of shortnose sturgeon.

The shortnose sturgeon (*Acipenser brevirostrum*) is the smallest of the three sturgeon species that occur in eastern North America. It has a benthic fusiform body and its head and snout are smaller while its mouth is larger relative to Atlantic sturgeon (Dadswell 1984). Shortnose sturgeon vary in color but are generally dark brown to olive/black on the dorsal surface, lighter along the row of lateral scutes and nearly white on the ventral surface (Gilbert 1989). The shortnose sturgeon was listed as endangered on March 11, 1967 (32 FR 4001) and remained on the endangered species list with the enactment of the ESA in 1973 (Table 16).

Table 16. Shortnose sturgeon information bar provides species Latin name, common name and current Federal Register notice of listing status, designated critical habitat, Distinct Population Segment, recent status review, and recovery plan.

Species	Common Name	Distinct Population Segment	ESA Status	Recent Review Year	Listing	Recovery Plan	Critical Habitat
Acipenser brevirostrum	Sturgeon, Shortnose	Entire Population	Endangered	2010	1967 32 FR 4001	1998	None Designated

Life history

Shortnose sturgeon are relatively slow growing, late maturing and long-lived. Growth rate, maximum age and maximum size vary with latitude; populations in southern areas grow more rapidly and mature at younger ages but attain smaller maximum sizes than those in the north (Dadswell *et al*. 1984). In general, females reach sexual maturity in the south as early as age 4 and in the north as late as age 18, and males display similar difference in latitudinal development, maturing between ages 2 and 11 (SSSRT 2010). Shortnose sturgeon overwinter in the lower portions of rivers and migrate upriver to spawn in the spring. Spawning periodicity is poorly understood, but males seem to spawn more frequently than females. Dadswell (1984) estimated that Saint John River males spawned at 2-year intervals; females at 3-5 year intervals. Spawning females deposit their eggs over gravel, rubble, and/or cobble often in the farthest accessible upstream reach of the river (Kynard 1997). After spawning, adult shortnose sturgeon move rapidly to downstream feeding areas where they forage on benthic insects, crustaceans, mollusks, and polychaetes (Dadswell 1984; Buckley and Kynard 1985; Kieffer and Kynard 1993; O'Herron *et al*. 1993).

Upon hatching, shortnose sturgeon shelter in dark substrate or are found in schools swimming against the current. Around 4-12 days after hatching individuals begin to feed exogenously and are dispersed downstream. These larvae are often found in the deepest water, usually within the channel (Taubert and Dadswell 1980; O'Connor *et al*. 1981; Kieffer and Kynard 1993; Parker and Kynard 2014). Young of the Year remain in freshwater habitats upstream of the salt wedge for about one year (Dadswell *et al*. 1984; Kynard 1997). The age at which juveniles begin to utilize habitat associated with the salt/fresh water interface varies with river system from age one to eight (Dadswell 1979; Flournoy *et al*. 1992; Collins *et al*. 2002). Overwintering habitat and behavior of shortnose sturgeon varies with latitude: fish in northern rivers form tight aggregations with little movement and will inhabit either freshwater or saline reaches of the river, while fish in the south are more active and are found predominantly near the fresh/saltwater interface (Collins and Smith 1993; Weber *et al*. 1998; Kynard *et al*. 2012).

The general pattern of coastal migration of shortnose sturgeon indicates movement between groups of rivers proximal to each other across the geographic range (Quattro *et al*. 2002; Wirgin *et al*. 2005; Dionne *et al*. 2013; Altenritter *et al*. 2015). NMFS's 2010 biological assessment of shortnose sturgeon grouped the species into five regional population clusters: Gulf of Maine, Connecticut/Housatonic rivers, Hudson River, Delaware River/Chesapeake Bay, and Southeast. King *et al*. (2014) identified three metapopulations: 1) Maine rivers, 2) Delaware River and Chesapeake Bay proper, and 3) the Southeast assemblage. The shortnose sturgeon status review team recommends that recovery and management actions consider each riverine population as a management/recovery unit (SSSRT 2010).

Population dynamics

The following is a discussion of the species' population and its variance over time. This section includes: abundance, population growth rate, genetic diversity, and spatial distribution as it relates to shortnose sturgeon.

The 2010 biological assessment of shortnose sturgeon identified five regional population clusters of shortnose sturgeon. See Table 17 for abundance estimates for populations within each of these population clusters.

Genetic diversity estimates for shortnose sturgeon have been shown to be moderately high in both mitochondrial (Quattro *et al*. 2002; Wirgin *et al*. 2005, 2010) and nuclear genomes (King *et al*. 2014). The mtDNA and nDNA studies performed to date suggest that dispersal is a very important factor in maintaining these high levels of genetic diversity.

Shortnose sturgeon occur along the East Coast of North America in rivers, estuaries and the sea. They were once present in most major rivers systems along the Atlantic coast (Evermann and Bean 1898; Scott and Scott 1988). Their current distribution extends north to the Saint John River, New Brunswick, Canada, and south to the St. Johns River, FL (NMFS 1998a). Currently, the distribution of shortnose sturgeon across their range is disjunct, with northern populations separated from southern populations by a distance of about 400 km near their geographic center in North Carolina and Virginia. Some river systems host populations which rarely leave freshwater while in other areas coastal migrations between river systems are common. Spawning locations have been identified within a number of river systems (SSSRT 2010).

Table 17. Shortnose sturgeon populations and estimated abundances

Regional Population Cluster	Location[a]	Abundance Estimate (Upper/Lower 95% CI)[b]	(Source) Year of Collection Data
Gulf of Maine	Penobscot River Kennebec Complex Merrimack River	1,049 (673 / 6,939) 9,488 (6,942 / 13,358) 2000 (NA)	(NMFS 2012) 2006 – 2007 (Squiers 2004) 1998 – 2000 (SSSRT 2010) 2009
Connecticut and Housatonic Rivers	Connecticut River – upper* Connecticut River – lower*	143 (14 / 360) 1,297 (NA)	(Kynard *et al*. 2012) 1994 – 2001 (Savoy and Benway 2004) 1996 – 2002
Hudson River	Hudson River	30,311 (NA)	(SSSRT 2010) 1980
Delaware River/Chesapeake Bay	Delaware River	12,047 (10,757 / 13,580)	(Brundage 2006) 1999 – 2003
Southeast Rivers	Cape Fear River Cooper River Lake Marion Savannah River Ogeechee River Altamaha River	50 (NA) 301 (150 / 659) Unknown (NA) 940 adults (535 / 1753) 147 (104 / 249) 1,209 (556 / 2759)	(SSSRT 2010) NA (Cooke *et al*. 2004) 1996 – 1998 (SSSRT 2010) NA (Bahr and Peterson 2017) 2015 (Fleming *et al*. 2003) 1999 – 2000 (Bednarski 2012) 2004 – 2010

[a]Locations listed here are those for which population estimates are available. Additional waterbodies with confirmed shortnose sturgeon include Piscataqua River, Housatonic River, Chesapeake Bay, Susquehanna River, Potomac River, Roanoke River, Chowan River, Tar/Pamlico River, Neuse River, New River, North River, Santee River, ACE Basin – Edisto (Smith et al. 2002), Satilla River, St. Mary's River, St. Johns River (SSSRT 2010).
[b]Abundance estimates are established using different techniques and should be viewed with caution. Estimates listed here are those identified by NMFS in the 2010 Biological Assessment of Shortnose Sturgeon (SSSRT 2010).
**The Connecticut River population of shortnose sturgeon is separated into an upstream and downstream segment bisected by the Holyoke Dam.*

Status

The decline in abundance and slow recovery of shortnose sturgeon has been attributed to pollution, overfishing, bycatch in commercial fisheries, and an increase in industrial uses of the nation's large coastal rivers during the 20th century (e.g., hydropower, nuclear power, treated sewage disposal, dredging, construction) (SSSRT 2010). In addition, the effects of climate change may adversely impact shortnose sturgeon by reducing the amount of available habitat, exacerbating existing water quality problems, and interfering with migration and spawning cues (SSSRT 2010). Without substantial mitigation and management to improve access to historical habitats and water quality of these systems, shortnose sturgeon populations will likely continue to be depressed. This is particularly evident in some southern rivers that are suspected to no longer support reproducing populations of shortnose sturgeon (SSSRT 2010). The number of river systems in which spawning has been confirmed has been reduced to around 12 locations (SSSRT 2010).

Recovery Goals

The long-term recovery objective for the shortnose sturgeon is to recover all 19 populations to levels of abundance at which they no longer require protection under the ESA. Each population may become a candidate for downlisting when it reaches a minimum population size that: 1) is large enough to prevent extinction, and 2) will make the loss of genetic diversity unlikely. The minimum population size for each population segment has not yet been determined (NMFS 1998a; SSSRT 2010).

5.0 CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Additionally, we present the available information on predicted effects of climate change in the action area and how listed sea turtles and sturgeon may be affected by those predicted environmental changes over the life of the proposed action (i.e., five years). Climate change is relevant to the Status of the Species, Environmental Baseline, and Cumulative Effects sections of this opinion; and rather than include partial discussions in several sections of this opinion, we are synthesizing this information into one discussion. Consideration of the effects of the proposed action in light of predicted changes in environmental conditions due to anticipated climate change are included in the *Effects of the Actions* section below (Section 7.0).

5.1 Background Information on Global Climate Change

In its Fifth Assessment Report (AR5) from 2014, the Intergovernmental Panel on Climate Change (IPCC) stated that the globally averaged combined land and ocean surface temperature data has shown a warming of 0.85°C (likely range: 0.65° to 1.06°C) over the period of 1880-2012. Similarly, the total increase between the average of the 1850-1900 period and the 2003-2012 period is 0.78°C (likely range: 0.72° to 0.85°C). On a global scale, ocean warming has been largest near the surface, with the upper 75 meters of the world's oceans having warmed by 0.11°C (likely range: 0.09° to 0.13°C) per decade over the period of 1971-2010 (IPCC 2014). In regards to resultant sea level rise, it is very likely that the mean rate of global averaged sea level rise was 1.7 millimeters/year (likely range: 1.5 to 1.9 millimeters/year) between 1901 and 2010, 2.0 millimeters/year (likely range: 1.7 to 2.3 millimeters/year) between 1971 and 2010, and 3.2 millimeters/year (likely range: 2.8 to 3.6 millimeters/year) between 1993 and 2010.

Climate model projections exhibit a wide range of plausible scenarios for both temperature and precipitation over the next several decades. The global mean surface temperature change for the period 2016-2035 relative to 1986-2005 will likely be in the range of 0.3° to 0.7°C (medium confidence). This assessment is based on multiple lines of evidence and assumes there will be no major volcanic eruptions or secular changes in total solar irradiance. Relative to natural internal variability, near-term increases in seasonal mean and annual mean temperatures are expected to be larger in the tropics and subtropics than in mid- and high latitudes (high confidence). This temperature increase will very likely be associated with more extreme precipitation and faster evaporation of water, leading to greater frequency of both very wet and very dry conditions. Climate warming has also resulted in increased river discharge and glacial and sea-ice melting (Greene *et al.* 2008). The strongest ocean warming is projected for the surface in tropical and Northern Hemisphere subtropical regions. At greater depths, the warming will be most pronounced in the Southern Ocean (high confidence). Best estimates of ocean warming in the top 100 meters are about 0.6° to 2.0°C, and about 0.3° to 0.6°C at a depth of about 1,000 meters by the end of the 21st century (IPCC 2014).

Under Representative Concentration Pathway (RCP) 8.5, the projected change in global mean surface air temperature and global mean sea level rise for the mid- and late 21st century relative to the reference period of 1986-2005 is as follows. Global average surface temperatures are likely to be 2.0°C higher (likely range: 1.4° to 2.6°C) from 2046-2065 and 3.7°C higher (likely range: 2.6° to 4.8°C) from 2081-2100. Global mean sea levels are likely to be 0.30 meters higher (likely range: 0.22 to 0.38 meters) from 2046-2065 and 0.63 meters higher (likely range: 0.45 to 0.82 meters) from 2081-2100, with a rate of sea level rise during 2081-2100 of 8 to 16 millimeters/year (medium confidence).

The past few decades have witnessed major changes in ocean circulation patterns in the Arctic, and these were accompanied by climate associated changes as well (Greene *et al.* 2008). Shifts in atmospheric conditions have altered Arctic Ocean circulation patterns and the export of freshwater to the North Atlantic (IPCC 2007; Greene *et al.* 2008). With respect specifically to the North Atlantic Oscillation (NAO), changes in salinity and temperature are thought to be the result of changes in the Earth's atmosphere caused by anthropogenic forces (IPCC 2007). The NAO impacts climate variability throughout the Northern Hemisphere (IPCC 2007). Data from the 1960s through the 2000s showed that the NAO index increased from minimum values in the 1960s to strongly positive index values in the 1990s and somewhat declined since (IPCC 2007). This warming extends over 1,000 meters deep and is deeper than anywhere in the world's oceans and is particularly evident under the Gulf Stream/North Atlantic Current system (IPCC 2007). On a global scale, large discharges of freshwater into the North Atlantic subarctic seas can lead to intense stratification of the upper water column and a disruption of North Atlantic Deepwater (NADW) formation (IPCC 2007; Greene *et al.* 2008). There is evidence that the NADW has already freshened significantly (IPCC 2007). This in turn can lead to a slowing down of the global ocean thermohaline (large-scale circulation in the ocean that transforms low-density upper ocean waters to higher density intermediate and deep waters and returns those waters back to the upper ocean), which can have climatic ramifications for the entire world (Greene *et al.* 2008).

There is a high confidence, based on substantial new evidence, that observed changes in marine systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels, and circulation. Ocean acidification resulting from massive amounts of carbon dioxide and pollutants released into the air can have major adverse impacts on the calcium balance in the oceans. Changes to the marine ecosystem due to climate change include shifts in ranges and changes in algal, plankton, and fish abundance (IPCC 2007). These trends have been most apparent over the past few decades, although this may also be due to increased research. Information on future impacts of climate change in the action area is discussed below.

While predictions are available regarding potential effects of climate change globally, it is more difficult to assess the potential effects of climate change over the next few decades on coastal and marine resources on smaller geographic scales, such as the action area, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Additional information on potential effects of climate change specific to the action area is discussed below. Warming is very likely to continue in the U.S. over the next 50 years regardless of reduction in greenhouse gases, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 50 years, and it is possible that they will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

Expected consequences of climate change for river systems could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources along the U.S. Atlantic coast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development will experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2ºC per decade; and 3) a rise in sea level (NAST 2000). Sea level is expected to continue rising; during the 20th century global sea level increased 15 to 20 centimeters. It is also important to note that ocean temperature in the U.S. Northeast Shelf and surrounding Northwest Atlantic waters have warmed faster than the global average over the last decade (Pershing *et al.* 2015). New projections for the U.S. Northeast Shelf and Northwest Atlantic Ocean suggest that this region will warm two to three times faster than the global average and thus existing projections from the IPCC may be too conservative (Saba *et al.* 2015).

5.2 Species Specific Information on Climate Change Effects

5.2.1 Northwest Atlantic DPS of Loggerhead Sea Turtles

The most recent Recovery Plan for loggerhead sea turtles as well as the 2009 Status Review Report identifies global climate change as a threat to loggerhead sea turtles. However, trying to assess the likely effects of climate change on loggerhead sea turtles is extremely difficult given the uncertainty in all climate change models and the difficulty in determining the likely rate of temperature increases and the scope and scale of any accompanying habitat effects. Additionally, no significant climate change-related impacts to loggerhead sea turtle populations have been observed to date. Over the long-term, climate change related impacts are expected to influence biological trajectories on a century scale (Parmesan and Yohe 2003). As noted in the 2009 Status Review (Conant *et al.* 2009), impacts from global climate change induced by human activities are likely to become more apparent in future years (IPCC 2007). Climate change related increasing temperatures, sea level rise, changes in ocean productivity, and increased frequency of storm events may affect loggerhead sea turtles.

Increasing temperatures are expected to result in increased polar melting and changes in precipitation which may lead to rising sea levels (Titus and Narayanan 1995 in Conant *et al.* 2009), which could result in increased erosion rates along nesting beaches. Sea level rise could result in the inundation of nesting sites and decrease available nesting habitat (Daniels *et al.* 1993; Fish *et al.* 2005; Baker *et al.* 2006). The Biological Review Team (BRT) noted that the loss of habitat as a result of climate change could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion (Antonelis *et al.* 2006; Baker *et al.* 2006; both in Conant *et al.* 2009). Along developed coastlines, and especially in areas where erosion control structures have been constructed to limit shoreline movement, rising sea levels may cause severe effects on nesting females and their eggs as nesting females may deposit eggs seaward of the erosion control structures potentially subjecting them to repeated tidal inundation. However, if global temperatures increase and there is a range shift northwards, beaches not currently used for nesting may become available for loggerhead sea turtles, which may offset some loss of accessibility to beaches in the southern portions of the range.

Climate change has the potential to result in changes at nesting beaches that may affect loggerhead sex ratios. Loggerhead sea turtles exhibit temperature-dependent sex determination. Rapidly increasing global temperatures may result in warmer incubation temperatures and highly female-biased sex ratios (*e.g.*, Glen and Mrosovsky 2004; Hawkes *et al.* 2009); however, to the extent that nesting can occur at beaches further north where sand temperatures are not as warm, these effects may be partially offset. The BRT specifically identified climate change as a threat to loggerhead sea turtles in the neritic/oceanic zone where climate change may result in future trophic changes, thus impacting loggerhead prey abundance and/or distribution. In the threats matrix analysis, climate change was considered for oceanic juveniles and adults and eggs/hatchlings. The report states that for oceanic juveniles and adults, "although the effect of trophic level change from…climate change…is unknown it is believed to be very low." For eggs/hatchlings the report states that total mortality from anthropogenic causes, including sea level rise resulting from climate change, is believed to be low relative to the entire life stage. However, only limited data are available on past trends related to climate effects on loggerhead sea turtles; current scientific methods are struggling to reliably predict the future magnitude of climate change, associated impacts, whether and to what extent some impacts will offset others, or the adaptive capacity of this species.

However, Van Houtan and Halley (2011) recently developed climate based models to investigate loggerhead nesting (considering juvenile recruitment and breeding remigration) in the Northwest Atlantic and North Pacific. These models found that climate conditions/oceanographic influences explain loggerhead nesting variability, with climate models alone explaining an average 60% (range 18%-88%) of the observed nesting changes in the Northwest Atlantic and North Pacific over the past several decades. In terms of future nesting projections, modeled climate data show a future positive trend for Florida nesting that contributes to the Northwest Atlantic DPS, with increases through 2040 as a result of the Atlantic Multidecadal Oscillation signal. Although the authors forecasted an opposite projection for North Pacific nesting, those nesting populations do not fall within the range of the Northwest Atlantic DPS considered here.

5.2.2 Kemp's Ridley Sea Turtles

The recovery plan for Kemp's ridley sea turtles (NMFS *et al.* 2011) identifies climate change as a threat; however, as with the other species discussed above, no significant climate change-related impacts to Kemp's ridley sea turtles have been observed to date. Atmospheric warming could cause habitat alteration which may change food resources such as crabs and other invertebrates. It may increase hurricane activity, leading to an increase in debris in nearshore and offshore waters, which may result in an increase in entanglement, ingestion, or drowning. In addition, increased hurricane activity may cause damage to nesting beaches or inundate nests with sea water. Atmospheric warming may change convergence zones, currents and other oceanographic features that are relevant to Kemp's ridleys, as well as change rain regimes and levels of nearshore runoff.

Considering that the Kemp's ridley has temperature-dependent sex determination (Wibbels 2003) and the vast majority of the nesting range is restricted to the State of Tamaulipas, Mexico, global warming could potentially shift population sex ratios towards females and thus change the reproductive ecology of this species. A female bias is presumed to increase egg production (assuming that the availability of males does not become a limiting factor) (Coyne and Landry 2007) and increase the rate of recovery; however, it is unknown at what point the percentage of males may become insufficient to facilitate maximum fertilization rates in a population. If males become a limiting factor in the reproductive ecology of the Kemp's ridley, then reproductive output in the population could decrease (Coyne 2000). Low numbers of males could also result in the loss of genetic diversity within a population; however, there is currently no evidence that this is a problem in the Kemp's ridley population (NMFS *et al.* 2011). Models (Davenport 1997, Hulin and Guillon 2007, Hawkes *et al.* 2007, all referenced in NMFS *et al.* 2011) predict very long-term reductions in fertility in sea turtles due to climate change, but due to the relatively long life cycle of sea turtles, reductions may not be seen until 30 to 50 years in the future.

Another potential impact from global climate change is sea level rise, which may result in increased beach erosion at nesting sites. Beach erosion may be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents. In the case of the Kemp’s ridley where most of the critical nesting beaches are undeveloped, beaches may shift landward and still be available for nesting. The Padre Island National Seashore (PAIS) shoreline, where increasing numbers of Kemp’s ridley are beginning to nest due to a successful U.S.-Mexico headstarting program, is accreting, unlike much of the Texas coast. With nesting increasing and sand temperatures slightly cooler than at Rancho Nuevo, PAIS could become an increasingly important source of males for a species that already has one of the most restricted nesting ranges of all sea turtles.

5.2.3 North Atlantic DPS of Green Sea Turtles

The five year status review for green sea turtles (Seminoff *et al*. 2015) notes that global climate change is affecting green sea turtles and is likely to continue to be a threat. There is an increasing female bias in the sex ratio of green turtle hatchlings. While this is partly attributable to imperfect egg hatchery practices, global climate change is also implicated as a likely cause. This is because warmer sand temperatures at nesting beaches are likely to result in the production of more female embryos. At least one nesting site, Ascension Island, has had an increase in mean sand temperature in recent years (Hays *et al.* 2003 in Seminoff *et al*. 2015). Climate change may also affect nesting beaches through sea level rise, which may reduce the availability of nesting habitat and increase the risk of nest inundation. Loss of appropriate nesting habitat may also be accelerated by a combination of other environmental and oceanographic changes, such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion. Oceanic changes related to rising water temperatures could result in changes in the abundance and distribution of the primary food sources of green sea turtles, which in turn could result in changes in behavior and distribution of this species. Seagrass habitats may suffer from decreased productivity and/or increased stress due to sea level rise, as well as salinity and temperature changes (Short and Neckles 1999; Duarte 2002).

As noted above, the increasing female bias in green sea turtle hatchlings is thought to be at least partially linked to increases in temperatures at nesting beaches. However, at this time, we do not know how much of this bias is due to hatchery practice and how much is due to increased sand temperature. Because we do not have information to predict the extent and rate to which sand temperatures at the nesting beaches used by green sea turtles may increase in the short-term future, we cannot predict the extent of any future bias. Also, we do not know the extent to which green sea turtles may be able to cope with this change by selecting cooler areas of the beach or shifting their nesting distribution to other beaches at which increases in sand temperature may not be experienced.

5.2.4 Leatherback sea turtles

Global climate change has been identified as a factor that may affect leatherback habitat and biology (NMFS and U.S. FWS 2013b); however, no significant climate change related impacts to leatherback sea turtle populations have been observed to date. Over the long term, climate change related impacts will likely influence biological trajectories in the future on a century scale (Parmesan and Yohe 2003). Changes in marine systems associated with rising water temperatures, changes in ice cover, salinity, oxygen levels and circulation including shifts in ranges and changes in algal, plankton, and fish abundance could affect leatherback prey distribution and abundance. Climate change is expected to expand foraging habitats into higher latitude waters and some concern has been noted that increasing temperatures may increase the female:male sex ratio of hatchlings on some beaches (Mrosovsky *et al.* 1984 and Hawkes *et al.* 2007 in NMFS and U.S. FWS 2013b). However, due to the tendency of leatherbacks to have individual nest placement preferences and deposit some clutches in the cooler tide zone of beaches, the effects of long-term climate on sex ratios may be mitigated (Kamel and Mrosovsky 2004 in NMFS and U.S. FWS 2013b).

Additional potential effects of climate change on leatherbacks include range expansion and changes in migration routes as increasing ocean temperatures shift range-limiting isotherms north (Robinson *et al.* 2008). Leatherbacks have expanded their range in the Atlantic north by 330 km in the last 17 years as warming has caused the northerly migration of the 15°C sea surface temperature (SST) isotherm, the lower limit of thermal tolerance for leatherbacks (McMahon and Hays 2006). Leatherbacks are speculated to be the best able to cope with climate change of all the sea turtle species due to their wide geographic distribution and relatively weak beach fidelity. Leatherback sea turtles may be most affected by any changes in the distribution of their primary jellyfish prey, which may affect leatherback distribution and foraging behavior (NMFS and U.S. FWS 2013b). Jellyfish populations may increase due to ocean warming and other factors (Brodeur *et al.* 1999; Attrill *et al.* 2007; Richardson *et al.* 2009). However, any increase in jellyfish populations may or may not impact leatherbacks as there is no evidence that any leatherback populations are currently food-limited.

Increasing temperatures are expected to result in increased polar melting and changes in precipitation which may lead to rising sea levels (Titus and Narayanan 1995 in Conant *et al.* 2009), which could result in increased erosion rates along nesting beaches. Sea level rise could result in the inundation of nesting sites and decrease available nesting habitat (Fish *et al.* 2005). This effect would potentially be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents. While there is a reasonable degree of certainty that climate change related effects will be experienced globally (*e.g.*, rising temperatures and changes in precipitation patterns), due to a lack of scientific data, the specific effects of climate change on this species are not quantifiable at this time (Hawkes *et al.* 2009).

5.2.5 Atlantic sturgeon

Global climate change may affect all DPSs of Atlantic sturgeon in the future; however, effects of increased water temperature and decreased water availability are most likely to effect the South Atlantic and Carolina DPSs. Rising sea level may result in the salt wedge moving upstream in affected rivers. Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile Atlantic sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, Atlantic sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the salt wedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the salt wedge. It is unlikely that shifts in the location of the salt wedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Atlantic sturgeon prefer water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all Atlantic sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

5.2.6 Shortnose sturgeon

Global climate change may affect shortnose sturgeon in the future. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile shortnose sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, shortnose sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the salt wedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, for most spawning rivers there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the salt wedge. It is unlikely that shifts in the location of the salt wedge would eliminate freshwater spawning or rearing habitat. If habitat was severely restricted, productivity or survivability may decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with DO and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all shortnose sturgeon life stages, including adults, may become susceptible to strandings. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing shortnose sturgeon in rearing habitat; however, this would be mitigated if prey species also had a shift in distribution or if developing sturgeon were able to shift their diets to other species.

5.3 Effects of Climate Change in the Action Area on Sea Turtles

Sea turtle species have persisted for millions of years and throughout this time have experienced wide variations in global climate conditions and have successfully adapted to these changes. As such, climate change at normal rates (thousands of years) is not thought to have historically been a problem for sea turtle species. However, at the current rate of global climate change, future effects to sea turtles are possible. As explained previously, sea turtles are most likely to be affected by climate change due to (1) changing air temperature and rainfall at nesting beaches, which in turn could impact nest success (hatching success and hatchling emergence rate) and sex ratios among hatchlings; (2) sea level rise, which could result in a reduction or shift in available nesting beach habitat and increased risk of nest inundation; (3) changes in the abundance and distribution of forage species, which could result in changes in the foraging behavior and distribution of sea turtle species; and (4) changes in water temperature, which could possibly lead to a northward shift in their range and changes in phenology (timing of nesting seasons, timing of migrations). Over the time period of the action considered in this opinion, sea surface temperatures are expected to rise less than 1°C. It is unknown if that is enough of a change to contribute to shifts in the range, distribution, and recruitment of sea turtles. Theoretically, we expect that as waters in the action area warm, more sea turtles could be present or sea turtles could be present for longer periods of time.

It has been speculated that the nesting range of some sea turtle species may shift northward. Nesting in the Mid-Atlantic generally is extremely rare and no nesting has been documented at any beach in the Northeast. In 2010, one green sea turtle came up on the beach in Sea Isle City, New Jersey; however, it did not lay any eggs. In August 2011, a loggerhead came up on the beach in Stone Harbor, New Jersey, but did not lay any eggs. On August 18, 2011, a green sea turtle laid one nest at Cape Henlopen Beach in Lewes, Delaware, near the entrance to Delaware Bay. The nest contained 190 eggs and was transported indoors to an incubation facility on October 7. A total of 12 eggs hatched, with eight hatchlings surviving. In December, seven of the hatchlings were released in Cape Hatteras, North Carolina. It is important to consider that in order for nesting to be successful in the Mid-Atlantic, fall and winter temperatures need to be warm enough to support the successful rearing of eggs and sea temperatures must be warm enough for hatchlings not to die when they enter the water. The projected increase in ocean temperature over the next five years is not great enough to allow successful rearing of sea turtle eggs in the any new parts of the action area. Therefore, it is unlikely that over the time period considered here, that there would be an increase in nesting activity in the action area.

As noted above, sea level rise has the potential to remove possible beach nesting habitat. A recent study by the U.S. Geological Survey found that sea levels in a 620-mile "hot spot" along the East Coast are rising three to four times faster than the global average (Sallenger *et al.* 2012). The disproportionate sea level rise is due to the slowing of Atlantic currents caused by fresh water from the melting of the Greenland Ice Sheet. Sharp rises in sea levels from North Carolina to Massachusetts could threaten wetland and beach habitats, and negatively affect sea turtle nesting along the North Carolina coast. If warming temperatures moved favorable nesting sites northward, it is possible that rises in sea level could constrain the availability of nesting sites on existing beaches. In the next 100 years, the study predicted that sea levels will rise an additional 20-27 centimeters along the Atlantic coast "hot spot" (Sallenger *et al.* 2012).

Warming sea temperatures are likely to result in a shift in the seasonal distribution of sea turtles in the action area, such that sea turtles may begin northward migrations from their southern overwintering grounds earlier in the spring and thus would be present in the action area earlier in the year. Likewise, if water temperatures were warmer in the fall, sea turtles could remain in the action area later in the year. In the next five years, the expected small increase in temperature is unlikely to cause a significant effect to sea turtles or a significant modification to the number of sea turtles likely to be present in the action area.

Changes in water temperature may also alter the forage base and thus, foraging behavior of sea turtles. Changes in the foraging behavior of sea turtles in the action area could lead to either an increase or decrease in the number of sea turtles in the action area, depending on whether there was an increase or decrease in the forage base and/or a seasonal shift in water temperature. For example, if there was a decrease in sea grasses in the action area resulting from increased water temperatures or other climate-change related factors, it is reasonable to expect that there may be a decrease in the number of foraging green sea turtles in the action area. Likewise, if the prey base for loggerhead, Kemp's ridley, or leatherback sea turtles was affected, there may be changes in the abundance and distribution of these species in the action area. However, as noted above, because we do not know the adaptive capacity of these individuals or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict changes to the foraging behavior of sea turtles over the next five years. If sea turtle distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sea turtles shifted to areas where different forage was available and sea turtles were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sea turtles shifted to an area or time where insufficient forage was available; however, the likelihood of this happening seems low because sea turtles feed on a wide variety of species and in a wide variety of habitats. Finally, it is important to note that ocean temperature in the U.S. Northeast continental shelf and surrounding Northwest Atlantic waters have warmed faster than the global average over the last decade (Pershing *et al.* 2015). New projections for the U.S. Northeast shelf and Northwest Atlantic Ocean suggest that this region will warm two to three times faster than the global average and thus existing projections from the IPCC may be too conservative (Saba *et al.* 2015).

5.4 Effects of Climate Change in the Action Area on Sturgeon

Shortnose and Atlantic sturgeon have persisted for millions of years and have experienced wide variations in global climate conditions, to which they have successfully adapted. Climate change at historical rates (thousands of years) is not thought to have been a problem for sturgeon species. However, at the current rate of global climate change, future effects to sturgeon are possible. Rising sea level may result in the salt wedge moving upstream in affected rivers. Shortnose and Atlantic sturgeon spawning occurs in fresh water reaches of rivers because early life stages have little to no tolerance for salinity. Similarly, juvenile sturgeon have limited tolerance to salinity and remain in waters with little to no salinity. If the salt wedge moves further upstream, sturgeon spawning and rearing habitat could be restricted. In river systems with dams or natural falls that are impassable by sturgeon, the extent that spawning or rearing may be shifted upstream to compensate for the shift in the movement of the salt wedge would be limited. While there is an indication that an increase in sea level rise would result in a shift in the location of the salt wedge, at this time there are no predictions on the timing or extent of any shifts that may occur; thus, it is not possible to predict any future loss in spawning or rearing habitat. However, in all river systems, spawning occurs miles upstream of the salt wedge. It is unlikely that over the next five years shifts in the location of the salt wedge would reduce freshwater spawning or rearing habitat. If habitat was restricted or somehow eliminated, productivity or survivability would likely decrease.

The increased rainfall predicted by some models in some areas may increase runoff and scour spawning areas and flooding events could cause temporary water quality issues. Rising temperatures predicted for all of the U.S. could exacerbate existing water quality problems with dissolved oxygen (DO) and temperature. While this occurs primarily in rivers in the southeast U.S. and the Chesapeake Bay, it may start to occur more commonly in the northern rivers. Shortnose and Atlantic sturgeon are tolerant to water temperatures up to approximately 28°C (82.4°F); these temperatures are experienced naturally in some areas of rivers during the summer months. If river temperatures rise and temperatures above 28°C are experienced in larger areas, sturgeon may be excluded from some habitats.

Increased droughts (and water withdrawal for human use) predicted by some models in some areas may cause loss of habitat including loss of access to spawning habitat. Drought conditions in the spring may also expose eggs and larvae in rearing habitats. If a river becomes too shallow or flows become intermittent, all sturgeon life stages, including adults, may become susceptible to strandings or habitat restriction. Low flow and drought conditions are also expected to cause additional water quality issues. Any of the conditions associated with climate change are likely to disrupt river ecology causing shifts in community structure and the type and abundance of prey. Additionally, cues for spawning migration and spawning could occur earlier in the season causing a mismatch in prey that are currently available to developing sturgeon in rearing habitat.

Shortnose and Atlantic sturgeon in the action area are most likely to experience the effects of global climate change in warming water temperatures, which could change their range and migratory patterns. Warming temperatures predicted to occur over the next 100 years would likely result in a northward shift/extension of their range (i.e., into the St. Lawrence River, Canada) while truncating the southern distribution, thus affecting the recruitment and distribution of sturgeon rangewide. In the next five years, this increase in sea surface temperature is expected to be minimal, and thus, it is unlikely that this expanded range will be observed in the near future. If any shift does occur, it is likely to be minimal and thus, it seems unlikely that this small increase in temperature will cause a significant effect to shortnose and Atlantic sturgeon or a significant modification to the number of sturgeon likely to be present in the action area over the life of the proposed actions. However, even a small increase in temperate can affect DO concentrations. A one degree change in temperature in Chesapeake Bay could make parts of Chesapeake Bay inaccessible to sturgeon due to decreased levels of DO (Batiuk *et al.* 2009).

Although the action area does not include spawning grounds for shortnose and Atlantic sturgeon, sturgeon are migrating through the action area to reach their natal rivers to spawn. Elevated temperatures could modify cues for spawning migration, resulting in an earlier spawning season, and thus, altering the time of year sturgeon may or may not be present within the action area. This may cause an increase or decrease in the number of sturgeon present in the action area. However, because spawning is not triggered solely by water temperature, but also by day length (which would not be affected by climate change) and river flow (which could be affected by climate change), it is not possible to predict how any change in water temperature alone will affect the seasonal movements of sturgeon through the action area.

In addition, changes in water temperature may also alter the forage base and thus, foraging behavior of sturgeon. Any forage species that are temperature-dependent may also shift in distribution as water temperatures warm and cause a shift in the distribution of sturgeon. However, because we do not know the adaptive capacity of these species or how much of a change in temperature would be necessary to cause a shift in distribution, it is not possible to predict how these changes may affect foraging sturgeon. If sturgeon distribution shifted along with prey distribution, it is likely that there would be minimal, if any, impact on the availability of food. Similarly, if sturgeon shifted to areas where different forage was available and sturgeon were able to obtain sufficient nutrition from that new source of forage, any effect would be minimal. The greatest potential for effect to forage resources would be if sturgeon shifted to an area or time where insufficient forage was available; however, the likelihood of this happening seems low because sturgeon feed on a wide variety of species and in a wide variety of habitats.

6.0 ENVIRONMENTAL BASELINE

Environmental baselines for biological opinions include the past and present impacts of all state, federal or private actions and other human activities in the action area, the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this opinion includes the effects of several activities that may affect the survival and recovery of the listed species in the action area. The activities that shape the environmental baseline in the action area of this consultation generally include: commercial and recreational fisheries, hopper dredging operations, sand mining and beach nourishment activities, energy generating facilities, bridge construction projects, commercial shipping and other vessel activities, military operations, scientific research, projects affecting water quality and pollution, and recovery activities associated with reducing impacts to listed species.

6.1 Federal Actions that have Undergone Section 7 Consultation

We have undertaken a number of section 7 consultations to address the effects of Federal actions on threatened and endangered species in the action area. Each of those consultations sought to develop ways to reduce the probability of adverse impacts of the action on listed species.

6.1.1 Authorization of Fisheries through Fishery Management Plans

NMFS authorizes the operation of several Federal fisheries in the action area for this consultation under the authority of the Magnuson-Stevens Fishery Conservation Act and through fishery management plans (FMPs) and their implementing regulations. Federal commercial and recreational fisheries in the action area employ gear that is known to harass, injure, and/or kill sea turtles and Atlantic sturgeon. However, adverse effects from these Federally managed fisheries on shortnose sturgeon are not anticipated.

In the action area (U.S. territorial waters from Maine through Virginia), formal ESA section 7 consultations have been conducted on the American lobster; batched Northeast multispecies, monkfish, spiny dogfish, Atlantic bluefish, Northeast skate complex, Atlantic mackerel/squid/butterfish, and summer flounder/scup/black sea bass; and Atlantic sea scallop fisheries. Each of these consultations has considered adverse effects to loggerhead, green, Kemp's ridley, and leatherback sea turtles. In each of the opinions on these Federal fisheries, we concluded that the ongoing action was likely to adversely affect but was not likely to jeopardize the continued existence of any sea turtle species. Each of these opinions included an Incidental Take Statement (ITS) exempting a certain amount of lethal or non-lethal take resulting from interactions with the fishery. These ITSs are summarized in the table below (Table 18). Further, in each opinion, we concluded that the potential for collisions between sea turtles/Atlantic sturgeon and fishing vessels was extremely low and similarly that any effects to their prey and/or habitat would be insignificant and discountable. We have also determined that the Atlantic herring, Atlantic surf clam and ocean quahog, and golden and blueline tilefish fisheries do not adversely affect any ESA-listed species.

Table 18. Dates of the most recent opinions prepared by NMFS GARFO and SERO for federally managed fisheries in the action area and their respective ITSs for sea turtles. Unless noted, levels of incidental take exempted are on an annual basis.

	Date	Loggerhead	Kemp's ridley	Green	Leatherback
GARFO FMPs					
American lobster	July 31, 2014	1 (lethal or non-lethal)	0	0	7 (lethal or non-lethal)
Northeast Multispecies, Monkfish, Spiny Dogfish, Atlantic Bluefish, Northeast Skate Complex, Mackerel/Squid/Butterfish, and Summer Flounder/ Scup/Black Sea Bass (Batched Fisheries)	December 16, 2013 (ITS amended March 10, 2016)	1,345 (835 lethal) every 5 years in gillnets; 1,020 (335 lethal) every 5 years in bottom trawls; 1 (lethal or non-lethal) annually in pot/trap gear	4 (3 lethal) annually in gillnets; 3 (2 lethal) annually in bottom trawls	4 (3 lethal) annually in gillnets; 3 (2 lethal) annually in bottom trawls	4 (3 lethal) annually in gillnets; 4 (2 lethal) annually in bottom trawls; 4 (lethal or non-lethal) annually in pot/trap gear
Atlantic sea scallop	July 12, 2012 (ITS amended May 1, 2015)	322 (92 lethal) every 2 years in dredges; 700 (330 lethal) every 5 years in trawls	3 (2 lethal) in dredges and trawls combined	2 (lethal) in dredges and trawls combined	2 (lethal) in dredges and trawls combined
SERO FMPs					
Pelagic longline under the HMS FMP (per the RPA)	June 1, 2004	1,905 (339 lethal) every 3 years	**105 (18 lethal) every 3 years	**105 (18 lethal) every 3 years	1,764 (252 lethal) every 3 years

*** combination of 16 turtles total every 3 years with 2 lethal (Kemp's ridley, green, hawksbill, leatherback)*

In addition to these consultations, the NMFS Southeast Regional Office (SERO) has conducted a formal consultation on the pelagic longline component of the Atlantic highly migratory species FMP. Small segments of this fishery occur in nearshore waters of the action area. In a June 1, 2004 opinion, NMFS concluded that the ongoing action was likely to adversely affect but was not likely to jeopardize the continued existence of loggerhead, Kemp's ridley or green sea turtles but was likely to jeopardize the continued existence of leatherback sea turtles. This opinion included a Reasonable and Prudent Alternative (RPA) that when implemented would modify operations of the fishery in a way that would remove jeopardy. This fishery is currently operated in a manner that is consistent with the RPA. The RPA included an ITS which is reflected in Table 18 below. Unless specifically noted, all numbers denote an annual number of captures that may be lethal or non-lethal.

Although there are documented incidental takes of sea turtles in these Federal fisheries, the action area for them includes the entire EEZ along the U.S. Atlantic coast. Action areas for some of these fisheries range from Maine through Virginia, while others extend from Maine through Cape Hatteras or even as far south as Key West, Florida. The nearshore and coastal waters of the U.S. Northeast and Mid-Atlantic states represent a fraction of the action area assessed and for which interactions of sea turtles are anticipated in the American lobster, batched, and scallop fisheries and pelagic longline fishery opinions. Thus, the amount of incidental take of sea turtles that occurs in territorial waters as a result of Federal fisheries is also a fraction of the amount exempted in those opinions. However, the distribution and likelihood of sea turtle takes in the waters of the U.S. EEZ during these Federal fisheries is highly variable such that in some years interactions in nearshore and coastal waters could be higher if greater fishing effort is expended (due to less travel time and ease of access to a wider range of vessels) or sea turtles were present in greater numbers in those waters. The amount of observer coverage allocated to nearshore versus offshore trips may also be a factor in how many sea turtle interactions are recorded in and/or estimated for these fisheries on an annual basis and where.

Atlantic sturgeon originating from each the five listed DPSs are captured and killed in commercial otter trawl, sink gillnet, and hook and line fisheries that operate in the action area for this consultation and are the subject of the fisheries opinions in Table 18 above. At the time of this writing, the batched fisheries opinion covers Atlantic sturgeon interactions in most commercial trawl and gillnet gear in the Greater Atlantic Region. In 2011, the NEFSC prepared a bycatch estimate for Atlantic sturgeon captured in Federally managed commercial sink gillnet and otter trawl fisheries operated from Maine through Virginia. This estimate indicated that from 2006-2010, an annual average of 3,118 Atlantic sturgeon were captured in these fisheries with 1,569 in sink gillnet and 1,548 in otter trawls. The mortality rate in sink gillnets was estimated at approximately 20% and the mortality rate in otter trawls was estimated at 5%. Based on this estimate, a total of 391 Atlantic sturgeon were estimated to be killed annually in these fisheries that are prosecuted in the Greater Atlantic Region (NMFS NEFSC 2011). Again, nearshore and coastal waters of the U.S. Northeast and Mid-Atlantic states represent a fraction of the action area assessed and for which interactions of Atlantic sturgeon are anticipated in the batched fisheries opinion. Nonetheless, any Federal fisheries that use sink gillnets, otter trawls, or hook and line gear are likely to interact with Atlantic sturgeon and be an additional source of incidental take and mortality in the action area for this consultation. An updated, although unpublished Atlantic sturgeon bycatch estimate in Northeast sink gillnet and otter trawl fisheries for 2011-2015 was prepared by the NEFSC in 2016. Using this information, the authors of the recent ASMFC (2017a) Atlantic Sturgeon Benchmark Stock Assessment estimated that 1,139 fish (295 lethal; 25%) were caught in gillnet fisheries and 1,062 fish (41 lethal; 4%) were caught in otter trawl fisheries per year from 2000-2015. Atlantic sturgeon bycatch estimates for Northeast gillnet and trawl gear from 2011-2015 (approximately 761 fish per year for gillnets, 777 for trawls) are substantially lower than those from 2006-2010 (approximately 1,074 fish per year for gillnets, 1,016 for trawls) (ASMFC 2017a).

6.1.2 Hopper Dredging, Sand Mining, and Beach Nourishment

The construction and maintenance of federal navigation channels and sand mining ("borrow") areas have also been identified as sources of sea turtle mortality. Shortnose and Atlantic sturgeon may also be killed during hopper dredging operations, although this is rare. All hopper dredging projects are authorized or carried out by the U.S. Army Corps of Engineers (ACOE). In the action area, these projects are under the jurisdiction of the districts within the North Atlantic Division. Hopper dredging projects in this area have resulted in the recorded mortality of approximately 87 loggerheads, four greens, nine Kemp's ridleys and four unidentified hard shell turtles since observer records began in 1993. To date, nearly all of these interactions have occurred in nearshore coastal waters with very few interactions in the open ocean. Few interactions between hopper dredges and Atlantic sturgeon have been observed, with just three records documenting interactions between hopper dredges and Atlantic sturgeon in the action area (two in Virginia near the Chesapeake Bay entrance, and one in the New York Bight).

We have completed several ESA section 7 consultations with the ACOE to consider effects of these dredging, sand mining, and nourishment projects on listed sea turtles, shortnose sturgeon, and Atlantic sturgeon. In an opinion issued to the ACOE in 2012, we estimated that over a 50-year period of the ACOE's maintenance dredging of the Chesapeake Bay entrance channels and use of sand borrow areas for beach nourishment (from 2012-2062), up to 937 loggerhead (452 lethal), 275 Kemp's ridley (48 lethal), and 38 green (11 lethal) sea turtles will be incidentally taken. We also anticipated that up to 750 Atlantic sturgeon (124 lethal) will be incidentally taken during the same action over the same period. Non-lethal takes of Atlantic sturgeon were anticipated as a result of relocation trawling that is sometimes required in association with channel dredging. Up to 50 lethal sea turtle takes (37 loggerheads, 11 Kemp's ridleys, and 2 greens) were anticipated during the same relocation trawling activities over the 50-year maintenance dredging period.

In two other 2012 opinions, we determined that the U.S. Navy's Dam Annex Shoreline Protection System Repairs project and Joint Expeditionary Base (JEB) Little Creek/Fort Story Shoreline Restoration and Protection project would both result in the lethal entrainment of up to one loggerhead or Kemp's ridley sea turtle and up to one Atlantic sturgeon from any of the five DPSs during hopper dredging operations at the Sandbridge Shoal borrow area, located a short distance offshore of the installations. Both projects were also anticipated to result in the lethal entrainment of up to one Atlantic sturgeon from any of the five DPSs during mechanical dredging operations at the installations themselves.

From 2012 to 2014, we conducted three additional formal consultations on dredging, beach nourishment, and hurricane protection projects in coastal areas of New York, New Jersey, and Delaware. Those three projects identified in Table 19 below are expected to result in small numbers of potentially lethal takes of sea turtles and Atlantic sturgeon over their 50-year lifespans (amounting to less than one incidental take or mortality per year of any species).

Most recently in November 2017, we issued an opinion on the deepening and maintenance of the Delaware River Federal Navigational Channel from Trenton, New Jersey, to the sea. In that opinion, we exempted the lethal take of loggerhead and Kemp's ridley sea turtles (up to 26 and two, respectively) as well as shortnose and Atlantic sturgeon (up to 93 adults, subadults, or juveniles of each and between 1.3% and 1.8% of eggs and larvae of each) during hopper dredging and blasting activities through 2068. In addition, we exempted the non-lethal capture of up to one thousand sturgeon (shortnose or Atlantic) during relocation trawling over the course of the 50-year project, of which up to 100 could be injured during acoustic tagging.

Aside from commercial fishing and fisheries research activities, these dredging projects represent one of the largest sources of incidental take for sea turtles, shortnose, and Atlantic sturgeon in the action area, and potentially one of the largest sources of lethal take. Table 19 below provides information on Opinions covering dredging, beach nourishment, and shoreline restoration/ stabilization projects in the action area and the associated ITS for sea turtles (unless otherwise noted, take estimates are per dredge cycle). Takes of sea turtles, shortnose, and Atlantic sturgeon during relocation trawling activities are also included in the ACOE consultations. Relocation trawling has been successful at temporarily displacing loggerhead, Kemp's ridley, leatherback, and green sea turtles, and more recently Atlantic sturgeon, from navigation channels and nearshore mining/borrow areas during periods when hopper dredging was imminent or ongoing.

Table 19. Information on consultations conducted by NMFS for dredging projects that occur in the action area, and their respective ITSs for sea turtles.

<table>
<tr><th>Project</th><th>Date of Opinion</th><th>Loggerhead</th><th>Kemp's ridley</th><th>Green</th><th>Leatherback</th><th>Notes</th></tr>
<tr><td>ACOE Atlantic Coast of Maryland Shoreline Protection Project</td><td>11/30/2006</td><td>1 (≤0.5 million cy); 2 (>0.5 to ≤1 million cy); 3 (>1 to ≤1.5 million cy); 4 (>1.5 to ≤1.6 million cy)</td><td>2</td><td>0</td><td>0</td><td>over life of project (through 2044), ~10-12 million cy will be dredged with an anticipated 24 turtles killed (2 Kemp's ridleys, 22 loggerheads)</td></tr>
<tr><td>ACOE Sconset Beach Dredge and Nourishment Project</td><td>10/5/2007</td><td>1 (≤2 million cy); 2 (>2 million cy)</td><td>0</td><td>0</td><td>0</td><td></td></tr>
<tr><td>U.S. Navy Shoreline Restoration and Protection Project, JEB Little Creek/ Fort Story, VA Beach</td><td>7/13/2012</td><td colspan="2">1 loggerhead or Kemp's ridley</td><td>0</td><td>0</td><td></td></tr>
<tr><td>U.S. Navy Shoreline Protection Sys Repairs, Naval Air Station Oceana, Dam Neck Annex, VA Beach</td><td>7/20/2012</td><td colspan="2">1 loggerhead or Kemp's ridley</td><td>0</td><td>0</td><td></td></tr>
<tr><td>NASA Wallops Isl Shoreline Restoration/ Infrastructure Protection Program</td><td>8/3/2012</td><td>up to 9</td><td>no more than 1</td><td>0</td><td>0</td><td>total takes over 50-year project life</td></tr>
<tr><td rowspan="2">ACOE Dredging of Chesapeake Bay Entrance Channels and Beach Nourishment</td><td rowspan="2">10/16/2012</td><td>937 non-lethal captures, 452 mortalities</td><td>275 non-lethal captures, 48 mortalities</td><td>38 non-lethal captures, 11 mortalities</td><td>0</td><td rowspan="2">total takes over 50-year project life</td></tr>
<tr><td colspan="4">Relocation Trawling: up to 938 captures (37 mortalities) of loggerheads, 275 captures (11 mortalities) of Kemp’s ridleys, and 37 captures (2 mortalities) of green sea turtles</td></tr>
</table>

Project	Date of Opinion	Loggerhead	Kemp's ridley	Green	Leatherback	Notes
ACOE NY and NJ Harbor Deepening	10/25/2012	1 loggerhead or Kemp's ridley		0	0	total takes over 50-year project life
ACOE Sea Bright Offshore Borrow Area Beach Nourishment	3/7/2014	Port Monmouth: 1 loggerhead or Kemp's ridley; Union Beach: 1 loggerhead or Kemp's ridley; Elberon to Loch Arbour: 5 loggerheads and 1 loggerhead or Kemp's ridley (all lethal or non-lethal)		0	0	total takes over 50-year project life
ACOE Sand borrow areas for beach nourishment and hurricane protection, offshore DE and NJ	6/26/2014	29	2	1	0	total takes over 50-year project life
ACOE Delaware Deepening	11/17/2017	26	2	0	0	total takes over 50-year project life

6.1.3 Nuclear Generating Stations and Other Energy-Related Projects

Salem and Hope Creek – Delaware River

PSEG Nuclear operates two nuclear power plants pursuant to licenses issued by the U.S. Nuclear Regulatory Commission (NRC). These facilities are the Salem and Hope Creek Generating Stations (Salem and HCGS), which are located on adjacent sites within a 740-acre parcel of 118 property at the southern end of Artificial Island in Lower Alloways Creek Township, Salem County, New Jersey. Salem Unit 1 is authorized to operate until 2036 and Salem Unit 2 until 2040. Hope Creek is authorized to operate until 2046.

Consultation pursuant to section 7 of the ESA between NRC and NMFS on the effects of the operation of these facilities has been ongoing since 1979. We most recently completed consultation with NRC in 2014 and issued a biological opinion considering the effects of operations under the renewed operating licenses (issued in 2011). In the opinion we concluded that the continued operation of the Salem 1, Salem 2, and Hope Creek Nuclear Generating Stations through the duration of extended operating licenses may adversely affect but is not likely to jeopardize the continued existence of any listed species. As described below, the 2014 opinion authorizes the incidental take (injury, mortality, capture, or collection) of shortnose sturgeon, Atlantic sturgeon, and loggerhead, green, and Kemp's ridley sea turtles resulting from the operation of the cooling water system. It authorizes the capture at the intake, trash bars, or traveling screens of Salem Units 1 and 2 (and potential injury or mortality) of 500 Atlantic sturgeon, 26 shortnose sturgeon, nine loggerheads, four Kemp's ridleys, and one green sea turtle through the license expirations in 2036 and 2040, respectively. The opinion also exempts the capture of one live shortnose sturgeon and one live Atlantic sturgeon (originating from any of the five DPSs) during gillnet sampling at either Salem 1, Salem 2, or Hope Creek. We estimated that the continuation of an interrelated bottom trawl survey would result in the non-lethal capture of nine shortnose sturgeon, 11 Atlantic sturgeon (six NYB, two CB, and three SA, GOM, or Carolina DPS), and five sea turtles (four loggerheads and one Kemp's ridley or green). Finally, we also expected an interrelated beach seine survey near the facilities to result in the non-lethal capture of one Atlantic sturgeon (likely NYB DPS origin) and one shortnose sturgeon.

With the exception of 1991 and 1992, when 23 and 10 sea turtles were captured at the intakes, the actual level of take has been far lower than the level authorized. Inclusive of 1991 and 1992, for the period between 1976 and 2017, a total of three green (one dead), 30 Kemp's ridley (15 dead), and 68 loggerheads (24 dead) have been captured at the intakes. Since monitoring of the intakes was initiated in 1976, nearly 30 shortnose sturgeon have been recovered from the Salem intakes or captured during bay-wide sampling activities. No shortnose sturgeon have been observed at the Hope Creek intakes. A slightly smaller number of Atlantic sturgeon have been observed at the Salem intakes or caught during bottom trawl sampling; none have been observed at the Hope Creek intakes.

Indian Point – Hudson River
Indian Point 1 (IP1) operated from 1962 through October 1974. IP2 and IP3 have been operational since 1973 and 1975, respectively. Since 1963, shortnose and Atlantic sturgeon in the Hudson River have been exposed to effects of this facility. Eggs and early larvae would be the only life stages of sturgeon small enough to be vulnerable to entrainment at the Indian Point intakes (openings in the wedge wire screens are 6 mm x 12.5 mm (0.25 inches by 0.5 inches); eggs are small enough to pass through these openings but are not expected to occur in the immediate vicinity of the Indian Point site.

Studies to evaluate the effects of entrainment at IP2 and IP3 occurred from the early 1970s through 1987, with intense daily sampling during the spring of 1981-1987. As reported by the Nuclear Regulatory Commission (NRC) in its Final Environmental Impact Statement considering the proposed relicensing of IP2 and IP3, entrainment monitoring reports list no shortnose or Atlantic sturgeon eggs or larvae at IP2 or IP3. Given what is known about these life stages (i.e., no eggs expected to be present in the action area; larvae only expected to be found in the deep channel area away from the intakes) and the intensity of the past monitoring, it is reasonable to assume that this past monitoring provides an accurate assessment of past entrainment of sturgeon early life stages. Based on this, it is unlikely that any entrainment of sturgeon eggs and larvae occurred historically.

We have no information on any monitoring for impingement that may have occurred at the IP1 intakes. Therefore, we are unable to determine whether any monitoring did occur at the IP1 intakes and whether shortnose or Atlantic sturgeon were recorded as impinged at IP1 intakes. Despite this lack of data, given that the IP1 intake is located between the IP2 and IP3 intakes and operates in a similar manner, it is reasonable to assume that some number of shortnose and Atlantic sturgeon were impinged at the IP1 intakes during the time that IP1 was operational. However, based on the information available to NMFS, we are unable to make a quantitative assessment of the likely number of shortnose and Atlantic sturgeon impinged at IP1 during the period in which it was operational.

The impingement of shortnose and Atlantic sturgeon at IP2 and IP3 has been documented. Impingement monitoring occurred from 1974-1990, and during this time period, 21 shortnose sturgeon were observed impinged at IP2. For Unit 3, 11 impinged shortnose sturgeon were recorded. At Unit 2, 251 Atlantic sturgeon were observed as impinged during this time period, with an annual range of 0-118 individuals (peak number in 1975); at Unit 3, 266 Atlantic sturgeon were observed as impinged, with an annual range of 0-153 individuals (peak in 1976). No monitoring of the intakes for impingement occurred from 1990-2013, although it recommenced in 2014 and the intakes are being monitored through the present.

While models of the current thermal plume are available, it is not clear whether this model accurately represents past conditions associated with the thermal plume. As no information on past thermal conditions are available and no monitoring was done historically to determine if the thermal plume was affecting shortnose or Atlantic sturgeon or their prey, it is not possible to estimate past effects associated with the discharge of heated effluent from the Indian Point facility. No information is available on any past impacts to shortnose sturgeon prey due to impingement or entrainment or exposure to the thermal plume. This is because no monitoring of sturgeon prey in the action area has occurred.

On January 9, 2017, Entergy entered into an agreement with the State of New York to permanently cease commercial operations at IP2 and IP3 prior to the dates specified in the previously requested 20-year license. On February 8, 2017, Entergy submitted to NRC amendments to the pending license renewal application. These amendments modified the proposed terms of the renewed licenses for commercial operations from 20 years for each unit to periods ending April 30, 2024 (IP2) and April 30, 2025 (IP3). The closure agreement specifies that IP2 and IP3 will cease commercial electric generating operations by April 30, 2020 and 2021, respectively. However, the closure agreement allows that in certain extraordinary circumstances, New York State and Entergy may mutually agree to extend the operation of IP2 and IP3 to no later than April 30, 2024 (IP2) and April 30, 2025 (IP3).

NRC's proposed action was the subject of a section 7 consultation with NMFS that concluded on January 30, 2013 (and was later amended on February 9, 2018). In our biological opinion, we considered the effects of the continued operation of the facility from the time a new license is issued (2013 and 2015 for Units 2 and 3 respectively) through the 20 year extended operating period (2033 and 2035) on shortnose and Atlantic sturgeon. We determined that the proposed action was likely to adversely affect, but not likely to jeopardize, the continued existence of shortnose sturgeon or the New York Bight, Gulf of Maine, or Chesapeake Bay DPSs of Atlantic sturgeon. As explained in the *Effects of the Actions* section of that opinion, an average of five shortnose sturgeon per year are likely to be impinged at Unit 2 during the extended operating period, with a total of no more than 104 shortnose sturgeon over the 20 year period (dead or alive). Additionally, over the 20 year operating period, an additional six shortnose sturgeon (dead or alive) are likely to be impinged at the Unit 1 intakes which will provide service water for the operation of Unit 2. At Unit 3, an average of three shortnose sturgeon are likely to be impinged per year during the extended operating period, with a total of no more than 58 shortnose sturgeon (dead or alive) taken as a result of the operation of Unit 3 over the 20 year period. This level of take was exempted through an Incidental Take Statement that applies only to the period when the facility operates under a new operating license (September 28, 2013 through September 28, 2033 for Units 1 and 2; December 12, 2015 through December 12, 2035 for Unit 3). It is likely that the operation of Indian Point continues to cause the impingement, and possible mortality, of some number of individual Atlantic sturgeon in the Hudson River.

6.1.4 Bridge Construction Projects

Tappan Zee Bridge Replacement
The U.S. Federal Highway Authority (FHWA), the New York Department of Transportation (DOT), the New York State Thruway Authority (NYSTA) are in the process of replacing the existing Tappan Zee Bridge. A Record of Decision was signed in September 2012. The construction of the piles, pile caps, pylons, and bridge deck began in 2013 and is expected to be completed by 2019. Since 2012, we have issued multiple biological opinions to FHWA, the lead Federal agency for this project. These opinions, the most recent of which was signed on July 10, 2018, have all concluded that the proposed bridge replacement project may adversely affect but was not likely to jeopardize the continued existence of shortnose sturgeon or any DPS of Atlantic sturgeon. The ITS included with the 2018 opinion exempts the lethal take of four shortnose sturgeon and four Atlantic sturgeon (from the Gulf of Maine, New York Bight or Chesapeake Bay DPS) as a result of vessel strikes, as well as the injury of two shortnose sturgeon and two Atlantic sturgeon (from the Gulf of Maine, New York Bight, or Chesapeake Bay DPS) as a result of exposure to underwater noise from pile driving that has yet to occur.

6.2 Non-federally regulated fisheries

Several fisheries for species that are not managed by a Federal FMP occur in both state and Federal waters of the action area. The amount of gear contributed to the environment by these fisheries is currently unknown. In most cases, there is limited observer coverage of these fisheries and the extent of interactions with ESA-listed species is difficult to estimate. Sea turtles, shortnose, and Atlantic sturgeon may be vulnerable to capture, injury, and mortality in a number of these fisheries. Captures of loggerhead, Kemp’s ridley, green, and leatherback sea turtles (NMFS SEFSC 2001; Murray 2009a; Warden 2011a, 2011b) and Atlantic sturgeon (ASSRT 2007; NMFS Sturgeon Workshop 2011) in these fisheries have been reported.

The available bycatch data for FMP fisheries indicate that sink gillnets and otter trawl gear pose the greatest risk to Atlantic sturgeon (ASMFC TC 2007), although Atlantic sturgeon are occasionally caught by hook and line, fyke nets, and crab pots as well (NMFS Sturgeon Workshop 2011). It is likely that this vulnerability to these types of gear is similar for non-

Federal fisheries, although there is little data available to support this. Information on the number of Atlantic sturgeon captured or killed in non-Federal fisheries, which primarily occur in state waters, is extremely limited. An Atlantic sturgeon "reward program," where commercial fishermen were provided monetary rewards for reporting captures of Atlantic sturgeon in Chesapeake Bay, operated from 1996 to 2012 in Maryland (Mangold *et al.* 2007). The data from this program show that Atlantic sturgeon have been caught in a wide variety of gear types, including hook and line, pound nets, gillnets, crab pots, eel pots, hoop nets, trawls, and fyke nets. Pound nets (58.9%) and gillnets (40.7%) accounted for the vast majority of captures. Of the more than 2,000 Atlantic sturgeon reported in the reward program during 11 years (1996-2006), biologists counted ten individuals that died as a result of their capture. No information on post-release mortality is available.

Efforts are currently underway to obtain more information on the numbers of Atlantic sturgeon captured and killed in state-water fisheries and a handful of states (e.g., Delaware, New Jersey, New York, and North Carolina) are in the process of applying for ESA section 10 permits to cover the incidental capture of Atlantic sturgeon in their state fisheries. Preliminary and anecdotal information suggests the numbers of Atlantic sturgeon captured or killed in state-water fisheries is small. Atlantic sturgeon are also vulnerable to capture in state-water fisheries occurring in rivers, such as shad fisheries; however, these riverine areas are outside the action area under consideration in this opinion. Where available, state-specific information on sea turtle and Atlantic sturgeon interactions in non-Federal fisheries is provided below.

Atlantic croaker fishery

An Atlantic croaker fishery using trawl and gillnet gear also occurs within the action area and sea turtle interactions have been observed in the fishery. The average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the Atlantic croaker fishery was estimated to be 92 loggerhead sea turtles (with a 95% CI of 63-121) from 2009-2013 (Murray 2015a). Additional information on sea turtle interactions with gillnet gear used in the Atlantic croaker fishery has also been recently published by Murray (2013). The average annual bycatch of loggerhead sea turtles in gillnet gear used in the Atlantic croaker fishery, based on VTR data from 2007-2011, was estimated to be 6 per year with a 95% CI of 2-10 (Murray 2013). These estimates encompass the bycatch of loggerheads in the Atlantic croaker fishery in both state and Federal waters.

Atlantic sturgeon interactions have also been observed in the Atlantic croaker fishery, but a quantitative assessment of the number of Atlantic sturgeon captured in the croaker fishery is not available. A mortality rate of Atlantic sturgeon in commercial trawls has been estimated at 5%. A review of the NEFOP database indicates that from 2006-2010, 60 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as croaker. This represents a minimum number of Atlantic sturgeon captured in the croaker fishery during this time period as it only considers trips that included a NEFOP observer onboard.

Weakfish fishery
The weakfish fishery occurs in both state and Federal waters, but the majority of commercially and recreationally caught weakfish are caught in state waters (ASMFC 2002). The dominant commercial gears include gillnets, pound nets, haul seines, flynets, and trawls, with the majority of landings occurring in the fall and winter months (ASMFC 2002). Weakfish landings were dominated by the trawl fishery through the mid-1980s, after which gillnet landings began to account for most weakfish landed (ASMFC 2002). North Carolina has accounted for the majority of the annual landings since 1972 while Virginia ranks second, followed by New Jersey (ASMFC 2002). Sea turtle bycatch in the weakfish fishery has occurred (Murray 2013, 2015a) and NMFS originally assessed the impacts of the fishery on sea turtles in an Opinion back in 1997 (NMFS 1997b). Currently, the average annual bycatch of loggerhead sea turtles in bottom otter trawl gear used in the weakfish fishery is estimated to be 0 loggerheads (with a 95% CI of 0-1) from 2009-2013 (Murray 2015a). Additional information on loggerhead sea turtle interactions with gillnet gear has also been recently published by Murray (2009a, 2009b). The average annual bycatch of loggerhead sea turtles in gillnet gear used in the weakfish fishery, based on VTR data from 2002-2006, was estimated to be one per year with a 95% CI of 0-1 (Murray 2009b), although the more recent Murray (2013) gillnet bycatch estimate for 2007-2011 does not include a loggerhead bycatch estimate for the weakfish gillnet fishery. These estimates encompass the bycatch of loggerheads in the weakfish fishery in both state and Federal waters.

A quantitative assessment of the number of Atlantic sturgeon captured in the weakfish fishery is not available. A mortality rate of Atlantic sturgeon in commercial trawls has been estimated at 5%. A review of the NEFOP observer database indicates that from 2006-2010, 36 Atlantic sturgeon (out of a total of 726 observed interactions) were captured during observed trips where the trip target was identified as weakfish. This represents a minimum number of Atlantic sturgeon captured in the weakfish fishery during this time period as it only considers observed trips, and most inshore fisheries are not observed. An earlier review of bycatch rates and landings for the weakfish fishery reported that the weakfish-striped bass fishery had an Atlantic sturgeon bycatch rate of 16% from 1989-2000; the weakfish-Atlantic croaker fishery had an Atlantic sturgeon bycatch rate of 0.02%, and the weakfish fishery had an Atlantic sturgeon bycatch rate of 1.0% (ASSRT 2007).

Whelk fishery
A whelk fishery using pot/trap gear is known to occur in several parts of the action area, including waters off of Maine, Massachusetts, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia. Landings data for Delaware suggests that the greatest effort in the whelk fishery for waters off of that state occurs in the months of July and October; times when sea turtles are present. Whelk pots, which unlike lobster traps are not fully enclosed, have been suggested as a potential source of entrapment for loggerhead sea turtles that may be enticed to enter the trap to get the bait or whelks caught in the trap (Mansfield *et al*. 2001). Loggerhead, leatherback, and green sea turtles are known to become entangled in lines associated with pot/trap gear used in several fisheries including lobster, whelk, and crab species (NMFS SEFSC 2001; Dwyer *et al*. 2002: NMFS 2007). Whelk fisheries in Massachusetts, New York, New Jersey, and Virginia were verified as the fisheries involved in 18 sea turtle entanglements from 2001 to 2010. Twelve entanglement events involved a leatherback sea turtle, five involved a

loggerhead sea turtle, and one involved a green sea turtle (Northeast Region Sea Turtle Disentanglement Network [STDN] database). Whelk pots are not known to interact with Atlantic sturgeon.

Crab fisheries

Various crab fisheries, such as horseshoe crab and blue crab, also occur in Federal and state waters. Loggerhead, leatherback, and green sea turtles are known to become entangled in lines associated with pot/trap gear used in several fisheries including lobster, whelk, and crab species (NMFS SEFSC 2001; Dwyer *et al*. 2002: NMFS 2007). The Virginia blue crab fishery was verified as the fishery involved in four sea turtle entanglements from 2001 to 2010. Two entanglement events involved a leatherback sea turtle and two involved a loggerhead sea turtle (Northeast Region STDN database).

The crab fisheries may have detrimental impacts on sea turtles beyond entanglement in the fishing gear itself. Loggerheads are known to prey on crab species, including horseshoe and blue crabs. In a study of the diet of loggerhead sea turtles in Virginia waters from 1983 to 2002, Seney and Musick (2007) found a shift in the diet of loggerheads in the area from horseshoe and blue crabs to fish, particularly menhaden and Atlantic croaker. The authors suggested that a decline in the crab species have resulted in the shift and loggerheads are likely foraging on fish captured in fishing nets or on discarded fishery bycatch (Seney and Musick 2007). The physiological impacts of this shift are uncertain although it was suggested as a possible explanation for the declines in loggerhead abundance noted by Mansfield (2006). Other studies have detected seasonal declines in loggerhead abundance coincident with seasonal declines of horseshoe and blue crabs in the same area (Maier *et al*. 2005). While there is no evidence of a decline in horseshoe crab abundance in the Southeast during the period 1995-2003, declines were evident in some parts of the Mid-Atlantic (ASMFC 2004; Eyler *et al*. 2007). Given the variety of loggerheads prey items (Dodd 1988; Burke *et al*. 1993; Bjorndal 1997; Morreale and Standora 1998) and the differences in regional abundance of horseshoe crabs and other prey items (ASMFC 2004; Eyler *et al*. 2007), a direct correlation between loggerhead sea turtle abundance and horseshoe crab and blue crab availability cannot be made at this time. Nevertheless, the decline in loggerhead abundance in Virginia waters (Mansfield 2006), and possibly Long Island waters (Morreale *et al*. 2005), coincident with noted declines in the abundance of horseshoe crab and other crab species raises concerns that crab fisheries may be impacting the forage base for loggerheads in some areas of their range.

Atlantic sturgeon are known to be caught in state water horseshoe crab fisheries, which currently operate in all action area states except New Jersey. Along the U.S. East Coast, hand, trawl, and dredge fisheries account for more than 85% of the commercial horseshoe crab landings in the bait fishery. Other methods used are gillnets, pound nets, and traps (ASMFC 2016). State waters from Delaware to Virginia are closed to horseshoe crab harvest and landing from January 1 to June 7 (ASMFC 2016). The majority of horseshoe crab landings in 2010 came from Massachusetts, Virginia, and Delaware. Stein *et al*. (2004b) examined bycatch of Atlantic sturgeon using the NMFS sea-sampling/observer database (1989-2000) and found that the bycatch rate for horseshoe crabs was low, at 0.05%. An Atlantic sturgeon “reward program,” where commercial fishermen were provided monetary rewards for reporting captures of Atlantic sturgeon in the Maryland waters of Chesapeake Bay, operated from 1996 to 2012 (Mangold *et al*. 2007).[3] The data from this program during the 11-year period of 1996-2006 show that one of 1,395 wild Atlantic sturgeon was found caught in a crab pot (Mangold *et al*. 2007).

Virginia pound net fishery
Sea turtles, including loggerheads, leatherbacks, and Kemp's ridleys, have been observed to interact with the Virginia pound net fishery, which is contiguous to the action area at the mouth of Chesapeake Bay. Pound nets with large-mesh and stringer leaders set in Virginia waters of Chesapeake Bay have been implicated in leatherback sea turtle mortalities as a result of entanglement in the pound net leader, and live loggerhead and Kemp's ridley sea turtles have also been found in the pounds. As described in section 6.5 below, NMFS has taken regulatory action to address sea turtle bycatch in the Virginia pound net fishery. Atlantic sturgeon are also captured in pound nets and leaders; however, mortality rates are believed to be low. Our most recent opinion in 2018 estimated that up to 13 Atlantic sturgeon may be captured per year in Virginia pound net gear, one of which may be lethal.

American lobster trap fishery
An American lobster trap fishery also occurs in state waters of New England and the Mid-Atlantic and is managed under the ASMFC's Interstate Fishery Management Plan (ISFMP). Like the Federal waters component of the fishery mentioned in section 6.1, the state waters fishery has also been identified as a source of gear causing injuries to and mortality of loggerhead and leatherback sea turtles as a result of entanglement in vertical buoy lines of the pot/trap gear. Between 2001 and 2010, lobster trap gear traced back to a fisherman possessing a state permit was verified as the gear involved in 33 leatherback entanglements in the Greater Atlantic Region. Of those, 28 were state-permitted only (i.e., they had to have occurred in state waters). The other five could have potentially occurred in Federal waters, as the fisherman either had both state and Federal permits or it was not known if they had a Federal permit. All entanglements involved the vertical line of the gear. These verified/confirmed entanglements occurred in waters off Maine, Massachusetts, Rhode Island, and Connecticut from June through October; the vast majority (27 of the 33) were documented in waters off Massachusetts (Northeast Region STDN database). Atlantic sturgeon are not known to interact with lobster trap gear.

Fish trap, seine, and channel net fisheries
Incidental captures of loggerheads in fish traps have been reported from several states along the U.S. Atlantic coast (Shoop and Ruckdeschel 1989; W. Teas, NMFS, pers. comm.), while leatherbacks have been documented as entangled in the buoy line systems of conch and sea bass traps off Massachusetts (Northeast Region STDN database). Long haul seines, purse seines, and channel nets are also known to incidentally capture sea turtles in sounds and other inshore waters along the U.S. Atlantic coast, although no lethal interactions have been reported (NMFS SEFSC 2001). No information on interactions between Atlantic sturgeon and fish traps, long haul seines, purse seines, or channel nets is currently available; however, depending on where this

[3] The program was terminated in February 2012, with the listing of Atlantic sturgeon under the ESA.

gear is set and the mesh size, the potential exists for Atlantic sturgeon to be entangled or captured in this gear.

Northern shrimp fishery
A Northern shrimp fishery also occurs in state waters of Maine, New Hampshire, and Massachusetts, and is managed under the ASMFC's ISFMP. In 2010, the ISFMP implemented a 126-day season, from December 1 to April 15, but the shrimp fishery has exceeded its TAC and closed early every year, ending on February 17 in 2012. Due to recruitment failure and a collapsed stock, fishing moratoria were instituted by the ASMFC for the 2014, 2015, and 2016 fishing seasons. The majority of northern shrimp are caught with otter trawls, which must be equipped with Nordmore grates (ASMFC NSTC 2011). Otter trawls in this fishery are known to interact with Atlantic sturgeon, but exact numbers are not available (NMFS Sturgeon Workshop 2011). A majority (84%) of Atlantic sturgeon bycatch in otter trawls occurs at depths <20 meters, with 90% occurring at depths of <30 meters (Miller 2007). During the NEFSC's spring and fall inshore northern shrimp trawl surveys, northern shrimp are most commonly found in tows with depths of >64 meters (ASFMC NSTC 2011), which is well below the depths at which most Atlantic sturgeon bycatch occurs. Atlantic sturgeon are known to interact with shrimp trawls, but mortality is low: NEFOP data from 2002-2004 showed 0.2% Atlantic sturgeon mortality in shrimp and otter trawls; Stein *et al*. (2004b) reported no immediate Atlantic sturgeon mortality in trawls from 1989-2000 from North Carolina to Maine; and Cooperative Winter Tagging Cruises captured 146 Atlantic sturgeon from 1988-2006, of which none died (Laney *et al*. 2007; ASSRT 2007).

American shad fishery
An American shad fishery also occurs in state waters of New England and the Mid-Atlantic and is managed under the ASMFC's ISFMP. In 2005, the directed fishery for Atlantic shad was closed, and subsequently landings from the ocean are only from the bycatch fishery. In 2015, approximately 414,921 pound of Atlantic shad were landed (http://www.asmfc.org/species/shad-river-herring).

About 40-500 Atlantic sturgeon were reportedly captured in the spring shad fishery in the past, primarily from the Delaware Bay, with only 2% caught in the river. The fishery uses five-inch mesh gillnets left overnight to soak, but, based on the available information, there is little bycatch mortality. Unreported mortality may be occurring in the recreational shad fishery, but the extent is unknown (NMFS Sturgeon Workshop 2011).

Recreational hook and line shad fisheries are known to capture Atlantic sturgeon, particularly in southern Maine (NMFS Sturgeon Workshop 2011). Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the shad fishery accounted for 8% of Atlantic sturgeon recaptures.

Striped bass fishery
The striped bass fishery occurs only in state waters, as Federal waters have been closed to the harvest and possession of striped bass since 1990, except that possession is allowed in a defined area around Block Island, Rhode Island (ASMFC 2017b). The ASMFC has managed striped

bass since 1981, and provides guidance to states from Maine to North Carolina through an ISFMP. All states are required to have recreational and commercial size limits, recreational creel limits, and commercial quotas. The commercial striped bass fishery is closed in Maine, New Hampshire, and Connecticut, but open in Massachusetts (hook and line only), Rhode Island, New Jersey (hook and line only), Delaware, Maryland, and Virginia. Recreational striped bass fishing occurs all along the U.S. East Coast.

Several states have reported incidental catch of Atlantic sturgeon during striped bass fishing activities (NMFS Sturgeon Workshop 2011). In southern Maine and New Hampshire, the recreational striped bass fishery is known to catch Atlantic sturgeon, although numbers are not available. The recreational striped bass fishery along the south shore of Long Island has reports of Atlantic sturgeon bycatch, with hundreds of reports of sturgeon caught or snagged in recreational gear particularly around Fire Island and Far Rockaway. Atlantic sturgeon bycatch is occurring in the Delaware Bay and River, but little bycatch mortality has been reported. Unreported mortality is likely occurring.

Data from the Atlantic Coast Sturgeon Tagging Database (2000-2004) shows that the striped bass fishery accounted for 43% of Atlantic sturgeon recaptures (ASSRT 2007). The striped bass-weakfish fishery also had one of the highest bycatch rates of 30 directed fisheries according to NMFS Observer Program data from 1989-2000 (ASSRT 2007).

State gillnet fisheries
Two 10- to 14-inch (25.6- to 35.9-centimeter) mesh gillnet fisheries, the black drum and sandbar shark gillnet fisheries, occur in Virginia state waters along the tip of the eastern shore. Given the gear type, these fisheries may capture or entangle sea turtles. Entanglements of sea turtles in gillnet sets targeting and/or landing both species have been recorded in the NEFOP database. Similarly, sea turtles are thought to be vulnerable to capture in small mesh gillnet fisheries occurring in Virginia state waters. During May-June 2001, NMFS observed 2% of the Atlantic croaker fishery and 12% of the dogfish fishery (which represent approximately 82% of Virginia’s total small mesh gillnet landings from offshore and inshore waters during this time), yet no sea turtle captures were observed (NMFS 2004). Based on gear type (i.e., gillnets), it is likely that Atlantic sturgeon would be vulnerable to capture in these fisheries. The majority of reports of Atlantic sturgeon captures during the Atlantic sturgeon reward program have been in drift gillnets and pound nets.

State recreational fisheries
Observations of state recreational fisheries have shown that loggerhead, leatherback, and green sea turtles are known to bite baited hooks, and loggerheads frequently ingest the hooks. Hooked sea turtles have been reported by the public fishing from boats, piers, beaches, banks, and jetties, and from commercial fishermen fishing for snapper, grouper, and sharks with both single rigs and bottom longlines (NMFS SEFSC 2001). A summary of known impacts of hook-and-line captures on loggerhead sea turtles can be found in the TEWG (1998, 2000, 2009) reports. Stranding data also provide some evidence of interactions between recreational hook-and-line gear and sea turtles, but assigning the gear to a specific fishery is rarely, if ever, possible. Atlantic sturgeon have also been observed captured in hook-and-line gear, yet the number of

interactions that occur annually is unknown. There have been no post-release survival studies for this species. However, we anticipate that Atlantic sturgeon we likely be released alive, due to the overall hardiness of the species and educational outreach efforts in the region on behalf of NMFS in regards to disentanglement and release as well as handling and resuscitation. NMFS is currently working on a project to assess the extent of sea turtle interactions that occur in recreational fisheries of the Southeast (North Carolina to Florida) and believes that the survey platform and questionnaire may also be applicable for determining the amount of Atlantic sturgeon interactions as well.

6.3 Vessel Activity and Military and Energy Exploration Operations

Potential sources of adverse effects to sea turtles, shortnose, and Atlantic sturgeon from Federal vessel operations in the action area include operations of the U.S. Navy, U.S. Coast Guard (USCG), Bureau of Ocean Energy Management (BOEM), Maritime Administration (MARAD), Environmental Protection Agency (EPA), and ACOE to name a few. NMFS has previously conducted formal consultations with the Navy and USCG on their vessel-based operations. NMFS has also conducted section 7 consultations with BOEM and MARAD on vessel traffic related to energy projects in the Greater Atlantic Region and has implemented conservation measures. Through the section 7 process, where applicable, NMFS has and will continue to establish conservation measures for all these agency vessel operations to avoid or minimize adverse effects to listed species. To date, ocean-going vessels and military activities have not been identified as significant threats to shortnose and Atlantic sturgeon. However, the possibility exists for interactions between vessels and these species in marine, estuarine, and riverine environments.

Although consultations on individual Navy and USCG activities have been completed, only one formal consultation on overall military activities in all of the Atlantic has been completed at this time. In June 2009, NMFS prepared an Opinion on Navy activities in each of their four training range complexes along the U.S. Atlantic coast—Northeast, Virginia Capes, Cherry Point, and Jacksonville (NMFS 2009a). In addition, the following Opinions for the Navy (NMFS 1996, 1997a, 2008, 2009b) and USCG (NMFS 1995, 1998b) contain details on the scope of vessel operations for these agencies and the conservation measures that are being implemented as standard operating procedures. In the U.S. Atlantic, the operation of USCG boats and cutters is estimated to take no more than one individual sea turtle, of any species, per year (NMFS 1995).

Military activities such as ordnance detonation also affect sea turtles. A section 7 consultation was conducted in 1997 for Navy aerial bombing training in the ocean off the southeast U.S. coast, involving drops of live ordnance (500 and 1,000-lb bombs). The resulting Opinion for this consultation determined that the activity was likely to adversely affect sea turtles but would not jeopardize their continued existence. In the ITS included within the Opinion, these training activities were estimated to have the potential to injure or kill, annually, 84 loggerheads, 12 leatherbacks, and 12 greens or Kemp's ridleys, in combination (NMFS 1997a).

NMFS has also conducted more recent section 7 consultations on Navy explosive ordnance disposal, mine warfare, sonar testing (e.g., AFAST, SURTASS LFA), and other major training exercises (e.g., bombing, Naval gunfire, combat search and rescue, anti-submarine warfare, and torpedo and missile exercises) in the Atlantic Ocean. These consultations have determined that the proposed Navy activities may adversely affect but would not jeopardize the continued existence of ESA-listed sea turtles (NMFS 2008, 2009a, 2009b). NMFS estimated that five loggerhead and six Kemp's ridley sea turtles are likely to be harmed as a result of training activities in the Virginia Capes Range Complex from June 2009 to June 2010, and that nearly 1,500 sea turtles, including ten leatherbacks, are likely to experience harassment (NMFS 2009a).

Similarly, operations of vessels by other Federal agencies within the action area (BOEM, MARAD, EPA, and ACOE) may adversely affect sea turtles, shortnose, and Atlantic sturgeon. However, vessel activities of those agencies are often limited in scope, as they operate a limited number of vessels or are engaged in research/operational activities that are unlikely to contribute a large amount of risk.

In regards to pile driving, seismic surveys, and other activities associated with ocean energy exploration (which are under the guise of BOEM), there are a handful of opinions in the Greater Atlantic Region that have exempted the incidental take of sea turtles and Atlantic sturgeon resulting from acoustic sources. For Atlantic sturgeon, we anticipate the harassment of an unquantifiable number from all five DPSs due to these projects, where the spatial and temporal extent of the area where underwater noise is elevated above 150 dB re 1uPa RMS serves as a surrogate for estimating the amount of incidental take from harassment. For sea turtles, we have been able to better predict the number of animals likely to be harassed during seismic surveys and the construction of wind energy turbines off the Northeast U.S. coast. For the Outer Continental Shelf Wind Energy Areas, Deepwater Wind, and Virginia Offshore Wind Technology Advancement Project (VOWTAP) projects, the number of sea turtles anticipated to experience acoustic harassment, where noise exposure is greater than 166 dB re 1uPa, ranges from the hundreds to thousands over the course of the projects. However, no lethal takes of sea turtles or Atlantic sturgeon are anticipated to occur during these BOEM projects.

6.4 Other Activities

6.4.1 Maritime Industry

Private and commercial vessels, including fishing vessels, operating in the action area of this consultation also have the potential to interact with sea turtles and Atlantic sturgeon. The effects of fishing vessels, recreational vessels, or other types of commercial vessels on ESA-listed species may involve disturbance or injury/mortality due to collisions or entanglement in anchor lines. It is important to note that minor vessel collisions may not kill an animal directly, but may weaken or otherwise affect it so it is more likely to become vulnerable to effects such as entanglement.

6.4.2 Pollution

Anthropogenic sources of marine pollution, while difficult to attribute to a specific Federal, state, local, or private action, may affect sea turtles, shortnose, and Atlantic sturgeon in the action area.

Sources of pollutants in the action area include atmospheric loading of pollutants such as PCBs; storm water runoff from coastal towns, cities, and villages; runoff into rivers emptying into bays; groundwater discharges; sewage treatment plant effluents; and oil spills. Oil spills could affect sea turtles and sturgeon either directly or through the food chain. Larger oil spills may result from severe accidents, although these events would be rare. The pathological effects of oil spills on sea turtles specifically have been documented in several laboratory studies (Vargo *et al.* 1986).

Nutrient loading from land-based sources, such as coastal communities and agricultural operations, is known to stimulate plankton blooms in closed or semi-closed estuarine systems. The effect to larger embayments is unknown. Contaminants could degrade habitat if pollution and other factors reduce the food available to marine animals.

6.4.3 Coastal development

Beachfront development, lighting, and beach erosion control all are ongoing activities along the Mid- and South Atlantic coastlines of the U.S. These activities potentially reduce or degrade sea turtle nesting habitats or interfere with hatchling movement to sea. Nocturnal human activities along nesting beaches may also discourage sea turtles from nesting sites. The extent to which these activities reduce sea turtle nesting and hatchling production is unknown. However, more and more coastal counties are adopting stringent protective measures to protect hatchling sea turtles from the disorienting effects of beach lighting. Coastal development may also impact Atlantic sturgeon if it disturbs or degrades foraging habitats or otherwise affects the ability of sturgeon to use coastal habitats.

6.5 Reducing Threats to ESA-listed Sea Turtles

Numerous efforts are ongoing to reduce threats to listed sea turtles. Below, we detail efforts that are ongoing within the action area. The majority of these activities are related to regulations that have been implemented to reduce the potential for incidental mortality of sea turtles from commercial fisheries. These include sea turtle release gear requirements for Atlantic HMS; TED requirements for Southeast shrimp trawl fishery and the southern part of the summer flounder trawl fishery; mesh size restrictions in the North Carolina gillnet fishery and Virginia's gillnet and pound net fisheries; modified leader requirements in the Virginia Chesapeake Bay pound net fishery; area closures in the North Carolina gillnet fishery; and gear modifications in the Atlantic sea scallop dredge fishery. In addition to regulations, outreach programs have been established and data on sea turtle interactions and strandings are collected. The summaries below discuss these measures in more detail.

6.5.1 Use of a Chain-Mat Modified Scallop Dredge in the Mid-Atlantic

In response to the observed capture of sea turtles in scallop dredge gear, including serious injuries and sea turtle mortality as a result of capture, NMFS proposed a modification to scallop dredge gear (70 FR 30660, May 27, 2005). The rule was finalized as proposed (71 FR 50361, August 25, 2006) and required federally permitted scallop vessels fishing with dredge gear to modify their gear by adding an arrangement of horizontal and vertical chains (hereafter referred to as a "chain mat") between the sweep and the cutting bar when fishing in Mid-Atlantic waters south of 41°9'N from the shoreline to the outer boundary of the EEZ during the period of May 1-November 30 each year. The requirement was subsequently modified by emergency rule on November 15, 2006 (71 FR 66466), and by a final rule published on April 8, 2008 (73 FR 18984). On May 5, 2009, NMFS proposed additional minor modifications to the regulations on how chain mats are configured (74 FR 20667). Since 2008, the chain mat gear modifications have reduced the severity of most sea turtle interactions with scallop dredge gear (Murray 2011, 2015b). However, these modifications are not expected to reduce the overall number of sea turtle interactions with scallop dredge gear.

6.5.2 Sea Turtle Handling and Resuscitation Techniques

NMFS has developed and published as a final rule in the *Federal Register* (66 FR 67495, December 31, 2001) sea turtle handling and resuscitation techniques for sea turtles that are incidentally caught during scientific research or fishing activities. Persons participating in fishing activities or scientific research are required to handle and resuscitate (as necessary) sea turtles as prescribed in the final rule. These measures help to prevent mortality of hard-shelled turtles caught in fishing or scientific research gear.

6.5.3 Sea Turtle Entanglements and Rehabilitation

A final rule (70 FR 42508) published on July 25, 2005, allows any agent or employee of NMFS, the U.S. FWS, the U.S. Coast Guard, or any other Federal land or water management agency, or any agent or employee of a state agency responsible for fish and wildlife, when acting in the course of his or her official duties, to take endangered sea turtles encountered in the marine environment if such taking is necessary to aid a sick, injured, or entangled endangered sea turtle, or dispose of a dead endangered sea turtle, or salvage a dead endangered sea turtle that may be useful for scientific or educational purposes. NMFS already affords the same protection to sea turtles listed as threatened under the ESA (50 CFR 223.206(b)).

6.5.4 Education and Outreach Activities

Education and outreach activities do not directly reduce the threats to ESA-listed sea turtles. However, education and outreach are a means of better informing the public of steps that can be taken to reduce impacts to sea turtles (*i.e.*, reducing light pollution in the vicinity of nesting beaches) and increasing communication between affected user groups (*e.g.*, the fishing community). For the HMS fishery, NMFS has been active in public outreach to educate fishermen regarding sea turtle handling and resuscitation techniques. For example, NMFS has conducted workshops with longline fishermen to discuss bycatch issues including protected species, and to educate them regarding handling and release guidelines. NMFS intends to continue these outreach efforts in an attempt to increase the survival of protected species through education on proper release techniques.

6.5.5 Sea Turtle Stranding and Salvage Network (STSSN)

As is the case with education and outreach, the STSSN does not directly reduce the threats to sea turtles. However, the extensive network of STSSN participants along the Atlantic and Gulf of Mexico coasts not only collects data on dead sea turtles, but also rescues and rehabilitates live stranded turtles. Data collected by the STSSN are used to monitor stranding levels and identify areas where unusual or elevated mortality is occurring. These data are also used to monitor incidence of disease, study toxicology and contaminants, and conduct genetic studies to determine population structure. All of the states that participate in the STSSN tag live turtles when encountered (either via the stranding network through incidental takes or in-water studies). Tagging studies help provide an understanding of sea turtle movements, longevity, and reproductive patterns, all of which contribute to our ability to reach recovery goals for the species.

6.6 Reducing Threats to Shortnose and Atlantic sturgeon

Several conservation actions aimed at reducing threats to shortnose and Atlantic sturgeon are currently ongoing, including dam removals, moratoria on commercial and recreational fishing, and the implementation of a Sturgeon Salvage Network and educational programs for sturgeon throughout the U.S. Atlantic (e.g., SCUTES: Students Collaborating to Undertake Tracking Efforts for Sturgeon). In the near future, NMFS will be convening a recovery team and will be drafting a recovery plan which will outline recovery goals and criteria and steps necessary to recover all Atlantic sturgeon DPSs. Numerous research activities are underway, involving NMFS and other Federal, State and academic partners, to obtain more information on the distribution and abundance of shortnose and Atlantic sturgeon throughout their range, including in the action area. Efforts are also underway to better understand threats faced by the populations and ways to minimize these threats, including bycatch and water quality, and to develop population estimates for each population. Fishing gear research is underway to design fishing gear that minimizes interactions with shortnose and Atlantic sturgeon while maximizing retention of targeted fish species. Several states are in the process of preparing ESA Section 10 Habitat Conservation Plans aimed at minimizing the effects of state fisheries on sturgeon.

6.7 Summary of Available Information on Listed Species Likely to be Adversely Affected by the Proposed Action in the Action Area

6.7.1 Sea Turtles

As described in sections 4.2.2.1 - 4.2.2.4, the occurrence of loggerhead, Kemp’s ridley, green, and leatherback sea turtles along the U.S. Atlantic coast is primarily temperature dependent. In general, sea turtles move up the U.S. Atlantic coast from southern wintering areas as water temperatures warm in the spring. The trend is reversed in the fall as water temperatures cool. By December, sea turtles have passed Cape Hatteras, returning to more southern waters for the winter (Thompson 1984; Keinath *et al.* 1987; Shoop and Kenney 1992; Musick and Limpus 1997; Morreale and Standora 1998, 2005; Mitchell *et al.* 2003; Braun-McNeill and Epperly 2004; James *et al.* 2005).

Recreational anglers have reported sightings of sea turtles in waters defined as inshore waters (bays, inlets, rivers, or sounds; Braun-McNeill and Epperly 2004) as far north as New York as early as March-April, but in relatively low numbers (Braun-McNeill and Epperly 2004). Greater numbers of loggerheads, Kemp's ridleys, and greens are found in inshore, nearshore, and offshore waters of North Carolina (north of Cape Hatteras) and Virginia from May through November and in inshore, nearshore, and offshore waters of New York from June through October (Keinath *et al.* 1987; Morreale and Standora 1993; Braun-McNeill and Epperly 2004). Leatherback sea turtles have a similar seasonal distribution but have a more extensive range in the Gulf of Maine and further north into Canadian waters compared to the hard-shelled species (Shoop and Kenney 1992; Mitchell *et al.* 2003; STSSN database).

Extensive survey effort of the continental shelf from Cape Hatteras to Nova Scotia, Canada in the 1980s (CeTAP 1982) revealed that loggerheads were observed at the surface in waters from the beach to waters with bottom depths of up to 4,481 meters. However, they were generally found in waters where bottom depths ranged from 22-49 meters deep (the median value was 36.6 meters; Shoop and Kenney 1992). Leatherbacks were sighted at the surface in waters with bottom depths ranging from 1-4,151 meters deep (Shoop and Kenney 1992). However, 84.4% of leatherback sightings occurred in waters where the bottom depth was less than 180 meters (Shoop and Kenney 1992), whereas 84.5% of loggerhead sightings occurred in waters where the bottom depth was less than 80 meters (Shoop and Kenney 1992). The CeTAP study did not include Kemp's ridley and green sea turtle sightings, given the difficulty of sighting these smaller sea turtle species (CeTAP 1982).

Sea turtles are generally present in Greater Atlantic waters from May to November each year, with the highest number of individuals present from June to October. Sea turtles occur throughout the bays and estuaries of nearly all Mid-Atlantic states and some Northeast ones as well (e.g., Cape Cod Bay, Massachusetts), from shallow waters along the shoreline and near river mouths to deeper waters of the Atlantic Ocean. One of the main factors influencing sea turtle presence in Mid-Atlantic waters is seasonal temperature patterns (Ruben and Morreale 1999). Temperature is correlated with the time of year, with warmer waters in the late spring, summer, and early fall being the most suitable for cold-blooded sea turtles. Sea turtles are most likely to occur in the action area when water temperatures are above 11°C, although depending on seasonal weather patterns and prey availability, they could be also present in months when water temperatures are cooler (as evidenced by fall and winter cold stunning records as well as year round stranding records). Sea turtles have also been documented in the action area through aerial and vessel surveys, satellite tracking programs, and by fisheries observers. The majority of sea turtle observations in the action area and vicinity are of loggerhead sea turtles, yet all four species of sea turtles have been recorded in the action area.

To some extent, water depth also dictates the number of sea turtles occurring in a particular area. Satellite tracking studies of sea turtles in the Northeast U.S. found that foraging turtles mainly occurred in areas where the water depth was between approximately 16 and 49 feet (Ruben and Morreale 1999). This depth was interpreted not to be as much an upper physiological depth limit for turtles, as a natural limiting depth where light and food are most suitable for foraging turtles

(Morreale and Standora 1990). The areas to be fished and the depths preferred by sea turtles do overlap, suggesting that if suitable forage is present, adult and juvenile loggerhead, leatherback, and green sea turtles as well as juvenile Kemp's ridley sea turtles may be foraging in the areas where state fisheries surveys will occur.

6.7.2 Atlantic Sturgeon

The marine and estuarine range of all five Atlantic sturgeon DPSs overlaps and extends from Canada through Cape Canaveral, Florida. Based on the best available information, Atlantic sturgeon originating from any of five DPSs could occur in the waters of the action area, although further upstream in spawning rivers only individuals from that river's associated DPS are likely to be present (Damon-Randall *et al*. 2013; Wirgin *et al*. 2015). The fisheries research activities do not overlap with freshwater; therefore, eggs and early life stages are unlikely to be present in the action area. Juvenile, subadult, and adult Atlantic sturgeon are likely to occur in nearshore waters off the states as they have been documented in spring, summer, and fall in Northeast states and in coastal ocean waters of the Mid-Atlantic year round. Atlantic sturgeon are known to use the action area for spawning migrations, foraging, and as juvenile development habitat prior to entering marine waters as subadults and adults.

Atlantic sturgeon from all five DPSs can be found in nearshore and coastal waters, typically from spring through fall. Migratory behaviors occur from April to November for adults and subadults and year round for juveniles (Dovel and Berggren 1983; Secor *et al.* 2000; Welsh *et al.* 2002; Horne and Stence 2016). Each of these life stages are expected to wander among coastal and estuarine habitats of the bay. Foraging behaviors typically occur in areas where suitable forage and appropriate habitat conditions are present. These areas include tidally influenced flats and mud, sand, and mixed cobble substrates (Stein *et al.* 2004a). The areas to be fished by state survey gear and the depths preferred by Atlantic sturgeon do overlap, suggesting that if suitable forage and/or habitat features are present, adult and subadults from any of the five listed DPSs may be foraging or undertaking migrations in the areas where fisheries research activities will occur.

6.7.3 Shortnose Sturgeon

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. The range extended from the St John River in New Brunswick, Canada to the Indian River in Florida. Today, only 19 populations remain ranging from the St. Johns River, Florida (possibly extirpated from this system) to the Minas Basin in Nova Scotia, Canada (NMFS 1998a; Dadswell *et al.* 2016). The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 kilometers. Population sizes vary across the species' range. From available estimates, the smallest populations in the action area occur in the Merrimack and Penobscot rivers (~ several hundred to several thousand adults depending on population estimates used; M. Kieffer, U.S. Geological Survey, pers. comm.; Dionne 2010), while the largest populations are found in the nearby Saint John River in Canada (~18,000; Dadswell 1979) and Hudson River (~61,000; Bain *et al.* 1998). As indicated in Kynard (1997), adult abundance is less than the minimum estimated viable population abundance of 1,000 adults for five of 11 surveyed northern populations and all natural southern populations. Kynard (1997) indicates that all aspects of the species' life history indicate that shortnose sturgeon should be abundant in most rivers. As such, the expected abundance of adults in northern and north-central populations should be thousands to tens of thousands of adults. The only river systems likely supporting populations of these sizes are the Saint John, Hudson and possibly the Delaware and the Kennebec, making the continued success of shortnose sturgeon in these rivers critical to the species as a whole. While no reliable estimate of the size of either the total species or the shortnose sturgeon population in the Northeastern U.S. exists, it is clearly below the size that could be supported if the threats to shortnose sturgeon were removed.

Shortnose sturgeon mainly occupy the deep channel sections of large rivers. They feed on a variety of benthic and epibenthic invertebrates including mollusks, crustaceans (amphipods, chironomids, isopods), and oligochaete worms (Vladykov and Greeley 1963; Dadswell 1979 *in* NMFS 1998a). Shortnose sturgeon have similar lengths at maturity (45-55 centimeters fork length) throughout their range, but, because sturgeon in southern rivers grow faster than those in northern rivers, southern sturgeon mature at younger ages (Dadswell *et al.* 1984). Shortnose sturgeon are long-lived (30-40 years) and, particularly in the northern extent of their range, mature at late ages. In the north, males reach maturity at 5 to 10 years, while females mature between 7 and 13 years. Based on limited data, females spawn every three to five years while males spawn approximately every two years. The spawning period is estimated to last from a few days to several weeks. Spawning begins from late winter/early spring (southern rivers) to mid to late spring (northern rivers)[4] when the freshwater temperatures increase to 8º-9ºC. Several published reports have presented the problems facing long-lived species that delay sexual maturity (Crouse *et al.* 1987; Crowder *et al.* 1994; Crouse 1999). In general, these reports concluded that animals that delay sexual maturity and reproduction must have high annual survival as juveniles through adults to ensure that enough juveniles survive to reproductive maturity and then reproduce enough times to maintain stable population sizes.

7.0 EFFECTS OF THE ACTIONS

As discussed in the *Description of the Proposed Actions,* the proposed Federal actions are the disbursement of funds by the U.S. FWS for 113 fisheries surveys carried out by 11 states and the District of Columbia. U.S. FWS provides these funds on a five-year cycle. The majority of the fisheries surveys to be funded (80 out of 113) were included and assessed in the prior 2013 opinion, while some new studies have been added and others have been completed and are no longer included. Sea turtles, shortnose sturgeon, and Atlantic sturgeon may be affected by the state fisheries surveys proposed to be funded in a number of ways including: (1) capture in or interactions with survey or sampling gear; (2) interactions with research vessels; (3) effects to their prey; and (4) effects to their habitat. The analysis will be organized along these topics.

[4] For purposes of this consultation, Northern rivers are considered to include tributaries of the Chesapeake Bay northward to the Minas Basin in Canada. Southern rivers are those south of the Chesapeake Bay down to Florida.

We consider 113 studies in this consultation. We have five or more years of monitoring data for 85 of these studies. Of the 85 studies for which we have five or more years of data, 25 studies have had at least one interaction with a NMFS listed species and 60 studies have not interacted with any NMFS listed species. The 25 studies that have previously interacted with listed species will not be changed in a way that would be expected to increase or decrease the risk of future interactions, so we anticipate that these studies will continue to interact with listed species. Similarly, the 60 studies where no interactions with NMFS listed species have occurred will not be changed in a way that would be expected to increase the risk of future interactions, so we anticipate that there will continue to be no interactions.

We have less than five years of data for 28 studies, some of which are newly funded and others which began to be funded under the last U.S. FWS funding cycle from 2013-2017. For these studies, we could not rely on prior interactions or a lack of interactions with listed species as a primary indicator of future interactions. Instead, for each of these studies, we considered the gears to be used and the areas to be surveyed. If the study utilized gear types that were extremely unlikely to interact with listed species (e.g., fyke nets, plankton nets, dip nets, push nets, hoop nets, trap nets, cast nets, eel pots, pound nets, surface trawls, among others, as determined by our review of fishing gear interactions in this and prior opinions), we determined that no future interactions were likely to occur. However, if the study utilized a gear type known to interact with NMFS listed species (e.g., bottom trawls, gillnets, seines, fishway traps, electrofishing gear), we then looked to the geographic location of the study and considered whether there was an overlap in time and space between the studies to be conducted and NMFS listed species such that an interaction was reasonably likely to occur over the next five years.

In total, 88 of the 113 studies have not interacted with NMFS listed species in the past and are not expected to going forward following our assessment of their history of takes, the gears being used, and the geographic areas being surveyed (Table 20). We anticipate that 25 of the studies proposed for funding over the next five years will interact with NMFS listed species due to their overlap in time and space with those species and our knowledge of past interactions for those types of gears (Table 21). Two of the 25 studies for which we anticipate interactions are cooperative research projects involving the NEFSC and are covered for incidental takes under an existing and still valid 2016 programmatic opinion. Of the 33 newly funded studies, only two are likely to result in adverse effects to NMFS listed species: the Rhode Island Weekly Fish Trawl Surveys and the Massachusetts Holyoke Dam Fish Passage Evaluation. The Holyoke Dam study is anticipated to result in incidental take that is already covered under an existing Federal Regulatory Energy Commission (FERC) opinion for that hydroelectric facility.

Table 20. State fisheries surveys proposed to be funded by U.S. FWS with no documented interactions with ESA-listed species through 2017 and for which we do not anticipate future interactions. A set of stars (***) next to a survey name indicates that it was added to the list of projects proposed for funding since the previous 2013 opinion.

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
ME	Striped Bass Acoustic Telemetry Study	Hook and line	2007-2016	N/A	0	0	0	0
NH	Anadromous Alosid Restoration and Evaluation	Fishway trap	1972-2016	N/A	0	0	0	0
NH	Estuarine Survey of Juvenile Finfish	Beach seine (30.5 m)	1997-2016	1,980 hauls	0	0	0	0
NH	Rainbow Smelt Survey***	Fyke net	2008-2017	518 sampling trips	0	0	0	0
MA	Fish Community Assessments	Boat, backpack and barge electrofishing, Gill net, Beach seine (100 ft)	2003-2016	3 hours boat electrofishing and 3 seine hauls in Connecticut River	0	0	0	0
MA	Essex Dam Fish Passage Facility Evaluation	Fishway trap	1982-2016	N/A	0	0	0	0
MA	Pawtucket Dam Fish Passage Facility Evaluation***	Fish lift	1986-2016	N/A	0	0	0	0
MA	Winter Founder Year Class Strength Survey	Beach seine (6 m)	1976-2016	1,866 hauls	0	0	0	0
MA	Cooperative Striped Bass Tagging Study	Hook and line	1991-2016	N/A	0	0	0	0
MA	Massachusetts Large Pelagics Research Project	Hook and line	1988-2016	N/A	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
MA	Striped Bass Acoustic Telemetry Study	Hook and line	2008-2016	N/A	0	0	0	0
MA	Monitoring Spawning Behavior and Movement of Atlantic Cod - Hook and line	Hook and line	2009-2016	N/A	0	0	0	0
MA	Monitoring Spawning Behavior and Movement of Atlantic Cod - Long line	Long line	2012-2016	N/A	0	0	0	0
MA	Population and Spawning Habitat Monitoring for Rainbow Smelt	Fyke net	1988-2016	N/A	0	0	0	0
MA	Monitoring of Biological Parameters and Habitat Characteristics for River Herring and American Shad	Dip net	1984-2016	N/A	0	0	0	0
MA	Restoration of American Shad in the Charles River	Boat electrofishing	2006-2016	N/A	0	0	0	0
MA	River Herring Trap and Transfer	Beach seine	1984-2016	N/A	0	0	0	0
RI	Seasonal Fishery Assessment in Rhode Island and Block Island Sound	Bottom trawl (12.1 m)	1977-2016	3,755 tows	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
RI	Narragansett Bay Monthly Fish Assessment	Bottom trawl (12.1 m)	1990-2016	3,334 tows	0	0	0	0
RI	Young-of-the-Year Survey of Selected Rhode Island Coastal Ponds and Embayments	Beach seine	1994-2016	2,391 hauls	0	0	0	0
RI	Juvenile Marine Finfish Survey	Beach seine	1988-2016	2,520 hauls	0	0	0	0
RI	Block Island Juvenile Finfish Survey***	Beach seine	2015-2017	96 hauls	0	0	0	0
RI	Assessment of Marine Fish Habitat***	Beach seine	2016-2017	14 hauls	0	0	0	0
RI	Enhancing Degraded Marine Habitats***	Gill net, Eel pot	2014-2017	144 sets	0	0	0	0
RI	Winter Flounder Spawning Stock Biomass	Fyke net	1999-2017	461 sets	0	0	0	0
RI	Ventless Pot Multispecies Monitoring	Fish pot	2014-2017	667 sets	0	0	0	0
RI	American Shad and River Herring Restoration and Enhancement - Fishway trap***	Fishway trap (Potter Hill Dam)	1979-2016	N/A	0	0	0	0
RI	American Shad and River Herring Restoration and	Beach seine	1986-2016	N/A	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
	Enhancement - Beach seine***							
CT	Estuarine Seine Survey	Beach seine (7.6 m)	1988-2016	2,601 hauls	0	0	0	0
CT	Monitor Warmwater Fish Populations in Lakes and Large Rivers***	Boat electrofishing	2012-2016	9 hours	0	0	0	0
CT	Channel Catfish Management***	Boat electrofishing, trap net, hoop net	2012-2016	96 hours (hoop nets)	0	0	0	0
CT	Survey of Diadromous Fishes in the Connecticut River***	Beach seine	2008-2016	3,904 hauls	0	0	0	0
NY	Long Island Sound Trap Survey	Fish trap	2007-2016	3,977 hauls	0	0	0	0
NY	Western Long Island Sound Seine Survey	Beach seine (61 m, 152 m)	1984-2016	5,617 hauls	0	0	0	0
NY	Young-of-the-Year American Eel Survey	Fyke net	2000-2016	924 sets	0	0	0	0
NY	Artificial Reef Monitoring	Fish trap	2007-2009	N/A	0	0	0	0
NY	Alosine Juvenile Abundance Survey	Beach seine (30.5 m)	1980-2016	7,249 hauls	0	0	0	0
NJ	Protection and Restoration of Inland Fisheries and Aquatic Habitats - Invasive Species Assessments***	Boat electrofishing	2012-2016	3.5 hours	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
NJ	Assessment of the Biological Integrity of Inland Fisheries - Warmwater Species Assessments***	Boat electrofishing	2012-2016	1.5 hours	0	0	0	0
NJ	Assessment of the Biological Integrity of Inland Fisheries - Anadromous Species Assessments***	Boat electrofishing, backpack electrofishing, gill net, trap net, seine, cast nets, dip net, fyke net	2012-2016	N/A	0	0	0	0
NJ	Relative Abundance of Selected Finfish Species in Delaware Bay	Bottom trawl (4.9 m)	1991-2016	1,938 tows	0	0	0	0
NJ	River Herring Survey***	Gill net, beach seine	2013-2016	N/A	0	0	0	0
PA	Estimate of Black Bass Population Density	Boat electrofishing	1982-2016	464 hours	0	0	0	0
PA	Long Term Fish Population Monitoring and Management Technique Evaluations (Striped Bass)	Boat electrofishing	1995-2016	243 hours	0	0	0	0
DE	Nanticoke River Juvenile Shad Seine Survey***	Beach seine	2012-2016	153 hauls	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
DE	Nanticoke River Adult Shad Boat Electrofishing***	Boat electrofishing	2012-2016	37.9 hours	0	0	0	0
DE	Christina River Juvenile Alosid Survey***	Beach seine	2014-2016	121 hauls	0	0	0	0
DE	Stream and Tidal Tributary Fish Survey***	Bottom trawl, beach seine, electrofishing	1986-1990	242 trawl hauls, 60 seine hauls, 155 electrofishing samples	0	0	0	0
DE	Structure Oriented Fish Assessment Program***	Fish trap, hook and line	Started 2017	N/A	0	0	0	0
MD	Tidal Largemouth Bass Survey	Boat electrofishing	1999-2016	194 hours	0	0	0	0
MD	Invasive Species Studies	Boat electrofishing	2008-2016	N/A	0	0	0	0
MD	Coastal Bays Fisheries Investigations - Beach Seine Survey	Beach seine (15.2 m, 30 m)	1972-2016	1,593 hauls	0	0	0	0
MD	Submerged Aquatic Vegetation Beach Seining Program	Beach seine (15.2 m)	2012-2016	171 hauls	0	0	0	0
MD	Summer Juvenile American and Hickory Shad Seine Survey	Beach seine (61 m)	2004-2016	2,354 hauls	0	0	0	0
MD	Spring Adult American and Hickory Shad Electrofishing Survey	Boat electrofishing	2001-2016	650 runs	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
MD	Spring American Shad Gill Net Brood Stock Collection	Gill net	2002-2016	1,395 sets	0	0	0	0
MD	Spring Hickory Shad Electrofishing Brood Stock Collection	Boat electrofishing	2005-2016	139 days	0	0	0	0
MD	American Shad Larval Survey***	Plankton net	2015-2016	N/A	0	0	0	0
MD	American Shad Adult Gillnet Survey***	Gill net	2015-2016	62 sets	0	0	0	0
MD	Upper Chesapeake Bay Winter Trawl Survey	Bottom trawl (7.6 m)	1999-2016	1,565 tows	0	0	0	0
MD	Fishery Independent Choptank River Fyke Net Survey	Fyke net	1989-2016	6,990 days	0	0	0	0
MD	Juvenile Aloside Trawl and Seine Survey	Bottom trawl (4.9 m), Beach seine (30.5 m)	2005-2016	N/A	0	0	0	0
MD	American Shad Hook and Line Survey***	Hook and line	1987-2016	1,615 hours fished	0	0	0	0
MD	River Herring Gill Net Survey***	Gill net	2013-2017	200 sets	0	0	0	0
MD	Alosid Ichthyoplankton Survey***	Towed plankton net	2011-2016	N/A	0	0	0	0
MD	Migratory Fish Gill Net Survey***	Gill net	2013-2016	194 sets	0	0	0	0
MD	Juvenile Striped Bass Seine Survey	Beach seine (30.5 m)	1957-2016	10,432 hauls	0	0	0	0
MD	Marine and Estuarine Finfish Ecological and Habitat Investigations	Bottom trawl (4.9 m), Beach seine (30.5 m)	1957-2016	1,952 samples from 2012-2016	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
MD	Ichthyoplankton Surveys***	Towed plankton net (0.5 m)	2012-2016	2,233 sets	0	0	0	0
MD	Mycobacteriosis in Striped Bass Resident to Chesapeake Bay	Hook and line, Pound net, Beach seine	2003-2016	N/A	0	0	0	0
DC	Fish Population Surveys – Electrofishing	Boat electrofishing	1990-2016	762.5 hours	0	0	0	0
DC	Fish Population Surveys - Seining	Beach seine (30.5 m)	1990-2016	1,451 hauls	0	0	0	0
DC	Fish Tagging Surveys	Boat electrofishing	1999-2016	77 hours	0	0	0	0
DC	Push Net Survey	Push net	2005-2016	755 pushes	0	0	0	0
DC	American Eel Studies (Adult)	Eel pot	2009-2016	92,160 pot soak hours	0	0	0	0
DC	American Shad Stock Enhancement	Gill net	2006-2016	91 hours	0	0	0	0
DC	Blue Catfish Diet Study***	Low frequency electrofishing	2011-2016	24 hours	0	0	0	0
VA	Tidal River Fish Community Monitoring	Boat electrofishing	1990-2016	490 hours	0	0	0	0
VA	Tidal River Fish Catfish Surveys	Boat electrofishing	1993-2016	123 hours	0	0	0	0
VA	American Shad Restoration - Gill Netting	Gill net	1994-2016	>9,000 sets	0	0	0	0

State	Survey	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles	Marine Mammals
VA	American Shad Restoration – Electrofishing	Boat electrofishing	1994-2016	>350 hours	0	0	0	0
VA	Northern Snakehead Monitoring in Virginia	Boat electrofishing	2004-2016	N/A	0	0	0	0
VA	American Shad Monitoring Program - Fyke Netting	Fyke net	2011-2016	N/A	0	0	0	0
VA	Adult Spawning River Herring Monitoring – Rappahannock***	Staked gill net	Started 2016	8 fishing days	0	0	0	0
VA	Adult Spawning River Herring Monitoring – Chickahominy***	Staked and drift gill nets	2014-2016	28 days staked net in 2016, 10 days drift net in 2016	0	0	0	0
VA	Juvenile Alosid Monitoring***	Surface trawl	2015-2016	204 tows in 2016	0	0	0	0
VA	Juvenile Striped Bass Beach Seine Survey	Beach seine (30.5 m)	1967-2016	10,330 hauls	0	0	0	0
VA	Striped Bass Spawning Stock Assessment – Electrofishing***	Boat electrofishing	Starting 2018	N/A	0	0	0	0

Table 21. U.S. FWS funded state surveys with documented past interactions with ESA-listed species through 2017 and for which we anticipate future interactions. A set of stars (***) next to a survey name indicates that it was added to the list of projects proposed for funding since the previous 2013 opinion.

State	Survey	Location	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
ME	Juvenile Striped Bass and Alosine Beach Seine Survey	Kennebec, Androscoggin, and Penobscot estuaries	Beach seine (17 m)	1979-2016	3,554 hauls	0	3	0
ME	Maine-New Hampshire Inshore Trawl Survey (also covered under NEFSC programmatic biological opinion)	Coastal Maine and New Hampshire	Bottom trawl (17.3 m)	2000-2017	3,196 tows	23	0	0
MA	Holyoke Dam Fish Passage Facility Evaluation (covered under FERC biological opinion)***	Connecticut River	Fish lift	1998-2016	N/A	1 reported since 1975	Numerous (180 reported between 2016-2017)	0
MA	Westfield River Fish Passage Facility Evaluation	Westfield River	Fishway trap	1997-2016	N/A	0	1	0
MA	Fishery Resource Assessment (also covered under NEFSC programmatic biological opinion)	Coastal Massachusetts	Bottom trawl (11.8 m)	1978-2016	7,286 tows	1	0	0
RI	University of Rhode Island Weekly fish Trawl Survey***	Narragansett Bay	Bottom trawl	1959-2017	5,500 tows	2	0	0
CT	Long Island Sound Trawl Survey	Long Island Sound	Bottom trawl (9.1 m)	1984-2016	6,989 tows	443	0	2

State	Survey	Location	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
NY	New York Small Mesh Survey	Peconic Bay	Bottom trawl (4.9 m)	1987-2016	11,220 tows	0	0	2
NY	Spawning Stock Survey of American Shad, River Herring and Striped Bass	Hudson River	Haul seine (152 m, 305 m)	1983-2016	2,052 hauls	0	3	0
NY	Striped Bass Electrofishing	Hudson River	Boat electrofishing	1989-2016	N/A	0	33	0
NY	Striped Bass Juvenile Abundance Survey	Hudson River	Beach seine (71 m)	1979-2016	5,221 hauls	2	1	0
NY	American Shad Spawning Habitat Studies	Hudson River	Gill net	2009-2011	94 sets	1	0	0
NJ	New Jersey Ocean Trawl Survey	Coastal New Jersey	Bottom trawl (25 m)	1988-2016	5,364 tows	390	0	16
NJ	Cooperative Striped Bass Tagging in Delaware Bay	Delaware Bay	Gill net	1989-2016	3,621 sets	60	0	0
NJ	Delaware River Juvenile Striped Bass Seine Survey	Delaware River	Beach seine (30.5 m)	1980-2016	7,782 hauls	0	1	0
DE	Delaware River Striped Bass Spawning Stock Assessment	Delaware River	Boat electrofishing	1991-2016	444 hours	0	1	0
DE	Delaware River Largemouth Bass Monitoring Program	Delaware estuaries	Boat electrofishing	1989-2016	399 hours	1	0	0
DE	Bottom Trawl Sampling of Juvenile Fishes in Delaware's Estuaries	Delaware estuaries	Bottom trawl (4.9 m)	1980-2016	12,124 tows	14	6	4

State	Survey	Location	Gear	Historical Time Period	Historical Total Effort	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
DE	Bottom Trawl Sampling of Adult Groundfish in Delaware Bay	Coastal waters of Delaware	Bottom trawl (9.3 m)	1966-2016	2,975 tows	53	3	18
MD	Coastal Bays Fisheries Investigations - Trawl Survey	Coastal bays of Maryland	Bottom trawl (4.9 m)	1972-2016	5,197 tows	0	0	1
MD	Spring Striped Bass Experimental Drift Gill Net Survey	Potomac River and Upper Chesapeake Bay	Gill net	1985-2016	2,260 days	2	0	0
VA	American Shad Monitoring Program - Gill Netting	York, James and Rappahannock rivers	Gill net	1998-2016	23,760 hours through 2011	229	0	0
VA	Juvenile Fish Trawl Survey	Chesapeake Bay	Bottom trawl (9.1 m)	1955-2016	31,722 tows from 1988-2016	56	0	4
VA	Chesapeake Bay Multispecies Monitoring and Assessment Program	Chesapeake Bay	Bottom trawl (13.7 m)	2002-2016	5,240 tows	4	0	8
VA	Striped Bass Spawning Stock Assessment - Gill Netting	James and Rappahannock rivers	Gill net	1991-2011	N/A	3	0	0

These 25 state survey activities identified in Table 21 fall into several broad categories: beach and haul seining, bottom trawling, fish passage facilities (fishway trap), boat electrofishing, and gillnetting. Our effects analysis below as it relates to impacts of the state fisheries surveys to listed sea turtles, shortnose sturgeon, and Atlantic sturgeon is organized by gear type.

7.1 Beach and Haul Seines

Captures of sea turtles and sturgeon in beach and haul seines are rare, with serious injury or mortality as a result of the interaction extremely unlikely due to the short duration of tow times and limited amount of spatial area covered. We are aware of many nearshore seine studies that occur annually in rivers and coastal waters where these species are present with very few observations recorded. Three beach seine studies carried out with grant funds have captured shortnose and/or Atlantic sturgeon. Additionally, New York's haul seine study targeting juvenile American shad, river herring, and striped bass has captured shortnose sturgeon. No beach or haul seine studies in the action area are known to have captured sea turtles, and thus we do not expect them to over the five-year funding cycle. While the haul seine study uses seines that are set by boat, they are hauled in by hand on the beach, making it similar to the other beach seine studies considered here.

The Maine DMR study targeting alosines and striped bass in the Kennebec, Androscoggin, and Penobscot estuaries has been ongoing since 1979. Approximately 3,554 beach seine hauls have been conducted and only three shortnose sturgeon have been captured. There have been no interactions with Atlantic sturgeon or sea turtles. New Jersey's Delaware River juvenile striped bass beach seine survey has been ongoing since 1980. Approximately 7,782 beach seine hauls have been conducted with the capture of one shortnose sturgeon. Similarly, New York's Hudson River striped bass beach seine survey has been ongoing since 1979. The survey proponents have completed 5,221 hauls and captured just one shortnose sturgeon and two Atlantic sturgeon. New York's haul seine survey has captured three shortnose sturgeon over 2,052 hauls since 1983.

The type of habitats where beach and haul seining occurs somewhat overlap with the preferred habitat for adult shortnose and sub-adult and adult Atlantic sturgeon, the only life stages of sturgeon likely to be encountered during these surveys. However, shortnose and Atlantic sturgeon are a benthic species typically found in deeper river channels near the bottom. Shortnose and Atlantic sturgeon also forage on tidal mud flats where an abundance of preferred prey items are found. Typically, beach and haul seines will be set in shallow sub-tidal waters near the shore on sandy, gravel or mud substrates. Given the area to be sampled, the short duration of the net sets (15 minutes), and the limited amount of spatial area covered, there is a low likelihood of an encounter with a sturgeon. This is consistent with the low number of encounters that have occurred in the Maine, Delaware, and New York studies noted above. In the future, we anticipate that no more than three shortnose will be captured in Maine DMR beach seine surveys during any five-year grant period. We also expect that no more than one shortnose sturgeon will be captured in New Jersey's Delaware River juvenile striped bass beach seine survey every five years and that no more than two Atlantic sturgeon and four shortnose sturgeon will be captured every five years in beach and haul seine studies carried out by New York. This is consistent with past capture rates.

The New York beach and haul seine surveys occur in the Hudson River. Mixed stock analysis for the Hudson River indicates that the majority of Atlantic sturgeon in the river are likely to originate from the New York Bight DPS (92%), with 6% originating from the Gulf of Maine DPS and 2% from the Chesapeake Bay DPS. These percentages are based on genetic sampling of individuals (n=39) captured within the Hudson River and, therefore, represent the best available information on the likely genetic makeup of individuals occurring in that area. Based on this, we anticipate that the two Atlantic sturgeon captured in the New York seine surveys are most likely to originate from the New York Bight DPS. However, it is possible that they may be from the Gulf of Maine or Chesapeake Bay DPS.

Direct effects from handling and capture in the seine net may result in some physical damage (e.g., chafing, minor abrasions) and physiological stress to shortnose and Atlantic sturgeon, which may extend post-capture. However, captured sturgeon will be handled for minimal amounts of time and released immediately. Any injuries are expected to be minor and full recovery is expected to be rapid and complete. No serious injuries or mortalities are anticipated.

Beach and haul seine net sampling typically involves sets of up to 15-20 minutes. This will cause sturgeon to be temporarily withheld from normal behaviors. However, based on results of gill net studies in other river systems where the same fish have been repeatedly captured, the stress related to this capture is likely to be temporary and sturgeon are expected to be able to rapidly recover and resume their normal behaviors. Accordingly, if captured fish are handled correctly, we expect the level of stress to be low enough to result in no long term physiological effects, behavioral change, or changes to normal migratory behaviors.

In summary, we anticipate the following captures of shortnose and Atlantic sturgeon in beach and haul seine surveys during the five-year grant period:

Survey	**No. of Shortnose Sturgeon**	**No. of Atlantic sturgeon**
Maine beach seine	3	0
New Jersey beach seine	1	0
New York beach and haul	4	2: 1 NYB DPS and either 1 GOM or 1 CB DPS

7.2 Bottom Otter Trawls

As indicated in Table 21, the only trawl surveys to be funded with the potential for ESA listed species interactions are eleven bottom otter trawl surveys conducted by the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, and Virginia. The potential for capture of sea turtles, shortnose sturgeon, and Atlantic sturgeon in bottom otter trawl gear is well established (see for example, Henwood and Stuntz 1987; NRC 1990; Lutcavage and Lutz 1997; Lutcavage *et al*. 1997; ASSRT 2007; Murray 2015a). Here, we establish the expected number of sea turtles and sturgeon that will be captured in the various bottom otter trawl surveys.

Background information on sea turtle interactions with bottom otter trawl gear

Sea turtles forcibly submerged in any type of restrictive gear can eventually suffer fatal consequences from prolonged anoxia and/or seawater infiltration of the lung (Lutcavage and Lutz 1997; Lutcavage *et al.* 1997). A study examining the relationship between tow time and sea turtle mortality in the shrimp trawl fishery showed that mortality was strongly dependent on trawling duration, with the proportion of dead or comatose sea turtles rising from 0% for the first 50 minutes of capture to 70% after 90 minutes of capture (Henwood and Stuntz 1987).

Following the recommendations of the NRC to reexamine the association between tow times and sea turtle deaths, the data set used by Henwood and Stuntz (1987) was updated and re-analyzed (Epperly *et al.* 2002; Sasso and Epperly 2006). Seasonal differences in the likelihood of mortality for sea turtles caught in trawl gear were apparent. For example, the observed mortality exceeded 1% after 10 minutes of towing in the winter (defined in Sasso and Epperly (2006) as the months of December-February), while the observed mortality did not exceed 1% until after 50 minutes in the summer (defined as March-November; Sasso and Epperly 2006). In general, tows of short duration (<10 minutes) in either season have little effect on the likelihood of mortality for sea turtles caught in the trawl gear and would likely achieve a negligible mortality rate (defined by the NRC as <1%). Longer tow times (up to 200 minutes in summer and up to 150 minutes in winter) result in a rapid escalation of mortality, and eventually reach a plateau of high mortality, but will not equal 100%, as a sea turtle caught within the last hour of a long tow will likely survive (Epperly *et al.* 2002; Sasso and Epperly 2006). However, in both seasons, a rapid escalation in the mortality rate did not occur until after 50 minutes (Sasso and Epperly 2006) as had been found by Henwood and Stuntz (1987). Although the data used in the NRC reanalysis were specific to bottom otter trawl gear in the U.S. south Atlantic and Gulf of Mexico shrimp fisheries, the authors considered the findings to be applicable to the impacts of forced submergence in general (Sasso and Epperly 2006).

Sea turtle behaviors may influence the likelihood of them being captured in bottom trawl gear. Video footage recorded by the NMFS, Southeast Fisheries Science Center (SEFSC), Pascagoula Laboratory indicated that sea turtles will keep swimming in front of an advancing shrimp trawl, rather than deviating to the side, until they become fatigued and are caught by the trawl or the trawl is hauled up (NMFS 2002). Sea turtles have also been observed to dive to the bottom and hunker down when alarmed by loud noise or gear (Memo to the File, L. Lankshear, December 4, 2007), which could place them in the path of bottom gear such as a bottom otter trawl. With respect to oceanographic features, a review of the data associated with the 11 sea turtles captured by the scallop dredge fishery in 2001 concluded that the sea turtles appeared to have been near the shelf/slope front (D. Mountain, pers. comm.).

There are very few reports of sea turtles dying during research trawls. Based on the analysis by Sasso and Epperly (2006) and Epperly *et al.* (2002) as well as information on captured sea turtles from past state trawl surveys, the NEAMAP and NEFSC bottom trawl surveys, as well as the NEFSC FSB observer program, tow times less than 30 minutes will likely eliminate the risk of death from forced submergence for sea turtles caught in the bottom otter trawl survey gear.

During the spring and fall bottom trawl surveys conducted by the NEFSC from 1963-2017, a total of 85 loggerhead sea turtles were captured. Only one of the 85 loggerheads suffered injuries (cracks to the carapace) causing death. All others were alive and returned to the water unharmed. One leatherback and one Kemp's ridley sea turtle have also been captured in the NEFSC bottom trawl surveys and both were released alive and uninjured. NEFSC bottom trawl survey tows are approximately 30 minutes in duration. All 20 loggerhead, 28 Kemp's ridley, and one green sea turtles captured in the NEAMAP surveys since 2007, as well as those in all other trawl surveys considered in this opinion, have also been released alive and uninjured. At present, we do not know what rates of post-release mortality may be occurring, although studies for bottom trawl gear have begun to be funded in recent years. However, Swimmer *et al*. (2014) indicate that there are few reliable estimates of post-release mortality for sea turtles because of the many challenges and costs associated with tracking animals released at sea. For now, we assume that post-release mortality for sea turtles in bottom otter trawl gear where tow times are short (less than 30 minutes) is minimal to non-existent unless the turtle is already compromised to begin with. In that case, however, the animal would likely be retained onboard the vessel and transported to a rehabilitation center rather than released back into the water.

Background information on shortnose and Atlantic sturgeon interactions with trawl gear
Atlantic sturgeon captured in trawl gear as bycatch during commercial fishing operations have a mortality rate of approximately 5% (based on information in the NEFOP database). The shorter tow durations and careful handling of any sturgeon once on deck during fisheries research surveys is likely to result in an even lower potential for mortality, as commercial fishing trawls tend to be significantly longer in duration. None of the hundreds of Atlantic and shortnose sturgeon captured in past state ocean, estuary, and inshore trawl surveys have had any evidence of serious injury and there have been no recorded mortalities. Both the NEFSC and NEAMAP surveys have recorded the capture of hundreds of Atlantic sturgeon since the inception of each. To date, there have been no recorded serious injuries or mortalities. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no serious injuries or mortalities of any sturgeon have been recorded in those surveys either.

7.2.1 Maine and New Hampshire Inshore Trawl Survey

The Maine-New Hampshire Inshore Trawl Survey is a stratified random survey with a fixed component. The inshore area sampled includes four depth strata: 5-20 fathoms, 21-35 fathoms, 36-55 fathoms, and >56 fathoms out to approximately the 12-mile limit, and five longitudinal regions off the coasts of Maine and New Hampshire based on oceanographic, geologic, and biological features. Together, 20 separate strata exist. With the addition of the fourth strata, the total survey area increased from ~3,626 nautical miles (NM^2) to ~4,665 NM^2. To keep sampling density of the original strata roughly equivalent with previous surveys, an additional 15 stations were added to the original goal of 100 stations per survey. A target of 115 stations is selected for sampling in each survey resulting in a sampling density of one station for every 40 NM^2. Number of tows per stratum is apportioned according to its total area.

No sea turtles have ever been captured during these surveys, and we do not expect them to be going forward as the project area is not known as an area of regular occurrence for any of the four listed species. A total of 23 Atlantic sturgeon have been captured and released alive out of a total of 3,196 total tows made by this survey from 2000 to 2017. The annual catch rate has been low, ranging from one to three, with no more than two sturgeon caught per month. There has been an average of two Atlantic sturgeon captured per year. Based on this long term average, we would expect no more than 10 Atlantic sturgeon to be captured in any five-year grant period. Based on the mixed stock analysis (using results from the NEFOP database because we do not have site-specific analysis), we expect that: 49% of the captured Atlantic sturgeon will originate from the NYB DPS (five individuals), 20% from the SA DPS (two individuals), 14% from the CB DPS (one individual), 11% from the GOM DPS (one individual) and 4% from Carolina DPS (one individual). Given the short duration of the tows (less than 30 minutes), we do not anticipate the serious injury or mortality of any Atlantic sturgeon captured in this trawl survey.

Although there have been no recorded shortnose sturgeon interactions in the Maine-New Hampshire Inshore Trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Although primarily found in river systems along the U.S. Atlantic coast, shortnose sturgeon have been known to migrate from the Penobscot River to the Merrimack River via the Gulf of Maine and from the Merrimack River to the Connecticut River via the Gulf of Maine and Long Island Sound (SSSRT 2010). They also prefer benthic habitats in which to forage, over which the bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period, yet like Atlantic sturgeon, this capture would not lead to serious injury or mortality.

7.2.2 Massachusetts Fishery Resource Assessment Bottom Trawl Survey

The objective of these surveys is to collect, analyze, and summarize bottom trawl data for fishery management purposes. This survey occurs statewide in coastal/territorial waters. The daytime survey of Massachusetts inshore territorial waters is conducted in three-week time spans during the months of May and September. The survey utilizes a stratified random sampling design consisting of 23 sampling strata based on six depth zones (<30, 31-60, 61-90, 91-120, 120-180, and >180 feet) and five geographic regions (Massachusetts Bay north to the Merrimac River, Cape Cod Bay, waters south and east of Cape Cod and Nantucket, Nantucket Sound, and Vineyard Sound/ Buzzards Bay). A total of 101 stations are allocated to strata, in approximate proportion to each stratum's area; a minimum of two stations are assigned to each stratum to provide estimates of variance. Sampling intensity is about one station every 19 square nautical miles. Tow locations within each stratum are randomly chosen. An alternate tow site in the same stratum is selected if concentrations of fixed gear or untowable bottom are expected.

Trawl survey sampling is conducted using a *MarineFisheries* 3/4, North Atlantic type, two seam "whiting" trawl (39' headrope/51' footrope). The trawl is equipped with a fine mesh cod end liner, rubber disc (3.5"), chain sweep, wooden trawl doors (6' x 40" x 325 lbs) and 10 fathom legs. At each station, the standard tow is 20 minutes at an average speed of 2.5 knots with a 3:1

scope. Vessel services are provided by the Northeast Fisheries Science Center, NOAA R/V GLORIA MICHELLE (65' LOA, 355 hp); this vessel has been chartered since 1982. As a results, these surveys and any incidental takes of listed species are also assessed and covered under the NEFSC's 2016 programmatic opinion for fisheries and ecosystem research.

The bottom trawl survey has been conducted for nearly 40 consecutive years. During that time, over 7,286 tows have been completed. No shortnose sturgeon or sea turtles have been encountered to date. To date, only one Atlantic sturgeon has been captured (in Cape Cod Bay in May 1986) and it was released alive. Because future surveys will follow identical protocols to the past and operate in the same areas, it is reasonable to anticipate similar catch levels as in the past. Based on this, we expect that no more than one Atlantic sturgeon from any of the five listed DPSs will be captured during the spring or fall Massachusetts survey over the five-year grant period.

Although there have been no recorded shortnose sturgeon interactions in the Massachusetts trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Although primarily found in river systems along the U.S. Atlantic coast, shortnose sturgeon have been known to migrate from the Penobscot River to the Merrimack River via the Gulf of Maine and from the Merrimack River to the Connecticut River via the Gulf of Maine and Long Island Sound (SSSRT 2010). They also prefer benthic habitats in which to forage, over which the bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period, yet like Atlantic sturgeon, this capture would not lead to serious injury or mortality.

Given the rarity of sea turtle captures during this study, but also considering that due to warming ocean temperatures, Cape Cody Bay and other Massachusetts waters are likely to become an increasingly utilized area of occurrence for juvenile hard-shelled sea turtles (primarily Kemp's ridleys and loggerheads) and adult leatherbacks (NMFS unpublished data), we anticipate that an interaction is reasonably certain to occur going forward, but at a rate of no more than one sea turtle captured over the five-year grant period. We expect that future captures could be of loggerhead, Kemp's ridley, leatherback, or green sea turtles as any of the four species could be present in Massachusetts waters during the spring or fall survey periods.

The short duration of the tows and careful handling of any sturgeon or sea turtles once on deck are likely to result in a low potential for mortality. None of the sturgeon and only one sea turtle captured in similar research trawl surveys over the past 70 years have had any evidence of serious injury leading to mortality. Based on this information, we expect that all sturgeon or sea turtles captured in future Massachusetts surveys will be alive and released uninjured.

7.2.3 Rhode Island Weekly Fish Trawl Survey

The University of Rhode Island (URI), Graduate School of Oceanography (GSO) has been monitoring finfish populations in Narragansett Bay since 1959 using a coastal trawl survey.

These data provide weekly identification of finfish and crustacean assemblages. Since the inception of the weekly fish trawl, survey tows have been conducted within Rhode Island territorial waters at two stations, one representing habitat of Narragansett Bay and one representing more open-water type habitats, characteristic of Rhode Island Sound. The weekly time step of this survey and its long duration are two unique characteristics of this survey. The short duration time step (weekly) has enough definition to capture migration periods and patterns of important finfish species and the length of the time series allows for the characterization of these patterns back into periods of time that may represent different productivity or climate regimes for many of these species.

A weekly trawl survey is conducted on the URI research vessel Cap'n Bert. Two stations are sampled each week: one off Wickford represents conditions in mid Narragansett Bay (Fox Island) and one at the mouth of Narragansett Bay represents conditions in Rhode Island Sound (Whale Rock). The same otter trawl net design has been used for the past 57 years. A half-hour tow is made at each station at a speed of two knots.

Since survey inception in 1959 more than 5,500 tows have been conducted. There have been no incidental captures of shortnose sturgeon or sea turtle, although there have been two captures of live Atlantic sturgeon (one in 1963 and one in 1965). Due to these historic captures and the likelihood of Atlantic sturgeon foraging and occurrence in the trawling areas in and around Narragansett Bay (ASSRT 2007), we expect the potential non-lethal capture of one Atlantic sturgeon per year. Because future surveys will follow identical protocols to the past and operate in the same areas, it is reasonable to anticipate similar catch levels as in the past. Based on this, we expect that no more than one Atlantic sturgeon will be captured during the URI weekly trawl surveys from any of the five listed DPSs over the five-year grant period.

Although there have been no recorded shortnose sturgeon interactions in the URI weekly trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given its distribution, habitat preferences, and migratory patterns. Although primarily found in river systems along the U.S. Atlantic coast, shortnose sturgeon have been known to migrate from the Merrimack River to the Connecticut River via the Gulf of Maine and Long Island Sound and can potentially occur throughout Narragansett Bay in areas where suitable forage is present (SSSRT 2010). They prefer benthic habitats in which to forage, over which the bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period.

Given the rarity of sea turtle captures during this study, but also considering that due to warming ocean temperatures, Narragansett Bay and other Rhode Island waters are likely to become an increasingly utilized area of occurrence for sea turtles (NMFS unpublished data), we anticipate that an interaction is reasonably certain to occur going forward, but at a rate of no more than one sea turtle capture over the five-year grant period. We expect that future captures could be of loggerhead, Kemp's ridley, leatherback, or green sea turtles as any of the four sea turtle species could be present in Rhode Island waters during the spring or fall survey periods.

The short duration of the tows and careful handling of any sturgeon or sea turtles once on deck are likely to result in a low potential for mortality. None of the sturgeon and only one sea turtle captured in similar research trawl surveys over the past 70 years have had any evidence of serious injury leading to mortality. Based on this information, we expect that all sturgeon or sea turtles captured in future URI weekly trawl surveys will be alive and released uninjured.

7.2.4 Connecticut Long Island Sound Trawl Survey

The Connecticut Department of Energy and Environmental Protection's (CT DEEP) principal fishery independent sampling program is their long-term trawl survey, used to monitor trends in species composition and abundance in Long Island Sound. The Long Island Sound Trawl Survey began in 1984 to provide fishery independent monitoring of important recreational species in Long Island Sound. A stratified-random design based on bottom type and depth interval is used and 40 sites are sampled monthly to establish seasonal patterns of abundance and distribution. Since 1991, the sampling schedule has been conducted under a spring/fall format.

The Long Island Sound Trawl Survey is conducted from longitude 72°03' W to 73°39' W (New London to Greenwich, Connecticut). The sampling area includes Connecticut and New York waters from 5-46 meters in depth and is conducted over mud, sand, and transitional (mud/sand) sediment types. Sampling is divided into spring (April-June) and fall (September-October) periods, with 40 sites sampled monthly for a total of 200 sites annually. The sampling gear employed is a 14-meter otter trawl with a 51-millimeter codend set. The otter trawl is towed from the R/V John Dempsey for 30 minutes at approximately 3.5 knots, depending on the tide.

Sampling procedures have been modified in recent years to minimize the potential for injury to listed species, namely Atlantic sturgeon. When sampling in a season and area where the chance of catching a sturgeon is high (based on historic survey catch) and water depth is greater than 27 meters, gear retrieval speed is reduced to decrease the stress induced by rapid changes in pressure. When a sturgeon is detected in the net, it is removed as quickly and carefully as possible. Subsequent handling and processing follow protocols described in "A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons" (Kahn and Mohead 2010). Although not required, we recommend that all U.S. FWS funded state fisheries surveys follow those protocols.

7.2.4.1 Capture in trawl gear – sea turtles

The potential for capture of sea turtles in bottom otter trawl gear is well established (see Henwood and Stuntz 1987, NRC 1990, Lutcavage and Lutz 1997, Lutcavage *et al*. 1997). Here, we establish the expected number of sea turtles that will be captured in the Long Island Sound Trawl Surveys. The surveys take place in April, May, June, September, and October.

To date, only two sea turtles have been captured in these surveys since they began in 1984. One loggerhead sea turtle was observed in the Hempstead Harbor (NY) area of western Long Island Sound on September 12, 1989. The state of Connecticut reported that this capture occurred during a major hypoxia event. The dissolved oxygen level at that site was 0.3 mg/L and little else was observed in that sample (a few crabs and lobster and less than 20 fish). The turtle was a fairly small individual (estimated at approximately 40 lbs) and was released in good condition. In

September 2015, a juvenile Kemp's ridley sea turtle was captured in the survey and released alive and uninjured.

Because sea turtles are known to regularly occur in Long Island Sound and are vulnerable to capture in bottom trawl gear, we expect that future surveys will capture sea turtles. However, based on the capture of only two sea turtles during the surveys to date, we expect that no more than one sea turtle will be captured over the five-year grant period. While the captures were of a loggerhead and Kemp's ridley, we know that green and leatherback sea turtles also occur in the action area and are vulnerable to capture in trawl gear. Because these species have been captured in trawl gear operating in nearby areas in similar surveys (*i.e.*, the NEAMAP surveys carried out by VIMS), we anticipate that future Long Island Sound trawl surveys could capture any of the four species of sea turtles. Because of this, we expect that the one sea turtle captured over the next five years could be any of the four species likely to occur in the action area. Based on past results and the short duration of the tows, we do not anticipate that any sea turtles captured during the Long Island Sound Trawl surveys will be seriously injured or killed.

7.2.4.2 Capture in trawl gear – Atlantic sturgeon

Since 1984, the state of Connecticut has conducted 6,989 survey tows in Long Island Sound, while a total of 395 Atlantic sturgeon have been captured since 1991 (Table 22). There have been no known mortalities of Atlantic sturgeon encountered in the history of this survey. The fall period (September-October) has accounted for 71% while spring sampling (April-June) has accounted for 29% of Atlantic sturgeon captured since 1991. Tow data from the previous 2013 opinion on these U.S. FWS funded surveys indicated that the frequency of survey tows that encounter Atlantic sturgeon (percent of positive tows) is similar in the spring and fall periods, varying from 0.0%-6.3% in the spring and from 0.0%-7.5% in the fall. Sturgeon ranged from 54 to 213 centimeters fork length indicating that both adults and sub-adults have been captured. Up to 47 Atlantic sturgeon have been captured in a single tow with no serious injuries observed.

Because CT DEEP has recorded all captures of Atlantic sturgeon, we have information that allows us to predict future interactions. The maximum number of captures in a given year is 60, while the mean number of captures per year since 1991 is 14.6 (395 captures/27 years). Over a five-year period, that equates to 75 Atlantic sturgeon captures during these surveys (after rounding 14.6 up to 15). However, it is important to consider that in some years dating back to the switch to spring and fall seasonal surveys, the number of captures has been high (reaching 60 individuals per year in 1993 and 1994). The greatest number of Atlantic sturgeon captured in any five-year period in the last 15 years was 85 individuals (2002-2006). Because these surveys will follow identical protocols to the past and operate in the same areas, it is reasonable to anticipate similar catch levels in future years. Based on this, we anticipate that no more than 85 Atlantic sturgeon will be captured during any five-year grant period. This number is similar in scale to the five-year average from 1991-2017 and takes into account the potential for high capture years which, based upon past records, are reasonably certain to occur given the overlap between the surveys and spring and fall aggregations which are known to routinely occur off Long Island, New York.

Table 22. Captures of Atlantic Sturgeon in the Long Island Sound Trawl survey: 1991-2017.

Year	**Spring (April – June)**	**Fall (September – October)**	**Annual Total**
1991	2	1	3
1992	8	22	30
1993	3	57	60
1994	7	53	60
1995	3	3	6
1996	2	1	3
1997	2	3	5
1998	14	3	17
1999	27	12	39
2000	4	3	7
2001	3	15	18
2002	10	8	18
2003	0	29	29
2004	0	8	8
2005	6	3	9
2006	8	13	21
2007	5	13	18
2008	2	5	7
2009	1	17	18
2010	1	-	1
2011	3	2	5
2012	0	1	1
2013	0	0	0
2014	0	0	0
2015	0	1	1
2016	3	7	10
2017	0	1	1
Total	**114**	**281**	**395**

Based on the mixed stock analysis available for Long Island Sound, we expect that 79% of the captured Atlantic sturgeon will originate from the NYB DPS (66 individuals), 10% from the SA DPS (nine individuals), 7% from the CB DPS (six individuals), 4% from the GOM DPS (three individuals), and 0.5% from the Carolina DPS (one individual).

The short duration of the tow and careful handling of any Atlantic sturgeon once on deck is likely to result in an extremely low potential for mortality. None of the 395 Atlantic sturgeon captured since 1991 have had any evidence of serious injury and there have been no recorded mortalities. The NEFSC and NEAMAP surveys have recorded the capture of hundreds of Atlantic sturgeon since their inceptions, and to date, there have been no recorded serious injuries or mortalities in those similar surveys. In the Hudson River, a trawl survey that incidentally captures shortnose and Atlantic sturgeon has been ongoing since the late 1970s. To date, no serious injuries or mortalities of any sturgeon species have been recorded. Similarly, no serious injuries or mortalities of Atlantic sturgeon captured in the New Jersey ocean trawl surveys have been recorded. Based on this information, we expect that all Atlantic sturgeon captured in the Long Island Sound Trawl surveys will be alive and released uninjured.

7.2.4.3 Capture in trawl gear – shortnose sturgeon
Although there have been no recorded shortnose sturgeon interactions in the Long Island Sound Trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Although primarily found in river systems along the U.S. Atlantic coast, shortnose sturgeon have been known to migrate from the Merrimack River to the Connecticut River via the Gulf of Maine and Long Island Sound and from the Connecticut River to the Hudson River via Long Island Sound and the East River (SSSRT 2010). They also prefer benthic habitats in which to forage, over which the bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period, yet like Atlantic sturgeon, this capture would not lead to serious injury or mortality.

7.2.5 New York Peconic Bay Small Mesh Survey

The New York Small Mesh Trawl Survey is used for long-term monitoring and assessment of annual recruitment of important marine finfish species in New York waters, including weakfish, winter flounder, scup, tautog, bluefish and northern puffer. The survey is also used to meet the ASMFC compliance criteria for the ISFMP for winter flounder, horseshoe crab, and weakfish.

The research vessel used throughout the survey has been the *David H. Wallace,* a 10.7-meter lobster-style workboat. At each location, a 4.9-meter semi-balloon shrimp trawl with a small mesh liner was towed for 10 minutes at approximately 2.5 knots. From 1987 through 1990, nets were rigged using nylon scissors and tow ropes set by hand and retrieved using a hydraulic lobster pot hauler. Following the 1990 sampling season, the research vessel was re-outfitted to include an A-frame, wire cable and hydraulic trawl winches. For the remainder of the study, wire cable was substituted for the nylon scissor and tow ropes, and nets were set and retrieved using hydraulic winches.

Since the inception of this project in 1987 a total of 11,220 sample tows have been completed in the Peconic Bay study area with two sea turtles captured (see Figure 14 below for capture locations). Both sea turtles, one loggerhead and one green, were released from the net alive and uninjured. There have been no interactions with shortnose or Atlantic sturgeon during this survey and therefore no adverse effects to them are expected.

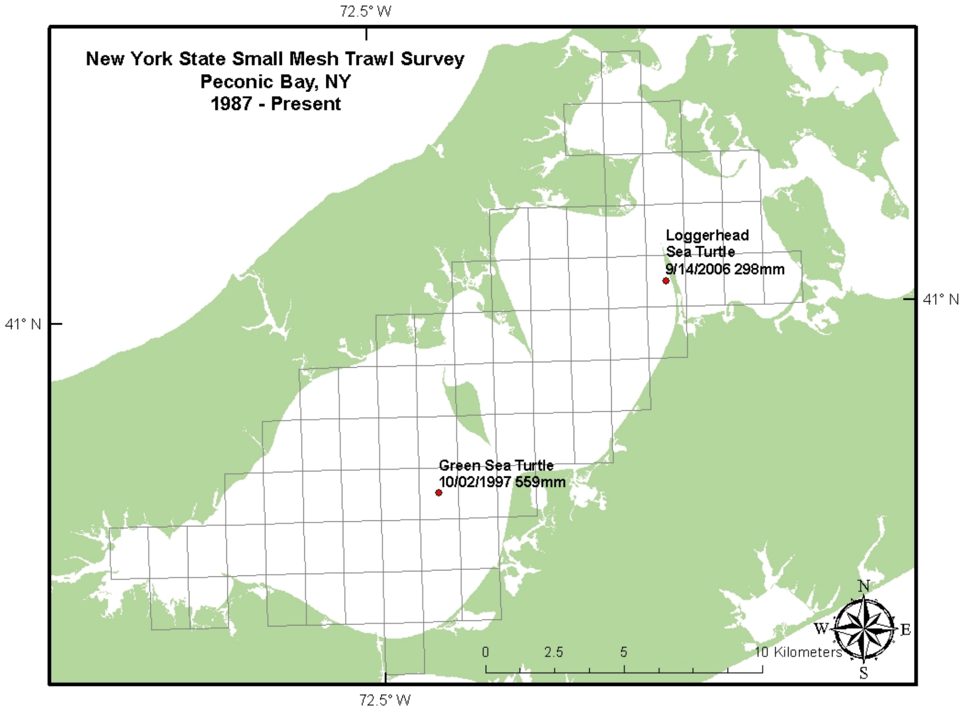

Figure 14. Sampling grid and turtle catch data for the New York Small Mesh Trawl Survey.

Based the history of past captures (only two over the past 30 years of surveys), the use of Peconic Bay for juvenile sea turtle foraging (Morreale and Standora 1998), and the knowledge that due to warming ocean temperatures, inshore waters of Long Island are likely to become increasingly utilized by hard-shelled sea turtles (NMFS unpublished data), we anticipate the capture of no more than one sea turtle during any five-year grant period. We expect that the individual captured will be either a loggerhead, Kemp’s ridley, or green sea turtle. Given the short tow times, we do not anticipate any serious injuries or mortalities.

7.2.6 New Jersey Ocean Trawl Survey

The Ocean Trawl stock assessment program monitors the occurrence, distribution, and relative abundance of fishes inhabiting the nearshore coastal waters of New Jersey and has been ongoing since August 1988. The data collected in the Ocean Trawl survey are used in the coastwide stock assessments for summer flounder, winter flounder, striped bass, bluefish, black sea bass, scup, tautog and weakfish. The survey is also used to meet the ASMFC compliance criteria for the ISFMP for winter flounder.

The survey is a random stratified sampling design with a total of five cruises per year. Annually, 186 trawl samples are performed during January (30), April (39), June (39), August (39), October (39). Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net is a two-seam trawl with forward netting of 12 centimeters (4.7 inches) stretch mesh and rear netting of 8 centimeters (3.0 inches) and is lined with a 6.4 millimeter

(0.25 inch) bar mesh liner. The headrope is 25 meters (82 feet) long and the footrope is 30.5 meters (100 feet) long. The trawl bridle is 20 fathoms long, the top leg consisting of 0.5 inch wire rope and the bottom leg comprised of 0.75 inch wire rope covered with 2 3/8-inch diameter rubber cookies. A 10-fathom groundwire, also made of 0.75-inch wire rope covered with 2 3/8-inch diameter rubber cookies, extends between the bridle and trawl doors. The survey upgraded to ”Type 11” Thyboron brand steel trawl doors, measuring 1.5 m x 1.2 m and weighing 720 lbs, in August 2015.

Trawl samples are collected by towing the net for 20 minutes (approximately 1 nautical mile), timed from the moment the winch brakes are set to stop the deployment of tow wire to the beginning of haulback. Enough tow wire is released to provide a wire length to depth ratio of at least 3:1, but in shallow (<10 meters) water this ratio is often much greater, in order to provide separation between the vessel and the net. The survey area consists of New Jersey coastal waters from Ambrose Channel, or the entrance to New York Harbor, south to Cape Henlopen Channel, or the entrance to Delaware Bay, and from about the 3 fathom isobath inshore to approximately the 15 fathom isobath offshore.

7.2.6.1 Capture in trawl gear – sea turtles

Here, we establish the expected number of sea turtles that will be captured in the New Jersey ocean trawl surveys. As noted above, these surveys take place in January, April, June, August and October. Table 23 below provides information on all sea turtles captured in past New Jersey ocean trawl surveys conducted since the program began in 1989 (n=16, nine loggerheads, one leatherback, four Kemp’s ridleys, and two greens).

Table 23. Captures of Sea Turtles in the New Jersey Ocean Trawl Survey: 1989-2017.

Year	Month	Species	Weight (kg)	Alive	Injured
1991	August	loggerhead	80	YES	NO
1993	June	Loggerhead	19.87	YES	NO
1993	June	Loggerhead	28.32	YES	NO
2002	October	Loggerhead	30	YES	NO
2005	June	Loggerhead	N/A	YES	NO
2005	August	Leatherback	227.27	YES	NO
2005	August	Loggerhead	160	YES	NO
2007	October	Loggerhead	19.78	YES	NO
2009	August	Loggerhead	117.22	YES	NO
2011	June	Loggerhead	41.93	YES	NO
2012	October	Kemp’s ridley	3.71	YES	NO
2013	October	Green	6.05	YES	NO
2015	June	Kemp’s ridley	5.23	YES	NO
2015	October	Green	2.78	YES	NO
2016	October	Kemp’s ridley	4.44	YES	NO
2016	October	Kemp’s ridley	2.54	YES	NO

This study has been ongoing for 28 years and the mathematical average capture of sea turtles per year is 0.57 turtles/year. The number of sea turtles captured is variable from year to year, with most years having zero captures. However in 2005, three turtles were captured (the highest number recorded per year thus far), while in 1993, 2015, and 2016, two turtles were captured. The capture of sea turtles has become more frequent since 2002, as compared to the 1980s and 1990s. Applying the annual average over the complete time series, we would expect two sea turtles to be captured during any five-year grant period. However, the capture rate is higher in more recent years. The capture of three sea turtles in 2005 suggests that future interaction rates could be as high as three sea turtles per year. The maximum number of sea turtles captured in any particular survey has been two (August 2005 and October 2016), with no more than one sea turtle captured in all other surveys. Therefore, based upon the highest interaction rate, we anticipate the capture of no more than 15 sea turtles in any five-year grant period.

With the exception of one capture of a leatherback in 2005, all other captures of sea turtles in the ocean trawl survey have been hard-shelled species. Based on past interactions, we anticipate that the majority of the 15 captured sea turtles will be loggerheads, closely followed by Kemp's ridleys, greens, and then leatherbacks. Using the percentages of turtles recorded during the New Jersey Ocean Surveys to date, we expect that up to eight loggerheads, four Kemp's ridleys, two greens, and one leatherback will be captured over the next five-year funding period.

Tows for the New Jersey Ocean trawl surveys will be 20 minutes in duration. Based on the analysis by Sasso and Epperly (2006) and Epperly *et al*. (2002) discussed previously, as well as information on captured sea turtles from past New Jersey trawl surveys, the NEAMAP and NEFSC trawl surveys, as well as the NEFSC FSB observer program, a 20-minute tow time for the bottom otter trawl gear to be used in the survey will likely eliminate the risk of serious injury and mortality from forced submergence for sea turtles caught in the bottom otter trawl survey gear. We do not anticipate any serious injuries or mortalities of captured sea turtles.

7.2.6.2 Capture in trawl gear – Atlantic sturgeon

The New Jersey Department of Environmental Protection has recorded all sturgeon interactions since 1988 (Table 24). This information allows us to predict future interactions. To date, a total of 390 Atlantic sturgeon captures have been recorded, with a maximum of 35 captures in a given year (range of 0-35, mean of 13 captures per year).

Table 24. Captures of Atlantic Sturgeon in the New Jersey Ocean Trawl Survey: 1988-2017.

Year	Number of Atlantic Sturgeon Caught
1988	2
1989	33
1990	15
1991	25
1992	27
1993	10
1994	0
1995	6
1996	3
1997	12
1998	1
1999	11
2000	1
2001	4
2002	5
2003	16
2004	23
2005	18
2006	35
2007	24
2008	26
2009	12
2010	10
2011	3
2012	3
2013	1
2014	1
2015	32
2016	10
2017	21
Total	**390**

Because these surveys will follow identical protocols to the past and operate in the same areas, it is reasonable to anticipate similar catch levels in the next five years. The highest number of sturgeon captures for any consecutive five-year period is 126 captures from 2004-2008. Because the capture rate has a high level of interannual variability, it is reasonable to use the highest five year total to predict future interactions, especially since that five-year period from 2004-2008 was not too long ago in the past. Therefore, we anticipate that no more than 126 Atlantic sturgeon will be captured during a five-year grant period. Based on the mixed stock analysis (using results from the NEFOP database because we do not have site-specific analysis), we expect that 49% of the captured Atlantic sturgeon will originate from the NYB DPS (62 individuals), 20% from the SA DPS (26 individuals), 14% from the CB DPS (18 individuals), 11% from the GOM DPS (14 individuals) and 4% from Carolina DPS (six individuals).

The short duration of the tow and careful handling of any sturgeon once on deck is likely to result in a low potential for mortality. None of the 390 Atlantic sturgeon captured in past New Jersey ocean trawl surveys have had any evidence of serious injury and there have been no recorded mortalities. The NEFSC and NEAMAP surveys have recorded the capture of hundreds of Atlantic sturgeon since their inception. To date, there have been no recorded serious injuries or mortalities. In the Hudson River, a similarly conducted trawl survey that incidentally captures Atlantic sturgeon has been ongoing since the late 1970s. To date, no serious injuries or mortalities of any sturgeon have been recorded. Based on this information, we expect that all Atlantic sturgeon captured in the New Jersey ocean trawl surveys will be alive and released uninjured.

7.2.6.3 Capture in trawl gear – shortnose sturgeon
There have been no recorded shortnose sturgeon interactions in the New Jersey Ocean Trawl Survey, and given the species' distribution, habitat preferences, and migratory patterns, there is currently no evidence of shortnose sturgeon making migrations in ocean waters along the coast of New Jersey (SSSRT 2010). Most shortnose sturgeon in New Jersey waters are likely to be found in the Hudson and Delaware River estuaries rather than open ocean waters. As a result, we do not expect shortnose sturgeon to be captured over the five-year funding period, and therefore no adverse effects to them are anticipated.

7.2.7 Delaware Estuary Bottom Trawl Survey

The objective of this study is to monitor trends in abundance and distribution and to determine year-class strength for a selected group of juvenile finfish. Sampling is conducted monthly from April through October at 33 stations in the Delaware Bay and six stations in the Delaware River above the Chesapeake and Delaware Canal. Twelve stations are sampled monthly in the Indian River and Rehoboth Bays (Inland Bays). The net used is a 4.9-meter (16-foot) semi-balloon otter trawl. Sampling at each station consists of a ten-minute trawl tow, usually made against the prevailing tide. Given the short tow times, we do not anticipate any serious injury or mortality of any captured sturgeon or sea turtles. All captured sturgeon and sea turtles are expected to be returned to the water alive and uninjured.

Since 1980, Delaware's 16-foot trawl survey has completed 12,124 bottom trawl tows in the Delaware Bay and River. Atlantic sturgeon have been captured on fourteen occasions. These fish were caught in 1989, 1990, 1993, 1995, 2006, 2010, 2011, 2014, 2015(x4), 2016, and 2017. The captured Atlantic sturgeon were measured and quickly returned to the water. There have been no mortalities associated with any of the 14 Atlantic sturgeon caught during these surveys. A total of six shortnose sturgeon have been captured during the surveys in 1996, 2002, 2008, 2010, 2015, and 2017, respectively. All of the shortnose sturgeon were returned to the water alive and uninjured. Five sea turtles have been caught by the surveys since 1980. Four of the sea turtles were loggerheads (in 1995, 1999, 2002, and 2015), and there was one recent Kemp's ridley capture in 2017. All these turtles were incidentally captured in the months of June and July. All sea turtles caught during the trawl surveys were released alive and in good condition.

Because these surveys will follow identical protocols to the past and operate in the same areas, it is reasonable to anticipate similar catch levels in these years. The highest average of Atlantic sturgeon captures for any consecutive five-year period is seven captures during 2013-2017. Because the capture rate has a high level of interannual variability, it is reasonable to use the highest five year total to predict future interactions, especially since that five-year period has happened very recently. Therefore, we anticipate that no more than seven Atlantic sturgeon will be captured during the five-year grant period.

Based on mixed stock analysis, we have determined that Atlantic sturgeon in the project area likely originate from the five DPSs at the following frequencies: NYB 58%; CB 18%; SA 17%; GOM 7%; and Carolina 0.5%. These percentages are largely based on genetic sampling of individuals (n=105) sampled in directed research targeting Atlantic sturgeon along the Delaware Coast, just south of Delaware Bay. This is the closest sampling effort (geographically) to the action area for which mixed stock analysis results are available. Because the genetic composition of the mixed stock changes with distance from the rivers of origin, it is appropriate to use mixed stock analysis results from the nearest sampling location. Therefore, this represents the best available information on the likely genetic makeup of individuals occurring in the action area. We also considered information on the genetic makeup of individuals captured within the Delaware River. However, we only have information on the assignment of these individuals to the river of origin and do not have a mixed stock analysis for these samples. The river assignments are very similar to the mixed stock analysis results for the Delaware Coastal sampling, with the Hudson/Delaware accounting for 55%-61% of the fish, James River accounting for 17%-18%, South Atlantic 17%-18%, and Gulf of Maine 9%-11%. The range in assignments considers the slightly different percentages calculated by treating each sample individually versus treating each fish individually (some fish were captured in more than one of the years during the three year study). Carolina DPS origin fish are only occasionally detected in samples taken in the Northeast and are not detected in either the Delaware Coast or in-river samples noted above. However, mixed stock analysis from some sampling efforts (e.g., Long Island Sound, n=275), indicates that approximately 0.5% of the fish sampled were Carolina DPS origin. Additionally, 4% of Atlantic sturgeon sampled in the NEFOP program were Carolina DPS origin. Because any Carolina origin sturgeon that were sampled in Long Island Sound could have swam through the action area on their way between Long Island Sound and their rivers of origin, it is reasonable to expect that 0.5% of the Atlantic sturgeon captured in the action area could originate from the Carolina DPS. Based on this analysis, of the seven anticipated Atlantic sturgeon captures, we expect four to originate from the New York Bight DPS, one from the Chesapeake Bay DPS, one from the South Atlantic DPS, and one from either the Gulf of Maine or Carolina DPS.

Based on past capture rates as described above (i.e., the maximum number of animals captured over any previous five-year period of the surveys), we anticipate the incidental capture of no more than two shortnose sturgeon and two sea turtles in the current five-year grant period from 2018-2022. Due to the known population trends and distribution of sea turtles in the area and capture rates from similar trawl surveys nearby, we anticipate that one of the sea turtles captured will be a loggerhead while the other will be either a Kemp's ridley, green, or leatherback. The short duration of the tows and careful handling of any sturgeon or sea turtles once on deck are likely to result in a low potential for mortality. None of the sturgeon and only one sea turtle captured in similar research trawl surveys over the past 70 years have had any evidence of serious injury leading to mortality. Based on this information, we expect that all sturgeon or sea turtles captured in future Delaware estuary bottom trawl surveys will be alive and released uninjured.

7.2.8 Delaware Bay Groundfish Bottom Trawl Survey

The objective of the Delaware Bay groundfish bottom trawl study is to monitor trends in abundance and distribution, to determine population age/size composition, and to develop pre-recruitment indices for selected inshore finfish species. Early sampling was conducted with the University of Delaware's research vessel "Wolverine," a 47-foot (14.3-meter) A-framed stern trawler. Sampling from March 1990 through July 2002 was conducted using the 65-foot (20-meter) research vessel "Ringgold Brothers." The "Ringgold Brothers" was a wooden displacement-hulled skipjack and was equipped with an eastern-rigged trawling system that deployed and retrieved the trawling gear from the starboard side. The State of Delaware purchased a custom-built stern-rigged research vessel which began service as the surveys' research platform in August of 2002. The 62-foot (19-meter) deep-'V' semi-displacement hulled research vessel, "First State," is equipped with an 'A'-frame stern trawling rig.

Tow durations in some of the previous surveys were 30 minutes; whereas, tow durations in the present survey are 20 minutes. Tows less than 20 minutes were rarely made (due to gear conflicts, etc.); however, in such cases, a 10-minute minimum tow time was required for the tow to be considered valid. The net used in the survey consisted of 3-inch (7.6-cm) stretch mesh in the wings and body, and 2-inch (5.1-cm) stretch mesh in the cod end. The trawl had a 30-foot 6-inch (9.3-m) x 1/2-inch (1.2-cm) headrope and a 39-foot 6-inch (12.0-m) x 1/2-inch footrope with 40-foot (12.2-m) leglines. The 54-inch x 28-inch (1.37-m x 0.71-m) doors were constructed of ¾-inch (1.9-cm) virgin pine lumber, bolted to a 2 inch x 4 inch (5.1cm x 10.2cm) strong back. The doors had a 2-inch x ¾-inch (5.1-cm x 1.9-cm) milled steel bottom shoe runner and ¼-inch (0.64-cm) galvanized chain bridles attached to ½-inch (1.3-cm) galvanized swivels at the head.

To date, Delaware's 30-foot trawl survey has completed 2,975 bottom trawl samples (20-minute tows) and 53 Atlantic sturgeon have been captured since the surveys began in 1966 (Table 25). The captured Atlantic sturgeon were measured and quickly returned to the water. There have been no mortalities associated with any of 53 Atlantic sturgeon caught during this survey.

Table 25. Annual numbers of Atlantic sturgeon caught from trawl sampling in the Delaware Bay.

YEAR	Number of Atlantic Sturgeon Caught
1966	2
1967	-
1968	-
1969	-
1970	-
1971	-
1979	12
1980	2
1981	2
1982	-
1983	-
1984	-
1990	3
1991	-
1992	-
1993	-
1994	1
1995	2
1996	3
1997	-
1998	-
1999	1
2000	2
2001	1
2002	-
2003	-
2004	-
2005	-
2006	1
2007	-
2008	1
2009	-
2010	-
2011	8
2012	
2013	1
2014	1
2015	2
2016	1
2017	7

The number of Atlantic sturgeon captured in this survey is highly variable, ranging from 0-12 with typical years having a catch of three or less and most years a catch of zero. The long-term annual average is 1.3 Atlantic sturgeon/year. Given the high interannual variability in captures, we have considered the possibility that catches in the future will be as high as the maximum number captured in any consecutive five-year period (16). As such, we expect that no more than 16 Atlantic sturgeon will be captured in any five-year grant period; none of the captures are assumed to result in serious injury or mortality. Based on the mixed stock analysis for Atlantic sturgeon in Delaware Bay, we have determined that Atlantic sturgeon in the project area likely originate from the five DPSs at the following frequencies: NYB 58%; CB 18%; SA 17%; GOM 7%; and Carolina 0.5%. Therefore, we anticipate the capture of nine individuals from the NYB DPS, three from the CB DPS, three from the SA DPS, and one from either the GOM or Carolina DPS.

Three shortnose sturgeon have been collected during the surveys since they began: one in 1991, one in 2006, and the third in 2009. The shortnose sturgeon were all returned to the water alive. As very few shortnose sturgeon have been captured in the past, with only two captures occurring in the highest five-year period from 2006-2010, we expect no more than two captures of shortnose sturgeon in the five-year grant period assessed in this opinion. Given the short tow times involved (10 minutes or less), we do not anticipate any serious injury or mortality. All captured shortnose sturgeon are expected to be returned to the water alive and uninjured.

A total of 18 sea turtles have been collected during the Delaware Bay groundfish trawl survey since 1966 (Table 26). Fifteen of the sea turtles captured were loggerheads and the remaining three were Kemp's ridleys. Nine of the turtles were captured in July and the remaining three were captured in June (two), August (four), September (two), and October (one). All sea turtles caught during the survey were released alive and in good condition.

The number of sea turtles captured has been variable, ranging from 0-4 per year. The highest number of captures in any consecutive five-year period was seven (2006-2010). Both loggerheads and Kemp's ridleys have been captured in this survey, with a ratio of 5:1 loggerheads to Kemp's ridleys. Based on past captures, in any future five-year period we expect the capture of no more than seven sea turtles. We expect the majority of these turtles will be loggerheads. We expect that at least one will be a Kemp's ridley and given the known occurrence of green and leatherback sea turtles in Delaware Bay, there could also be a capture of a green or leatherback. Therefore, we anticipate the capture of up to five loggerheads and up two Kemp's ridley, green, or leatherbacks (any combination of the three species). Given the short tow times and careful handling procedures in place, we do not anticipate any serious injury or mortality of sea turtles during these trawl surveys.

Table 26. Annual number of sea turtles caught from trawl sampling in the Delaware Bay.

Year	Loggerhead	Kemp's ridley
1966	-	-
1967	-	-
1968	-	-
1969	-	-
1970	-	-
1971	-	-
1979	-	-
1980	-	-
1981	-	-
1982	-	-
1983	-	-
1984	-	-
1990	-	-
1991	-	-
1992	-	-
1993	-	-
1994	-	-
1995	1	-
1996	1	-
1997	-	-
1998	-	2
1999	1	1
2000	2	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	4	-
2007	-	-
2008	2	-
2009	1	-
2010	-	-
2011	-	-
2012		
2013	1	
2014		
2015		
2016	2	

7.2.9 Maryland Coastal Bays Fisheries Investigations Trawl Survey

The Maryland Department of Natural Resources has conducted the Coastal Bays Fisheries Investigations Trawl Survey in the state's coastal bays since 1972, sampling with a standardized protocol since 1989. Trawl sampling is conducted at 20 fixed sites throughout Maryland's coastal bays on a monthly basis from April through October. A standard 4.9-meter (16 foot) semi-balloon trawl net is used in areas with a depth of greater than 1.1 meters (3.5 feet). Each trawl is a standard six-minute tow at a speed of approximately 2.8 knots. Trawl sites include locations in Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays, and 5,197 tows have been completed in these coastal bays since the trawl survey's inception.

Only one sea turtle has been captured since the trawl survey began, a loggerhead in October 1976 in Isle of Wight Bay. Given the rarity of sea turtle captures during this study, we anticipate that no more than one sea turtle will be captured in the five-year grant period. While only a loggerhead has been captured in the past, we expect that future captures could be of loggerhead, Kemp's ridley, green, or leatherback sea turtles since all are known to utilize Maryland coastal bays for foraging. Like each of the other trawl surveys discussed in this section, all sea turtle interactions are expected to be live captures that do not lead to serious injury or mortality.

No shortnose sturgeon have been captured since the trawl survey began, and none are anticipated to occur over the five-year period since shortnose sturgeon are not currently known to frequent the coastal bays of the Maryland Eastern Shore in which trawling will occur. Thus, no adverse effects to shortnose sturgeon are expected. Although there have been no recorded Atlantic sturgeon interactions in the Maryland coastal bays surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Atlantic sturgeon are primarily found in ocean waters and associated bays, estuaries, and coastal river systems along the U.S. Atlantic coast and have a more extensive range throughout U.S. Atlantic bays and estuaries than shortnose sturgeon. They also prefer benthic habitats in which to forage and overwinter, where the bottom trawling activities associated with these surveys will occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one Atlantic sturgeon from any of the five listed DPSs could be captured over the five-year funding period. As for sea turtles, this capture would not lead to serious injury or mortality.

7.2.10 Virginia Juvenile Fish Trawl Survey

The Virginia juvenile fish trawl survey conducted by VIMS is the oldest continuing monitoring program (56 years) for marine and estuarine fishes in the U.S. This survey provides a monthly assessment of abundance of juvenile marine and estuarine fishes and crustaceans in the tidal rivers and main stem of Chesapeake Bay.

They use a 30-foot (9.14-meter) semi-balloon otter trawl, with 1.5-inch (38.1-millimeter) stretched mesh and 0.25-inch (6.35-millimeter) cod-end liner, that is towed along the bottom for five minutes during daylight hours. Sampling in the Bay occurs monthly except during January and March, when few target species are available. Sampling in the tributaries also occurs monthly, at both the random stratified and historical fixed (mid-channel) stations. The stratification system is based on depth and latitudinal regions in the Bay, or depth and longitudinal regions in the rivers. Each Bay region spans 15 latitudinal minutes and consists of six strata: western and eastern shore shallow (4-12 feet), western and eastern shoal (12-30 feet), central plain (30-42 feet), and deep channel (≥42 feet). Each tributary is partitioned into four regions of approximately ten longitudinal minutes, with four depth strata in each (4-12 feet, 12-30 feet, 30-42 feet, and ≥42 feet). Strata are collapsed in areas where certain depths are limited.

There have been 56 Atlantic sturgeon captures since the study has been ongoing, with captures ranging from 1-7 Atlantic sturgeon per year. From 2014-2017, between one and three Atlantic sturgeon have been captured each year. The highest number of Atlantic sturgeon caught in any five-year period was 17 (1978-1982). Given the high interannual variability in captures, we have considered the possibility that catches in the future will be as high as the maximum number captured in any consecutive five-year period (17). As such, we expect that no more than 17 Atlantic sturgeon will be captured in any five-year grant period. Based on the mixed stock analysis (using results from the NEFOP database because we do not have site-specific analysis), we expect that: 49% of the captured Atlantic sturgeon will originate from the NYB DPS, 20% from the SA DPS, 14% from the CB DPS, 11% from the GOM DPS, and 4% from Carolina DPS. Therefore, we anticipate the capture of eight individuals from the NYB DPS, three from the SA DPS, three from the CB DPS, two from the GOM DPS and one from the Carolina DPS. Given the short duration of tows (less than 30 minutes), we do not anticipate the serious injury or mortality of any Atlantic sturgeon captured in this trawl survey.

Although there have been no recorded shortnose sturgeon interactions in the Virginia juvenile trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Recent evidence indicates that shortnose sturgeon have been found in the Rappahannock and James rivers and in the Virginia portion of the Bay mainstem, and they may also be present in the York River if suitable forage is present (Spells 1998; Balazik 2017; Balazik, pers. comm., February 10, 2018). They prefer benthic habitats in which to forage, over which the bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period, and like Atlantic sturgeon, this capture would not lead to serious injury or mortality.

Only four sea turtles have been captured during the 60-plus year history of this study, three loggerheads and one Kemp's ridley. Because sea turtles are known to regularly occur in Chesapeake Bay and the mouths of its tributaries, and are vulnerable to capture in bottom trawl gear, we expect that future surveys will capture sea turtles. Based on the capture of only four sea turtles during the surveys to date, we expect that no more than one sea turtle will be captured during the five-year funding period. While the captures have only been of loggerheads and a Kemp's ridley, we know that green and leatherback sea turtles also occur in the survey area and are vulnerable to capture in trawl gear. Because these species have been captured in trawl gear operating in nearby areas in similar surveys (*i.e.*, the NEAMAP surveys carried out by VIMS), we anticipate that future juvenile fish trawl surveys could capture any of the four species of sea turtles. Because of this, we expect that the one turtle captured over the five-year grant period is most likely to be a loggerhead or Kemp's ridley, but could also be a leatherback or green sea turtle. Based on past results and the short duration of the tows (less than 30 minutes), we do not anticipate that any of the sea turtles captured during the juvenile fish trawl surveys will be seriously injured or killed.

7.2.11 Virginia Chesapeake Bay Multispecies Monitoring and Assessment Program

The Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP) survey consists of five research cruises conducted by VIMS annually (usually around the months of March, May, July, September, and November) throughout the mainstem of Chesapeake Bay. During each cruise, up to 80 sites are sampled according to a stratified random design. At each sampling site, trawl gear is towed along the bottom for 20 minutes at approximately 3.0 knots and in the same general direction as the prevailing current. To date, there have been four Atlantic sturgeon captured and eight sea turtles (seven loggerheads and one Kemp's ridley), but no shortnose sturgeon. Information on these captures is detailed in Tables 27 and 28 below.

Table 27. Atlantic sturgeon interactions in the Virginia ChesMMAP surveys.

DATE	Time	Depth (ft)	Latitude	Longitude	Fork Length (mm)
01-Jul-05	1:45 PM	39	36.959	-76.084	708
18-May-06	7:48 AM	41	38.327	-76.353	508
02-Nov-10	3:49 PM	19	37.041	-76.200	1150
26-May-11	12:53 PM	19	37.075	-76.236	550

Table 28. Sea turtle interactions in the Virginia ChesMMAP surveys.

DATE	SPECIES	Length (cm)
7/10/2007	Loggerhead	104.5
6/4/2013	Loggerhead	N/A
6/4/2013	Loggerhead	91
6/5/2013	Loggerhead	85
7/10/2013	Loggerhead	N/A
9/5/2014	Kemp's ridley	70
7/10/2015	Loggerhead	98
5/28/2016	Loggerhead	96

The maximum number of sea turtles captured in any particular survey has been four (June and July 2013 survey), with no more than one sea turtle captured in all other surveys. Given the recent uptick of sea turtle captures during this study, we anticipate that no more than seven sea turtles will be captured in the five-year grant period, as that is the total number of captures that occurred during the most recent funding cycle (2013-2017) and is the maximum number captured during any five-year period of the surveys to date. While only loggerheads and one Kemp's ridley have been captured in the past, we expect that future captures could be loggerhead, Kemp's ridley, green, or leatherback sea turtles. We expect that at least one capture will be a Kemp's ridley and given the known occurrence of green and leatherback sea turtles in Chesapeake Bay, there could also be a capture of a green or leatherback. Therefore, we anticipate the capture of up to five loggerheads and up two Kemp's ridley, green, or leatherbacks (any combination of the three species). Given the short duration of the tows (less than 20 minutes), we do not anticipate the serious injury or mortality of any sea turtles captured in this survey.

Given these past interaction rates with Atlantic sturgeon, we expect that future surveys will capture no more than two Atlantic sturgeon during the five-year grant period, as that equates to the maximum number of captures that has been observed over any five-year period of the surveys. Based on the mixed stock analysis (using results from the NEFOP database because we do not have site-specific analysis), we expect that one of the captured Atlantic sturgeon will originate from the NYB DPS with the remaining individual originating from the SA, CB, GOM, or Carolina DPS. Given the short duration of the tows (less than 20 minutes), we do not anticipate the serious injury or mortality of any Atlantic sturgeon captured in this survey.

Although there have been no recorded shortnose sturgeon interactions in the ChesMMAP trawl surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Recent evidence indicates that shortnose sturgeon have been found in the Virginia portion of the Bay mainstem where suitable foraging, resting, or overwintering habitat is present (Balazik 2017; Balazik, pers. comm., February 10, 2018). They prefer benthic habitats in which to perform these activities, over which bottom trawling activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one shortnose sturgeon could be captured over the five-year funding period, and like Atlantic sturgeon, this capture would not lead to serious injury or mortality.

7.3 Fish Passage Facilities

The State of Massachusetts monitors the West Springfield fish passage facility (a Denil ladder) located at the first dam on the Westfield River, a tributary to the Connecticut River. Monitoring occurs seasonally, during the spring (April-July) and fall (September-October) fish passage seasons when American shad, blueback herring, and Atlantic salmon are migrating. The facility has been operational for over 20 years. To date, one shortnose sturgeon has been observed in the fishway. During the summer of 2007, a shortnose sturgeon was observed swimming near the base of the ladder. Around 48 hours later the fish was observed in the fish trap at the top of the ladder. The fish was removed from the trap and returned to the river with no apparent injuries.

The use of Denil ladders by shortnose sturgeon is rare. Ladders are installed at several hydroelectric facilities in the Northeast where shortnose sturgeon are known to occur, including the Brunswick Dam on the Androscoggin River, Maine, and Cabot Station on the Connecticut River, Massachusetts. Despite extensive monitoring programs at both facilities, no shortnose sturgeon have ever been documented using either ladder. The only documented occurrence of a shortnose sturgeon using a Denil ladder is at the Westfield River project.

As evidenced by the occurrence of only shortnose sturgeon in the trap in 20 years, the capture of a shortnose sturgeon in a fish trap at the top of a Denil ladder is a rare event. Because of this, we anticipate that no more than one shortnose sturgeon will be captured in the fish trap monitored by the State of Massachusetts in any five-year grant period. Given the intense monitoring of the fishway that occurs when it is open, any shortnose sturgeon in the ladder are expected to be seen. Ultimately, these fish would be removed and placed back downstream of the ladder. While these fish may experience minor injuries such as abrasions due to contact with the concrete, no significant injuries or mortalities are anticipated. The State of Massachusetts will ensure that any shortnose sturgeon in the ladder or fish trap are identified and safely removed. As such, any shortnose sturgeon caught in the Denil will not be allowed to pass upstream of the project where they could be permanently trapped or subject to serious injury or mortality while attempting to pass downstream of the project. Further, as response and removal from the ladder is anticipated to occur within 24 hours, any delay in carrying out normal behaviors will be temporary and not likely to result in the abandonment of spawning or any other fitness consequences for that individual.

No Atlantic sturgeon or sea turtles have been observed at the Westfield River fish trap, and given its location, no individuals from any of these species are anticipated to occur in the area.

The State of Massachusetts also monitors fish passage at the Holyoke Dam. The Holyoke Dam is located on the Connecticut River at rkm 139 between the City of Holyoke and the Town of South Hadley. The Holyoke Dam consists of a single dam structure, a three-level canal system, an impoundment, upstream and downstream fish passage facilities, six powerhouses, and appurtenant facilities. The counting/trapping facility at the Holyoke fishlifts is monitored during the period of upstream migration of American shad, blueback herring, sea lamprey, and other anadromous fish. From mid-April to mid-July anadromous fish species are identified and counted. The fishway is continuously monitored during these months in terms of efficiency and fishway induced mortality is evaluated daily. The fishway is also operated from mid-July through November for shortnose sturgeon upstream passage. In regards to fish ladder operations at the Holyoke Dam, all shortnose and Atlantic sturgeon passage at that facility is assessed and exempted under a recent 2017 opinion issued by NMFS GARFO to FERC (PCTS ID: NER-2017-14221). Therefore, the State of Massachusetts should refer to that opinion when funding or undertaking any research activities at that facility.

7.4 Boat Electrofishing

Electrofishing entails passing an electric current in the water to capture or control fish. The electric current causes fish within the effective area of the electric field to become temporarily stunned or immobilized (referred to as electrotaxis) to facilitate capture by nets. Three electrofishing surveys funded by U.S. FWS in the action area have interacted with shortnose or Atlantic sturgeon. Given the freshwater location of these surveys, we do not anticipate sea turtles to be present and therefore, do not anticipate any future interactions with sea turtles.

The three studies considered here in which prior interactions with listed species have occurred and are expected to continue include the New York Striped Bass Electrofishing project in the Hudson River, the Delaware Striped Bass Spawning Stock Assessment, and the Delaware River Largemouth Bass Monitoring Program. All three are described in detail in Appendix A and are discussed below.

New York Striped Bass Electrofishing

The New York study targets striped bass in the spring (late April-early May), near Kingston, New York (River Miles 87-96). This study has been ongoing since 1989. To date, 33 shortnose sturgeon have been captured (Table 29). These fish were observed stunned on the surface, and were then captured and returned to the river with no apparent injuries or mortality.

In most years (19 of 22) that sampling has occurred, no interactions with sturgeon have been recorded. In the years when sturgeon were observed, the number of interactions ranged from 3-22. For the most recent five year period when sampling occurred and interactions were documented (2011, 2010, 2008, 2007, 2006), the total number of interactions was 33 individuals. As a result, we would expect no more than 33 interactions with shortnose sturgeon in any future five-year grant period. No interactions with Atlantic sturgeon have been recorded in the past; therefore, we do not anticipate any future interactions with Atlantic sturgeon. Sea turtles do not occur in the area being sampled; therefore, we do not anticipate any future interactions with any species of sea turtle.

Table 29. Interactions with Sturgeon during New York Striped Bass Electrofishing Study in the Hudson River, 1989-2011.

	Electrofishing				
	Minutes	Target Species		Sturgeon	
Years	of Fishing	American Shad	Striped Bass	Shortnose	Atlantic
1989	300	0	129	0	0
1990	199	0	549	0	0
1991	1284	5	344	0	0
1992	1730	41	402	0	0
1993	1707	29	556	0	0
1994	1148	0	256	0	0
1995	393	150	177	0	0
1996	1305	0	623	0	0
1997	a	0	152	0	0
1998	1008	0	388	0	0
1999	2044	31	606	0	0
2000	2031	2	641	0	0
2001	1970	0	877	0	0
2002	2324	28	733	0	0
2003	2225	0	776	0	0
2004	1760	1	867	0	0
2005	1683	0	740	0	0
2006	1064	1	470	22	0
2007	1215	0	429	3	0
2008	2508	0	1144	8	0
2009	b	0		b	b
2010	903	0	457	0	0
2011	890	13	172	0	0
Total	28,801	301	11,488	33	0

a. Not recorded

b. No sampling

Delaware Striped Bass Spawning Stock Assessment and Largemouth Bass Monitoring Program

The Delaware striped bass spawning stock assessment survey is conducted in the lower Delaware River from the Delaware Memorial Bridge at rkm 110 to the mouth of Big Timber Creek, New Jersey, at rkm 152. The survey has been conducted since 1991 with 444 hours of electrofishing time. On May 3, 2011, the survey encountered a shortnose sturgeon. It experienced normal electrotaxis from electrofishing gear and was netted and allowed to recover in the live well. It was then measured, examined for external tags, and released after full recovery. The fish showed no signs of injury.

The state of Delaware also samples largemouth bass in the freshwater portion of the Nanticoke River in the fall (September-October). Sampling was conducted annually between 1989 and 2004, but was conducted only bi-annually (even number years) beginning in 2006. Only one interaction with a sturgeon has occurred since the study began. In 2008, while sampling the portion of the Nanticoke River that is between the U.S. Route 13 Bridge and the Blades drawbridge, one Atlantic sturgeon was observed. It came partially out of the water while the electric current was flowing. It was not stunned and was not collected but was estimated to be a sub-adult. That is the only sturgeon observed during the 28 years of electrofishing within this system.

For the Delaware studies, interactions with sturgeon have been rare, with one shortnose and one Atlantic sturgeon observed since both studies began (1989 and 1991). Given the past interaction rate, during the five year grant period, we expect that no more than one shortnose and no more than one Atlantic sturgeon will be encountered during the Delaware River striped bass and largemouth bass surveys. Atlantic sturgeon from all five DPSs could be present in the project area; therefore, the affected Atlantic sturgeon could be from any of the five DPSs.

Electrofishing Effects to Shortnose and Atlantic Sturgeon
As explained above, in a given five-year grant period, we anticipate electrofishing studies to interact with no more than 35 shortnose sturgeon in the New York survey and no more than one shortnose and one Atlantic sturgeon during the Delaware survey. Electrofishing can cause mortality or injury to fish. Limited information is available regarding effects to sturgeon. Moser (2000) conducted limited laboratory experiments on the effects of electrofishing on shortnose sturgeon. Shortnose sturgeon were exposed to electrical current for up to 60 seconds at a time, four to five minutes a day. Despite this extensive level of exposure, no mortality occurred. Shortnose sturgeon recovered very quickly from exposures and no difference in growth was seen in control and exposed subjects suggesting that feeding behaviors were not affected. Sturgeon were initially more responsive to the electroshocking treatment than catfish; however, they recovered quickly and moved to avoid the stimulus. More sturgeon than catfish rolled onto their side or completely rolled upside-down within the first 15 seconds. They also exhibited more twitching, rigor and avoidance behaviors than did catfish. But, sturgeon generally recovered immediately after the experiment. Over 75% of the sturgeon recovered immediately, with maximum recovery times of 5 minutes. Sturgeon were exposed repeatedly over a 32-day period and no long term mortality was seen.

Electrofishing injury rates for shovelnose sturgeon (*Scaphirhynchus platorynchus)* were documented to be 0% according to Snyder (2003). Lab studies conducted on juvenile white sturgeon (*Acipenser transmontanus*) showed higher injury rates for pulsed DC current compared to normal DC current (68% versus 10%) with no mortality (Holliman and Reynolds 2002). Available data for sturgeon indicate that mortality resulting from exposure to electrofishing current is likely to be zero. Based upon this information none of the shortnose and Atlantic sturgeon that are likely to be exposed to the electrofishing current (35 shortnose in New York, 1 shortnose and 1 Atlantic in Delaware) are expected to experience mortality. Exposed sturgeon are likely to be stunned and may roll or twitch. The available information indicates that most sturgeon will recover immediately, with all exposed sturgeon recovering within five minutes. It is likely that most sturgeon will recover and swim away before they are netted.

As none of the proposed studies overlap with spawning windows for sturgeon and any adults encountered during sampling will have time to recover prior to any subsequent spawning activities, no significant effects to spawning sturgeon are expected. Further, as recovery from exposure is expected to occur within five minutes, any delay in carrying out normal behaviors will be temporary and not likely to result in the abandonment of spawning or any other fitness consequences for that individual.

7.5 Gill Net

Five gill net surveys carried out by the states of New York, New Jersey, Maryland, and Virginia have captured Atlantic sturgeon. No interactions with shortnose sturgeon or sea turtles have been recorded in any of the gill net studies funded by the U.S. FWS, and therefore no adverse effects to them are anticipated going forward. Nearly all Atlantic sturgeon that have been captured in these state gillnet surveys have been released alive and uninjured, although there is the potential for mortality due to the gear type being used and potential for longer sets compared to bottom trawl, seine, and other types of gears known to interact with Atlantic sturgeon.

7.5.1 New York American Shad Spawning Habitat Studies

The State of New York initiated this program in 2009 to study the movement and habitat use of mature American shad in the Hudson River. Drift gill nets with 14-centimeter stretch mesh are set for short periods of time in early spring (April-early May), from areas just south of Kingston (rkm 148-155) downstream to Haverstraw Bay and the Tappan Zee Bridge area (rkm 20-65). To date, only one Atlantic sturgeon has been reported as captured. This fish was captured in 2011 and released with no apparent injuries.

Drift gill nets fish primarily at the surface. Sturgeon are benthic fish and are less likely to occur in the upper water column near the surface where the drift gill net fishes; therefore, the low number of encounters is consistent with our expectation that the interaction rate would be low. Based on past interactions, we expect no more than one Atlantic sturgeon will be captured during this study during the five year grant period. Atlantic sturgeon from all five DPSs could be present in the project area; therefore, the affected Atlantic sturgeon could be from any of the five DPSs. Gill net sets will be short. However, Atlantic sturgeon can be killed if entangled in gillnets. Based on NEFOP data, mortality rates in commercial fisheries using gillnets are approximately 20%. Given the known vulnerability of Atlantic sturgeon to gillnets, it is possible that the captured Atlantic sturgeon may be killed.

7.5.2 New Jersey Striped Bass Gillnet Survey

The gillnet survey for striped bass has been ongoing since 1989. Gillnets are set in water depths of 6-12 feet in areas of lower Delaware Bay near Bidwell's Creek and Reeds Beach, New Jersey. Nets are 5-6 inches stretch mesh. The survey takes place from early March through early May. Since the mid-1990s, the survey has operated with drift gill nets rather than anchored gear; average soak time is about 30 minutes. Only one 600-foot net is set at a time and all nets are monitored/tended throughout the study.

Since 1989, 3,621 sets have occurred. No interactions with any sea turtles or shortnose sturgeon have occurred. These species are vulnerable to capture in gillnets; however, the location of the deployment makes interactions with either unlikely. Because no captures of these species have occurred in this study in the past and there are no changes to the study proposed that would increase the potential for interactions (i.e., movement of the study to areas where certain listed species are more prevalent), we do not anticipate any future interactions with any species of sea turtles or shortnose sturgeon in the New Jersey striped bass gillnet survey.

No Atlantic sturgeon were captured prior to 1997. Since then, 60 Atlantic sturgeon have been captured in the striped bass survey (Table 30). With the exception of 2005, when 33 individuals were captured, the number of captures has been less than six per year. The maximum number of interactions in any consecutive five-year period was 41 (2003-2007). Given the high level of interannual variability in Atlantic sturgeon captures since the inception of the surveys, we consider it reasonable that the maximum number of Atlantic sturgeon caught in any five-year period (41) could be captured in a future five-year period. As a result, we anticipate that no more than 41 Atlantic sturgeon will be captured in any five-year grant period. Based on the mixed stock analysis for Delaware Bay, we have determined that Atlantic sturgeon in the project area likely originate from the five DPSs at the following frequencies: New York Bight 58%; Chesapeake Bay 18%; South Atlantic 17%; Gulf of Maine 7%; and Carolina 0.5%. Therefore, we anticipate the capture of 23 individuals from the NYB DPS, seven from the CB DPS, seven from the SA DPS, three from the GOM DPS, and one from the Carolina DPS.

The short duration of the net sets, constant monitoring/tending of the gear, and careful handling of any sturgeon once the net is hauled is likely to result in a low potential for mortality. None of the 60 Atlantic sturgeon captured in past New Jersey gillnet surveys for striped bass have had any evidence of injury and there have been no recorded mortalities. Information available from the NEFOP database suggests that mortality of Atlantic sturgeon in commercially fished sink gillnets is, on average, approximately 20%; however, mortality of sturgeon in gillnets set for fisheries research is much lower, on average around 1%. The duration of gillnet deployment is likely a primary factor in mortality rates. Based on the short duration of net sets (average of 30 minutes) and the constant observation/tending of the net, and past monitoring which indicates that no mortalities have occurred, we expect that the likelihood of an Atlantic sturgeon captured in future striped bass gillnet surveys suffering serious injury or mortality is very low (around 1% based on other research using gillnets to capture sturgeon). Therefore, we expect that no more than one of the 41 Atlantic sturgeon will die; this individual could originate from any of the five DPSs. All other captured Atlantic sturgeon will be alive and released uninjured.

Table 30. Atlantic sturgeon captures in the New Jersey striped bass gillnet survey: 1989-2017.

Year	# Atlantic sturgeon caught
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	2
1998	0
1999	0
2000	3
2001	1
2002	0
2003	2
2004	0
2005	33
2006	3
2007	3
2008	0
2009	1
2010	6
2011	1
2012	0
2013	0
2014	0
2015	3
2016	2
2017	0
Total	60

7.5.3 Maryland Spring Striped Bass Experimental Drift Gill Net Survey

Since 1985, the Maryland Department of Natural Resources has used multi-panel experimental drift gill nets to monitor the Chesapeake Bay component of the Atlantic coast striped bass population. Multi-panel experimental drift gill nets were deployed in the Potomac River and in the Upper Chesapeake Bay in 2011. Gill nets are fished six days per week, weather permitting, from late March through May. Individual net panels were 150 feet long, and range from 8.0 to 11.5 feet deep depending on mesh size. The panels are constructed of multifilament nylon webbing in 3.0-10.0-inch stretch-mesh. In the Upper Bay, all ten panels are tied together, end to end, to fish the entire suite of meshes simultaneously. In the Potomac River, because of the design of the fishing boat, the gang of panels is split in half, with two suites of panels (five meshes tied together) fished simultaneously end to end. In both systems, all ten panels are fished twice daily unless weather prohibits a second set. The order of panels within the suite of nets is randomized with gaps of 5-10 feet between each panel. Overall soak times for each panel ranges from six to 105 minutes.

Since 1985, a total of 2,260 gill net sampling days have been conducted by the state of Maryland. Only two Atlantic sturgeon have been captured in this survey during the entire time series of this project: one in 2001 and another most recently in 2016. The 2001 fish was captured in the Upper Chesapeake Bay sampling area on May 3 off Betterton at the mouth of the Sassafras River. The 2016 fish was also captured in the Upper Chesapeake Bay area on April 29, just west of main shipping channel off Still Pond; the soak time for the April 29, 2016, set was 23 minutes and the mesh was 4.5 inches. Both fish were found to be in good condition and were released unharmed.

No shortnose sturgeon have been seen or captured during the entire time series of this project (1985 to present). Similarly, no sea turtles have been seen or sampled during the entire time series of this project (1985 to present). Therefore, no adverse effects to them are anticipated.

Based on past interactions, we expect that no more than one Atlantic sturgeon will be captured during this study for each five year grant period. Atlantic sturgeon originating from all five of the DPSs occur in the Chesapeake Bay; given that, the individual captured could belong to any of the five DPSs. Given the variable soak times used in this survey (up to 105 minutes), it is possible that this fish could be killed.

7.5.4 Virginia American Shad Monitoring Program - Gill Netting

To carry out this study, one staked gill net 900 feet (approximately 274 meters) in length is set on the York and James rivers and one staked gill net 912 feet (approximately 277 meters) in length is set on the Rappahannock River. Locations of the sets are consistent over the time series and are as follows: lower James River near the James River Bridge at river mile 10; middle York River near Clay Bank at river mile 14; and middle Rappahannock River near the Rappahannock River bridge (at Tappahannock, Virginia) at river mile 36.

Each week during the American shad spawning run (typically late February to early May), nets are fished on two succeeding days (two 24-hour sets). In 2009, VIMS American shad program personnel began tagging Atlantic sturgeon that were captured in good condition during this survey. All sturgeon are processed according to U.S. FWS tagging protocols in the following manner: fork and total lengths (mm) are recorded, they are scanned for PIT tags. Fish without PIT tags present are tagged using T-Bar and PIT tags provided by the U.S. FWS, fin clipped and then released alive (depending on specific circumstances, e.g., animal condition, only a subset of the above processing may take place).

Atlantic sturgeon have been captured in the staked gill nets used to monitor abundance of adult American shad in the James, York, and Rappahannock rivers. From 1998-2011, 191 Atlantic sturgeon were captured during 987 trips, totaling approximately 23,760 hours of fishing. The total numbers of Atlantic sturgeon captured in this survey from 1998-2012 are shown below in Table 31. Up through 2017, 229 Atlantic sturgeon have been captured during these studies.

Table 31. Atlantic sturgeon caught during the Virginia American shad gill net study: 1998-2012.

Year	Total Atlantic Sturgeon	James River	York / Rappahannock
1998	34	27	7
1999	24	22	2
2000	16	15	1
2001	8	7	1
2002	1	1	0
2003	3	3	0
2004	6	4	2
2005	26	22	4
2006	41	31	10
2007	30	22	8
2008	9	7	2
2009	7	6	1
2010	10	7	3
2011	10	9	1
2012	2	2	0

Most Atlantic sturgeon caught during this survey have been released alive and in good condition; past mortality is estimated at approximately 2% which is consistent with levels of mortality in gillnet studies that target Atlantic sturgeon. The long-term annual average is 15 Atlantic sturgeon captures per year. Using this estimate, we would expect no more than 75 captures in any five-year grant period. However, interannual variability is high, with annual captures ranging from 1-41. The highest number of Atlantic sturgeon captured in any five-year period is 113 from 2005-2009. Because the capture rate has a high level of interannual variability, it is more reasonable to use the highest five year average to predict future interactions, especially since that five-year period from 2005-2009 was not too long ago in the past. Therefore, we anticipate that no more than 113 Atlantic sturgeon will be captured during a five-year grant period. Based on mixed stock analysis (from the NEFOP data because we do not have site-specific analysis), we have determined that Atlantic sturgeon in the project area likely originate from the five DPSs at the following frequencies: 49% from the NYB DPS, 20% from the SA DPS, 14% from the CB DPS, 11% from the GOM DPS and 4% from the Carolina DPS. Therefore, we anticipate the capture of 56 individuals from the NYB DPS, 23 from the SA DPS, 16 from the CB DPS, 13 from the GOM DPS, and five from the Carolina DPS. Assuming a

1%-2% mortality rate, we expect no more than two mortalities during any five-year period; these fish could be from any of the five DPSs.

Although there have been no recorded shortnose sturgeon interactions in the Virginia American shad gill net surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Recent evidence indicates that shortnose sturgeon have been found in the Rappahannock and James rivers and in the Virginia portion of the Bay mainstem, and they may also be present in the York River if suitable forage is present (Spells 1998; Balazik 2017; Balazik, pers. comm., February 10, 2018). They prefer benthic habitats in which to forage, over which the staked gill netting activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one adult shortnose sturgeon could be captured over the five-year funding period, and like Atlantic sturgeon, this capture could potentially lead to mortality.

No interactions with any sea turtles have occurred during these gill net surveys. These species are vulnerable to capture in gillnets; however, the location of the deployment makes interactions with them unlikely. Because no captures of sea turtles have occurred in this study in the past and there are no changes to the study proposed that would increase the potential for interactions (i.e., movement of the study into deeper portions of river mouths and the Chesapeake Bay where sea turtles are more prevalent), we do not anticipate any future interactions with any species of sea turtles in the Virginia American shad gillnet survey.

7.5.5 Virginia Striped Bass Spawning Stock Assessment - Gill Netting

The James and Rappahannock gill net surveys consist of twice-weekly samples of two 300-foot gill nets (24 hour set time) in each river. Each gill net is six feet in depth and consists of ten 30-foot panels of varied mesh sizes (3, 3 ¾, 4 ½, 5 ¼, 6, 6 ½, 7, 8, 9 and 10 inches stretched mesh). The nets are located approximately 100 miles apart at mile 48 on the Rappahannock River and mile 60 on the James River. The gill net surveys commenced in 1991 on the Rappahannock River and in 1994 on the James River.

To date, one Atlantic sturgeon has been captured in the Rappahannock River gill nets (2005) and two Atlantic sturgeon have been captured in the James River gill nets (one each in 2008 and 2010). Based on the past capture rate, we expect no more than two captures over the next five year period, as that is the maximum number of captures that have occurred over any previous five-year period. Based on the mixed stock analysis (using results from the NEFOP database because we do not have site-specific analysis), we expect that one of the captured Atlantic sturgeon will originate from the NYB DPS, with the other originating from either the SA, CB, GOM, or Carolina DPS. Given an expected 1-2% mortality rate in research gillnets, we expect that no more than one Atlantic sturgeon will be killed during the five-year period; this individual could originate from any of the five DPSs.

Although there have been no recorded shortnose sturgeon interactions in the Virginia striped bass gill net surveys, we anticipate that an interaction is reasonably certain to occur going forward given the species' distribution, habitat preferences, and migratory patterns. Recent evidence indicates that shortnose sturgeon have been found in the Rappahannock and James rivers and in the Virginia portion of the Bay mainstem, and they may also be present in the York River if suitable forage is present (Spells 1998; Balazik 2017; Balazik, pers. comm., February 10, 2018). They prefer benthic habitats in which to forage, over which the staked gill netting activities of these surveys primarily occur. Due to their potential overlap in occurrence with the surveys, it is reasonable to expect that up to one adult shortnose sturgeon could be captured over the five-year funding period, and like Atlantic sturgeon, this capture could potentially lead to mortality.

No interactions with any sea turtles have occurred during these gill net surveys. These species are vulnerable to capture in gillnets; however, the location of the deployment makes interactions with them unlikely. Because no captures of sea turtles have occurred in this study in the past and there are no changes to the study proposed that would increase the potential for interactions (i.e., movement of the study into deeper portions of river mouths and the Chesapeake Bay where sea turtles are more prevalent), we do not anticipate any future interactions with any species of sea turtles in the Virginia American shad gillnet survey.

7.6 Interactions with the research vessels

Vessel strikes are a threat to a number of marine species worldwide including sea turtles, shortnose, and Atlantic sturgeon (Hazel *et al*. 2007; Brown and Murphy 2010; Work *et al*. 2010; Balazik *et al*. 2012b; Barco *et al*. 2016). Sea turtles are known to be injured or killed as a result of being struck by commercial and recreational vessels on the water. Interactions between vessels and sea turtles occur and can take many forms, from the most severe (death or bisection of an animal or penetration to the viscera), to severed limbs or cracks to the carapace which can also lead to mortality directly or indirectly. Sea turtle stranding data for the U.S. Gulf of Mexico and Atlantic coasts, Puerto Rico, and the U.S. Virgin Islands show that between 1986 and 1993, about 9% of living and dead stranded sea turtles had propeller or other boat strike injuries (Lutcavage *et al*. 1997). According to 2001 STSSN stranding data, at least 33 sea turtles (including loggerhead, green, Kemp's ridley and leatherbacks) that stranded on beaches within the Northeast (Maine through North Carolina) were struck by a boat. However, these numbers underestimate the actual number of boat strikes that occurred since not every boat-struck turtle will strand, every stranded turtle will not be found, and many stranded turtles are too decomposed to determine whether the turtle was struck by a boat. It should be noted, however, that it is not known whether all boat strikes were the cause of death or whether they occurred post-mortem (NMFS SEFSC 2001). More recently, boat strike wounds were confirmed to be ante-mortem in over 75% of sea turtles that were found dead or stranded along the U.S. Atlantic coast (B. Stacy, NMFS, pers. comm., 2017) and a majority of sea turtles struck in Virginia waters were healthy prior to those collisions (Barco *et al.* 2016).

Information is lacking on the type or speed of vessels involved in turtle vessel strikes. However, there does appear to be a correlation between the number of vessel struck turtles and the level of recreational boat traffic (NRC 1990). Although little is known about a sea turtle's reaction to vessel traffic, it is generally assumed that sea turtles are more likely to avoid injury from slower moving vessels since the turtle has more time to maneuver and avoid the vessel. In addition, the risk of ship strike will be influenced by the amount of time the animal remains near the surface of the water. With respect to the proposed actions, the effects to sea turtles as a result of vessel activities are discountable. The small number of vessels that will operate on the water as a result of the proposed actions are extremely unlikely to strike sea turtles given that the vessels will operate/travel at slow speeds during both gear sampling and transit such that sea turtles would have the speed and maneuverability to avoid contact with the vessel. This applies to survey vessel operations in both nearshore ocean waters as well as more confined areas such as estuaries and river mouths.

As noted in the listing rules and status reviews for these species, and the recovery plan for shortnose sturgeon, vessel strikes have been identified as a threat to shortnose and Atlantic sturgeon in certain regions. While the exact number of sturgeon killed as a result of being struck by boat hulls or propellers is unknown, it is an area of concern in the Delaware and James rivers. Brown and Murphy (2010) examined 28 dead Atlantic sturgeon observed in the Delaware River from 2005-2008. Fifty-percent (50%) of the mortalities resulted from apparent vessel strikes and 71% of these (ten of 14) had injuries consistent with being struck by a large vessel (Brown and Murphy 2010). Eight of the 14 vessel struck sturgeon were adult-sized fish (Brown and Murphy 2010). Given the time of year in which the fish were observed (predominantly May through July; Brown and Murphy 2010), it is likely that many of the adults were migrating through the river to the spawning grounds.

The factors relevant to determining the risk to shortnose and Atlantic sturgeon from vessel strikes are not fully known, but are likely related to size and speed of the vessels, navigational clearance (i.e., depth of water and draft of the vessel) in the area where the vessel is operating, and the behavior of sturgeon in the area (e.g., foraging, migrating, etc.). It is important to note that vessel strikes have only been identified as a significant concern in the upper Delaware and James rivers and current thinking suggests that there may be unique geographic features in these areas (e.g., potentially narrow migration corridors combined with shallow/narrow river channels) that increase the risk of interactions between vessels and shortnose/Atlantic sturgeon. The risk of vessel strikes between sturgeon and research/fishing vessels operating in the open ocean or large estuaries, as they will be during the studies addressed here, is likely to be low given that the vessels will be operating at slow speeds during both gear sampling and transit and there will be no barriers to passage forcing shortnose or Atlantic sturgeon into close proximity with the vessel as may be present in very narrow rivers and creeks further upstream of the areas to be surveyed.

Given the small and localized increase in vessel traffic that would result from the state fisheries surveys, the slow speeds at which any vessels would be operating, and the ability of most sturgeon to maneuver and avoid vessels in open waters where surveys utilizing vessels will most often occur, it is unlikely that there would be any detectable increase in the risk of vessel strike. As such, effects to sturgeon from the increase in vessel traffic are extremely unlikely and therefore discountable. In addition, any increased risk of a vessel strike caused by the project will be too small to be meaningfully measured or detected. As a result, the effect of the state surveys on the risk of a vessel strike in the action area is also insignificant. No vessel strikes of sea turtles, shortnose, or Atlantic sturgeon have been documented or reported during the history of any of the state fisheries surveys considered in this opinion.

7.7 Effects to Prey

Sea turtles could be negatively affected by the loss of prey as a result of mobile fishing gear that removes or incidentally kills such prey during the proposed actions. However, the amount of potential prey that will be disturbed or removed is minimal. The gears to be used during the proposed actions are expected to catch a variety of organisms including fish and crab species. However, none of the bycatch species expected from any activity (i.e., utilizing otter trawl and gillnet gear) proposed in this opinion are typical prey species of leatherback sea turtles or of neritic juvenile or adult green sea turtles (Rebel 1974; Mortimer 1982; Bjorndal 1985, 1997; U.S. FWS and NMFS 1992). Those organisms that are caught in either trawl or gillnet will be sampled according to the survey protocol. Species that meet the sampling criteria will be sampled for scientific purposes and may not be returned to the water, while the other species will be returned to the water alive, dead, or injured to the extent that they will subsequently die. Nearly all of the species that will be retained for further study are fish. Crabs, on the other hand, which are the preferred prey of loggerhead and Kemp's ridley sea turtles, will often not be retained for further study, and thus would still be available as prey for loggerheads and Kemp's ridleys when returned to the water, as both of these species of sea turtles are known to eat a variety of live prey as well as scavenge dead organisms (Lutcavage and Musick 1985; Keinath *et al.* 1987; Dodd 1988; Burke *et al.* 1993, 1994; Morreale and Standora 2005). Thus, the proposed actions considered here are expected to have an insignificant effect on the availability of prey for loggerhead and Kemp's ridley sea turtles in the action area given that: (a) the sea turtle food items that are returned to the water could still be preyed upon by loggerheads and Kemp's ridleys, (b) the number of trawl tows and gillnet hauls for the surveys and study are limited in scope and duration, (c) the priority species that will be retained for scientific analysis are almost entirely fish species, which are not preferred prey for loggerheads and Kemp's ridleys (Keinath *et al.* 1987; Lutcavage and Musick 1985; Burke *et al.* 1993, 1994; Morreale and Standora 2005), and (d) and there is no evidence loggerhead or Kemp's ridley sea turtles are prey limited.

Shortnose and Atlantic sturgeon use the action area as a migratory route and for overwintering and foraging. Any effects on habitat due to fisheries research gear are most likely to be on sturgeon prey items, as discussed above. Shortnose and Atlantic sturgeon are known to aggregate in certain areas and at certain times of the year, and some of these areas experience high fishing effort. Despite the overlap in aggregations with some areas of high fishing effort, we have no information that indicates negative effects on sturgeon prey items.

Shortnose and Atlantic sturgeon feed primarily on small benthic invertebrates and occasionally on small fish. Because of the small size or benthic nature of these prey species, it is unlikely that the proposed actions will capture any sturgeon prey items. Thus, the surveys and study will not affect the availability of prey for sturgeon. Again, any effects to prey will be limited to minor disturbances to the river/estuary/ocean bottom from the trawl and gillnet gear. Because of this, we have determined that any effects to sturgeon prey or foraging sturgeon will be insignificant.

7.8 Effects to Habitat

A panel of experts has previously concluded that the effects of even light weight otter trawl gear would include: (1) the scraping or plowing of the doors on the bottom, sometimes creating furrows along their path, (2) sediment suspension resulting from the turbulence caused by the doors and the ground gear on the bottom, (3) the removal or damage to benthic or demersal species, and (4) the removal or damage to structure forming biota. The panel also concluded that the greatest impacts from otter trawls occur in high and low energy gravel habitats and in hard clay outcroppings, and that sand habitats were the least likely to be impacted (NREFHSC 2002). The areas to be surveyed for the state fisheries surveys include very few habitats that are purely gravel or hard clay—so few that the area encompassed by these habitats is insignificant compared to the area encompassed by sand and silt type habitats, which are more resilient to bottom trawling. For benthic feeding sea turtles, shortnose sturgeon, and Atlantic sturgeon, the effects on habitat due to bottom otter trawl gear would be felt as an effect on their benthic prey species. As stated above, the effects on sea turtle and sturgeon benthic prey items from bottom trawl gear are expected to be insignificant.

As gillnet and pot/trap gears are a form of fixed gear (i.e., stationary, not moving), limited effects to bottom habitat are possible as a result of utilizing these forms of fish harvest gear. The gear rests on the bottom and is capable of getting pushed by slow moving currents, or, when the gear is in process of being retrieved. Because the gillnet and pot/trap gear hauls proposed in this opinion will not be conducted during adverse weather conditions (i.e., when ocean currents may be stronger) and will have brief soak durations, adverse effects on habitat are not expected. As stated above, the effects on sea turtle and sturgeon benthic prey items from fixed gear are expected to be insignificant.

In regards to effects on the pelagic habitat of some sea turtles (e.g., leatherbacks), we do not anticipate any adverse effects from the state fisheries surveys on those areas since the gear will simply be towed or dropped through them. The gears and vessels to be used by the states and their partners are not expected to significantly affect the prevailing currents, water quality, or other environmental conditions of those habitats.

8.0 CUMULATIVE EFFECTS

Cumulative effects as defined in 50 CFR 402.02 include the effects of future State, tribal, local, or private actions that are reasonably certain to occur within the action area considered in this opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. For that reason, future effects of other Federal fisheries are not considered in this section of the document; all Federal fisheries that may affect listed species are the subject of formal section 7 consultations. Effects of ongoing Federal activities, including other fisheries, are considered in the *Environmental Baseline* and *Status of the Species* sections above and are also factored into the *Integration and Synthesis of Effects* section below.

Sources of human-induced mortality, injury, and/or harassment of sea turtles, shortnose, and Atlantic sturgeon in the action area that are reasonably certain to occur in the future include interactions in state-regulated and recreational fishing activities, vessel collisions, ingestion of plastic debris, pollution, global climate change, coastal development, and catastrophic events. Actions carried out or regulated by the states within the action area also include the regulation of dredged material discharges through CWA Section 401-certification and point and non-point source pollution through the National Pollutant Discharge Elimination System. We are not aware of any local or private actions that are reasonably certain to occur in the action area that may affect listed species. It is important to note that the definition of "cumulative effects" in the section 7 regulations is not the same as the NEPA definition of cumulative effects.[5] While the combination of these activities may affect sea turtles, shortnose, and Atlantic sturgeon, preventing or slowing a species' recovery, the full magnitude of these effects is not completely known. However, we have considered the best information available in our assessment of both direct effects from the proposed action as well as cumulative effects.

State Water Fisheries - Future recreational and commercial fishing activities in state waters may capture, injure, or kill sea turtles and sturgeon. However, it is not clear to what extent these future activities would affect listed species differently than the current state fishery activities described in the *Environmental Baseline* section. Shortnose and Atlantic sturgeon are captured and killed in fishing gear operating in the action area; however, at this time we are not able to quantify the number of interactions that occur. However, this opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the *Status of the Species* and *Environmental Baseline* sections.

Fishing activities are considered one of the most significant causes of death and serious injury for sea turtles. Finkbeiner *et al*. (2011) compiled cumulative sea turtle bycatch information in U.S. fisheries from 1990 through 2007, before and after implementation of bycatch mitigation measures. In the Atlantic, a mean estimate of 137,700 bycatch interactions, of which 4,500 were mortalities, occurred annually (since implementation of bycatch mitigation measures). Kemp's ridleys interacted with fisheries most frequently, with the highest level of mean annual mortality (2,700), followed by loggerheads (1,400), greens (300), and leatherbacks (40). The Southeast/Gulf of Mexico shrimp trawl fishery was responsible for the vast majority of U.S. interactions (up to 98%) and mortalities (more than 80%). Fishing gear in state waters, including bottom trawls, gillnets, trap/pot gear, and pound nets, interacts with sea turtles each year. NMFS is working with state agencies to address the bycatch of sea turtles in state water fisheries within the action area of this consultation where information exists to show that these fisheries capture sea turtles. Action has been taken by some states to reduce or remove the likelihood of sea turtle bycatch and/or the likelihood of serious injury or mortality in one or more gear types. However, given that state managed commercial and recreational fisheries along the U.S. Atlantic coast are reasonably certain to occur within the action area in the foreseeable future, additional interactions of sea turtles with these fisheries are anticipated. There is insufficient information to

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[5] Cumulative effects are defined for NEPA as "the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

quantify the number of sea turtle interactions with state water fisheries as well as the number of sea turtles injured or killed as a result of these interactions. While actions have been taken to reduce sea turtle bycatch in some state water fisheries, the overall effect of these actions is not fully known, and the future effects of state water fisheries on sea turtles are presently difficult to quantify due to data and monitoring limitations. However, this opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the *Status of the Species* and *Environmental Baseline* sections.

Vessel Interactions - NMFS's STSSN data indicate that vessel interactions are responsible for a number of sea turtle strandings within the action area each year. In the U.S. Atlantic from 1997-2005, 14.9% of all stranded loggerheads were documented as having sustained some type of propeller or collision injuries (NMFS and U.S. FWS 2007a). The incidence of propeller wounds rose from approximately 10% in the late 1980s to a record high of 20.5% in 2004 (STSSN database). Such collisions are reasonably certain to continue into the future. Collisions with boats can stun, injure, or kill sea turtles, and many live-captured and stranded sea turtles have obvious propeller or collision marks (Dwyer *et al*. 2003). However, it is not always clear whether the collision occurred pre- or post-mortem. NMFS believes that vessel interactions with sea turtles will continue in the future. An estimate of the number of sea turtles that will likely be killed by vessels is not available at this time. Similarly, we are unable at this time to assess the risk that vessel operations in the action area pose to shortnose and Atlantic sturgeon. While vessel strikes have been documented in several rivers, the extent that interactions occur in the marine environment is not fully known. However, this opinion assumes effects in the future would be similar to those in the past and are, therefore, reflected in the anticipated trends described in the *Status of the Species* and *Environmental Baseline* sections.

Pollution and Contaminants - Human activities in the action area causing pollution are reasonably certain to continue in the future, as are impacts from them on sea turtles, shortnose, and Atlantic sturgeon. However, the level of impacts cannot be projected. Sources of contamination in the action area include atmospheric loading of pollutants, stormwater runoff from coastal development, groundwater discharges, and industrial development. Chemical contamination may have effects on listed species' reproduction and survival. Excessive turbidity due to coastal development and/or construction sites could influence marine mammal, sea turtle, sturgeon, or salmon foraging ability. Marine debris (e.g., discarded fishing line or lines from boats, plastics) also has the potential to entangle ESA-listed species in the water or to be fed upon by them. Sea turtles commonly ingest plastic or mistake debris for food and sometimes this may lead to asphyxiation. This opinion assumes effects in the future would be similar to those in the past and are therefore reflected in the anticipated trends described in the *Status of the Species* and *Environmental Baseline* sections.

State NPDES Permits – All of the states in the action area, with the exception of Massachusetts, New Hampshire, and Washington D.C., have been delegated authority to issue NPDES permits by the EPA. These permits authorize the discharge of pollutants in the action area. Permittees include municipalities for sewage treatment plants and other industrial users. The states will continue to authorize the discharge of pollutants through these state issued permits. State standards are ultimately devised using EPA's techniques, which we anticipate to be insignificant and/or discountable to all listed species, so effects of discharges should also be. This opinion assumes that effects in the future will be similar to those in the past and are, therefore, reflected in the anticipated trends described in the status of the species/environmental baseline section.

In the future, *global climate change* is expected to continue and may impact listed species and their habitat in the action area. However, as noted in the *Status of the Species* and *Environmental Baseline* sections above, given the likely rate of change associated with climate impacts (i.e., on a decadal to century scale), it is unlikely that climate related impacts will have a significant effect on the status of any listed species over the temporal scale of the proposed actions (i.e., over the next five years) or that in this time period, the abundance, distribution, or behavior of these species in the action area will significantly change as a result of climate change related impacts.

9.0 INTEGRATION AND SYNTHESIS OF EFFECTS

We have determined that Atlantic sturgeon, shortnose sturgeon, and sea turtles will be captured in or interact with several of the studies considered in this opinion. No serious injuries or mortalities of any sea turtle species are anticipated. A small number of shortnose and Atlantic sturgeon may be seriously injured or killed due to interactions with gillnets (eight total in a five-year period, two shortnose and six Atlantic sturgeon). We anticipate the following interactions during the five-year grant period from 2018-2022 (all non-lethal captures, unless otherwise indicated):

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
ME beach seine	3	0	0	0	0	0	0	0	0	0	0
NJ beach seine	1	0	0	0	0	0	0	0	0	0	0
NY beach and haul seine	4	2	1 GOM or CB	1	1 GOM or CB	0	0	0	0	0	0
MA fish ladder (Westfield only)	1	0	0	0	0	0	0	0	0	0	0
ME/NH trawl	1	10	1	5	1	1	2	0	0	0	0
MA trawl	1	1	one Atlantic sturgeon from any of the five DPSs					1 sea turtle any species			
RI weekly trawl	1	1	one Atlantic sturgeon from any of the five DPSs					1 sea turtle any species			
CT Long Island Sound trawl	1	85	3	66	6	1	9	1 sea turtle any species			
NY Peconic trawl	0	0	0	0	0	0	0	1 loggerhead, Kemp's ridley, or green			0
NJ Ocean Surveys trawl	0	126	14	62	18	6	26	8	4	2	1
DE Estuary bottom trawl	2	7	1 GOM or Carolina	4	1	1 GOM or Carolina	1	1	1 Kemp's ridley, green, or leatherback		
DE Bay Groundfish trawl	2	16	1 GOM or Carolina	9	3	1 GOM or Carolina	3	5	2 Kemp's ridleys, greens, or leatherbacks (any combination)		
MD Coastal Bays	0	1	one Atlantic sturgeon from any of the five DPSs					1 sea turtle any species			

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
VA juvenile fish	1	17	2	8	3	1	3	1 sea turtle any species			
VA ChesMMAP	1	2	1 GOM, CB, Carolina, or SA	1	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	5	2 Kemp's ridleys, greens, or leatherbacks (any combination		
NY striped bass electrofishing	33	0	0	0	0	0	0	0	0	0	0
DE striped bass electrofishing	1	1	one Atlantic sturgeon from any of the five DPSs					0	0	0	0
NY shad gillnet	0	1	one capture (may be lethal) from any of the five DPSs					0	0	0	0
VA striped bass gillnet	1 (may be lethal)	2	1 GOM, CB, Carolina, or SA	1	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	0	0	0	0
			one mortality - individual could originate from any of the five DPSs								
NJ striped bass gillnet	0	41	3	23	7	1	7	0	0	0	0
			one mortality - individual could originate from any of the five DPSs								
MD striped bass drift gillnet	0	1	one capture (may be lethal) from any of the five DPSs					0	0	0	0
VA shad gillnet	1 (may be lethal)	113	13	56	16	5	23	0	0	0	0
			two mortalities - individuals could be from any of the five DPSs								

As explained in the *Effects of the Actions* section, all effects to sea turtles, shortnose, and Atlantic sturgeon, including to their prey, beyond those described in the table above, will be insignificant or discountable.

In the discussion below, we consider whether the effects of the proposed actions reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the listed species in the wild by reducing the reproduction, numbers, or distribution of the listed species that will be adversely affected by the action. The purpose of this analysis is to determine whether the proposed actions, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of any listed species. In the NMFS/U.S. FWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as:

> "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter."

Recovery is defined as, "improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." We summarize below the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of these species and then consider whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of these species, as those terms are defined for purposes of the ESA.

9.1 Northwest Atlantic DPS of loggerhead sea turtles

We have estimated that the actions under consideration in this opinion will result in the capture of up to 25 loggerhead sea turtles over a five-year period. We do not anticipate these captures to result in any serious injuries or mortalities. Some level of minor injury due to capture or release from the sampling gear may occur (e.g., chips, cuts, or abrasions to the carapace or skin), but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. All other effects to loggerhead sea turtles, including effects to prey, are expected to be insignificant and discountable.

The NWA DPS of loggerhead sea turtles is listed as "threatened" under the ESA. It takes decades for loggerhead sea turtles to reach maturity. Once they have reached maturity, females typically lay multiple clutches of eggs within a season, but do not typically lay eggs every season (NMFS and U.S. FWS 2008). There are many natural and anthropogenic factors affecting the survival of loggerheads prior to their reaching maturity as well as for those adults who have reached maturity. As described in the Status of the Species/Environmental Baseline and Cumulative Effects sections above, loggerhead sea turtles in the action area continue to be affected by multiple anthropogenic impacts including bycatch in commercial and recreational fisheries, habitat alteration, dredging, power plant intakes and other factors that result in mortality of individuals at all life stages. Negative impacts causing death of various age classes occur both on land and in the water. Many actions have been taken to address known negative impacts to loggerhead sea turtles. However, many remain unaddressed, have not been sufficiently addressed, or have been addressed in some manner but whose success cannot be quantified.

The NMFS SEFSC (2009) estimated the number of adult females in the NWA DPS at 30,000, and if a 1:1 adult sex ratio is assumed, the result is 60,000 adults in this DPS. Based on the reviews of nesting data, as well as information on population abundance and trends, NMFS and U.S. FWS determined in the September 2011 listing rule that the NWA DPS should be listed as threatened. They found that an endangered status for the NWA DPS was not warranted given the large size of the nesting population, the overall nesting population remains widespread, the trend for the nesting population appears to be stabilizing, and substantial conservation efforts are underway to address threats.

As there will be no serious injury or mortality to any individual loggerhead sea turtle and no effects to the prey base that would cause sea turtles to leave the action area to forage elsewhere, the proposed actions not likely to reduce the numbers of loggerhead sea turtles in the action area, the numbers of loggerheads in any subpopulation or the species as a whole. Similarly, as the proposed actions will not affect the fitness of any individuals, no effects to reproduction are anticipated. The action is also not likely to affect the distribution of loggerhead sea turtles in the action area or affect the distribution of sea turtles throughout their range. Because effects are limited to capture, with no serious injury or mortality, there are not anticipated to be any population level impacts. Despite the threats faced by individual loggerhead sea turtles inside and outside of the action area, the proposed action will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact loggerhead sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, no additional effects related to climate change to loggerhead sea turtles in the action area are anticipated over the life of the proposed action (*i.e.*, for five years). We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above regarding potential reductions in numbers, reproduction, or distribution do not change.

Based on the information provided above, the non-lethal capture of 25 or fewer NWA DPS loggerhead sea turtles in the trawl surveys considered here will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of

NWA DPS sea turtles; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the species; (3) and, the action will have only a minor and temporary effect on the distribution of NWA DPS loggerhead sea turtles in the action area (related to the temporary capture and handling of captured individuals) and no effect on the distribution of the species throughout its range.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the NWA DPS will survive in the wild. Here, NMFS considers the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will not result in a reduction in the number of NWA DPS loggerhead sea turtles and since it will not affect the overall distribution of the species other than to cause minor temporary adjustments in movements in the action area. The proposed action is not likely to result in any mortality or reductions in fitness or future reproductive output and therefore, it is not expected to affect the persistence of the species. There will not be a change in the status or trend of the species. As there will be no reduction in numbers or future reproduction the action would not cause any reduction in the likelihood of improvement in the status of the NWA DPS. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will not cause any mortality or reduction of overall reproductive fitness for the species. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that the NWA DPS can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.2 Leatherback sea turtles

We have estimated that the actions under consideration in this opinion will result in the capture of up to 11 leatherback sea turtles over a five-year period. We do not anticipate any serious injury or mortality. Some level of minor injury due to capture or release from the sampling gear may occur (e.g., chips, cuts, or abrasions to the carapace or skin), but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. All other effects to leatherback sea turtles, including effects to prey, are expected to be insignificant and discountable.

Leatherback sea turtles are listed as "endangered" under the ESA. Leatherbacks are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian Oceans, the Caribbean Sea, Mediterranean Sea, and the Gulf of Mexico (Ernst and Barbour 1972). Leatherback nesting occurs on beaches of the Atlantic, Pacific, and Indian Oceans as well as in the Caribbean (NMFS and U.S. FWS 2013b). Leatherbacks face a multitude of threats that can cause death prior to and after reaching maturity. Some activities resulting in leatherback mortality have been addressed. There are some population estimates for leatherback sea turtles although there appears to be considerable uncertainty in the numbers. The most recent population size estimate for the North Atlantic alone is 34,000-94,000 adult leatherbacks (TEWG 2007; NMFS and U.S. FWS 2013b).

Leatherback nesting in the eastern Atlantic (*i.e.,* off Africa) and in the Caribbean appears to be stable, but there is conflicting information for some sites and it is certain that some nesting groups (*e.g.*, St. John and St. Thomas, U.S. Virgin Islands) have been extirpated (NMFS and U.S. FWS 1995). Data collected for some nesting beaches in the western Atlantic, including leatherback nesting beaches in the U.S., clearly indicate increasing numbers of nests (NMFS SEFSC 2001; NMFS and U.S. FWS 2013b). However, declines in nesting have been noted for beaches in the western Caribbean (NMFS and U.S. FWS 2013b). The largest leatherback rookery in the western Atlantic remains along the northern coast of South America in French Guiana and Suriname. More than half the present world leatherback population is estimated to nest on the beaches in and close to the Marowijne River Estuary in Suriname and French Guiana (Hilterman and Goverse 2004). The long-term trend for the Suriname and French Guiana nesting group seems to show an increase (Hilterman and Goverse 2004). In 2001, the number of nests for Suriname and French Guiana combined was 60,000, one of the highest numbers observed for this region in 35 years (Hilterman and Goverse 2004). Studies by Girondot *et al*. (2007) also suggest that the trend for the Suriname - French Guiana nesting population over the last several decades is stable or slightly increasing.

Increased nesting by leatherbacks in the Atlantic is not expected to affect leatherback abundance in the Pacific where the abundance of leatherback sea turtles on nesting beaches has declined dramatically over the past 10 to 20 years (NMFS and U.S. FWS 2013b). Although genetic analyses suggest little difference between Atlantic and Pacific leatherbacks (Bowen and Karl 2007), it is generally recognized that there is little to no genetic exchange between these turtles.

There will be no serious injury or mortality to any individual leatherback sea turtle; there will be no effects to the prey base that would cause sea turtles to leave the action area. Therefore, the proposed actions are not likely to reduce the numbers of leatherback sea turtles in the action area, the numbers of leatherbacks in any subpopulation or the species as a whole. The proposed action will not affect the fitness of any individuals and we do not anticipate any effects to reproduction. The action is also not likely to affect the distribution of leatherback sea turtles in the action area or affect the distribution of leatherback sea turtles throughout their range. Because effects are limited to capture, with no serious injury or mortality, we do not anticipate any population level impacts. Despite the threats faced by individual leatherback sea turtles inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact leatherback sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, no additional effects related to climate change to leatherback sea turtles in the action area are anticipated over the five-year life of the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above regarding potential reductions in numbers, reproduction, or distribution do not change.

Based on the information provided above, the non-lethal capture of up to 11 leatherback sea turtles will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of leatherback sea turtles; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the species; (3) and, the action will have only a minor and temporary effect on the distribution of leatherback sea turtles in the action area (related to the temporary capture and handling of captured individuals) and no effect on the distribution of the species throughout its range.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the leatherback sea turtle species will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

We do not expect the proposed actions to modify, curtail or destroy the range of the species since it will not result in a reduction in the number of leatherback sea turtles and since it will not affect the overall distribution of the species other than to cause minor temporary adjustments in movements in the action area. The proposed action is not likely to result in any mortality or reductions in fitness or future reproductive output and therefore, the proposed actions will not affect the persistence of the species. There will not be a change in the status or trend of the species. As there will be no reduction in numbers or future reproduction the action would not cause any reduction in the likelihood of improvement in the status of leatherback sea turtles. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will not cause any mortality or reduction of overall reproductive fitness for the species. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that leatherback sea turtles can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.3 Kemp's ridley sea turtles

We have estimated that the actions under consideration in this opinion will result in the capture of up to 15 Kemp's ridley sea turtles over a five-year period. We do not anticipate any serious injury or mortality. Some level of minor injury due to capture or release from the sampling gear may occur (e.g., chips, cuts, or abrasions to the carapace or skin), but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. All other effects to Kemp's ridley sea turtles, including effects to prey, are expected to be insignificant and discountable.

Kemp's ridley sea turtles are listed as a single species classified as "endangered" under the ESA. Kemp's ridleys occur in the Atlantic Ocean and Gulf of Mexico. The only major nesting site for Kemp's ridleys is a single stretch of beach near Rancho Nuevo, Tamaulipas, Mexico (Carr 1963; U.S. FWS and NMFS 1992; NMFS and U.S. FWS 2015).

Nest count data provides the best available information on the number of adult females nesting each year. As is the case with the other sea turtles species discussed above, nest count data must be interpreted with caution given that these estimates provide a minimum count of the number of nesting Kemp's ridley sea turtles. In addition, the estimates do not account for adult males or juveniles of either sex. Without information on the proportion of adult males to females, and the age structure of the Kemp's ridley population, nest counts cannot be used to estimate the total population size (Meylan 1982; Ross 1996; Zurita *et al*. 2003; Hawkes *et al*. 2005; letter to J. Lecky, NMFS Office of Protected Resources, from N. Thompson, NMFS Northeast Fisheries Science Center, December 4, 2007). Nevertheless, the nesting data does provide valuable information on the extent of Kemp's ridley nesting and the trend in the number of nests laid. Estimates of the adult female nesting population reached a low of approximately 250-300 in 1985 (U.S. FWS and NMFS 1992; TEWG 2000). From 1985 to 1999, the number of nests observed at Rancho Nuevo and nearby beaches increased at a mean rate of 11.3% per year (TEWG 2000). Recent population abundance for Kemp's ridleys, based on nests and hatchling recruitment, was estimated by Gallaway *et al*. (2013). They estimated the female population size for age-2 and older in 2012 to be 188,713 (SD = ±32,529). Assuming females comprise 76% (sex ratio = 0.76; TEWG 1998, 2000) of the population, they estimated the total population of age 2 years and over at 248,307. Based on the number of hatchlings released in 2011 and 2012 (1+ million) and recognizing mortality over the first two years is high, Gallaway *et al.* (2013) thought the total population, including hatchlings younger than 2 years, may exceed 1 million turtles (NMFS and U.S. FWS 2015).

The most recent five-year review of the Kemp's ridley suggests that the population growth rate (as measured by numbers of nests) stopped abruptly after 2009. Given the recent lower nest numbers, the population is not projected to grow at former rates. As a result, the status review team determined that the population is not recovering and cannot meet recovery goals unless survival rates improve (NMFS and U.S. FWS 2015). However, some positive outlooks for the species include recent conservation actions (including the protection of females, nests, and hatchlings on nesting beaches since the 1960s) and the enhancement of survival in marine habitats through the implementation of TEDs in the early 1990s and a decrease in the amount of shrimping off the coast of Tamaulipas and in the Gulf of Mexico (NMFS and U.S. FWS 2015). There is also the recent record nesting year in Mexico and Texas for Kemp's ridleys in 2017.

As there will be no serious injury or mortality to any individual Kemp's ridley sea turtle and no effects to the prey base that would cause sea turtles to leave the action area to forage elsewhere, the proposed actions are not likely to reduce the numbers of Kemp's ridley sea turtles in the action area, the numbers of Kemp's ridleys in any subpopulation or the species as a whole. Similarly, as the proposed actions will not affect the fitness of any individual, no effects to reproduction are anticipated. The action is also not likely to affect the distribution of Kemp's ridley sea turtles in the action area or affect the distribution of sea turtles throughout their range. Because effects are limited to capture, with no serious injury or mortality, there are not anticipated to be any population level impacts. Despite the threats faced by individual Kemp's ridley sea turtles inside and outside of the action area, the proposed action will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact Kemp's ridley sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, no additional effects related to climate change to leatherback sea turtles in the action area are anticipated over the five-year life of the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above regarding potential reductions in numbers, reproduction, or distribution do not change.

Based on the information provided above, the non-lethal capture of up to 15 Kemp's ridley sea turtles in the NJ ocean trawl surveys will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of Kemp's ridley sea turtles; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the species; (3) and, the action will have only a minor and temporary effect on the distribution of Kemp's ridley sea turtles in the action area (related to the temporary capture and handling of captured individuals) and no effect on the distribution of the species throughout its range.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the Kemp's ridley sea turtle species will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed actions are not expected to modify, curtail or destroy the range of the species since it will not result in a reduction in the number of Kemp's ridley sea turtles and since it will not affect the overall distribution of the species other than to cause minor temporary adjustments in movements in the action area. The proposed actions are not likely to result in any mortality or reductions in fitness or future reproductive output and therefore, it is not expected to affect the persistence of the species. There will not be a change in the status or trend of the species. As there will be no reduction in numbers or future reproduction the action would not cause any reduction in the likelihood of improvement in the status of Kemp's ridley sea turtles. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will not cause any mortality or reduction of overall reproductive fitness for the species. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that Kemp's ridley sea turtles can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

9.4 North Atlantic DPS of green sea turtles

We have estimated that the actions under consideration in this opinion will result in the capture of up to 13 green sea turtles over a five-year period. We do not anticipate any serious injury or mortality. Some level of minor injury due to capture or release from the sampling gear may occur (e.g., chips, cuts, or abrasions to the carapace or skin), but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. All other effects to green sea turtles, including effects to prey, are expected to be insignificant and discountable.

The North Atlantic DPS of green sea turtles is listed as threatened under the ESA. As is also the case with the other sea turtle species, North Atlantic DPS green sea turtles face numerous threats on land and in the water that affect the survival of all age classes.

The greatest abundance of green sea turtle nesting in the North Atlantic occurs on beaches in Tortuguero, Costa Rica. Nesting in the area has increased considerably since the 1970s and nest count data from 1999-2003 suggested that 17,402-37,290 females nested there per year (Seminoff *et al*. 2015). In 2010, an estimated 180,310 nests were laid at Tortuguero, the highest level of green sea turtle nesting estimated since the start of nesting track surveys in 1971. This equated to somewhere between 30,052 and 64,396 nesters in 2010 (Seminoff *et al*. 2015).

The results of genetic analyses show that green sea turtles in the Atlantic do not contribute to green sea turtle nesting elsewhere in the species' range (Bowen and Karl 2007). Therefore, increased nesting by green sea turtles in the Atlantic is not expected to affect green sea turtle abundance in other ocean basins in which the species occurs. NMFS recognizes that the nest count data available for green sea turtles in the Atlantic clearly indicates increased nesting at many sites. However, NMFS also recognizes that the nest count data, including data for green sea turtles in the Atlantic, only provides information on the number of females currently nesting, and is not necessarily a reflection of the number of mature females available to nest or the number of immature females that will reach maturity and nest in the future. Given the late age to maturity for green sea turtles (20 to 50 years) (Balazs 1982; Frazer and Ehrhart 1985; Seminoff 2004), caution is urged regarding the trend for any of the nesting groups since no area has a dataset spanning a full green sea turtle generation (NMFS and U.S. FWS 2007b).

We do not expect any of the captured green sea turtles to be seriously injured or killed. There will be no effects to the prey base that would cause sea turtles to leave the action area to forage elsewhere. Therefore, the proposed actions are not likely to reduce the numbers of green sea turtles in the action area, the numbers of greens in any subpopulation or the species as a whole. Similarly, as the proposed actions will not affect the fitness of any individual, no effects to reproduction are anticipated. The actions are also not likely to affect the distribution of green sea turtles in the action area or affect the distribution of sea turtles throughout their range. Because effects are limited to capture, with no serious injury or mortality, we do not anticipate any population level impacts. Despite the threats faced by individual green sea turtles inside and outside of the action area, the proposed action will not increase the vulnerability of individual sea turtles to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact green sea turtles in the action area or how the species will adapt to climate-change related environmental impacts, no additional effects related to climate change to green sea turtles in the action area are anticipated over the five-year life of the proposed action. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above regarding potential reductions in numbers, reproduction, or distribution do not change.

Based on the information provided above, the non-lethal capture of up to 13 green sea turtles will not appreciably reduce the likelihood of survival of this species (*i.e.*, it will not increase the risk of extinction faced by this species) given that: (1) there will be no mortality and therefore, no reduction in the numbers of green sea turtles; (2) there will be no effect to the fitness of any individuals and no effect on reproductive output of the species; (3) and, the action will have only a minor and temporary effect on the distribution of green sea turtles in the action area (related to the temporary capture and handling of captured individuals) and no effect on the distribution of the species throughout its range.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that the green sea turtle species will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, "threatened") because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed action is not expected to modify, curtail or destroy the range of the species since it will not result in a reduction in the number of green sea turtles and since it will not affect the overall distribution of the species. The proposed action is not likely to result in any mortality or reductions in fitness or future reproductive output and therefore, it is not expected to affect the persistence of the species. There will not be a change in the status or trend of the species. As there will be no reduction in numbers or future reproduction the action would not cause any reduction in the likelihood of improvement in the status of green sea turtles. The effects of the proposed action will not delay the recovery timeline or otherwise decrease the likelihood of recovery since the action will not cause any mortality or reduction of overall reproductive fitness for the species. The effects of the proposed action will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed action will not appreciably reduce the likelihood that green sea turtles can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed action is not likely to appreciably reduce the survival and recovery of this species.

9.5 Atlantic sturgeon

The proposed actions are likely to result in the interaction with or capture of up to 427 Atlantic sturgeon over the next five years. These captures or interactions are likely to occur in seine surveys, bottom trawl surveys, electrofishing surveys, and gillnet studies. We expect that the Atlantic sturgeon captured will be either adults or subadults, although juveniles could be captured on rare occasions. No capture of eggs or larvae is anticipated. All other effects to Atlantic sturgeon, including effects from vessel traffic and effects to habitat and prey resources due to the U.S. FWS funded state fisheries surveys, will be insignificant and discountable.

We have considered the best available information to determine from which DPSs these individuals are likely to have originated. Using site specific or regional mixed stock analyses whenever possible, we have determined that the 427 affected Atlantic sturgeon will consist of: up to 47 individuals from the GOM DPS, up to 242 from the NYB DPS, up to 64 from the CB DPS, up to 25 from the Carolina DPS, and up to 82 from the SA DPS. We have determined that there are likely to be no more than six mortalities, all in state gill net surveys. These individuals could originate from any of the five listed DPSs. It is unlikely that there would be more than two mortalities from any one DPS but we have considered the possibility that up to six individuals from any one DPS could be killed. However, given the distribution of individuals from each DPS throughout the action area, it is much more likely that each DPS will lose one or two individuals over the five-year period.

9.5.1 Gulf of Maine DPS

The GOM DPS is listed as threatened, and while Atlantic sturgeon occur in several rivers of the Gulf of Maine region, recent spawning has only been physically documented in the Kennebec River. However, spawning is suspected to occur in the Androscoggin, Piscataqua, and Merrimack Rivers. There is currently no census of the number of Atlantic sturgeon in any river nor is any currently available for the entire DPS. However, the ASSRT stated that there were likely less than 300 spawners per year while the NEAMAP data indicates that the estimated ocean population of GOM DPS Atlantic sturgeon is 7,455 individuals. Gulf of Maine origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. While there are some indications that the status of the GOM DPS may be improving, there is currently not enough information to establish a trend for any life stage or for the DPS as a whole.

We have estimated that the proposed actions will result in the capture of 427 or fewer Atlantic sturgeon over a five-year period, of which up to 47 are expected to be GOM DPS Atlantic sturgeon. We anticipate the mortality of up to six individuals; no serious injury or mortality of any other captured Atlantic sturgeon is anticipated. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. While it is unlikely that all six Atlantic sturgeon that die as a result of the proposed actions will originate from the GOM DPS, we have considered this worst-case scenario in this analysis.

With the exception of a small percentage of Atlantic sturgeon captured in gill net surveys, all sturgeon captured in beach or haul seines, trawl surveys, or gill nets are anticipated to fully recover from capture without any serious injury or impact on fitness or future reproductive potential. We also anticipate that any Atlantic sturgeon exposed to electrical current during electrofishing will fully recover within a few minutes and not experience any serious injury or impact to fitness or future reproductive potential. The short duration of any capture and handling (*i.e.*, less than 45 minutes total, 20-30 minutes tow or gillnet set plus up to 10-15 minutes of handling time) will not cause a delay or disruption of any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing foraging or overwintering sites or the spawning grounds. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of individuals.

Here, we consider the effect of the loss of up to six Atlantic sturgeon over a five-year period from the GOM DPS. Serious injuries and mortalities are likely to occur in gillnets. The gillnet surveys that may result in mortality will take place in the Hudson River, Delaware Bay, and Chesapeake Bay. Atlantic sturgeon killed may be juveniles, subadults, or adults.

The reproductive potential of the GOM DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a total of up to six individuals over a five-year period, would have the effect of reducing the amount of potential reproduction as any dead GOM DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. As noted above, reproductive potential of Atlantic sturgeon captured and not killed is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior of captured fish will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where GOM DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by GOM DPS fish.

Because we do not have a true census of the GOM DPS, it is difficult to evaluate the effect of the mortality caused by these actions on the species. However, because the proposed actions will result in the loss of no more than six individuals over a five-year period, it is unlikely that these deaths will have a detectable effect on the numbers and population trend of the GOM DPS, which unlike the other four listed DPSs of Atlantic sturgeon is listed as threatened and thus is not currently as vulnerable to the threat of extinction. The loss of six individuals every five years represents only 0.08% of the estimated ocean population of GOM DPS Atlantic sturgeon, which does not include additional numbers of Atlantic sturgeon occurring further inshore in estuaries and rivers of the action area.

The proposed actions are not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by GOM DPS subadults or adults. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where suspended sediment levels are high.

Based on the information provided above, the death of up to six GOM DPS Atlantic sturgeon over a five-year period, will not appreciably reduce the likelihood of survival of the GOM DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect GOM DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population (which includes an estimated 7,455 individuals in the ocean at a minimum), represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, nor will it result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the total loss of up to six individuals over five years will not change the status or trends of the species as a whole; (2) the loss of these GOM DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (3) the loss of these GOM DPS Atlantic sturgeon over a five-year period is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (4) the actions will have only a minor and temporary effect on the distribution of GOM DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the actions will have no effect on the ability of GOM DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging GOM DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the GOM DPS will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the GOM DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the GOM DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria, which once attained would allow the species to be delisted. We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether the proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed actions to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of GOM DPS Atlantic sturgeon and since it will not affect the overall distribution of GOM DPS Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed actions will result in an extremely small amount of mortality annually (one individual) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the actions to affect the persistence of the GOM DPS of Atlantic sturgeon. These actions will not change the status or trend of the GOM DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed actions will not reduce the likelihood of improvement in the status of the GOM DPS of Atlantic sturgeon. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that the GOM DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual GOM DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to six GOM DPS Atlantic sturgeon over a five-year period, are not likely to appreciably reduce the survival and recovery of this species.

9.5.2 New York Bight DPS

The NYB DPS is listed as endangered, and while Atlantic sturgeon occur in several rivers in the New York Bight, recent spawning has only been physically documented in the Hudson and Delaware Rivers. The capture of age-0 Atlantic sturgeon in the Connecticut River in 2014 indicates that spawning may also occur in this river. However, as these young sturgeon represent the only evidence of spawning since the population began being studied in the 1980s, and we do not have any information on the genetic identity of these individuals, we do not know if these represent a unique Connecticut River population or were spawned by migrants from the Hudson River. Spawning may also occur in the Housatonic River due to the presence of features necessary to support reproduction and recruitment (82 FR 39160; August 17, 2017). Nonetheless, based on existing data, we expect any NYB DPS Atlantic sturgeon in the action area to originate from the Hudson or Delaware River. There is limited information on the demographics of the Hudson and Delaware River populations of Atlantic sturgeon and there is currently no census for these populations of Atlantic sturgeon (ASSRT 2007). However, an annual mean estimate of 863 mature adults (596 males and 267 females) was calculated for the Hudson River based on fishery-dependent data from 1985-1995 (Kahnle *et al.* 2007). Also, as discussed in Section 4.2.3, the NEAMAP based methodology estimates a total of 34,566 sub-adult and adult NYB DPS Atlantic sturgeon in the ocean.

We have estimated that the proposed actions will result in the capture of 427 or fewer Atlantic sturgeon over a five-year period, of which up to 242 are expected to be NYB DPS Atlantic sturgeon. We anticipate the mortality of only up to six individuals; no serious injury or mortality of any other captured Atlantic sturgeon is anticipated. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. While it is unlikely that all six Atlantic sturgeon that die as a result of the proposed actions will originate from the NYB DPS, we have considered this worst-case scenario in this analysis.

With the exception of a small percentage of Atlantic sturgeon captured in gill net surveys, all sturgeon captured in beach or haul seines, trawl surveys, or gill nets are anticipated to fully recover from capture without any serious injury or impact on fitness or future reproductive potential. We also anticipate that any Atlantic sturgeon exposed to electrical current during electrofishing will fully recover within a few minutes and not experience any serious injury or impact to fitness or future reproductive potential. The short duration of any capture and handling (*i.e.*, less than 45 minutes total, 20-30 minutes tow or gillnet set plus up to 10-15 minutes of handling time) will not cause a delay or disruption of any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, given the locations of the surveys and the time of year, we do not anticipate the capture or handling of any spawning individuals. The proposed actions will also not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing foraging or overwintering sites or the spawning grounds. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of individuals.

Here, we consider the effect of the loss of up to six Atlantic sturgeon over a five-year period from the NYB DPS. Serious injuries and mortalities are likely to occur in gillnets. The gillnet surveys that may result in mortality will take place in the Hudson River, Delaware Bay, and Chesapeake Bay. Atlantic sturgeon killed may be juveniles, subadults or adults.

The reproductive potential of the NYB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a total of up to six individuals over a five-year period, would have the effect of reducing the amount of potential reproduction as any dead NYB DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. As noted above, reproductive potential of Atlantic sturgeon captured and not killed is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior of captured fish will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where NYB DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by NYB DPS fish.

Because we do not have a true census of the NYB DPS, it is difficult to evaluate the effect of the mortality caused by these actions on the species. However, because the proposed actions will result in the loss of no more than six individuals over a five-year period, it is unlikely that these deaths will have a detectable effect on the numbers and population trend of the NYB DPS. The loss of six individuals every five years represents only 0.02% of the estimated ocean population of NYB DPS Atlantic sturgeon, which does not include additional numbers of Atlantic sturgeon occurring further inshore in estuaries and rivers of the action area.

Based on the information provided above, the death of up to six NYB DPS Atlantic sturgeon over a five-year period, will not appreciably reduce the likelihood of survival of the New York Bight DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The actions will not affect NYB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population (which includes an estimated 34,566 individuals in the ocean at a minimum), represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, nor will it result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the death of these NYB DPS Atlantic sturgeon over a five-year period represents an extremely small percentage of the species as a whole; (2) the death of these NYB DPS Atlantic sturgeon will not change the status or trends of the species as a whole; (3) the loss of these NYB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (4) the loss of these NYB DPS Atlantic sturgeon is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (5) the actions will have only a minor and temporary effect on the distribution of NYB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (6) the actions will have no effect on the ability of NYB DPS Atlantic sturgeon to shelter and only an insignificant effect on individual foraging NYB DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the NYB DPS will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the NYB DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the NYB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria which once attained would allow the species to be delisted. We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether these proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

The proposed actions are not expected to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of NYB DPS Atlantic sturgeon and since it will not affect the overall distribution of NYB DPS Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed actions will result in a small amount of mortality (no more than one individual per year) and a subsequent small reduction in future reproductive output. For these reasons, it is not expected to affect the persistence of the NYB DPS of Atlantic sturgeon. These actions will not change the status or trend of the NYB DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed actions will not reduce the likelihood of improvement in the status of the NYB DPS of Atlantic sturgeon. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that the NYB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual NYB DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to six NYB DPS Atlantic sturgeon over a five-year period, is not likely to appreciably reduce the survival and recovery of this species.

9.5.3 Chesapeake Bay DPS

The CB DPS is listed as endangered, and while Atlantic sturgeon occur and may potentially spawn in several rivers of the Chesapeake Bay, recent spawning has only been physically documented in the James River. Chesapeake Bay origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently no census nor enough information to establish a trend for any life stage, for the James River spawning population, or for the DPS as a whole, although the NEAMAP data indicates that the estimated ocean population of CB DPS Atlantic sturgeon is 8,811 individuals.

We have estimated that the proposed actions will result in the capture of 427or fewer Atlantic sturgeon over a five-year period, of which up to 64 are expected to be CB DPS Atlantic sturgeon. We anticipate the mortality of only six individuals; no serious injury or mortality of any other captured Atlantic sturgeon is anticipated. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. While it is unlikely that all six Atlantic sturgeon that die as a result of the proposed actions will originate from the CB DPS, we have considered this worst-case scenario in this analysis.

With the exception of a small percentage of Atlantic sturgeon captured in gill net surveys, all sturgeon captured in beach or haul seines, trawl surveys, or gill nets are anticipated to fully recover from capture without any serious injury or impact on fitness or future reproductive potential. We also anticipate that any Atlantic sturgeon exposed to electrical current during electrofishing will fully recover within a few minutes and not experience any serious injury or impact to fitness or future reproductive potential. The short duration of any capture and handling (*i.e.*, less than 45 minutes total, 20-30 minutes tow or gillnet set plus up to 10-15 minutes of handling time) will not cause a delay or disruption of any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, given the locations of the surveys and the time of year, we do not anticipate the capture or handling of any spawning individuals. The proposed actions will also not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing foraging or overwintering sites or the spawning grounds. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of individuals.

Here, we consider the effect of the loss of up to six Atlantic sturgeon over a five-year period from the CB DPS. Serious injuries and mortalities are likely to occur in gillnets. The gillnet surveys that may result in mortality will take place in the Hudson River, Delaware Bay, and Chesapeake Bay. Atlantic sturgeon killed may be juveniles, subadults or adults.

The reproductive potential of the CB DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a total of up to six individuals over a five-year period, would have the effect of reducing the amount of potential reproduction as any dead CB DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. As noted above, reproductive potential of Atlantic sturgeon captured and not killed is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior of captured fish will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where CB DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by CB DPS fish.

Because we do not have a true census of the CB DPS, it is difficult to evaluate the effect of the mortality caused by these actions on the species. However, because the proposed actions will result in the loss of no more than six individuals over a five-year period, it is unlikely that these deaths will have a detectable effect on the numbers and population trend of the CB DPS. The loss of six individuals every five years represents only 0.07% of the estimated ocean population of CB DPS Atlantic sturgeon, which does not include additional numbers of Atlantic sturgeon occurring further inshore in estuaries and rivers of the action area.

The proposed actions are not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by CB DPS subadults or adults. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where suspended sediment levels are high.

Based on the information provided above, the death of up to six CB DPS Atlantic sturgeon over a five-year period, will not appreciably reduce the likelihood of survival of the CB DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect CB DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population (which includes an estimated 8,811 individuals in the ocean at a minimum), represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, nor will it result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the total loss of up to six individuals will not change the status or trends of the species as a whole; (2) the loss of these CB DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (3) the loss of these CB DPS Atlantic sturgeon over a five-year period is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (4) the actions will have only a minor and temporary effect on the distribution of CB DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the actions will have no effect on the ability of CB DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging CB DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the CB DPS will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the CB DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the CB DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria, which once attained would allow the species to be delisted. We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether the proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed actions to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of CB DPS Atlantic sturgeon and since it will not affect the overall distribution of CB DPS Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed actions will result in an extremely small amount of mortality annually (one individual) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the actions to affect the persistence of the CB DPS of Atlantic sturgeon. These actions will not change the status or trend of the CB DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed actions will not reduce the likelihood of improvement in the status of the CB DPS of Atlantic sturgeon. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that the CB DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual CB DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to six CB DPS Atlantic sturgeon over a five-year period, are not likely to appreciably reduce the survival and recovery of this species.

9.5.4 Carolina DPS

The Carolina DPS is listed as endangered and consists of Atlantic sturgeon originating from at least five rivers where spawning is still thought to occur. Carolina DPS origin Atlantic sturgeon are affected by numerous sources of human induced mortality and habitat disturbance throughout the riverine and marine portions of their range. There is currently no census of the number of Atlantic sturgeon in any river nor is any currently available for the entire DPS, although the NEAMAP data indicates that the estimated ocean population of Carolina DPS Atlantic sturgeon is 1,356 individuals.

We have estimated that the proposed actions will result in the capture of 427 or fewer Atlantic sturgeon over a five-year period, of which up to 25 are expected to be Carolina DPS Atlantic sturgeon. We anticipate the mortality of only six individuals; no serious injury or mortality of any other captured Atlantic sturgeon is anticipated. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. While it is unlikely that all six Atlantic sturgeon that die as a result of the proposed actions will originate from the Carolina DPS, we have considered this worst-case scenario in this analysis.

With the exception of a small percentage of Atlantic sturgeon captured in gill net surveys, all sturgeon captured in beach or haul seines, trawl surveys, or gill nets are anticipated to fully recover from capture without any serious injury or impact on fitness or future reproductive potential. We also anticipate that any Atlantic sturgeon exposed to electrical current during electrofishing will fully recover within a few minutes and not experience any serious injury or impact to fitness or future reproductive potential. The short duration of any capture and handling (*i.e.*, less than 45 minutes total, 20-30 minutes tow or gillnet set plus up to 10-15 minutes of handling time) will not cause a delay or disruption of any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, given the locations of the surveys and the time of year, we do not anticipate the capture or handling of any spawning individuals. The proposed actions will also not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing foraging or overwintering sites or the spawning grounds. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of individuals.

Here, we consider the effect of the loss of up to six Atlantic sturgeon over a five-year period from the Carolina DPS. Serious injuries and mortalities are likely to occur in gillnets. The gillnet surveys that may result in mortality will take place in the Hudson River, Delaware Bay, and Chesapeake Bay. Atlantic sturgeon killed may be juveniles, subadults or adults.

The reproductive potential of the Carolina DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a total of up to six individuals over a five-year period, would have the effect of reducing the amount of potential reproduction as any dead Carolina DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. As noted above, reproductive potential of Atlantic sturgeon captured and not killed is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior of captured fish will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where Carolina DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by Carolina DPS fish.

Because we do not have a true census of the Carolina DPS, it is difficult to evaluate the effect of the mortality caused by these actions on the species. However, because the proposed actions will result in the loss of no more than six individuals over a five-year period, it is unlikely that these deaths will have a detectable effect on the numbers and population trend of the Carolina DPS. The loss of six individuals every five years represents only 0.44% of the estimated ocean population of Carolina DPS Atlantic sturgeon, which does not include additional numbers of Atlantic sturgeon occurring further inshore in estuaries and rivers of the action area.

The proposed actions are not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by Carolina DPS subadults or adults. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where suspended sediment levels are high.

Based on the information provided above, the death of up to six Carolina DPS Atlantic sturgeon over a five-year period, will not appreciably reduce the likelihood of survival of the Carolina DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect Carolina DPS Atlantic sturgeon in a way that prevents the species from having a sufficient population (which includes an estimated 1,356 individuals in the ocean at a minimum), represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, nor will it result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the total loss of up to six individuals will not change the status or trends of the species as a whole; (2) the loss of these Carolina DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (3) the loss of these Carolina DPS Atlantic sturgeon over a five-year period is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (4) the actions will have only a minor and temporary effect on the distribution of Carolina DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the actions will have no effect on the ability of Carolina DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging Carolina DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the Carolina DPS will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the Carolina DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the Carolina DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria, which once attained would allow the species to be delisted. We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether the proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed actions to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of Carolina DPS Atlantic sturgeon and since it will not affect the overall distribution of Carolina DPS Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed actions will result in an extremely small amount of mortality annually (one individual) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the actions to affect the persistence of the Carolina DPS of Atlantic sturgeon. These actions will not change the status or trend of the Carolina DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed actions will not reduce the likelihood of improvement in the status of the Carolina DPS of Atlantic sturgeon. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that the Carolina DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual Carolina DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to six Carolina DPS Atlantic sturgeon over a five-year period, are not likely to appreciably reduce the survival and recovery of this species.

9.5.5 South Atlantic DPS

The SA DPS is listed as endangered and consists of Atlantic sturgeon originating from at least six rivers where spawning is still thought to occur. Schueller and Peterson (2006) estimate that there were 343 adults spawning in the Altamaha River, Georgia, in 2004 and 2005. This represents a percentage of the total adult population for the Altamaha River. Males spawn every 1-5 years and females spawn every 2-5 years; thus, the total Altamaha River adult population, assuming a 2:1 ratio of males to females as seen in the Hudson River, could range from 457-1,715. Spawning occurs in at least five other rivers in this DPS. Therefore, the number of Atlantic sturgeon in the Altamaha River population is only a portion of the total DPS. No census of the number of Atlantic sturgeon in any of the other spawning rivers or for the DPS as a whole is available. However, the NEAMAP data indicates that the estimated ocean population of South Atlantic DPS Atlantic sturgeon is 14,911 individuals.

We have estimated that the proposed actions will result in the capture of 427 or fewer Atlantic sturgeon over a five-year period, of which up to 82 are expected to be SA DPS Atlantic sturgeon. We anticipate the mortality of six individuals; no serious injury or mortality of any other captured Atlantic sturgeon is anticipated. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. While it is unlikely that all six Atlantic sturgeon that die as a result of the proposed actions will originate from the SA DPS, we have considered this worst-case scenario in this analysis.

With the exception of a small percentage of Atlantic sturgeon captured in gill net surveys, all sturgeon captured in beach or haul seines, trawl surveys, or gill nets are anticipated to fully recover from capture without any serious injury or impact on fitness or future reproductive potential. We also anticipate that any Atlantic sturgeon exposed to electrical current during electrofishing will fully recover within a few minutes and not experience any serious injury or impact to fitness or future reproductive potential. The short duration of any capture and handling (*i.e.*, less than 45 minutes total, 20-30 minutes tow or gillnet set plus up to 10-15 minutes of handling time) will not cause a delay or disruption of any essential behavior including spawning, there will be no reduction in individual fitness or any future reduction in numbers of individuals. Additionally, given the locations of the surveys and the time of year, we do not anticipate the capture or handling of any spawning individuals. The proposed actions will also not affect their spawning habitat in any way and will not create any barrier to pre-spawning sturgeon accessing foraging or overwintering sites or the spawning grounds. Any effects to distribution will be minor and temporary and limited to the temporary capture and handling of individuals.

Here, we consider the effect of the loss of up to six Atlantic sturgeon over a five-year period from the SA DPS. Serious injuries and mortalities are likely to occur in gillnets. The gillnet surveys that may result in mortality will take place in the Hudson River, Delaware Bay, and Chesapeake Bay. Atlantic sturgeon killed may be juveniles, subadults or adults.

The reproductive potential of the SA DPS will not be affected in any way other than through a reduction in numbers of individuals. The loss of a total of up to six individuals over a five-year period, would have the effect of reducing the amount of potential reproduction as any dead SA DPS Atlantic sturgeon would have no potential for future reproduction. However, this small reduction in potential future spawners is expected to result in an extremely small reduction in the number of eggs laid or larvae produced in future years and similarly, an extremely small effect on the strength of subsequent year classes. Even considering the potential future spawners that would be produced by the individual that would be killed as a result of the proposed action, any effect to future year classes is anticipated to be extremely small and would not change the status of this species. As noted above, reproductive potential of Atlantic sturgeon captured and not killed is not expected to be affected in any way. Additionally, we have determined that any impacts to behavior of captured fish will be minor and temporary and that there will not be any delay or disruption of any normal behavior including spawning; there will also be no reduction in individual fitness or any future reduction in numbers of individuals. The proposed actions will also not affect the spawning grounds within the rivers where SA DPS fish spawn. The actions will also not create any barrier to pre-spawning sturgeon accessing the overwintering sites or the spawning grounds used by SA DPS fish.

Because we do not have a true census of the SA DPS, it is difficult to evaluate the effect of the mortality caused by these actions on the species. However, because the proposed actions will result in the loss of no more than six individuals over a five-year period, it is unlikely that these deaths will have a detectable effect on the numbers and population trend of the SA DPS. The loss of six individuals every five years represents only 0.04% of the estimated ocean population of SA DPS Atlantic sturgeon, which does not include additional numbers of Atlantic sturgeon occurring further inshore in estuaries and rivers of the action area.

The proposed actions are not likely to reduce distribution because the actions will not impede Atlantic sturgeon from accessing any seasonal concentration areas, including foraging areas within the action area that may be used by SA DPS subadults or adults. Further, the actions are not expected to reduce the river by river distribution of Atlantic sturgeon. Any effects to distribution will be minor and temporary and limited to the temporary avoidance of the area where suspended sediment levels are high.

Based on the information provided above, the death of up to six SA DPS Atlantic sturgeon over a five-year period, will not appreciably reduce the likelihood of survival of the SA DPS (*i.e.*, it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). The action will not affect SADPS Atlantic sturgeon in a way that prevents the species from having a sufficient population (which includes an estimated 14,911 individuals in the ocean at a minimum), represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, nor will it result in effects to the environment which would prevent Atlantic sturgeon from completing their entire life cycle, including reproduction, sustenance, and shelter. This is the case because: (1) the total loss of up to six individuals will not change the status or trends of the species as a whole; (2) the loss of these SA DPS Atlantic sturgeon is not likely to have an effect on the levels of genetic heterogeneity in the population; (3) the loss of these SA DPS Atlantic sturgeon over a five-year period is likely to have such a small effect on reproductive output that the loss of these individuals will not change the status or trends of the species; (4) the actions will have only a minor and temporary effect on the distribution of SA DPS Atlantic sturgeon in the action area and no effect on the distribution of the species throughout its range; and, (5) the actions will have no effect on the ability of SA DPS Atlantic sturgeon to shelter and only an insignificant effect on any foraging SA DPS Atlantic sturgeon.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that the SA DPS will survive in the wild. Here, we consider the potential for the actions to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Thus, we have considered whether the proposed actions will affect the likelihood that the SA DPS can rebuild to a point where listing is no longer appropriate. No Recovery Plan for the SA DPS has been published. The Recovery Plan will outline the steps necessary for recovery and the demographic criteria, which once attained would allow the species to be delisted. We know that in general, to recover, a species must have a sustained positive trend over time and an increase in population. To allow those things to happen, a species must have enough habitat in suitable condition that allows all normal life functions to occur (i.e., spawning, foraging, resting) and have access to enough food. Here, we consider whether the proposed actions will affect the population size and/or trend in a way that would affect the likelihood of recovery.

We do not expect the proposed actions to modify, curtail or destroy the range of the species since it will result in an extremely small reduction in the number of SA DPS Atlantic sturgeon and since it will not affect the overall distribution of SA DPS Atlantic sturgeon. Any effects to habitat will be insignificant and discountable and will not affect the ability of Atlantic sturgeon to carry out any necessary behaviors or functions. Any impacts to available forage will also be insignificant. The proposed actions will result in an extremely small amount of mortality annually (one individual) and a subsequent small reduction in future reproductive output. For these reasons, we do not expect the actions to affect the persistence of the SA DPS of Atlantic sturgeon. These actions will not change the status or trend of the SA DPS of Atlantic sturgeon. The very small reduction in numbers and future reproduction resulting from the proposed actions will not reduce the likelihood of improvement in the status of the SA DPS of Atlantic sturgeon. The effects of the proposed actions will not delay the recovery timeline or otherwise decrease the likelihood of recovery. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that the SA DPS of Atlantic sturgeon can be brought to the point at which they are no longer listed as threatened. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

Despite the threats faced by individual SA DPS Atlantic sturgeon inside and outside of the action area, the proposed actions will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed actions. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and have concluded that even in light of the ongoing impacts of these activities and conditions; the conclusions reached above do not change. Based on the analysis presented herein, the proposed actions, resulting in the mortality of up to six SA DPS Atlantic sturgeon over a five-year period, are not likely to appreciably reduce the survival and recovery of this species.

9.6 Shortnose sturgeon

We have determined that over a five-year period, the proposed actions are likely to result in the capture of 20 shortnose sturgeon in seine, bottom trawl, and gillnet sampling gear; the exposure of 34 shortnose sturgeon to electric current resulting from electrofishing; and the capture of one shortnose sturgeon in the fish ladder on the Westfield River. Aside from two potential mortalities in gill net gear, we do not anticipate any serious injury or mortality of any captured shortnose sturgeon; we expect all seine, bottom trawl, electrofishing, and fish ladder captured shortnose sturgeon will be returned to the water alive. Some level of minor harassment (e.g., startling, handling stress) or injury (e.g., scrapes, cuts, or abrasions to the scutes or skin) due to capture or release from the sampling gear may occur, but none would not rise to the level where it would cause a reduction in the species' numbers, reproduction, or distribution. Affected shortnose sturgeon are likely to be from the Penobscot, Kennebec, Androscoggin, Merrimack, Connecticut, Hudson, Delaware, and Chesapeake Bay river spawning populations.

Historically, shortnose sturgeon are believed to have inhabited nearly all major rivers and estuaries along nearly the entire east coast of North America. Today, only 19 populations remain. The present range of shortnose sturgeon is disjunct, with northern populations separated from southern populations by a distance of about 400 kilometers. Population sizes range from under 100 adults in the Cape Fear and Merrimack Rivers to tens of thousands in the St. John and Hudson Rivers.

Based on the number of adults in the population for which estimates are available, there are at least 104,662 adult shortnose sturgeon, including 18,000 in the Saint John River in Canada. Based on the best available information (2010 Draft Biological Assessment for Shortnose Sturgeon) trends in abundance for shortnose sturgeon in Northeast rivers demonstrate the majority of populations are stable (*i.e.*, Delaware, Hudson, Connecticut, Merrimack). The Kennebec River Complex is the only population in the Northeast that shows an increasing trend in abundance. In the Southeast abundance trends for many riverine populations are unknown due to lack of data (*i.e.*, Chowan, Tar Pamlico, Neuse, New, North, Santee, S-C Reservoir system, Satilla, St. Mary's, and St. John's). The Winyah Bay Complex, Cooper, Savannah, Ogeechee, and Altamaha Rivers show stable trends in abundance. The only riverine population in the Southeast demonstrating increasing trends in abundance is the Ashepoo-Combahee-Edisto (ACE) Basin.

The U.S FWS proposes to fund several state studies within nearshore/estuarine/riverine areas of the action area using non-selective sampling gear types (seines, bottom trawls, gillnets, and boat electrofishing equipment). As explained in the *Effects of the Actions* section, the deployment of those gear types is likely to result in interactions with a limited number of shortnose sturgeon over the five-year funding period (approximately 11 per year). We have estimated that the proposed actions will result in up to 55 captures and two mortalities over the next five years. The potential for effects are possible when fish encounter or are trapped by the sampling gear. These effects could range from alteration of normal behavior such as a temporary startle or avoidance of the sampling area, to minor physiological stress and minor physical injury from abrasion associated with physically interacting with the gear, to serious injury and mortality due to prolonged entanglement or severe injuries from exposure to, capture in, or release from the gear. Non-lethal behavioral responses are expected to be temporary and spatially limited to the area and time fish interact with or are restricted by sampling gear. Capture in sampling gear is anticipated to increase physiological effects associated with handling stress and result in minor injuries that for the majority will not impair the fitness of any individuals or affect survival, however a small percentage could suffer lethal injuries or death. We have further determined the behavior and physiological responses as a result of sturgeon becoming captured would increase physiological stress (i.e., associated with physically removing the animal from the trap) and potentially cause serious injury, which would likely result in mortality.

Shortnose sturgeon captured in seine, bottom trawl, or gill net gear, entering fishways, or stunned by electrofishing gear will experience a disruption in normal behavior for up to 30 minutes and may experience physical injury that may lead to death. As outlined above, no more than 55 shortnose sturgeon are likely to interact with these types of gears or technology over the course of five years. While precautions will be taken to minimize handling stress, physical injuries due to being captured by net gear could result in lethal injury or mortality. Data from commercial trawling indicates a low mortality rate of shortnose sturgeon incidentally caught in otter trawl gear. Interactions between shortnose sturgeon and beach seines are anticipated to be very brief in duration (<20 minutes) and limited to the immediate area of the net set. Because shortnose sturgeon could become captured in this gear, protocols will be in place to expedite release and reduce stress from handling. Adverse effects may also result from interactions with gill nets. Specifically, shortnose sturgeon encountering gill nets may become trapped within the gill net mesh until it is tended and the catch is processed and released. This will result in the disruption of normal behaviors for a maximum of 24 hours. While gill net sampling is generally considered to be non-lethal, there is the potential for sturgeon to become trapped or entangled in the gear or otherwise suffer lethal injury or mortality. However, based on previous studies considered here the mortality rate is expected to be very low (around 1%-2%).

We only expect up to two of the shortnose sturgeon captured in gill net surveys in Virginia to be killed over the five-year funding period; both are presumed to be adults. While the proposed sampling may result in the mortality of two adult shortnose sturgeon, this number represents a very small percentage of shortnose sturgeon in the action area, and an even smaller percentage of the total population of shortnose sturgeon range-wide. It is also important to note that this mortality estimate is considered to be a worst case scenario and is based on conservative assumptions outlined in the *Effects of the Actions* section. While the death of two adult shortnose sturgeon will reduce the number of shortnose sturgeon in the action area compared to the number that would have been present absent the proposed action, it is not likely that this reduction in numbers will change the status of this population as this loss represents an extremely small percentage of fish residing in the action area.

The proposed actions are expected to cause an undetectable reduction in reproduction of shortnose sturgeon for the following reasons: (1) the proposed research projects are far enough downstream and small enough in scale that they are unlikely to bar upstream passage for any spawning shortnose sturgeon; thus, there will be no disruption of use of the spawning grounds; and (2) at worst, the actions will result in the mortality of two adult shortnose sturgeon. As there are many hundreds to thousands of available spawners in the action area rivers, the reduction in available spawners by no more than two is expected to result in an undetectable reduction in the number of eggs laid or larvae produced and similarly, an undetectable effect on the strength of subsequent year classes. Additionally, the proposed actions will not affect spawning habitats in any way and will not create any barrier to pre-spawning sturgeon accessing their spawning grounds. The proposed actions are not likely to reduce distribution because the actions will not impede shortnose sturgeon from accessing any seasonal concentration areas, including foraging, spawning or overwintering grounds. Further, the actions are not expected to reduce the river by river distribution of shortnose sturgeon or the ability of shortnose sturgeon to migrate between coastal rivers. Additionally, as the number of shortnose sturgeon likely to be killed as a result of the proposed actions is extremely small, there is not likely to be a loss of any unique genetic haplotypes and therefore, it is unlikely to result in the loss of genetic diversity. While generally speaking, the loss of two individuals from a subpopulation or species may have an appreciable effect on the numbers, reproduction, and distribution of the species, this is likely to occur only when there are very few individuals in a population, the individuals occur in a very limited geographic range, or the species has extremely low levels of genetic diversity. This situation is not likely in the case of shortnose sturgeon because: (1) the species is widely geographically distributed; (2) it is not known to have low levels of genetic diversity (see *Status of Listed Species* section); and (3) there are thousands of shortnose sturgeon spawning each year.

There will be no effects to the prey base that would cause shortnose sturgeon to leave the action area to forage elsewhere. Therefore, the proposed actions are not likely to reduce the numbers of shortnose sturgeon in the action area, the numbers of shortnose sturgeon in any river population or the species as a whole. Similarly, as the proposed actions will not affect the fitness of any released individuals, no effects to reproduction are anticipated. The actions are also not likely to affect the distribution of shortnose sturgeon in the action area or affect the distribution of shortnose sturgeon throughout their range. Because effects are limited to capture, with only a small amount of mortality, we do not anticipate any population level impacts. Despite the threats faced by individual shortnose sturgeon inside and outside of the action area, the proposed action will not increase the vulnerability of individual sturgeon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will continue to impact shortnose sturgeon in the action area or how the species will adapt to climate-change related environmental impacts, no additional effects related to climate change to shortnose sturgeon in the action area are anticipated over the five-year life of the proposed action. We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and has concluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above regarding potential reductions in numbers, reproduction, or distribution do not change.

Based on the information provided above, the death of no more than two shortnose sturgeon as a result of the proposed actions will not appreciably reduce the likelihood of survival (i.e., it will not increase the risk of extinction faced by this species) for this species given that: (1) the death of two shortnose sturgeon represents an extremely small percentage of the number of shortnose sturgeon in the action area and even a smaller percentage of the species as a whole (less than 0.002%); (2) the loss of two shortnose sturgeon will not change the status or trends of the species as a whole; (3) the loss of two shortnose sturgeon is likely to have an undetectable effect on reproductive output of the species as a whole; (4) and, the actions will have no effect on the distribution of shortnose sturgeon in the action area or throughout its range.

In certain instances, an action that does not appreciably reduce the likelihood of a species' survival might affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed actions will not appreciably reduce the likelihood that shortnose sturgeon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate. Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (*i.e.*, “endangered”), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (*i.e.*, “threatened”) because of any of the following five listing factors: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

The proposed actions are not expected to modify, curtail, or destroy the range of the species since they will result in of the loss of up to two shortnose sturgeon every five years from an estimated population of over 100,000 and since they will not affect the overall distribution of shortnose sturgeon other than to cause minor temporary adjustments in movements within the action area. The proposed actions will not utilize shortnose sturgeon for recreational or commercial purposes or affect the adequacy of existing regulatory mechanisms to protect this species. The proposed actions are likely to result in up to two mortalities, a slight reduction in future reproductive output; therefore, the U.S. FWS funded state fisheries surveys over the next five years are not expected to affect the persistence of shortnose sturgeon range-wide. There will be no change in the status or trend of shortnose sturgeon. As there will be only a slight reduction in numbers or future reproduction, the actions would not cause any reduction in the likelihood of improvement in the status of shortnose sturgeon. The effects of the proposed actions will not hasten the extinction timeline or otherwise increase the danger of extinction since the actions will not cause any significant reduction of overall reproductive fitness for the species. The effects of the proposed actions will also not reduce the likelihood that the status of the species can improve to the point where it is recovered and could be delisted. Therefore, the proposed actions will not appreciably reduce the likelihood that shortnose sturgeon can be brought to the point at which they are no longer listed as endangered. Based on the analysis presented herein, the proposed actions are not likely to appreciably reduce the survival and recovery of this species.

10.0 CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the effects of the proposed actions, and the cumulative effects, it is our biological opinion that the proposed actions may adversely affect but are not likely to jeopardize the continued existence of NWA DPS loggerhead sea turtles, Kemp’s ridley sea turtles, North Atlantic DPS green sea turtles, leatherback sea turtles; the GOM, NYB, CB, Carolina, and SA DPSs of Atlantic sturgeon; or shortnose sturgeon.

11.0 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA prohibits the take of endangered species of fish and wildlife. “Fish and wildlife” is defined in the ESA “as any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, non-migratory, or endangered bird for which protection is also afforded by treaty or other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate, and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof." 16 U.S.C. 1532(8). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS to include any act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns including breeding, spawning, rearing, migrating, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. "Otherwise lawful activities" are those actions that meet all State and Federal legal requirements except for the prohibition against taking in ESA Section 9 (51 FR 19936, June 3, 1986), which would include any state endangered species laws or regulations. Section 9(g) makes it unlawful for any person "to attempt to commit, solicit another to commit, or cause to be committed, any offense defined [in the ESA.]" 16 U.S.C. 1538(g). See also 16 U.S.C. 1532(13)(definition of "person"). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by U.S. FWS so that they become binding conditions for the exemption in section 7(o)(2) to apply. U.S. FWS has a continuing duty to regulate the activity covered by this Incidental Take Statement. If U.S. FWS (1) fails to assume and implement the terms and conditions or (2) fails to require any grantees (i.e., state partners) to adhere to the terms and conditions of the Incidental Take Statement through enforceable terms that are added contracts or other documents as appropriate, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, U.S. FWS or its grantees (i.e., state partners) must report the progress of the action and its impact on the species to us as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)] (See U.S. Fish and Wildlife Service and National Marine Fisheries Service's Joint Endangered Species Act Section 7 Consultation Handbook (1998) at 4-49). The process for this reporting is detailed later on in the reasonable and prudent measures and terms and conditions (Section 11.2).

11.1 Anticipated Amount or Extent of Incidental Take

Based on the information presented in the opinion, we anticipate that the surveys described in this opinion, to be funded by U.S. FWS and carried out by the states over a five-year period from 2018-2022, will result in the capture of:

- Up to 37 sea turtles (all in bottom trawl studies);
- Up to 427 Atlantic sturgeon (including two in beach/haul seine studies, 266 in bottom trawl studies, 158 in gill net studies, and one interaction during electrofishing activities); and
- Up to 55 shortnose sturgeon (including eight in beach/haul seine studies, one in the Westfield River fish passage facility, ten in bottom trawl studies, two in gill net studies, and 34 interactions during electrofishing activities).

We anticipate two shortnose sturgeon and six Atlantic sturgeon (originating from any of the five DPSs) mortalities during gillnet surveys carried out by New York, New Jersey, Maryland, and Virginia.

While we have completed one biological opinion, the actions considered here consist of 12 independent actions carried out by U.S. FWS (i.e., awarding of each grant fund to each state and the District of Columbia is an independent action). As such, we have further organized the ITS by activity and provided a summary by state in the following pages. However, the ITS would only be considered exceeded if the total number of takes or mortalities of listed sea turtles, shortnose, or Atlantic sturgeon listed above was exceeded across the entire set of surveys over the five-year period. Thus, the table below is only meant as a benchmark for the states to compare their reported takes to what we have anticipated over the next five years.

As explained in the *Effects of the Actions* section of the opinion, none of the captured sea turtles are expected to die, immediately or later, as a result of interactions with the proposed actions. Two of the shortnose sturgeon and six of the Atlantic sturgeon captured during state gill net studies are likely to die. In the accompanying opinion, we determined that this level of anticipated take is not likely to result in jeopardy to any listed species.

This ITS exempts the following take:

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
Maine beach seine	3	0	0	0	0	0	0	0	0	0	0
Maine/NH trawl	1	10	1	5	1	1	2	0	0	0	0
ME/NH TOTAL	**4**	**10**	**1**	**5**	**1**	**1**	**2**	**0**	**0**	**0**	**0**
MA trawl	1	1	one capture from any of the five DPSs					1 sea turtle any species			
MA fish ladder (excluding Holyoke Dam)	1	0	0	0	0	0	0	0	0	0	0
MA TOTAL	**2**	**1**	**one capture from any of the five DPSs**					**1 sea turtle any species**			
RI fish trawl	1	1	one capture from any of the five DPSs					1 sea turtle any species			
RI TOTAL	**1**	**1**	**one capture from any of the five DPSs**					**1 sea turtle any species**			
CT LIST	1	85	3	66	6	1	9	1 sea turtle any species			
CT TOTAL	**1**	**85**	**3**	**66**	**6**	**1**	**9**	**1 sea turtle any species**			
NY striped bass beach/ haul seine	4	2	1 from GOM or CB DPS	1	1 from GOM or CB DPS	0	0	0	0	0	0
NY striped bass electrofishing	33	0	0	0	0	0	0	0	0	0	0

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
NY shad gillnet	0	1	one capture (may be lethal) from any of the five DPSs					0	0	0	0
NY Peconic small mesh trawl	0	0	0	0	0	0	0	1 loggerhead, Kemp’s ridley, or green			0
NY TOTAL	**37**	**3 (1 lethal)**	**up to 2**	**up to 2**	**up to 2**	**up to 1**	**up to 1**	**1 loggerhead, Kemp’s ridley, or green**			**0**
			one mortality overall - individual could originate from any of the five DPSs								
NJ Delaware River striped bass seine	1	0	0	0	0	0	0	0	0	0	0
NJ Ocean Trawl Survey	0	126	14	62	18	6	26	8	4	2	1
NJ striped bass gillnet	0	41	3	23	7	1	7	0	0	0	0
			one mortality - individual could originate from any of the five DPSs								
NJ TOTAL	**1**	**167 (1 lethal)**	**17**	**85**	**25**	**7**	**33**	**8**	**4**	**2**	**1**
			one mortality - individual could originate from any of the five DPSs								
DE Estuary bottom trawl	2	7	1 GOM or Carolina	4	1	1 GOM or Carolina	1	1	1 Kemp’s ridley, green, or leatherback		
DE Bay Groundfish	2	16	1 GOM or Carolina	9	3	1 GOM or Carolina	3	5	2 Kemp’s ridleys, greens, or leatherbacks (any combination)		
DE bass electrofishing	1	1	one Atlantic sturgeon from any of the five DPSs					0	0	0	0

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
DE TOTAL	**5**	**24**	**up to 3**	**up to 14**	**up to 5**	**up to 3**	**up to 5**	**6**	**up to 3**	**up to 3**	**up to 3**
MD Coastal Bays	0	1	one capture from any of the five DPSs					1 sea turtle any species			
MD striped bass drift gillnet	0	1	one capture (may be lethal) from any of the five DPSs					0	0	0	0
MD TOTAL	**0**	**2 (1 lethal)**	**2 captures (1 may be lethal) from any of the five DPSs**					**1 sea turtle any species**			
VA ChesMMAP	1	2	1 GOM, CB, Carolina, or SA	1	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	5	2 Kemp's ridleys, greens, or leatherbacks (any combination)		
VA juvenile fish	1	17	2	8	3	1	3	1 sea turtle any species			
VA striped bass gillnet	1 (may be lethal)	2	1 GOM, CB, Carolina, or SA	1	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	1 GOM, CB, Carolina, or SA	0	0	0	0
			one mortality - individual could originate from any of the five DPSs								
VA shad gillnet	1 (may be lethal)	113	13	56	16	5	23	0	0	0	0
			two mortalities - individuals could be from any of the five DPSs								

Study	shortnose sturgeon	Total Atlantic sturgeon	GOM DPS Atlantic sturgeon	NYB DPS Atlantic sturgeon	CB DPS Atlantic sturgeon	Carolina DPS Atlantic sturgeon	SA DPS Atlantic sturgeon	loggerhead sea turtle	Kemp's ridley sea turtle	green sea turtle	leatherback sea turtle
VA TOTAL	**4 (up to 2 may be lethal)**	**134 (no more than 3 lethal)**	**up to 17 (up to 3 lethal)**	**up to 66 (up to 3 lethal)**	**up to 21 (up to 3 lethal)**	**up to 8 (up to 3 lethal)**	**up to 28 (3 lethal)**	**up to 6**	**up to 3**	**up to 3**	**up to 3**

11.2 Reasonable and Prudent Measures

We believe the following reasonable and prudent measures (RPMs) and associated terms and conditions listed in Table 32 below are necessary and appropriate to minimize and monitor impacts of incidental take resulting from the proposed action. In order to be exempt from prohibitions of section 9 of the ESA, U.S. FWS and their state funding partners must comply with all terms and conditions identified below, which implement the RPMs and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary. Any taking that is in compliance with the terms and conditions specified in this ITS shall not be considered a prohibited taking of the species concerned (ESA section 7(o)(2)). U.S. FWS should ensure that their state grantees comply with these RPMs and terms and conditions by including these required measures in the award conditions for each state grant being issued.

The RPMs, with their implementing terms and conditions, are designed to minimize and monitor the impact of incidental take that might otherwise result from the proposed actions. Specifically, these RPMs and Terms and Conditions will keep us informed of when and where sea turtle, shortnose sturgeon, and Atlantic sturgeon interactions with state fisheries research gear are taking place and will require survey crews to report any takes in a reasonable amount of time, as well as implement measures to monitor for captures in or interactions with specific gears utilized during these proposed and ongoing surveys. The third column below explains why each of these RPMs and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the proposed action.

In order to effectively monitor the effects of the proposed action, it is necessary to monitor the impacts of the action to document the amount of incidental take (i.e., the number of sea turtles, shortnose sturgeon, and Atlantic sturgeon captured, injured, or killed) and to assess any sea turtles or sturgeon that are captured during this monitoring. Monitoring provides information on the characteristics of sea turtles and sturgeon encountered and may provide data which will help develop more effective measures to avoid future interactions with ESA-listed species. We do not anticipate any additional injury or mortality to be caused by handling, assessing, and ultimately releasing sea turtles and sturgeon as required in the RPMs listed below.

Table 32. RPMs, Terms and Conditions, and Justifications.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
1. <u>PROTECTED SPECIES DISENTANGLEMENT TRAINING MATERIALS</u>: U.S. FWS and their state grantees must ensure that fisheries survey staff who intend to disentangle sea turtles from their gear possess adequate sea turtle disentanglement training materials provided by NMFS.	1. U.S. FWS must explicitly state in the award conditions for each state grant that fisheries survey staff intending to disentangle sea turtles on their own possess adequate sea turtle disentanglement training materials. Staff possessing adequate disentanglement training materials are authorized through this opinion to disentangle sea turtles according to the Northeast Atlantic Coast STDN Disentanglement Guidelines at http://www.greateratlantic.fisheries.noaa.gov/protected/stranding/disentanglements/turtle/stdn.html. State survey staff should contact the NMFS Greater Atlantic Region Sea Turtle Stranding and Disentanglement Coordinator (currently Kate Sampson; 978-282-8470) or the GARFO PRD Sea Turtle Program (978-281-9328) for information on required disentanglement protocols and equipment. All disentanglement must be done in accordance with the procedures described in "Careful Release Protocols for Sea Turtle Release with Minimal Injury" (NOAA Technical Memorandum 580; http://www.sefsc.noaa.gov/turtles/TM_NMFS_SEFSC_580.pdf) and the disentanglement placards provided in Appendix D of the NOAA Technical Memorandum.	RPM #1 and the accompanying Term and Condition establishes the sea turtle disentanglement training materials that fisheries survey staff must possess prior to responding to the incidental take of sea turtles in fisheries research gear. These training materials will provide staff with adequate guidance in the handling, resuscitation, release, and reporting of sea turtles that may be incidentally captured over the course of the proposed actions.

Reasonable and Prudent Measures (RPMs)	**Terms and Conditions (T&Cs)**	**Justifications for RPMs and T&Cs**
2. HANDLING AND RESUSCITATION: Any sea turtles, shortnose sturgeon, or Atlantic sturgeon caught and retrieved in fishing activities covered under this opinion must be handled and resuscitated (if unresponsive) according to established protocols and whenever environmental conditions are safe for those handling and resuscitating the animal(s) to do so.	2. U.S. FWS and their state grantees must ensure that all fisheries survey staff have copies of the sea turtle handling and resuscitation requirements found at 50 CFR 223.206(d)(1) (Appendix B) and as reproduced in the wheelhouse card in Appendix C. Fisheries survey staff must carry out these handling and resuscitation procedures any time a sea turtle is incidentally captured and brought onboard a vessel during the proposed actions. If possible, it is requested that only trained or NMFS permitted staff perform the handling and resuscitation of captured sea turtles. 3. U.S. FWS and their state grantees must ensure that fisheries survey staff give priority to the handling and resuscitation of any sea turtles that are captured or entangled in fishing gear, if environmental conditions are safe to do so. Handling times for sea turtles should be minimized (i.e., kept to 15 minutes or less) to limit the amount of stress placed on the animals. 4. For sea turtles encountered during the proposed actions that appear injured (i.e., beyond minor chips, cuts, or abrasions to the carapace or skin), sick, distressed, or dead (including stranded or entangled individuals), fisheries survey staff must immediately contact their state's stranding	RPM #2 and the accompanying Terms and Conditions establish the requirements for handling and resuscitating sea turtles, shortnose sturgeon, and Atlantic sturgeon captured in fisheries research gear in order to avoid the likelihood of serious injury or mortality to these species from the hauling, handling, and emptying of the gear.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
	and salvage network partner for further instructions and guidance on handling, retention, and/or disposal of the animal. If unable to contact the state's stranding and salvage organization, they must contact the Greater Atlantic Region Marine Animal Hotline at 866-755-NOAA (6622). If unable to contact either of the above (e.g., due to distance from shore or lack of ability to communicate via phone), the USCG should be contacted via VHF marine radio on Channel 22A. If required, hard-shelled sea turtles (i.e., non-leatherbacks) may be held onboard a vessel for up to 24 hours provided that conditions during holding are approved by the state's stranding and salvage organization or GARFO PRD and safe handling practices are followed. Unless environmental conditions are unsafe, survey crews should make every effort to get an injured sea turtle to a rehabilitation facility. If the state or Federal stranding and salvage hotline or an available veterinarian cannot be contacted and the injured animal cannot be taken to a rehabilitation facility, fisheries survey staff must cease activities that could further stress the animal, allow it to rest and recuperate as conditions dictate, and then return the animal to the water.	

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
	5. U.S. FWS and their state grantees must ensure that fisheries survey staff who attempt to handle and resuscitate any incidentally taken shortnose and Atlantic sturgeon are aware of the NMFS guidelines for doing so, which are included in Appendix D. If an entangled sturgeon is determined to be unresponsive or comatose, fisheries survey staff should attempt to resuscitate the fish by placing it in oxygenated water or providing a running source of water over the gills. Resuscitation should be attempted on all nonresponsive fish for at least 30 minutes. If the fish remains nonresponsive after 30 minutes, the fish should be considered dead and the carcass reported to either GARFO PRD or a co-investigator, cooperating facility, or laboratory affiliated with the Sturgeon Salvage Network. In the event of a sturgeon mortality, also refer to the requirements in RPM #4 and T&C #11 below.	
3. <u>DATA COLLECTION, SAMPLING, AND TAGGING</u>: Any sea turtles, shortnose sturgeon, or Atlantic sturgeon caught or retrieved in fishing activities covered under this opinion must be identified to species	6. U.S. FWS and their state grantees must ensure that fisheries survey staff are trained in the identification of sea turtles, shortnose sturgeon, and Atlantic sturgeon. Although the NEFOP training manuals found at http://www.nefsc.noaa.gov/fsb/training/ are the best resource for species identification, we have also provided a general	RPM #3 and the accompanying Terms and Conditions specify the collection of information for any sea turtles, shortnose sturgeon, or Atlantic sturgeon observed captured in fisheries research gear. This is essential for monitoring the impacts of the proposed action and level of

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
or species group and properly documented using appropriate materials and data collection forms provided by NMFS. Biological, external and internal tagging, and gear description data must also be collected or estimated for all sea turtles, shortnose sturgeon, and Atlantic sturgeon caught and retrieved from fisheries research gear. External or internal tags may be applied to the animals if it is determined that they have not been tagged already and the survey staff member possesses a NMFS issued scientific research permit to do so. Biological samples may also be taken if the survey staff member has adequate training or a NMFS issued permit.	identification key in Appendix E to assist survey staff members. 7. U.S. FWS and their state grantees must ensure that all fisheries survey staff take or estimate measurements of and either photograph or video all sea turtles, shortnose sturgeon, or Atlantic sturgeon incidentally captured in fisheries research gear. The condition of each animal and any visible or potential injuries must be documented to the best of the staff member's ability. Any external tagging information must also be recorded. These data must be entered into the reporting form provided in Appendix F for each incidental take. 8. On all vessels where appropriate Passive Integrated Transponder (PIT) tag readers are available, captured sturgeon must be scanned for existing PIT tags. Any recorded sturgeon PIT tags must be reported to the U.S. FWS tagging database (POC: Mike Mangold at mike_mangold@fws.gov). 9. Any invasive sampling (e.g., biopsy samples, fin clips) or tagging (e.g., flipper, PIT) of incidentally captured sea turtles,	incidental take associated with them. Sampling of sea turtle, shortnose, and Atlantic sturgeon tissue is used for genetic sampling. The taking of biopsy samples for sea turtles and fin clips for shortnose and Atlantic sturgeon allows us to fund or conduct genetic analysis to determine the nesting beach/DPS origin of sea turtles and the river/DPS origin of sturgeon. This allows us to determine if the actual level of take has been exceeded. These procedures do not harm sea turtles or sturgeon and are a common practice in fisheries science. Tissue sampling does not appear to impair an animal's ability to swim and is not thought to have any long-term adverse impact. We have received no reports of injury or mortality to any sea turtles or sturgeon sampled in this way.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
	shortnose sturgeon, and Atlantic sturgeon can only be performed by individuals trained in those activities or possessing a NMFS issued scientific research permit. Fin clip sampling procedures for shortnose and Atlantic sturgeon must be done in accordance with protocols in Appendix G. Fin clips must be taken prior to preservation of other fish parts or whole bodies and must be sent to a NMFS approved laboratory capable of performing genetic analysis. To the extent authorized by law, U.S. FWS or their state grantees are responsible for the cost of any genetic/DPS analyses.	
4. <u>RELEASE OR RETENTION</u>: Any <u>live</u> sea turtles, shortnose sturgeon, or Atlantic sturgeon caught and retrieved in fisheries research gear covered under this opinion must ultimately be released according to guidance provided by the state's stranding response group, NMFS Marine Animal hotline, or established protocols and whenever environmental conditions are safe for those releasing the animal(s) to do	10. All live, non-seriously injured sea turtles and live shortnose and Atlantic sturgeon that are incidentally captured in fisheries research gear must be released from the gear and back into the water as quickly as possible to minimize stress to the animal. All injured sea turtles (i.e., beyond minor chips, cuts, or abrasions to the carapace or skin) should be reported to the state's stranding response group or NMFS Marine Animal hotline for further guidance on handling and transport, if necessary, to a rehabilitation facility. U.S. FWS or their state grantees must make arrangements with a NMFS-approved facility that agrees to receive any sea turtles injured during the proposed actions. This	RPM #4 and the accompanying Terms and Conditions establish the requirements for releasing or retaining sea turtles, shortnose sturgeon, and Atlantic sturgeon captured in fisheries research gear in order to provide live animals with the best chance for survival post-capture and to gather additional information on the cause of death of dead animals.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
so. Injured sea turtles should be transferred to an appropriately permitted facility identified by and at the suggestion of the state level stranding network partner or NMFS Marine Animal hotline. Any <u>dead</u> sea turtles, shortnose, or Atlantic sturgeon encountered during sampling must be retained, if logistically feasible and instructed by state stranding/salvage network partners or GARFO PRD to do so, and then transferred to an appropriately permitted research facility so that a necropsy can be undertaken. Sea turtle, shortnose sturgeon, and Atlantic sturgeon carcasses should be held in cold storage until shipping or transfer.	arrangement must include procedures for transferring these turtles to the care of the facility. To the extent authorized by law, arrangements must address funding of any necessary care and/or rehabilitation. 11. In the event of any lethal takes of sea turtles, shortnose sturgeon, or Atlantic sturgeon, any dead specimens or body parts retained by or on behalf of individuals with NMFS issued permits should be preserved (frozen is preferred, although refrigerated is permitted if a freezer is not available) until retention or disposal procedures are discussed with the appropriate stranding and salvage network organization or GARFO PRD. In the event a permitted stranding or salvage network recipient is not available or the carcass is severely damaged or decayed to the point at which a necropsy would not be feasible, the animal should be disposed of at sea. It is up to the fisheries survey staff member to contact the state's stranding response group, or if not available, the Marine Animal hotline or Sturgeon Salvage Network partner for assistance in determining the state of damage/decay and to see whether a necropsy or salvage of the carcass is needed. The form included as Appendix H (sturgeon salvage form) should be completed and submitted to us for any dead sturgeon captured.	

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
5. REPORTING: GARFO PRD must be notified of all observed takes of sea turtles, shortnose sturgeon, and Atlantic sturgeon resulting from fisheries research activities covered under this opinion.	12. In the event of any captures of sea turtles, shortnose sturgeon, or Atlantic sturgeon (lethal or non-lethal), you must follow the species-specific Standard Operating Procedures (SOPs) found on our website at: www.greateratlanticfisheries.noaa.gov/ protected/section7/reporting.html). 13. U.S. FWS or their state grantees must ensure that GARFO PRD is notified within 24 hours of any interaction with a sea turtle, shortnose sturgeon, or Atlantic sturgeon. These reports, included in Appendix F, must be sent via e-mail to Incidental.take@noaa.gov (preferred) or called in to GARFO PRD. The report must include at a minimum: (1) reporter name and affiliation; (2) GPS coordinates (in decimal degrees or degrees/minutes/seconds) or a geographic description describing the specific location of the interaction; (3) portion and details of the gear involved (e.g., bottom trawl, gillnet, longline, pot/trap); (4) time and date of the interaction; and (5) identification of the animal to the species level. We also request the following information be provided: (1) a link to or acknowledgement that a clear photograph or video of the animal was taken (multiple photographs are suggested, including at least one photograph of the head scutes for sea	RPM #5 and the accompanying Terms and Conditions specify protocols for the reporting of information to GARFO PRD for any sea turtles, shortnose sturgeon, and Atlantic sturgeon observed captured in fisheries research gear. This is essential for monitoring the level of incidental take associated with the proposed action and ensuring that we can track any exceedance of the ITS.

Reasonable and Prudent Measures (RPMs)	Terms and Conditions (T&Cs)	Justifications for RPMs and T&Cs
	turtles or mouth for sturgeon); (2) exact or estimated length/width of the animal; (3) ID numbers of external or internal tags either recorded from or applied to the animal; (4) condition of the animal upon retrieval and release/retention (e.g., alive uninjured, alive potentially injured, comatose or unresponsive, fresh dead, decomposed); and (5) a description of any care or handling provided. If reporting within 24 hours is not possible (e.g., due to distance from shore or lack of ability to communicate via phone or email), the interaction must be reported as soon as the survey staff member is in a position to do so and absolutely no later than 24 hours after the vessel returns to port.	
6. All electrofishing procedures must be designed to minimize the potential for injury or mortality of listed species.	14. For electrofishing, no sturgeon over two feet in length shall be netted. All observations of netted sturgeon must be reported to NMFS as required in Term and Condition #13. All observations of non-netted sturgeon should be reported to us via e-mail (incidental.take@noaa.gov), as soon as practicable. This report must contain the date, location, species identification (if known), and approximate size of the fish. 15. In the event sturgeon come in contact with sampling gear, all electrofishing must cease for five minutes or until the fish is observed to recover and leave the sampling area.	RPM #6 and its implementing Terms and Conditions specify procedures to minimize the potential for injury of shortnose or Atlantic sturgeon during electrofishing activities.

12.0 CONSERVATION RECOMMENDATIONS

In addition to section 7(a)(2), which requires agencies to ensure that proposed actions are not likely to jeopardize the continued existence of listed species, section 7(a)(1) of the ESA places a responsibility on all Federal agencies to utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of endangered and threatened species. Conservation Recommendations are discretionary activities designed to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. The following additional measures are recommended regarding incidental take and sea turtle/sturgeon conservation:

1. U.S. FWS should advise the Principal Investigators for all surveys to provide guidance, before each survey to the vessel crew members (including scientific crew and vessel operators) to the effect that: (a) all personnel are alert to the possible presence of ESA listed species in the study area, (b) care must be taken when emptying/retrieving sampling gear to avoid damage to sea turtles and sturgeon , and (c) survey gear should be emptied as quickly as possible after retrieval in order to determine whether sea turtles or sturgeon are present in the gear.

13.0 REINITIATION OF CONSULTATION

This concludes formal consultation on the proposed actions. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In the event that the amount or extent of incidental take is exceeded section 7 consultation must be reinitiated immediately.

Depending on the circumstances associated with the cause for reinitiation, it may not be necessary to reinitiate consultation for all of the actions considered here. For example, if a new species is listed that may be affected by surveys carried out by all states, it would likely be necessary to reinitiate consultation on all of the activities considered here. However, if the cause for reinitiation has effects that are limited to one or a few actions (for example, a change in a surveys carried out by one state or a species is listed or critical habitat designated in only a small portion of the action area) it is possible that reinitiation of the consultation would be necessary only for those actions. We expect that determinations about the scope of any future reinitiation(s) will be made in cooperation between the U.S. FWS and us.

14.0 LITERATURE CITED

Aguilar, A. 2002. Fin whale, *Balaenoptera physalus*. Pages 435-438 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego: Academic Press.

Altenritter, M.E., M.T. Kinnison, G.B. Zydlewski, D.H. Secor, and J.D. Zydlewski. 2015. Assessing dorsal scute microchemistry for reconstruction of shortnose sturgeon life histories. Environmental Biology of Fishes 98(12):2321-2335.

Antonelis, G.A., J.D. Baker, T.C. Johanos, R.C. Braun, and A.L. Harting. 2006. Hawaiian monk seal (*Monachus schauinslandi*): status and conservation issues. Atoll Research Bulletin 543:75-101.

Armstrong, J.L., and J.E. Hightower. 2002. Potential for restoration of the Roanoke River population of Atlantic sturgeon. Journal of Applied Ichthyology 18:475-480.

ASMFC (Atlantic States Marine Fisheries Commission). 1998a. Atlantic Sturgeon Stock Assessment Peer Review Report. March 1998. 139 pp.

ASMFC. 1998b. Amendment 1 to the interstate fishery management plan for Atlantic sturgeon. Management Report No. 31. 43 pp.

ASMFC. 2002. Amendment 4 to the Interstate Fishery Management Plan for weakfish. Fishery Management Report No. 39. Washington, D.C.: Atlantic States Marine Fisheries Commission.

ASMFC. 2004. Horseshoe crab 2004 stock assessment. Washington, D.C.: Atlantic States Marine Fisheries Commission.

ASMFC. 2010. Atlantic Sturgeon. Pages 19-20 in Atlantic States Marine Fisheries Commission 2010 Annual Report. 68 pp.

ASMFC. 2016. 2016 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Horseshoe Crab (*Limulus polyphemus*); 2015 Fishing Year. October 2016. 25 pp.

ASMFC. 2017a. Atlantic Sturgeon Benchmark Stock Assessment and Peer Review Report, Arlington, VA. 456 pp.

ASMFC. 2017b. 2017 Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Atlantic Striped Bass (*Morone saxatilis*). October 2017. 32 pp.

ASMFC NSTC (Atlantic States Marine Fisheries Commission Northern Shrimp Technical Committee). 2011. Assessment Report for Gulf of Maine Northern Shrimp - 2011. October 2011. 75 pp.

ASMFC TC (Atlantic States Marine Fisheries Commission Technical Committee). 2007. Special Report to the Atlantic Sturgeon Management Board: Estimation of Atlantic sturgeon bycatch in coastal Atlantic commercial fisheries of New England and the Mid-Atlantic. August 2007. 95 pp.

ASSRT (Atlantic Sturgeon Status Review Team). 1998. Status review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). National Marine Fisheries Service. September 1998. 126 pp.

ASSRT (Atlantic Sturgeon Status Review Team). 2007. Status review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). National Marine Fisheries Service. February 23, 2007. 188 pp.

Attrill, M.J., J. Wright, and M. Edwards. 2007. Climate-related increases in jellyfish frequency suggest a more gelatinous future for the North Sea. Limnology and Oceanography 52:480-485.

Avens, L., J.C. Taylor, L.R. Goshe, T.T. Jones, and M. Hastings. 2009. Use of skeletochronological analysis to estimate the age of leatherback sea turtles *Dermochelys coriacea* in the western North Atlantic. Endangered Species Research 8:165-177.

Bagley, D.A., W.E. Redfoot, and L.M. Ehrhart. 2013. Marine turtle nesting at the Archie Carr NWR: Are loggerheads making a comeback? Page 167 *in* T. Tucker and coeditors. Thirty-Third Annual Symposium on Sea Turtle Biology and Conservation. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Baltimore, Maryland.

Bahr, D.L., and D.L. Peterson. 2017. Status of the Shortnose Sturgeon Population in the Savannah River, Georgia. Transactions of the American Fisheries Society 146(1):92-98.

Bain, M.B. 1997. Atlantic and shortnose sturgeons of the Hudson River: Common and Divergent Life History Attributes. Environmental Biology of Fishes 48:347-358.

Bain, M.B, K. Arend, N. Haley, S. Hayes, J. Knight, S. Nack, D. Peterson, and M. Walsh. 1998. Sturgeon of the Hudson River. Final report on 1993-1996 research. Prepared for the Hudson River Foundation. May 1998.

Bain, M.B., N. Haley, D. Peterson, J.R. Waldman, and K. Arend. 2000. Harvest and habitats of Atlantic sturgeon *Acipenser oxyrinchus* Mitchill, 1815, in the Hudson River Estuary: Lessons for Sturgeon Conservation. Instituto Espanol de Oceanografia Boletin 16:43-53.

Baker, J.D., C.L. Littnan, and D.W. Johnston. 2006. Potential effects of sea level rise on the terrestrial habitats of endangered and endemic megafauna in the Northwestern Hawaiian Islands. Endangered Species Research 2:21-30.

Balazik, M.T. 2017. First verified occurrence of the shortnose sturgeon (*Acipenser brevirostrum*) in the James River, Virginia. Fishery Bulletin 115(2):196-200.

Balazik, M.T., G.C. Garman, M.L. Fine, C.H. Hager, and S.P. McIninch. 2010. Changes in age composition and growth characteristics of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) over 400 years. Biology Letters Online, 17 March 2010. 3 pp.

Balazik, M.T., S.P. McInnich, G.C. Garman, and R.J. Latour. 2012a. Age and growth of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the James River, Virginia, 1997-2011. Transactions of the American Fisheries Society 141(4):1074-1080.

Balazik, M.T., K.J. Reine, A.J. Spells, C.A. Fredrickson, M.L. Fine, G.C. Garman, and S.P. McIninch. 2012b. The potential for vessel interactions with adult Atlantic sturgeon in the James River, Virginia. North American Journal of Fisheries Management 32(6):1062-1069.

Balazs, G.H. 1982. Growth rates of immature green turtles in the Hawaiian Archipelago. Pages 117-125 in K.A. Bjorndal, ed. Biology and conservation of sea turtles. Washington, D.C.: Smithsonian Institution Press.

Barco, S., M. Law, B. Drummond, H. Koopman, C. Trapani, S. Reinheimer, S. Rose, W.M. Swingle, and A. Williard. 2016. Loggerhead turtles killed by vessel and fishery interaction in Virginia, USA, are healthy prior to death. Marine Ecology Progress Series 555:221-234.

Batiuk, R.A., D.L. Breitburg, R.J. Diaz, T.M. Cronin, D.H. Secor, and G. Thursby. 2009. Derivation of habitat-specific dissolved oxygen criteria for Chesapeake Bay and its tidal tributaries. Journal of Experimental Marine Biology and Ecology 381:S204-S215.

Bednarski, M.S. 2012. Population dynamics of Shortnose Sturgeon, *Acipenser brevirostrum*, in the Altamaha River, Georgia. University of Georgia.

Benson, S.R., T. Eguchi, D.G. Foley, K.A. Forney, and others. 2011. Large-scale movements and high-use areas of western Pacific leatherback turtles, *Dermochelys coriacea*. Ecosphere 2(7):art84.

Berry, R.J. 1971. Conservation aspects of the genetical constitution of populations. Pages 177-206 in E.D. Duffey and A.S. Watt, editors. The Scientific Management of Animal and Plant Communities for Conservation. Blackwell, Oxford.

Bigelow, H.B., and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin, U.S. Fish and Wildlife Service 74(53). 577 pp.

Bjorndal, K.A. 1985. Nutritional ecology of sea turtles. Copeia 1985(3):736-751.

Bjorndal, K.A. 1997. Foraging ecology and nutrition of sea turtles. Pages 199-233 in P.L. Lutz and J.A. Musick, eds. The Biology of Sea Turtles. New York: CRC Press.

Bjorndal, K.A., A.B. Bolten, and M.Y. Chaloupka. 2005. Evaluating trends in abundance of immature green turtles, *Chelonia mydas*, in the greater Caribbean. Ecological Applications 15(1):304-314.

BOEM (Bureau of Ocean Energy Management). 2012. Atlantic OCS proposed geological and geophysical activities Mid-Atlantic and South Atlantic planning areas draft programmatic environmental impact statement. U.S. Department of the Interior, New Orleans.

Boreman, J. 1997. Sensitivity of North American sturgeons and paddlefish to fishing mortality. Environmental Biology of Fishes 48:399-405.

Borodin, N. 1925. Biological observations on the Atlantic sturgeon, *Acipenser sturio*. Transactions of the American Fisheries Society 55:184-190.

Bowen, B.W., and J.C. Avise. 1990. Genetic structure of Atlantic and Gulf of Mexico populations of sea bass, menhaden, and sturgeon: Influence of zoogeographic factors and life-history patterns. Marine Biology 107(3):371-381.

Bowen, B.W., and S.A. Karl. 2007. Population genetics and phylogeography of sea turtles. Molecular Ecology 16:4886-4907.

Braun-McNeill, J., and S.P. Epperly. 2004. Spatial and temporal distribution of sea turtles in the western North Atlantic and the U.S. Gulf of Mexico from Marine Recreational Fishery Statistics Survey (MRFSS). Marine Fisheries Review 64(4):50-56.

Breece, M.W., M.J. Oliver, M.A. Cimino, and D.A. Fox. 2013. Shifting distributions of adult Atlantic sturgeon amidst post-industrialization and future impacts in the Delaware River: A maximum entropy approach. Plos One 8(11):e81321.

Brodeur, R.D., C.E. Mills, J.E. Overland, G.E. Walters, and J.D. Schumacher. 1999. Evidence for a substantial increase in gelatinous zooplankton in the Bering Sea, with possible links to climate change. Fisheries Oceanography 8(4):296-306.

Brown, J.J., and G.W. Murphy. 2010. Atlantic Sturgeon Vessel-Strike Mortalities in the Delaware Estuary. Fisheries 35(2):72-83.

Brundage, H.M. 2006. Final report of shortnose sturgeon population studies in the Delaware River, January 1999 through March 2003. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and New Jersey Division of Fish and Wildlife.

Brundage, H., and J. O’Herron. 2009. Investigations of juvenile shortnose and Atlantic sturgeons in the Delaware River. Bulletin of the New Jersey Academy of Science 52:1-8.

Buckley, J., and B. Kynard. 1985. Habitat use and behavior of pre-spawning and spawning shortnose sturgeon, *Acipenser brevirostrum*, in the Connecticut River. North American Sturgeons, Dr W. Junk Publications, Dordrecht, The Netherlands:111-117.

Burke, V.J., E.A. Standora, and S.J. Morreale. 1993. Diet of juvenile Kemp's ridley and loggerhead sea turtles from Long Island, New York. Copeia 1993(4):1176-1180.

Burke, V.J., S.J. Morreale, and E.A. Standora. 1994. Diet of the Kemp's ridley sea turtle, *Lepidochelys kempii*, in New York waters. Fishery Bulletin 92:26-32.

Bushnoe, T.M., J.A. Musick, and D.S. Ha. 2005. Essential spawning and nursery habitat of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) in Virginia. VIMS Special Scientific Report 145. 44 pp.

Calvo, L., H.M. Brundage, D. Haivogel, D. Kreeger, R. Thomas, J.C. O'Herron, and E. Powell. 2010. Effects of flow dynamics, salinity, and water quality on the Eastern oyster, the Atlantic sturgeon, and the shortnose sturgeon in the oligohaline zone of the Delaware Estuary. Prepared for the U.S. Army Corps of Engineers, Philadelphia District. 108 pp.

Caron, F., D. Hatin, and R. Fortin. 2002. Biological characteristics of adult Atlantic sturgeon (*Acipenser oxyrinchus*) in the Saint Lawrence River estuary and the effectiveness of management rules. Journal of Applied Ichthyology 18:580-585.

Carr, A.R. 1963. Panspecific reproductive convergence in *Lepidochelys kempi*. Ergebnisse der Biologie 26:298-303.

CeTAP (Cetacean and Turtle Assessment Program). 1982. Final report or the cetacean and turtle assessment program, University of Rhode Island, to Bureau of Land Management, U.S. Department of the Interior. Ref. No. AA551-CT8-48. 568 pp.

Colette, B.B., and G. Klein-MacPhee. 2002. Bigelow and Schroeder's fishes of the Gulf of Maine. Smithsonian Institution Press, Washington, D.C.

Collins, M.R., and T.I. Smith. 1993. Characteristics of the adult segment of the Savannah River population of shortnose sturgeon. Pages 485-491 *in* Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies.

Collins, M.R., and T.I.J. Smith. 1997. Distribution of shortnose and Atlantic sturgeons in South Carolina. North American Journal of Fisheries Management 17:995-1000.

Collins, M. R., S. G. Rogers, T. I. J. Smith, and M. L. Moser. 2000. Primary factors affecting sturgeon populations in the southeastern United States: fishing mortality and degradation of essential habitats. Bulletin of Marine Science 66:917-928.

Collins, M.R., W.C. Post, D.C. Russ, and T.I. Smith. 2002. Habitat use and movements of juvenile shortnose sturgeon in the Savannah River, Georgia-South Carolina. Transactions of the American Fisheries Society 131(5):975-979.

Conant, T.A., P.H. Dutton, T. Eguchi, S.P. Epperly, C.C. Fahy, M.H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act. Report of the Loggerhead Biological Review Team to the National Marine Fisheries Service, August 2009. 222 pp.

Cooke, D.W., J.P. Kirk, J.V. Morrow Jr, and S.D. Leach. 2004. Population dynamics of a migration limited shortnose sturgeon population. Pages 82-91 *in* Proceedings of Annual Conference of Southeastern Association for Fish and Wildlife Agencies.

Coyne, M.S. 2000. Population Sex Ratio of the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*): Problems in Population Modeling. PhD Thesis, Texas A&M University. 136 pp.

Coyne, M., and A.M. Landry, Jr. 2007. Population sex ratios and its impact on population models. Pages 191-211 in P.T. Plotkin, ed. Biology and Conservation of Ridley Sea Turtles. Baltimore: Johns Hopkins University Press.

Crance, J.H. 1987. Habitat suitability index curves for anadromous fishes. *In*: Common Strategies of Anadromous and Catadromous Fishes, M.J. Dadswell (ed.). Bethesda, Maryland, American Fisheries Society Symposium 1:554.

Crowder, L.B., D.T. Crouse, S.S. Heppell, and T.H. Martin. 1994. Predicting the impact of turtle excluder devices on loggerhead sea turtle populations. Ecological Applications 4(3):437-445.

Crouse, D.T. 1999. The consequences of delayed maturity in a human-dominated world. American Fisheries Society Symposium 23:195-202.

Crouse, D.T., L.B. Crowder, and H. Caswell. 1987. A stage- based population model for loggerhead sea turtles and im- plications for conservation. Ecology 68:1412-1423.

Dadswell, M. 1979. Biology and population characteristics of the shortnose sturgeon, *Acipenser brevirostrum* LeSueur 1818 (Osteichthyes: Acipenseridae), in the Saint John River estuary, New Brunswick, Canada. Canadian Journal of Zoology 57(11):2186-2210.

Dadswell, M. 1984. Status of the shortnose sturgeon, *Acipenser brevirostrum,* in Canada. Canadian Field Naturalist 98:75-79.

Dadswell, M. 2006. A review of the status of Atlantic sturgeon in Canada, with comparisons to populations in the United States and Europe. Fisheries 31:218-229.

Dadswell, M.J., B.D. Taubert, T.S. Squiers, D. Marchette, and J. Buckley. 1984. Synopsis of biological data on shortnose sturgeon, *Acipenser brevirostrum*, LeSuer 1818. NOAA Technical Report NMFS 14, Washington, D.C.

Dadswell, M.J., S.A. Wehrell, A.D. Spares, M.F. McLean, and others. 2016. The annual marine feeding aggregation of Atlantic sturgeon *Acipenser oxyrinchus* in the inner Bay of Fundy: population characteristics and movement. Journal of Fish Biology 89(4):2107-2132.

Damon-Randall, K., M. Colligan, and J. Crocker. 2013. Composition of Atlantic Sturgeon in Rivers, Estuaries, and Marine Waters. National Marine Fisheries Service, NERO, Unpublished Report. February 2013. 33 pp.

Daniels, R.C., T.W. White, and K.K. Chapman. 1993. Sea-level rise: destruction of threatened and endangered species habitat in South Carolina. Environmental Management 17(3):373-385.

Davenport, J. 1997. Temperature and the life-history strategies of sea turtles. Journal of Thermal Biology 22(6):479-488.

Dionne, P.E. 2010. Shortnose sturgeon of the Gulf of Maine: the importance of coastal migrations and social networks. Masters Thesis, University of Maine, Orono. 89 pp.

Dionne, P.E., G.B. Zydlewski, M.T. Kinnison, J. Zydlewski, and G.S. Wippelhauser. 2013. Reconsidering residency: characterization and conservation implications of complex migratory patterns of shortnose sturgeon (*Acispenser brevirostrum*). Canadian Journal of Fisheries and Aquatic Sciences 70(1):119-127.

Dodd, C.K. 1988. Synopsis of the biological data on the loggerhead sea turtle *Caretta caretta* (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 88(14):1-110.

Dovel, W.L., and T.J. Berggren. 1983. Atlantic sturgeon of the Hudson River Estuary, New York. New York Fish and Game Journal 30:140-172.

Duarte, C.M. 2002. The future of seagrass meadows. Environmental Conservation 29:192-206.

Dunton, K.J., D.D. Chapman, A. Jordaan, K.A. Feldheim, S.J. O'Leary, K.A. McKown, and M.G. Frisk. 2012. Genetic mixed-stock analysis of Atlantic Sturgeon *Acipenser oxyrinchus oxyrinchus* in a heavily exploited marine habitat indicates the need for routine genetic monitoring. Journal of Fish Biology 80:207-217.

Dutton, P.H., B.W. Bowen, D.W. Owens, A. Barragan, and S.K. Davis. 1999. Global phylogeography of the leatherback turtle (*Dermochelys coriacea*). Journal of Zoology 248:397-409.

Dutton, P.H., V. Pease, and D. Shaver. 2006. Characterization of mtDNA variation among Kemp's ridleys nesting on Padre Island with reference to Rancho Nuevo genetic stock. Page

189 in Proceedings of the 26th Annual Symposium on Sea Turtle Biology and Conservation. Athens, Greece: International Sea Turtle Society.

DWH NRDA Trustees (Deepwater Horizon Natural Resource Damage Assessment Trustees). 2016. Deepwater Horizon oil spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Retrieved from http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan.

Dwyer, K.L., C.E. Ryder, and R. Prescott. 2002. Anthropogenic mortality of leatherback sea turtles in Massachusetts waters. Poster presentation for the 2002 Northeast Stranding Network Symposium.

Dwyer, K.L., C.E. Ryder, and R. Prescott. 2003. Anthropogenic mortality of leatherback sea turtles in Massachusetts waters. Page 260 in J.A. Seminoff, compiler. Proceedings of the Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Eckert, K.L., B.P. Wallace, J.G. Frazier, S.A. Eckert, and P.C.H. Pritchard. 2012. Synopsis of the biological data on the leatherback sea turtle (*Dermochelys coriacea*). U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication BTP-R4015-2012, Washington, D.C. 172 pp.

Ehrhart, L.M., D.A. Bagley, and W.E. Redfoot. 2003. Loggerhead turtles in the Atlantic Ocean: geographic distribution, abundance, and population status. Pages 157-174 in A.B. Bolten and B.E. Witherington, eds. Loggerhead Sea Turtles. Washington, D.C.: Smithsonian Institution Press.

Ehrhart. L.M., W.E. Redfoot, and D.A. Bagley. 2007. Marine turtles of the central region of the Indian River Lagoon System, Florida. Florida Scientist 70(4):415-434.

EPA (Environmental Protection Agency). 2008. National Coastal Condition Report III. Office of Research and Development/Office of Water. Washington, D.C. 298 pp.

EPA CBP (Environmental Protection Agency Chesapeake Bay Program). 2010. 2010 State of the Chesapeake Bay Program. Summary Report to the Chesapeake Executive Council, June 3, 2010. 7 pp.

Epperly, S., L. Avens, L. Garrison, T. Henwood, W. Hoggard, J. Mitchell, J. Nance, J. Poffenberger, C. Sasso, E. Scott-Denton, and C. Yeung. 2002. Analysis of sea turtle bycatch in the commercial shrimp fisheries of southeast U.S. waters and the Gulf of Mexico. NOAA Technical Memorandum NMFS-SEFSC-490:1-88.

Ernst, C.H., and R.W. Barbour. 1972. Turtles of the United States. Lexington: University Press of Kentucky.

Evermann, B.W., and B.A. Bean. 1898. Indian River and its Fishes. Report for the U.S. Commission on Fish and Fisheries for 1896.

Eyler, S., T. Meyer, S. Michaels, and B. Spear. 2007. Review of the fishery management plan in 2006 for horseshoe crab (*Limulus polyphemus*). Prepared by the ASMFC Horseshoe Crab Plan Review Team. 15pp.

Fenster, M., and D. FitzGerald. 1996. Morphodynamics, stratigraphy, and sediment transport patterns of the Kennebec River estuary, Maine. Sedimentary Geology 107:99-120.

Fernandes, S.J., G.B. Zydlewski, J.D. Zydlewski, G.S. Wippelhauser, M.T. Kinnison. 2010. Seasonal Distribution and Movements of Shortnose Sturgeon and Atlantic Sturgon in the Penobscot River Estuary, Maine. Transactions of the American Fisheries Society 139:1436-1449.

Finkbeiner, E.M., B.P. Wallace, J.E. Moore, R.L. Lewison, L.B. Crowder, and A.J. Read. 2011. Cumulative estimates of sea turtle bycatch and mortality in USA fisheries between 1990 and 2007. Biological Conservation 144(11): 2719-2727.

Fish, M.R., I.M. Cote, J.A. Gill, A.P. Jones, S. Renshoff, and A.R.Watkinson. 2005. Predicting the impact of sea-level rise on Caribbean sea turtle nesting habitat. Conservation Biology 19:482-491.

Fisher, M. 2009. Atlantic Sturgeon Progress Report. State Wildlife Grant Project T-4-1. Delaware Division of Fish and Wildlife Department of Natural Resources and Environmental Control. Smyrna, Delaware. 24 pp.

Fisher, M. 2011. Atlantic Sturgeon Final Report. State Wildlife Grant Project T-4-1. Delaware Division of Fish and Wildlife Department of Natural Resources and Environmental Control. Smyrna, Delaware. 44 pp.

Fleming, J., T. Bryce, and J. Kirk. 2003. Age, growth, and status of shortnose sturgeon in the lower Ogeechee River, Georgia. Pages 80-91 *in* Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies.

Flournoy, P.H., S.G. Rogers, and P.S. Crawford. 1992. Restoration of shortnose sturgeon in the Altamaha River, Georgia. Final Report to the U.S. Fish and Wildlife Service, Atlanta, Georgia.

Frazer, N.B., and L.M. Ehrhart. 1985. Preliminary growth models for green, *Chelonia mydas*, and loggerhead, *Caretta caretta*, turtles in the wild. Copeia 1985(1):73-79.

Gilbert, C.R. 1989. Atlantic and shortnose sturgeons. United States Department of Interior Biological Report 82, 28 pp.

Girondot, M., M.H. Godfrey, L. Ponge, and P. Rivalan. 2007. Modeling approaches to quantify leatherback nesting trends in French Guiana and Suriname. Chelonian Conservation and Biology 6(1):37-46.

Glen, F., and N. Mrosovsky. 2004. Antigua revisited: the impact of climate change on sand and nest temperatures at a hawksbill turtle (*Eretmochelys imbricata*) nesting beach. Global Change Biology 10:2036-2045.

Greene, C.H., A.J. Pershing, T.M. Cronin, and N. Ceci. 2008. Arctic climate change and its impacts on the ecology of the North Atlantic. Ecology 89(11) Supplement 2008:S24-S38.

Greene, K.E., J.L. Zimmerman, R.W. Laney, and J.C. Thomas-Blate. 2009. Atlantic Coast Diadromous Fish Habitat: A Review of Utilization, Threats, Recommendations for Conservation, and Research Needs. Habitat Management Series No. 9. Washington, D.C.: Atlantic States Marine Fisheries Commission.

Groombridge, B., and L. Wright. 1982. Kemp's Ridley or Atlantic Ridley, *Lepidochelys kempii* (Garman 1880). Pages 201-208 in The IUCN Amphibia - Reptilia Red Data Book. Gland, Switzerland.

Grunwald, C., L. Maceda, J. Waldman, J. Stabile, and I. Wirgin. 2008. Conservation of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus*: delineation of stock structure and distinct population segments. Conservation Genetics 9:1111-1124.

Guilbard, F., J. Munro, P. Dumont, D. Hatin, and R. Fortin. 2007. Feeding ecology of Atlantic sturgeon and lake sturgeon co-occurring in the St. Lawrence Estuarine Transition Zone. American Fisheries Society Symposium 56:85-104.

Hale, E.A., I.A. Park, M.T. Fisher, R.A. Wong, M.J. Stangl, and J.H. Clark. 2016. Abundance estimate for and habitat use by early juvenile Atlantic sturgeon within the Delaware River estuary. Transactions of the American Fisheries Society 145(6):1193-1201.

Hager, C., J. Kahn, C. Watterson, J. Russo, and K. Hartman. 2014. Evidence of Atlantic sturgeon spawning in the York River system. Transactions of the American Fisheries Society 143(5):1217-1219.

Hawkes, L.A., A.C. Broderick, M.H.Godfrey, and B.J. Godley. 2005. Status of nesting loggerhead turtles *Caretta caretta* at Bald Head Island (North Carolina, USA) after 24 years of intensive monitoring and conservation. Oryx 39(1):65-72.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2007. Investigating the potential impacts of climate change on a marine turtle population. Global Change Biology 13:1-10.

Hawkes, L.A., A.C. Broderick, M.H. Godfrey, and B.J. Godley. 2009. Climate change and marine turtles. Endangered Species Research 7:137-154.

Hayes S.A., E. Josephson, K. Maze-Foley, and P.E. Rosel, editors. 2017. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2016. NOAA Technical Memorandum NMFS NE 241; 274 pp.

Hayes S.A., E. Josephson, K. Maze-Foley, P.E. Rosel, B. Byrd, S. Chavez-Rosales, T.V.N. Cole, L. Engleby, L.P. Garrison, J. Hatch, A. Henry, S.C. Horstman, J. Litz , M.C. Lyssikatos, K.D. Mullin, C. Orphanides, R.M. Pace, D.L. Palka, M. Soldevilla, and F.W. Wenzel. 2018. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2017. NOAA Technical Memorandum NMFS NE-245; 371 pp.

Hays, G.C. 2000. The implications of variable remigration intervals for the assessment of population size in marine turtles. Journal of Theoretical Biology 206(2):221-227.

Hays, G.C., S. Åkesson, A.C. Broderick, F. Glen, B.J. Godley, F. Papi, and P. Luschi. 2003. Island-finding ability of marine turtles. Royal Society of London. Proceedings B. Biological Sciences 270(Suppl. 1, Aug 7):S5-S7.

Hazel, J., I.R. Lawler, H. Marsh, and S. Robson. 2007. Vessel speed increases collision risk for the green turtle *Chelonia mydas*. Endangered Species Research 3:105-113.

Henwood, T.A., and W. Stuntz. 1987. Analysis of sea turtle captures and mortalities during commercial shrimp trawling. Fishery Bulletin 85(4):813-817.

Heppell, S.S., D.T. Crouse, L.B. Crowder, S.P. Epperly, and others. 2005. A population model to estimate recovery time, population size, and management impacts on Kemp's ridley sea turtles. Chelonian Conservation and Biology 4(4):767-773.

Hildebrand, S.F., and W.C. Schroeder. 1928. Fishes of the Chesapeake Bay. Washington, D.C.: Smithsonian Institute Press.

Hilterman, M.L., and E. Goverse. 2004. Annual report of the 2003 leatherback turtle research and monitoring project in Suriname. World Wildlife Fund - Guianas Forests and Environmental Conservation Project (WWF-GFECP) Technical Report of the Netherlands Committee for IUCN (NC-IUCN), Amsterdam, the Netherlands. 21 pp.

Hirth, H.F. 1997. Synopsis of the biological data of the green turtle, *Chelonia mydas* (Linnaeus 1758). U.S. FWS Biological Report 97(1):1-120.

Holland, B.F., Jr. and G.F. Yelverton. 1973. Distribution and biological studies of anadromous fishes offshore North Carolina. North Carolina Department of Natural and Economic Resources, Division of Commercial and Sports Fisheries, Morehead City. Special Scientific Report 24:1-132.

Holliman, M., and J.B. Reynolds. 2002. Electroshock-Induced Injury in Juvenile White Sturgeon. North American Journal of Fisheries Management 22:494-499.

Holton, J.W., Jr., and J.B. Walsh. 1995. Long-Term Dredged Material Management Plan for the Upper James River, Virginia. Virginia Beach, Waterway Surveys and Engineering, Limited. 94 pp.

Horne, A.N., and C.P. Stence. 2016. Assessment of Critical Habitats for Recovering the Chesapeake Bay Atlantic Sturgeon Distinct Population Segment. Grant number: NA13NMF4720042, Final report.

Horwood, J. 2002. Sei whale, *Balaenoptera borealis*. Pages 1069-1071 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego: Academic Press.

Hulin, V., and J.M. Guillon. 2007. Female philopatry in a heterogeneous environment: ordinary conditions leading to extraordinary ESS sex ratios. BMC Evolutionary Biology 7:13.

Hulme, P.E. 2005. Adapting to climate change: is there scope for ecological management in the face of global threat? Journal of Applied Ecology 43: 617-627.

IPCC (Intergovernmental Panel on Climate Change). 2007. Summary for Policymakers. *In* Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (editors). Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom, and New York, New York, USA.

IPCC. 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

James, M.C., R.A. Myers, and C.A. Ottenmeyer. 2005. Behaviour of leatherback sea turtles, *Dermochelys coriacea*, during the migratory cycle. Proceedings of the Royal Society of London B 272:1547-1555.

Jensen, A.S., and G.K. Silber. 2003. Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25. 37 pp.

Johnson, J.H., D.S. Dropkin, B.E. Warkentine, J.W. Rachlin, and W.D. Andres. 1997. Food habits of Atlantic sturgeon off the New Jersey coast. Transactions of the American Fisheries Society 126:166-170.

Johnston, C.E, and C.T Phillips. 2003. Sound production in sturgeon *Scaphirhynchus albus* and *S. platorynchus* (Acipenseridae). Environmental Biology of Fishes 68(1):59-64.

Kahn, J., and M. Mohead. 2010. A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons. NOAA Technical Memorandum NMFS-OPR-45:1-62 .

Kahn, J.E., C. Hager, J.C. Watterson, J. Russo, K. Moore, and K. Hartman. 2014. Atlantic sturgeon annual spawning run estimate in the Pamunkey River, Virginia. Transactions of the American Fisheries Society 143(6):1508-1514.

Kahnle, A.W., K.A. Hattala, K.A. McKown, C.A. Shirey, M.R. Collins, T.S. Squiers, Jr., and T. Savoy. 1998. Stock Status of Atlantic sturgeon of Atlantic Coast Estuaries. Report for the Atlantic States Marine Fisheries Commission. Draft III.

Kahnle, A.W., K.A. Hattala, and K.A. McKown. 2007. Status of Atlantic sturgeon of the Hudson River Estuary, New York, USA. American Fisheries Society Symposium 56:347-363.

Kamel, S.J., and N. Mrosovsky. 2004. Nest-site selection in leatherbacks (*Dermochelys coriacea*): individual patterns and their consequences. Animal Behaviour 68:357-366.

Keinath, J.A., J.A. Musick, and R.A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979-1986. Virginia Journal of Science 38(4):329-336.

Kenney, R.D. 2002. North Atlantic, North Pacific and Southern Right Whales. Pages 806-813 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego: Academic Press.

Kieffer, M., and B. Kynard. 1993. Annual movements of shortnose and Atlantic sturgeons in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 122:1088-1103.

King, T.L., B.A. Lubinski, and A.P. Spidle. 2001. Microsatellite DNA variation in Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and cross-species amplification in the Acipenseridae. Conservation Genetics 2:103-119.

King, T.L., A.P. Henderson, B.E. Kynard, M.C. Kieffer, and others. 2014. A nuclear DNA perspective on delineating evolutionarily significant lineages in polyploids: the case of the endangered shortnose sturgeon (*Acipenser brevirostrum*). PLoS One 9(8):e102784.

Kynard, B. 1997. Life history, latitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48:319-334.

Kynard, B., and M. Horgan. 2002. Ontogenetic behavior and migration of Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, and shortnose sturgeon, *A. brevirostrum*, with notes on social behavior. Environmental Behavior of Fishes 63:137-150.

Kynard, B., P. Bronzi, and H. Rosenthal. 2012. Life history and behaviour of Connecticut River Shortnose and other sturgeons. World Sturgeon Conservation Society Special Publication, No.4, 320 pp.

Laist, D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, M. Podesta. 2001. Collisions between ships and whales. Marine Mammal Science 17(1):35-75.

Lamont, M.M., I. Fujisaki, and R.R. Carthy. 2014. Estimates of vital rates for a declining loggerhead turtle (*Caretta caretta*) subpopulation: implications for management. Marine Biology 161(11):2659-2668.

Laney, R.W., J.E. Hightower, B.R. Versak, M.F. Mangold, W.W. Cole Jr., and S.E. Winslow. 2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises, 1988-2006. Pages 167-182 *in* J. Munro, D. Hatin, J.E. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle, and F. Caron, editors. Anadromous sturgeons: habitats, threats, and management. American Fisheries Society Symposium 56, Bethesda, Maryland.

Leland, J.G., III. 1968. A survey of the sturgeon fishery of South Carolina. Bears Bluff Labs. No. 47, 27 pp.

Lichter, J., H. Caron, T.S. Pasakarnis, S.L. Rodgers, T.S. Squiers Jr., and C.S. Todd. 2006. The ecological collapse and partial recovery of a freshwater tidal ecosystem. Northeastern Naturalist 13:153-178.

Lovell, J.M., M.M. Findlay, R.M. Moate, J.R. Nedwell, and M.A. Pegg. 2005. The inner ear morphology and hearing abilities of the paddlefish (*Polyodon spathula*) and the lake sturgeon (*Acipenser fulvescens*). Comparative Biochemistry and Physiology. Part A, Molecular and Integrative Physiology 142(3):286-296.

Lutcavage, M.E., and P.L. Lutz. 1997. Diving physiology. Pages 277-296 in P.L. Lutz and J.A. Musick, eds. The Biology of Sea Turtles. Boca Raton, Florida: CRC Press.

Lutcavage, M., and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985(2):449-456.

Lutcavage, M.E., P. Plotkin, B. Witherington, and P.L. Lutz. 1997. Human impacts on sea turtle survival. Pages 387-409 in P.L. Lutz and J.A. Musick, eds. The Biology of Sea Turtles. Boca Raton, Florida: CRC Press.

Maier, P.P., A.L. Segars, M.D. Arendt, and J.D. Whitaker. 2005. Examination of local movement and migratory behavior of sea turtles during spring and summer along the Atlantic coast off the southeastern United States. Annual report for grant number NA03NMF4720281. 29pp.

Mangold, M., S. Eyler, S. Minkkinen, and B. Richardson. 2007. Atlantic Sturgeon Reward Program for Maryland Waters of the Chesapeake Bay and Tributaries 1996-2006. Annapolis, Maryland: U.S. Fish and Wildlife Service.

Mansfield, K. L. 2006. Sources of mortality, movements, and behavior of sea turtles in Virginia. Ph.D. dissertation, College of William and Mary. 343 pp.

Mansfield, K.L., J.A. Musick, and R.A. Pemberton. 2001. Characterization of the Chesapeake Bay pound net and whelk pot fisheries and their potential interactions with marine sea turtle species. Final Report to the National Marine Fisheries Service under Contract No. 43EANFO30131. 75 pp.

Masuda, A. 2010. Natal Origin of Juvenile Loggerhead Turtles from Foraging Ground in Nicaragua and Panama Estimated Using Mitochondria DNA. Master's dissertation, California State University, Chico, California.

McMahon, C.R., and G.C. Hays. 2006. Thermal niche, large-scale movements and implications of climate change for a critically endangered marine vertebrate. Global Change Biology 12:1330-1338.

Meyer, M., D. Plachta, and A.N. Popper. 2003. When a "primitive" fish listens to tones: Encoding of sound in the auditory periphery of the shortnose sturgeon, *Acipenser brevirostrum*. Abstracts of the Association of Research in Otolaryngolology 26:48.

Meyer, M., R.R. Fay, and A.N. Popper. 2010. Frequency tuning and intensity coding of sound in the auditory periphery of the lake sturgeon, *Acipenser fulvescens*. Journal of Experimental Biology 213(9):1567-1578.

Meylan, A. 1982. Estimation of population size in sea turtles. Pages 135-138 in K.A. Bjorndal, ed. Biology and Conservation of Sea Turtles. Washington, D.C.: Smithsonian Institute Press.

Miller, T.J. 2007. Factors associated with mortality of incidentally caught sturgeon in the Northwest Atlantic Ocean in estimation of Atlantic sturgeon bycatch in coastal Atlantic commercial fisheries of New England and the mid-Atlantic. A Special Report to ASMFC Atlantic Sturgeon Technical Committee.

Mitchell, G.H., R.D. Kenney, A.M. Farak, and R.J. Campbell. 2003. Evaluation of occurrence of endangered and threatened marine species in naval ship trial areas and transit lanes in the Gulf of Maine and offshore of Georges Bank. NUWC-NPT Technical Memo 02-121A. March 2003. 113 pp.

Moore, S., and J. Reblin. 2010. The Kennebec Estuary: Restoration Challenges and Opportunities. Biological Conservation, Bowdoinham, Maine.

Morreale, S.J., and E.A. Standora. 1990. Occurrence, movement and behavior of the Kemp's ridley and other sea turtles in New York waters. Annual Report, April 1989-April 1990. Okeanos Ocean Foundation, Inc. New York.

Morreale, S.J., and E.A. Standora. 1993. Occurrence, movement, and behavior of the Kemp's ridley and other sea turtles in New York waters. Okeanos Ocean Research Foundation Final Report April 1988-March 1993. 70 pp.

Morreale, S.J., and E.A. Standora. 1998. Early life stage ecology of sea turtles in northeastern U.S. waters. NOAA Technical Memorandum NMFS-SEFSC-413:1-49.

Morreale, S.J., and E.A. Standora. 2005. Western North Atlantic waters: crucial developmental habitat for Kemp’s ridley and loggerhead sea turtles. Chelonian Conservation and Biology 4(4):872-882.

Morreale, S.J., C.F. Smith, K. Durham, R.A. DiGiovanni, Jr., and A.A. Aguirre. 2005. Assessing health, status, and trends in northeastern sea turtle populations. Interim report - Sept. 2002 - Nov. 2004. Gloucester, Massachusetts: National Marine Fisheries Service.

Mortimer, J.A. 1982. Feeding ecology of sea turtles. Pages 103-109 in K.A. Bjorndal, ed. Biology and conservation of sea turtles. Washington, D.C.: Smithsonian Institution Press.

Moser, M.L., and S.W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeons in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124(2):225-234.

Moser, M.L., M. Bain, M.R. Collins, N. Haley, B. Kynard, J.C. O’Herron II, G. Rogers, and T.S. Squiers. 2000. A Protocol for Use of Shortnose and Atlantic Sturgeons. NOAA Technical Memorandum NMFS-OPR-18:1-18.

Mrosovsky, N., P.H. Dutton, and C.P. Whitmore. 1984. Sex ratios of two species of sea turtle nesting in Suriname. Canadian Journal of Zoology 62:2227-2239.

Murawski, S.A., and A.L. Pacheco. 1977. Biological and fisheries data on Atlantic sturgeon, *Acipenser oxyrhynchus* (Mitchill). National Marine Fisheries Service Technical Series Report 10:1-69.

Murdoch, P.S., J.S. Baron, and T.L. Miller. 2000. Potential effects of climate change on surface-water quality in North America. Journal of the American Water Resources Association 36:347-366.

Murray, K.T. 2009a. Proration of estimated bycatch of loggerhead sea turtles in U.S. Mid-Atlantic sink gillnet gear to vessel trip report landed catch, 2002-2006. NEFSC Reference Document 09-19; 7 pp.

Murray, K.T. 2009b. Characteristics and magnitude of sea turtle bycatch in US mid-Atlantic gillnet gear. Endangered Species Research 8:211-224.

Murray, K.T. 2011. Sea turtle bycatch in the U.S. sea scallop (*Placopecten magellanicus*) dredge fishery, 2001–2008. Fish Res. 107:137-146.

Murray, K.T. 2013. Estimated loggerhead and unidentified hard-shelled turtle interactions in Mid-Atlantic gillnet gear, 2007-2011. NOAA Technical Memorandum NMFS-NE-225:1-20.

Murray, K.T. 2015a. The importance of location and operational fishing factors in estimating and reducing loggerhead turtle (*Caretta caretta*) interactions in U.S. bottom trawl gear. Fisheries Research 172:440-451.

Murray, K.T. 2015b. Estimated loggerhead (*Caretta caretta*) interactions in the Mid-Atlantic scallop dredge fishery, 2009-2014. NEFSC Reference Document 15-20; 15 pp.

Musick, J.A., and C.J. Limpus. 1997. Habitat utilization and migration in juvenile sea turtles. Pages 137-164 in P.L. Lutz and J.A. Musick, eds. The Biology of Sea Turtles. Boca Raton, Florida: CRC Press.

Musick, J.A., R.E. Jenkins, and N.B. Burkhead. 1994. Sturgeons, family Acipenseridae. Pages 183-190 in R.E. Jenkins and N.B. Burkhead, eds. Freshwater Fishes of Virginia. Bethesda, Maryland: American Fisheries Society.

NAST (National Assessment Synthesis Team). 2000. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, U.S. Global Change Research Program, Washington D.C., 2000.

Niklitschek, E.J., and D.H. Secor. 2005. Modeling spatial and temporal variation of suitable nursery habitats for Atlantic sturgeon in the Chesapeake Bay. Estuarine and Coastal Shelf Science 64:135-148.

Niklitschek, E.J., and D.H. Secor. 2010. Experimental and field evidence of behavioral habitat selection by juvenile Atlantic (*Acipenser oxyrinchus*) and shortnose (*Acipenser brevirostrum*) sturgeons. Journal of Fish Biology 77:1293-1308.

NMFS (National Marine Fisheries Service). 1995. Endangered Species Act Section 7 consultation on United States Coast Guard vessel and aircraft activities along the Atlantic coast. Biological Opinion. September 15, 1995.

NMFS. 1996. Endangered Species Act Section 7 Consultation on the proposed shock testing of the SEAWOLF submarine off the Atlantic Coast of Florida during the summer of 1997. Biological Opinion. December 12, 1996.

NMFS. 1997a. Endangered Species Act Section 7 consultation on Navy activities off the southeastern United States along the Atlantic Coast. Biological Opinion. May 15, 1997.

NMFS. 1997b. Reinitiated section 7 consultation on the regulations for Atlantic coast weakfish fishery in the Exclusive Economic Zone (EEZ). Biological Opinion. June 27, 1997.

NMFS. 1998a. Final recovery plan for the shortnose sturgeon *(Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland. October 1998.

NMFS. 1998b. Second reinitiation of Endangered Species Act Section 7 consultation on United States Coast Guard vessel and aircraft activities along the Atlantic coast. Biological Opinion. June 8, 1998.

NMFS (National Marine Fisheries Service). 2002. Endangered Species Act Section 7 Consultation on Shrimp Trawling in the Southeastern United States, under the Sea Turtle Conservation Regulations and as Managed by the Fishery Management Plans for Shrimp in the South Atlantic and Gulf of Mexico. Biological Opinion. December 2, 2002.

NMFS (National Marine Fisheries Service). 2004. Final Environmental Assessment and Regulatory Impact Review Regulatory Flexibility Act Analysis on Sea Turtle Conservation Measures for the Pound Net Fishery in Virginia Waters of the Chesapeake Bay. Prepared by the National Marine Fisheries Service, Northeast Region. April 2004.

NMFS. 2007. Final Environmental Impact Statement for amending the Atlantic Large Whale Take Reduction Plan: broad-based gear modifications. Volume I of II.

NMFS. 2008. Endangered Species Act Section 7 Consultation on the U.S. Navy Atlantic Fleet's conduct of active sonar training along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2009 to January 2014. Biological Opinion. January 16, 2008.

NMFS (National Marine Fisheries Service). 2009a. Endangered Species Act Section 7 Consultation on U.S. Navy activities in the Virginia Capes, Cherry Point, and Jacksonville Range Complexes from June 2009 to June 2010. Biological Opinion. June 5, 2009.

NMFS (National Marine Fisheries Service). 2009b. Endangered Species Act Section 7 Consultation on the U.S. Navy Atlantic Fleet's conduct of active sonar training along the Atlantic Coast of the United States and in the Gulf of Mexico from January 2009 to January 2010. Biological Opinion. January 21, 2009.

NMFS. 2011. Biennial Report to Congress on the Recovery Program for Threatened and Endangered Species, October 1, 2008 – September 30, 2010. Washington, D.C.: National Marine Fisheries Service. 194 pp.

NMFS. 2012. Biological Opinion on the Permits, Conservation and Education Division's proposal to issue Permit 16306 for research on shortnose sturgeon in Maine, Massachusetts, and New Hampshire Rivers pursuant to section 10(a)(1)(A) of the Endangered Species Act of 1973. Silver Spring, Maryland: National Marine Fisheries Service.

NMFS. 2014. Endangered Species Act Section 4(b)(2) Report: Critical Habitat for the North Atlantic Right Whale (*Eubalaena glacialis*). Prepared by the National Marine Fisheries Service, Greater Atlantic Regional Fisheries Office and Southeast Regional Office. July 2014.

NMFS (National Marine Fisheries Service) and U.S. FWS (U.S. Fish and Wildlife Service). 1991. Recovery plan for U.S. population of loggerhead turtle *Caretta caretta*. Washington, D.C.: National Marine Fisheries Service. 64 pp.

NMFS and U.S. FWS. 1992. Recovery plan for leatherback turtles *Dermochelys coriacea* in the U.S. Caribbean, Atlantic, and Gulf of Mexico. Washington, D.C.: National Marine Fisheries Service. 65 pp.

NMFS and U.S. FWS. 1993. Recovery plan for hawksbill turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. St. Petersburg, Florida: National Marine Fisheries Service. 52 pp.

NMFS and U.S. FWS. 1995. Status reviews for sea turtles listed under the Endangered Species Act of 1973. Silver Spring, Maryland: National Marine Fisheries Service. 139 pp.

NMFS and U.S. FWS. 1998. Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle (*Dermochelys coriacea*). Silver Spring, Maryland: National Marine Fisheries Service. 65 pp.

NMFS and U.S. FWS. 2007a. Loggerhead sea turtle (*Caretta caretta*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 65 pp.

NMFS and U.S. FWS. 2007b. Green sea turtle (*Chelonia mydas*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 102 pp.

NMFS and U.S. FWS. 2008. Recovery plan for the Northwest Atlantic population of the loggerhead turtle (*Caretta caretta*), Second revision. Washington, D.C.: National Marine Fisheries Service. 325 pp.

NMFS and U.S. FWS. 2013a. Hawksbill sea turtle (*Eretmochelys imbricata*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 89 pp.

NMFS and U.S. FWS. 2013b. Leatherback sea turtle (*Dermochelys coriacea*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 91 pp.

NMFS and U.S. FWS. 2015. Kemp's ridley sea turtle *(Lepidochelys kempii*) 5 year review: summary and evaluation. Silver Spring, Maryland: National Marine Fisheries Service. 61 pp.

NMFS, U.S. FWS, and SEMARNAT. 2011. Bi-National Recovery Plan for the Kemp's Ridley Sea Turtle (*Lepidochelys kempii*), Second Revision. National Marine Fisheries Service. Silver Spring, Maryland 156 pp. + appendices.

NMFS NEFSC (Northeast Fisheries Science Center). 2011. Summary of discard estimates for Atlantic sturgeon. Report prepared by Tim Miller and Gary Shepard, NEFSC Population Dynamics Branch, NMFS Northeast Fisheries Science Center. August 19, 2011.

NMFS SEFSC (Southeast Fisheries Science Center). 2001. Stock assessments of loggerhead and leatherback sea turtles and an assessment of the impact of the pelagic longline fishery on the loggerhead and leatherback sea turtles of the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-455. 343 pp.

NMFS SEFSC. 2009. An assessment of loggerhead sea turtles to estimate impacts of mortality reductions on population dynamics. NMFS SEFSC Contribution PRD-08/09-14. 45 pp.

Novak, A.J., A.E. Carlson, C.R. Wheeler, G.S. Wippelhauser, and J.A. Sulikowski. 2017. Critical foraging habitat of atlantic sturgeon based on feeding habits, prey distribution, and movement patterns in the Saco River estuary, Maine. Transactions of the American Fisheries Society 146(2):308-317.

NRC (National Research Council). 1990. Decline of the Sea Turtles: Causes and Prevention. Washington, D.C.: National Academy Press. 259 pp.

NREFHSC (Northeast Region Essential Fish Habitat Steering Committee). 2002. Workshop on the effects of fishing gear on marine habitat off the northeastern United States. October 23-25, Boston, Massachusetts. NEFSC Reference Document 02-01, 86 pp.

Oakley, N.C. 2003. Status of shortnose sturgeon, *Acipenser brevirostrum*, in the Neuse River, North Carolina. Master's thesis. North Carolina State University, Raleigh, North Carolina.

O'Connor, J.M., J.B. Alber, and L.G. Arvidson. 1981. Development and identification of larval Atlantic sturgeon (*Acipenser oxyrhynchus*) and shortnose sturgeon (*A. brevirostrum*) from the Hudson River estuary, New York. Copeia 1981(3):711-717.

O'Herron, J.C., K.W. Able, and R.W. Hastings. 1993. Movements of shortnose sturgeon (*Acipenser brevirostrum*) in the Delaware River. Estuaries 16(2):235-240.

Ong, T.-L., J. Stabile, I. Wirgin, and J.R. Waldman. 1996. Genetic divergence between *Acipenser oxyrinchus oxyrinchus* and *A. o. desotoi* as assessed by mitochondrial DNA sequencing analysis. Copeia 1996(2):464-469.

Palmer M.A., C.A. Reidy, C. Nilsson, M. Florke, J. Alcamo, P.S. Lake, and N. Bond. 2008. Climate change and the world's river basins: anticipating management options. Frontiers in Ecology and the Environment 6:81-89.

Parker, E., and B. Kynard. 2014. Latitudinal variation in ontogenetic behaviour of shortnose sturgeon, *Acipenser brevirostrum* Lesueur, 1818: an artificial stream study. Journal of Applied Ichthyology 30(6):1115-1124.

Parmesan, C., and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37-42.

Pershing, A., M.A. Alexander, C.M. Hernandez, L.A. Kerr, A. Le Bris, K.E. Mills, J.A. Nye, N.R. Record, H.A. Scannell, J.D. Scott, G.D. Sherwood, and A.C. Thomas. 2015. Slow Adaptation in the Face of Rapid Warming Leads to Collapse of the Gulf of Maine Cod Fishery. Science 350(6262):809-812. doi 10.1126/science.aac9819.

Peterson, D.L., M.B. Bain, and N. Haley. 2000. Evidence of declining recruitment of Atlantic sturgeon in the Hudson River. North American Journal of Fisheries Management 20(1):231-238.

Peterson, D.L., P. Schueller, R. DeVries, J. Fleming, C. Grunwald, and I. Wirgin. 2008. Annual run size and genetic characteristics of Atlantic sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society 137:393-401.

Popper, A.N. 2005. A review of hearing by sturgeon and lamprey. U.S. Army Corps of Engineers, Portland District.

Post, W.C., T. Darden, D.L. Peterson, M. Loeffler, and C. Collier. 2014. Research and management of endangered and threatened species in the southeast: Riverine movements of shortnose and Atlantic sturgeon. South Carolina Department of Natural Resources, Project NA10NMF4720036, Final Report, Charleston.

Price, E.R., B.P. Wallace, R.D. Reina, J.R. Spotila, F.V. Paladino, R. Piedra, and E. Vélez. 2006. Size, growth, and reproductive output of adult female leatherback turtles *Dermochelys coriacea*. Endangered Species Research 1:41-48.

Pyzik, L., J. Caddick, and P. Marx. 2004. Chesapeake Bay: introduction to an ecosystem. Chesapeake Bay Program, EPA Publication 903-R-04-003. Annapolis, Maryland.

Quattro, J., T. Greig, D. Coykendall, B. Bowen, and J. Baldwin. 2002. Genetic issues in aquatic species management: the shortnose sturgeon (*Acipenser brevirostrum*) in the southeastern United States. Conservation Genetics 3(2):155-166.

Rebel, T.P. 1974. Sea turtles and the turtle industry of the West Indies, Florida and the Gulf of Mexico. Coral Gables, Florida: University of Miami Press.

Reina, R.D., P.A. Mayor, J.R. Spotila, R. Piedra, and F.V. Paladino. 2002. Nesting ecology of the leatherback turtle, *Dermochelys coriacea*, at Parque Nacional Marino Las Baulas, Costa Rica: 1988-1989 to 1999-2000. Copeia 2002(3):653-664.

Richardson, A.J., A. Bakun, G.C. Hays, and M.J. Gibbons. 2009. The jellyfish joyride: causes, consequences and management responses to a more gelatinous future. Trends in Ecology and Evolution 24:312-322.

Robinson, M.M., H.J. Dowsett, and M.A. Chandler. 2008. Pliocene role in assessing future climate impacts. Eos, Transactions of the American Geophysical Union 89(49):501-502.

Ross, J.P. 1996. Caution urged in the interpretation of trends at nesting beaches. Marine Turtle Newsletter 74:9-10.

Ruben, H.J., and S.J. Morreale. 1999. Draft Biological Assessment for Sea Turtles: New York and New Jersey Harbor Complex. Unpublished Biological Assessment submitted to the National Marine Fisheries Service.

Saba, V.S., S.M. Griffies, W.G. Anderson, M. Winton, M.A. Alexander, T.L. Delworth, J.A. Hare, M.J. Harrison, A. Rosati, G.A. Vecchi, and R. Zhang. 2015. Enhanced warming of the Northwest Atlantic Ocean under climate change. Journal of Geophysical Research, Oceans 121:118-132. doi:10.1002/2015JC011346.

Sallenger, A.H., Jr., K.S. Doran, and P.A. Howd. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. Nature Climate Change 2:884-888. doi: 10.1038/NCLIMATE1597.

Sasso, C.R., and S.P. Epperly. 2006. Seasonal sea turtle mortality risk from forced submergence in bottom trawls. Fisheries Research 81:86-88.

Savoy, T. 2007. Prey eaten by Atlantic sturgeon in Connecticut waters. American Fisheries Society Symposium 56:157-165.

Savoy T., and J. Benway. 2004. Food habits of shortnose sturgeon collected in the lower Connecticut River from 2000 through 2002. Pages 353-360 in P.M. Jacobson, D.A. Dixon, W.C. Leggett, B.C. Marcy II., and R.R. Massengill, editors. The Connecticut River Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. Bethesda, Maryland: American Fisheries Society, Monograph 9.

Savoy, T., and D. Pacileo. 2003. Movements and habitats of subadult Atlantic sturgeon in Connecticut waters. Transactions of the American Fisheries Society 131:1-8.

Savoy, T., and D. Shake. 1992. Anadromous fish studies in Connecticut waters. Connecticut Department of Environmental Protection, AFC-20-1. 51 pp.

Savoy, T., L. Maceda, N.K. Roy, D. Peterson, and I. Wirgin. 2017. Evidence of natural reproduction of Atlantic sturgeon in the Connecticut River from unlikely sources. Plos One 12(4):e0175085.

Schmid, J.R. 1998. Marine turtle populations on the west-central coast of Florida: Results of tagging studies at the Cedar Keys, Florida, 1986-1995. Fishery Bulletin 96(3):589-602.

Schueller, P., and D.L. Peterson. 2006. Population status and spawning movements of Atlantic sturgeon in the Altamaha River, Georgia. Presentation to the 14th American Fisheries Society Southern Division Meeting, San Antonio, February 8-12th, 2006.

Schueller, P., and D.L. Peterson. 2010. Abundance and recruitment of juvenile Atlantic sturgeon in the Altamaha River, Georgia. Transactions of the American Fisheries Society 139(5):1526-1535.

Schultz, J.P. 1975. Sea turtles nesting in Surinam. Zoologische Verhandelingen (Leiden) 143:3-172.

Scott, W.B., and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin 184:80-82.

Scott, W.B., and M.G. Scott. 1988. Atlantic Fishes of Canada. University of Toronto Press, Toronto, Canada.

Secor, D.H.. 2002. Atlantic sturgeon fisheries and stock abundances during the late nineteenth century. American Fisheries Society Symposium. 2002:89-98.

Secor, D.H., and J.R. Waldman. 1999. Historical abundance of Delaware Bay Atlantic sturgeon and potential rate of recovery. American Fisheries Society Symposium 23:203-216.

Secor, D.H., P.J. Anders, W. Van Winkle, and D.A. Dixon. 2002. Can we study sturgeon to extinction? What we do and don't know about the conservation of North American sturgeon. American Fisheries Society Symposium 28:183-189.

Secor, D.H., E. Niklitschek, J.T. Stevenson, T.E. Gunderson, S. Minkkinnen, B. Florence, M. Mangold, J. Skjeveland, and A. Henderson-Arzapalo. 2000. Dispersal and growth of yearling Atlantic sturgeon *Acipenser oxyrinchus* released into the Chesapeake Bay. Fishery Bulletin 98:800-810.

Sears, R. 2002. Blue whale, *Balaenoptera musculus*. Pages 112-116 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego: Academic Press.

Seminoff, J.A. 2004. *Chelonia mydas*. In 2007 IUCN Red List of Threatened Species. Accessed 1 October 2018. http://www.iucnredlist.org/details/4615/0.

Seminoff, J.A., C.D. Allen, G.H. Balazs, P.H. Dutton, T. Eguchi, H.L. Haas, S.A. Hargrove, M.P. Jensen, D.L. Klemm, A.M. Lauritsen, S.L. MacPherson, P. Opay, E.E. Possardt, S.L. Pultz, E.E. Seney, K.S. Van Houtan, and R.S. Waples. 2015. Status Review of the Green Turtle (*Chelonia mydas*) Under the U.S. Endangered Species Act. NOAA Technical Memorandum NMFS-SWFSC-539. 571 pp.

Seney, E.E., and J.A. Musick. 2007. Historical diet analysis of loggerhead sea turtles (*Caretta caretta*) in Virginia. Copeia 2007(2):478-489.

Shaffer, M.L. 1981. Minimum population sizes for species conservation. BioScience 31(2):131-134.

Shamblin, B.M., A.B. Bolten, K.A. Bjorndal, P.H. Dutton, and others. 2012. Expanded mitochondrial control region sequences increase resolution of stock structure among North Atlantic loggerhead turtle rookeries. Marine Ecology Progress Series 469:145-160.

Shamblin, B.M., A.B. Bolten, F. Alberto Abreu-Grobois, K.A. Bjorndal, and others. 2014. Geographic patterns of genetic variation in a broadly distributed marine vertebrate: New insights into loggerhead turtle stock structure from expanded mitochondrial DNA sequences. Plos One 9(1):e85956.

Shamblin, B.M., P.H. Dutton, D.J. Shaver, D.A. Bagley, and others. 2017. Mexican origins for the Texas green turtle foraging aggregation: A cautionary tale of incomplete baselines and poor marker resolution. Journal of Experimental Marine Biology and Ecology 488:111-120.

Shoop, C.R., and R.D. Kenney. 1992. Seasonal distributions and abundance of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetological Monographs 6:43-67.

Shoop, C.R., and C.A. Ruckdeschel. 1989. Long-distance movement of a juvenile loggerhead sea turtle. Marine Turtle Newsletter 47:15.

Short, F.T., and H.A. Neckles. 1999. The effects of global climate change on seagrasses. Aquatic Botany 63:169-196.

Smith, T.I.J. 1985. The fishery, biology, and management of Atlantic sturgeon, *Acipenser oxyrhynchus*, in North America. Environmental Biology of Fishes 14(1):61-72.

Smith, T.I.J., and J.P. Clugston. 1997. Status and management of Atlantic sturgeon, *Acipenser oxyrinchus*, in North America. Environmental Biology of Fishes 48:335-346.

Smith, T.I.J., D.E. Marchette, and R.A. Smiley. 1982. Life history, ecology, culture and management of Atlantic sturgeon, *Acipenser oxyrhynchus oxyrhynchus,* Mitchill, in South Carolina. South Carolina Wildlife Marine Resources. Resources Department, Final Report to U.S. Fish and Wildlife Service Project AFS-9. 75 pp.

Smith, T.I.J., J. McCord, M. Collins, and W. Post. 2002. Occurrence of stocked shortnose sturgeon *Acipenser brevirostrum* in non-target rivers. Journal of Applied Ichthyology 18(4-6):470-474.

Snyder, D.E. 2003. Electrofishing and its harmful effects on fish. Information and Technology Report 2003-0002. Fort Collins, Colorado: U.S. Fish and Wildlife Service.

Soulé, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-170 in M.E. Soule and B.A. Wilcox, eds. Conservation Biology: An Evolutionary-Ecological Perspective. Sunderland, Massachusetts: Sinauer.

Spells, A. 1998. Atlantic sturgeon population evaluation utilizing a fishery dependent reward program in Virginia’s major western shore tributaries to the Chesapeake Bay. U.S. Fish and Wildlife Service, Charles City, Virginia.

Spotila, J.R., A.E. Dunham, A.J. Leslie, A.C. Steyermark, P.T. Plotkin and F.V. Paladino. 1996. Worldwide population decline of *Dermochelys coriacea*: are leatherback turtles going extinct? Chelonian Conservation and Biology 2:209-222.

Spotila, J.R., R.D. Reina, A.C. Steyermark, P.T. Plotkin, and F.V. Paladino. 2000. Pacific leatherback turtles face extinction. Nature 405:529-530.

Squiers, T.S., Jr. 1998. Progress Report: Kennebec River shortnose sturgeon population study. August-December 1998. NMFS Contract 40 EANF800053.

Squiers, T. 2004. State of Maine 2004 Atlantic sturgeon compliance report to the Atlantic States Marine Fisheries Commission. Report submitted to Atlantic States Marine Fisheries Commission, December 22, 2004, Washington, D.C.

Squiers, T., M. Smith, and L. Flagg. 1979. Distribution and abundance of shortnose and Atlantic sturgeon in the Kennebec River Estuary. Maine DMR Report, 51 pp.

Squiers, T., L. Flagg, M. Smith, K. Sherman, and D. Ricker. 1981. Annual Progress Report: American shad enhancement and status of sturgeon stocks in selected Maine waters. May 1, 1980 to April 30, 1981. Maine DMR Project AFC-20.

SSSRT (Shortnose Sturgeon Status Review Team). 2010. A Biological Assessment of shortnose sturgeon (*Acipenser brevirostrum*). Report to National Marine Fisheries Service, Northeast Regional Office. November 1, 2010. 417 pp.

Stacy, B. 2012. Summary of findings for sea turtles documented by directed captures, stranding response, and incidental captures under response operations during the BP DWH MC252 oil spill. ST_TR.12. DWH Sea Turtles NRDA Technical Working Group Report.

Stacy, N.I., and C. Innis. 2012. Analysis and interpretation of hematology and blood chemistry values in live sea turtles documented by response operations during the 2010 BP Deepwater Horizon oil spill response. ST_TR.14. DWH Sea Turtles NRDA Technical Working Group Report.

Stevenson, J.T. 1997. Life history characteristics of Atlantic sturgeon (*Acipenser oxyrinchus*) in the Hudson River and a model for fishery management. Master's thesis. University of Maryland, College Park.

Stevenson, J.T., and D.H. Secor. 2000. Age determination and growth of Hudson River Atlantic sturgeon, *Acipenser oxyrinchus*. Fishery Bulletin 98:153-166.

Stein, A.B., K.D. Friedland, and M. Sutherland. 2004a. Atlantic sturgeon marine distribution and habitat use along the northeastern coast of the United States. Transactions of the American Fisheries Society 133:527-537.

Stein, A.B., K.D. Friedland, and M. Sutherland. 2004b. Atlantic sturgeon marine bycatch and mortality on the continental shelf of the Northeast United States. North American Journal of Fisheries Management 24:171-183.

Sweka, J.A., J. Mohler, M.J. Millard, T. Kehler, A. Kahnle, K. Hattala, G. Kenney, and A. Higgs. 2007. Juvenile Atlantic sturgeon habitat use in Newburgh and Haverstraw bays of the Hudson River: Implications for population monitoring. North American Journal of Fisheries Management 27:1058-1067.

Swimmer, Y., C. Empey Campora, L. Mcnaughton, M. Musyl, and M. Parga. 2014. Post-release mortality estimates of loggerhead sea turtles (*Caretta caretta*) caught in pelagic longline fisheries based on satellite data and hooking location. Aquatic Conservation: Marine and Freshwater Ecosystems. 24. 10.1002/aqc.2396.

Tapilatu, R.F., P.H. Dutton, M. Tiwari, T. Wibbels, and others. 2013. Long-term decline of the western Pacific leatherback, *Dermochelys coriacea*: A globally important sea turtle population. Ecosphere 4:15.

Taubert, B.D., and M.J. Dadswell. 1980. Description of some larval shortnose sturgeon (*Acipenser brevirostrum*) from the Holyoke Pool, Connecticut River, Massachusetts, USA, and the Saint John River, New Brunswick, Canada. Canadian Journal of Zoology 58(6):1125-1128.

TEWG (Turtle Expert Working Group). 1998. An assessment of the Kemp's ridley (*Lepidochelys kempii*) and loggerhead (*Caretta caretta*) sea turtle populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409:1-96.

TEWG (Turtle Expert Working Group). 2000. Assessment update for the Kemp's ridley and loggerhead sea turtle populations in the western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-444:1-115.

TEWG (Turtle Expert Working Group). 2007. An assessment of the leatherback turtle population in the Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-555:1-116.

TEWG (Turtle Expert Working Group). 2009. An assessment of the loggerhead turtle population in the Western North Atlantic Ocean. NOAA Technical Memorandum NMFS-SEFSC-575:1-131.

Theodore, I., J. Smith, E.K. Dingley, and D.E. Marchette. 1980. Induced spawning and culture of Atlantic sturgeon. The Progressive Fish-Culturist 42(3):147-151.

Thompson, N.B. 1984. Progress report on estimating density and abundance of marine turtles: results of first year pelagic surveys in the Southeast U.S. Miami, Florida: National Marine Fisheries Service. 64 pp.

Titus, J.G., and V.K. Narayanan. 1995. The Probability of Sea Level Rise. EPA 230-R-95-008. Washington, D.C.: U.S. Environmental Protection Agency. 186 pp.

Tomas, J., and J.A. Raga. 2008 . Occurrence of Kemp's ridley sea turtle (*Lepidochelys kempii*) in the Mediterranean. Marine Biodiversity Records 1:e58.

U.S. FWS (U.S. Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1992. Recovery plan for the Kemp's ridley sea turtle (*Lepidochelys kempii*). St. Petersburg, Florida: National Marine Fisheries Service.

U.S. FWS and NMFS. 1998. Endangered Species Act Consultation Handbook: Procedures for Conducting Section 7 Consultations and Conferences. Washington, D.C.: U.S. FWS and NMFS.

Van Eenennaam, J.P., S.I. Doroshov, G.P. Moberg, J.G. Watson, D.S. Moore, and J. Linares. 1996. Reproductive conditions of the Atlantic sturgeon (*Acipenser oxyrhynchus*) in the Hudson River. Estuaries 19:769-777.

Van Houtan, K.S., and J.M. Halley. 2011. Long-Term Climate Forcing in Loggerhead Sea Turtle Nesting. PLoS ONE 6(4): e19043. doi:10.1371/journal.pone.0019043.

Vanderlaan, A.S.M., and C.T. Taggart. 2006. Vessel collisions with whales: the probability of lethal injury based on vessel speed. Marine Mammal Science 23(1):144-156.

Vargo, S., P. Lutz, D. Odell, E. Van Vleep, and G. Bossart. 1986. Final report: Study of effects of oil on marine turtles. Technical Report. OCS study MMS 86-0070. Volume 2. 181 pp.

Vladykov, V.D. and J.R. Greeley. 1963. Order Acipenseroidea. Pages 24-60 in Fishes of the Western North Atlantic. Memoir Sears Foundation for Marine Research 1(Part III). xxi + 630 pp.

Waldman, J.R, and I.I. Wirgin. 1998. Status and restoration options for Atlantic sturgeon in North America. Conservation Biology 12(3):631-638.

Waldman, J.R., J.T. Hart, and I.I. Wirgin. 1996. Stock composition of the New York Bight Atlantic sturgeon fishery based on analysis of mitochondrial DNA. Transactions of the American Fisheries Society 125:364-371.

Waldman J.R., C. Grunwald, J. Stabile, and I. Wirgin. 2002. Impacts of life history and biogeography on genetic stock structure in Atlantic Sturgeon, *Acipenser oxyrinchus oxyrinchus*, Gulf sturgeon *A. oxyrinchus desotoi*, and shortnose sturgeon, *A.brevirostrum*. Journal of Applied Ichthyology 18:509-518.

Wallace, B.P., S.S. Kilham, F.V. Paladino, and J.R. Spotila. 2006. Energy budget calculations indicate resource limitation in Eastern Pacific leatherback turtles. Marine Ecology Progress Series 318:263-270.

Wallace, B.P., P.R. Sotherland, P.S. Tomillo, R.D. Reina, J.R. Spotila, and F.V. Paladino. 2007. Maternal investment in reproduction and its consequences in leatherback turtles. Oecologia 152(1):37-47.

Wallace, B.P., A.D. DiMatteo, B.J. Hurley, E.M. Finkbeiner, and others. 2010. Regional management units for marine turtles: a novel framework for prioritizing conservation and research across multiple scales. Plos One 5(12):e15465.

Warden, M.L. 2011a. Modeling loggerhead sea turtle (*Caretta caretta*) interactions with US Mid-Atlantic bottom trawl gear for fish and scallops, 2005-2008. Biological Conservation 144:2202-2212.

Warden, M.L. 2011b. Proration of loggerhead sea turtle (*Caretta caretta*) interactions in U.S. Mid-Atlantic bottom otter trawls for fish and scallops, 2005-2008, by managed species landed. U.S. Department of Commerce, Northeast Fisheries Science Center Reference Document 11-04. 8 pp.

Waring, G.T., E. Josephson, K. Maze-Foley, and P.E. Rosel, editors. 2011. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2010. NOAA Technical Memorandum NMFS-NE-219; 595 pp.

Weber, W., C. Jennings, and S. Rogers. 1998. Population size and movement patterns of shortnose sturgeon in the Ogeechee River system, Georgia. Pages 18-28 *in* Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies.

Welsh, S.A., M.F. Mangold, J.E. Skjeveland, and A.J. Spells. 2002. Distribution and Movement of Shortnose Sturgeon (*Acipenser brevirostrum*) in the Chesapeake Bay. Estuaries 25(1):101-104.

Wenzel, F.W., D.K. Mattila, and P.J. Clapham. 1988. *Balaenoptera musculus* in the Gulf of Maine. Marine Mammal Science 4:172-175.

Whitehead, H. 2002. Sperm whale, *Physeter macrocephalus*. Pages 1165-1172 in W.F. Perrin, B. Würsig, and J.G.M. Thewissen, eds. Encyclopedia of Marine Mammals. San Diego: Academic Press.

Wibbels, T. 2003. Critical approaches to sex determination in sea turtle biology and conservation. Pages 103-134 in P.L. Lutz, J.A. Musick, and J. Wyneken, eds. Biology of Sea Turtles, Volume 2. Boca Raton: CRC Press.

Wirgin, I., and T. King. 2011. Mixed Stock Analysis of Atlantic sturgeon from coastal locales and a non-spawning river. Presented at February 2011 Atlantic and shortnose sturgeon workshop.

Wirgin, I., J.R. Waldman, J. Rosko, R. Gross, M.R. Collins, S.G. Rogers, and J. Stabile. 2000. Genetic structure of Atlantic sturgeon populations based on mitochondrial DNA control region sequences. Transactions of the American Fisheries Society. 129:476-486.

Wirgin, I., J. Waldman, J. Stabile, B. Lubinski, and T. King. 2002. Comparison of mitochondrial DNA control region sequence and microsatellite DNA analyses in estimating population structure and gene flow rates in Atlantic sturgeon *Acipenser oxyrinchus*. Journal of Applied Ichthyology 18(4-6):313-319.

Wirgin, I., C. Grunwald, E. Carlson, J. Stabile, D.L. Peterson, and J. Waldman. 2005. Range-wide population structure of shortnose sturgeon *Acipenser brevirostrum* based on sequence analysis of the mitochondrial DNA control region. Estuaries 28:406-421.

Wirgin, I., C. Grunwald, J. Stabile, and J.R. Waldman. 2010. Delineation of discrete population segments of shortnose sturgeon *Acipenser brevirostrum* based on mitochondrial control region sequence analysis. Conservation Genetics 11:689-708.

Wirgin, I., L. Maceda, J.R. Waldman, S. Wehrell, M. Dadswell, and T. King. 2012. Stock origin of migratory Atlantic sturgeon in the Minas Basin, Inner Bay of Fundy, Canada, determined by microsatellite and mitochondrial DNA analyses. Transactions of the American Fisheries Society 141:1389-1398.

Wirgin, I., L. Maceda, C. Grunwald, and T.L. King. 2015. Population origin of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* by-catch in U.S. Atlantic coast fisheries. Journal of Fish Biology 2015:1-20.

Witherington, B., P. Kubilis, B. Brost, and A. Meylan. 2009. Decreasing annual nest counts in a globally important loggerhead sea turtle population. Ecological Applications 19:30-54.

Work, P.A., A.L. Sapp, D.W. Scott, and M.G. Dodd. 2010. Influence of small vessel operation and propulsion system on loggerhead sea turtle injuries. Journal of Experimental Marine Biology and Ecology 393:168-175.

Zurita, J.C., R. Herrera, A. Arenas, M.E. Torres, C. Calderon, L. Gomez, J.C. Alvarado, and R. Villavicencio. 2003. Nesting loggerhead and green sea turtles in Quintana Roo, Mexico. Pages 125-127 in J.A. Seminoff, compiler. Proceedings of the Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503.

Zwinenberg, A.J. 1977. Kemp's ridley, *Lepidochelys kempii* (Garman 1880), undoubtedly the most endangered marine turtle today (with notes on the current status of *Lepidochelys olivacea*). Bulletin of the Maryland Herpetological Society 13(3):378-384.

APPENDIX A

1.0 Maine

The State of Maine distributes funds for surveys in inland waters and marine waters. Studies in inland waters are carried out by the Maine Department of Inland Fisheries and Wildlife. The State has indicated that they have no current studies in inland waters where shortnose or Atlantic sturgeon are present.

Studies in estuarine and marine waters are carried out by the Maine Department of Marine Resources (MDMR). Funds are used to carry out three research surveys: (1) Striped Bass Tagging in the Kennebec Estuary; (2) Kennebec and Penobscot Juvenile Striped Bass and Alosine Beach Seine Survey; and, (3) Maine – New Hampshire Inshore Trawl Survey.

1.1 ME F-41-R Striped Bass Telemetry in the Kennebec and Androscoggin Estuaries

In 2007, MDMR initiated an acoustic telemetry study of striped bass in the Kennebec Estuary. Sampling has been conducted by hook-and-line below the Brunswick Dam in the Androscoggin estuary (tidal fresh water), near the head-of-tide on the mainstem Kennebec (tidal fresh water), and below the Lockwood Dam in the upper Kennebec River (fresh water). Striped bass in good condition were measured (total length in millimeters), anaesthetized, and implanted with an acoustic transmitter.

1.2 ME F-41-R Kennebec River Juvenile Striped Bass and Alosine Beach Seine Survey

In the Kennebec, each of 20 permanent sites is sampled with a beach seine six times each year on a biweekly schedule beginning in mid-July and ending approximately in mid-September. Fourteen sites are in tidal freshwater (four on the Upper Kennebec River, three on the Androscoggin River, four on Merrymeeting Bay, one on the Cathance River, one on the Abagadasset River, and one on the Eastern River) and six are in the tidal salinity-stratified portion of the estuary. All samples are taken within three hours of low slack water with a beach seine made of 6.35 mm stretch mesh nylon, measuring 17m long and 1.8 m deep, and with a 1.8 m x 1.8 m bag at the center. The sample is sorted and processed in the field. All alosines and striped bass are counted, and the total lengths of a maximum of 50 of each species are measured. Other species are identified, enumerated, and the total lengths of a maximum of 10 of each species are measured. Soak time for each haul is approximately 10 min.

In the Penobscot, eight index sites are sampled with a beach seine 8 times each year on a biweekly schedule from July thru September. Five of the sites are in the tidal freshwater and 3 sites are in the tidal salinity-stratified portion of the Penobscot estuary. All samples are taken within three hours of low slack water with a beach seine made of 6.35 mm stretch mesh nylon, measuring 50 m long and 2.4 m deep, and with a 1.8 m x 1.8 m bag at the center. The sample is sorted and processed in the field. All alosines and striped bass are counted, and the total lengths of a maximum of 50 of each species are measured. Other species are identified, enumerated, and the total lengths of a maximum of 30 of each species are measured. Soak time for each haul is approximately 10 min.

1.3 ME F-43-R Maine-New Hampshire Inshore Trawl Survey

The Maine-New Hampshire Inshore Trawl Survey is a stratified random survey with a fixed component. The inshore area sampled includes four[1] depth strata: 5-20 fathoms, 21-35 fathoms, 36-55 fathoms, and >56 fathoms out to approximately the 12-mile limit, and five longitudinal regions based on oceanographic, geologic, and biological features (Figure 1). Together, 20 separate strata exist.

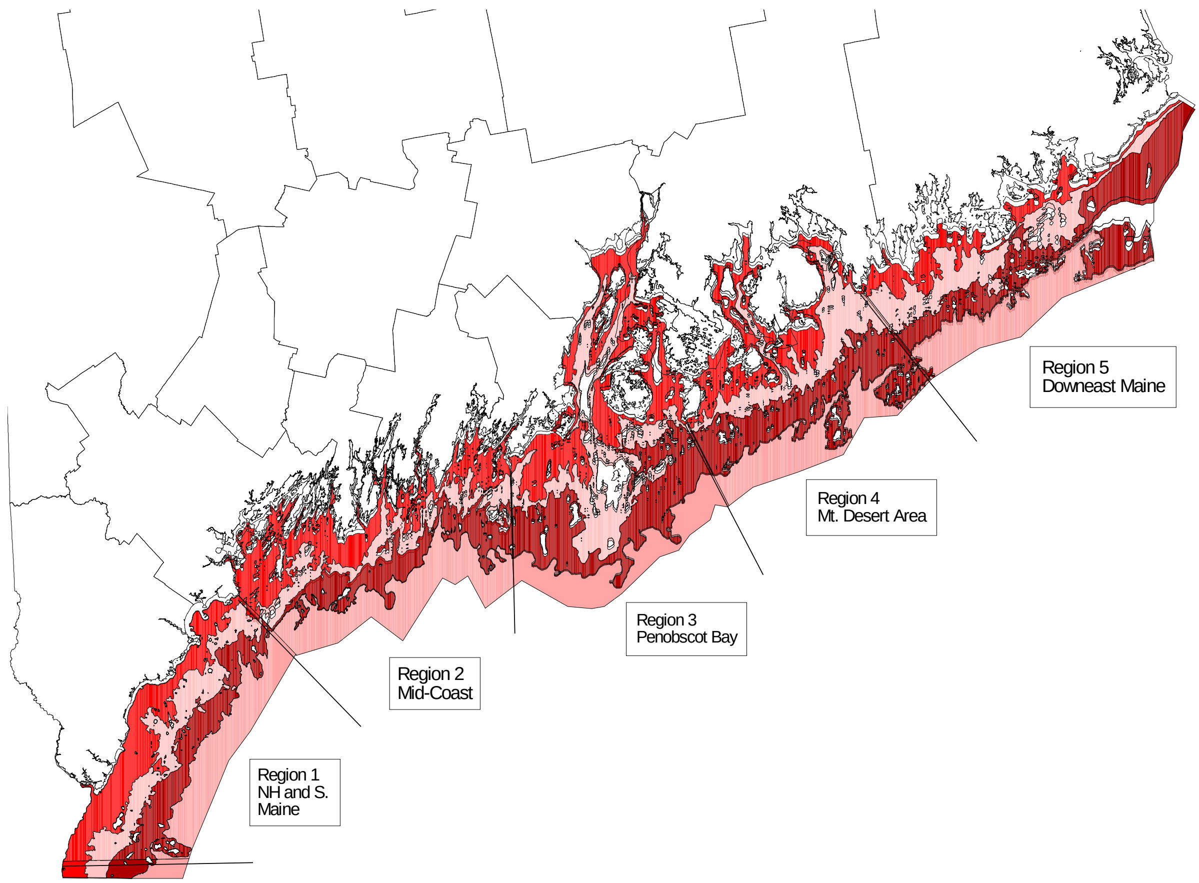


Figure 1. Regional and Depth Strata for the Maine-New Hampshire Inshore Trawl Survey

With the addition of the fourth strata, the total survey area increased from ~3,626 nautical miles (NM^2) to ~4,665 NM^2. To keep sampling density of the original strata roughly equivalent with previous surveys, an additional 15 stations were added to the original goal of 100 stations per survey. A target of 115 stations is selected for sampling in each survey resulting in a sampling

[1] From Fall 2000 to Fall 2002, the outer depth stratum was not sampled. The fourth stratum, 56 fathom to the 12-mile limit was added in the Spring 2003 survey. It expands our coverage area to approximately equal that area covered by the Atlantic States Marine Fisheries Commission (ASMFC) and allows more overlap between this survey and the NMFS survey area.

density of 1 station for every 40 NM^2. Number of tows per stratum is apportioned according to its total area (Tables 1 and 2).

Table 1. Area in square miles of the 20 strata of the ME/NH Trawl Survey

Region	5-20 fathoms	21-35 fathoms	36-55 fathoms	>56 fathoms	Total
1	253.27	214.22	227.35	225.65	920.50
2	279.63	191.23	211.66	263.49	946.02
3	259.62	262.90	280.03	183.69	986.25
4	205.30	206.12	310.49	170.72	892.63
5	138.54	220.49	365.04	196.11	920.19
Total	1136.37	1094.96	1394.59	1039.66	4665.58

Table 2. Number of tows per stratum of the ME/NH Trawl Survey

Region	5-20 fathoms	21-35 fathoms	36-55 fathoms	>56 fathoms	Total
1	6	6	6	5	23
2	7	5	6	5	23
3	6	7	7	4	24
4	5	5	8	4	22
5	4	6	9	4	23
Total	28	29	36	22	115

Random stations are selected from a NOAA nautical chart in Arc View™ GIS overlain with 1-NM^2 grids. Each grid within each region is assigned a unique identification number that serves as a call number. Grids are selected using an Excel™ random number generator. Tows approximately 1 NM long are proposed in each grid and plotted in P-Sea Windplot™ (using charts of the NAD 1983 datum). From prior experience and local knowledge, some grids are classified as untowable during the plotting process. Due to the large amount of fixed gear and the appeal to fishermen to cooperate with the survey by clearing the tows, identifying good tow locations is a priority. If no towable bottom can be found within a 2-mile radius, a new random number is chosen within the same stratum. Beginning and end points of each tow are identified in P-Sea Windplot. To the extent possible, for ease of identification by lobster industry members, tows follow loran lines. Loran C coordinates are converted to latitude/longitude degrees to the nearest 0.001 decimal minutes.[2]

[2] This conversion is not exact due to the distortion LORAN signals experience coming over land. The distortion is constant, so the position is repeatable in LORAN TD's. The final conversion to an accurate geographical position

After the initial survey in the fall of 2000, two stations per stratum were designated as fixed stations to be sampled on each subsequent survey. In areas where previous work had been done, the stations were selected due to their historical importance[3]. In areas with no history, one station was selected as being roughly representative of the average catch for its respective stratum and the other was randomly selected. After the addition of the fourth stratum in the spring of 2003, fixed stations were designated for that stratum using the same criteria.

Two virtually identical commercial fishing vessels, the F/V Tara Lynn and F/V Robert Michael, are used for this survey. Both vessels are Down East 54's constructed of a combination of solid and sandwich fiberglass, with full displacement hulls taken from the same mold. They are powered by 8-cylinder GMC diesel engines producing 365 H.P. Reverse gear is a Twin Disc, Model 514, with a 4.5 to 1 ratio. A 3-inch stainless steel shaft turns a 47x45-inch, 4-bladed power propeller housed in a 48-inch Michigan nozzle. The vessel's hull displacement is 73 gross tons, allowing it to perform well in sea states up to eight feet. While only one vessel at a time is planned for each survey, the other nearly identical sistership is immediately available in the event of an equipment breakdown, allowing the survey to be completed on schedule.

Since the fall 2000 survey, the two vessels have alternated between spring and fall surveys (Table 3), with the intent of alternating spring and fall vessel participation in blocks of 2 years (4 surveys). Starting with the spring 2004 survey, all future surveys will be conducted by the F/V Robert Michael, with the F/V Tara Lynn available as backup.

Table 3. Survey schedule for the F/V Robert Michael (RM) and the F/V Tara Lynn (TL)

	SPRING	**FALL**
2000	**------**	Robert Michael
2001	Tara Lynn	Robert Michael
2002	Tara Lynn	Robert Michael
2003	Robert Michael	Tara Lynn
2004	Robert Michael	Robert Michael

Trawl design considerations for the survey include effectiveness of the gear for sampling the complex bottom in the nearshore areas of the Gulf of Maine and comparability with previous and ongoing surveys by NMFS and Massachusetts Division of Marine Fisheries. The net is a modified version of the shrimp net design used in Maine waters (Appendix A), designed to fish for a variety of near-bottom dwelling species without targeting any specific component. Robert Tetrault, the vessels' owner, and net designer Jeff Flagg designed the net to fish effectively, be easily maintained, and be towed by vessels ranging from 45 to 70 feet in length with nominal horsepower. Three identical nets were constructed for this survey in the event of tearing or loss. Net tapers were cut to permit the shape of the net to get maximum height while allowing the net to remain tight on the bottom. The net is shackled from the footrope to the frame with two 3/8th inch shackles to a banded wire that runs parallel with the footrope. Heavy rubber wing bobbins

takes place when the area is visited and the vessel's equipment records the true geographical position using differentially corrected GPS.

[3] Historical data for several of these sites exists from previous surveys conducted by Maine DMR.

retard bottom wing lift at the net end of the bottom leg. Top legs are 7/16th wire, 60 feet in length with soft eyes at each end, and bottom legs are 5/8th inch wire, 58 feet in length with two feet of 5/8th inch chain at the end where the leg attaches to the bottom wing for a total of 60 feet. Bottom legs are covered with 2 -3/8" cookies to prevent them from digging into the mud. The net is constructed of 2-inch #24 polyethylene mesh, with a 1-inch (stretched measure) mesh liner in the cod end. Otter boards are #7.5 Bisons. Attached to the 70-foot, 5/8th inch Rander's Combination Wire Rope footrope is a roller frame strung onto ¾" IPS of 6x19 construction with a fiber core. The ten-foot wide bosom section is made up of eight-inch rubber discs on six-inch centers along with eight evenly spaced toggles. Spacing is maintained by smaller four-inch cookies strung between the discs. The two 29-foot wing sections are made up of six-inch rubber discs spaced 4 ½ inches apart, with the same four inch cookies used to maintain spacing. Each wing section contains twelve toggles spaced evenly to facilitate footrope attachment. The 5/8" Rander's combination rope headrope has twenty-eight 8" center-hole, deep-sea net floats strung with 5/8" yellow polyethylene float line. Between surveys, the net is sent back to the manufacturer where it is returned to specification (Appendix B). Nets will be replaced as they age to keep the gear in good working condition and insure consistency.

2.0 New Hampshire

The State of New Hampshire uses the FWS funds to carry out three projects: (1) Anadromous Alosid Restoration and Evaluation; (2) Estuarine Survey of Juvenile Finfish; and, (3) Monitoring of Rainbow Smelt Spawning Activity.

2.1 NH F-61-R Anadromous Alosid Restoration and Evaluation

The restoration or anadromous alosids in the coastal river systems of New Hampshire is assessed by regular monitoring of fish ladders owned by the Fish and Game Department. These fishways (Figure 1), their river location and their initial year of operation are Cocheco (1976), Lamprey (1972), Oyster (1976), Taylor (1978), Winnicut (1998) and Exeter (1975). Fish utilizing these coastal fish ladders (Table 1) are identified and enumerated by hand counting, electronic fish tubes or estimated by time counts. Counts recorded by electronic fish counters are adjusted by the results of regular calibration counts.

Biological samples are collected from anadromous alosids using fish traps at the upper end of five coastal fishways. Staff use dip nets to collect samples of river herring at the beginning, middle and end of the spawning run. Each sample consists of length measurements and sex determination from approximately 150 fish as well as collecting scale samples for aging and speciation from 50 of these fish. All returning adult American shad encountered at the fish passage facilities are enumerated, measured, sexed and scales collected for aging. If stressful conditions like high water temperatures exist, these fish are passed upriver without biological data taken to assure maximum survivability of all returns.

River herring are trapped and transferred to enhance runs in New Hampshire rivers. During May and June, river herring are collected by dip net from traps of selected fishways and transported to impoundments or lakes in the coastal and Merrimack River drainages. No more than 10 percent of run from the selected river is removed for out-of-basin transfers.

2.2 NH F-61-R Estuarine Survey of Juvenile Finfish

Since 1997, the New Hampshire Fish and Game Department annually monitors the relative abundance of juvenile finfish utilizing NH's estuaries for nursery habitat. A 30.5 m long by 1.8 m high, with 6.4 mm mesh, bag seine is used to sample for juvenile finfish in NH tidal waters. A single seine haul is performed each month from June through November in NH estuaries at 15 fixed stations: four in the Hampton/Seabrook Estuary (HSE), three in Little Harbor (GBE1), three in the Piscataqua River (GBE2), and five in Little Bay/Great Bay (GBE3) (Table 2 and Figures 2 through 4).

Seine hauls are performed during daylight between 2 hours before and 2 hours after low tide. Seine hauls are set by boat 15–25 m from shoreline, ideally in water depths less than 2 m in order to prevent the foot rope of the seine from lifting off of the bottom.

All captured finfish (Table 3) are identified to the lowest possible taxon, measured in total length to the nearest millimeter (with a maximum of 25 individual lengths recorded per species per seine haul), and then enumerated. Specific invertebrate species of special interest including the green crab *Carcinus maenas*, rock crab *Cancer irroratus*, Jonah crab *Cancer borealis*, Asian shore crab *Hemigrapsus sanguineus*, horseshoe crab *Limulus polyphemus*, and American lobster *Homarus americanus* are identified and enumerated although lengths are not obtained. All other captured invertebrate species are discarded. Water surface temperature (ºC), salinity (ppt), and substrate type are recorded at each fixed station for each seine haul.

Catch distributions for many forage species or juveniles of some species can be heavily skewed due to a few large catches as a result of schooling behavior. In these instances one or two large catches can often inflate the value of an arithmetic mean by orders of magnitude resulting in a false characterization of the true relative abundance of a species. To compensate for this potential bias, a log transformation of the catch data was used to produce a normal (as opposed to skewed) catch distribution and the resulting mean of the log-transformed data can be transformed back to produce a geometric mean. In recent years, the geometric mean has often replaced the arithmetic mean as a measure of relative abundance for juvenile finfish because it is a more statistically robust value.

2.3 NH F-61-R Rainbow Smelt Survey

Since 2008, New Hampshire has monitored trends in the smelt spawning population in an attempt to identify the nature and extent of the threats to rainbow smelt, and recommend management strategies to reduce, prevent, or reverse the threats to rainbow smelt within the Great Bay Estuary. To characterize the peak of the smelt run, fyke nets are set at ice-out conditions (generally middle to end of March) until the third Thursday in April. This threshold has been able to capture 97-100% of the run at the Squamscott River (2008-2012) and 82-98% (2010-2012) of the run at the Oyster River.

Nets are set in three rivers at head-of-tide: Oyster, Squamscott, and Winnicut (Figure 5). The fyke nets have six hoops measuring 2.5 feet (ft) in diameter attached to a box frame measuring 4x4 (ft). Throats are attached to the second and fourth hoop inside the mouth. Soft wings 4x16 (ft) with leads and floats are attached to both sides of the box frame mouth creating a net span 50-75% of the river channel at high tide. Fyke nets are deployed three nights each week during the spawning run at low tide and recovered at the next low tide. All smelt in the net are randomly distributed into 5-gallon buckets. One hundred males and one hundred females are measured to the nearest millimeter, and the length and sex of each fish recorded. All remaining smelt are enumerated and sexed. Approximately 500 scale samples are taken for aging over the course of the run at each site. At least 20 samples are taken from each site for each centimeter size class per sex (10 cm to 20 cm), and samples taken from size classes above 20 cm as they occur. Bycatch are identified, enumerated, and measured up to 25 fish per species. Table 4 lists all the species observed in the rainbow smelt spawning fyke net survey.

Egg tiles are deployed at each site to measure the relative egg density to be used as a potential predictor of future year-class strength. Each site location had two strings of five egg tiles (0.30 m by 0.30 m) located below mean low tide. Tiles are checked daily while fyke nets were deployed and all eggs were counted on each tile. Tiles were wiped clean after eggs were counted and returned to the water for repeat sampling. Egg density by river is quantified as eggs per tile per sample day.

Grab samples for water quality monitoring are collected at each site where pH, temperature, specific conductivity, dissolved oxygen, and turbidity are determined below the spawning rifle where the fyke net is placed. These parameters are collected with a YSI 6920v2 (YSI, Inc. Yellow Springs OH) data sonde which is calibrated each week during the sampling period.

The data collected are analyzed to recommend changes in policies and/or regulations to reduce, prevent, or reverse threats to rainbow smelt within the Great Bay Estuary.

Table 1. Species of fish observed in New Hampshire coastal fishways since 1990.

Species Name
Alewife
Bass, largemouth
Bass, rock
Bass, smallmouth
Bass, striped
Blueback herring
Bluegill
Bullhead, brown
Carp
Chub, creek
Crappie, black
Eel, American
Fallfish
Perch, white
Perch, yellow
Pickerel, eastern chain
Pumpkinseed/common sunfish
Salmon, Atlantic
Sea lamprey
Shad, American
Shiner, bridle
Shiner, common
Shiner, golden
Stickleback, threespine
Sucker, common white
Sunfish, banded
Sunfish, redbreast
Trout, brook
Trout, brown
Trout, rainbow
Trout, tiger

Table 2. Station number and its area code, location, coordinates, and substrate type, as well as historical seining data for each station, from a juvenile finfish seine survey conducted in New Hampshire estuaries.

Station #	Area	Station location	Latitude/longitude	Substrate	Historical data
5	GBE1	Fort Stark (Little Harbor)	43°03’28.0”N 070°42’51.7”W	sand	Grout & Heckman (1996)
7	GBE1	Wentworth (Little Harbor)	43°03’25.6”N 070°43’25.7”W	mud/sand	Grout & Heckman (1996)
9	GBE1	Odiorne Beach (Little Harbor)	43°03’07.9”N 070°43’22.9”W	sand	Grout & Heckman (1996)
30	GBE2	Schiller Plant (Piscataqua)	43°05’59.3”N 070°47’15.5”W	mud/gravel	NAI (1979)
35	GBE2	General Sullivan Bridge Cove (Piscataqua)	43°07’00.1”N 070°49’23.6”W	mud	NHFG (1981,1982)
39	GBE2	Upper Piscataqua (Power Lines)	43°10’16.2”N 070°49’43.9”W	mud/sand	None
54	GBE3	Broad Cove (Little Bay)	43°07’07.9”N 070°50’51.8”W	mud/sand	NHFG (1981)
72	GBE3	Fox Point (Little Bay)	43°07’15.0”N 070°51’33.2”W	mud/sand	NHFG (1981,1982)
93	GBE3	Herods Cove (Great Bay)	43°04’16.6”N 070°51’27.2”W	mud	NHFG (1981,1982)
107	GBE3	Moody Point (Lamprey/Squamscott)	43°04’07.0”N 070°54’12.5”W	mud	NHFG (1981)
147	GBE3	Oyster River	43°07’19.3”N 070°52’23.4”W	mud/shell	None
23	HSE	Smith & Gilmore (Hampton)	42°54’03.4”N 070°49’10.0”W	mud/shell	Grout & Heckman (1996)
25	HSE	Yankee Coop (Seabrook)	42°53’33.0”N 070°49’11.1”W	mud/sand	Grout & Heckman (1996)
29	HSE	Blackwater River	42°53’42.9”N 070°49’29.8”W	sand	Grout & Heckman (1996)
33	HSE	Brown’s River	42°53’56.3”N 070°49’33.4”W	mud/sand	Grout & Heckman (1996)

Area codes	Area names
HSE	Hampton/Seabrook Estuary
GBE1	Little Harbor
GBE2	Piscataqua River
GBE3	Little Bay/Great Bay

Table 3. Species captured in New Hampshire's finfish seine survey.

Alewife	Flounder, windowpane	Pipefish, Northern
Bass, black sea	Flounder, winter	Pollock
Bass, largemouth	Fourbeard rockling	Pumpkinseed
Bass, smallmouth	Gunnel, rock	Raven, sea
Bass, striped	Hake, red	Sculpin, little
Bay anchovy	Hake, silver	Sculpin, longhorn
Blue runner	Hake, white	Sculpin, shorthorn
Bluefish	Herring (unclassified)	Sculpins, (unclassified)
Bluegill	Herring, Atlantic	Shad, American
Butterfish	Herring, blueback	Shiner, common
Capelin	Killifish, banded	Shiner, emerald
Cod, Atlantic	Killifish, common	Shiner, golden
Crab, Asian shore	Killifish, striped	Silverside, Atlantic
Crab, green	Lamprey, sea	Skate, big
Crab, horseshoe	Lance, sand	Smelt, rainbow
Crab, jonah	Lobster, American	Spotfin butterflyfish
Crab, rock	Lumpfish	Squid (unclassified)
Crappie, black	Mackerel scad	Stickleback, fourspine
Crevalle	Mackerel, Atlantic	Stickleback, ninespine
Cunner	Menhaden, Atlantic	Stickleback, threespine
Eel, American	Mullet, white	Tautog (blackfish)
Flounder (unclassified)	Northern puffer	Tomcod, Atlantic
Flounder, smooth	Other fish (unclassified)	Trout, brown
Flounder, summer	Perch, white	Trout, rainbow

Table 4. Species captured in New Hampshire's Spring Rainbow Smelt Spawning Survey.

Alewife	Herring (unclassified)	Shiner, common
Bass, largemouth	Herring, Atlantic	Shiner, golden
Bluegill	Herring, blueback	Shiner, spottail
Bullhead, brown	Killifish (unclassified)	Silverside, Atlantic
Bullhead, yellow	Killifish, banded	Smelt, rainbow
Chub, creek	Killifish, common	Stickleback, fourspine
Crab, horseshoe	Killifish, striped	Stickleback, ninespine
Crappie, black	Lamprey, sea	Stickleback, threespine
Cunner	Other fish (unclassified)	Sucker, common white
Dace, blacknose	Perch, white	Sunfish, banded
Eel, American	Perch, yellow	Sunfish, redbreast
Fallfish	Pickerel, eastern chain	Tomcod, Atlantic
Flounder, smooth	Pike, northern	Trout, brook
Flounder, winter	Pipefish, northern	Trout, rainbow
Grubby	Pumpkinseed	

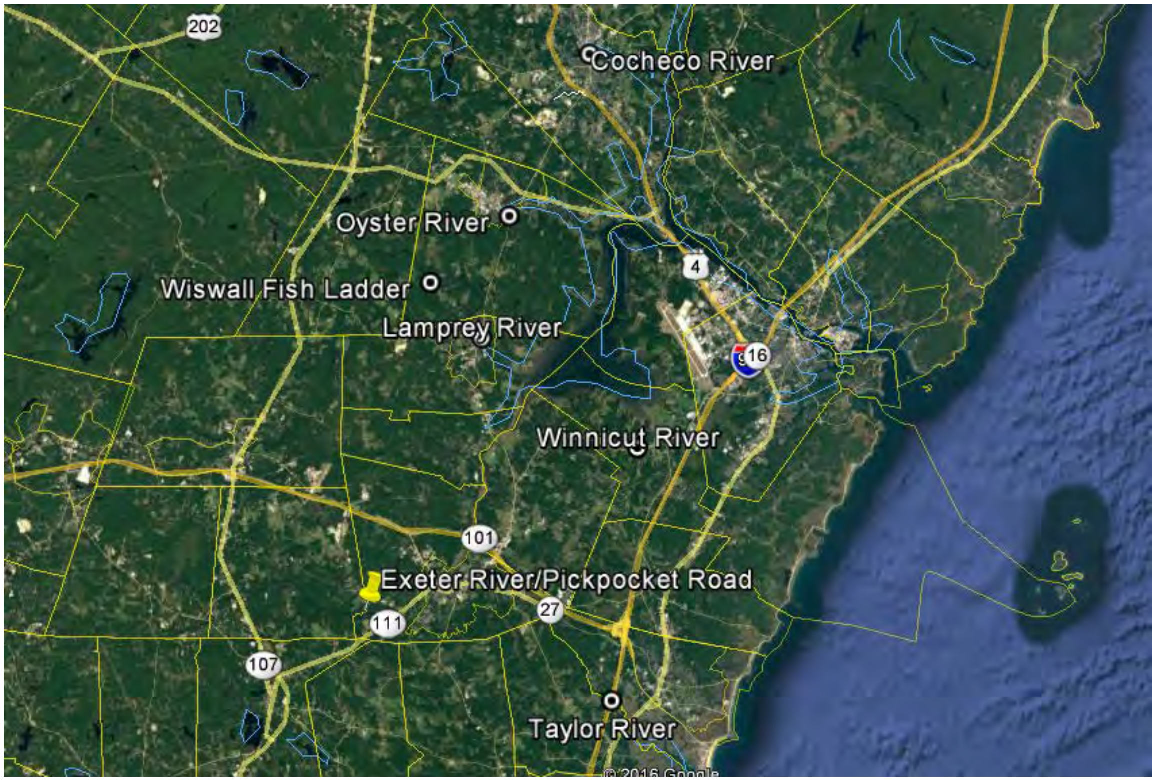


Figure 1. Location of fishways in coastal New Hampshire rivers.

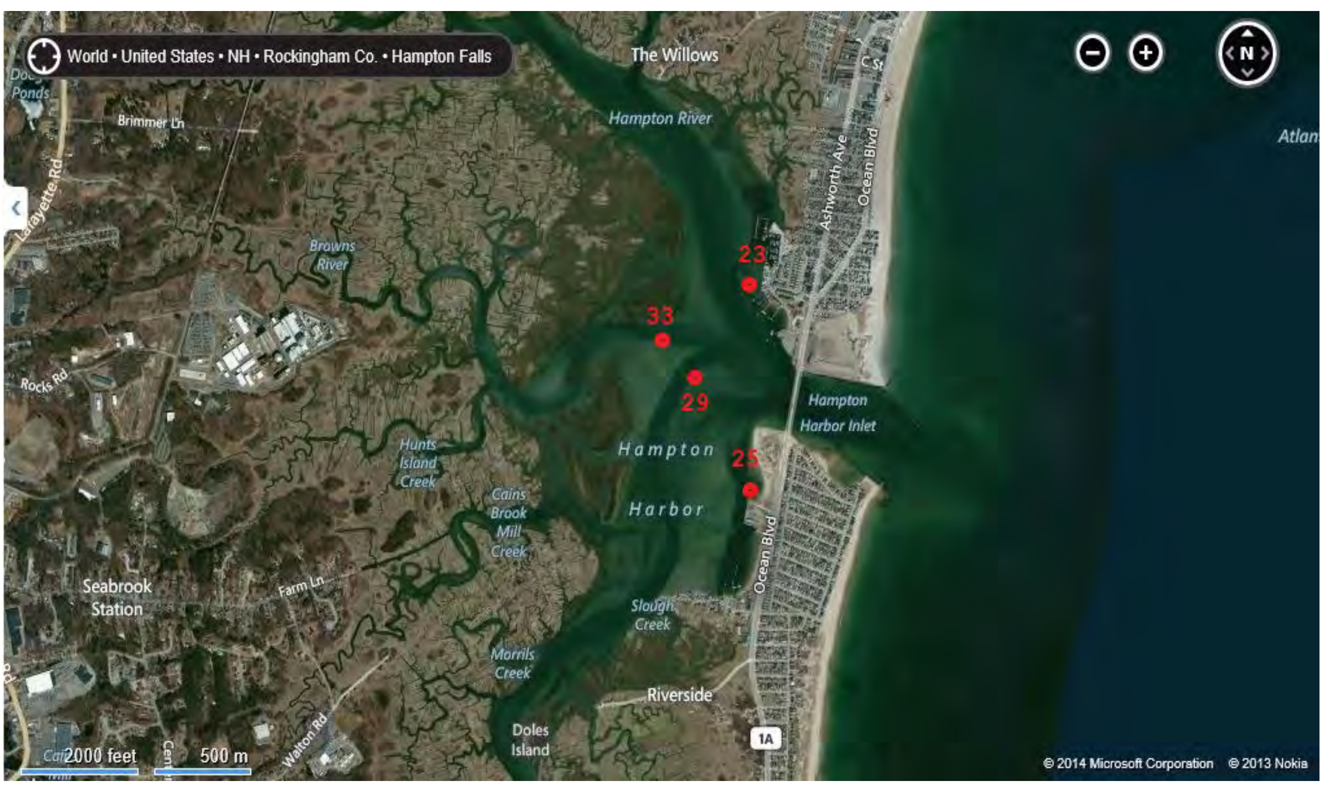


Figure 2. Sampling stations in Hampton/Seabrook Estuary, from a juvenile finfish seine survey conducted in New Hampshire estuaries.

Figure 3. Sampling stations in Little Harbor, from a juvenile finfish seine survey conducted in New Hampshire estuaries.

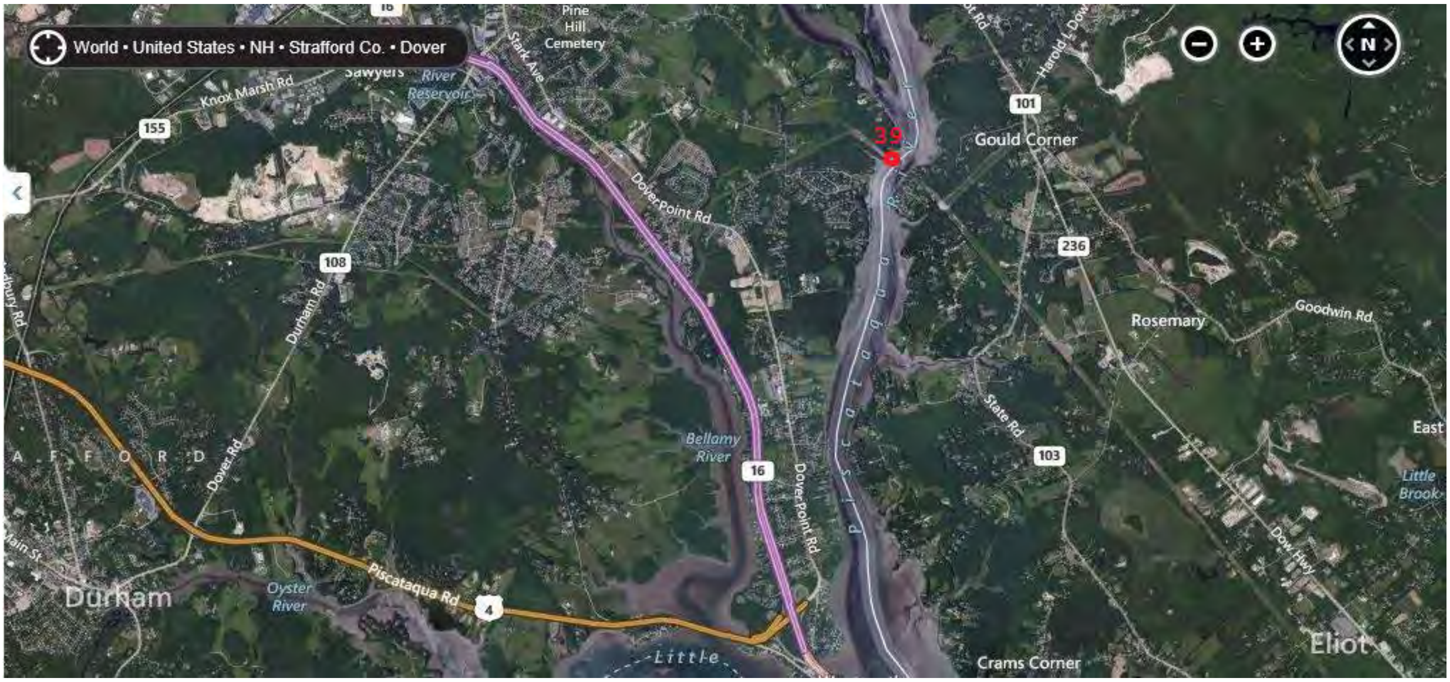
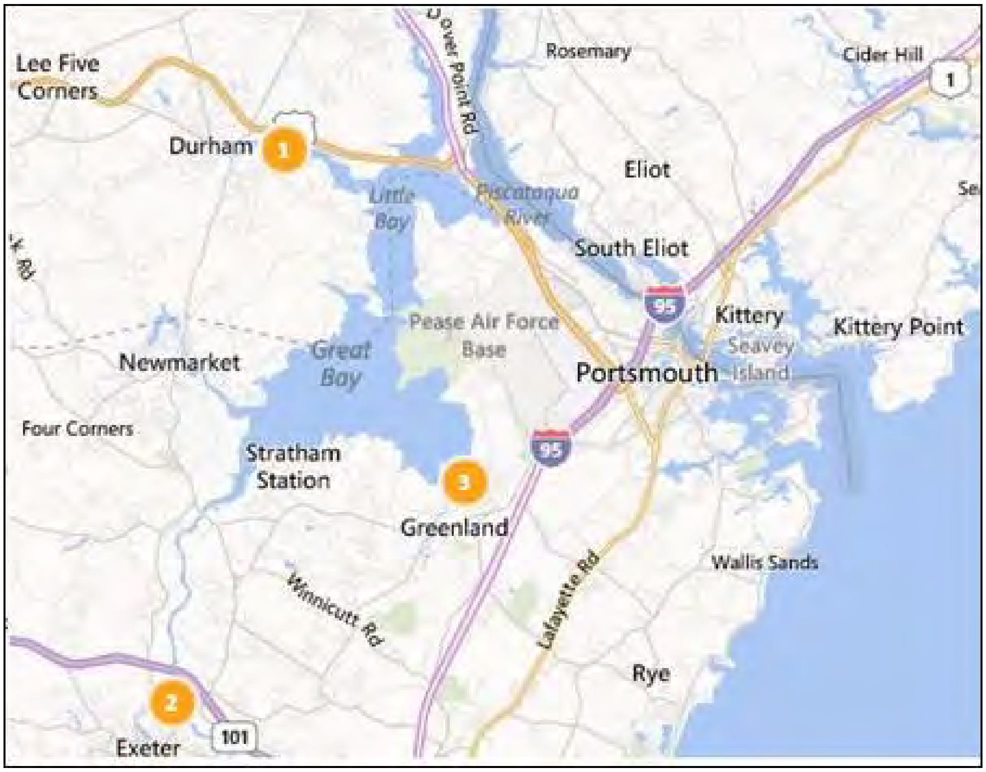


Figure 4. Sampling stations in the Piscataqua River and Little Bay/Great Bay area from a juvenile finfish seine survey conducted in New Hampshire estuaries.



*1= Oyster River, 2= Squamscott River, 3= Winnicut River

Figure 5. Fyke net sampling sites for spring spawning rainbow smelt in the Oyster, Squamscott, and Winnicut rivers, New Hampshire.

3.0 Massachusetts

The State of Massachusetts distributes funds for surveys in inland waters and marine waters. Studies in inland waters are carried out by the Massachusetts Division of Fisheries and Wildlife (MassWildlife). Studies in marine and estuarine waters are carried out by the MA Division of Marine Fisheries (*MarineFisheries*).

3.1 MA-T-3 Fish Community Assessments (Inland)

The approach for this state-wide project will be to continue to 1) determine fish species abundances and distributions in each watershed statewide, 2) use fish communities to set measurable goals for restoration as part of the Massachusetts State Wildlife Action Plan, and 3) determine the most efficient and effective paths for ecosystem restoration on a watershed basis. Standard fishery assessment tools will be used and will include: electroshocking (backpack, barge and boat methods), seining, gillnetting. Methodologies will be selected based on the habitat to allow us to use the most appropriate technique for any given situation. Division of Fisheries and Wildlife Standard Operating Procedures will be employed for each methodology. Sampling effort will be quantified, fish will be identified to species and measured for total length. In cases where more than 100 fish of one species are collected at one site, each fish of that species will be counted but not measured to length. Voucher collections will be kept at each site (1 or 2 specimens of each species in 10% formalin) to allow independent verification of species identification in the laboratory. Although historical surveys have been conducted, survey data gathered under the current SOP's is necessary to continue with the planning.

3.2 MA T-3 Westfield River Fish Passage Facility Evaluation

This project includes monitoring of the West Springfield fish passage facility on the Westfield River during the period of migration for American shad, blueback herring, and sea lamprey. The facility is monitored during the spring (April – July) fish passage season. There is a trap at the top of the fishway that is used to sample ascending fish. Migrating fish are identified to species and enumerated.

3.3 MA T-3 Essex Dam River Fish Passage Facility Evaluation

The Essex Dam fish lift on the Merrimack River in Lawrence, MA is monitored through the period of upstream migration of American shad, blueback herring, and sea lamprey. From May through July, all fish species will be identified to species and enumerated. The fishway will be monitored continuously for efficiency and to document fishway-induced mortality.

3.4 MA T-3 Holyoke Dam Fish Passage Facility Evaluation

The counting/trapping facility at the Holyoke fishlifts will be monitored during the period of upstream migration of American shad, Blueback Herring, Sea Lamprey and other anadromous fish. From mid-April to mid-July anadromous fish species will be identified and counted. A subsample of the shad utilizing the fishlift will be sampled for length, weight, sex, and scales will be removed for age analysis. The fishway will be continuously monitored in terms of efficiency. Fishway induced mortality will be evaluated daily. The fishway will be operated mid-July through November for Shortnose Sturgeon upstream passage.

3.5 MA T-3 Pawtucket Dam Fish Passage Facility Evaluation

Fish passage through the fish lift and ladder are not directly monitored. Passage at the lift will be observed by employees of the power company who will keep records of the species and numbers. Spot checks by MassWildlife staff throughout the passage season will be conducted to verify the reliability of the passage estimates. Passage through the fish ladder will be estimated by reviewing digital video
recordings of passage.

3.6 MA F-56-R Massachusetts Fishery Resource Assessment

3.6.1 MA F-56-R Fishery Resource Assessment, Coastal Massachusetts

The objective of this survey is to collect, analyze, and summarize bottom trawl data for fishery management purposes. This survey occurs statewide in coastal/ territorial waters. The daytime survey of Massachusetts inshore territorial waters is conducted in 3-week time spans during the months of May and September. The survey utilizes a stratified random sampling design consisting of 23 sampling strata based on six depth zones (< 30', 31-60', 61-90', 91-120', 120-180', and > 180') and five geographic regions (Massachusetts Bay north to the Merrimac River, Cape Cod Bay, waters south and east of Cape Cod and Nantucket, Nantucket Sound, and Vineyard Sound/ Buzzards Bay). A total of 101 stations are allocated to strata, in approximate proportion to each stratum's area; a minimum of two stations are assigned to each stratum to provide estimates of variance. Sampling intensity is about one station every 19 square nautical miles. Tow locations within each stratum are randomly chosen. An alternate tow site in the same stratum is selected if concentrations of fixed gear or untowable bottom are expected.

Trawl survey sampling is conducted using a *MarineFisheries* 3/4, North Atlantic type, two seam "whiting" trawl (39' headrope/ 51' footrope). The trawl is equipped with a fine mesh cod end liner, rubber disc (3.5"), chain sweep, wooden trawl doors (6' X 40" X 325 lbs) and 10 fathom legs. At each station, the standard tow is 20 minutes at an average speed of 2.5 kts with a 3:1 scope. Vessel services are provided by the Northeast Fisheries Science Center, NOAA R/V GLORIA MICHELLE (65' LOA, 355 hp); this vessel has been chartered since 1982.

The catch from each tow is manually sorted, and weights, numbers, and length-frequencies are recorded by species. Large catches, which are impractical to completely process are subsampled by weight or volume and expanded to represent the entire sample. Routine collections and observations include scale/otolith samples, sex, and maturity stage. Gross external pathology is routinely noted for a suite of species.

A variety of environmental observations and hydrographic data are recorded at each station. Surface and bottom water temperatures and surface salinity are recorded with a marine water quality instrument. Water samples are routinely taken for agency bacteriological testing.

3.6.2 MA F-56-R Winter Flounder Year-Class Strength

In order to effectively manage a resource and its fishery, it is desirable to assess spawning success and recruitment. Quantitative beach seining is a feasible sampling technique for young-of-the-year (YOY) winter flounder within areas of low tidal amplitude and smooth, sandy bottoms. These conditions occur in Cape Cod's southern estuaries (i.e., encompassing a fraction of the winter flounder's Southern New England stock unit range). A time series of YOY indices provides an additional, complementary index to trawl survey information and catch trends. Summer flounder (age 0) catches from the seine survey are also routinely utilized by assessment Working Groups as indices of recruitment.

Coincidental with the period of greatest availability of YOY winter flounder in intertidal and shallow subtidal zones, seining is conducted on the top half of the diurnal tidal cycle from mid-June through mid-July. Forty-nine fixed sites or stations are proportionately allocated by each estuary's littoral perimeter. For analytical purposes, each estuary is considered a stratum. The six estuaries seined are: Great Pond, Cotuit Bay, Waquoit Bay-Eel Pond, Lewis Bay, Bass River, and Stage Harbor. Stations are selected subjectively with consideration for efficient seining (i.e., smooth sediment bottom generally devoid of attached vegetation) and historic availability of 0-group flounder.

A 21' (6 m) straight seine of ¼" (6.5 mm) nylon mesh, equipped with weighted lead line to minimize escapement, is set and hauled perpendicular to shore from a depth of 3 to 4'. The three hauls made at every station are sufficiently separated along the beach so as not to scare fish from the path of adjacent hauls. To enumerate 0-group winter flounder (and other species') density (# YOY per square meter), each haul is quantified to area swept by maintaining a taut spreader rope (5.5 m) and measuring seining distance.

Statistical analysis of the seine data employs stratification techniques; each estuary is considered a stratum, and the three hauls at each station are treated as one sample. A stratified mean density index and confidence limits are derived from standard and modified formulae for mean and variance.

3.7 MA F-57-R Marine Recreational Fisheries Investigations

3.7.1 MA F-57-R Cooperative Striped Bass Tagging Study.

The goal of this study is to conduct tagging and long-term monitoring of tag recoveries to improve understanding of distribution and movement of Atlantic striped bass stocks and to generate vital information related to mortality rates with special emphasis on larger individuals. The study takes place in State waters in Nantucket Sound and east of Monomy Island and Nantucket Island.. Although tags have been applied to over 150,000 wild and hatchery fish along the East coast, very few fish in excess of 30" have been tagged. During summer and fall, large striped bass concentrate and are available for tagging on shoal grounds around Cape Cod, Massachusetts.

Tagging will be conducted by trained *MarineFisheries* biologists aboard 2 to 3 charter boats contracted by the *MarineFisheries*. Fish will be caught using traditional hook and line. Internal anchor tags will be applied in accordance with protocol established by the State-Federal

Cooperative Striped Bass Tagging Study. The total number of tagged fish targeted is 700 annually but numbers may increase or decrease according to weather, availability of vessels and/or fish, status of funding, etc. Information collected will include a summary of the tagging activity, fishing operations and characteristics of the catch. Information will be input annually into the coastwide striped bass tagging database maintained by USFWS.

Two modeling approaches, recommended by the ASMFC striped bass tagging committee, will be used to analyze the tagging data. Program MARK will be used to estimate a time series of annual survival rates (S). The instantaneous rates model of Jiang et al. (2007) that accounts for the re-release of previously tagged fish will be used to estimate fishing mortality and natural mortality. The models will be compared over time and analyses will be conducted to determine the efficacy of each modeling approach. These data will be supplied to the ASMFC Striped Bass Technical Committee for use in regularly conducted stock assessments.

3.7.2 MA F-57-R Massachusetts Large Pelagics Research Project.

The objective of this study is to investigate the life history, ecology, physiology, and relative abundance of large pelagic fish species (sharks, tunas, swordfish, billfish) of recreational importance in the coastal and offshore waters of Massachusetts. The study occurs in Massachusetts Bay, Cape Cod Bay, Nantucket Sound, and Buzzards Bay.

Large pelagic fish species, including sharks, tunas, and billfish, will be sampled during research cruises and in conjunction with commercial/recreational fishing activities and big game tournaments. Sharks, tunas, and billfish will be captured by standard recreational single hook and line fishing. Biological parameters including age structure, feeding ecology, and reproductive status will be described through the dissection of a representative sample of specimens. All other specimens may be blood sampled and tagged with conventional, acoustic, or satellite tags to examine the physiological effects of capture, behavior, essential habitat, local and broad-scale movements, and post-release mortality. Research will be conducted in cooperation with the NMFS Apex Predator Investigation (Narragansett, RI) and researchers from other state, federal, academic, and private institutions with assistance from the recreational and commercial fishing sectors. Information generated by this research will made available to the scientific community, the general public, and fisheries managers through peer reviewed publications, educational presentations, and intra- and inter-agency correspondence. This information will contribute to more effective state, federal, and international management of these species.

In addition, total catch and effort data will be collected from major offshore fishing tournaments targeting tunas, billfish and sharks. Data collected will include number of boats/fishermen, fishing hours (effort), number and weight of catch by species, number released and tagged by species, and weather conditions. Catch-per-unit-effort indices will be generated and analyzed annually. Data will be made available to NMFS tuna, billfish, and shark programs to enhance the coastwide database and contribute to more effective management.

3.7.3 MA F-56-R Monitoring Movements and Habitat Use by Striped Bass, Morone saxatilis, using Acoustic Telemetry

The only field work that will be conducted for the period of this study will be the maintenance of the acoustics arrays located in the Gulf of Maine at the eastern edge of Massachusetts Bay, and inshore areas along Massachusetts and Cape Cod Bay. We will check, clean and download data from the acoustic receivers on a monthly basis For data analysis, a variety of analytical techniques ranging from generalized linear models to neural networks will be used to examine and summarize the large amount of acoustic data collected. The study takes place in Massachusetts Bay. All acoustic buoys have been specially designed and deployed with breakaway lines under the direction of our agency's Protected Species Specialist in order to eliminate any chance of entanglement by listed marine mammals and/or sea turtles.

3.7.4 MA F-57-R Monitoring Spawning Behavior and Movement of Atlantic Cod (Gadus morhua) at Inshore Spawning Sites in the Western Gulf of Maine

The objectives of this project are to:

1) Observe the residence time and spawning behavior of cod on their spawning site.
2) Test for spawning site fidelity between each year of monitoring.
3) Examine the movement of the fish when not at the spawning ground.
4) Monitor environmental cues that may influence cod behavior.
5) Detect any variation in the behavior of males and females.
6) Estimate immigration and emigration rates from the spawning area
7) Estimate biomass of mature Atlantic cod on the spawning ground
8) Characterize the habitat of the spawning site.

The project takes place in Massachusetts Bay. The following procedures are implemented:

<u>Spring Cod Conservation Zone</u>

MarineFisheries has partnered with researchers at the University of Massachusetts-Dartmouth/Massachusetts Marine Fisheries Institute to implement a comprehensive study of the biology, behavior and habitat of spawning Atlantic cod in the Spring Cod Conservation Zone. One doctoral student will be funded to investigate site fidelity, immigration-emigration rates, residence time, spawning behavior, and movement patterns. *MarineFisheries* staff will conduct complementary studies to observe fine-scale movements on the spawning site, as well as characterize habitat parameters and estimate spawning stock biomass.

Tagging Strategy

Atlantic cod will be captured using a traditional hook and line method for cod called "jigging" in which lures, or jigs, are used instead of bait; thereby, virtually eliminating bycatch. Beginning in 2012, cod will also be captured using demersal long lines. Those fish for which the sex can be determined and spawning condition verified will be tagged with archival data storage tags (DST's) traditional T-bar anchor tag. After tagging, the fish will be held on board in a tank with fresh-flowing seawater pumped from below the thermocline and the health of the fish will be assessed. When the fish has been observed to be in good condition and fully recovered from the tagging procedure, it will be released at the surface. In 2008 through 2010, 66 Atlantic cod were tagged with VEMCO V16 acoustic transmitters. The tags have a battery life of over 3 years and therefore it is anticipated they will be returning to the spawning aggregation every spring.

Acoustic Monitoring

VEMCO VR2W receivers will be organized into an array that will allow us to monitor the entire area of focus, as well as, some of the surrounding area. The receivers will allow us to observe the behavior and residence time of the cod on and near the spawning ground, as well as their on-site and off-site movements and how they may be related to time of day. Monitoring in multiple years will allow us to test for spawning site fidelity. Records of cod activity will also be analyzed to observe any variation in behavior between males and females in relation to spawning activity, arrivals/departures, on-site/off-site movements, size relationships, and potential lekking behavior.

Cod Movement
Recaptured DST's will be used to geolocate the movements of the cod as well as to investigate seasonal habitat preferences. Any detections from *MarineFisheries* array will be incorporated into the analysis of movement. DST records will permit observation of potential 'spawning columns', or vertical behavior during spawning. Movement of fish can be used to infer how they are incorporated in the population structure of the GOM.

Environmental Cues
Temperature data from loggers attached to the acoustic moorings will allow inferences to be made on the role that temperature may play in the movement of cod related to the spawning ground. In addition, physical parameters such as moon phase and tide will be monitored to observe how they may influence cod behavior. Weather patterns will also be recorded while receivers are deployed to observe potential responses of cod to weather changes.

Habitat Characteristics
Using a combination of side scan sonar, underwater video, and bottom grabs we will characterize the immediate area where cod are aggregated (already identified as a small 2-meter high plateau in 50 m of water in the SCCZ) and other areas within and outside the SCCZ where cod aggregations are not present. We will examine such factors as sediment type, algal and invertebrate cover, prey availability, and bottom relief in order to quantify/qualify attributes that are associated with spawning aggregations.

Spawning Biomass
Semi-weekly bioacoustic surveys will be conducted in the SCCZ during the spawning period using a Biosonics 200 kHz split-beam scientific echosounder deployed from *MarineFisheries* 28-foot research boat, R/V Alosa. Resulting data will be analyzed using Sonardata Inc.'s Echoview software. Combining data from semi-week surveys of standing biomass with immigration/emigration rates will allow estimates of total spawning biomass in the SCCZ to be made.

Biological Sampling
Genetic fin clip samples will be collected from spawning cod for use in a study of cod stock structure in US waters by researchers at the University of New Hampshire. Such genetic investigations are expected to help identify the fine-scales at which population processes occur. Furthermore, otoliths will be collected for researchers at the University of Massachusetts-Dartmouth for incorporation into a study on the spawning origin of juveniles, natal homing, and growth rates.

Passive Acoustics

In collaboration with researchers from the Stellwagen Bank National Marine Sanctuary from the national Oceanic and Atmospheric Administration (NOAA), an array of passive acoustic receivers will be used to document sound production of cod while on the spawning ground. Investigating sound production during active spawning is expected to provide further insight into the spawning behavior of cod by including the timing of spawning events and movements away from the spawning site. In addition, if proven successful, using passive acoustic technology could be used as a new tool for locating cod spawning activity in new areas. A passive acoustic receiver was deployed near the spawning aggregation in 2011. In 2012, 5-7 additional receivers were deployed into a full array, which will increase our resolution and coverage of the spawning site.

<u>Winter Cod Conservation Zone</u>

Our research plans have primarily focused on the SCCZ due to the spatial and temporal reliability of that spawning group. This allows us to partner with other researchers and pursue multiple agendas, without having to expend time in locating the aggregation. In contrast, the spawning group in the WCCZ appears to be far more variable from year to year, and therefore presents a greater challenge to study. Research efforts in the WCCZ will focus on expanding our understanding of the timing, spatial extent and size of the spawning aggregation.

Spatiotemporial Distribution:

MarineFisheries's Fisheries Dependent Investigations Program is actively sea sampling local day boat gillnetters that are commercially fishing around the borders of the WCCZ. By monitoring the sex and maturity information and the cod catch rates collected by samplers in the fishery, researchers will use this information to identify the most appropriate time to conduct fishfinder surveys. These surveys will be conducted on *MarineFisheries* 28' research vessel and data collected will assist in the documentation of the presence timing and location of the spawning aggregations and spawning habitat.

Spawning Biomass:

Using similar techniques that have already been proven in our work in the SCCZ, BioSonics echosounder surveys will be conducted on the aggregations located through the fishfinder surveys to estimate biomass of the aggregations. Surveys will be conducted in concert with the fishfinder surveys until permanent and predictable aggregations are located at which semi-weekly surveys will be conducted.

Biological Sampling:

Similar to work previously conducted in the SCCZ, genetic fin clip samples will be collected from spawning cod for use in a study of cod stock structure in US waters by researchers at the University of New Hampshire. Such genetic investigations are expected to help identify the fine-scales at which population processes occur. Furthermore, otoliths will be collected for researchers at the University of Massachusetts-Dartmouth for incorporation into a study on the spawning origin of juveniles, natal homing, and growth rates. Atlantic cod will be caught using demersal long-line fishing gear using large 13/0 circle hooks to minimize bycatch of juvenile cod. Traditional hook and line using artificial lures will also be used.

Tagging Strategy
Atlantic cod that are not biologically sampled will be tagged with T-bar anchor tags. The UMass tagging program was started in 2000 and has tagged approximately 32,000 cod to date. Tagged cod will assist the UMass cod tagging project determine the large-scale seasonal movement patterns of cod throughout the Gulf of Maine and Georges Bank, measure growth rates and recruitment of cod in the wild, and evaluate the environmental conditions (e.g. temperature, salinity, habitat) in areas where cod are found.

Real-Time Acoustic Tracking
In 2010 and 2011 it was observed in the SCCZ that spawning activity most often occurred over flat featureless mud bottom during the night. During the day, the fish left the mud bottom and returned to a gravel/cobble outcrop forming aggregations in the exact same location every day where they remain before the next evening spawning event. To assist in the location of aggregating cod in the WCCZ, 4 large spawning females will be caught using traditional hook and line and/or demersal longline, and tagged with VEMCO V16 acoustic continuous transmitting tags. Tagged fish will be tracked using our VR100 acoustic field receiver and VR110 directional hydrophone. Tagged fish will be tracked to aggregations. Once other aggregations are located data elements that were collected in SCCZ will also be attainable for the WCCZ (e.g. residency time, wandering rates, fidelity, and spawning behavior).

3.8 MA F-67-R Diadromous Fish Research and Restoration

3.8.1 MA F-67-R Diadromous Fish Biological Studies
The objective of this study is to conduct studies to better understand the biology and demographics of local diadromous fish populations, and to understand the biotic and abiotic factors affecting these populations. Through these studies, the goal is to be able to provide accurate scientific advice to managers that will allow for population increases and sustainability of our diadromous fish resources.

Several separate studies will be conducted under this job and are listed below. All work conducted is designed to investigate abundance, movement, habitat conditions, and biological characteristics of populations of diadromous fishes in Massachusetts coastal waters and streams.

<u>Population and Spawning Habitat Monitoring for Rainbow Smelt</u>
Rainbow smelt spawning populations will be monitored in eight coastal rivers (Parker, Crane, North, Saugus, Fore, Jones, Weweantic, and Westport) through fyke net sampling. Fyke nets will be set and hauled three times each week at each river throughout the spawning season (approximately Mar 7th to May 15th). All fishes caught will be counted and measured and basic water chemistry parameters will be recorded during each sampling event. A sub-sample will be collected each week from the Fore River for aging and to collect brood stock for restoration efforts. Scales will be removed, processed, and aged by the Age and Growth Project (F-68-R) according to standard protocol. An age key will be created and applied to the fyke net samples. An annual relative index of abundance will be calculated for each river and for separate age groups. Relative year class strength will be tracked over time. Fyke net catch data, water quality data and environmental data will be maintained in an Access database. In addition, specific efforts will focus on the quality of smelt spawning habitat at the fyke net stations.

Spawning habitat conditions will be assessed and negative influences on spawning success (related to water flow, periphyton, and sedimentation) will be documented.

Monitoring of Biological Parameters and Habitat Characteristics for River Herring (alewives - Alosa pseudoharengus and blueback herring - Alosa aestivalis) and American Shad (Alosa sapidissima) Populations Along the Massachusetts Coast

This study will investigate the demographics and other biological characteristics of river herring and shad in Massachusetts coastal rivers. Additionally, MA will perform assessments of river herring spawning habitat.

Each year approximately 250 alewives will be collected from a minimum of three spawning runs (e.g., Nemasket River, Monument River, and Town Brook) representing the two distinct geographic regions of Massachusetts: Gulf of Maine and Southern New England. When present, equal numbers of bluebacks will also be collected. Additionally, 250 shad will be collected from the Merrimack River at the Lawrence Dam. All fish will be collected with the use of dip nets. For all three species, five collections of 50 fish will be staggered during the duration of the run so as to capture any temporal changes in the composition of migrating fish. All collected fish will be measured, weighed, and dissected for sex determination, and scales and otoliths will be removed for ageing. This sampling effort will yield up to 1,250 scale/otolith samples that will be aged according to standard methodology by the Age and Growth Project (F-68-R). Length-weight relationships, age structure, sex ratios, and length-at-age for each run will be compared across geographic regions. The data will be examined for co-occurrence of dominant year classes among regions. Where the data are appropriate, instantaneous rates of total mortality will be estimated from age composition.

Outward migrating young-of-the-year alewives and blueback herring will be collected from the Monument River, and additional rivers as staffing allows, during July through December. Lengths and weights will be recorded for all individuals and seasonal changes in the size and condition of individuals will be analyzed and compared across months. An age-1 index of abundance will be generated each year using data from the Massachusetts Spring Bottom Trawl Survey.

Spawning and nursery habitat for river herring will be assessed at coastal ponds, lakes and rivers using *MarineFisheries* Quality Assurance Program Plan (QAPP) protocols (Chase 2010). The assessments include the measurement of parameters important to the spawning and rearing success of river herring including dissolved oxygen, pH, turbidity, nutrient levels (nitrogen and phosphorus), presence and amount of invasive aquatic plant species, depth, and acreage of suitable habitat. Assessments will be conducted over two years in order to capture interannual variability of parameters. Each year, one or two watersheds will be selected for assessments.

3.8.2. MA F-67-R Stock Enhancement of Diadromous Species

The objective of this study is to restore depleted populations of American shad by augmentation of natural runs with fry/larva from hatchery culture and to augment weak alewife/blueback herring runs or runs with newly created/improved access with adult spawners transferred from other healthy systems.

Spawning-condition American shad will be brought into hatcheries and spawned by various means, and the resulting larvae will be stocked into historic nursery grounds to restore populations. Alewives will be netted from spawning runs where populations are judged to be healthy and transferred via stocking truck to systems that have depleted populations. The specific projects and methods are presented below.

American Shad Propagation: Restoration of Shad in the Charles River

The Charles River is the longest river in the Commonwealth (i.e., 80 miles) and is bordered by approximately 20,000 acres of wetland (Fig. 1). Historical records of American shad in the Charles date back to the 1600s, when thousands of migrating adults were captured and sold near Watertown. *MarineFisheries* has been engaged in the restoration of American shad in the Charles River since 1971; however, attempts at both egg stocking and adult transfer programs have met with little success. The transfer of adults ceased in 1992. More recently, the artificial propagation and stocking of shad fry have resulted in the successful enhancement of adult shad populations in southern systems, such as the Susquehanna and Nanticoke Rivers and tributaries of the Delaware River. For example, since 1989 an estimated 60 to 76 percent of shad returning to the Susquehanna River have been of hatchery origin, and in 2005 more than 68,000 fish returned to this system. Additionally, the Susquehanna program has been so successful that on average, approximately 181 stocked larvae are required to produce one returning adult (Hendricks 2006).

The intent of the current project is to restore viable populations of American shad to the Charles River. This will be accomplished through a fry stocking program in conjunction with fish passage improvements. The fry stocking program will be modeled after the successful programs implemented by Virginia, Maryland, and Pennsylvania for restoring shad to the tributaries of the Chesapeake Bay (Hendricks 1995). The Charles River was selected for this restoration effort due to (a) the availability of spawning/rearing habitat, (b) the availability of functioning fishways suitable for shad, and (c) the historical significance of shad in this system.

Approximately 500 brood stock shad will be obtained annually from the Merrimack River at the Essex Dam fish lift in Lawrence, MA. Most shad will be transported to and spawned at the USFWS hatcheries in North Attleboro, MA and Nashua, NH. The production goal is three million fry each year for distribution in the Charles River.

Rearing of larvae will take place at the USFWS hatcheries. The larvae will be raised for about 7-10 days before release as fry into the upper Charles River. All fry will be immersed in an oxytetracycline bath in order to mark their otoliths prior to release. Marking in this way will enable us to quantify hatchery returns in 3-4 years. Fry that have been released in this manner have shown high fidelity to their natal rivers (Hendricks et al. 2002).

To estimate juvenile survival and to help establish recruitment indices for the Charles River, juvenile sampling will begin in the weeks following stocking and continue through fall. Sampling will generally occur downriver of the stocking site(s) and will include several methods. First, qualitative samples will be taken by electroshocking. Second, drop nets will be used in open bays at the Moody Street Dam in Waltham, and third, a large incline plane trap will be installed near the pedestrian walkway above the Watertown Dam in Watertown. Drop nets and the inclined plane trap will be employed via specific quantitative protocols.

Returning adults will be collected by electroshocking below the Watertown Dam and by a trap placed in the fishway at that dam. The otoliths from these individuals will be examined for oxytetracycline marks. A successful restoration will be indicated by the presence of a greater number of naturally spawned individuals as compared to hatchery spawned individuals.

This project is a collaborative effort between *MarineFisheries* and the U.S. Fish and Wildlife Service (Central New England Fishery Resource Complex).

River Herring Trap and Transfer

Alewives and bluebacks will be transported from healthy donor runs using the agency stocking truck, and placed in streams that have recently or will soon have improvements to fish passage, and have been depleted owing to the lack of adequate passage. Healthy donor sites are identified using a run's historic population data and data from continuous biological monitoring of the run during the current spring spawning season. This combined data set allows biologists to specifically select appropriate runs for each year's donor sites. This list may include the Nemasket River, Agawam River, Charles River, and Monument River. The following is a list of the proposed stocking that will occur under this project, listed by species. The actual number of sites stocked and fish transferred will be dependent on the annual availability of herring in the donor streams. These sites are all associated with recent or pending construction or improvements to fishways or dam removals. The number of fish stocked into each river is based on the acreage of the potential spawning grounds and the severity of depletion – generally between 1.000 and 5,000 individuals. All sites are be stocked for a minimum of three years and runs will be monitored for the return of progeny of the stocked fish three years post-stocking (river herring first return to spawn at age-3).

Species Site	No. of fish stocked
Sippican River, Rochester	3,000
Herring Brook, Pembroke/Hanson	3,000
Town Brook, Plymouth	3,000
Island Creek, Duxbury	2,000
Monument River, Bourne/Plymouth	3,000
Three Mile River, Dighton	3,000
Eel River, Plymouth	2,000

The stocking of fish is essential to the re-establishment of herring runs that have been eliminated or weakened by poor or lacking fish passage structures. Stocking is the next critical step following or in conjunction with *MarineFisheries* continuing efforts to improve fish passage. Because anadromous herring exhibit some degree of fidelity to their natal streams, re-establishment of runs generally will not occur without stocking. Stocked runs will be monitored for at least three years. Successful re-establishment of spawning populations will be indicated by the return of new recruits at age-3.

4.0 Rhode Island

4.1 RI F-61-R Assessment of Recreationally Important Finfish Stocks in Rhode Island Waters.

4.1.1 RI F-61-R Seasonal Fishery Assessment in Rhode Island and Block Island Sound

Job focuses on spring and fall sampling of twenty-six stations in Narragansett Bay, six stations in Rhode Island Sound and 10 stations in Block Island Sound.

Starting January 1, 2012, the trawl survey will be conducted using new doors and calibration study will begin. Each station will be sampled (towed) using a given set of doors and then re-sampled (re-towed) 1-tidal day later using the other set of doors. This type of experimental design allows for a paired-approach (offset by 1-tidal day) and allows the effect of net configuration due to door type to be assessed, resulting in catch calibration between door types comparing the catch at the same station between tows conducted using different door types (new and old).

4.1.2 RI F-61-R Narragansett Bay Monthly Fishery Assessment

Job focuses on monthly collection of finfish and hydrological data at thirteen fixed stations in Narragansett Bay.

Starting January 1, 2012, the trawl survey will be conducted using new doors and calibration study will begin. Each station will be sampled (towed) using a given set of doors and then re-sampled (re-towed) 1-tidal day later using the other set of doors. This type of experimental design allows for a paired-approach (offset by 1-tidal day) and allows the effect of net configuration due to door type to be assessed, resulting in catch calibration between door types comparing the catch at the same station between tows conducted using different door types (new and old). Since 1990, 2,896 tows have taken place.

4.1.3 RI F-61-R Young of the Year Survey of Selected Rhode Island Coastal Ponds and Embayments

Job focuses on monthly collection of young of the year finfish species in four Rhode Island coastal embayment during spring, summer and fall seasons. The abundance and size composition of spawning adults are also monitored. Species are collected thru the deployment of a beach seine. RIDFW samples 24 stations in eight coastal ponds along Rhode Island's southwestern coastline once a month during May – October, (Figure 1). Sampling requires 6 days of field sampling. The sampling methodology for the Coastal Pond Juvenile Fish Survey is as follows. All seining is attempted on incoming tides. To collect animals, investigators use a seine 130 ft. long (39.62m), 5.5 ft deep (1.67m) with ¼" mesh (6.4mm). The seine has a bag at its midpoint, a weighted footrope and floats on the head rope. The beach seine is set in a semi-circle, away from the shoreline and back again using an outboard powered 16' Aluminum boat. The net is then hauled toward the beach by hand and the bag emptied into a large water-filled tote. All animals collected are identified to species, measured, enumerated, and sub-samples are taken when appropriate. Water quality parameters, (temperature, salinity and dissolved oxygen) are measured at each station.

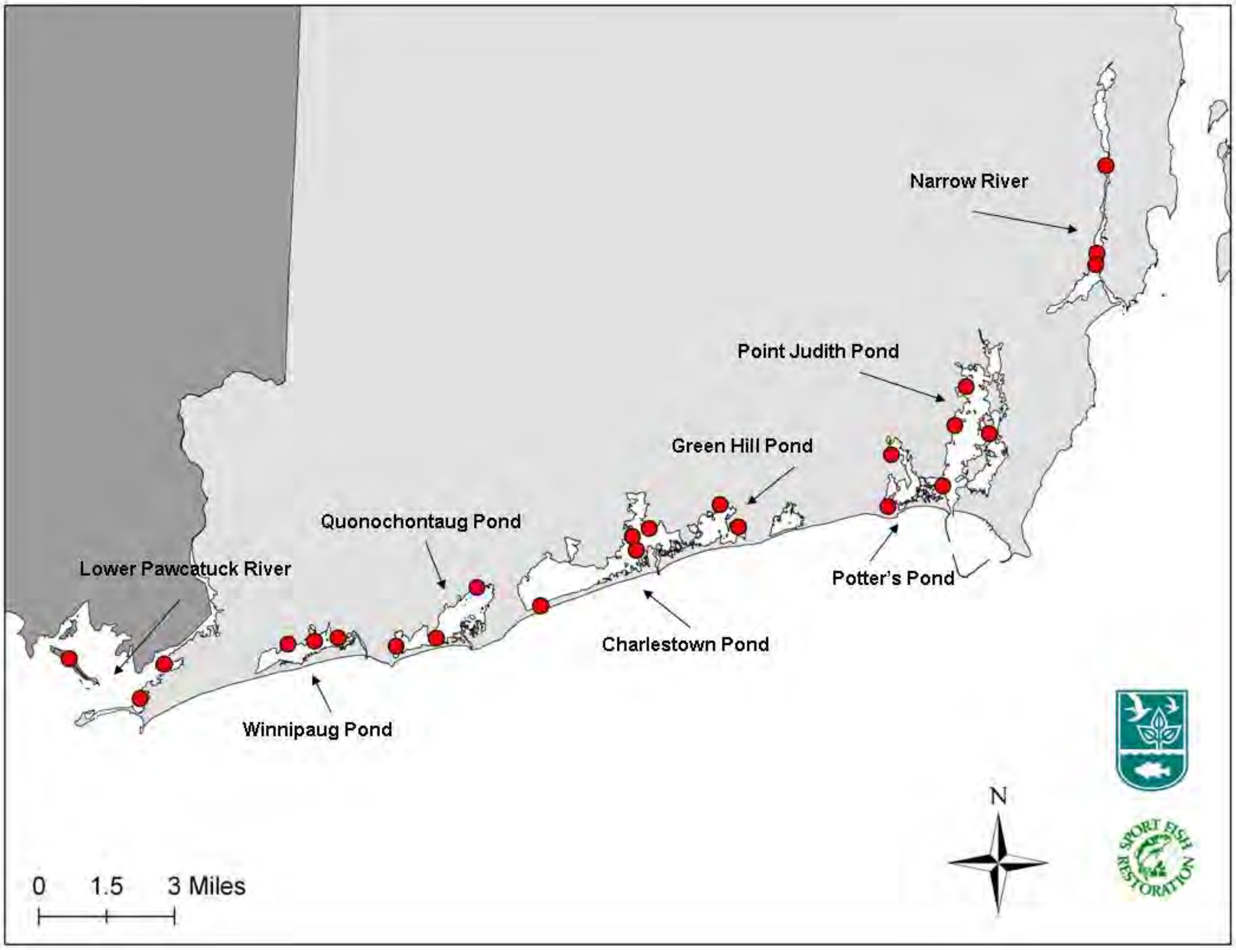


Figure 1. Location of coastal ponds sampled by the Coastal Pond Juvenile Finfish Survey in Southern Rhode Island.

4.1.4 RI F-61-R Juvenile Marine Finfish Survey

Job focuses on monitoring juvenile production of marine finfish stocks in Narragansett Bay, Rhode Island, which are subject to recreational fishing. It examines multi-species interactions and identifies and recommends management measures likely to result in optimum production of those species. Species are collected thru the deployment of a beach seine throughout Narragansett Bay and the Sakonnet River. Eighteen stations around Narragansett Bay are sampled once a month from June through October with a 61mX3.05m beach seine deployed from a boat.

Individuals of all finfish species are counted and measured for fork or total length in millimeters. Visual estimates of abundance for invertebrate species are categorized as few, many, and abundant which could be used for qualitative data analysis. Individuals from the target species are measured for length frequency analysis. Where appropriate a sub-sample of at least fifty fish is measured. Every effort is made to return all fish and invertebrates to the water alive.

Data on environmental covariates are also collected. Measurements of water temperature, salinity and dissolved oxygen are taken close to the bottom with an YSI Professional Plus meter.

4.1.5 RI F-61-R Block Island Juvenile Finfish Survey

Methodology and sampling gear is consistent with the current Division of Fish and Wildlife (DFW) survey entitled "Young of the Year Survey of Selected Rhode Island Coastal Ponds and Embayments". In partnership with DFW, the Nature Conservancy samples 8 stations located in Great Salt Pond and 3 stations located in Old Harbor, Block Island. At each station, a seine is set and immediately hauled once a month from May to October annually. The seine net used in this project (130' knotless heavy delta ¼ mesh, 6' deep with a 6'/6'/6' bag, with a weighted footrope and floats on the head rope) is consistent with that deployed by the DFW in the coastal ponds for the aforementioned project. All catch is identified to species, enumerated, measured, and released.

4.1.6 RI F-61-R Assessment, Protection and Enhancement of Marine Fish Habitat

The purpose and scope of this project in the intial project area is to develop a Habitat Management and Restoration Plan Providence-Seekonk tidal Rivers in upper Narragansett Bay (Head of the Bay). Our approach is to collect information in areas where very little recent habitat data available. This approach will allow us to evaluate and develop recommendations for restoration and enhancement techniques that can be rapidly deployed as part of a state-wide plan. The initial work is a collaborative project with The Nature Conservancy (TNC) to assess fish habitat in the Head of the Bay. In the next 2-3 years we will concentrate on the urban marine waters at the Head of the Bay where substantial water quality improvements have been recorded.

We have developed GIS maps that summarize key aspects of all available data involving physical characteristics of the habitat (e.g., TOC%, frequency of hypoxia, depth of hypoxic zone) and biological data from two old datasets: one from a year-long 1996 study of the fish assemblages by Division of Fish and Wildlife in this urbanized area, and a second study investigating benthic juvenile fish in this area (summer 2002-2003) by the US Environmental Protection Agency (EPA), Atlantic Ecology Division Laboratory (AED, Narragansett, RI) using a special benthic sled equipped with a trawl net and video camera. The sampling plan for this study includes 8 stations in the Providence tidal River and 6 in the Seekonk (see Fig below). We use a 130' long by 5.5' tall seine net with ¼" mesh and bag for assessment of juvenile fish in the near-intertidal at each station. We are using the same seine gear and setting approach used by the current Division of Fish and Wildlife (DFW) survey entitled "Young of the Year Survey of Selected Rhode Island Coastal Ponds and Embayments". Once set, the net is hauled by hand and the bag is emptied into a large water-filled tote. All animals collected are identified to species, measured, and enumerated, with sub-samples taken when appropriate. Water quality parameters temperature, salinity and dissolved oxygen, are measured at each station.

For benthic habitat video transects, we use a PVC benthic sled dragged behind a 21' boat at < 1 knot and assess habitat type and quality using CMECS designations. We plan to utilize fish (scup) pots at a subset of the stations during the spring-summer of 2017 to assess larger fish using the area. The scup pots used in this survey are identical to those used by Project 5: RI F-61-R, Job 12: Narragansett Bay Ventless Pot, Multi-species Monitoring and Assessment Program (see below). These pots were used in the NOAA funded research conducted by URI/Sea Grant summarized as "2012 Fisheries independent Scup Survey of Hard Bottom Areas in Southern New England Waters" and "2012 Industry Based Survey on Black Sea Bass Utilizing Ventless Traps". These scup pots (2'x2'x2') are constructed of 1.5" x 1.5" coated wire mesh and unvented.

Results indicated certain areas of this Providence-Seekonk estuary are highly diverse and productive. In 2017, we expect to complete monthly seines and fish pot deployments from May through Oct, in addition to seasonal video transects to more fully characterize the area. We also expect to add monthly fish (scup) pot sampling as the technique to further assess fish assemblages in the Head of the Bay.

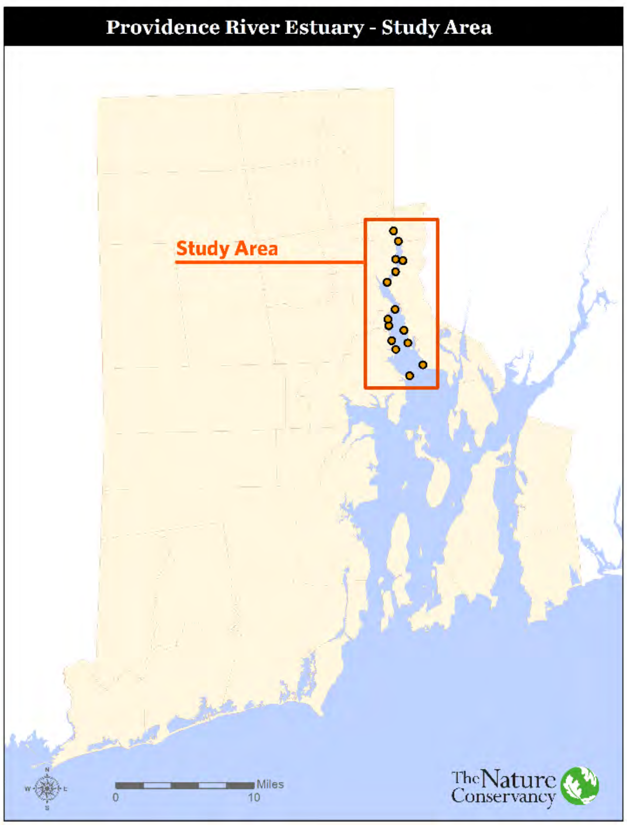


Figure 1. Location map of the study area. Map produced by Kevin Ruddock, TNC.

Figure 2. Video Sled with HD Video Cameras + Manta 2 WQ Sonde. Video camera is ~ 30 cm off bottom and Manta 2 WQ sonde is sampling ~ 35 cm off bottom

Figure 3. Beach seine and video transect stations on the Providence River (n=8) and Seekonk River (n=6)

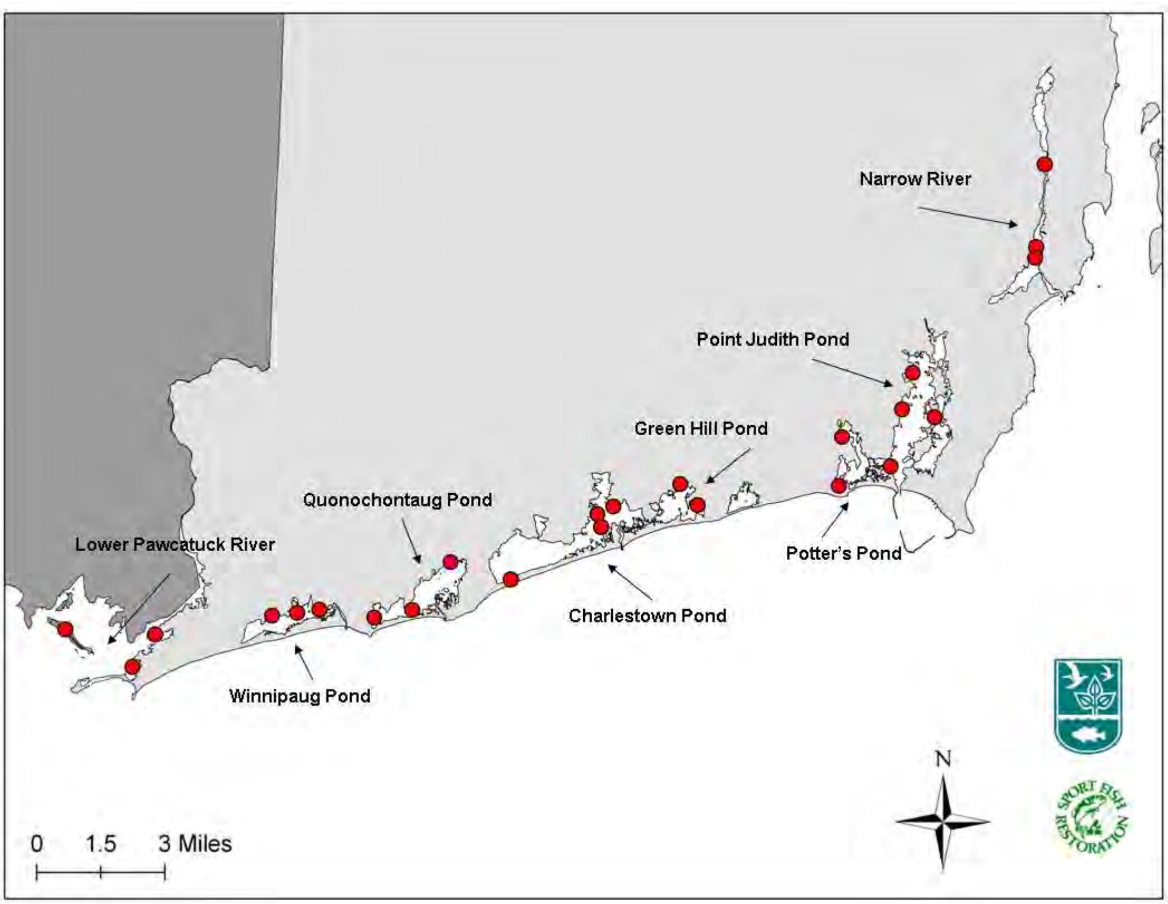
4.1.7 RI F-61-R Investigating Techniques to Enhance Degraded Marine Habitats

This project aims to positively affect local fish populations by improving degraded marine habitat. Specifically, the goal is to determine if oyster reef construction can be used to improve growth and survival (i.e., productivity) of early-life stages of recreationally important fishes such as black sea bass (*Centropristis striata*), tautog (*Tautoga onitis*), scup (Stenotomus chrysops), summer flounder (Paralichthys dentatus), and winter flounder (Pseudopleuronectes americanus). This project will be completed in the coastal ponds of South County, Rhode Island (Figure 1). To date we have created 17 fish habitat enhancement reefs across Ninigret (Figures 2,3) and Quonochontaug Pond (Figures 4,5). We expect to create reefs in Pt. Judith Pond in 2018.

Briefly, this project can be broken into two main aspects: enhancing fish habitat by the construction of oyster reefs and fish community monitoring pre- and post-habitat enhancement to determine if there are changes in fish productivity. Since there is no critical habitat documented for Atlantic sturgeon, shortnosed sturgeon, or marine turtles within the project area (Figure 1), we expect that the construction of oyster reefs should have no effect on the habitat for these listed species.

Fish community monitoring is conducted using fish pots and gillnets. Fish pot sampling consists of setting 2 eel pots (12"x12"x23" constructed from ½" x ½" vinyl coated wire mesh) and 3 minnow pots connected on a trot line per site. Pots are soaked for 6 hours before hauling at each site (reef and associated control). At each site gillnets are typically set between 18:00 or 19:00 and soaked for 12 hours. Gillnets consist of two 15’ long by 4’ tall panels, with one panel made of 3.8cm (1.5”) stretch mesh (monofilament) and the other panel made of 7.6cm (3”) stretch mesh (monofilament). Fish captured with all of the aforementioned gears are identified, measured, counted, and released alive whenever possible.

Figure 1. Coastal ponds located in Southern Rhode Island, as well as the Lower Pawcatuck River system. Red circles indicate sites sampled by the RI DEM Division of Fish and Wildlife Coastal Pond Juvenile Finfish Survey. The coastal ponds, which excludes the Lower Pawcatuck River, present potential areas for Fish Habitat Enhancement work under this project.



Type	Site ID	longitude	lattitude
control	1c	71° 41' 27.87" W	41° 21' 22.27" N
seeded pile	1s	71° 41' 24.84" W	41° 21' 23.38" N
unseeded pile	1u	71° 41' 25.59" W	41° 21' 22.04" N
control	2c	71° 41' 21.05" W	41° 21' 27.93" N
seeded pile	2s	71° 41' 21.36" W	41° 21' 24.78" N
unseeded pile	2u	71° 41' 21.70" W	41° 21' 26.50" N

Figure 2. Fish Habitat Enhancement sites in the northern portion of Ninigret Pond. The RI Div. of Fish and Wildlife Marine Fishery management closure (i.e., Shellfish Spawner Sanctuary) is depicted by the yellow outline. Map produced by Kevin Ruddock.

Type	Site ID	longitude	lattitude
control	3c	71° 41' 15.11" W	41° 20' 52.53" N
seeded pile	3s	71° 41' 13.07" W	41° 20' 51.46" N
unseeded pile	3u	71° 41' 15.33" W	41° 20' 50.65" N
control	4c	71° 41' 10.01" W	41° 20' 54.22" N
seeded pile	4s	71° 41' 7.93" W	41° 20' 53.15" N
unseeded pile	4u	71° 41' 10.21" W	41° 20' 52.35" N

Figure 3. Fish Habitat Enhancement sites in the southern portion of Ninigret Pond. The RI Div. of Fish and Wildlife Marine Fishery management closure (i.e., Shellfish Spawner Sanctuary) is depicted by the yellow outline. Points marked to the south of our reefs are restored oyster reefs created by the NRCS EQIP Program between 2008 and 2010.   Map produced by Kevin Ruddock.

Figure 4. Configuration for Fish Habitat Enhancement sites (i.e., research plot #1), which contains experimental reefs (3) and control (1) in the western end of Quonochontaug Pond, Westerly, RI**.**

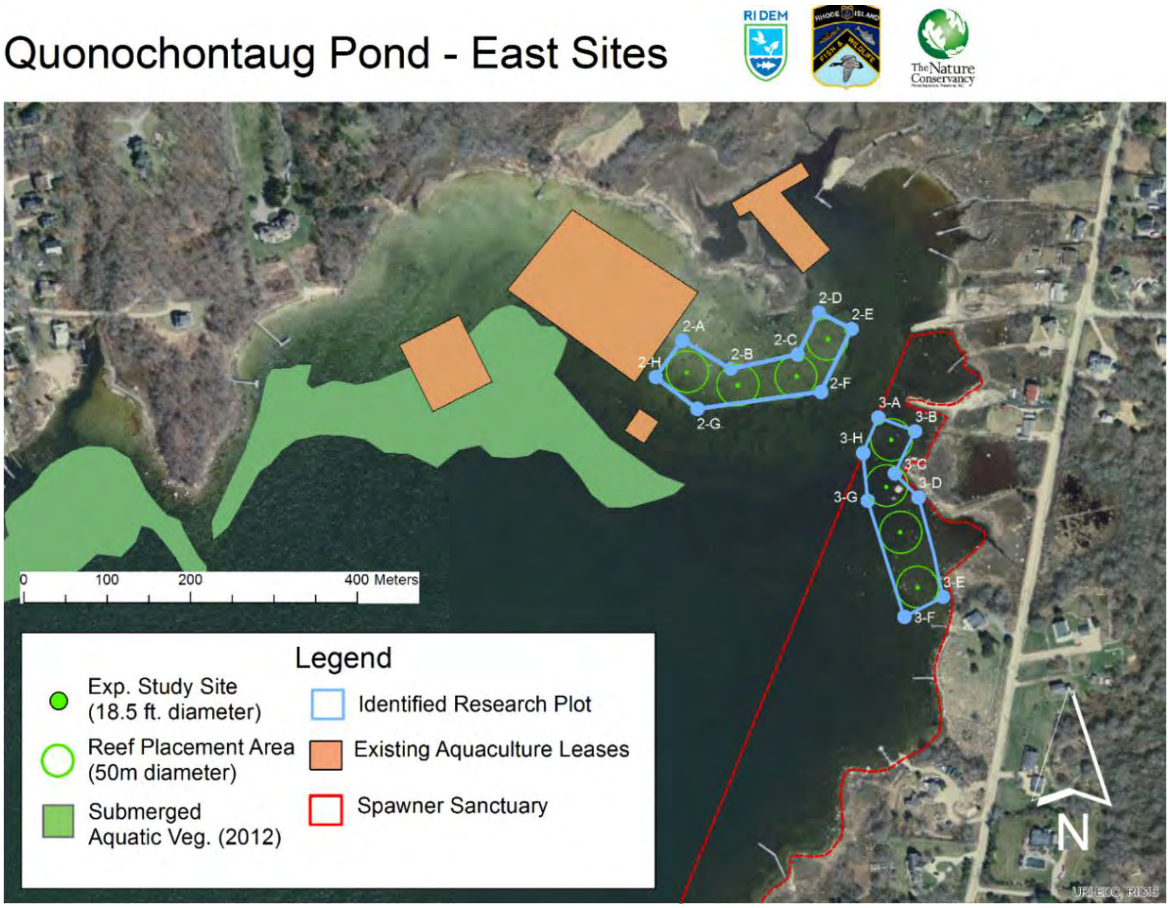


Figure 5. Configuration for Fish Habitat Enhancement sites (i.e., research plot #2 and #3), which contain experimental reefs (3) and control (1) in each site located in the eastern end of Quonochontaug Pond, Charlestown, RI**.**

4.1.8 RI F-61-R Winter Flounder Spawning Stock Biomass in Rhode Island Coastal Ponds

This winter phase of the seasonal coastal pond juvenile flounder collects data on adult spawning populations of winter flounder in the south shore coastal ponds. The research project runs from January - May annually. Fish are captured using fyke nets and some adult winter flounder are tagged using Petersen disk tags. Fyke Nets are a passive fixed fishing gear, attached perpendicular to the shoreline at mean low water. A vertical section of net wall or leader directs fish toward the body of the net where the catch is funneled through a series of parlors, eventually being retained in the terminal parlor. The wings of the net accomplish further direction of the catch.

Net dimensions:

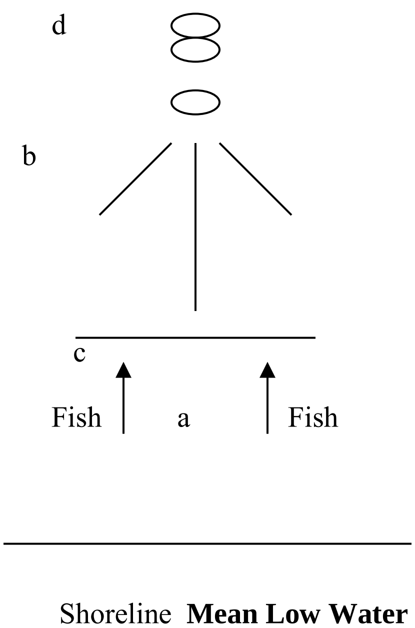
a. Leader - 100'

b. Wings - 25'

c. Spreader Bar - 15'

d. Net parlors – 2.5’

Mesh size - 2.5" throughout



Station water profile:

Depth / turbidity - feet

Dissolved oxygen - mg/l

Salinity - ppt

Temperature - degree C

Fyke nets are deployed depending on ice cover in the ponds and the gear is generally hauled on three to seven night sets. There are a total of eight stations are sampled, all found in the Pt. Judith Pond system including Potters Pond. (NOAA Nautical Chart 13219). These two ponds use the same breach to connect to Block Island and Rhode Island Sounds.

4.1.9 RI F-61-R Narragansett Bay Ventless Pot Survey

The goal of this project is to assess and standardize a time series of abundance for structure oriented finfish (scup, black sea bass, and tautog) in Narragansett Bay. Investigators will also collect age and weight at length information for these species, as well as collect data on other biological characteristics. These latter aspects are not covered in this summary.

A monthly ventless black sea bass and scup pot survey will be conducted in the Narragansett Bay, North of the colregs lines in the East and West passages and North of a line from Lands End in Newport to Sakonnet Point in Little Compton (Figure 1). The survey is currently conducted from April through October, however, it may be exteneded into November in the future. The scup pots and black sea bass pots used in this survey will be identical to those used by the URI/Sea Grant for the last several years under “2012 Fisheries independent Scup Survey of Hard Bottom Areas in Southern New England Waters” and “2012 Industry Based Survey on Black Sea Bass Utilizing Ventless Traps”. The scup pots (2'x2'x2') will be constructed of 1.5” x 1.5” coated wire mesh and unvented. Black Sea Bass Pots (43.5” L, 23” W, and16” H) will be also be constructed of 1.5” x 1.5” coated wire mesh, single mesh entry head, and single mesh inverted parlor nozzle. In addition all pots will be unvented and will be covered with vexar in August and September in an attempt to capture age 1 sea bass.

The survey design divides Narragansett Bay into five sampling areas, The Providence/lower Seekonk River including portions of the Upper Bay/Greenwich Bay, West Passage, East Passage, Mount Hope Bay including portions of the Upper Bay, and the Sakonnet River including the area from Lands End to Sakonnet Point (Figure 1). Each area is subdivided into 0.5 deg of latitude and longitude grids and numbered. These numbered grids are referred to as stations. Within each station, areas of structure, including hard bottom, shipwreck, major bridge abutments, or pilings, and areas without structure were identified. Each month (May-Oct) ½ of the stations with and without structure are sampled using methodology consistent with that used by aforementioned URI/Sea Grant projects. In short, baited and unbaited scup and black seabass pots are set and allowed to fish for either 96 or 24 hours based on the sampling design (see full proposal for details).

Upon hauling the gear, the catch will be sorted by species. Finfish are measured to the nearest centimeter and weighted. Individual length frequency data and weights will be recorded for all species. If individual fish weights are not manageable timewise, aggregate weights will be taken. Scales, otoliths, and opercula will be taken from a percentage of the catch, to be determined by statistical analysis, for the eventual aging of stocks caught as appropriate. Project personnel will collect data on water temperatures, salinities, dissolved oxygen, air temperature, and meteorological data and sea conditions at each sampling station.

Figure 6. Chart of Narragansett Bay with Colregs line of demarcation and Location of Five Sampling Areas.

4.1.10 RI F-61-R University of Rhode Island Weekly Fish Trawl

The University of Rhode Island (URI), Graduate School of Oceanography (GSO) has been monitoring finfish populations in Narragansett Bay since 1959 using a coastal trawl survey. These data provide weekly identification of finfish and crustacean assemblages. Since the inception of the weekly fish trawl, survey tows have been conducted within Rhode Island territorial waters at two stations, one representing habitat of Narragansett Bay and one representing more open-water type habitats, characteristic of Rhode Island Sound (Table 1). The weekly time step of this survey and its long duration are two unique characteristics of this survey. The short duration time step (weekly) has enough definition to capture migration periods and patterns of important finfish species and the length of the time series allows for the characterization of these patterns back into periods of time that may represent different productivity or climate regimes for many of these species.

A weekly trawl survey is conducted on the URI research vessel Cap'n Bert. Two stations are sampled each week: one off Wickford represents conditions in mid Narragansett Bay (Fox Island) and one at the mouth of Narragansett Bay represents conditions in Rhode Island Sound (Whale Rock) (see Table 1). A hydrographic profile at each station measures temperature, salinity and dissolved oxygen. The same otter trawl net design has been used for the past 57 years. A half-hour tow is made at each station at a speed of 2 knots. All species are counted and weighed with an electronic balance. Winter flounder are routinely measured and sexed. When present on board, an undergraduate intern measures all other species with an electronic measuring board. For more information about the GSO fish trawl go to www.gso.uri.edu/fishtrawl.

Since survey inception in 1959 more than 5,500 tows have been conducted. There have been two captures of live Atlantic sturgeon; one in 1963 and one in 1965. Since 1966 no Atlantic sturgeon have been caught or seen by this survey. There have been no shortnose sturgeon or sea turtles caught or seen.

The following are the station locations for the survey:

Site	Location	Coordinates	Depth Range at Low Tide (North to South Along Tow Line)	Bottom Substrate
Fox Island	Adjacent to Quonset Point and Wickford	41°34.5' N, 71°24.3' W	20 feet (6.1 meters) to 26 feet (7.9 meters)	Soft mud and shell debris
Whale Rock	Mouth of West Passage	41°26.3' N, 71°25.4' W	65 feet (19.8 meters) to 85 feet (25.9 meters)	Coarse mud/fine sand

4.2 RI-F-26-R American Shad and River Herring Restoration and Enhancement

Sampling for river herring and American shad will occur using two separate methodologies for the two different life stages to be studies. For adult river herring and American shad sampling will occur at the Potter Hill fish trap. This trap is located 7 miles upstream in the Pawcatuck

River at the exit of a denil fishway attached to the Potter Hill dam. To sample the fish, the fishway is shut down and the trap is entered from a hatchway in the top. Fish are netted and removed from the trap to be samples. They are then released into the river upstream of the trap.

Juvenile shad are monitored in the lower river using a 150' beach seine at five stations each week for a ten-week period beginning with the last week in August (Figure 7). The juveniles are sampled for length frequency distribution, and an index of juvenile abundance is calculated from these data using geometric means.

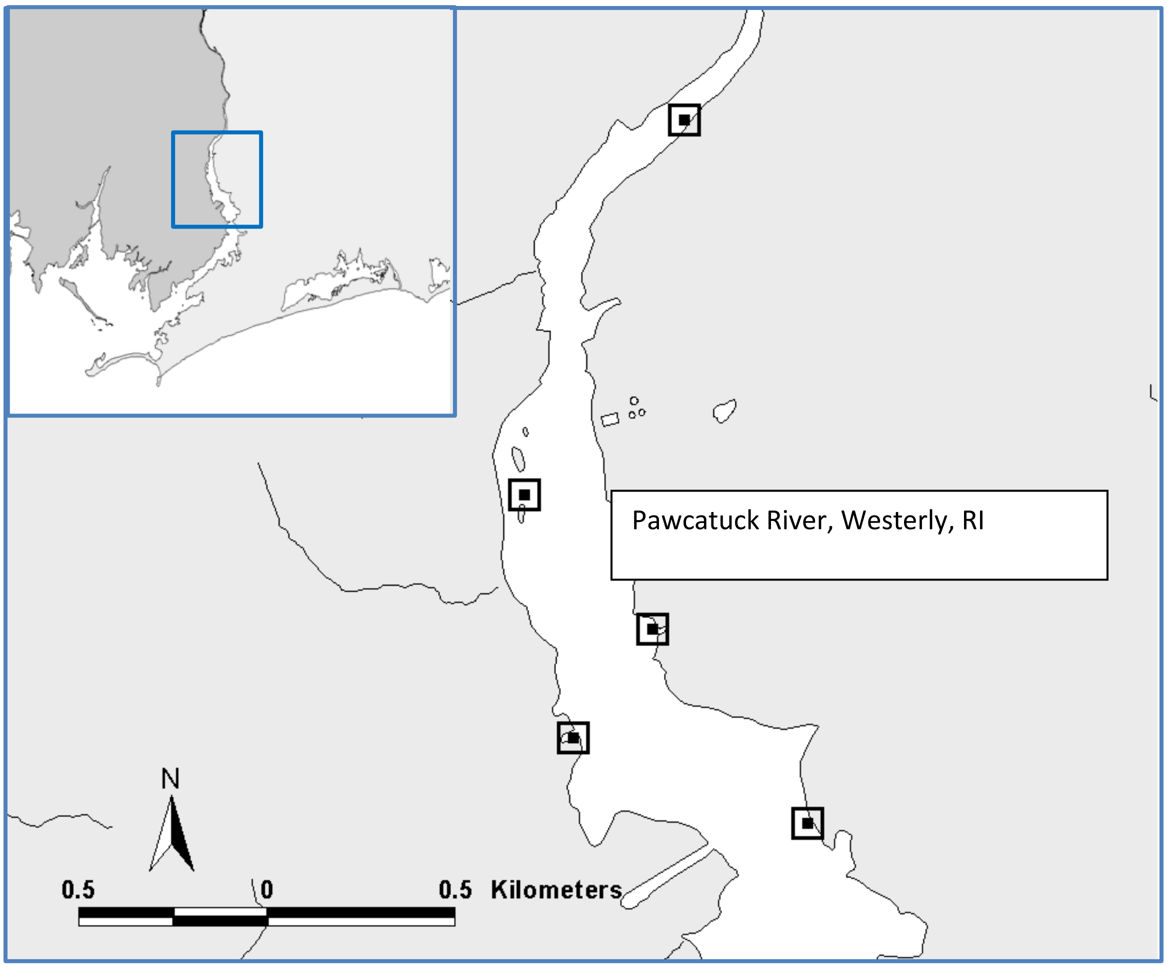


Figure 7. Pawcatuck River Seine Survey stations.

5.0 Connecticut

5.1 CT F-54-R Long Island Sound Trawl Survey

CT DEEP's principal fishery independent sampling program is the long-term trawl survey, used to monitor trends in species composition and abundance in Long Island Sound; this study has been ongoing since 1984.

The Long Island Sound Trawl Survey (LISTS) was initiated in 1984 to provide fishery independent monitoring of important recreational species in Long Island Sound. A stratified-random design based on bottom type and depth interval is used and forty sites are sampled monthly from April through November (1984-1990) to establish seasonal patterns of abundance and distribution. In 1991, the sampling schedule was changed to a spring/fall format, although sampling is still conducted on a monthly basis (April - June, September, and October).

LISTS is conducted from longitude 72° 03' (New London, Connecticut) to longitude 73° 39' (Greenwich, Connecticut). The sampling area includes Connecticut and New York waters from 5 to 46 m in depth and is conducted over mud, sand and transitional (mud/sand) sediment types. Sampling is divided into spring (April-June) and fall (Sept-Oct) periods, with 40 sites sampled monthly for a total of 200 sites annually. The sampling gear employed is a 14 m otter trawl with a 51 mm codend set from a 15.2m research vessel during daylight hours.

Prior to each tow, temperature (°C) and salinity (ppt) are measured at 1 m below the surface and 0.5 m above the bottom using an YSI model 30 S-C-T meter. Water is collected at depth with a five-liter Niskin bottle, and temperature and salinity are measured within the bottle immediately upon retrieval. Since 1992, coordinates for latitude and longitude have been collected when the water sample is taken. Beginning in 1995, GPS tow track logs were added to the data collected for each tow.

The survey's otter trawl is towed from the 15.2 m aluminum R/V John Dempsey for 30 minutes at approximately 3.5 knots, depending on the tide. At completion of the tow, the catch is placed onto a sorting table and sorted by species. Finfish, lobsters and squid are identified to species, counted and weighed in aggregate (to the nearest 0.1 kg) by species with a precision marine-grade scale (30 kg, +/- 10 gm capacity). Note, prior to acquisition of the marine-grade scale in 1992, there were no weights were collected. Catches weighing less than 0.1 kg are recorded as 0.1 kg. The complete time series of species counted and weighed in the survey is documented at: http://www.ct.gov/deep/lib/deep/fishing/publications/2015_marine_fisheries_division_study_of_marine_recreational_fisheries.pdf.

For selected finfish species, lengths are recorded to the centimeter as either total length or fork length (e.g. measurements from 100 mm to 109 mm are recorded as 10 cm) and entered in the database as 105 mm. Atlantic sturgeon are measured to fork length. All indices of abundance (geometric mean count, or weight per tow) are standardized to 30-minute tows.

Sampling procedures have been modified in recent years to minimize the potential for injury to Atlantic sturgeon. When sampling in a season and area where the chance of catching a sturgeon is high (based on historic LISTS catch) and water depth is greater than 27 m, gear retrieval speed is reduced to decrease the stress induced by rapid changes in pressure. When a sturgeon is detected in the net, it is removed as quickly and carefully as possible. Subsequent handling and processing follow protocols described in A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons (Kahn and Mohead 2010).

5.2 CT F-54-R Estuarine Seine Survey

During September, eight shallow subtidal sites are sampled with an eight meter (25 ft) bag seine with 6.4 mm (0.25 in) bar mesh. Area swept is standardized to 4.6 m (15 ft) width by means of a taut spreader rope and a 30 m (98feet) measured distance, parallel or at a 45 degree to the shoreline, against the current or tide if present. At each site, six seine hauls are taken within two hours before or after low slack tide during daylight hours. The eight sites, (Greenwich, Bridgeport, New Haven, Milford, Clinton, Old Lyme, Waterford, and Groton) have been sampled since 1988, except for Milford, which was added in 1990.

Finfish and crabs taken in each seine haul are identified to species and counted. Up to 30 winter flounder or other recreationally important species are measured to total length (mm) from each haul with flounder less than 12.5 cm classified as young-of-year and larger fish grouped into an age 1+ category. Temperature and salinity are recorded at each site 0.5 m from the surface using a YSI model 33 S-C-T meter and refractometer. GPS coordinates are taken at each site. The geometric mean (see Job 5) catch per haul is used as an index of abundance for all important recreational species captured, including winter flounder (YOY, Age 1+), Atlantic silversides, cunner, summer flounder, scup, black sea bass, grubby, mummichog, northern pipefish, northern puffer, striped killifish, striped searobin, tautog, and windowpane flounder.

To provide a context for the September index time series generated above, seven of the eight (all except Milford) sites will be sampled, using identical gear and methods, in early June, July and August in 2014 and 2015. These data will form a seasonal replicate of June-August data taken at these sites in 1988-1990. Because spring warming and summer temperature peaks have accelerated in past decades, comparison of the initial and current summer datasets will provide a means of confirming the relative value of September abundances of winter flounder YOY and other important sport fish. Additionally, recruitment of newly abundant mid-Atlantic species will be more completely documented.

5.3 CT F-57-R Monitor Warmwater Fish Populations in Lakes and Large Rivers

Warmwater fish populations will be sampled in selected lakes via night boat electrofishing (pulsed DC) during the spring and fall. During a night's electrofishing, abundant fish species will be sub-sampled, whereas rare species and gamefish will be sampled throughout the night. All fish will be netted and placed in a livewell and subsequently enumerated and measured. Additionally, scale samples will be taken from a sub-sample of reference species for age-and-growth analyses. Subsequent analyses will include calculation and reporting of relative abundance, size composition, growth rates, and in some instances mortality rates.

5.4 CT F-57-R Channel Catfish Management

Channel catfish will be periodically sampled as resources permit from stocked lakes/ponds and established populations. Baited hoop nets, a gear that has proven effective in preliminary sampling, will be used to collect riverine catfish during September-October. The most effective gear/season for sampling channel catfish from Connecticut lakes and ponds is yet to be determined. Accordingly, IFD staff will experiment with several sampling approaches in lakes as resources permit. Resident fish populations will be sampled during routine spring and fall boat electrofishing conducted under the Lake and Large River Monitoring Job.

5.5 CT T-18-R Survey of Diadromous Fishes of Conservation Concern in the Connecticut River

American Shad and Blueback Herring

Adult shad demography will be characterized using information collected by MA DFW at the Holyoke Fishlift in Holyoke, MA, including: daily fish lift numbers, size structure, and sex ratio. MA DFW will collect scale samples from adult shad at Holyoke, and DEEP staff will process these samples to estimate age structure and spawning history.

All shad sampled will be measured for fork length (mm). Sex determination will be accomplished by visual inspection of the gonads of sacrificed fish. Approximately 25 scales will be removed from the area above the lateral line anterior to the dorsal fin of each fish. Population sex ratio will be estimated by MA DFW from daily samples, weighted using daily passage totals.

All scale samples collected will be cleaned with an ultrasonic cleaner and pressed onto acetate slides. Representative numbers of scale samples per 1-cm length group from both sexes will be randomly selected for aging. Age of individual fish will be estimated by two or more readers independently viewing projected images (43x) of acetate scale impressions; readers will count annuli and spawning scars according to the criteria of Cating (1953). Final age and spawning history estimates will be assigned by consensus of readers.

The Connecticut River seine survey will occur weekly from July 15-October 15 at standardized sample stations distributed along-river from Holyoke MA to Essex CT. Sampling procedures will be similar to those utilized from 1978 to 2016 by DEEP. One seine haul per station will be made during daylight hours with a 15.2 m nylon bag seine (0.5 cm delta mesh) and 30.5 m lead ropes. The seine will be deployed with the aid of a boat. Using the lead ropes, the seine will be towed in a downstream arc to the shore and beached. All fish collected will be identified to species, enumerated (either directly or via subsampling), categorized by size, and released – with the exception of members of the family Clupeidae (American shad, blueback herring, alewife, and Atlantic menhaden), which will be returned to the laboratory for identification and enumeration.

Annual juvenile abundance indices (JI) for blueback herring and American shad in the Connecticut River will be calculated as the geometric mean catch per seine tow among all stations and dates sampled in a given year.

Atlantic and Shortnose Sturgeon

Juvenile sturgeon (<50 cm FL) will be sampled in the Connecticut River from the CT/MA border (river kilometer or "rkm" 112) to the estuary region (rkm 0) with gill nets and trawls. Specific sites sampled will be based on identification of likely habitats. Gill nets (2.3 m high by 100m long, single mesh size per net of 2.5 to 10.1 cm stretched mesh) will be fished in both anchored sets and in drift sets. Nets will be weighted to fish the bottom 2 m of the water column. Soak times will range from 0.25 to 2.0 hours depending upon prevailing conditions. All gill net sets will be limited to less than 2 hours in duration, with actual soak time being water temperature dependent as per federal sturgeon collection and processing requirements (Damon-Randall et al. 2009; Kahn and Moehead 2010). Anchored sets will have anchors and buoy lines on both ends of the net and will be set parallel to the prevailing river flow in snag-free locations suspected of harboring sturgeon. Drift nets will be deployed with minimal or no anchors and set around the times of slack tide (to minimize net movement). Drift nets will be fished perpendicular to the prevailing river flow. Trawling will be conducted with a skiff trawl (9.7 m x 7.0 m with variable mesh 8.0 to 3.0 cm stretched mesh in the body of the net with a 2.0 cm mesh codend and 0.5 cm mesh codend liner) fished against the river flow. Trawling will be conducted in 4-15 minute intervals at approximately 1.5 knots groundspeed. Length of tow duration and thus distance covered will be dependent on bottom topography, vessel traffic and other conditions specific to each sampling location. Netting efforts (both trawl and gill net) will be made from river kilometer 112 to 0 during all months from May through October where suitable sites are identified. Collections for sturgeon are authorized under endangered species permit 19641 for both Atlantic and shortnose sturgeon.

All fish captured will be identified (Thomson et al. 1978; Whitworth 1996) and enumerated. All fish from a single net haul will be processed at one time before setting additional nets. All non-sturgeon fish species will be released immediately after counting. All sturgeon captured will be placed into flow-through tanks onboard the research vessel. Sturgeon will then be individually moved from flow-through tanks into a water filled measuring box for examination and processing. Captured sturgeon will be examined, measured for fork and total length (cm) as well as intra-orbital distance and mouth width, and then weighed (kg) with either a spring or platform scale (Jennings 1989). Atlantic sturgeon will be distinguished from shortnose sturgeon by the intra-orbital/mouth width ratio (IO/MW). Sturgeon with IO/MW less than 0.50 are Atlantic sturgeon and IO/MW greater than 0.55 are shortnose sturgeon. All sturgeon will be handled as little as possible and will always be supported in at least two places during out of water experiences to avoid stressing the vertebral column. All necessary precautions will be taken to cause minimal amounts of stress to the sturgeon following NMFS sturgeon handling protocols (Moser et al. 2000) including the use of 'Stress Coat" in all water baths. Unmarked sturgeon or sturgeon lacking a PIT tag will have a PIT tag injected into the dorsal musculature on the left side of the body just anterior to the dorsal fin. A tissue sample (1 cm square) of left pelvic fin rays will be removed from all first-time captures and stored in 100% isopropyl alcohol for genetic stock identification and cataloged with Federal agencies. Up to 20 juvenile sturgeon (10 per each species) per year will be selected for telemetry monitoring. Ultrasonic transmitters will be coated with 'Silastic' before being surgically implanted to reduce possibility of foreign body rejection. Surgical implanting of transmitters is highly encouraged over external attachments for long term retention of the transmitter and reliability of the information (Summerfelt and Mosier 1984). Up to 50 sturgeon of each species will have a 1-cm section of the first hardened rays of the right pectoral fin surgically removed with bone shears for later processing and age estimation (Collins and Smith 1996). All wounds and surgical interventions will be treated topically with providone iodine before the fish is released.

Ultrasonic telemetry receivers will be deployed within the Connecticut River from the mouth of the Connecticut River (rkm 0) to the CT/MA border (rkm 112). All receivers will be deployed concurrently for up to a continuous twelve month period. Exact numbers of acoustic receivers deployed and precise locations will be determined at a future date based on available equipment and GIS analyses to determine best spacing/coverage of the river. Some receivers may have to be removed from the water during periods of adverse weather or during winter months when staff cannot maintain them.

6.0 New York

6.1 NY F-49-R Management and Enhancement of Marine and Diadromous Finfish – Marine Fisheries Investigations and Management

6.1.1 NY F-49-R Small Mesh Trawl Survey

The New York Small Mesh Trawl Survey is used for long-term monitoring and assessment of annual recruitment of important marine finfish species in New York waters, including weakfish, winter flounder, scup, tautog, bluefish and northern puffer. The survey is also used to meet the Atlantic States Marine Fisheries Commission (ASMFC) compliance criteria for the Interstate Fishery Management Plan for winter flounder, horseshoe crab and weakfish.

The research vessel used throughout the survey was the *David H. Wallace,* a 10.7 meter lobster-style workboat. At each location, a 4.9 meter semi-balloon shrimp trawl with a small mesh liner was towed for 10 minutes at approximately 2.5 knots. From 1987 through 1990, nets were rigged using nylon scissors and tow ropes set by hand and retrieved using a hydraulic lobster pot hauler. Following the 1990 sampling season, the research vessel was re-outfitted to include an A-frame, wire cable and hydraulic trawl winches. For the remainder of the study, wire cable was substituted for the nylon scissor and tow ropes, and nets were set and retrieved using hydraulic winches.

Since the inception of this project in 1987 a total of 11,220 sample tows have been completed in the Peconic Bay study area. Fish collected in each tow were sorted, identified, counted and measured to the nearest millimeter (fork or total length). Large catches were subsample, with length measurements taken on a minimum of 30 randomly selected individual fish of each species. Some samples were stratified by length group such that all large individuals were measured and only a subsample of small (usually yearlings or young of the year) specimens were measured. Subsampled counts greater than ten were then expanded by length group for each tow.

6.1.2 NY F-49-R Long Island Sound Trap Survey

The New York State Department of Environmental Conservation initiated a trap survey in Long Island Sound in 2007 to develop estimates of relative abundance, size distribution and catch per unit effort of tautog (*Tautoga onitis*) in New York waters. Repairs to the vessel used for the project prevented the survey from being done in 2009. The first year (2007) was used to evaluate the feasibility of the methodology and the project was expanded in 2008.

Sampling is conducted weekly, weather permitting, from May through October with small mesh, ventless fish traps. The traps are deployed between Mattituck Inlet, Southold NY (Lat: 41°00’09”; Long: 72°33’08”) and Rocky Point, Orient, NY (Lat:41°08’03”; Long: 71°21’02”). The majority of the traps are placed near shore (Figure 1), rocky areas in 20-30 feet of water. Three to five traps are placed in 55 feet of water north of Mattituck inlet. The sampling period, number of traps used, number of trap hauls and average soak time per year for the survey is given in Table 1.

The traps are 40.5 inches long, 21 inches wide and 15 inches tall, and are made of 1inch square, 14 gauge mesh wire. Each trap has one 5”x5” escape panel secured with biodegradable hog rings designed to fall open should the trap become lost. The traps are deployed with 3/8” poly line and marked at the surface with a foam buoy. The funnels at the entrance to the trap and between the two compartments in the trap are made from nylon mesh typical of other commercial type fish traps. The National Marine Fisheries Service has exempted Long Island Sound from gear restrictions established by Atlantic Large Whale Take Reduction Plan (ALWTRP Interim Final Rule 1997).

Although the survey is specifically designed to target tautog, data on all other species encountered by the traps is also collected. All finfish and lobster are enumerated and measured to the nearest millimeter. All other invertebrates are enumerated only.

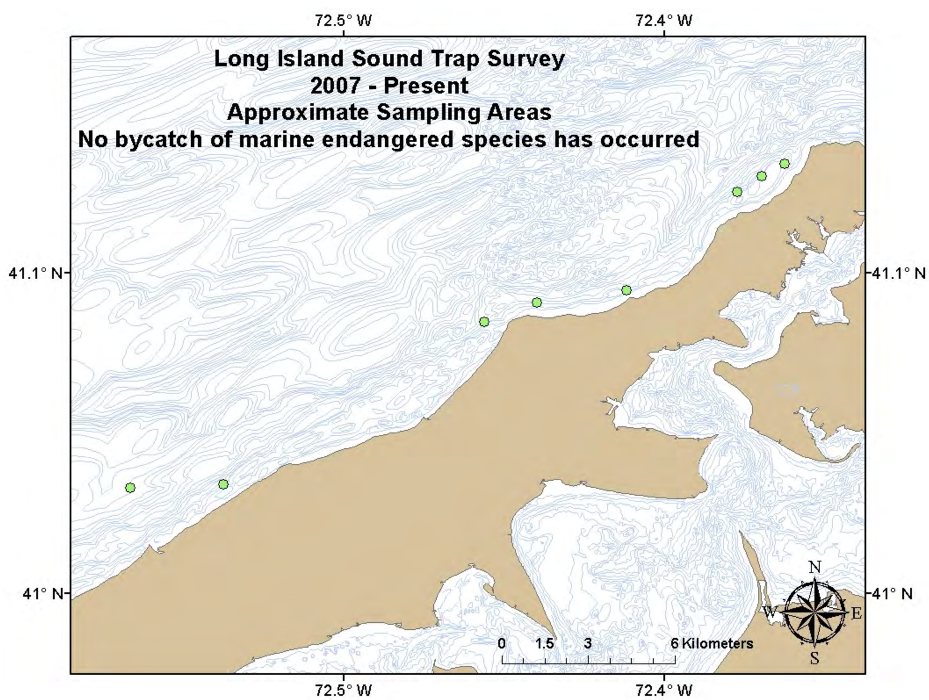


Figure 1. Sampling Locations for the Long Island Sound Trap Survey.

Table 1. Annual sampling period, number of traps, trap hauls and average soak time for the Long Island Sound Trap Survey.

Year	Sampling Period	# Traps	# Trap Hauls	Average Soak Time (Days)
2007	June- Dec	30	529	9.0
2008	May-Oct	40	685	8.7
2009		0	0	
2010	June-Oct	40	552	8.9
2011	May-Oct	35	441	11.1
Total			2207	

6.2 NY F-49-R Marine Fishing Access

6.2.1 NY F-49-R Artificial Reef Monitoring

The objectives of this project are to monitor the effectiveness of artificial reefs developed and enhanced with Sport Fish Restoration funding.

Lobster and black sea bass traps were used in 2007, 2008 and 2009 to monitor relative abundance of recreational important finfish species on artificial reefs. The reef sites surveyed were Hempstead Reef, Fire Island Reef, Kismet Reef, Moriches Reef and Shinnecock Reef. Although not used in recent years, it is possible that this sampling technique will be employed again in the future.

6.3 NY F-49-R Diadromous Fisheries Investigations and Management

6.3.1 NY F-49-R Western Long Island Seine Survey

The objectives of this survey are to annually determine catch per unit effort (CPUE) for juvenile striped bass and other important fisheries resources, including but not limited to bluefish, winter flounder, summer flounder, tautog, weakfish, American shad, river herring, and horseshoe crabs in western Long Island (WLI) bays; and to tag and release juvenile and adult striped bass in western Long Island bays.

In order to achieve these objectives, juvenile and adult striped bass are sampled in Little Neck Bay, Manhasset Bay, and Jamaica Bay bi-monthly from May through October. A 200 foot x 10 foot x 1/4 inch square mesh beach seine, with a 25 foot x 12 foot x 3/16 inch square mesh bunt area, is set by boat and hauled to shore by hand. All species captured by the beach seine are identified and counted.

Striped bass of the appropriate size and condition are tagged with internal anchor tags as part of a multi-state tagging program coordinated with the United States Fish and Wildlife Service (USFWS). Databases containing striped bass tag number, release date and site, total length, and age are sent to USFWS personnel at the end of each field season. The tag recapture data are used to examine survival and movements of juvenile and adult striped bass tagged in western Long Island bays.

Since 1984, stations have been seined twice a month from May through October in western Long Island bays, including Little Neck Bay, Manhasset Bay, and Jamaica Bay. Sampling was conducted in the past in eastern bays, when striped bass stock sizes were low. These bays are now no longer sampled, due to staffing shortages. Sampling has also occurred in bays in central Long Island, including Hempstead Harbor and Oyster Bay. In addition to the 200 ft x 10 ft beach seine mentioned above, (the gear used most consistently during the 28 years of the survey), a 500 foot x 12 foot beach seine with 3 inch stretched mesh in the wings, and a 2 inch stretched mesh bag, was used occasionally in the 1980's through the early 2000's, to supplement the catch of older, larger fish. From 1984 to 2002, one hundred sixty three (163) hauls were conducted using the larger, 500 foot seine.

6.3.2 NY F-49-R Young of the Year American Eel Survey

The objective of this survey is to annually determine the abundance of young-of-the-year American eels in the Carman's River, on the south shore of Long Island, as a requirement of the ASMFC American Eel Fishery Management Plan.

The survey uses a fyke net, constructed of two wings of equal length attached to a tapered section which includes a single funnel. The entire length across the wings is thirty feet by eight feet deep. A line of seine floats is strung across the top of the fyke to keep it upright in the water column. A chain line holds the bottom down against the current. The net is set so that eels swimming upstream enter into the tapered section and are trapped after passing through the funnel section into the hold. This single fyke net is set in the tidal portion of the Carman's River, near the first impassable barrier on the River.

The fyke is checked daily over a nine-week period during early Spring. Each daily catch is sorted and enumerated by species. Glass eels are easily distinguishable from pigmented elvers, and each catch is recorded separately. Environmental and climatological data are also recorded for each catch. These included water and air temperature, tide stage, time of the previous high tide, and the amount of the previous day's precipitation. In addition the elapsed time between checks of the net, and the condition of the gear upon arrival to the survey site are also recorded. The catch of eels is released upriver, above a dam separating the tidal and non-tidal portions of the river so as not to affect estimates of annual recruitment.

6.4 NY F-49-R Research and Management of Fisheries Resources of the Hudson River Estuary and the Delaware River

6.4.1 NY F-49-R Spawning Stock Survey of American Shad, River Herring, and Striped Bass

NY has sampled the spawning populations of Hudson River American shad and striped annually since 1983. Fish are collected by 152 m and 305 m haul seine in the vicinity of known spawning areas and at beaches where adults are susceptible to capture by shore gear. The nets are 3.7 m deep with 10.2 cm stretch mesh. Both nets have center located bags. The nets are set by boat and retrieved to shore by hand. Collections usually occur from late April through early June at sites between rkm 90 through 200. Captured fish are transferred to a floating net pen after which they are identified to species and sex, measured, weighed, and scale samples taken. Striped bass in good condition are tagged with USFWS internal anchor tags. Shad were tagged with dart tags until 2010.

6.4.2 NY F-49-R Striped Bass and American Shad Electrofishing.

Since 1989, NY has augmented haul seine collections of striped bass and American shad for tagging by electrofishing. Sampling generally occurs in late April and early May at various upriver locations (rkm 140+) using low amperage DC current. Fish are captured with long handled landing nets and placed in an onboard live tank with flow through river water and oxygenation. Once a few fish are collected (< 30), all captured fish are transferred to the floating net pen described above and processed in the same manner as fish collected in the spawning stock survey.

6.4.3 NY F-49-R Alosine Juvenile Abundance Survey.

NY has sampled recruitment of age zero (young of the year, YOY) American shad and river herring annually in the Hudson River Estuary since 1980. Collections are made with a 30.5 x 3.0 m beach seine with 0.64 mm mesh at 28 standard sites between river km 88 and 225. Sites are located in reaches of the river bracketing known near-shore concentrations of age zero alosines. Sampling generally occurs during the day on alternate weeks from July through October.

Fish collected by beach seine are sorted by species and life stage, counted, and returned to the river. Up to 30 age-zero American shad, alewife, and blueback herring from each haul are measured for total length (mm). Annual abundance indices are calculated as a geometric mean using data from weeks 26 through 42 (mid-June through October).

6.4.4 NY F-49-R Striped Bass Juvenile Abundance Survey.

NY has sampled recruitment of age zero, or YOY, striped bass in the Hudson River Estuary annually since 1979. Collections are made with a 71 m x 3 m beach seine with 0.64 mm mesh at 25 stations selected from a suite of 36 fixed stations in the Tappan Zee to Haverstraw Bay, portion of the Hudson River (rkm 35 – 63). Sites are located in reaches of the river bracketing known near-shore concentrations of YOY striped bass. Sampling occurs during the day on alternate weeks from mid-July through early November.

Fish captured by seine are sorted by species and life stage, counted, and returned to the river. Lengths of striped bass and selected other species are obtained from a subset of the catch. Annual abundance indices are calculated as a geometric mean of total catch / number of hauls using data from sample weeks four through nine (late August through early November).

6.4.5 NY F-49-R American Shad Spawning Habitat Studies

NY initiated a five-year study of movement and habitat use of mature American shad in the Hudson River in 2009. The study involved use of both sonic and radio tags, mobile tracking, and stationary receivers to identify movement throughout the river. Sonic tags generally work best when fish are in deep water and radio tags work best in shallow water. NY used several different tag types, during the first two years to see if one type of technology would produce better data for identifying shad spawning habitat as both deep and shallow area are common through the spawning reach.

NY captured mature prespawning American shad for tagging by short sets of drifted gill net with 14 cm stretch mesh. Sampling occurred well downriver of, and at the lower end of, suspected spawning reaches from early April through early May. This period encompasses the first part of the shad spawning migration in the Hudson River Estuary. Most shad were collected in Haverstraw Bay and the Tappan Zee (rkm 20-65), near Poughkeepsie (rkm 115-130), and near Kingston (rkm148-155). Captured fish were measured for total length and sex was identified. American shad in good condition were tagged.

7.0 New Jersey

7.1 NJ F-15-R NJ Ocean Trawl Survey

The Ocean Trawl stock assessment program monitors the occurrence, distribution, and relative abundance of fishes inhabiting the nearshore coastal waters of New Jersey and has been ongoing since August 1988 (Figure 1). The data collected in the Ocean Trawl survey are used in the coastwide stock assessments for summer flounder, winter flounder, striped bass, bluefish, black sea bass, scup, tautog and weakfish. The survey is also used to meet the Atlantic States Marine Fisheries Commission (ASMFC) compliance criteria for the Interstate Fishery Management Plan for winter flounder.

The survey is a random stratified sampling design with a total of five cruises per year. Annually, 186 trawl samples are performed during January (30), April (39), June (39), August (39), October (39). Samples are collected with a three-in-one trawl, so named because all the tapers are three to one. The net is a two-seam trawl with forward netting of 12 cm (4.7 inches) stretch mesh and rear netting of 8 cm (3.0 inches) and is lined with a 6.4 mm (0.25 inch) bar mesh liner. The headrope is 25 m (82 feet) long and the footrope is 30.5 m (100 feet) long. The trawl bridle is 20 fathoms long, the top leg consisting of 0.5 inch wire rope and the bottom leg comprised of 0.75 inch wire rope covered with 2 3/8-inch diameter rubber cookies. A 10-fathom groundwire, also made of 0.75-inch wire rope covered with 2 3/8-inch diameter rubber cookies, extends between the bridle and trawl doors. The survey upgraded to ”Type 11” Thyboron brand steel trawl doors, measuring 1.5 m x 1.2 m and weighing 720 lbs, in August, 2015.

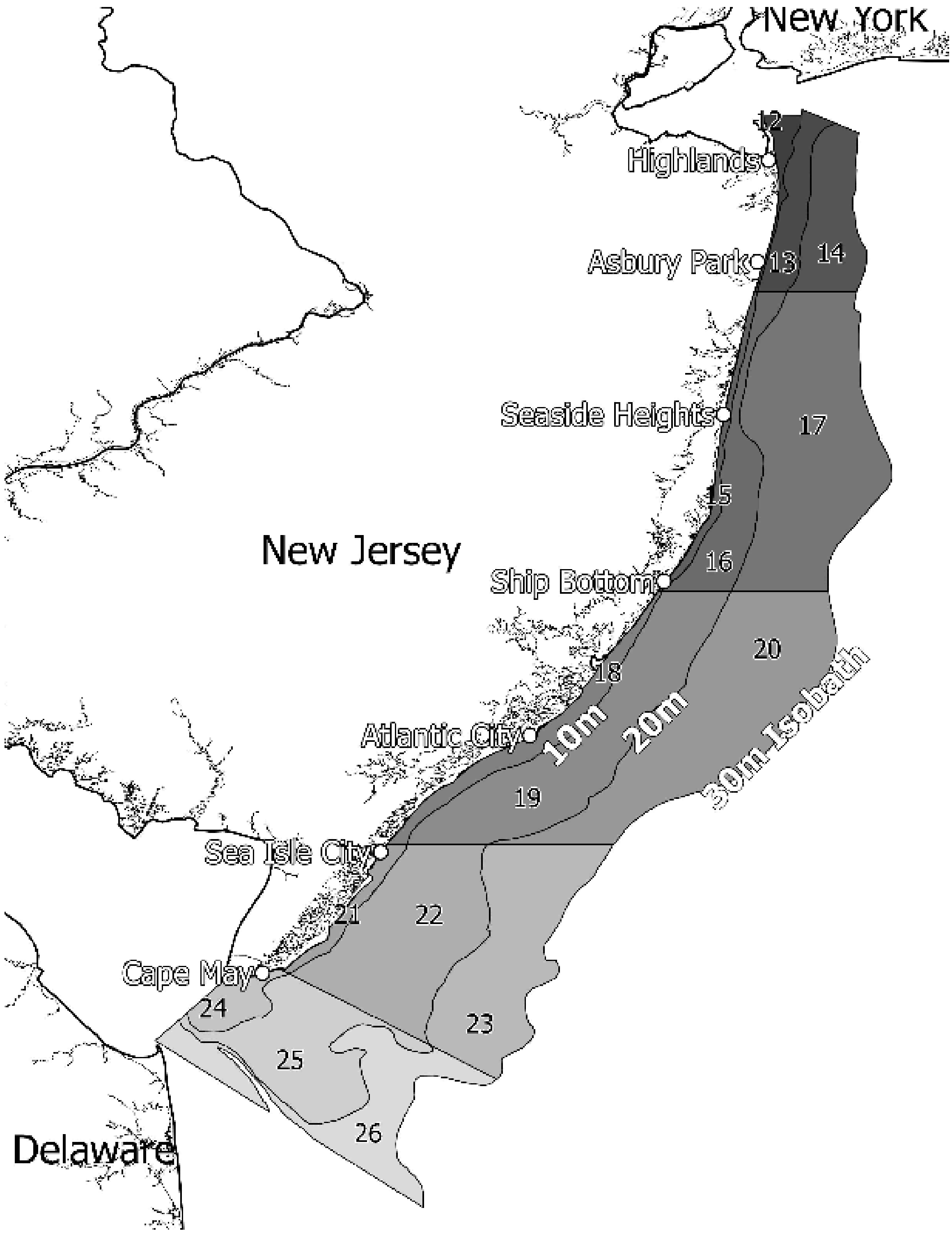


Figure 1. New Jersey Ocean Trawl Survey Sampling Strata

Trawl samples are collected by towing the net for 20 minutes (approximately 1 nautical mile), timed from the moment the winch brakes are set to stop the deployment of tow wire to the beginning of haulback. Enough tow wire is released to provide a wire length to depth ratio of at least 3:1, but in shallow (< 10 m) water this ratio is often much greater, in order to provide separation between the vessel and the net. Following haulback, the catch is placed into a 4 x 8-ft. sorting table where fishes and macroinvertebrates are sorted by species into plastic buckets and fish baskets. The depth of tow is contingent on the water depth at the station location. The total weight of each species is measured with metric scales and the length of all individuals comprising each species caught, or a representative sample by weight for large catches, is measured to the nearest cm. Fork or total length, depending on tail shape, is measured for all fishes except stingrays, which have disk width measured instead. For invertebrates, carapace width is measured on crabs, carapace length (in mm) on lobster, and mantle length on squid. Catches containing large numbers of relatively small specimens are often mixed and the mix subsampled by weight. The mix is then sorted and measured and species components later extrapolated, based upon their representation in the subsample, to determine contribution to the total catch.

The survey area consists of New Jersey coastal waters from Ambrose Channel, or the entrance to New York Harbor, south to Cape Henlopen Channel, or the entrance to Delaware Bay, and from about the 3 fathom isobath inshore to approximately the 15 fathom isobath offshore (Figure 1). This area is divided into 15 sampling strata. Latitudinal boundaries are identical to those that define the sampling strata of the National Marine Fisheries Service (NMFS) Northwest Atlantic groundfish survey. Exceptions are those strata at the extreme northern and southern ends of New Jersey. Where NMFS strata extended into New York or Delaware waters, truncated boundaries were drawn which included only waters adjacent to New Jersey, except for the ocean waters off the mouth of Delaware Bay, which were also included.

Longitudinal boundaries consist of the 5, 10, and 15 fathom isobaths. Where these bottom contours were irregular, stratum boundaries were smoothed by eye. As a result, the longitudinal strata boundaries for the New Jersey survey area are similar, but not identical, to the corresponding NMFS boundaries.

Each stratum is divided by grid lines into blocks which represent potential sampling sites; each block is identified by a number assigned sequentially within each stratum. The dimensions of mid-shore (5-10 fathoms) and offshore (10-15 fathoms) blocks are 2.0 minutes longitude by 2.5 minutes latitude; inshore (3-5 fathoms) blocks were 1.0 minutes longitude by 1.0 minutes latitude. Inshore block dimensions were smaller because inshore strata were narrower and of much less area compared to mid- and offshore strata; small block size permits a greater number of potential sampling sites than would be possible with the larger dimensions. This is important for statistical analysis and follows the strategy of NMFS Northeast Fisheries Science Center (NEFSC) for their groundfish survey.

Dimensions of blocks transected by stratum boundaries have less area than described above; blocks reduced in area by more than one-half were generally not assigned a number. Sampling sites in 1988-91 were determined by blindly picking disks numbered to correspond to stratum blocks and mixed to assure randomness. In 1992, this method was replaced by using a computer to generate random numbers.

7.2 NJ F-15-R NJ Striped Bass Tagging Program

In 1989, New Jersey Division of Fish and Wildlife (NJDFW) began collaborating with other agencies by entering the U.S. Fish and Wildlife Service (USFWS) Cooperative Coastal Striped Bass Tagging Program. Sampling was initiated in areas of lower Delaware Bay near Bidwell's Creek/Reeds Beach, New Jersey where striped bass had been reported as bycatch in the shad gill net fishery (Figure 2). In 1995, this program became a mandatory compliance issue under the ASMFC Atlantic Striped Bass Interstate Fishery Management Plan. Failure to complete this program annually could result in a closure to New Jersey's recreational striped bass fishery.

The program currently utilizes 0.40 mm to 0.47 mm diameter monofilament gill nets, ranging from 5 to 6 inch stretch mesh from early March through early May. Nets are 300 to 600 feet in length, 6 to 12 feet in depth and typically set in water depths of 5 to 12 feet. The average soak time in recent years has been 0.8 hours. In the mid 1990s, the NJDFW began the switch over from anchored gear to the use of drifting gear resulting in a decrease in average annual soak times since 2000. Usually, only one net is set at a time, and all nets are monitored to diminish potential mortalities to any species.

Although the survey specifically targets striped bass, it has developed into a valuable assessment mechanism for collecting multispecies biological information. All species, especially Atlantic sturgeon and horseshoe crabs, are examined for tags or other markings, while otoliths are collected from bluefish, weakfish and black drum.

American shad collected during the survey are an essential component in the development of the Delaware River Sustainable Fishing Plan for American Shad. American shad caught in good condition are tagged while a subsample of fish provides scale and otolith samples for age determination and fin clips for genetic analysis.

In 2005, NJDFW began tagging Atlantic sturgeon captured in good condition while targeting striped bass during this program. All sturgeon were processed according to USFWS tagging protocols in the following manner: fork and total length (millimeters) recorded, scanned for pit tags, tagged using dart and pit tags provided by the USFWS, fin clipped and then released alive. Note: the NJDFW would like to continue tagging Atlantic sturgeon during this project if possible.

Striped bass in good condition are processed as follows: fork and total lengths (millimeters) recorded, scale samples taken, tagged using internal anchor/external streamer tags provided by the USFWS and then released. A subsample of tagged fish is weighed. In addition, a subsample of fish caught is retained for biological characterization including otolith removal. Basic water quality parameters, net specifications, duration of the sets and other data as outlined by the USFWS are also recorded.

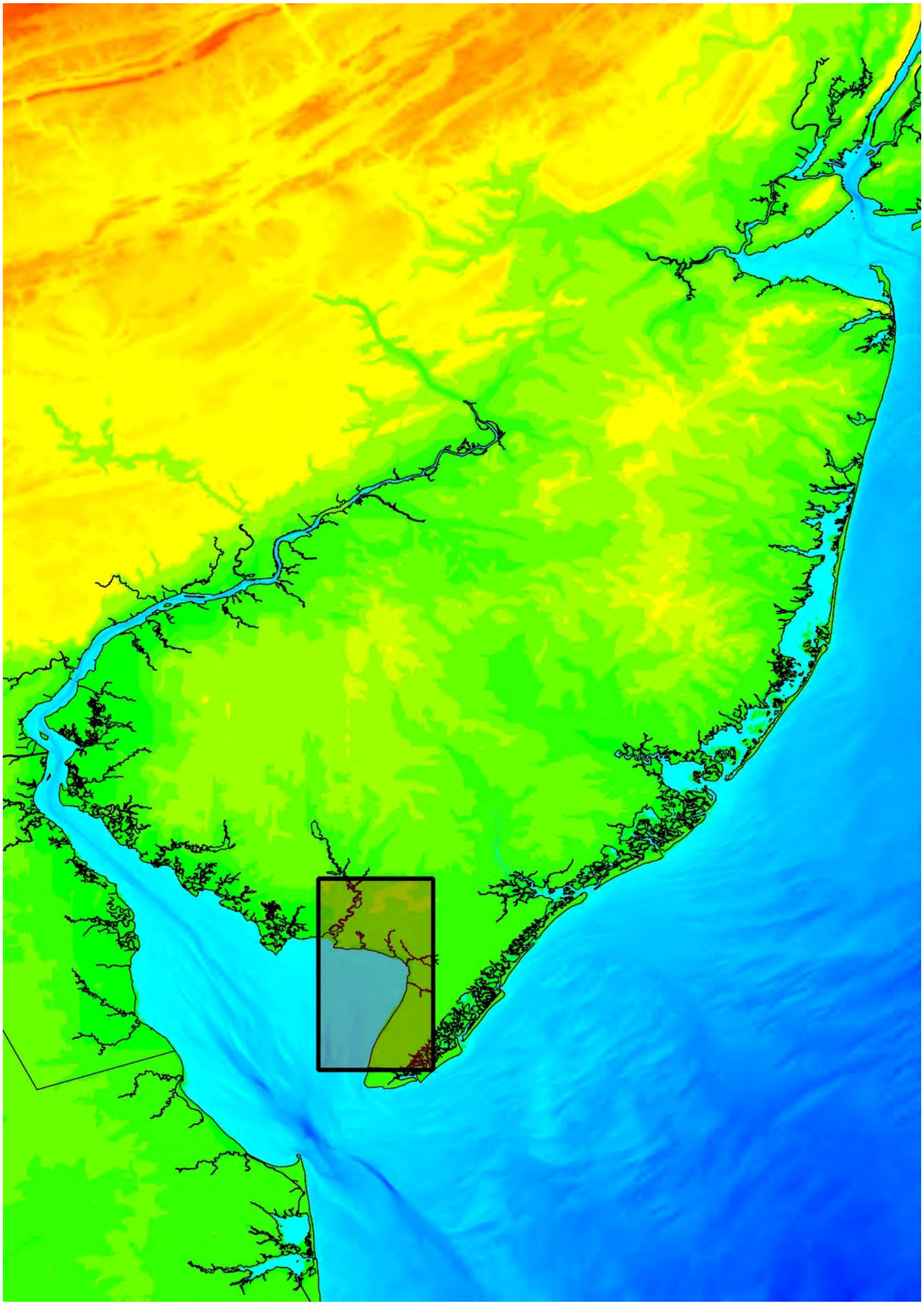


Figure 2. General area of Delaware Bay tagging efforts

7.3 NJ F-15-R Delaware River Juvenile Striped Bass Seine Survey

Since 1980, NJDFW has conducted a juvenile striped bass survey in the Delaware River to provide an annual index of striped bass juvenile abundance. Field sampling utilizes a bagged, 100-foot long by 6-foot deep by ¼-inch mesh beach seine. The seine is set by boat in nearshore waters normally less than six feet in depth and therefore soak times are typically less than ten minutes. All striped bass, as well as other target species, caught are quantified and measured. Basic water quality parameters that include water temperature, salinity and dissolved oxygen are also recorded.

This program was identified in 1989 as an essential tool for the management of the coastwide stocks of striped bass. The ASMFC mandated that the NJDFW continue this program as a compliance criterion. Data collected for American shad was added as a compliance criterion in 1999. As with the striped bass tagging program in Delaware Bay, discontinuation of this program would be costly in regards to New Jersey's recreational fishing industry.

Although the survey specifically targets striped bass, it has always been a valuable tool for collecting multispecies information essential for ASMFC stock assessments and management plans. Annual abundance indices are developed for the following species: American shad (ASMFC compliance), alewife, blueback herring, Atlantic croaker, weakfish, bluefish, spot, American eel, white perch, menhaden and black drum. The survey has provided samples for various species including striped bass, blueback herring, alewife, American shad, hogchoker and bunker for research at various universities across the US and Canada. In addition, this survey is available tool for providing information for use in waterfront development projects and dredging operations.

Although the juvenile survey has been modified throughout the time series the current fixed station format has been followed since 2002. The NJDFW samples 32 stations from mid-June through October for a total of 288 annual hauls (Table 1). During the time series, the sampling area has ranged from river mile 44.9 to 129.7. Since 1998, sampling stations are located from Augustine Beach to Newbold Island. Occasionally due to tidal extremes, sediment, or construction, alternate sites are sampled.

The Delaware River recruitment survey area (Figure 3) is divided into three distinct habitats:

1) Region I -- brackish, tidal water extending from the springtime saltwater/freshwater interface to the Delaware Memorial Bridges
2) Region II -- brackish to fresh tidal water extending from the Delaware Memorial Bridges to the Schuylkill River at the Philadelphia Naval Yard, and
3) Region III --tidal freshwater from Philadelphia to the fall line at Trenton

Saltmarsh vegetation predominates along the Region I shoreline while Region II is primarily urban with a shoreline heavily developed for commerce and industry. Region III is sporadically developed by industry with considerable freshwater marsh.

DELAWARE RIVER RECRUITMENT SURVEY SAMPLING AREA

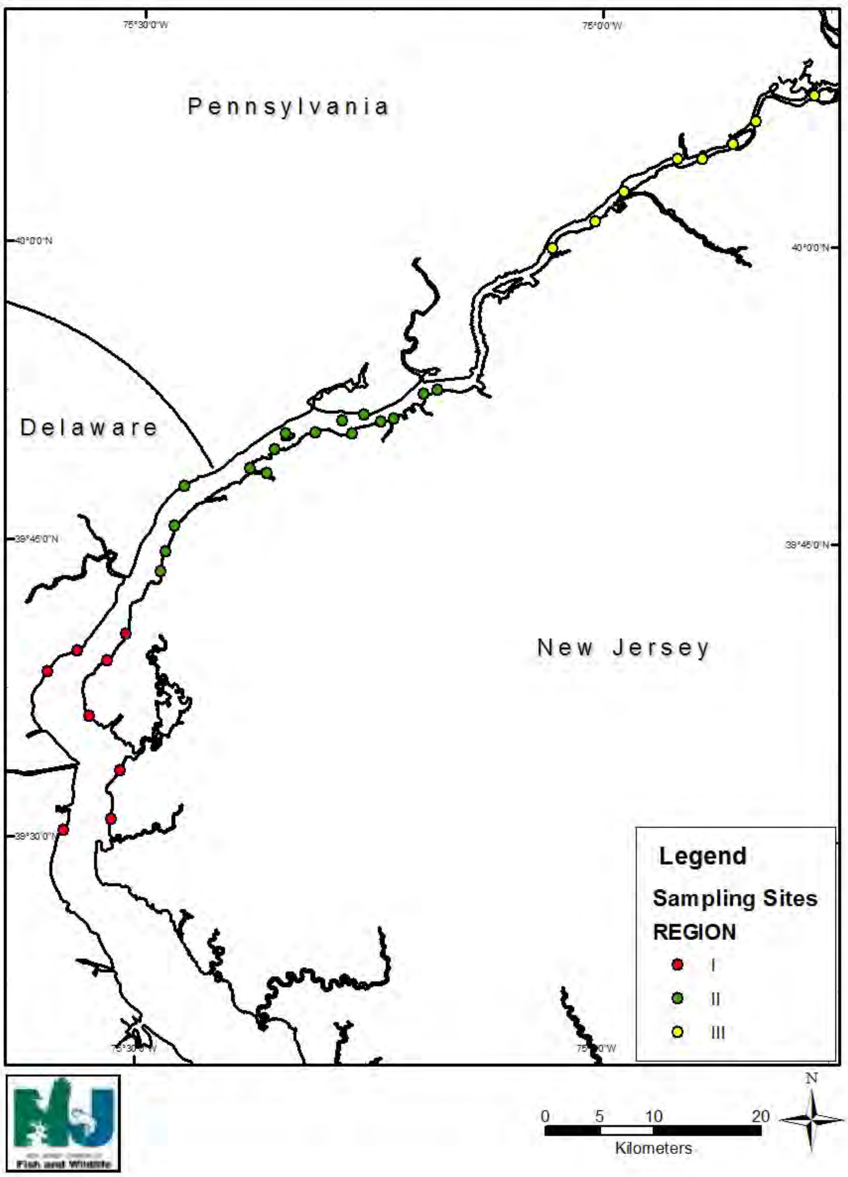


Figure 3. Striped Bass Seine Survey Locations

Table 1. Delaware River Recruitment Survey sampling station locations: 1980-2016

Region	Rivermile	Station Name	Station Code	Latitude	Longitude
1	54.2	Augustine Beach	29	3930.435	7534.617
1	55.4	Clay Beach	1	3930.955	7531.622
1	58.7	Oakwood beach	2	3933.418	7531.079
1	61.4	Fort Mott	3	3936.092	7533.155
1	63.4	Gambles Gut	4	3938.318	7535.886
1	65.9	New Castle	5	3939.422	7533.984
1	66.2	Penns Beach	6	3938.908	7531.956
1	66.3	Pennsville	35	3938.987	7531.907
1	67.7	Churchtown	7	3940.246	7530.790
2	70.9	Helms Cove	30	3942.847	7528.722
2	71.9	South Penns Grove	33	3944.566	7528.172
2	73.0	Rodneys Hideout	8	3944.425	7528.261
2	74.8	Oldmans Point	9	3945.758	7527.693
2	77.6	Naaman Creek	10	3947.762	7527.136
2	80.7	Raccoon Creek	11	3948.668	7522.871
2	82.4	Old Canal Corner	12	3949.610	7521.241
2	83.5	Chester Island	13	3950.393	7520.542
2	84.9	Sand Ditch	14	3950.531	7518.672
2	86.1	South Tinicum Island	36	3951.222	7518.076
2	86.9	Tinicum Island	15	3951.132	7516.836
2	87.5	Tinicum Island (NE; Pa SIDE)	16	3951.270	7516.360
2	87.6	Bramell Point	31	3950.487	7516.162
2	88.5	UPS Beach	17	3951.443	7515.407
2	88.9	Paulsboro	34	3951.031	7514.671

2	89.0	Billingsport	18	3951.058	7514.360
2	89.8	Mantua Creek	19	3951.175	7513.500
2	90.8	Riverwinds Beach	37	3951.706	7512.635
2	92.6	Pebble Beach	20	3952.498	7511.577
2	93.4	Eagle Point	21	3952.685	7510.647
3	105.8	Pennsauken Creek	22	3959.890	7503.186
3	108.8	Pompestron Creek	23	4001.237	7500.397
3	111.8	Hawk Island	24	4002.720	7458.514
3	114.8	Cornwells Heights	25	4004.415	7455.069
3	116.5	Edgewater Park	26	4004.365	7453.400
3	118.5	Burlington Island	27	4005.222	7451.395
3	120.4	Landreth Channel	28	4006.276	7449.950
3	125.4	Newbold Island	32	4007.671	7446.070

7.4 NJ F-15-R Relative Abundance of Selected Finfish Species in Delaware Bay

The New Jersey Division of Fish and Wildlife initiated an estuarine finfish sampling program in Delaware Bay in 1991 to identify and develop relative abundance estimates for finfish utilizing this estuary. The estimated year class strength of important finfish and the creation of a time series provide data necessary to assess trends in relative abundance for select species, assess spawning success via juvenile abundance and assess the effects of various management strategies instituted for these species.

Sampling is conducted monthly from April to October at eleven fixed stations on the New Jersey side of Delaware Bay (Figure 4, Table 2). The area sampled ranges from the Villas in Cape May to the mouth of the Cohansey River. All samples collected during this program are taken on shoals located near shore.

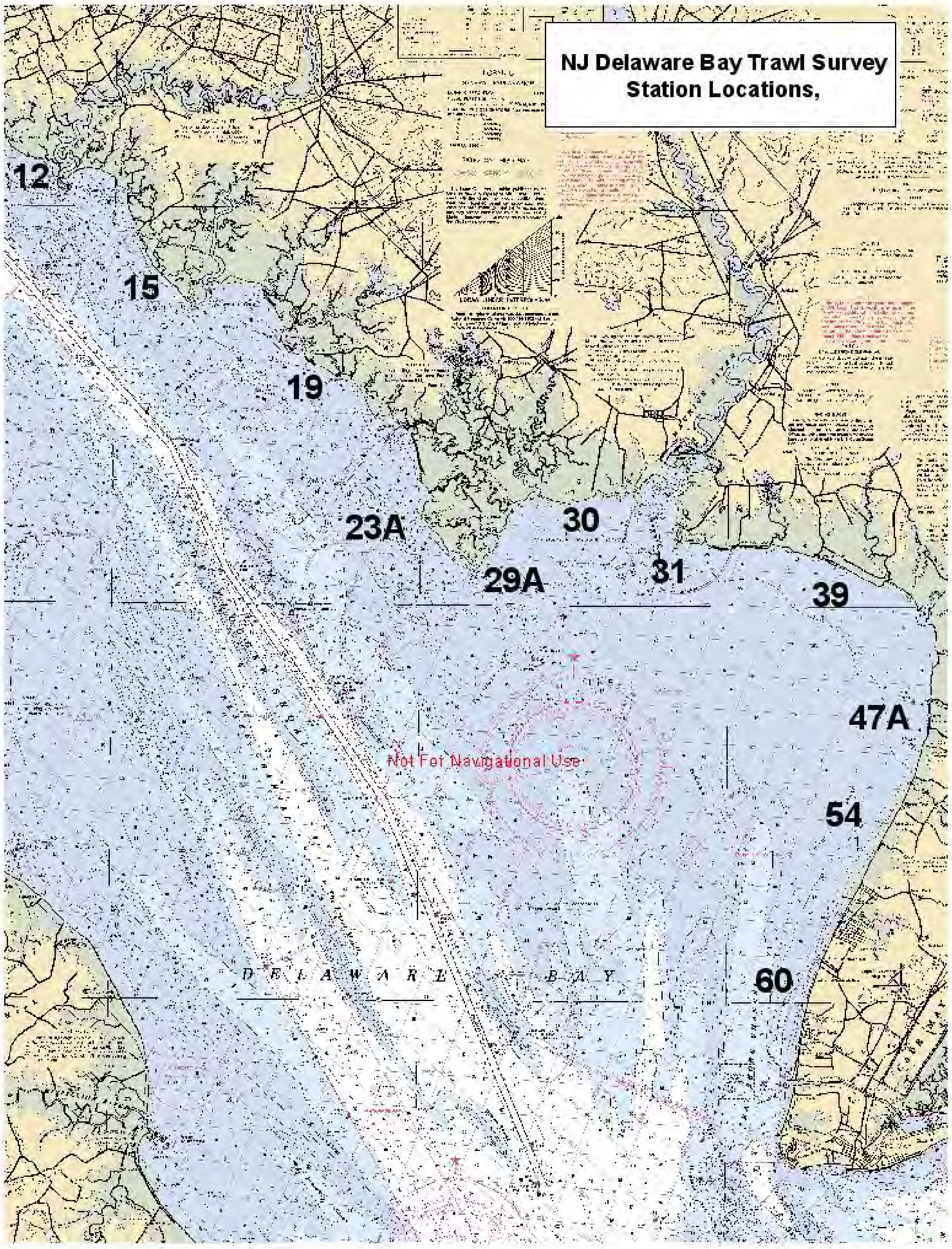


Figure 4. Delaware Bay Trawl Station Location Chart:

A 4.9-m (16-foot) otter trawl with a 3.8 cm (1.5 inch) stretch body mesh and 3.2 cm (1.25 inch) stretch mesh in the cod end is used for sampling. The cod end is lined with a 1.3 cm (0.5 inch) knotless stretch mesh net. The headrope is buoyed with several can-shaped molded fish net floats. The bottom of the net's mouth is weighted with a 0.3 cm (0.125 inch) galvanized chain looped along the footrope. The door dimensions are 30.5 cm (12 inches) x 61.0 cm (24 inches) and were constructed of 1.9 cm (0.75 inch) marine plywood with 1.3 cm (0.5 inch) by 5.1 cm (2 inch) steel shoes. The doors are attached to 1.6 cm (0.625 inch) twisted three strand nylon towlines, by a 0.5 cm (0.188 inch) galvanized chain bridle with 1.0 cm (0.375 inch) swivels.

Single ten-minute tows are conducted against the prevailing tide at each station. All stations are sampled once during the second or third week of the month. The engine tow speed is usually set depending on tidal velocity, to maintain a speed-over-ground of approximately 3.9 km/hr (or 2.1 knots). Speed-over-ground, tow distance and depth are monitored using a Garmin 2010 GPS Receiver/Depthfinder. Engine speed is constantly monitored and adjusted during the sampling period to maintain trawl speed. The estimated distance towed (nautical miles) is calculated from the average speed over ground (knots) and multiplying it by the duration (in hours) of each tow (Distance = Speed x Time).

On board the trawl net is manually deployed with 60 feet of towline tied to the stern cleats and retrieved with the towlines being spooled through blocks at the end of a 4.6 m (15 foot) A-frame made of 7.62 cm (3 inch) inside diameter aluminum, marine grade pipe. On retrieval, the A-frame and net are hauled at the transom using a Gearmatic GH5 Hydraulic Winch installed on the mast located aft of the wheelhouse bulkhead. The cod end of the net is manually retrieved and the contents emptied onto a sorting table affixed to the stern of the vessel.

All fish collected are identified to the lowest possible taxonomic level, enumerated and measured to the nearest millimeter. When large numbers (>50) of a single species are taken, fifty individuals were randomly selected and measured. Annual relative abundance (catch per tow = c/t) for all species combined and for each single species are calculated as the total number of individual fish collected over the total number of tows.

Table 2. Approximate coordinates of Delaware Bay trawl stations

Station	Latitude	Longitude
12	39 20.72	75 22.10
15	39 18.14	75 18.41
19	39 15.89	75 13.28
23A	39 12.27	75 10.16
29A	39 11.47	75 07.49
30	39 12.52	75 05.10

31	39 11.48	75 02.22
39	39 10.80	74 56.05
47A	39 07.09	74 53.59
54	39 04.58	74 55.18
60	39 00.57	74 57.32

7.5 NJ F-15-R Artificial Reef Monitoring

Epifaunal colonization on artificial reefs is assessed by remotely operated vehicle (ROV) or underwater video camera and scuba diving to determine colonization rates over time. Utilization by demersal fishes is assessed by determining the relative abundance through tagging studies to determine reef site fidelity and through food habitat studies.

Monitoring the recreational use of reefs is an intricate part of reef management and the ultimate indicator of how successful reef construction efforts are. The use of mail, internet and phone surveys as well as boat counts and other methods is utilized to assess angler catch rates and utilization of reefs. These types of studies in addition to socio-economic surveys are paramount to proper reef management.

7.6 NJ F-15-R River Herring Abundance Survey

The New Jersey Division of Fish and Wildlife initiated a river herring sampling program targeting alewife and blueback herring in 2013. The survey was initiated in order to develop a better understanding of adult river herring abundance and spawning success in the sampled watersheds. From 2013 to 2014 the survey was conducted in the tidal and freshwater regions of the Rancocas Creek and Maurice River. In 2015 the Rancocas Creek was dropped from the survey in order to add the Great Egg Harbor River as a new sampling location (Figures 5-8).

Sampling is conducted on a weekly basis for adult river herring in each river system from March through May. Anchored gillnets measuring 141' x 6' x 3" stretch mesh are deployed at two locations in each river representing the freshwater/saltwater interface as well as full freshwater. Sets range from 90 to 120 minutes in duration and are made perpendicular to the shoreline whenever possible. River herring are counted and measured by fork length (mm), total relaxed length (mm), sex, and inspected for ripeness. All other species are counted and a total length (mm) of the smallest and largest individual are recorded. Air temperature, water temperature, salinity, dissolved oxygen, pH weather conditions, wind speed and direction, moon phase, percentage of cloud cover, and tide are recorded.

Sampling for juvenile river herring was initially conducted on a weekly basis from June through October for each river system from 2013-2015. After a thorough review of the data, sampling was adjusted to a biweekly basis with the river systems being sampled on alternating weeks. Field sampling utilizes a bagged, 100' x 6" x ¼" mesh beach seine. The seine is set by boat in nearshore waters normally less than six feet in depth and immediately hauled on shore once the set is complete. All target species, including river herring, are counted and measured (fork length, mm). In cases of large samples, target species are counted and a sub-sample of 30 randomly selected individuals are measured. All other species are counted and a total length (mm) of the smallest and largest individual are recorded. Air temperature, water temperature, salinity, dissolved oxygen, pH weather conditions, wind speed and direction, moon phase, percentage of cloud cover, and tide are recorded.

Since 2013, all survey activities have been accomplished with no Atlantic sturgeon, shortnose sturgeon or sea turtles caught or seen during the entire time series (Table 3 & 4).

Table 3. River Herring Survey Sturgeon Interactions, Gill net

Year	Rancocas Creek			Maurice River			Great Egg Harbor River		
	# Sets	# River Herring	# Sturgeon	# Sets	# River Herring	# Sturgeon	# Sets	# River Herring	# Sturgeon
2013	16	11	0	8	14	0	-	-	-
2014	24	71	0	24	66	0	-	-	-
2015	-	-	-	20	40	0	20	82	0
2016	-	-	-	22	77	0	22	250	0
Totals	40	82	0	74	197	0	42	332	0

Table 4. River Herring Survey Sturgeon Interactions, Seine Net

Year	Rancocas Creek			Maurice River			Great Egg Harbor River		
	# Sets	# River Herring	# Sturgeon	# Sets	# River Herring	# Sturgeon	# Sets	# River Herring	# Sturgeon
2013	68	441	0	89	450	0	-	-	-
2014	89	7611	0	98	1547	0	-	-	-
2015	-	-	-	93	1028	0	119	1140	0
2016	-	-	-	43	144	0	63	390	0
Totals	157	8052	0	323	3169	0	182	1530	0

Figure 5. Gill net sampling locations on the Maurice River sampled bi-weekly March 16th through May 25th 2016.

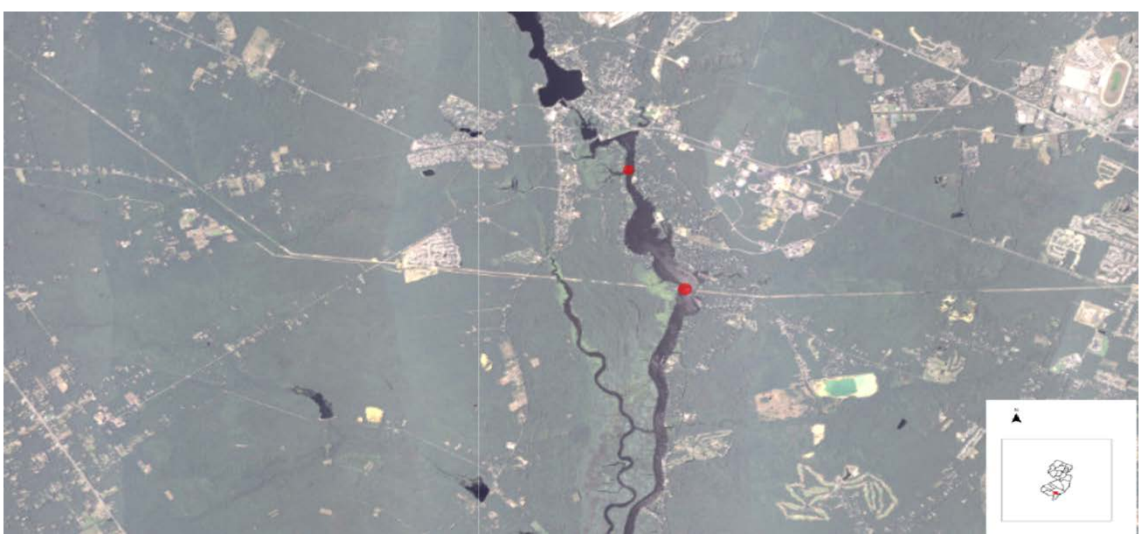


Figure 6. Gill net sampling locations on the Great Egg Harbor sampled bi-weekly March 16th through May 25th 2016

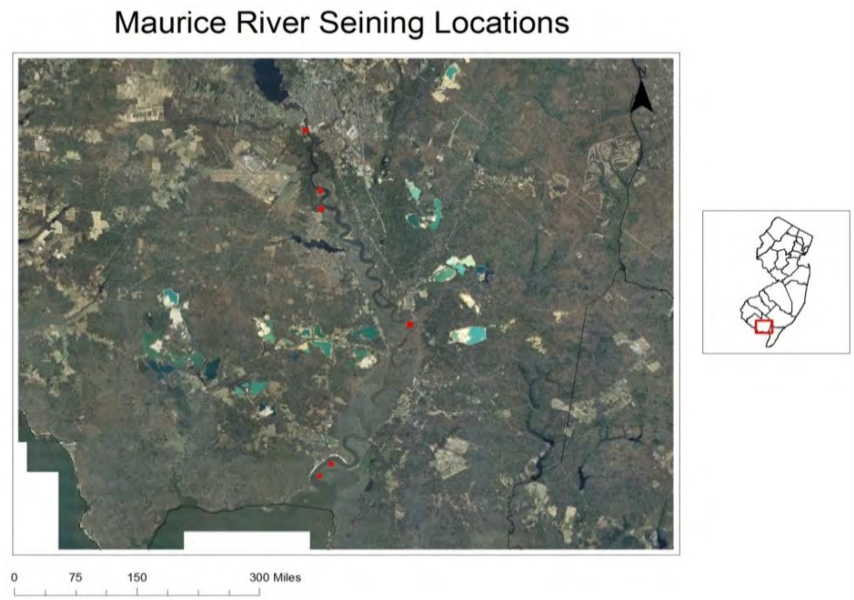


Figure 7. Beach seining locations on the Maurice River sampled bi-weekly July 6th through October 25th 2016.

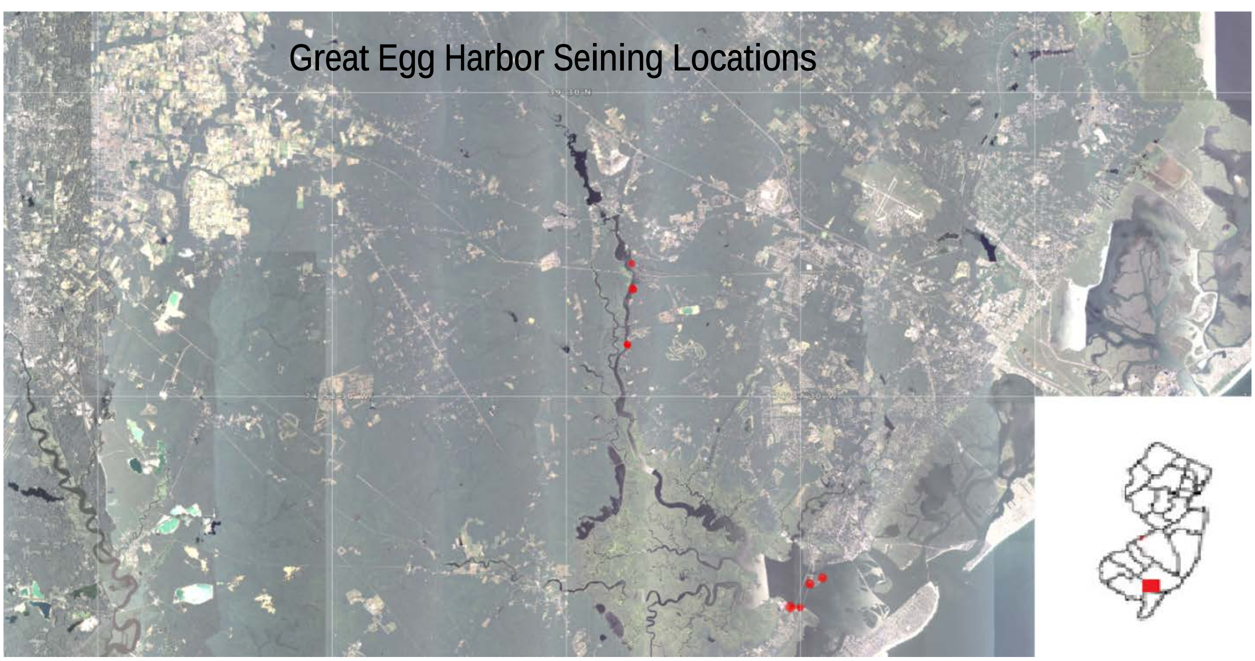


Figure 8. Beach seining locations on the Great Egg Harbor sampled bi-weekly July 6th through October 25th 2016

7.7 *NJ F-48-R Protection and Restoration of Inland Fisheries and Aquatic Habitats- Invasive Species Assessments*

Procedure for Limiting the Spread of Invasive Fish and Aquatic Macrophyte Species:
a) Promote public awareness and the reporting of invasive fish and macrophyte species.
b) Confirm reported sightings and maintain a database of documented occurrences that can be mapped using GIS.
c) Monitor sites where invasive species have been previously documented.
d) Removal of invasive species when encountered during routine sampling.
e) Develop site specific invasive species management plans and, where practical and after additional consultation with USFWS, implement plans.
f) Staff training, which may include taking courses offered by AFS (i.e. Planning & Executing Successful Rotenone & Antimycin Projects), USFWS, and NJDEP Pesticide Control Program, and participate in eradication projects conducted in other states.
g) Develop policies, procedures, and/or regulations as needed to prevent or control the introduction and spread of invasive fish species.

Surveys in the Delaware River were only performed from 2012-2017 using an electrofishing boat.

7.8 *NJ F-48-R Assessment of the Biological Integrity of Inland Fisheries- Warmwater Species Assessments*

Surveys conducted in non-wadeable streams use a commercially built electrofishing boat and/or gill nets (experimental type, dimensions dependent upon species and size of fish targeted) deployed in deep sections of river. The length of sampling reach is determined by the size of the river. Surveys to assess anadromous clupeid fisheries may also use cast nets and fyke nets. Fish collected are enumerated by species, length and weight measurements may be taken as well as scales (for aging) or tissue samples (for genetic analysis).

Fish marking techniques (such as fin-clips, jaw tags, branding, anchor tags, visible implant tags, coded wire tags, PIT tags, and biotelemetry devices) may be used to evaluate specific fisheries to determine fish movement and population statistics. When using chemicals to anesthetize fish, only those approved for use by FDA are used and the label requirements are followed. Fish are marked in the hatchery prior to release or collected from streams, ponds, and lakes using sampling gear described above. Endangered fishes will not be marked without additional consultation with USFWS.

Surveys in the Delaware River were only performed from 2012-2017 using an electrofishing boat.

7.9 *NJ F-48-R Assessment of the Biological Integrity of Inland Fisheries- Anadromous Species Assessments*

Surveys conducted in wadeable streams generally use electrofishing gear (one or more backpack electrofishers or a generator positioned on land or in a barge with 2-3 hand-held anodes).

Surveys conducted to assess anadromous clupeid fisheries may also employ seines and dip nets. Fish collected are enumerated by species, length and weight measurements may be taken as well as scales (for aging) or tissue samples (for genetic analysis). Physicochemical parameters (water temperature, dissolved oxygen, pH, alkalinity, conductivity, specific conductance, and stream width, depth, and substrate type). The EPA Rapid Bio-assessment sampling habitat assessment protocol is used to assess in-stream habitat and riparian conditions (Barbour et al. 1999) with regional modifications (Kurtenbach 1994). A complete description of the sampling procedures used on wadeable streams is in New Jersey's Coldwater Fisheries Management Plan (Hamilton and Barno 2005). Surveys to specifically assess the status of trout populations nearly 200 trout production streams are conducted from mid-June to mid-September according to a rotating schedule (sampled at least once every 20 years). Surveys for surface water classification purposes are conducted in July and August. Surveys to assess anadromous clupeid spawning areas are conducted March – June (depending on water temperature and stream flow).

Surveys conducted in non-wadeable streams use a commercially built electrofishing boat and/or gill nets (experimental type, dimensions dependant upon species and size of fish targeted) deployed in deep sections of river. The length of sampling reach is determined by the size of the river. Surveys to assess anadromous clupeid fisheries may also use cast nets and fyke nets. Fish collected are enumerated by species, length and weight measurements may be taken as well as scales (for aging) or tissue samples (for genetic analysis).

Fish marking techniques (such as fin-clips, jaw tags, branding, anchor tags, visible implant tags, coded wire tags, PIT tags, and biotelemetry devices) may be used to evaluate specific fisheries to determine fish movement and population statistics. When using chemicals to anesthetize fish, only those approved for use by FDA are used and the label requirements are followed. Fish are marked in the hatchery prior to release or collected from streams, ponds, and lakes using sampling gear described above. Endangered fishes will not be marked without additional consultation with USFWS.

Surveys in the Delaware River were only performed from 2012-2017 using an electrofishing boat.

8.0 Pennsylvania

The State of Pennsylvania carries out three studies with the funds in waters where NMFS listed species are present. These are: (1) Estimate of Black Bass Population Density; (2) Species Occurrence Determination; and, (3) Long Term Fish Population Monitoring and Management Technique Evaluations.

8.1 PA F-57-R Estimate of Black Bass Population Density

The Pennsylvania Fish and Boat Commission has been collecting data on adult black bass from our major rivers nearly annually since 1982. These surveys are conducted to monitor population trends to changes in a variety of biotic and abiotic factors including, but not limited to, changes in angling effort, regulations, pollution events, and climatic events. These data help to inform biologists when making management decisions as well as help managers to inform the public with respect to realistic expectations when it comes to recreational angling activities. The Pennsylvania Fish and Boat Commission conducts this type of sampling on both the Delaware River and Estuary and the Susquehanna River. While the Pennsylvania Fish and Boat Commission has had minimal contact with shortnose sturgeon in the Delaware system, we have never collected shortnose or Atlantic sturgeon in the Susquehanna River system within the boundaries of Pennsylvania.

The objectives of the study are to:

1) Estimate density of black bass per hour of electrofishing effort (CPE) and per meter of shoreline (or track) sampled. Omissions have been detected in distance sampled in data fields in the ARDB.
2) Document any changes in density or trends in density through time.
3) Estimate age structure and compare to year class strength index. (Draft completed, edits in progress).
4) Waters sample should include waters where historic time series data has been collected and manager indicated they would sample the site/water in 2005 (see Table 1 attached). Sampling should focus upon the Susquehanna Basin with sites on Ohio Basin and Delaware Basin sampled for comparative examination. Sites can be added or expanded without consultation. Randomly selected new sample sites are imperative if other professionally defensible reasons for sampling are not requisite.
5) Area Fisheries Manager (AFM) insights and question should be communicated early and broadly discussed within the Division.
6) Record disease incidence of black bass and other species by length or size group.

Sampling takes place from a flatbottom boat equipped with bow safety railing, outboard, fuel tank, navigation lights, fish collection lights, and oars.

Only waters that have been historically sampled are selected with an emphasis on the waters with the lengthiest series of historic data. Sampling takes place from July through mid-September during the same time under similar sampling conditions as historic collections. Primary target species include all sizes of black bass (smallmouth bass primarily) including young of year.

Sampling of other fish species is secondary. Secondary targets included: rock bass, sander spp, and esocids. Any diseased fish of any species (catfish, carp, fallfish) are collected, measured, and anomaly or disease noted as for target species. A total of between 75 and 100 smallmouth bass (Age 1+ and older) are collected and measured per site sampled. A dual set of droppers (4) affixed to two booms is used to make all collections. Voltage, amperage (or watts) and pulse width (for those with variable pulse width) should be adjusted to deliver between 3 and 6 amps of current to the anode array. Two bow netters collect stunned targets and secondary targets.

8.2 PA F-57-R Species Occurrence Determination

During the early 1980's the Pennsylvania Fish and Boat Commission structured their Fisheries Management Division into regions. At that time, regional managers were able to focus sampling efforts on more waters in their region of responsibility. As part of the efforts by the regional managers to learn more about the waters with which they were responsible for managing, floating and sinking gill nets were fished in the Delaware Estuary between River Miles 78.83 (Pennsylvania/Delaware state line) and 133.43 (Trenton Falls) from 1982 – 1987. Since 1987 there have been no gill nets fished by the Pennsylvania Fish and Boat Commission in the Delaware Estuary. No future gillnet surveys by the PA Fish and Boat Commission are proposed for funding by FWS.

8.3 PA F-57-R Long Term Fish Population Monitoring and Management Technique Evaluations

As required by the ASMFC, the PFBC began yearly sampling of the Delaware River striped bass spawning stock in 1992. This was done in conjunction with the sampling efforts of Delaware and New Jersey as part of the overall monitoring of the striped bass population recovery along the east coast. Electrofishing index sites were evaluated in 1994 and 1995, with 21 sites established in 1995.

Daytime flatbottom boat electrofishing is conducted in the Delaware Estuary from Rancocas Creek in Burlington County, New Jersey (R.M. 109.76) downstream to the Commodore Barry Bridge in Chester, Pennsylvania (R.M. 81.77). Twenty-one (21) index sites between Rancocas Creek and the Commodore Barry Bridge are used to develop an index of spawning striped bass abundance and are sampled twice during the spawning period.

The electrofishing boat is rigged with a pair of fixed boom electrodes. Each boom supports four dropper style copper anodes arranged in a square array. The electrical power source is a 5,000-watt Honda generator combined with a Smith-Root model GPP electrofisher. The electrofishing unit is typically operated within the range of 6 amps to 7 amps of pulsed DC output and in water typically ranging from 3 to 10 feet in depth. Electrofishing is conducted by traveling in a serpentine pattern with the tidal flow.

Each index site (21) electrofishing run has a duration of 1,000 seconds as recorded on the electrofishing unit. This represents the period of time electric current is discharged into the water. The combined total index site sampling effort is 11.7 hours annually. In instances where striped bass are common at a particular index site and the 1,000-second electrofishing effort is complete additional electrofishing may be conducted as a spatial extension of the index site.

9.0 Delaware

9.1 DE F-75-R Tidal Largemouth Bass Monitoring Program

Largemouth bass have been sampled in freshwater portion of the Nanticoke River via fall (September/October) electrofishing since 1989. Sampling was conducted annually between 1989 and 2004 but was conducted only bi-annually (even number years) beginning in 2006. This is a large system so sampling has been conducted using a stratified random design. During sampling events, the mainstem Nanticoke River from the Delaware/Maryland state boundary to Middleford, Delaware on the Nanticoke Branch and the downstream 1.5 km section of Deep Creek, a headwater tributary, was divided into three segments. Broad Creek was divided into two segments between its junction with the mainstem Nanticoke and the town of Laurel (Figure 2). Each segment was further divided into five sections of similar length, and then separated into the north and south shores. Half of the resulting ten sections within each segment were sampled, resulting in the collection of fish from 25 of the 50 established sections, five per segment. The first shoreline to be sampled within a segment, either north or south shore, was selected randomly by coin toss. Sampling started at that point and continued to the end of the first section. The next section was sampled on the opposite shore. Subsequent sections were then sampled alternating from shore to shore with five sections (one segment) sampled during each day. A pulsed-DC, boat-mounted electrofisher (MBSTM-1D pulsed DC unit) cruised the shoreline in three feet of water typically traveling with the tide, and the pedal operator provided on and off bursts of current between 5-6 amps.

Largemouth bass were collected and held in an on-board, aerated livewell until a station was completed or the number of bass reached the livewell capacity. Fish were then measured for total length (TL in mm) and weight (g).

Additional Objective for 2018-Evaluate the seasonal movement and habitat use of 40 Largemouth Bass in the Nanticoke River system via acoustic tagging and tracking for 12-15 months.

Acoustic tagging of adult Largemouth Bass will provide information that is currently lacking regarding post-release movements as well as seasonal habitat use. A target number of bass (20 males and 20 females) will be surgically implanted with acoustic tags that record temperature and depth to improve the ability to pinpoint locations of detected fish. In addition, receivers will be placed within habitat suitable for spawning (up to 5 locations) to supplement the existing receiver array (n=20 receivers) that is being maintained for other Division projects using different grant sources. The bass will also be affixed with PIT tags and t-bar tags pre-spawn while sex can be determined and capture location is known. Bass will be collected via electrofishing in spawning areas in the spring or from bass tournaments. These bass will first serve as brood stock for the fingerling program and then prior to release they will be surgically implanted with Vemco Ltd V9-69hz acoustic tags using established tagging methods. Movement of released bass will be monitored via fixed acoustic receivers which will be downloaded monthly and via manual tracking at least two times per month to further examine seasonal habitat use.

The movement data will be used to assess dispersal behavior from a central release area and to evaluate return to original catch areas. It will also be used to identify important habitat in the river system that is utilized by reproductively valuable adult bass and that should be targeted for protection and restoration efforts. The identification (and generation of GIS maps) of these important areas could be used to guide land-use managers in habitat improvement, protection or restoration efforts. The maps would also facilitate implementing the work plan goals of the Fisheries Habitat Goal Implementation Team (http://www.chesapeakebay.net/managementstrategies/strategy/fish_habitat) which is part of the Chesapeake Bay Watershed Agreement, of which Delaware is a signatory.

The Nanticoke River bass population supports most of the state's freshwater tidal tournament activity, including multi-state and divisional tournaments, thus tournament derived data will be assessed. Existing data and literature that pertains to non-fishing related factors that can impact bass populations (such as land-use changes, water quality, and habitat condition) will also be assessed. These factors may play a large role in the decline in the abundance of the Nanticoke bass population. The population has been declining in recent years and identification of important habitat areas and movement patterns of the population will be used in conjunction with other data sets to determine appropriate management actions.

9.2 DE F-47-R Delaware River Striped Bass Spawning Stock Assessment

This assessment is conducted in the lower Delaware River from the Delaware Memorial Bridge at rkm 110 to the mouth of Big Timber Creek, NJ at rkm 152, which encompassed the main spawning grounds in the Delaware River. The spawning grounds were divided into lower and upper zones. The lower zone had twelve sampling stations and extended from rkm 110 at the Delaware Memorial Bridge to the boundary between the states of Delaware and Pennsylvania. The upper zone had thirteen sampling stations and extended from the Commodore Barry Bridge to rkm 152 at Big Timber Creek. The average station length was approximately 1.6 km and ranged from approximately 1.1 (Station 4P "Mobil Oil") to 2.2 km (Station 2P "Lower Monds Island"). However, the segment within each station sampled varied on any particular day depending on the direction of tidal current and fish abundance. Depth at each station ranged from 0.9 to 9.1 m. In addition to the shoreline stations, sampling was also conducted on Cherry Island Flats, a submerged island in the lower zone, as well as along Little Tinicum and Chester Islands in the upper zone.

Stations within the lower and upper zones of the spawning grounds were grouped into two categories based on average catch rates from the previous three years. Stations with catch rates below average were categorized as "poor" stations, while stations with average or above average catch rates were categorized as "good" stations. On each sampling day, five good stations and three poor stations were randomly selected from a given zone. Each of the upper and lower zones are typically sampled weekly throughout the spawning season, which generally extends from mid-April to late May or early June depending on water temperature. In addition to randomized collections, ancillary collections were made to increase the number of tags released and number of samples obtained for age and growth analysis.

Fish were collected using a Smith-Root, Inc. model 18-E boat electrofisher operated using pulsed direct current at 60 pps and 500 volts. Output amperage was kept within a range of 7.0 to 8.5

amps. The standardized sampling time at each station was 720 seconds of pedal time. The boat was operated moving with the tidal current in a serpentine-shaped pattern. Only fish approximately >200 mm total length (TL) were collected. Fish <200 mm TL, which are typically immature and not yet recruited to the spawning population, generally pass through the mesh of dip nets used aboard the electrofishing boat. Captured fish were held in an onboard, flow-through, 280 liter live-well until the station was completed or the live-well was deemed full.

All sexually mature fish were measured to the nearest mm TL. Sex was determined by the expression of milt by palpation of the gonadal region of the abdomen, obvious outward appearance, or presence of eggs. The condition of females was also noted as gravid or spent when apparent. Only sexually mature fish were included in total catch or catch rate calculations. All fish in good physical condition were tagged with a numbered internal anchor tag as part of the coast-wide tagging program coordinated by the FWS.

9.3 DE F-47-R Nanticoke River Juvenile Shad Seine Survey

Fisheries-independent monitoring requirements for the Nanticoke River include an annual juvenile fish survey for shad and river herring to establish a juvenile index of abundance. Four permanent seine sites will be sampled biweekly from July through October with a 45.7-m long x 3.0-m deep haul seine consisting of 6.35-mm nylon netting. One end of the net will be anchored to the shoreline while the remainder of the net is set in a semicircle pattern. All alosines will be identified, enumerated, and a sample of 90 individuals measured for total length. A sub-sample of the juvenile shad caught during monitoring will be examined for oxytetracycline marks on the otolith to determine what proportion of the present juvenile stock are of hatchery origin.

9.4 DE F-47-R Nanticoke River Adult Shad Boat Electrofishing

Sampling for adult American and Hickory Shad will be conducted to establish an annual adult shad index for the upper Nanticoke River and Deep Creek, a major tributary to the Nanticoke River. The methodology used for the collection of shad to establish an adult index will be the boat electrofishing used during the brood stock collection and eliminates the need for additional sampling to be conducted on the tributaries to determine an index of abundance. Sampling will be conducted from March through May. In addition to establishing an abundance index for adult shad, this work also will provide length and sex data, as well as scale samples necessary for the characterization of the adult population.

9.5 DE F-47-R Christina RiverJuvenile Alosid Survey

Boat electrofishing for adult American Shad, Hickory Shad and river herring during the spring spawning run will be used to observe presence or absence upstream and downstream of dams that have been removed, or are scheduled for removal. The electrofishing vessel used on the Delaware River and the electrofishing raft used on the Nanticoke River (Activity 1 & 3) will be used to sample shad and river herring in these New Castle County tributaries. Sampling will be limited in scope, (2 days or less of effort on one tributary) and will encompass peak run periods for anadromous species, and will occur in March and again in April when water temperatures typically range from 13-20° C. Electrofishing is an extremely effective sampling method in the Christina system. The number of alosines captured per amount of time electrofishing will be used to determine relative abundance reported as CPUE.

Five permanent seine sites will be sampled biweekly from July through October with a 45.7-m long x 3.0-m deep haul seine consisting of 6.35-mm nylon netting to sample juvenile alosines . One end of the net will be anchored to the shoreline while the remainder of the net is set in a semicircle pattern. All alosines and by-catch will be identified and a sub sample of up to 90 individuals of each alosine species will be measured for total length, with others being enumerated. A juvenile index of relative abundance for each species will be produced by calculating the geometric mean using a logarithmic transformation of the arithmetic mean number taken per seine haul.

9.6 DE F-37-R Stream and Tidal Tributary Fish Survey

Sixty-five sites located in the coastal plain of Delaware will be sampled for fish presence/absence with habitat types recorded. Physical characteristics of sampling locations such as maximum depth, stream width, and aquatic and shoreline vegetation will be noted. These metrics will be used to describe habitats and evaluate relationships between habitat and species composition. Gears similar to those used in previous sampling were given preference for comparative purposes.

Survey gear types employed will be otter trawl (tidal portions of coastal plain rivers) and electrofishing gear (headwater areas) as these gear types have been employed before at these or similar locations (Shirey 1991, Clark 2003, Martin 2013). A 40-foot seine may be used in cases where trawl and electrofishing equipment are compromised (i.e. no boat access, high conductivity).

Sampling in ensuing years will occur in the Inland Bays (n=40), Piedmont region (n=42), Nanticoke River watershed (n=34), and the Chesapeake Bay tributaries which lie in the State of Delaware (n=18).

9.7 DE F-42-R Coastal Finfish Assessment Survey

The Delaware Division of Fish & Wildlife conducts two distinct trawl surveys to monitor fish abundance in the Delaware Estuary and Delaware's Inland Bays (Indian River and Rehoboth Bays). The 16-foot trawl survey, which has been consistently conducted since 1980, is primarily used to monitor juvenile fish abundance. The 30-foot trawl survey, conducted from 1966 – 1971, 1979 – 1984, and from 1990 – present, is primarily used to monitor sub-adult and adult fish abundance. The indices generated from these surveys are used in the development of interstate fishery management plans and stock assessments. Most notably, the surveys are / were used in the weakfish (*Cynoscion regalis*), striped bass (*Morone saxatilis*) and summer flounder (*Paralichthys dentatus*) fishery management plans and stock assessments. In addition, data from the surveys are used in establishing time of year restrictions for beach replenishment, dredging, and other marine work. The surveys also serve as platforms for collecting specimens for researchers studying genetics, tissue contaminants, age and growth, food habits, etc.

Though the size of the nets differs in each survey, both are bottom trawls designed to collect a wide variety of species. Sampling with the 16-foot trawl is conducted monthly from April through October at 39 fixed stations in the Delaware Estuary and 12 fixed stations in the Inland Bays. Sampling with the 30-foot trawl is conducted monthly from March through December at nine fixed station in the Delaware Bay. Occasionally, some sampling is missed due to vessel problems or weather.

9.7.1 DE F-42-R Bottom Trawl Sampling of Adult Groundfish in Delaware Bay

The objective of this study is to monitor trends in abundance and distribution; to determine population age/size composition and develop pre-recruitment indices for selected inshore finfish species.

Efforts were made to replicate sampling and gear protocol of previous 30-foot trawl surveys conducted in the Delaware Bay by Abbe (1967), Daiber and Wockley (1968), Daiber and Smith (1972), and Smith (1987). Retired University of Delaware research vessel captain Tom White served as consultant to the project, making the necessary gear adjustments to ensure consistency. In addition, several members of the biological staff served onboard the previous (1979 – 84) survey and were on hand during the testing phase to further ensure catches were sampled correctly and the gear was fished properly. Data forms from the previous surveys were used, to ensure the data was entered on computer in matching formats and the data base maintained. Early sampling was conducted with the University of Delaware's research vessel "Wolverine" – a 47-foot (14.3- m) A-framed stern trawler. Sampling from March 1990 through July 2002 was conducted using the 65-foot (20-m) research vessel "Ringgold Brothers". The "Ringgold Brothers" was a wooden displacement-hulled skipjack converted to power and was equipped with an eastern-rigged trawling system that deployed and retrieved the trawling gear from the starboard side. The State of Delaware purchased a custom-built stern-rigged research vessel which began service as the survey's research platform in August of 2002. The 62-foot (19-m) deep-'V' semi-displacement hulled research vessel, "First State", is equipped with an 'A'-frame stern trawling rig. A limited number of comparative tows were made using the two vessels; however, analysis has not been completed to date.

Tow durations in some of the previous surveys were 30 minutes; whereas, tow durations in the present survey were 20 minutes. Tows less than 20-minutes were rarely made (due to gear conflicts, etc.); however, in such cases, a 10- minute minimum tow time was required for the tow to be considered valid. Expansion of CPUE (Catch-per-unit-effort) calculations was not necessary for the purposes of this report, since the unit effort was expressed as distance towed.

The net used in the survey consisted of 3-inch (7.6-cm) stretch mesh in the wings and body, and 2-inch (5.1-cm) stretch mesh in the cod end. The trawl had a 30-foot 6-inch (9.3-m) x 1/2-inch (1.2-cm) headrope and a 39-foot 6-inch (12.0-m) x 1/2-inch footrope with 40-foot (12.2-m) leglines. The 54-inch x 28-inch (1.37-m x 0.71-m) doors were constructed of ¾-inch (1.9-cm) virgin pine lumber, bolted to a 2 inch x 4 inch (5.1cm x 10.2cm) strong back. The doors had a 2-inch x ¾-inch (5.1-cm x 1.9-cm) milled steel bottom shoe runner and ¼-inch (0.64-cm) galvanized chain bridles attached to ½-inch (1.3-cm) galvanized swivels at the head.

The lack of towable bottom required a fixed sampling scheme. Station locations from the previous surveys were used (Figure 1-1). There was some randomization in the selection of tow starting sites within each quadrant due to weather, currents and inaccuracy inherent with electronic positioning equipment. Station 51 was permanently relocated in 1998 to approximately 0.5 NM south of the original station location due to repeated gear fouling on a fixed obstruction.

A global positioning system (GPS) was used to determine exact vessel position at the start and conclusion of each tow. Odometer readings from the GPS unit were used to determine distance towed (nautical miles). Mean water depth was determined from fathometer readings taken at five minute intervals including the start and finish points of each tow. A line-out to depth ratio of 6:1 was maintained.

A Yellow Springs Instrument Co. Model 85 oxygen, conductivity, salinity and temperature meter was used to measure surface and bottom temperature (°C), dissolved oxygen (ppm) and salinity (ppt) at the conclusion of each tow.

Upon completion of each tow, the sample was emptied on the deck and sorted by species. Aggregate weights were taken for each species. Species represented by less than 50 individuals were measured for fork length to the nearest half-centimeter. Species with more than fifty individuals were randomly sub-sampled (50 measurements) for length with the remainder being enumerated. Horseshoe crabs (*Limulus polyphemus*) were sexed and measured for prosomal width. Blue crabs (*Callinectes sapidus*) were sexed and measured for carapace width. Certain elasmobranchs were not measured due to difficulty in handling.

Scales and otoliths for selected species were collected from a sample of the catch. Impressions of summer flounder and striped bass scales were made on acetate slides using a roller press or a heated hydraulic press. Weakfish otoliths (used at the recommendation of the ASMFC Weakfish Technical Committee) were cut using a Hillquist® thin sectioning machine and mounted on glass slides using Loctite ultraviolet adhesive (34391). Scale impressions and otoliths were independently aged using a microfiche projector by at least two individuals. Differences in ages were reviewed; if a consensus in age determination was not reached, the sample was discarded. January first birthdates were assumed for each species. Age-length keys were constructed and expanded by the monthly length-frequency distributions for each species. These expansions were applied to the annual relative abundance measures to calculate catch-at-age.

Data were coded, entered in electronic format and analyzed using SAS® software. Fish densities were calculated by dividing the number of individuals for a species by the distance towed (No. /NM) at each station sampled, then calculating arithmetic means and standard errors in the typical fashion.

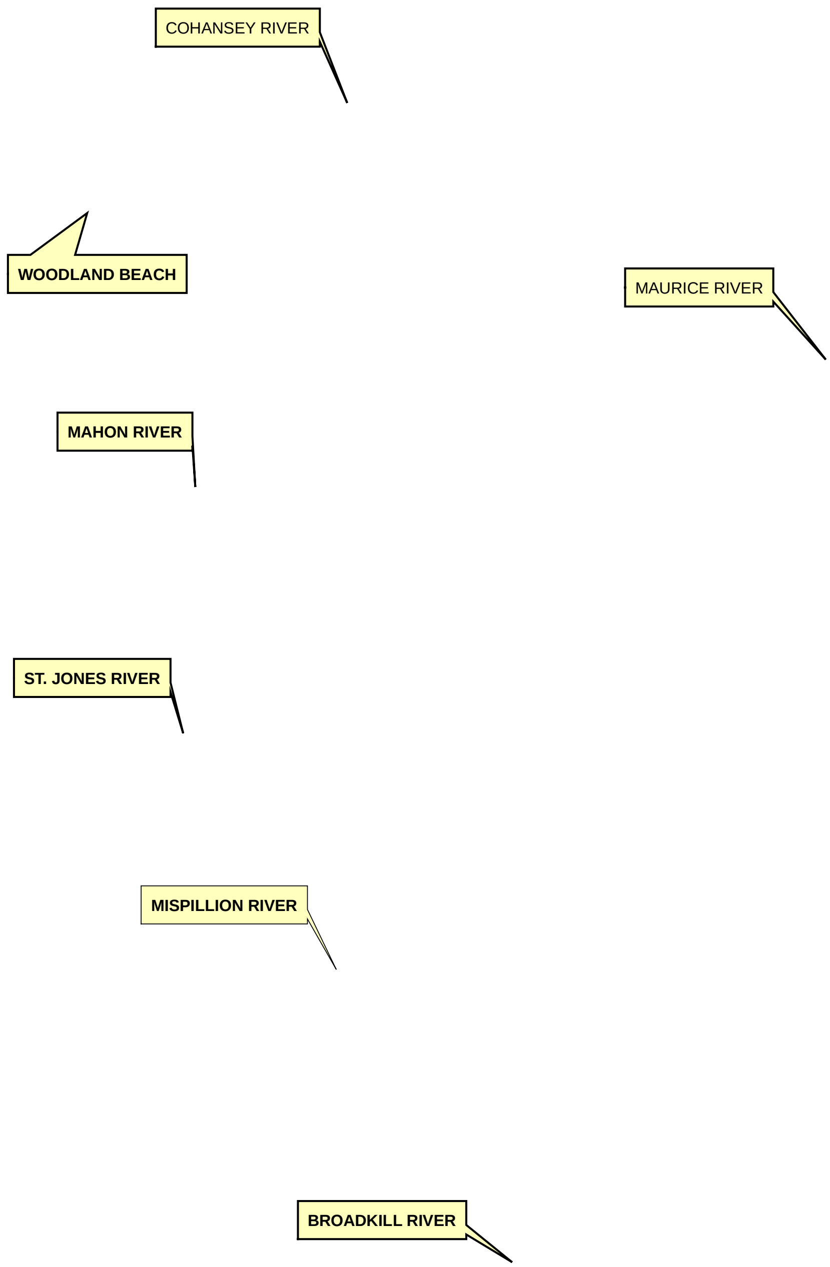


Figure 5. Stations currently with a 30-foot otter trawl in the Delaware Bay. Numbers indicate assigned station numbers.

9.7.2 DE F-42-R Bottom Trawl Sampling of Juvenile Fishes in Delaware's Estuaries

The objective of this study is to monitor trends in abundance and distribution and to determine year-class strength for a selected group of finfish.

Sampling was generally conducted aboard a 7-m (23-foot) Sea Ark aluminum 'V'-hull boat, powered by a 260-hp diesel Volvo Diesel I/O, from 1990 through 2003. A 7-m Mon Ark aluminum tri-hull boat, powered by a 260-hp Mercruiser I/O, was used from 1980 through 1989. On both vessels, the net was deployed and retrieved from the stern using a hydraulic winder. The R/V "First State", a custom-built 19-m (62-foot) deep-'V' semi-displacement hulled vessel equipped with two 641hp Daewoo V180 TIM, a hydraulic winch and an 'A' - framed boom, was used for the Delaware Estuary sampling in April 2003 and all sampling in subsequent years. The 7-m 'V'-hulled Sea Ark continued to serve as the survey's research vessel for the Inland Bays sampling. In October 1999, a 7-M (23-foot) fiberglass C-Hawk boat, powered by a 130-hp Honda outboard motor was used to complete sampling in the Delaware Estuary and Inland Bays due to mechanical problems with the survey's primary vessel. In this case, the net was deployed and retrieved by hand.

Sampling was conducted monthly from April through October at 33 stations in the Delaware Bay and six stations in the Delaware River above the Chesapeake and Delaware Canal in 2011 (Figure 2-1a and 2-1b). Twelve stations were sampled monthly in the Indian River and Rehoboth Bays (Inland Bays) (Figure 2-2). April sampling was missed in 2003 at station 22 in the Delaware Estuary and was permanently discontinued in July 2003 due to shoaling and draft considerations at the Mahon River entrance. Occasionally some stations have been missed due to extreme low water conditions or other navigational obstructions. There was no missed sampling in the 2011 survey.

The net used was a 4.9-m (16-foot) semi-balloon otter trawl. It consisted of a 5.2-m (17-foot) headrope and a 6.4-m (21-foot) footrope with a 3.8-cm (1.5-inch) stretch mesh number 9 thread body. A 1.3-cm (0.5-inch) knotless stretch mesh liner was inserted in the cod-end. Six evenly spaced 3.8-cm (1.5-inch) X 6.4-cm (2.5-inch) sponge floats were located on the bosom of headrope and 0.3-cm (0.125-inch) galvanized chain was hung loop style on the footrope. The doors measured 30.5-cm (12-inches) X 61-cm (24-inches) and were constructed of 1.9-cm (0.75-inch) marine plyboard with 3.18-cm (1.25-inch) X 0.64-cm (0.25-inch) straps and braces, 1.3-cm (0.5-inch) X 5.1-cm (2-inch) shoes, and 0.5-cm (0.188-inch) galvanized chain bridles, with 1.0-cm (0.375-inch) swivels. The bridle arrangement consisted of a single line of 0.64-cm (0.25-in) stainless cable attached to 30-m (100-foot) bridle warps of no-lay line.

Sampling at each station consisted of a ten-minute trawl tow, usually made against the prevailing tide. Occasionally, tows less than ten minutes were made in cases of unforeseen gear conflicts, draft considerations, etc. In such cases, tows were required to be at least five minutes in duration to be considered valid. Catches from short tows were standardized to ten minutes. Where only one individual of a species was collected in a short tow, no expansion was made. A 10:1 ratio of line-out was continually adjusted according to water depth.

The trawl was hauled over the stern and the catch was emptied on a sorting table upon completion of each tow. Finfish were sorted by species and enumerated. A representative subsample of 30 specimens per species was measured for fork length to the nearest half centimeter; the remainder were enumerated. Hogchoker, bay anchovy, cusk-eels and certain elasmobranches were not measured due to practical constraints in the field. Surface temperature (°C), salinity (ppt) and dissolved oxygen (ppm) were recorded at the beginning of each tow. Tidal stage, weather conditions, water depth and engine speed were recorded for each station at the start of each tow.

Data reduction included monthly and annual summaries of the catch including a listing of species collected, total number of each species taken, mean catch per tow (C/f) and standard deviations. Mean C/f was defined as the sum of the number of individuals for a given species divided by the total number of ten-minute tows in a given month or year.

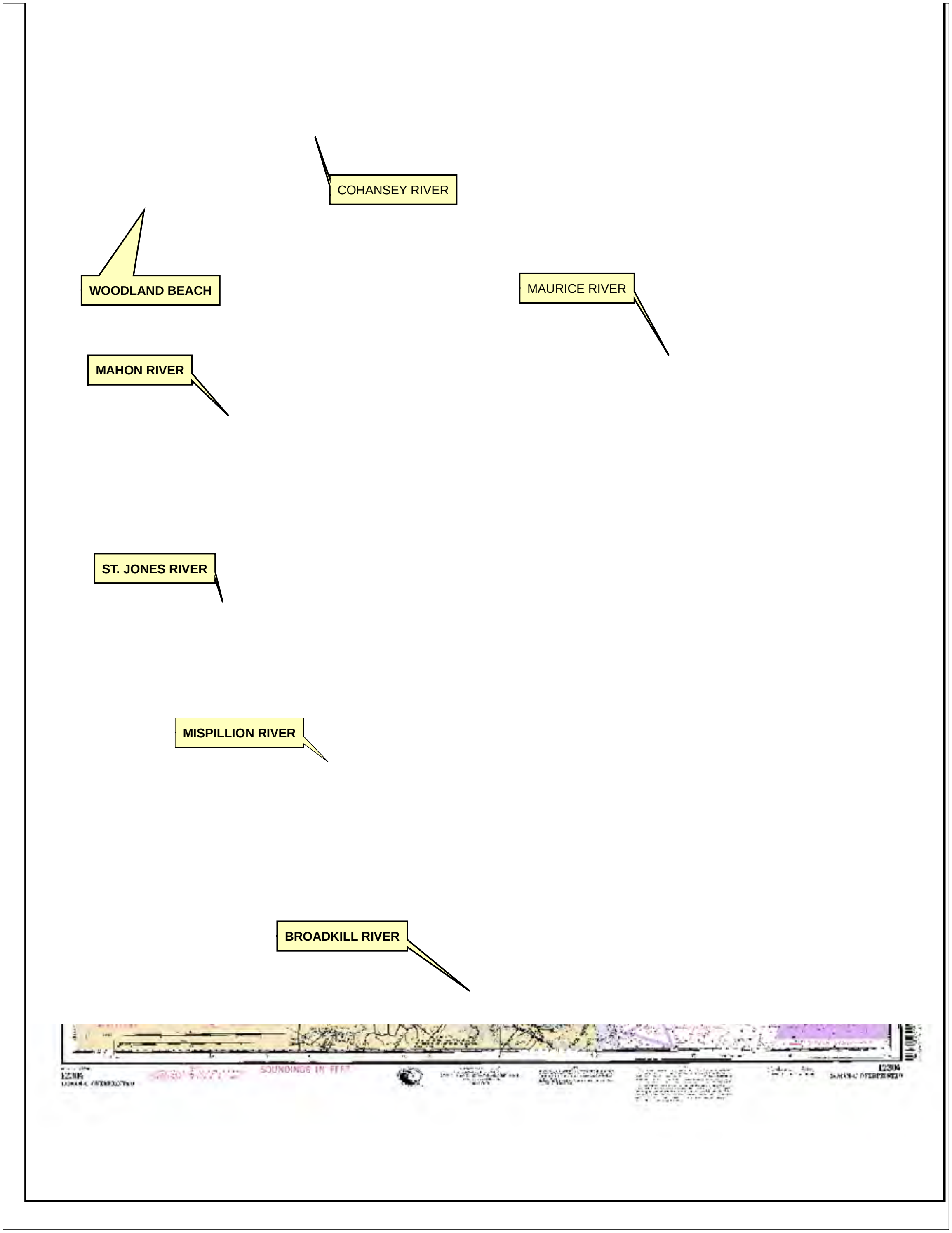


Figure 2-1a. Stations sampled with a 16-foot otter trawl in the lower Delaware Bay during 2011. Numbers indicate station numbers.

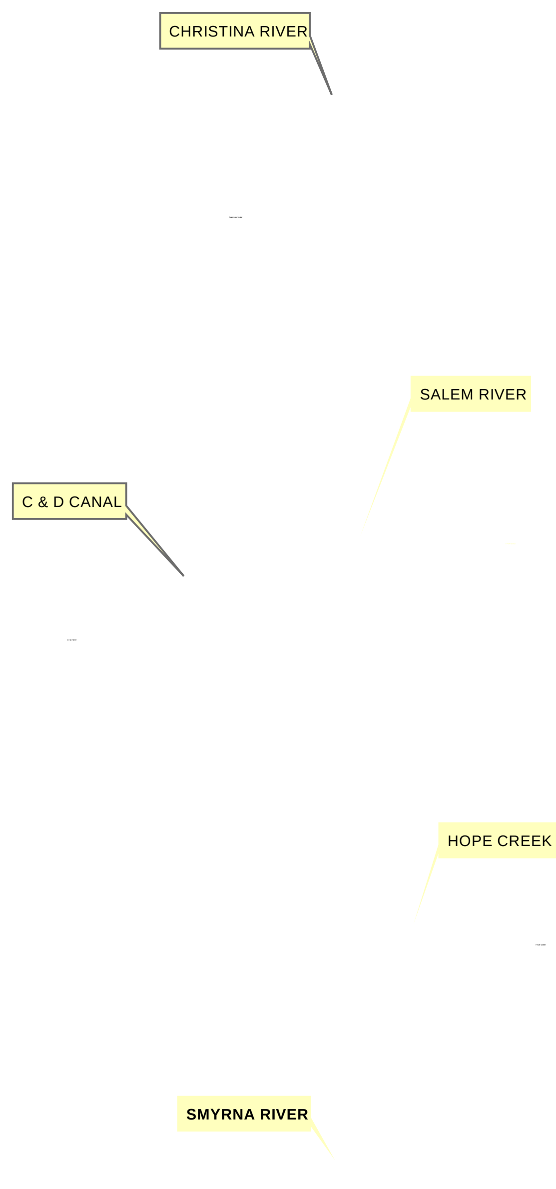


Figure 2-1b. Stations sampled with a 16-foot otter trawl in the upper Delaware Bay and River during 2011. Numbers indicate station numbers.

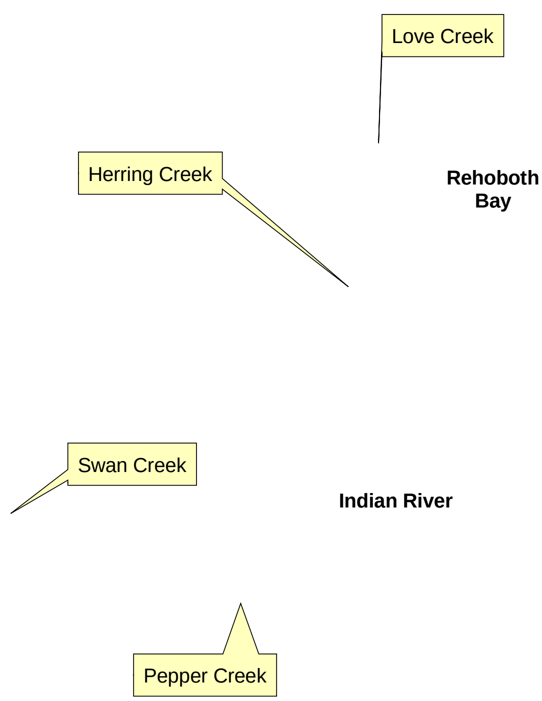


Figure 2-2. Stations sampled with a 16-foot otter trawl in the Indian River and Rehoboth Bays (Inland Bays) during 2011. Numbers indicate station numbers.

9.8 DE F-84-R Structure Oriented Fish Assessment Program

The project is focused on collecting fishery-independent data to index structure oriented fish populations (Black Sea Bass & Tautog). The initial phase of the project will be a sampling method feasibility study that will be located within the Delaware artificial reefs sites 3 – 11, which are located in the lower Delaware Bay and the near shore waters of the Atlantic Ocean, were selected to be sampled (Figure #). These reef sites were chosen because of their known potential for Tautog or Black Sea Bass inhabitation (J. Tinsman, personal communication, July, 2016). Each artificial reef site is defined by boundaries when the site is developed. Each site is broken into 10 minutes by 10 minutes squares (Tinsman 2016). Within each site, each square will be weighted by the presence of structure and randomly selected by weight for sampling. Sampling will occur within proximity to the structure that is closest to the center of the selected square. Sampling will be conducted using fish traps and hook & line.

Fish Traps

This project will use commercial traps similar to those that are used in the local trap fishery as they have been found to effectively collect Tautog and Black Sea Bass. Delaware commercial traps are made of one inch square 14 gauge black meshes that are 42.75 inches long by 18 inches wide by 12.5 inches high. Each trap has one entrance, made of twine, in the side near one end of the trap and is divided into two compartments with a twine mesh funnel between each compartment. Each trap will have biodegradable escape panels in the event that the trap is lost, but the traps will be fished ventless so all size ranges of Black Sea Bass and Tautog will be retained for future age at length analysis.

Four traps will be fished in each square and will be set around each side of the perimeter of each structure when possible. Trap density will be varied in the feasibility phase to guide implementation during the monitoring phase of the project. Commercial pots are typically fished between one and two weeks, whereas the Long Island Trap Survey has a soak time of one week. The project will begin in the feasibility phase of the project with an initial soak time of one week, with variability in soak time assessed during the feasibility phase. There are concerns that catch rates may not remain constant throughout the week period. A study with Black Sea Bass showed that trap saturation and exit rates have dramatic effects on catch rates, with trap saturation occurring in 50 minutes of set, and half of the Black Sea Bass that entered the pot, escaped in 90 minutes (Bacheler et al. 2013). GoPro Hero cameras will be attached to the traps over the mouth and facing away from the trap to document fish avoidance, and a GoPro camera will be mounted on the rear of the trap, facing towards the funnel to document entry/exit rates (Smart et al. 2015). Depending on the results of the visual survey, soak times will be adjusted accordingly. Traps will be marked and equipped with lines, warps and connections consistent with the federal Large Whale Take Reduction Plan requirements for Lobster Management Area 5:

> Gear Marking: Buoy lines are to be marker with three 12 inch, orange marks: one placed at the top of the buoy line, one midway along the buoy line and one at the bottom of the buoy line.
> Weak links: less than or equal to 600 lbs. breaking strength.
> Sinking groundline.

Hook and Line

Standardized hook and line sampling was effectively used to sample structure-oriented Bocaccio Rockfish (Sebastes paucispinis) in California (Harms et al. 2010) and may be effective in sampling Tautog and Black Sea Bass. National Marine Fisheries Service performs a standardized hook and line sampling in the Pacific Ocean for structure oriented fish, and their standardized hook and line protocol will be tested for feasibility in Delaware, with variations, to find the most effective set up for Tautog and Black Sea Bass in Delaware. All of the equipment used, including rod and reels, will be standardized between anglers to ensure that bias is not introduced because of fishing avidity. During the feasibility phase, two to four anglers will be tested and will make a random number of coordinated deployments (or drops) between five and ten at each sampling site. Each angler will be provided a stopwatch to time when the sinker reaches the bottom and when the fishing gear reaches the surface. In a survey performed by the Northwest Science Center, maximum allowable bottom time was 5 minutes (Harns et Al. 2010). The maximum allowable time the gear remains on the bottom will be randomly selected in the feasibility phase between 5, 10 and 15 minutes, or until the angler encounters a bite and believes there is a fish on the line. Hook selectivity has a measureable effect on mean fish length, even though a wide range in length distribution for each hook size exists, which equates to small fish being unable to be captured large hooks while large fish can be captured on relatively smaller hooks (Campbell et al. 2013).

To decrease potential sampling bias, the rig used will be a three hook rig with each hook size randomly chosen before each sampling trip. Use of either circle hooks or traditional j-hook will be randomly selected before each trip, and to decrease any potential bias from angler ability, with hooks varying from 2 to 5/0, the most common sizes based on local fishing knowledge. The most common types of baits will be tested, and will be randomly selected before each sampling site and will include squid, various types of crabs, and sand fleas. The boat will be divided into four areas, starboard fore and aft, and port fore and aft, with each angler assigned a random area of the boat to fish from, to reduce angler avidity bias. Similar to the trap component of the survey, artificial reefs will be divided into sampling squares or sites. Each site will be assigned a weight based on the number of structures within the site. Sites to be sampled will be randomly selected with weighting. Sites with higher weights should be selected more, with sites with little or no structure, least likely to be sampled. Within the site, the anchor will be deployed in the middle of the structure, allowing the boat to drift to the edge of the structure, with fishing occurring at the edge.

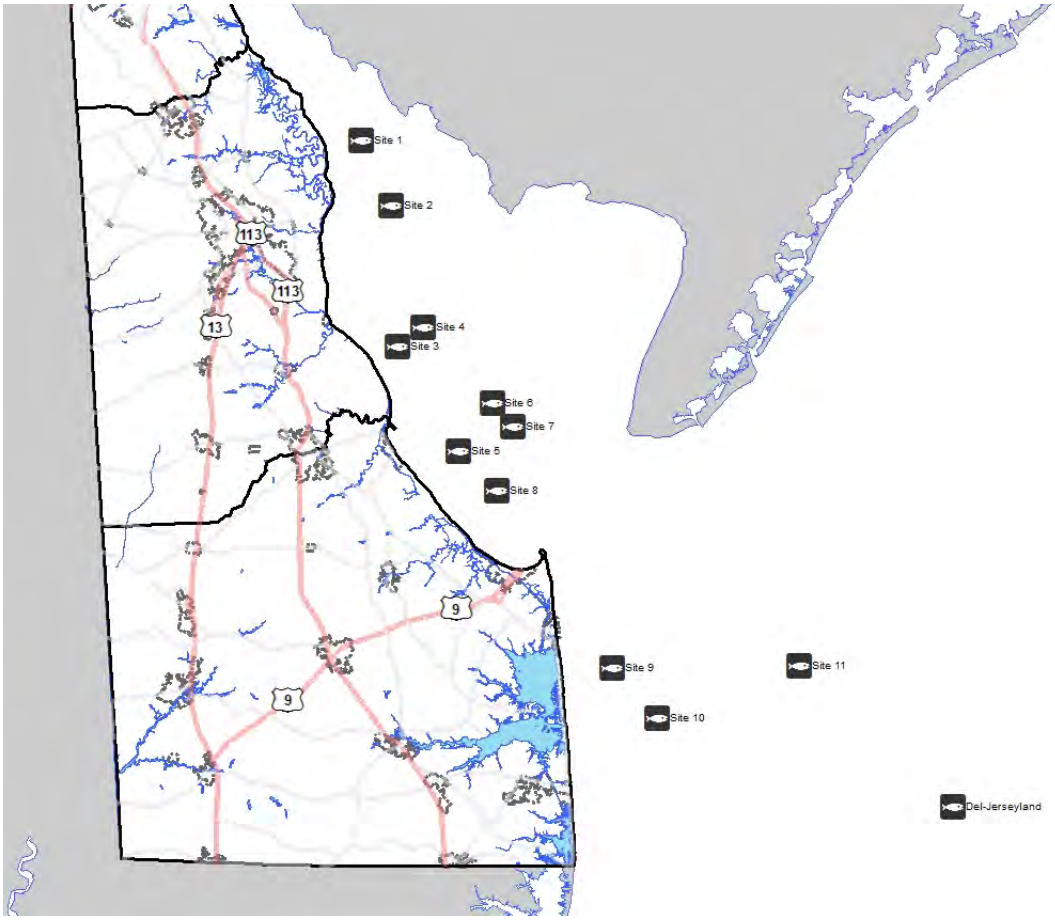


Figure #. Locations of Delaware's permitted artificial reef sites. Delaware's Structured Oriented Fish Project will sample sites 3 through 11 using fish traps and hook & line gear.

Effects Pertaining to Sturgeon & Sea Turtles

Shortnose sturgeon are not expected to occur in the area of the proposed work.   Effects of fish pot sampling are expected to be similar to the RI ventless trap survey. Given the small number and size of the unbaited traps, no interactions with sea turtles or Atlantic sturgeon are expected. Although interactions between hook & line gear, sea turtles and Atlantic sturgeon occur, the limited amount of sampling (bottom time and total effort) make it unlikely that an interaction would occur.

10.0 Maryland

This section describes methods or approach for each Wildlife and Sport Fish Restoration (WSFR) grant project managed by Maryland Department of Natural Resources.

Research summaries are provided for the following grant projects:

1) F-48-R Survey and management of freshwater fisheries resources
2) F-50-R Coastal bay finfish investigation
3) F-53-D Freshwater resources conservation
4) F-57-R American and hickory shad restoration in three Maryland rivers
5) F-61-R Chesapeake Bay finfish and habitat investigations
6) F-63-R Marine and estuarine finfish ecological and habitat investigations
7) F-110-R Health investigations of striped bass and other fishes in Maryland waters

10.1 MD F-48-R Survey and Management of Freshwater Fisheries Resources

10.1.1 MD F-48-R Largemouth Bass – Tidal Fresh

Largemouth Bass were sampled annualy in targeted drainages using a stratified, random design that has been described by Markham et al. (2002) and Love (2011). In 2017, the sampled drainages included: Potomac River, systems of the upper Chesapeake Bay (Northeast River, Susquehanna River, and the Susquehanna flats), Choptank River, and Gunpowder River. Sampling occurred during fall (September – November). The tidal bass survey data were used to: 1) develop drainage-specific indices that reflect the population status of Largemouth Bass; and 2) report some life history traits for river populations.

Habitat variables just prior to time of sampling were recorded and included: water temperature (°C), specific conductivity (µS), dissolved oxygen (mg/L), water clarity (as a Secchi depth in meters), and minimum and maximum depth (in meters). Some of these variables affected catchability of Largemouth Bass and were used in models to remove their influence on catch statistics (see below). Catchability constants that are useful for evaluating gear bias were estimated from mark-recapture studies conducted at two sites in the upper Chesapeake Bay. For each of these studies, Largemouth Bass was collected at a site (pass 1) and a specific fin, clipped. The fish were released at the center of the site. A second pass of the site was conducted and all Largemouth Bass were retained. Recaptures were noted. A different fin was marked for all fish. Fish were then released at the center of the site. This procedure was followed for two more passes. The probability of capturing a Largemouth Bass on the first pass (i.e., catchability) was computed using a Closed-Captures Huggin's Model and MARK (Version 5.1).

Sites were sampled throughout tidal fresh regions of the drainages (Figs. 1 – 4). At each site, approximately 250 m was sampled for Largemouth Bass using boat electrofishing. In most cases, the amount of time that electricity was applied to water was at least 250 seconds. When stunned, Largemouth Bass was removed from the electric field and allowed to recover in a live well with well-aerated and re-circulating water. Once the site had been sampled thoroughly, Largemouth Bass were counted, measured to total length (in mm), and weighed (in grams). Fish were then released to their site of capture.

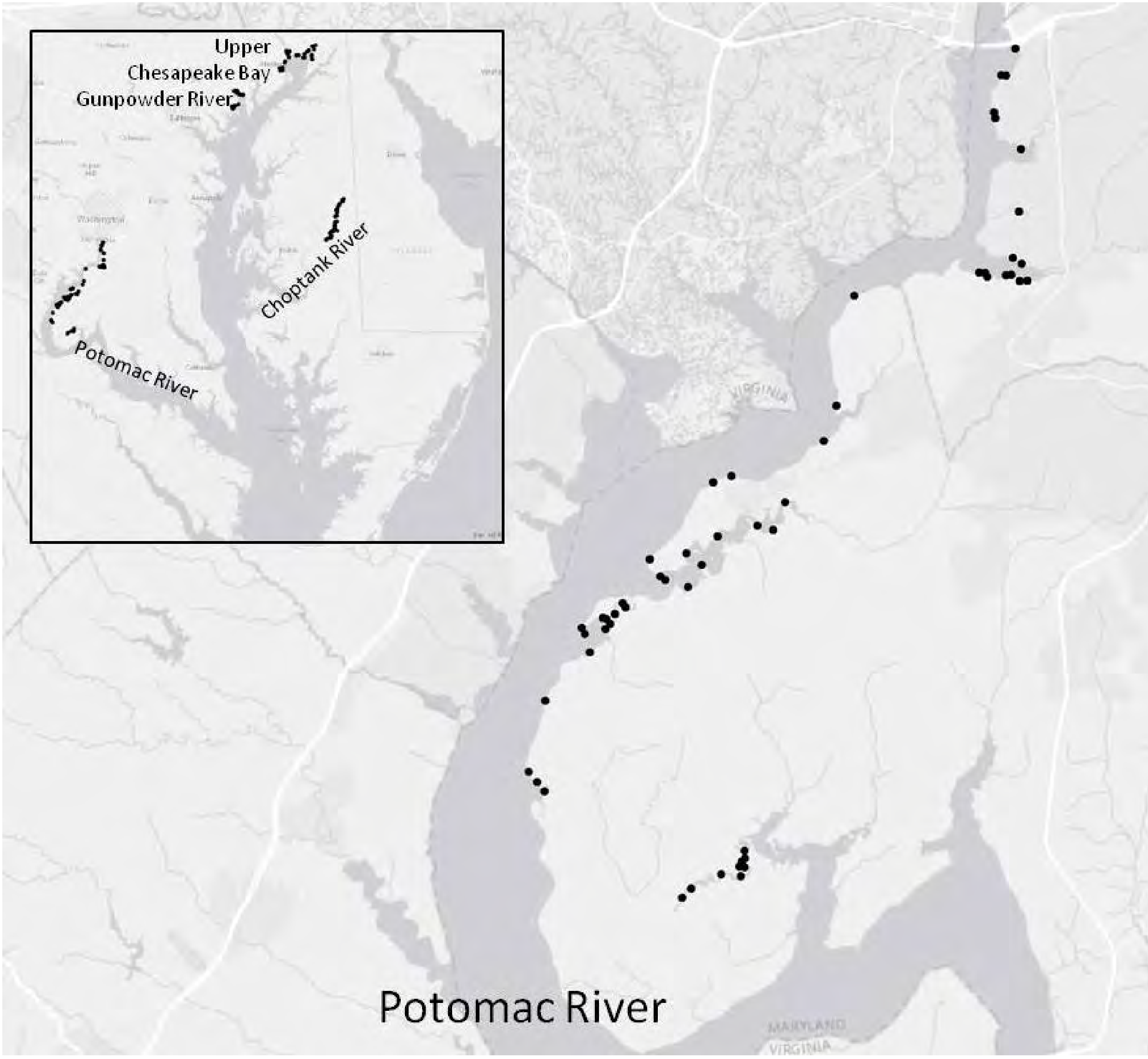


Figure 1. Map of survey sites for largemouth bass (*Micropterus salmoides*) in the Potomac River watershed during the tidal bass survey (fall, 2017). Inset shows location of the Potomac River in the Chesapeake Bay watershed and the distribution of potential sites from which the actual sites were chosen.

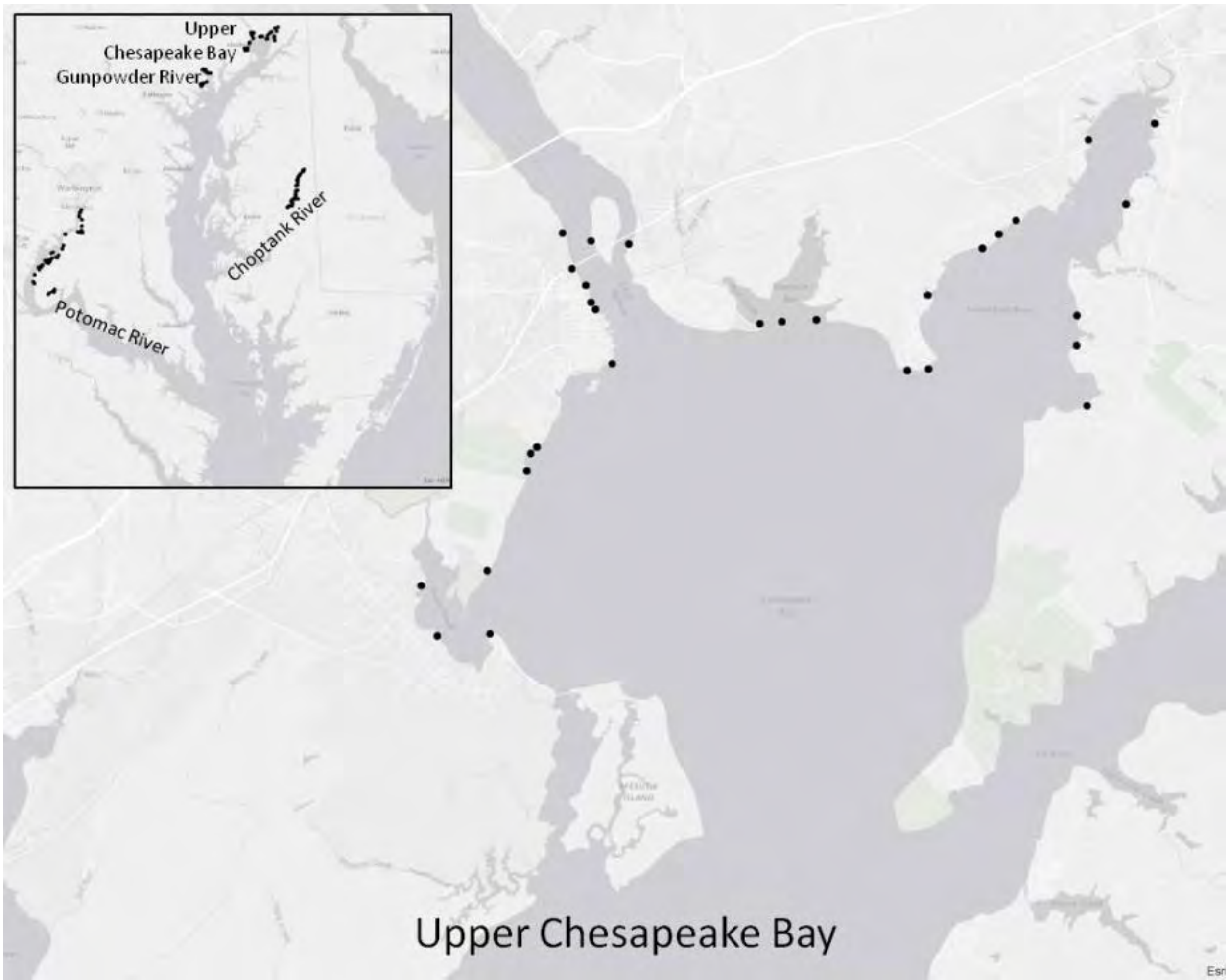


Figure 2. Map of survey sites for largemouth bass (*Micropterus salmoides*) in the upper Chesapeake Bay watershed during the tidal bass survey (fall, 2017). Inset shows location of the upper Bay in the Chesapeake Bay watershed.

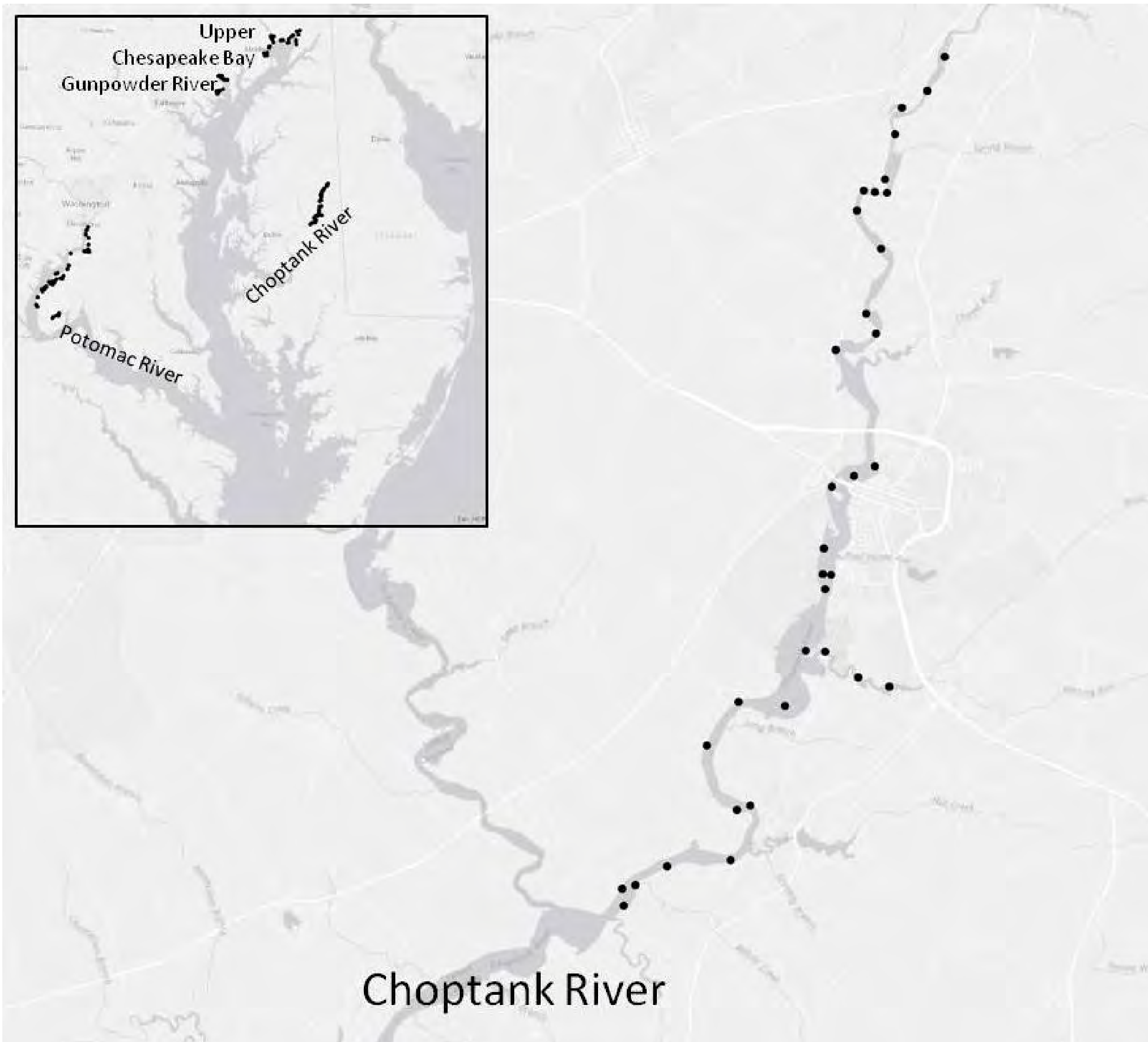


Figure 3. Map of survey sites for largemouth bass (*Micropterus salmoides*) in the Choptank River during the tidal bass survey (fall, 2017). Inset shows the location of the Choptank River in the Chesapeake Bay watershed.

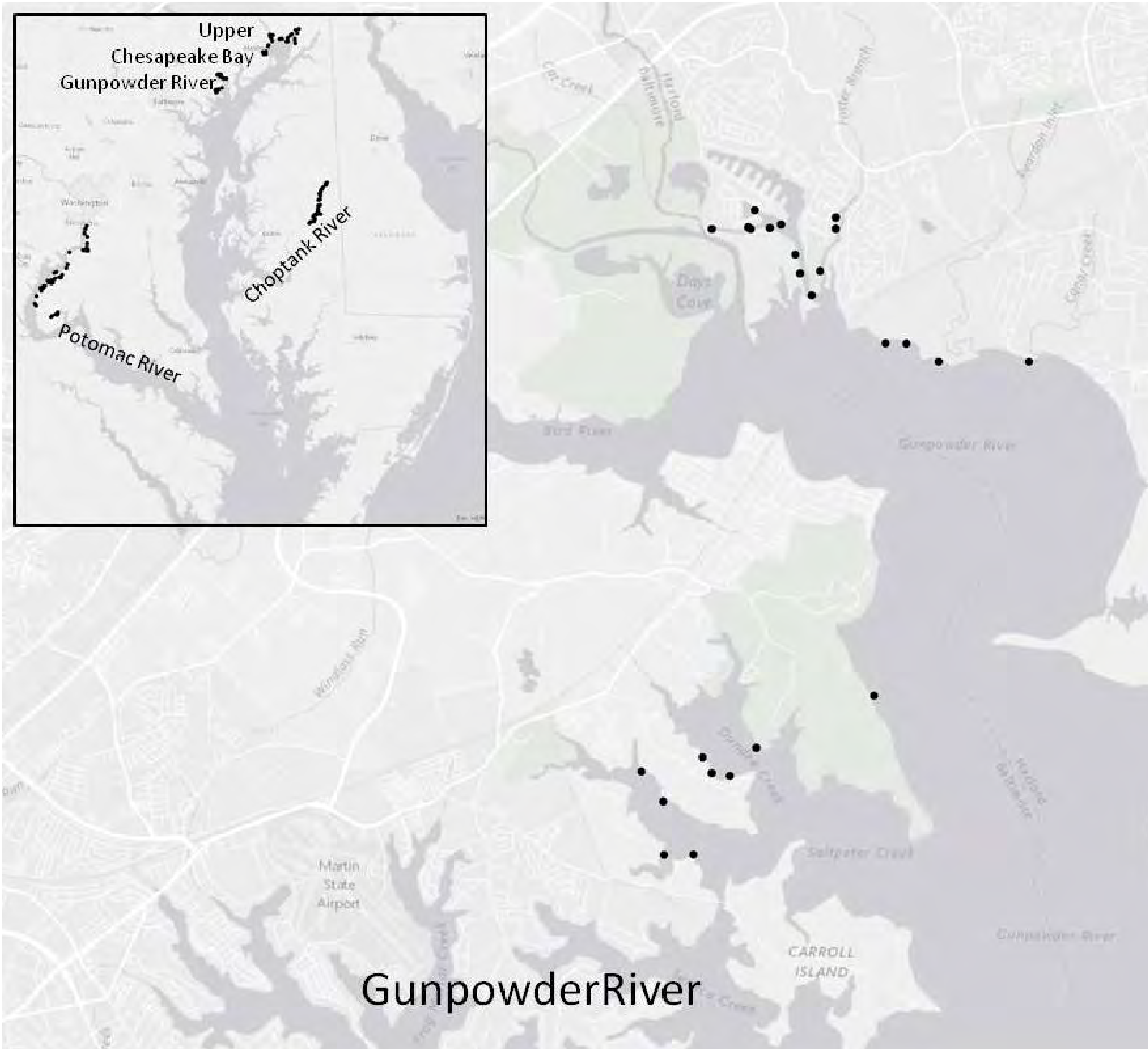


Figure 4. Map of survey sites for largemouth bass (*Micropterus salmoides*) in the Gunpowder River during the tidal bass survey (fall, 2017). Inset shows the location of the Gunpowder River in the Chesapeake Bay watershed.

10.1.2 MD F-48-R Invasive Species Studies

Maryland Department of Natural Resources (MDDNR), Fishing and Boating Services monitors several invasive species in tidal freshwater to determine influences on aquatic ecosystems. The data collected provides managers with information needed to make informed management decisions that minimize the impacts of these species. Of particular interest are blue catfish (*Ictalurus furcatus*), flathead catfish (*Pylodictus olivaris*), and northern snakehead (*Channa argus*).

Fishing and Boating Services has received reports of Blue Catfish occupying the tidal portion of the Potomac River for many years. Until the 1990s, most of these fish were misidentified as

Channel Catfish (Ictalurus punctatus). Although some historical literature states that Blue Catfish were stocked in the Potomac River at the turn of the 20th century, many researchers believe that this information was in error and that the early stockings were juvenile Channel Catfish. It is unclear of when or how Blue Catfish first appeared in the Potomac. The Virginia Department of Game and Inland Fish stocked their main tidal tributaries with Blue Catfish in the 1970's. It is possible that the Potomac fish came from this stocking. The first confirmed documentation of a Blue Catfish in the tidal Potomac occurred in 1987 by Nammack & Fulton (1987). Only recently, however, have Blue Catfish become widespread and abundant enough to be a regular target for the angling and commercial fishing community in the Potomac River.

Blue Catfish are considered an invasive species in Maryland. There is great concern that this top predator will have a negative impact on fish and other aquatic species. Also of concern is the potential for Blue Catfish to spread to other river systems within the Chesapeake Bay either through unauthorized stocking or natural movement in times of low salinity. For example, Fishing and Boating Services has not stocked Blue Catfish yet they can now be found in the Patuxent River, the Upper Bay and some Eastern Shore river systems.

Information on Blue Catfish populations in freshwater river systems and impoundment around the United States is abundant, particularly in the area of the country where they naturally occur (Mississippi River drainage). Less information is available on Blue Catfish occurring in estuarine environments. The Virginia Department of Game and Inland Fish (VDGIF) has the most comprehensive dataset for Blue Catfish occurring in tidal waters and has recently released a report describing the Blue Catfish populations in the James, Rappahannock, Mattaponi and Pamunkey Rivers (Greenlee and Lim, 2011).

Biologists with the MDDNR Fishing and Boating Services initiated a diet study on Blue Catfish in 2008. The purpose of the study was to determine if Blue Catfish were aggressively utilizing migrating shad and herring for forage and to determine if they were in competition with other major gamefish, such as largemouth bass, for food. As the Blue Catfish population increased, concern of further spread resulted in the desire for a Bay-wide Blue Catfish policy. Fishing and Boating Servies set up a routine sampling program for Blue Catfish in the Potomac in 2011 in order to compare catch indices from year to year and to allow managers to compare similar data with the VDGIF.

From October 2008 through December 2016, a Smith-Root SR 18 electrofishing boat equipped with a 9,000 Watt generator was used to collect Blue Catfish from the tidal Potomac River in order to examine gut contents. Water depths ranged from 5 feet in the coves to >50 feet in the main channel. The electrofishing unit was set to low frequency (7.5 – 15 pps, 680 or less volts), the most effective way to sample for Blue Catfish in deep water. In 2008 and 2009 stomach contents were extracted using a gastric lavage method that was adapted from a technique used on largemouth bass in St. Mary's Lake in 2003 (MDDNR, 2003). Later samples were collected from euthanized fish. Large Blue catfish (>610mm) were targeted because fish of this size are primarily piscivorous and more information on fish prey species would be obtained. Sampling was limited to good 'catfishing areas' as reported by anglers familiar with the Potomac River Blue Catfish population. As the study progressed, it became clear that more biological data on the species was needed and fish of all sizes were collected. In the Fall of 2011, the tidal freshwater portion of the Potomac River from Oxon Creek to Port Tobacco was divided into 509 sites, 1600m2. Sites were randomly selected and coordinates were loaded into a hand-held Garmin Map76 GPS. All catfish, regardless of size, were collected and sacrificed during each electrofishing event in order to remove otoliths for ageing and to document stomach contents, sex, and stage of maturity. Fish length and weight were also noted, along with water temperature, dissolved oxygen, conductivity, pH and salinity.

Catch per unit effort (CPUE) was standardized to number of fish collected per hour and only included the fish collected in the fall of 2011. A subset of all otoliths collected was used for ageing purposes. All other calculations used the entire dataset from 2008 through 2016. Otoliths were used for ageing all catfish. Mean total length at age, coefficient of variation (CV) and confidence intervals (CI=95%) were calculated using the descriptive statistics function in Excels' Analysis Tool Pak program. Proportional size distribution (PSD) was calculated as the number of quality size fish divided by the number of fish that were stock size(Anderson, 1980). PSD was expressed as a percentage. Relative weight (Wr) compared the weight of captured Blue Catfish against a standard and was also expressed as a percent (Muoneke and Pope, 1999) . Potomac growth rates and length at age were compared to four Virginia tidal tributaries, the James, Rappahannock, Pamunkey and Mattaponi. Comparisons were tested using Analysis of Variance (ANOVA) in Excels' Analysis Tool Pak program. Linear regressions were performed on all river systems to compare growth rates (m) among systems. In each regression, age was the independent variable and mean length at age was the dependent variable. The slope of this linear model was m. Von Bertalannfy growth functions and catch curve regressions run using the program Fishery Analysis and Simulation Tools (FAST version 2.1), and were used to estimate growth constants (k) and instantaneous mortality rates (z), respectively, for fish of known age. All aged fish (n=268) were used to determine growth rates. Only fish age-5 (n=234) and older were used to estimate z due to sampling biases. Stomach contents were examined for all Blue Catfish and items identified to genus and species when possible.

Flathead catfish were initially collected in the Potomac River in 2002. They were not observed again until 2012. Since then, flathead catfish have expanded their range in the Potomac River from Harpers Ferry to Hancock and can now be found in the Susquehanna River as well. Efforts to monitor flathead catfish in the Susquehanna River below the Conowingo Dam will begin in 2017. The survey methods include baiting 12 hoop nets in tandem sets of three at four sites. The sites will be located from the mouth of Deer Creek to the Route 40 bridge. The hoop nets will be set parallel to the shore at varying depths. Net size will be 1.2 m in diameter with 19 mm bar mesh and will soak for 72 hours. Upon retrieval, flathead catfish will be removed from the nets, counted, measured for total length and weight, and retained for otolith removal. Catch data will be recorded for each net, though catch per unit effort and other analyses will be calculated for each series of nets.

Fishing and Boating Services also monitors the expansion of northern snakehead in Maryland waters. Currently, northern snakehead have been found in the Potomac River drainage, Patuxent River, Wicomico River, Nanticoke River, and Blackwater River. The objectives of snakehead surveys are to monitor the relative abundance of northern snakehead in targeted tidal and freshwater habitats, determine population characteristics, and determine how predation by northern snakehead will impact existing fish communities. Northern snakehead data collection uses the tidal freshwater largemouth bass methods, with most snakehead surveys occurring simultaneously with largemouth bass surveys.

10.2 MD F-50-R Coastal Bay Finfish Investigation

Research is organized by twq project components pertinent to this Biological Opinion. These are: 1) the Coatal Bays Fisheries Investigations Trawl and Beach Seine Survey and 2) the Submerged Aquatic Vegetation Beach Seining Program. Each component will include a description of methods and an interaction summary for the referenced protected species.

10.2.1 MD F-50-R Coastal Bays Fisheries Investigations Trawl and Beach Seine Survey

The Maryland Department of Natural Resources (MDNR) Fisheries Service has conducted the Coastal Bays Fisheries Investigations (CBFI) Trawl and Beach Seine Survey in Maryland's Coastal Bays since 1972, sampling with a standardized protocol since 1989. These gears target finfish although bycatch of crustaceans, mollusks, sponges, and macroalgae are common.

Maryland's Coastal Bays are comprised of Assawoman Bay, Isle of Wight Bay, Sinepuxent Bay, Newport Bay, and Chincoteague Bay. Also included are several important tidal tributaries: St. Martins River, Turville Creek, Herring Creek, and Trappe Creek. Covering approximately 363 km^2 (140 mi^2), these bays and associated tributaries average only 0.9 m (3 feet) in depth and are influenced by a watershed of only 453 km^2 (175 mi^2). The bathymetry of the Coastal Bays is characterized by narrow channels, shallow sand bars, and a few deep holes.

Two inlets provide oceanic influences to these bays. Ocean City Inlet is formed at the boundaries of south Fenwick Island and north Assateague Island and is located at the convergence of Isle of Wight Bay and Sinepuxent Bay. Chincoteague Inlet, in Virginia (VA), is approximately 56 km (34 mi) south of the Ocean City Inlet.

The Coastal Bays are separated from the Atlantic Ocean to the east by Fenwick Island (Ocean City) and Assateague Island. Ocean City, Maryland is a heavily developed commercial area and the center of a $2 billion dollar tourism industry catering to approximately 12 million visitors annually. Assateague Island is owned by the State of Maryland and the National Park Service (NPS). These entities operate one state (Assateague State Park) and two national parks (Assateague Island National Seashore and Chincoteague National Wildlife Refuge). These properties have campgrounds, small buildings, dunes, beach front with some Off Road Vehicle (ORV) access, and marshes.

The Coastal Bays western shoreline habitat consists of forest, *Spartina* spp. marshes, small islands, residential development, and marinas. Assawoman Bay is bordered by Maryland and Delaware and is characterized by farmland, *Spartina* spp. marshes, a few small islands, and commercial/residential development. Isle of Wight Bay south into Sinepuxent Bay is a heavily developed commercial/residential area. Two seafood dealers, a public boat launch, and approximately 20 to 50 transient and permanent commercial fishing vessels utilize the commercial harbor located directly west of the Ocean City Inlet. In addition to the commercial harbor, the majority of marinas in Ocean City are located in Isle of Wight Bay. Vast *Spartina* spp. marshes and numerous small islands characterize Chincoteague Bay.

Submerged Aquatic Vegetation (SAV) and macroalgae (seaweeds) are common plants in these bays that provide habitat and foraging sites for fishes and shellfish. Two species of SAV are common in Maryland's Coastal Bays: widgeon grass, *Ruppia maritima*, and eelgrass, *Zostera marina*. Common species of macroalgae include *Chaetomorpha* sp., *Agardhiella* sp., *Gracilaria sp.*, and *Ulva* sp.

A 25 foot C-hawk with a 225 horsepower Evinrude E-tec engine was used for transportation to the sample sites and gear deployment. Latitude and longitude coordinates (waypoints) in decimal degrees, minutes, and fraction of minutes (ddmm.mmm) were used to navigate to sample locations. A GPS was used for navigation, marking sites, and monitoring speed.

Trawl sampling was conducted at 20 fixed sites throughout Maryland's Coastal Bays on a monthly basis from April through October (Table 1; Figure 1). Sampling gear complications due to an over-abundance of macroalgae necessitated moving trawl site T006 and T001 slightly (around one hundred meters) in order to complete the trawls. With the exception of June and September, samples were taken beginning the third week of the month. Occasionally, weather or mechanical issues required sampling to continue into the next month. Sampling began the second week in June and September in order to allow enough time to incorporate beach seine collections.

The boat operator took into account wind and tide (speed and direction) when determining trawl direction. A standard 4.9 m (16 ft) semi-balloon trawl net was used in areas with a depth of greater than 1.1 m (3.5 ft). Each trawl was a standard 6-minute (0.1 hr) tow at a speed of approximately 2.8 knots. Speed was monitored during tows using the GPS. Waypoints marking the sample start (gear fully deployed) and stop (point of gear retrieval) locations were taken using the GPS to determine the area swept (hectares). Time was tracked using a stopwatch which was started at full gear deployment.

Seines were used to sample the shallow regions of the Coastal Bays frequented by juvenile fishes. Shore beach seine sampling was conducted at 19 fixed sites beginning in the second weeks of June and September (Table 2; Figure 1). Occasionally, weather or mechanical issues required sampling to continue into the next month.

A 30.5 m X 1.8 m X 6.4 mm mesh (100 ft X 6 ft X 0.25 in. mesh) bag seine was used at 18 fixed sites in depths less than 1.1 m (3.5 ft.) along the shoreline. A 15.24 m (50 foot) version of the previously described net was used at site S019 due to it is restricted sampling area. However, some sites necessitated varying this routine to fit the available area and depth. GPS coordinates were taken at the start and stop points as well as an estimated percent of net open.

For each sampling method, physical and chemical data were documented at each sampling location. Chemical parameters included: salinity (ppt), temperature (°C), and Dissolved Oxygen (DO; mg/L). Physical parameters included: wind direction and speed (knots), water clarity (secchi disk; cm), water depth (ft), tide state, and weather condition. Data were recorded on a standardized project data sheet printed on Rite in the Rain All Weather paper.

Salinity, water temperature, and DO were taken with a Yellow Springs Instrument (YSI) YSI Pro2030 at two depths, 30 cm (1 foot) below the surface and 30 cm (1 foot) from the bottom, at each trawl site. Chemical data were only taken 30 cm below the surface for each seine site due to the shallow depth (<1.1 m). The YSI was calibrated each week, and the unit was turned on at the beginning of each day and left on from that time until the last site readings were taken.

Water turbidity was measured with a secchi disk. Secchi readings were taken on the shaded side of the boat without the user wearing sunglasses. The secchi disk was lowered into the water until it could not be seen. It was then raised until the black and white pattern could just be seen. The biologist marked the position on the string with their fingers and measured the length of the string to the end of the disk. Both beginning and ending depths for each trawl were read on a depth finder and recorded. At seine sites, depth was estimated by the biologists pulling the seine. Wind speed measurements were acquired using a La Crosse handheld anemometer with digital readout. Measurements were taken facing into the wind. Tidal states were estimated checking the published tide tables for the sampled areas.

Fishes and invertebrates were identified, counted, and measured for Total Length (TL) using a wooden millimeter (mm) measuring board with a 90 degree right angle. A meter stick was used for species over 500 mm. At each site, a sub-sample of the first 20 fish (when applicable) of each species were measured and the remainder counted. On occasion, invertebrate species counts were estimated.

Blue crabs were measured for carapace width, sexed, and maturity status was determined. Sex and maturity categories included: male, immature female, mature female (sook), and mature female with eggs. A subsample of the first 50 blue crabs at each site was measured and the rest were counted. Sex and maturity status of non-sub-sampled blue crabs were not recorded

Jellyfishes, ctenophores, bryozoans, sponges, SAV and macroalgae were measured volumetrically (liters, L) using calibrated containers with small holes in the bottom to drain the excess water. Small quantities (generally ≤ 10 specimens) of invertebrates were occasionally counted. Slightly larger quantities of invertebrates were sometimes visually estimated. Bryozoans and macroalgae were combined for one volume measurement and a biologist estimated the percentage of each species in the sample.

Table 1. MDNR Coastal Bays Fisheries Investigation Trawl Site Descriptions.

Site Number	Bay	Site Description	Longitude	Latitude
T001	Assawoman Bay	On a line from Corn Hammock to Fenwick Ditch	38 26.243	75 04.747
T002	Assawoman Bay	Grey's Creek (mid creek)	38 25.859	75 06.108
T003	Assawoman Bay	Assawoman Bay (mid-bay)	38 23.919	75 05.429
T004	Isle of Wight Bay	St. Martin's River, mouth	38 23.527	75 07.327
T005	Isle of Wight Bay	St. Martin's River, in lower Shingle Ldg. Prong	38 24.425	75 10.514
T006	Isle of Wight Bay	Turville Creek, below the race track	38 21.291	75 08.781
T007	Isle of Wight Bay	mid-Isle of Wight Bay, N. of the shoals in bay (False Channel)	38 22.357	75 05.776
T008	Sinepuxent Bay	#2 day marker, S. for 6 minutes (North end of Sinepuxent Bay)	38 19.418	75 06.018

T009	Sinepuxent Bay	#14 day marker, S. for 6 minutes (Sinepuxent Bay N. of Snug Harbor)	38 17.852	75 07.310
T010	Sinepuxent Bay	#20 day marker, S. for 6 minutes (0.5 mile S. of the Assateague Is. Bridge)	38 14.506	75 09.301
T011	Chincoteague Bay	Newport Bay, across mouth	38 13.024	75 12.396
T012	Chincoteague Bay	Newport Bay, opp. Gibbs Pond to Buddy Pond, in marsh cut	38 15.281	75 11.603
T013	Chincoteague Bay	Between #37 & #39 day marker	38 10.213	75 13.989
T014	Chincoteague Bay	1 mile off village of Public Landing	38 08.447	75 16.043
T015	Chincoteague Bay	Inlet Slough in Assateague Is. (AKA Jim's Gut)	38 06.370	75 12.454
T016	Chincoteague Bay	300 yds off E. end of Great Bay Marsh, W. of day marker (a.k.a. S. of #20 day marker)	38 04.545	75 17.025
T017	Chincoteague Bay	Striking Marsh, S. end about 200 yds	38 03.140	75 16.116
T018	Chincoteague Bay	Boxiron (Brockatonorton) Bay (mid-bay)	38 05.257	75 19.494
T019	Chincoteague Bay	Parker Bay, N end.	38 03.125	75 21.110
T020	Chincoteague Bay	Parallel to and just N. of the MD/VA line, at channel	38 01.328	75 20.057

Table 2. MDNR Coastal Bays Fisheries Investigation Beach Seine Site Descriptions.				
Site Number	Bay	SITE DESCRIPTION	Latitude	Longitude
S001	Assawoman Bay	Cove behind Ocean City Sewage Treatment Plant, 62nd St.	38 23.273	75 04.380
S002	Assawoman Bay	Bayside of marsh at Devil's Island, 95th St.	38 24.749	75 04.264
S003	Assawoman Bay	Small cove, E. side, small sand beach; Sandspit, bayside of Goose Pond	38 24.824	75 06.044
S004	Isle of Wight Bay	N. side, Skimmer Island (AKA NW side, Ocean City Flats)	38 20.259	75 05.299
S005	Isle of Wight Bay	Beach on sandspit N. of Cape Isle of Wight (AKA in cove on marsh spit, E. and S. of mouth of Turville Creek)	38 21.928	75 07.017
S006	Isle of Wight Bay	Beach on W. side of Isle of Wight, St. Martins River (AKA Marshy Cove, W. side of Isle of Wight, N. of Rt. 90 Bridge)	38 23.708	75 06.855
S007	Isle of Wight Bay	Beach, 50th St. (next to Seacrets)	38 22.557	75 04.301
S008	Sinepuxent Bay	Sandy beach, NE side, Assateague Is. Bridge at Nat'l. Seashore	38 14.554	75 08.581
S009	Sinepuxent Bay	Sand beach 1/2 mile S. of Inlet on Assateague Island,	38 19.132	75 06.174
S010	Sinepuxent Bay	Grays Cove, in small cove on N. side of Assateague Pointe development's fishing pier	38 17.367	75 07.977
S011	Chincoteague Bay	Cove, 800 yds NW. of Island Pt.	38 13.227	75 12.054
S012	Chincoteague Bay	Beach N. of Handy's Hammock (AKA N. side, mouth of Waterworks Cr.)	38 12.579	75 14.921
S013	Chincoteague Bay	Cove at the mouth of Scarboro Cr.	38 09.340	75 16.426
S014	Chincoteague Bay	SE of the entrance to Inlet Slew	38 08.617	75 11.105
S015	Chincoteague Bay	Narrow sand beach, S. of Figgs Ldg.	38 07.000	75 17.578
S016	Chincoteague Bay	Cove, E. end, Great Bay Marsh (AKA Big Bay Marsh)	38 04.482	75 17.597
S017	Chincoteague Bay	Beach, S. of Riley Cove in Purnell Bay	38 02.162	75 22.190
S018	Chincoteague Bay	Cedar Is., S. side, off Assateague Is.	38 02.038	75 16.619
S019	Chincoteague Bay	Land site - Ayers Cr. At Sinepuxent Rd.	38 18.774	75 09.414

Table 3. Total Number of Coastal Bays Fisheries Investigations Trawl and Beach Seine Survey Samples by Gear Type from 1972-2011, n=5,375.		
Gear	Total Number of Samples	Years Used
16’ Trawl	3,945	1972-present
25’ Trawl	134	1975, 1980-1981,1984-1985, 1988, 1993-1994
50’ Beach Seine	41	1991-present
100’ Beach Seine	1,155	1972-present

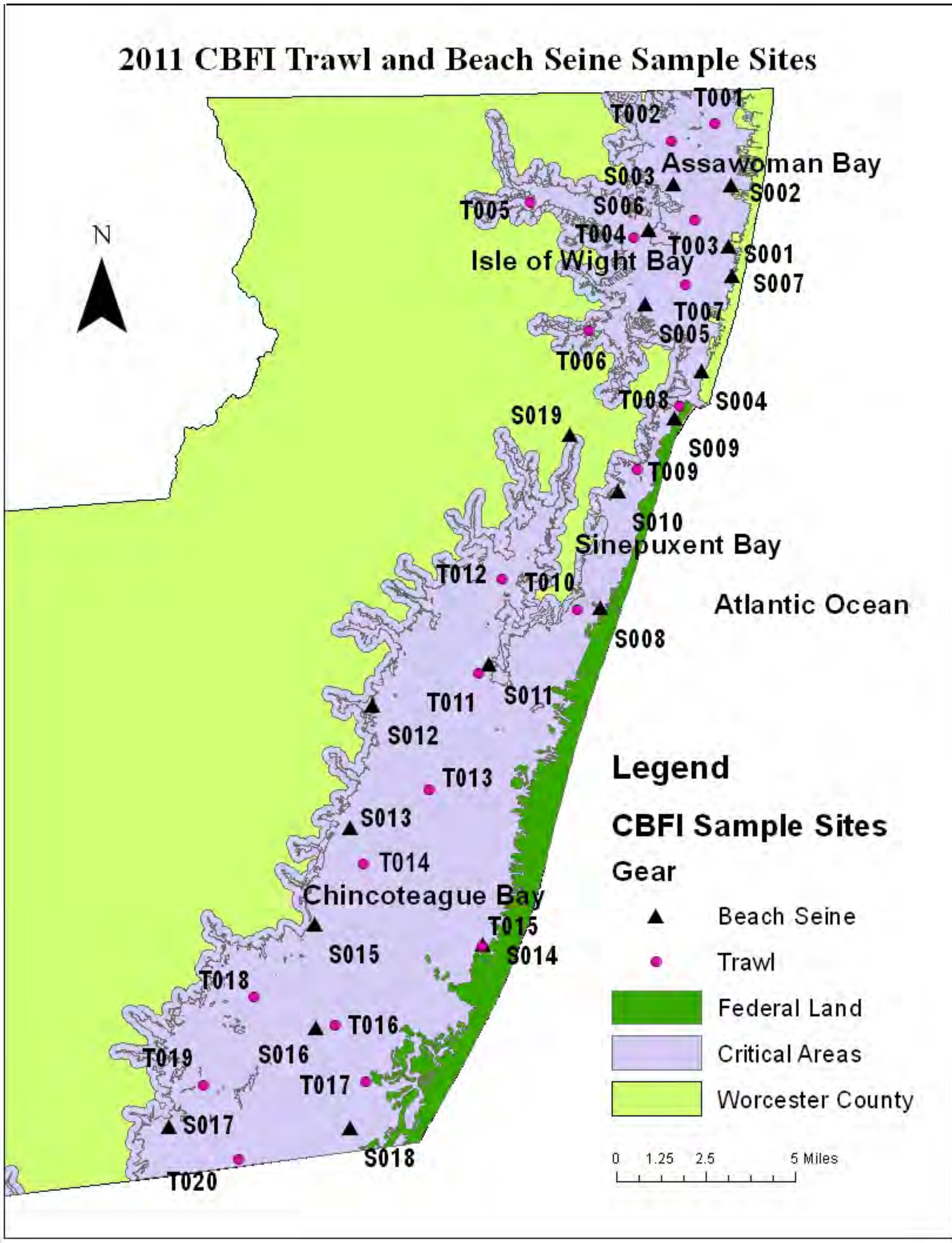


Figure 1. Site locations for the 2011 Coastal Bays Fishery Investigations Trawl and Beach Seine Survey.

10.2.2 MD F-50-R Submerged Aquatic Vegetation Beach Seining Program

The department has been conducting the Coastal Bays Fisheries Investigations Trawl and Beach Seine Surveys since 1972, with a standardized protocol since 1989. These surveys were designed to characterize and quantify juvenile finfish abundance, but they also encounter bycatch that includes crustaceans, molluscs, sponges, and macroalgae. The surveys rarely sample in submerged aquatic vegetation. Currently, there is limited information specific to Maryland's Coastal Bays' submerged aquatic vegetation beds as critical or essential habitat for living resources.

Although there are many species of submerged aquatic vegetation in the Mid-Atlantic, there are only two species found in Maryland's Coastal Bays: eelgrass (*Zostera marina*) and widgeon grass (*Ruppia maritima*; Coastal Bays Sensitive Areas Technical Task Force 2004). While submerged aquatic vegetation beds are found throughout the Coastal Bays, they are not distributed evenly. The majority of the eelgrass beds are located along the Assateague Island shoreline; widgeon grass is also present but at a lower abundance. Both submerged aquatic vegetation species provide a wide variety of functions essential to the ecological health of the bays; foremost among them is as prime nursery habitat. The young of many commercially, recreationally, and ecologically important species depend upon the grass beds for protection and feeding at some point in their life cycle (Coastal Bays Sensitive Areas Technical Task Force 2004). With submerged aquatic vegetation playing such a significant role in the life cycle of many fishes and its susceptibility to anthropogenic perturbations, the characterization of fisheries resources within these areas is important (Connolly and Hindell 2006). As a result, MDNR expanded the project to include sampling the submerged aquatic vegetation beds in 2012. This survey was designed to meet the following two objectives:

1. characterize submerged aquatic vegetation habitat usage by fish assemblages in Maryland's Coastal Bays; and
2. incorporate the results of this study to better guide management decisions.

Based on previous results, Sinepuxent Bay was selected for a three year investigation (2015-2017) to meet our objectives (Figure 1, Table 1). This small location was considered the best solution to minimize unwanted effects from multiple variable interactions and dynamics of other embayments. Moreover, Sinepuxent Bay had the most readily available submerged aquatic vegetation beds in proximity with our established Trawl and Beach Seine Survey sites discussed in Chapter 1.

In 2015, site verification was conducted to confirm submerged aquatic vegetation presence because it has been declining since the geographic information systems maps were created for this survey back in 2012. That map used a 305 meter x 305 meter grid overlaying areas where submerged aquatic vegetation beds had been present for at least five years prior to the implementation of this survey and was based on data from the Virginia Institute of Marine Sciences submerged aquatic vegetation survey. Potential sites were selected from the reconnaissance if submerged aquatic vegetation was present and the site was not too deep. The sites sampled in 2015 were revisited in 2016.

A 25 foot C Hawk with a 225 horsepower Evinrude E-tec engine was used as the sampling platform in September. Latitude and longitude coordinates (waypoints) in degrees and decimal minutes were used to navigate to sample locations. The global positioning system was also used to obtain coordinates at the start and stop points of the seine haul.

A 15.24 meter X 1.8 meter X 6.4 millimeter mesh (50 feet X 6 feet X 0.25 inch mesh) zippered bag seine was used. This gear was called the submerged aquatic vegetation Seine. Staff estimated percent of net open and a range finder was used to quantify the distance of the seine haul. The haul distance was 35 meters for all hauls. Staff ensured that the lead line remained on the bottom until the catch was enclosed in the zipper bag. The catch was taken to the boat for processing.

Water quality and physical characteristic data were collected using the same method and parameters described in Chapter 1. Only surface data were collected due to the shallow depth (<1.5 meters). Data were recorded on a standardized project data sheet printed on Rite in the Rain All Weather paper (Appendix 4).

Samples were processed using the same methods described in Chapter 1 with one exception. At each site, a sub-sample of the first 100 fish (when applicable) of each species were measured and the remainder were counted.

Component 3 interactions with Atlantic Sturgeon, Shortnose Sturgeon, Sea Turtles, and Marine Mammals Based on the 40 year history of the existing CBFI Beach Seine Survey, zero interactions with Atlantic Sturgeon, Shortnose Sturgeon, sea turtles, or marine mammals are anticipated with this project.

10.3 MD F-53-D Freshwater Resources Conservation
This project works primarily in freshwater systems and includes freshwater fish production, stocking and maintenance of facilities and freshwater lakes. Some tidal species are produced for stocking into freshwater or tidal-fresh systems, including striped bass and largemouth bass. Hatchery staff collect brood stock from tidal habitats where Atlantic sturgeon, shortnose sturgeon or sea turtles could occur. All brood stock collection takes place during sampling activities associated with federal grant projects already described elsewhere in this document.

10.4 MD F-57-R American and Hickory Shad Restoration in Three Maryland Rivers

10.4.1 MD F-57-R Summer Juvenile Seine Survey Methods
Funding obtained through Sportfish Restoration Act (F-57-R) has supported a Maryland Department of Natural Resources (MDNR) restoration project since 1999. MDNR restoration work thus far indicates that American shad restoration will likely occur over decades, rather than years. Reintroduction of juvenile American shad began in the Patuxent River in 1994. Choptank River American shad stocking began in 1996. Intermittent Nanticoke River stocking began in 1995, with consistent stockings of Marshyhope Creek beginning in 2002. Marshyhope Creek is a large tributary of the Nanticoke River. MDNR began a pilot project in 1993 to assess the resiliency of American shad adult broodstock during collection, handling and captive holding. In 1994, experimental spawning was conducted using timed-release hormone implants. The success of these trials encouraged development of a long-term spawning, culture, stocking and

assessment program. In 1995, a non-funded, full-scale hatchery production effort was conducted with positive results. The project continued over the next three years through various short-term funding sources. In 1998, it was determined that a long term funding source would be required since it would take several years of additional stocking and assessment to successfully support restoration. Federal Aid in Sport Fish Restoration funds were utilized to conduct this long-term effort. Choptank River work includes the large tributary of Tuckahoe Creek. The Nanticoke River drainage is comprised of the mainstem Nanticoke and the large tributary of Marshyhope Creek. The state of Delaware contributes culture and sampling resources to the mainstem Nanticoke River and MDNR conducts the culture and assessment of the Marshyhope Creek portion of the watershed. The Patuxent River watershed is heavily urban-impacted, but has been the subject of numerous mitigation efforts due to its designation as a targeted watershed (i.e. sewage treatment upgrades). The Choptank River watershed is influenced by agriculture and low density development. The Nanticoke River watershed is predominated by agriculture in the middle and lower river. The upper Nanticoke River is urban and industrial-impacted.

The anadromous restoration project samples juvenile American and hickory shad by beach seine in the summer between August and October. The objective is to assess the contribution of hatchery-produced American shad on the resident/pre-migratory stock in the Patuxent River, Choptank River, and Marshyhope Creek and monitor the abundance and mortality of larval and juvenile American shad using marked hatchery-produced fish. (Figures 1, 2, 3)

A seine 61.0 meters long, 3.1 meters deep, with 6.4mm stretch mesh, was deployed by boat and pulled to shore by hand at established seine sites. Juvenile American shad were picked from the seine collection, placed in plastic bags, labeled, and stored on ice. Upon return to the lab, the samples were frozen to -9 °C.

In an effort to increase juvenile American shad recaptures on the Patuxent River in 2009, MDNR experimented with a boat mounted push net supplied by District of Columbia Fisheries and Wildlife biologists. D.C. biologists successfully use a push net, one meter long, 2.7 meters deep, with 6.4 mm mesh to capture juvenile shad in the Potomac and Anacostia Rivers. The net was attached to an aluminum frame that rotates from the center of the boat and rests on the bow of the boat to deploy the net. Trawls are conducted with the tide and after sunset. Trawls are typically eight to ten minutes. (Joe Swann, D.C. Fisheries pers.comm.). Seine sites historically sampled by MDNR were sampled with the boat mounted push net for the presence of American shad.

10.4.2 MD F-57-R Spring Adult Electrofishing Survey

The anadromous restoration project samples adult American and hickory shad by electrofishing in the spring between March and June. The objective is to analyze the contribution of hatchery origin American shad and hickory shad to the adult spawning population and monitor the recovery of naturally produced stocks.

Patuxent River and Choptank River spawning ground surveys commenced in 1999 to collect adult American shad (Figure 4). Restorative stocking of American shad in these two target tributaries began in 1994 and 1996 respectively. Marshyhope Creek restorative stocking and the associated spawning ground surveys began in 2002 (Figure 5). Three quantifiable population variables have been determined for evaluation of restoration progression of adult American shad spawning stocks in the targeted rivers.

1) Estimate catch-per-unit effort (CPUE) in each targeted river using arithmetic and geometric means.
2) Estimate the contribution of hatchery produced fish to the adult spawning populations.
3) Estimate the frequency of virgin and repeat spawning.

Sampling was conducted in historical spawning areas described by anecdotal data and concentrated in river sections where shad were encountered during previous sampling. The survey was conducted with a Smith-Root (Vancouver, WA) electrofishing boat model SR18-E. Target tributaries were sampled weekly from March to June. The survey was usually accomplished with three people. One person piloted the boat and two people netted shad from the bow. Each river was sampled from upstream to downstream with constant voltage applied for the entire run. Total sample time (secs.) and total shock time (secs.) was recorded for CPUE calculations. Water temperature (°C), dissolved oxygen (mg/L), and conductivity (µS/cm) were obtained using a YSI 85 water quality meter (Yellow Springs, OH) and a secchi disk was used to quantify turbidity (cm).

Adult shad were encountered in all three rivers in areas that displayed similar physical characteristics. Sites are generally characterized as encompassing from the uppermost areas just below the fall line to the lowermost areas near the salt wedge. In the Patuxent River, this encompasses the area from the wastewater treatment plant located north of the intersection of Bayard Road and Sands Road (4500 block of Sands Road) to approximately 2.44 miles upstream just above the Patuxent River 4H Center. In the Choptank River, shad were captured from just above the Route 313 Bridge in Greensboro, Maryland to approximately 1.28 miles upstream. Adult shad were captured in Marshyhope Creek from the Federalsburg Marina to approximately 1.04 miles upstream. In all of the targeted rivers it is likely that shad also utilize tidal freshwater areas downstream of our collection sites, but increasing river width and depth reduced capture efficiency with electrofishing gear. Sampling upstream habitat is precluded by electrofishing boat access but anecdotal evidence indicates that substantial spawning habitat and fish movement exists upstream of currently sampled stream sections (Table 1.)

Table 1. *Maryland DNR adult American shad electrofishing survey starting and ending coordinates for target tributaries.*

River	**Starting latitude/longitude**	**Ending latitude/longitude**
Patuxent River	38° 53’ 08.24” N 76° 40’ 29.53” W	38° 51’ 05.09” N 76° 41’ 33.04” W
Choptank River	38° 59’ 11.91” N 75° 47’ 11.29” W	38° 58’ 36.79” N 75° 48’ 06.79” W
Marshyhope Creek	38° 42’ 15.13” N 75° 46’ 27.06” W	38° 41’ 26.24” N 75° 46’ 14.17” W

American shad were generally sub-sampled to no more than 20 individuals per day for otolith and CWT analysis. All other observed shad were counted for CPUE and other analyses. Fish collected were processed in the following manner: TL (mm), FL (mm) and sex determination. The fish were scanned for CWT that were implanted and stocked as late juveniles. CWT data allow for analysis of specific stocking events, origin and age validation studies.

Scale samples were taken for age and spawning mark analysis and otoliths were extracted to identify hatchery OTC marks. All hatchery origin American shad are marked with OTC and/or CWT, which allow for collection of data on hatchery contribution to the adult spawning stock. Shad scales were cleaned, mounted between glass slides, and aged using a microfiche reader. Scales were aged using methods described by Cating (1953).

10.4.3 MD F-57-R Spring American Shad Gill Net Brood Stock Collection

American shad were originally produced utilizing tank spawn culture methods developed by the project. Declining production success of American shad from tank spawn operations dictated that an additional source of larvae be developed.

In 2001, the decision was made to collect ripe fish on the spawning grounds and manually strip eggs and milt from mature brood fish. The Potomac River was chosen as the source population due to its strong American shad spawning population (Figure 6). The project hired a commercial fisherman to assist in egg collections that year. In 2002, it was determined that project personnel could perform these collections more efficiently and economically and this method is still utilized. Different areas along the Potomac River were evaluated for their ability to concentrate American shad. The channel in front of Fort Belvoir concentrates the greatest amount of American shad. The collections were carried out aboard a 7.0 m flat-bottom, center console skiff equipped with an outboard motor.

Weather and temperature conditions in late March and early April greatly influence the timing of American shad spawning on the Potomac River. It is essential to begin sampling in early April to ensure that collections occur during peak shad spawn. Sampling should normally begin in early April when water temperatures are 14 to 16°C. Gill nets were set parallel to the channel edge at depths varying between approximately 7.0 and 18.0 m. The time of net set depended exclusively on tide. Nets were ideally set at the beginning of slack tide. Past efforts indicated that setting nets at or near slack tide had a tendency to collect more shad. Nets were allowed to fish for approximately one hour. American shad are predisposed to spawn near, or just after sundown (Mansueti and Kolb 1953). For that reason, nets were set during the period from 1530 to 2130. Collecting shad before or after this six-hour window was deemed ineffective.

Catch per unit effort (CPUE) is used as an index of relative abundance. Gill net CPUE is established by dividing the number of fish caught per net, by the square footage of net fished per hour of soak time. A hand tally counter (tallycounterstore.com) is used to keep accurate count of all American shad caught from each net. Although trends in overall American shad catch rates can be monitored using CPUE ,the use of non-standardized gear through the years makes it difficult to establish an accurate relative abundance over time. CPUE has been an accurate tool in evaluating the most efficient gear to collect American shad. CPUE of a net differs greatly based on the net construction (monofilament vs. multifilament), net mesh size, and net depth.

Various nets were evaluated to study catch efficiency using different net mesh size and net depth. Gill nets with smaller mesh size have the tendency to catch smaller fish while nets with larger mesh sizes have a tendency to catch larger fish. In 2011, MDNR staff fished three different types of floating gill nets to determine catch efficiency for each net. Three to five nets were set per night, depending on weather conditions and boat traffic. In 2011, the 127 mm stretch mesh, 5.49 m deep, 100 m long monofilament net was determined to be the most effective net for catching American shad.

10.4.4 MD F-57-R Spring Hickory Shad Electrofishing Broodstock Collection

MDNR's American shad hatchery based restoration project incorporated hickory shad into the project in 1996. The project continued over the next three years through various short-term funding sources. In 1998 it was determined that a long term funding source would be required since it would take an estimated minimum five to ten years additional stocking and assessment to successfully support restoration. Federal Aid in Sport Fish Restoration funds was utilized to conduct this long-term effort. Hickory shad broodstock were collected from the Susquehanna River. Since the mid-1990s, hickory shad numbers have increased in the upper Chesapeake Bay and its tributaries (ASMFC 1999).

Prior to 2005, hickory shad broodstock were collected by hook and line either immediately downstream of Deer Creek or at Shure's Landing, near the base of Conowingo Dam. In 2005, MDNR staff began using an electrofishing boat to collect hickory shad brood. The sample area was along the western shore of the Susquehanna River, from just downstream of Deer Creek at Rock Run Mill down to the Lapidum boat launch (Figure 7). Electrofishing was used for its ability to efficiently collect larger numbers of hickory shad than could be collected by hook and line collection. Electrofishing for hickory shad brood stock requires less project staff and reduces handling stress to the fish. During brood collection, immobilized hickory shad were netted and placed in the electrofishing boat's hull-mounted live well (220L). The live well water was recirculated, oxygenated, and treated with anesthetic (0.26 ml/L) 2-Phenoxyethanol, 99% (Acros Organics, www.acros.com), to reduce stress and injury.

10.4.5 MD F-57-R American Shad Gillnet Survey

The Choptank River is sampled by gill net to determine adult American Shad presence. Gill netting surveys were conducted 4.02 km upstream to 0.32 km downstream of the boat launch at Daniel Crouse Memorial Park in Denton, MD (Figure 8). The survey reach generally includes the lowermost areas near the salt wedge to the uppermost areas just below the fall line (Figure 8). In the Choptank River, this area extends from the Greensboro, Maryland boat launch to 0.5 km below Denton, at the Daniel Crouse Memorial Park boat launch.

The survey is accomplished with at least three people. One person pilots the boat and two people fish nets. Anchored gill nets (30 m, 11.0 cm stretch mesh) are deployed to cover the entire water column. Gill nets are set parallel to the current and checked hourly for American Shad. Water temperature (◦C), dissolved oxygen (ppm), and conductivity (µS/cm) are obtained using a YSI Pro 2030 water quality meter (Yellow Springs, OH), and a Secchi disk was used to quantify turbidity (cm). Gill nets remained stationary throughout the duration of the sample day, and sampled the entire water column.

A sub-sample of no more than 20 American Shad is collected per sample trip for age, otolith, and CWT presence analysis. All other observed shad are counted to calculate CPUE. Fish are measured for TL (mm), fork length (FL, mm) and sex is determined. Scale samples are taken for age estimation and spawning mark interpretations, and otoliths are extracted to identify hatchery (OTC) marks. All hatchery origin American Shad are marked with OTC, which permits analysis of hatchery contribution to the juvenile abundance estimate and the adult spawning stock composition. Shad scales are cleaned, mounted between glass slides, and age is estimated and spawning attempts are counted using a microfiche reader. Two biologists interpret the scales independently. In cases where readers disagree on age or spawning attempt analysis, a consensus age is used as the final age. Scales are analyzed using methods described by Cating (1953). Otoliths are mounted on 76.2 mm x 25.4 mm glass slides with Crystalbond 509 (Aremco Products, Ossining, NY). Mounted otoliths are lightly ground on 600 grit silicon carbide wet sandpaper and viewed under epi-fluorescent light at 400X magnification at 50-100 watts with a Zeiss Axioscop 20 microscope. The presence and location of OTC mark epi-fluorescence is recorded. Epi-fluorescence is a technique in which transmitted light in the wavelength of 490-515 nm is allowed to strike the specimen. The specimen then absorbs this light energy and reflects light of a longer wavelength back through the microscope objective.

Since 2015, the Maryland DNR Anadromous Restoration project completed 62 gill net sets, and Atlantic sturgeon occurred in none of those samples.

To date, the Maryland DNR Anadromous Restoration project has had no contact with Shortnose sturgeon or sea turtles in the summer seine survey, the spring adult electrofishing survey, the brood stock gill net efforts, the brood stock electrofishing efforts, the Choptank larval survey, or the Choptank gillnet survey.

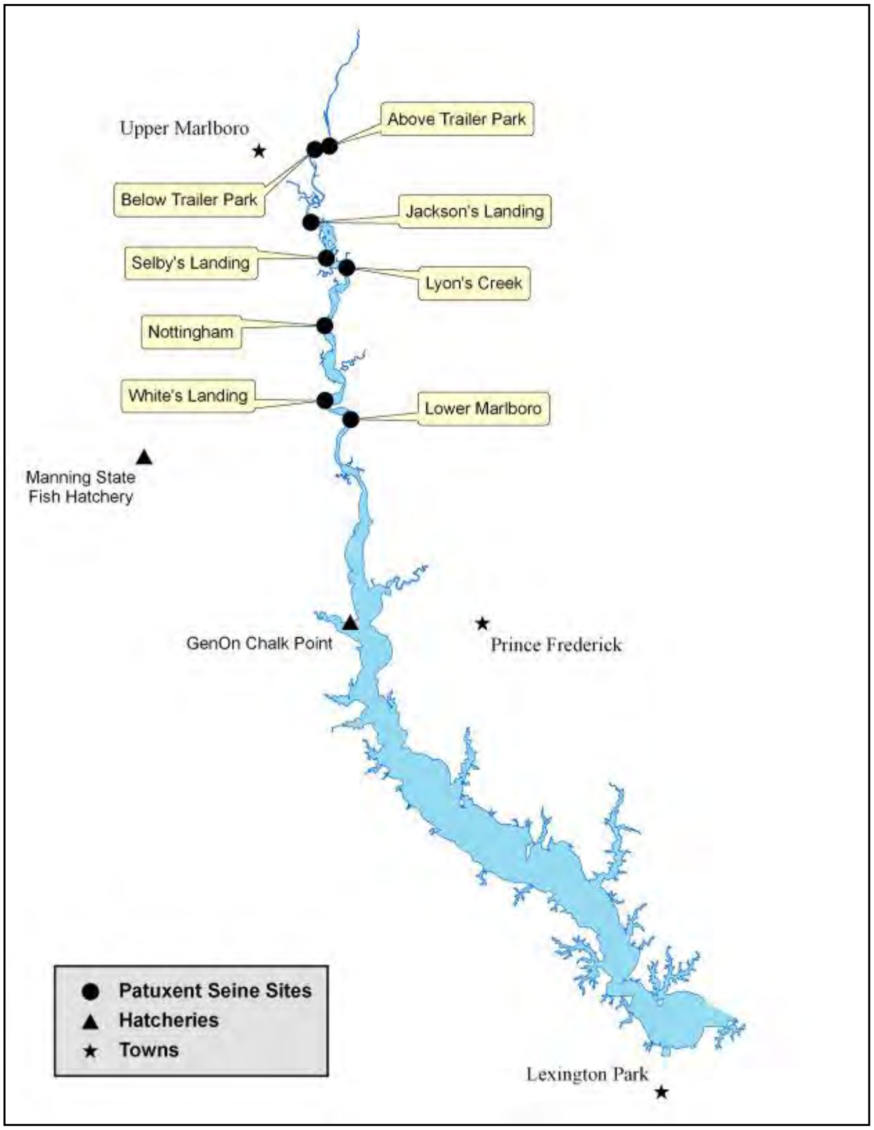


Figure 1. Maryland DNR Patuxent River juvenile American and hickory shad survey seine sites.

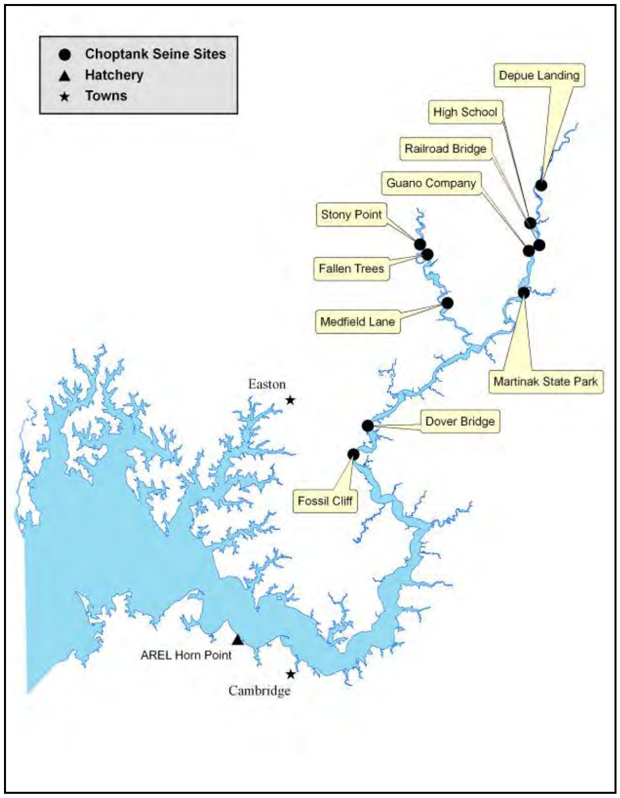


Figure 2. Maryland DNR Choptank River juvenile American and hickory shad survey seine sites.

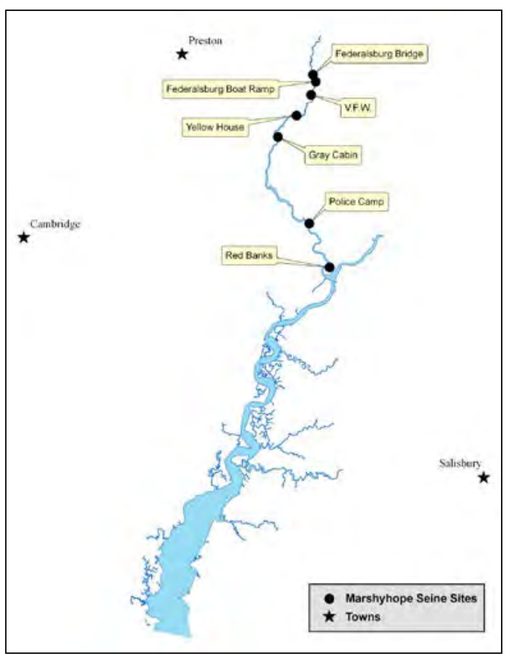


Figure 3. Maryland DNR Marshyhope Creek juvenile American and hickory shad survey seine sites.

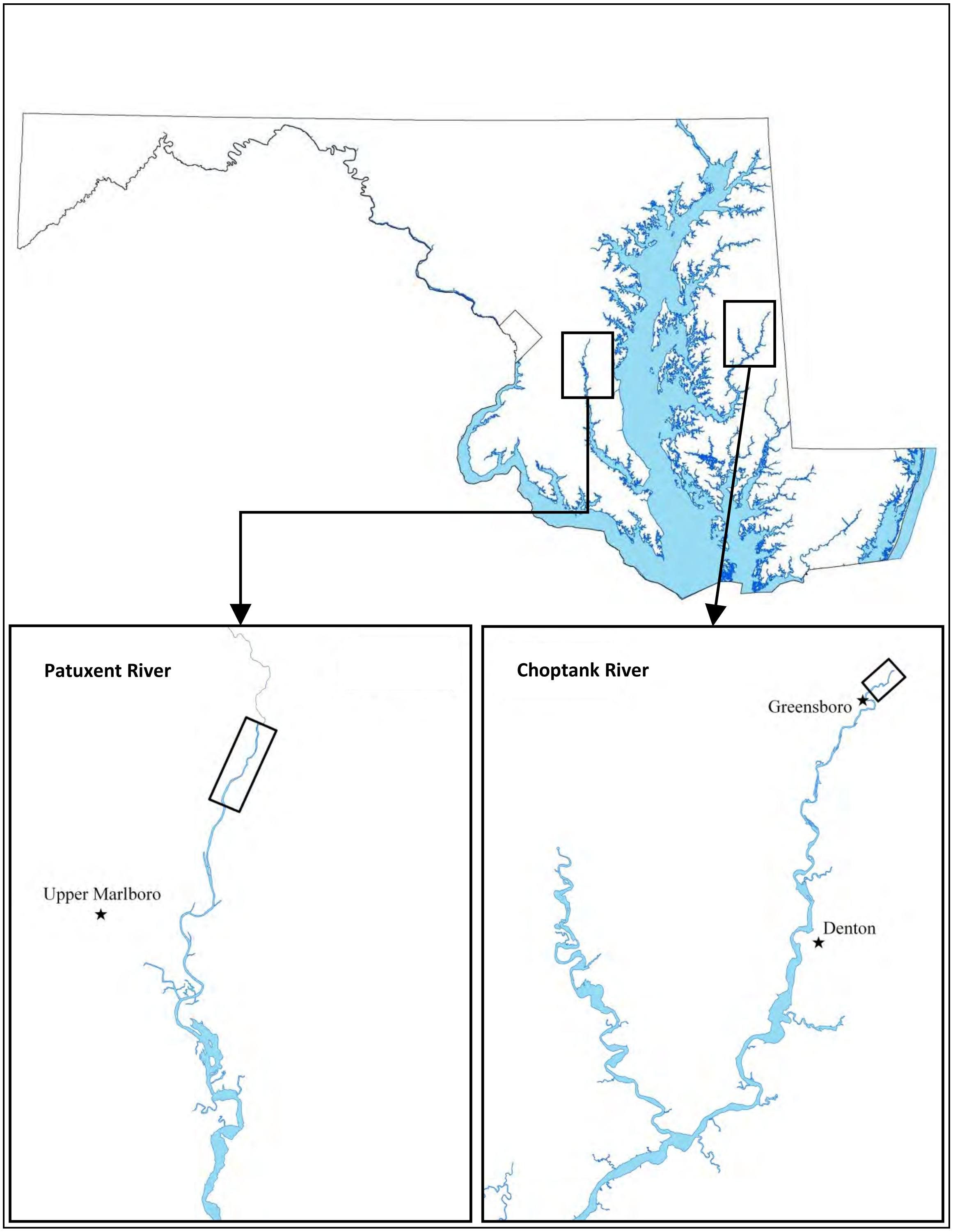


Figure 4. Maryland DNR adult American and hickory shad electrofishing survey areas sampled

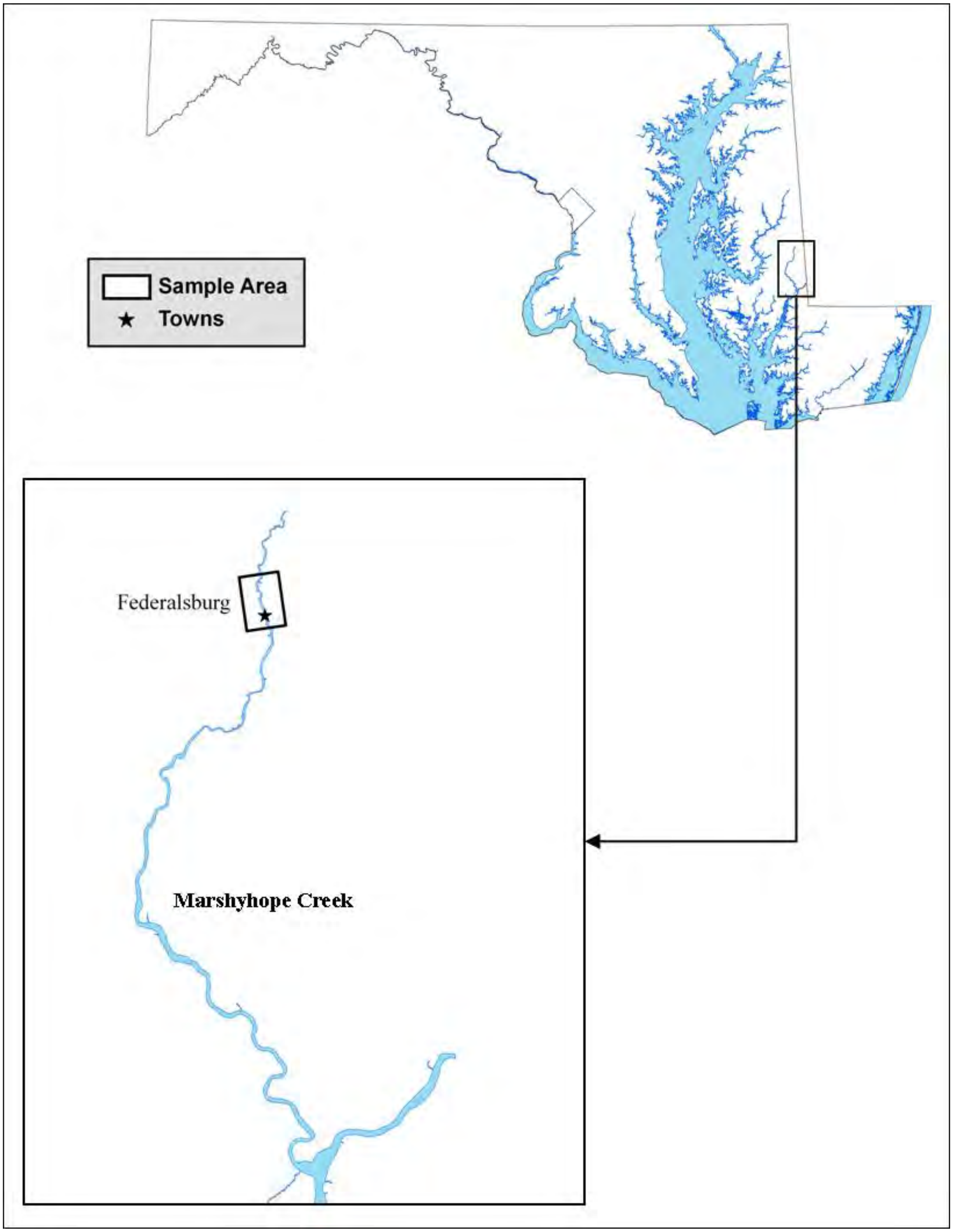


Figure 5. Maryland DNR adult American and hickory shad electrofishing survey areas sampled

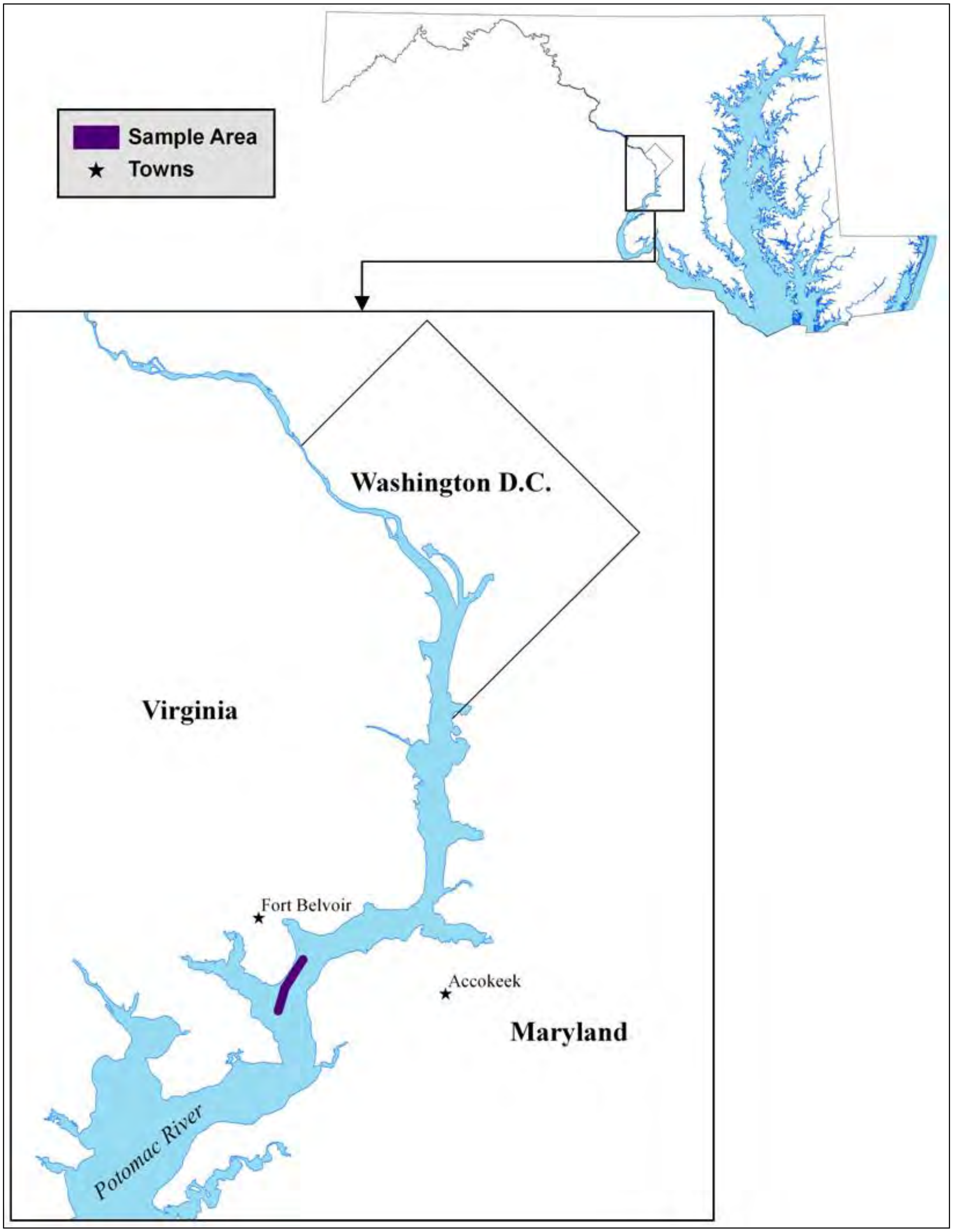


Figure 6. Maryland DNR American shad brood stock collection site on the Potomac River.

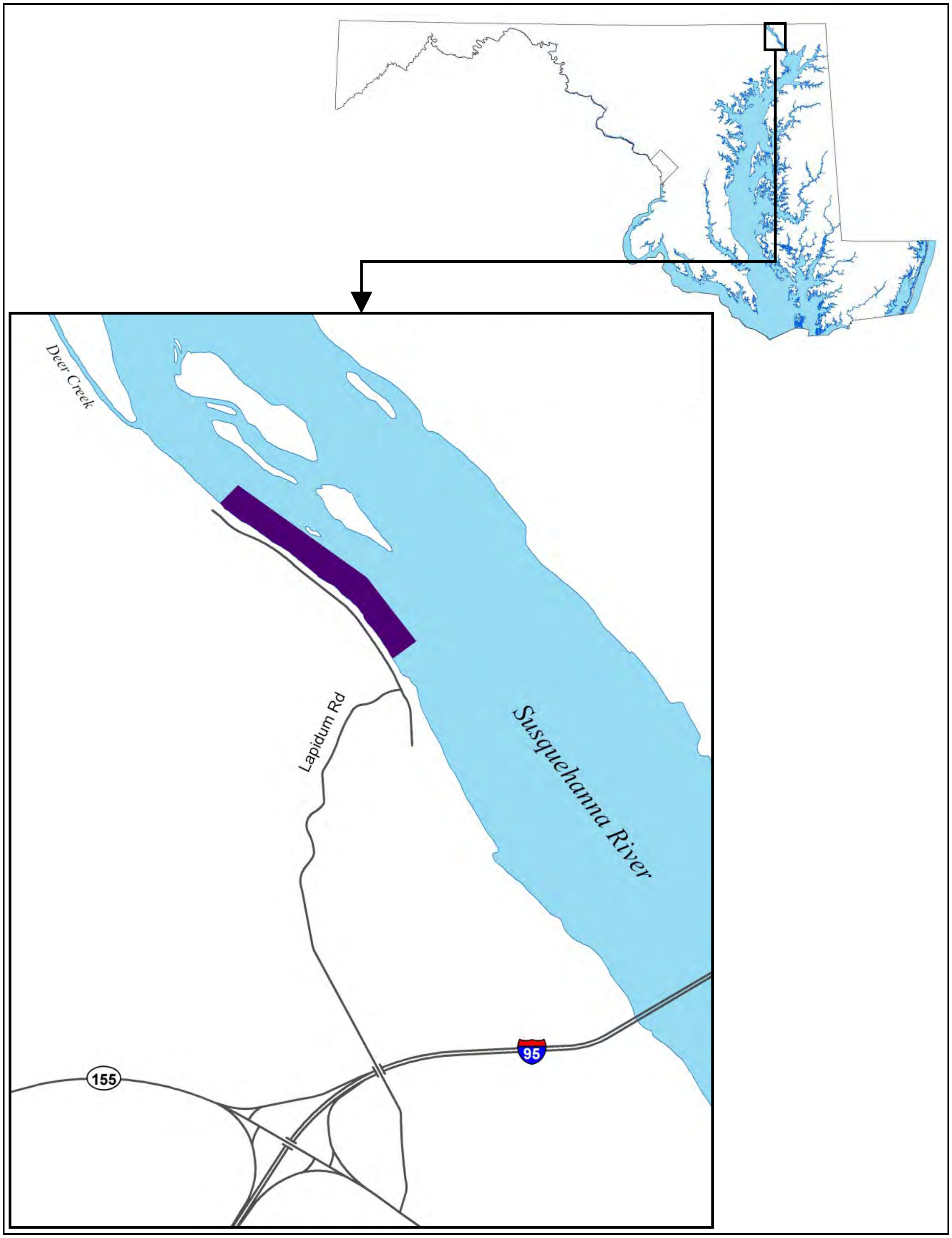


Figure 7. Maryland DNR hickory shad brood stock collection site on the Susquehanna River.

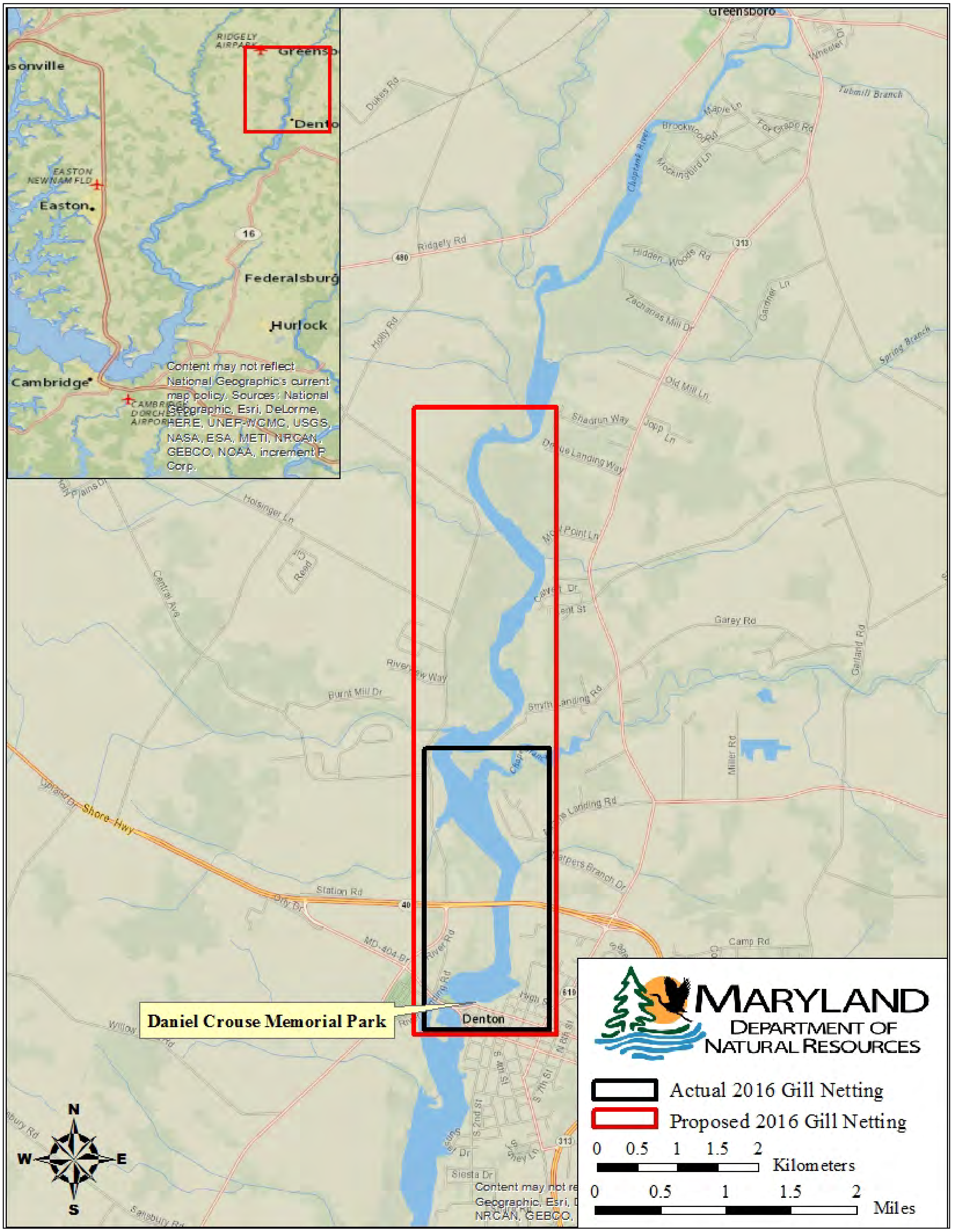


Figure 8. Maryland DNR American Shad survey areas sampled with gill nets.

10.5 MD F-61-R Chesapeake Bay Finfish and Habitat Investigations

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay. The F-61-R Survey provides information regarding recruitment, relative abundance, age and size structure, growth, mortality, and migration patterns of finfish populations in Maryland's Chesapeake Bay. The data generated are utilized in both intrastate and interstate management processes and provides a reference point for future fisheries management considerations**.**

10.5.1 MD F-61-R Resident Species Stock Assessment

This project includes two components: (1) Population vital rates of resident finfish in selected tidal areas of Maryland's Chesapeake Bay; and, (2) Population assessment of yellow perch in Maryland with special emphasis on the Head-of-Bay stocks.

The objective of Project 1, Job 1 is to determine population vital rates (relative abundance, age, growth, mortality, and recruitment) of yellow perch, white perch, and catfish species in tidal regions of Chesapeake Bay. Job 2 is a rotational, triennial stock assessment of yellow perch (integrated analysis), white perch (catch survey analysis) or channel catfish (surplus production modeling). As such, all data collections and surveys are performed under Job1, which includes two components subject to this Biological Opinion: (1) Upper Chesapeake Bay Winter Trawl and (2) Fishery Independent Choptank River Fyke Net Survey.

*10.5.1.1 MD F-61-R Upper Chesapeake Bay Winter Trawl*The upper Chesapeake Bay winter bottom trawl survey is designed to collect fishery-independent data for the assessment of population trends of white perch, yellow perch, channel catfish, and white catfish. For 2011, upper Chesapeake Bay was divided into four sampling areas; Sassafras River (SAS), Elk River (EB), upper Chesapeake Bay (UB), and middle Chesapeake Bay (MB). Eighteen sampling stations, each approximately 2.6 km (1.5 miles) in length and variable in width, were created throughout the study area (Figure 1; Table 1). Each sampling station was divided into west/north or east/south halves by drawing a line parallel to the shipping channel. Sampling depth was divided into two strata; shallow water (< 6 m) and deep water (>6 m). Each site visit was then randomized for depth strata and the north/south or east/west directional components.

The winter trawl survey employed a 7.6 m wide bottom trawl consisting of 7.6 cm stretch-mesh in the wings and body, 1.9 cm stretch-mesh in the cod end and a 1.3 cm stretch-mesh liner. Following the 10-minute tow at approximately 3 knots, the trawl was retrieved into the boat by winch and the catch emptied into either a culling board or large tub if catches were large. A minimum of 50 fish per species were sexed and measured. Non-random samples of yellow perch and white perch were sacrificed for otolith extraction and subsequent age determination. All species caught were identified and counted. If catches were prohibitively large to process, total numbers were extrapolated from volumetric counts. Volumetric subsamples were taken from the top of the tub, the middle of the tub, and the bottom of the tub. Six sampling rounds were scheduled from early December 2010 through February 2011.

Trawl sites have been consistent throughout the survey, but weather and operational issues caused incomplete sampling in some years. The 2003 survey was hampered by ice conditions such that only one of six rounds was completed. Retirement of the captain of the R/V Laidly during 2004 led to no rounds being completed. Only 1-½ rounds of the scheduled six rounds were completed in 2005 because of catastrophic engine failure. Ice-cover prevented the final two rounds of the 2007 survey and one round of the 2009 from being completed. Ice conditions also affected the 2010 and 2011 sample years where only 56 and 66 of the scheduled 108 trawls were completed, respectively (Table 2).

10.5.1.2 MD F-61-R Fishery Independent Choptank River Fyke Net Survey

In 2011, six experimental fyke nets were set in the Choptank River to sample the four resident species from this system. Nets were set at river kilometers 63.6, 65.4, 66.6, 72.5, 74.4 and 78.1 and were fished two to three times per week from 21 February through 6 April (Figure 2; Table **3**). These nets contained a 64 mm stretch-mesh body and 76 mm stretch-mesh in the wings (7.6 m long) and leads (30.5 m long). Nets were set perpendicular to the shore with the wings at 45°angles. Annual effort has varied from 40 fyke net days early in the time series to 353 fyke net days in 1999. More recently, fyke net effort has ranged from 200 – 250 fyke net days (Table 4).

Net hoops were brought aboard first to ensure that all fish were retained. Fish were then removed and placed into a tub and identified. All yellow perch and a subsample of up to 30 fish of each target species were sexed and measured. All non-target species were counted and released. Otoliths from a subsample of white and yellow perch were removed for age determination.

Table 1. General location of upper Chesapeake Bay Trawl Survey sites. Coordinates are for each site for the first round of the 2011 sampling season. Other rounds do not vary substantially.

SITENAME	LAT START	LONG START
EB1	39 27.8455	75 58.281
EB2	39 29.3914	75 56.4148
EB3	39 30.1579	75 55.1354
EB4	39 30.3733	75 54.2504
MB1	39 16.1559	76 14.2227
MB2	39 14.5882	76 14.3344
MB3	39 13.3743	76 14.9061
MB4	39 11.1943	76 16.7796
SA1	39 22.4793	76 01.2645
SA2	39 22.3325	75 59.1757
SA3	39 22.6005	75 57.7054
SA4	39 22.2418	75 55.8333
UB1	39 26.0095	76 00.6761
UB2	39 25.1319	76 02.892
UB3	39 23.2094	76 06.6192
UB4	39 21.6272	76 09.1285
UB5	39 20.3601	76 10.1529
UB6	39 19.2385	76 13.374

Table 2. Effort (Number of bottom trawl tows) for Upper Chesapeake Bay Winter Trawl Survey.

Year	# FykeNet Days	# Atlantic Sturgeon	# Shortnose Sturgeon	# Sea Turtles
2000	79	0	0	0
2001	114	0	0	0
2002	110	0	0	0
2003	0	0	0	0
2004	20	0	0	0
2005	43	0	0	0
2006	108	0	0	0
2007	71	0	0	0
2008	108	0	0	0
2009	90	0	0	0
2010	56	0	0	0
2011	66	0	0	0

Table 3. Coordinates for Choptank River Fyke Net Survey locations.

Site Name	Coordinates	
Kings Landing	38 46 44.5N	75 57 15.9W
Quidas Farm	38 47 09.4N	75 56 12.8W
Turkey Creek	38 48 25.4N	75 54 50.4W
Robins Marsh	38 49 22.9N	75 52 23.2W
Mill Creek	38 49 28.3N	75 51 30.9W
Lyphord Landing	38 50 21.3N	75 51 58.9W

Table 4. Effort (Number of fyke net days) for Choptank River Fyke Net Survey.

Year	# Fyke Net Days	# Atlantic Sturgeon	# Shortnose Sturgeon	# Sea Turtles
1989	80	0	0	0
1990	87	0	0	0
1991	40	0	0	0
1992	188	0	0	0
1993	343	0	0	0
1994	271	0	0	0
1995	298	0	0	0
1996	330	0	0	0
1997	330	0	0	0

1998	321	0	0	0
1999	359	0	0	0
2000	310	0	0	0
2001	310	0	0	0
2002	306	0	0	0
2003	261	0	0	0
2004	251	0	0	0
2005	235	0	0	0
2006	236	0	0	0
2007	203	0	0	0
2008	248	0	0	0
2009	210	0	0	0
2010	223	0	0	0
2011	242	0	0	0

Figure 1. Upper Chesapeake Bay Trawl Survey sites for 2011

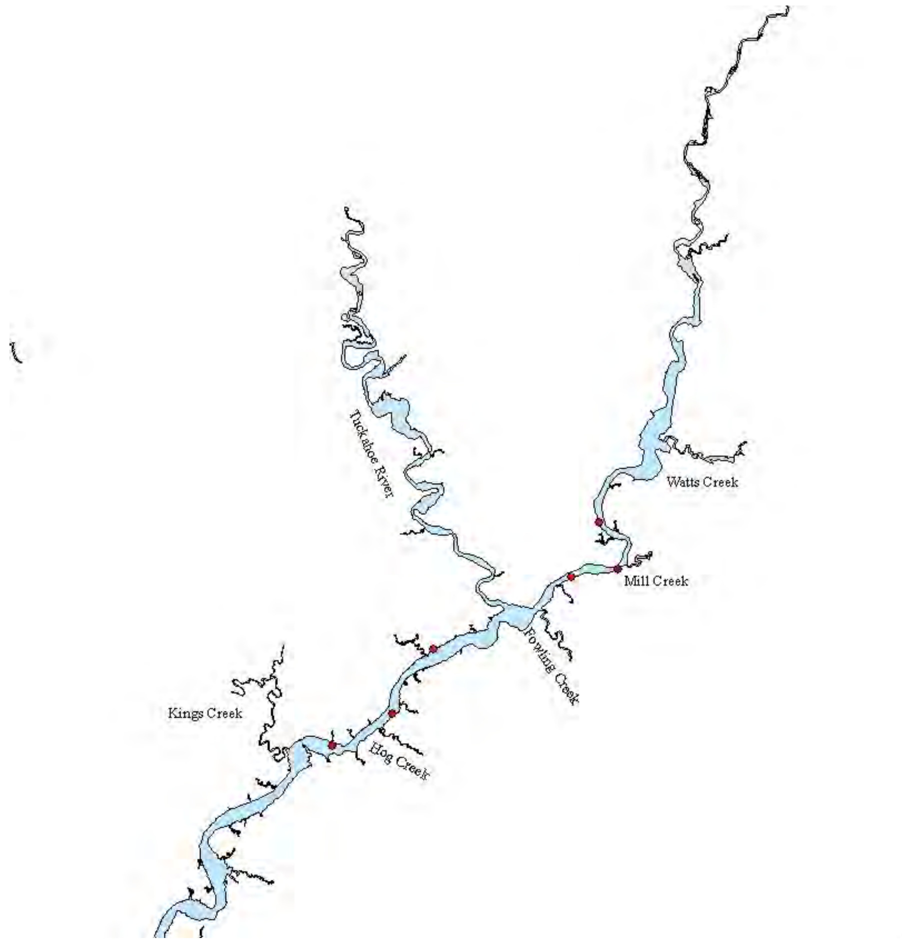


Figure 2. Fyke net locations for the Choptank River Fyke Net Survey, 2011. Circles indicate fyke net locations.

10.5.2 MD F-61-R Alosa Species Stock Assessment

Project 2 of F-61-R samples migratory species with interjurisdictional management. The objective of Job 1 is to characterize recreationally important migratory finfish stocks in Maryland's portion of Chesapeake Bay through collection and analysis of age, length, weight, growth, sex and relative abundance data. The objectives of Job 2 are to collect and analyze stock assessment information for American and hickory shad, and alewife and blueback herring (collectively, river herring) in Chesapeake Bay select tributaries.

10.5.2.1 MD F-61-R Juvenile Alosid Trawl and Seine Survey

MD DNR has conducted a juvenile survey for alosines in the Chester River since 2005. Collected data are used to contribute to our knowledge of juvenile alosine abundance. Data are also used by the Fisheries Habitat and Ecosystems Program at MDNR to understand how urbanization affects fish habitat.

Juvenile alosine species are sampled in the Chester River using a 30.5 x 1.2m x 6.4mm mesh haul seine and a 16' headrope bottom trawl. Sampling in this system begins in early July and continues bi-weekly through late September. There are 4-8 stations upriver of Shell Point: each station consists of one seine haul and one bottom trawl. Surface and bottom water quality (temperature, salinity, specific conductance, dissolved oxygen) is recorded at each trawl site. Only surface water quality is recorded for seine sites.

All seines are pulled with the tide. One person remains on shore holding one end of the seine. The person on shore "feeds" their end of the seine out as the other person pulls the seine. The other person pulls the seine straight out (perpendicular) from the beach until it is fully extended. When the seine is fully extended, it is pulled back toward the beach in an arc. Once both ends of the seine are on shore, the two individuals pull the seine toward each other and meet as closely as possible. The net is brought onshore by pulling evenly on the float and lead line of the seine, making sure the lead line remains on the bottom. When the net is fully retrieved, all of the fish are shaken down into a common area. Twenty of all alosine species, white and yellow perch, and striped bass are measured; any fish in excess of 20 are counted. The numbers of all other fishes and crabs captured in the seine net are recorded.

Trawls are towed with the tide at two knots for six minutes. The trawl is deployed by hand over the gunwale. After completion and retrieval of the trawl, fish captured in the upper part of the trawl are shaken down toward the cod end and released into a culling box or sorting tub. Twenty of all alosine species, white and yellow perch, and striped bass are measured; any fish in excess of 20 are counted. The numbers of all other fishes and crabs captured in the trawl net are recorded.

10.5.2.2 MD F-61-R American Shad Hook and Lne Survey

Adult American shad are angled by Maryland Department of Natural Resources staff from the Conowingo Dam tailrace on the lower Susquehanna River two to four times per week from April through May. Two or three rods are fished simultaneously; each rod is rigged with two shad darts and lead weight is added when required to achieve proper depth. American shad are sexed (by expression of gonadal products), total length (TL) and fork length (FL) are measured to the nearest mm, and scales are removed below the insertion of the dorsal fin for ageing and spawning history analysis. Fish in good physical condition, with the exception of spent or post-spawn fish, were tagged with Floy tags (color-coded to identify the year tagged) and released.

To date, no Atlantic sturgeon have been encountered in the American Shad Hook and Line Survey (survey initiated 1987; Table 1). To date, no shortnose sturgeon or sea turtles have been encountered in the American Shad Hook and Line Survey (survey initiated 1987; Table 1).

Table 1. Conowingo H & L

Year	Hours Fished	Trips	# Atlantic Sturgeon	# Shortnose Sturgeon	# Sea Turtles
1987	63.8	16	0	0	0
1988	43.0	11	0	0	0
1989	42.3	11	0	0	0
1990	47.8	13	0	0	0
1991	76.8	19	0	0	0
1992	62.8	16	0	0	0
1993	48.0	13	0	0	0
1994	88.5	24	0	0	0
1995	84.6	23	0	0	0
1996	44.3	11	0	0	0
1997	57.8	16	0	0	0
1998	23.3	7	0	0	0
1999	52.0	16	0	0	0
2000	44.7	14	0	0	0
2001	65.8	20	0	0	0
2002	60.0	18	0	0	0
2003	68.3	23	0	0	0
2004	38.8	13	0	0	0
2005	58.0	17	0	0	0
2006	36.0	12	0	0	0
2007	53.2	16	0	0	0
2008	39.9	15	0	0	0
2009	60.0	20	0	0	0
2010	65.0	21	0	0	0
2011	17.3	7	0	0	0
2012	50.5	18	0	0	0
2013	47.8	16	0	0	0
2014	45.3	13	0	0	0
2015	34.3	12	0	0	0
2016	53.7	19	0	0	0
2017	41.2	14	0	0	0

10.5.2.3 MD F-61-R River Herring Gill Net Survey

A multi-panel experimental anchored sinking gill net is utilized in the North East River to assess river herring relative abundance and demographic characteristics of the spawning runs. The gill net is fished at four randomly chosen sites once a week for 10 weeks from mid-March to mid-May. Sampling locations are randomly assigned from a grid consisting of 112, 0.04 square mile quadrants (Figure 1). Sampling sites are subsequently randomized for depth to determine if the net would be set in shallow or deeper water within the quadrant. Four alternate sites are also randomly chosen and used in cases where the chosen site is unable to be sampled. For example, if depth is below 6 feet at a given site, the next available alternate site is sampled.

Individual net panels are 100 feet long and 6 feet deep. The panels are constructed of 0.33 mm diameter monofilament twine in 2.5, 2.75 and 3 inch mesh. The net has a 1/2-3/8 inch poly-foamcore float line and a 50 pound lead line. Nets are hung with 200 feet of stretch netting for every 100 feet of net. The three panels were tied together to fish simultaneously and were soaked for 30 minutes before retrieval. Panel order was randomly chosen before the net was tied together at the start of the survey for each year.

To date, no Atlantic sturgeon have been encountered in the River Herring Gill Net Survey (survey initiated 2013; Table 1). To date, no shortnose sturgeon or sea turtles have been encountered in the River Herring Gill Net Survey (survey initiated 2013; Table 1).

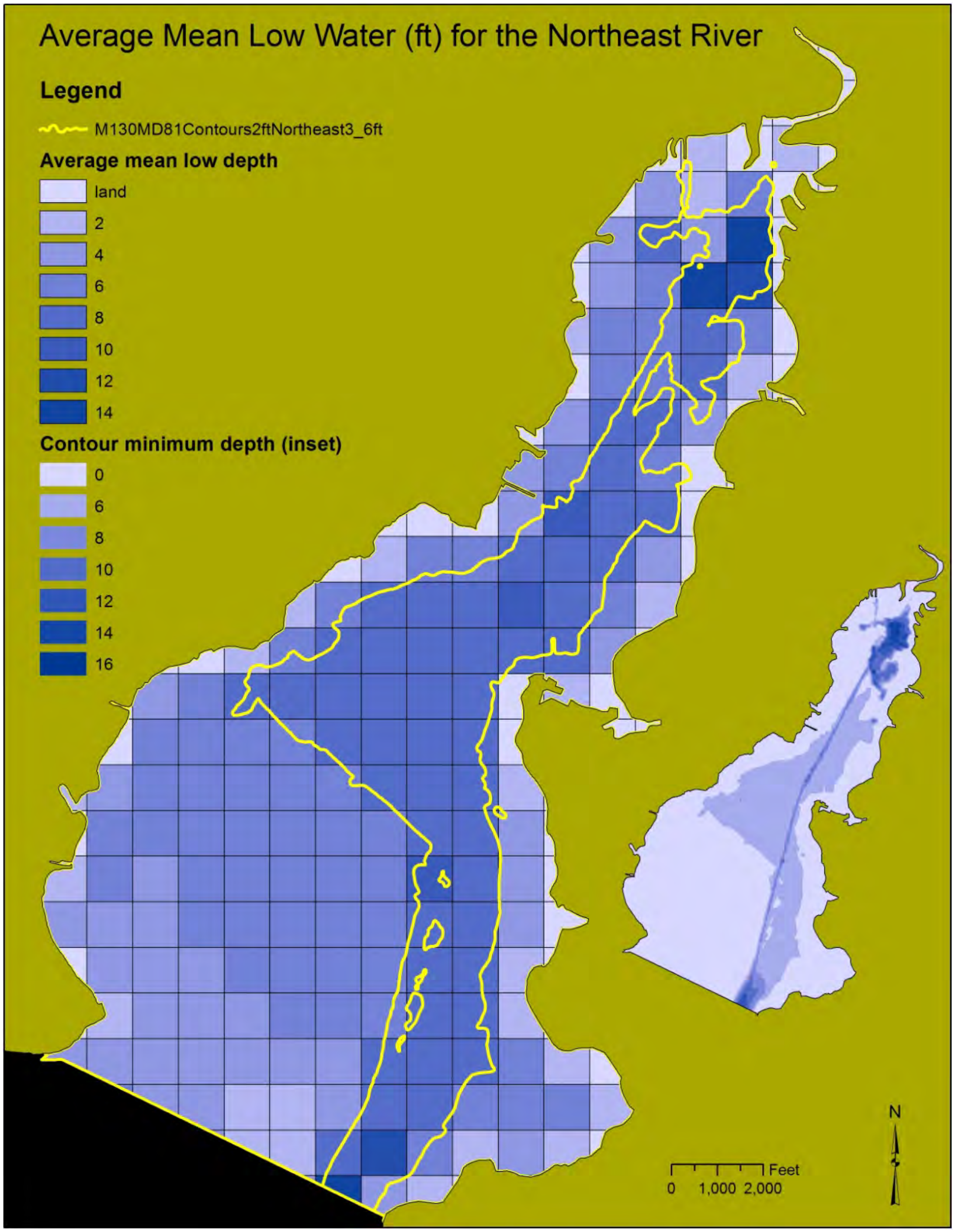


Figure 1. North East River sampling grid for River Herring Gill Net Survey.

Table 1. NE River Gill net

Year	# of Sets	# Atlantic Sturgeon	# Shortnose Sturgeon	# Sea Turtles
2013	40	0	0	0
2014	40	0	0	0
2015	40	0	0	0
2016	40	0	0	0
2017	40	0	0	0

10.5.2.4 MD F-61-R Alosid Ichthyoplankton Survey

Ichthyoplankton sampling is conducted on the Nanticoke River in cooperation with the Fish Habitat & Ecosystem Program (Federal Aid Grant F-63-R, Segment 2, Job 1, Section 3) twice per week in April. The presence/absence of alosine eggs or larvae is noted (time and field conditions prevented species identification of alosine eggs or larvae). These samples are collected following historical methodology: the river was divided into eighteen one-mile cells and ten of these cells were randomly selected during each sampling day (Figure 1). The ichthyoplankton net is constructed of 500 μm mesh net with a 500 mm metal ring opening. The net is towed into the tide for two minutes at approximately two knots. At the conclusion of the tow, the contents are flushed down into a mason jar for presence/absence determination.

To date, no Atlantic sturgeon have been observed in the Alosid Ichthyoplankton Survey (survey initiated 2011; Table 1).To date, no shortnose sturgeon or sea turtles have been observed in Alosid Ichthyoplankton Survey (survey initiated 2011; Table 1).

10.5.3 MD F-61-R Migratory Fish Gill Net Survey

The Migratory Fish Gill Net Survey consists of a fishery independent gill net survey in the lower Choptank River. The survey utilizes experimental gill nets sets (4 panels per set including 2 ½" 3", 3 ½" and 4" stretched mono mesh) for one hour within randomly selected square grids measuring 457 meters per side (Figures 1 & 2). Sampling is conducted once per week, with four sets per sampling day, throughout the months of June, July and August. All fish are identified and enumerated by species and gill net mesh size. From each gill net mesh size by site, all Atlantic croaker, spot, weakfish, spotted seatrout, red drum black drum, summer flounder bluefish, white perch and striped bass encountered are measured to the nearest millimeter TL, and a minimum of the first five Atlantic menhaden and all Spanish mackerel are measured to the nearest mm FL. These data are analyzed to derive CPUE and length frequency data by species for each gang of nets (all mesh sizes combined) and each mesh size individually as data permits. Additional data collected at each site includes date, location, surface water temperature, salinity, turbidity, weather conditions and tidal stage.

To date, no Atlantic sturgeon have been observed in the Migratory Fish Gill Net Survey (survey initiated 2013; Table 1). To date, no shortnose sturgeon or sea turtles have been observed in Migratory Fish Gill Net Survey (survey initiated 2013; Table 1).

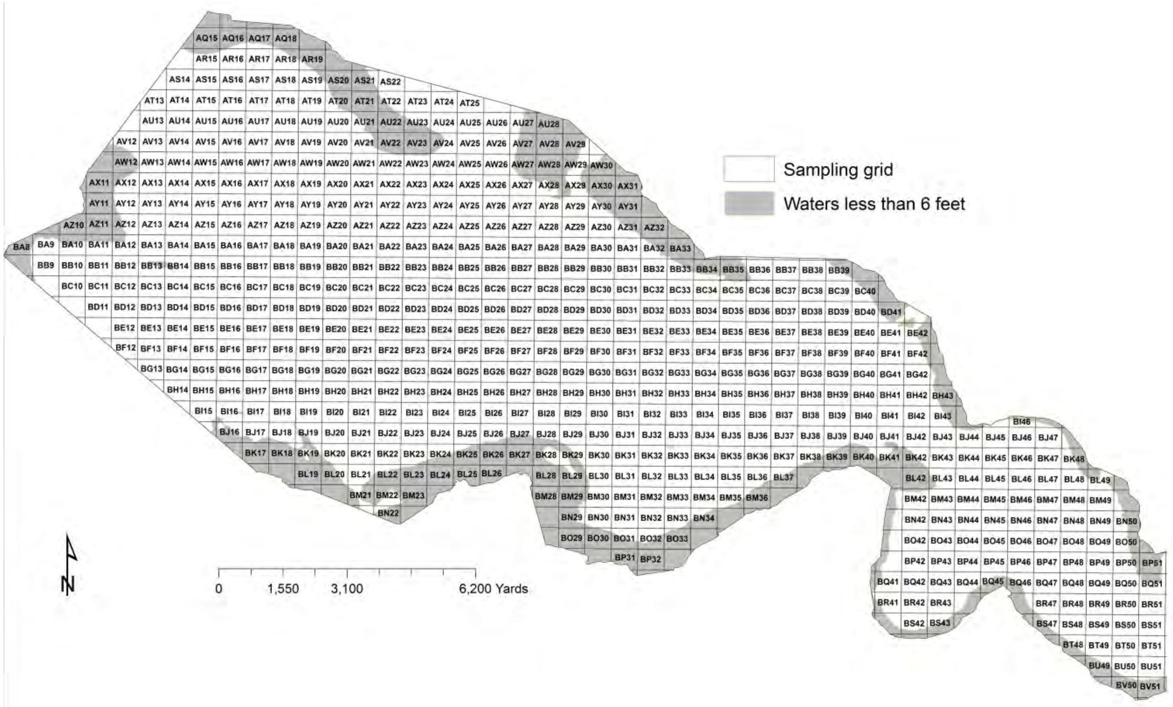


Figure 1. Migratory Fish Gill Net Survey sampling grid for Choptank River, Maryland.

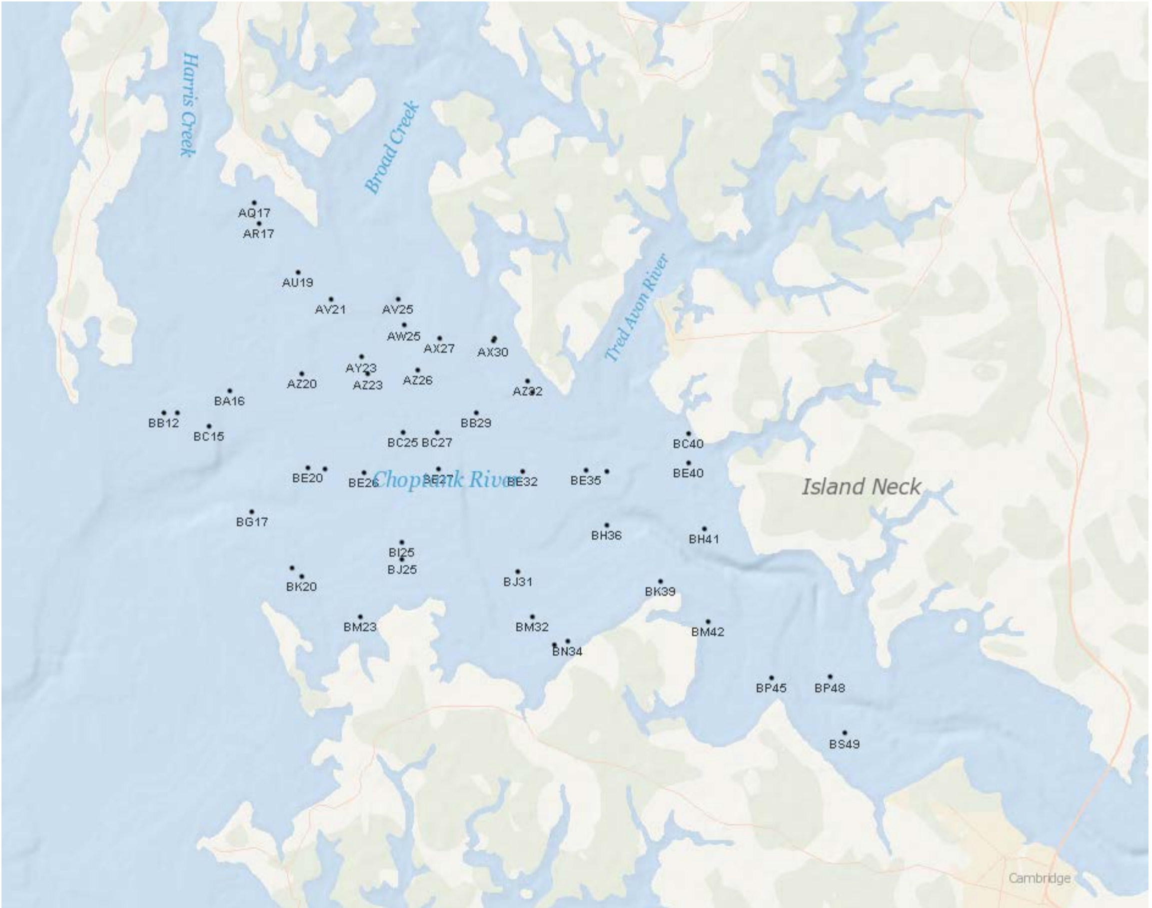


Figure 2. Actual sampling sites during 2015 for Migratory Fish Gill Net Survey in lower Choptank River.

Table 1.Choptank Gill net.

Year	# Sets	# Atlantic Sturgeon	# Shortnose Sturgeon	# Sea Turtles
2013	48	0	0	0
2014	52	0	0	0
2015	48	0	0	0
2016	46	0	0	0

10.5.4 MD F-61-R Striped Bass: Stock Assessment of Adult and Juvenile Striped Bass in Maryland's Chesapeake Bay and Selected Tributaries

This project includes several tasks to assess striped bass spawning stocks and juvenile production. Two of these are pertinent for this Biological Opinion.

10.5.4.1 F-61-R Spring Striped Bass Experimental Drift Gill Net Survey

The primary objective of Project 2, Job 3, Task 2 is to generate estimates of relative abundance-at-age for striped bass in Chesapeake Bay during the spring spawning season. A secondary objective of Task 2 was to characterize the striped bass spawning population within the Chesapeake Bay. Length distribution, age structure, average length-at-age, and percentage of striped bass older than age 8 present on the spawning grounds were examined. In addition, an Index of Spawning Potential (ISP) for female striped bass, an age-independent measure of female spawning biomass within the Chesapeake Bay, was calculated.

Since 1985, the Maryland Department of Natural Resources (MD DNR) has employed multi-panel experimental drift gill nets to monitor the Chesapeake Bay component of the Atlantic coast striped bass population. Because Chesapeake Bay spawners produce up to 90% of the Atlantic coastal stock (Richards and Rago 1999), indices derived from this effort are important in the coastal stock assessment process. Indices produced from this study are currently used to guide management decisions concerning recreational and commercial striped bass fisheries from North Carolina to Maine.

Multi-panel experimental drift gill nets were deployed in the Potomac River and in the Upper Chesapeake Bay in 2011 (Figure 1). Gill nets are fished 6 days per week, weather permitting, from late March through May. Individual net panels were 150 feet long, and ranged from 8.0 to 11.5 feet deep depending on mesh size. The panels were constructed of multifilament nylon webbing in 3.0, 3.75, 4.5, 5.25, 6.0, 6.5, 7.0, 8.0, 9.0 and 10.0-inch stretch-mesh. In the Upper Bay, all 10 panels were tied together, end to end, to fish the entire suite of meshes simultaneously. In the Potomac River, because of the design of the fishing boat, the gang of panels was split in half, with two suites of panels (5 meshes tied together) fished simultaneously end to end. In both systems, all 10 panels were fished twice daily unless weather prohibited a second set. The order of panels within the suite of nets was randomized with gaps of 5 to 10 feet between each panel. Overall soak times for each panel ranged from 6 to 105 minutes.

Sampling locations were assigned using a stratified random design. The Potomac River and Upper Bay spawning areas were each considered a stratum. One randomly chosen site per day was fished in each spawning area. Sites were chosen from a grid superimposed on a map of each system. The Potomac River grid consisted of 40, 0.5-square-mile quadrants, while the upper Bay grid consisted of 31, 1-square-mile quadrants. GPS equipment, buoys, and landmarks were used to locate the appropriate quadrant in the field. Once in the designated quadrant, air and surface water temperatures, surface salinity, and water clarity (Secchi depth) were measured.

All striped bass captured in the nets were measured for total length (mm TL), sexed by expression of gonadal products, and released. Scales were taken from 2-3 randomly chosen male striped bass per 10 mm length group, per week, for a maximum of 10 scale samples per length group over the entire season. Scales were also taken from all males over 700 mm TL and from all females regardless of total length. Scales were removed from the left side of the fish, between the lateral line and the first dorsal fin. Additionally, if time and fish condition permitted, U.S. Fish and Wildlife Service internal anchor tags were applied.

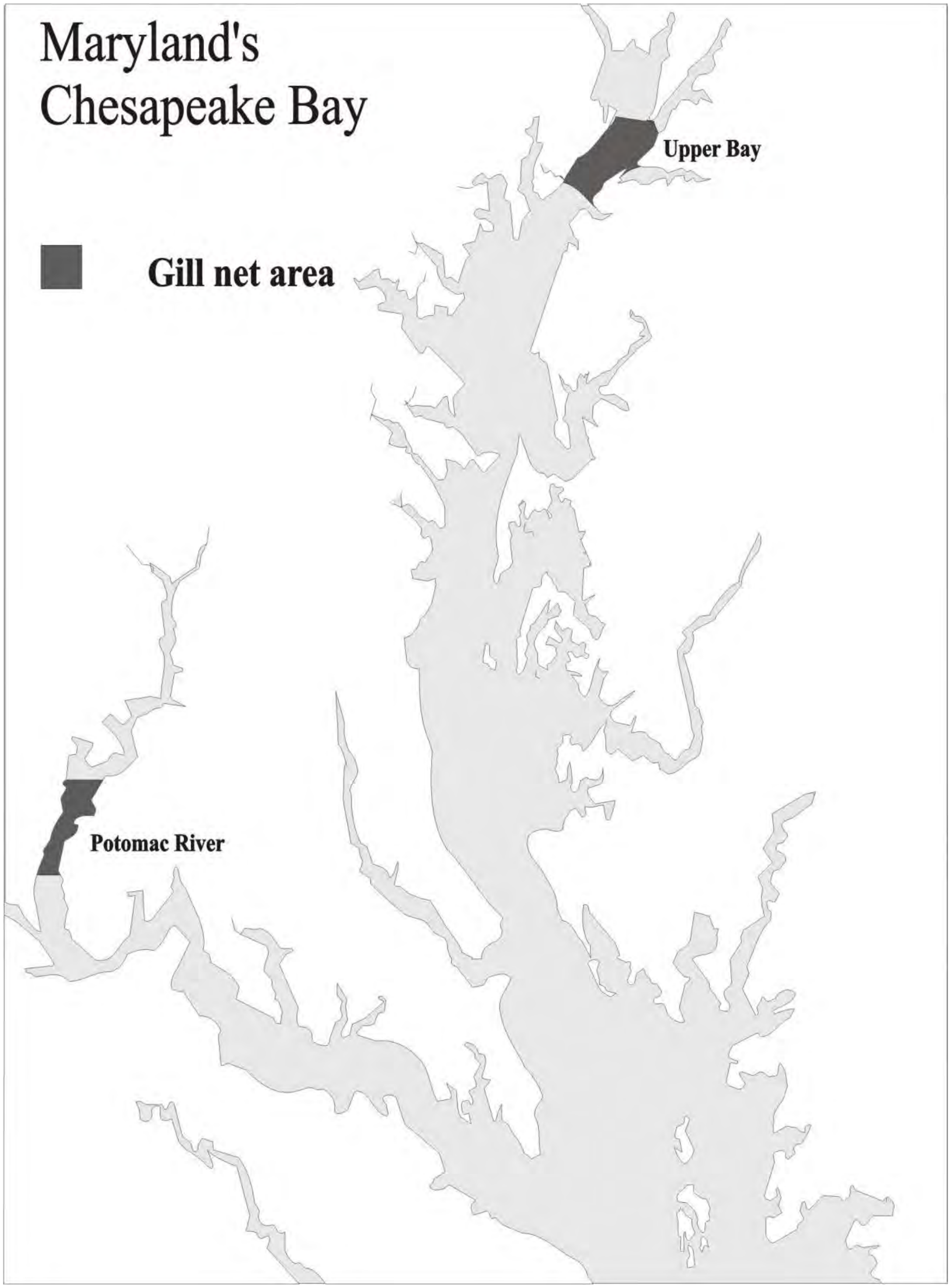


Figure 1. Drift gill net sampling locations in spawning areas of the upper Chesapeake Bay and the Potomac River, late March - May.

10.5.4.2 MD F-61-R Maryland Juvenile Striped Bass Survey

The primary objective of Project 2, Job 3, Task 3 was to document annual year-class success for young-of-the-year (YOY) striped bass (Morone saxatilis), and all other fish species encountered in Chesapeake Bay. Annual indices of relative abundance provide an early indicator of future adult stock recruitment (Schaefer 1972; Goodyear 1985) and document annual variation and long-term trends in abundance and distribution.

Juvenile indices for striped bass and all other fish species sampled are derived from sampling at 22 fixed stations within Maryland's portion of the Chesapeake Bay (Figure 1). Sample sites were divided among four of the major striped bass spawning and nursery areas; seven sites each in the Potomac River and Head of Bay areas and four each in the Nanticoke and Choptank rivers.

Stations have been sampled continuously since 1954. From 1954 to 1961, Maryland's juvenile surveys included inconsistent stations and rounds. Sample sizes ranged from 34 to 46. Indices derived for this period include only stations which are consistent with subsequent years. In 1962, stations were standardized and a second sample round was added for a total of 88 samples. A third sample round, added in 1966, increased sample size to 132.

Sites are sampled monthly, with rounds (sampling excursions) occurring during July (Round I), August (Round II), and September (Round III). Replicate seine hauls, a minimum of thirty minutes apart, were taken at each site in each sample round. This protocol produced a total of 132 samples from which Bay-wide means were calculated.

Auxiliary stations have been sampled on an inconsistent basis and were not included in survey indices. These data enhance geographical coverage in rivers with permanent stations or provide information from other river systems. They are also useful for replacement of permanent stations when necessary. Replicate hauls at auxiliary stations were discontinued in 1992 to conserve time and allow increased geographical coverage of spawning areas. Auxiliary stations were sampled at the Head of Bay (Susquehanna Flats and one downstream station) and the Patuxent River (Figure 1).

A 30.5-m x 1.24-m bagless beach seine of untreated 6.4-mm bar mesh was set by hand. One end was held on shore while the other was fully stretched perpendicular from the beach and swept with the current. Ideally, the area swept was equivalent to a 729 m^2 quadrant. When depths of 1.6-m or greater were encountered, the offshore end was deployed along this depth contour. An estimate of distance from the beach to this depth was recorded.

Striped bass and selected other species were separated into 0 and 1+ age groupings. Ages were assigned from length-frequencies and verified through scale examination. Age 0 fish were measured (mm total length) from a random sample of up to 30 individuals per site and round. All other finfish were identified to species and counted.

Additional data were collected at each site and sample round. These included: time of first haul, maximum distance from shore, weather, maximum depth, surface water temperature (°C), tide stage, surface salinity (ppt), primary and secondary bottom substrates, and submerged aquatic vegetation within the sample area (ranked by quartiles). Dissolved oxygen (DO), pH, and turbidity (Secchi disk) were added in 1997.

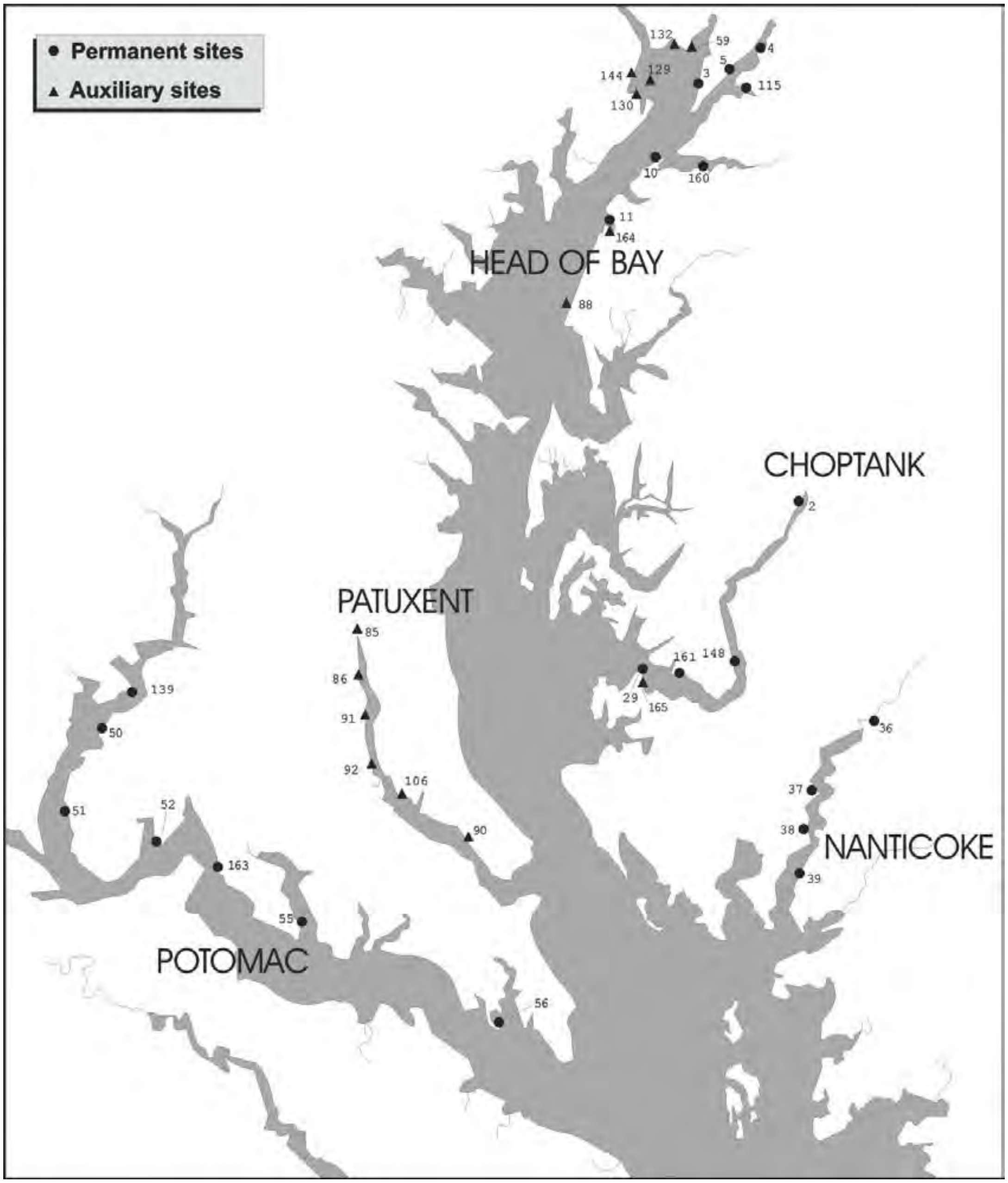


Figure 1. Maryland Chesapeake Bay juvenile striped bass survey site locations.

10.6 MD F-63-R Marine and Estuarine Finfish Ecological and Habitat Investigations

Project F-63-R, Marine and Estuarine Finfish Ecological and Habitat Investigations, was created in 2010. It existed as separate a Job in the Chesapeake Bay Finfish/Habitat Interactions Project during 2003-2017, (Figure 1). Activities are aimed at defining the impact of development and other human activities on target fish species populations and habitats.

Activities consist of spring stream anadromous fish icthyoplankton collections, spring yellow perch larval presence-absence sampling, and sampling of summer estuarine fish communities. Multiple systems have been surveyed during March-September, 2003-2011 (Figure 1). A subset of subestuaries have been sampled each year, depending on need for information. Target finfish consist of anadromous (American shad, alewife herring, blueback herring, striped bass), estuarine (white perch, yellow perch), marine migrant (Atlantic menhaden and spot), and fresh-tidal forage species (spottail shiner, silvery minnow, gizzard shad). These species are or were common enough to support recreational fisheries directly or through their role as abundant forage. Habitat loss and alteration have been cited as potential causes of declines in some of these species and their recovery could be limited by habitat suitability.

Yellow perch larvae are sampled twice a week in several sub-estuaries during March-April. Towed 0.5 m conical plankton nets collect larvae at up to 10 sites per system 2 days each week in the upper tidal portion of these estuaries. Up to eight systems have been sampled in a year. Samples are generally processed in the field for presence or absence of larvae, but some composite samples are held for larval gut analysis and RNA to DNA ratios.

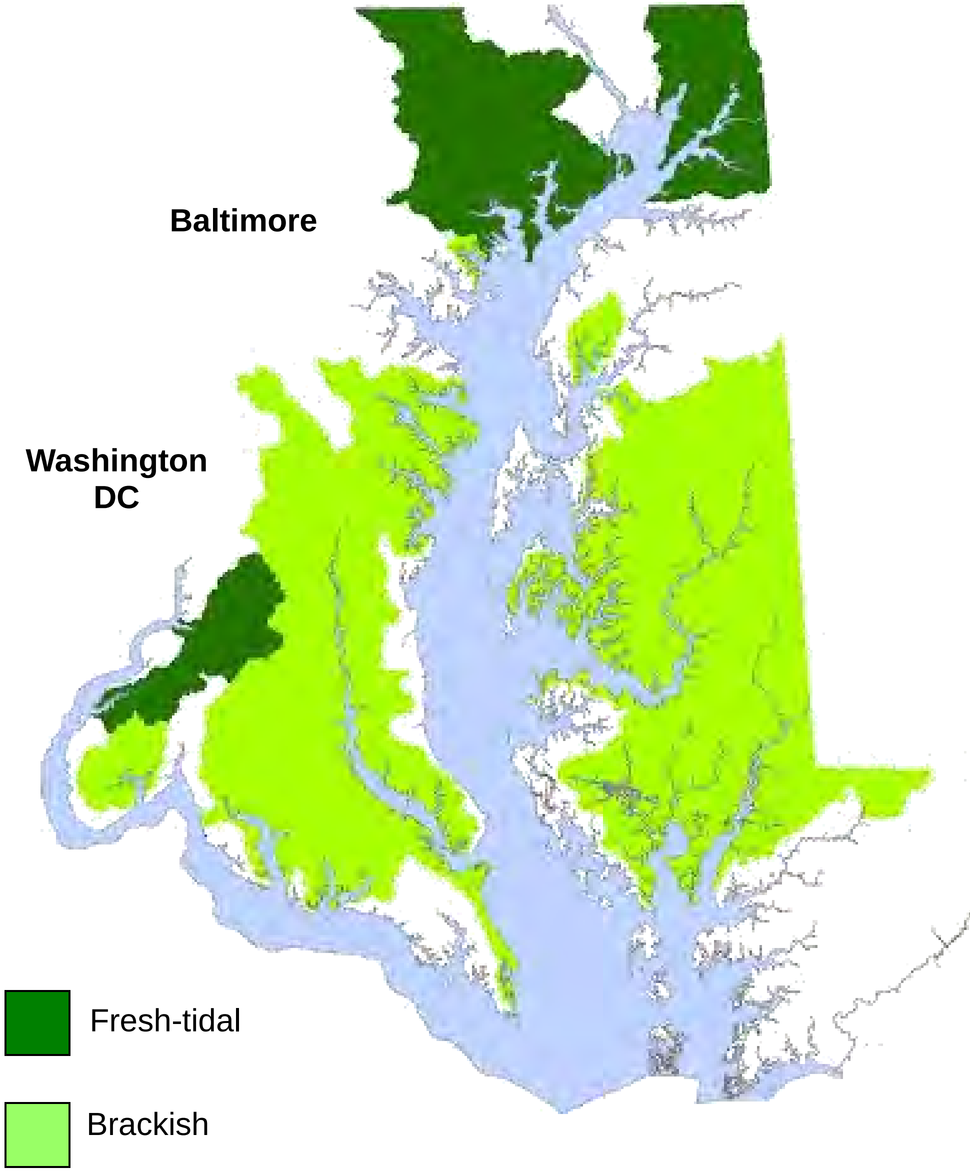
Maryland DNR inventoried its anadromous fish spawning streams in the 1970s-1980s. These surveys have been repeated since 2003 (1-3 systems per year) using citizen volunteers overseen by DNR professionals or by DNR staff. The main task of this effort is to sample historical sites with historically consistent techniques to determine how much stream spawning of anadromous fish has changed with land use changes. Ichthyoplankton samples were collected at each site using stream drift nets constructed of 360-micron mesh material, attached to a square frame with a 300 • 460 mm opening. Nets were placed in the stream for five minutes with the opening facing upstream. The nets were then retrieved and rinsed in the stream and preserved with formalin. Sorting occurred in the laboratory. Small wire traps were set in some streams in some years to collect adult anadromous fish.

Trawling and seining are used to sample juvenile and adult fish during July-September. Up to four evenly spaced sample sites are located in the upper two-thirds of each tributary. Sites are not located near the subestuary's mouth to reduce influence of Bay waters on measurements of watershed water quality. Sites on a subestuary are sampled once every two weeks.

A 4.9 m semi-balloon otter trawl is used to sample fish in the mid-channel bottom habitat. The trawl is constructed of treated nylon mesh netting measuring 38 mm stretch-mesh in the body and 33 mm stretch-mesh in the codend, with an untreated 12 mm stretch-mesh knotless mesh liner. The headrope is equipped with floats and the footrope is equipped with a 3.2 mm chain. The net uses 0.61 m long by 0.30 m high trawl doors attached to a 6.1 m bridle leading to a 24.4 m towrope. Trawls are towed in the same direction as the tide. The trawl is set up tide to pass the site halfway through the tow, allowing the same general area to be sampled regardless of tide direction. A single tow is made for six minutes at 3.2 km / hr (2.0 miles / hr) per site on each visit. The contents of the trawl are emptied into a tub for processing.

An untreated 30.5 m • 1.2 m bagless knotted 6.4 mm stretch mesh beach seine, the standard gear for Bay inshore fish surveys, is used to sample inshore habitat of subestuaries. Seine sites are located in the same vicinity as trawl sites. The float-line is rigged with 38.1 mm by 66 mm floats spaced at 0.61 m intervals and the lead-line rigged with 57 gm lead weights spaced evenly at 0.55 m intervals. One end of the seine is held on shore, while the other is stretched perpendicular to shore as far as depth permits and is then pulled with the tide in a quarter-arc. The open end of the net is moved towards shore once the net is stretched to its maximum. When both ends of the net are on shore, the net is retrieved by hand in a diminishing arc until the net is entirely pursed. The section of the net containing the fish is then placed in a washtub for processing. All fish captured are identified to species and counted. Striped bass and yellow perch were separated into juveniles and adults.

Watersheds Studied



10.7 MD F-110-R Health Investigations of Striped Bass and Other Fishes in Maryland waters

10.7.1 MD F-110-R Mycobacteriosis in Striped Bass Resident to Chesapeake Bay

The DNR Fish & Wildlife Health Program (FWHP) collect striped bass annually using fishing charter boats, commercial pound nets and beach seine (Table 1). Fishing charters target resident striped bass based on the time year chosen to sample, type of lures or bait used and method of angling. Angling by-catch is almost exclusively bluefish and croaker. Striped bass are sub-sampled from commercial pound nets concomitant with striped bass stock assessment surveys. Young-of year striped bass are targeted by beach seining in the fall at select sites. Seine by-catch consists of a variety of small fishes including mummichogs, killifish, anchovies, Atlantic menhaden, white perch, croaker and others.

Table 1.

Region	Technique	Frequency*	Target
Upper Bay[1]	Hook-and-line	5 cruises	1-5 year old fish
	Pound net	3 nets	1-5 year old fish
	Beach seine	3 sites	YOY fish
Middle Bay[2]	Hook-and-line	5 cruises	1-5 year old fish
	Pound net	3 nets	1-5 year old fish
	Beach seine	3 sites	YOY fish
Lower Bay[3]	Hook-and-line	5 cruises	1-5 year old fish
	Pound net	3 nets	1-5 year old fish
	Beach seine	3 sites	YOY fish

*Number of cruises or sampling trips during June-November.
[1]Above Bay Bridge
[2]Between Cove Point and Bay Bridge
[3]South of Cove Point

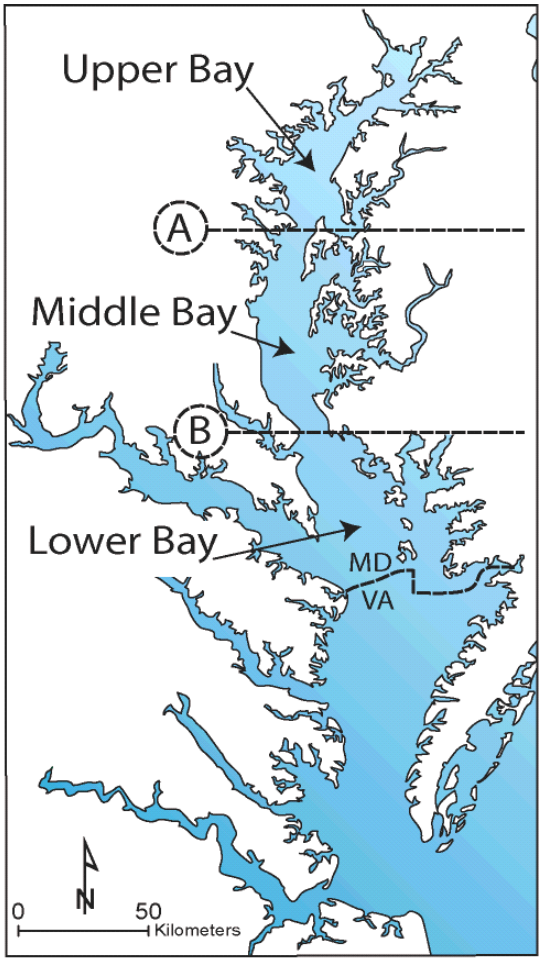


Figure 1. Regions of Striped bass collected from Maryland's Chesapeake Bay, 2011. Regions are demarcated by Bay Bridge (A), Cove Point (B) and the VA/MD state line.

10.7.2 MD F-110-R Fish Disease Diagnostics

Investigation of the morbidity/mortality events is responsive in nature. Fish health events are reported to either Maryland Department of the Environment, Fish Kill Investigation Unit (MDE), or Maryland Department of Natural Resources, Fish and Wildlife Health Project (DNR). Once the information is received, MDE or DNR initiate an investigation. Biologists proceed as soon as possible to the site of the fish-kill event and determine the scope and magnitude of the event, including a preliminary assessment of the environmental and physical conditions. This may include measurement of water quality parameters, detection of unusual conditions such as discoloration of the water or presence of noxious odors, location of the source or the area of the event, and estimation of the number of dead fish by conducting transects. Based on the initial investigation the biologist collects all pertinent samples for diagnostics such as water (algal composition and contaminants), fish samples (microbiology, parasites, histopathology, tissue contaminants), and other samples as warranted. Following the initial assessment, the biologist will attempt to collect moribund and seemingly healthy fish from the affected area if possible. Collection techniques to sample for moribund fish include bottom trawl, trot-line, hook-and-line, cast net, and beach seine. Sampling may be repeated 1-3 times over a period of days to weeks following the initial investigation. Fish-kill events resulting from contaminant spills or other activities that violate state or local laws are referred to the MDE compliance office and local jurisdictions and Department of Health are notified.

11.0 Virginia

The Virginia Department of Game and Inland Fisheries (VDGIF) uses Sport Fish Restoration funds to carry out four projects: Tidal River Fish Community Monitoring; Tidal River Catfish Surveys; American Shad Restoration Brood Stock Collection; and, Northern Snakehead Monitoring in Virginia. The Virginia Marine Resources Commission (VMRC) uses Sport Fish Restoration funds to carry out six projects: American Shad Monitoring Program; River Herring Monitoring; Juvenile Fish Trawl Survey; Juvenile Striped Bass Beach Seine Survey; Chesapeake Bay Multispecies Monitoring and Assessment Program; and Striped Bass Spawning Stock Assessment.

11.1 VA F-111-R Tidal River Fish Community Monitoring

The Virginia Department of Game and Inland Fisheries (VDGIF) conducts boat electrofishing surveys in tidal fresh-oligohaline reaches of Virginia tidal systems, assessing status and trends in fish species assemblage and, monitoring population parameters of recreationally important species. Results of this work inform development and implementation of science-based fisheries management strategies. The VDGIF began its fisheries survey work on Virginia tidal systems with an intensive, and extensive, boat electrofishing survey in the York drainage in 1990, sampling reaches of the Pamunkey River and Mattaponi River (Table 1). This effort was followed by an extensive seasonal baseline survey of the tidal Chickahominy system in 1994 – 1995, and a subsequent two year seasonal survey of the mainstem tidal James River and its tidal tributaries outside the Chickahominy sub-watershed during 1998 – 1999. Additional ad hoc boat electrofishing occurred on the James and York systems throughout the 1990s.

Current survey methodology is based on a stratified-random fixed station survey design. Sampling is conducted in the fall (generally October through mid-November) along shorelines and in shallow water habitat of rivers (Chickahominy, James, Mattaponi, Pamunkey, Piankatank, and Rappahannock) and their major tidal tributaries (Figure 1). Water depth at sample sites is generally 1 – 1.25 meters and never exceeds 2 meters. Effort consists of a single electrofishing run per station. With the exception of the tidal Rappahannock system, standard run time is 1000 seconds/run. Otoliths are collected from a random subsample to assess age and growth of recreationally important species such as largemouth bass and black crappie. Otolith sampling schedules in a given system for a given species are at the lead biologist’s discretion.

Time series under current survey design are as follows: 1998 – present for the tidal James system, 2000 – present for the tidal Chickahominy, 2003 – present for the York (Mattaponi and Pamunkey), and 2004 – present for the tidal Rappahannock system.

11.2 VA F-111-R Tidal River Catfish Surveys

In the period 1993 – present, low frequency (LF) electrofishing techniques have been used to sample catfish species (primarily introduced blue catfish and channel catfish, and native white catfish) in tidal fresh-oligohaline sections of four Virginia tidal river systems: the James, Pamunkey, Piankatank, Mattaponi, and Rappahannock (Figure 2). Since 2001, survey methodology has been standardized to the following protocol. Sampling is conducted in the late July–August timeframe, and occurs at fixed stations – either where the river channel cuts close to shoreline structure or where submerged structure (e.g., sunken boats and barges) occurs within or adjacent to the channel. Channel depth at sample locations is generally at least 6 meters. Effort consists of a single LF (15 pulses per second) electrofishing run per station. Since 2003 effort has been standardized to 600 seconds per run. Not all rivers are surveyed each year, and, in any given survey, some stations may be omitted. Sampling consists of two netters on the front of an electrofishing boat, and two netters on a chase boat, who attempt to maximize catch of catfish species that surface during these efforts. Additional netters assist in capture of unusually large fish (≈ ≥ 20 kg). In the years since 2002, otoliths have been collected from blue catfish for age and growth analyses. During 2002–2004, otoliths were collected based on a number of fish per cm-group sub-sampling strategy. Since 2004, otoliths have been collected from large random sub-samples of fish, stratified based on length, with larger size-groups being more intensively sampled in an effort to adequately sample older age-classes.

Since 2007, LF electrofishing has been used to conduct targeted sampling of flathead catfish in the tidal upper reaches of the James River (Figure 3), with the goal of assessing trends in this expanding introduced population. Survey methodology is as above, including the use of otoliths for age and growth analyses, except this sampling effort is conducted in June and station location is not fixed – efforts are ongoing through exploratory sampling to select sites for incorporation into an eventual fixed station design.

11.3 VA F-111-R American Shad Restoration

The VDGIF American shad restoration effort has involved three main activities: 1) brood fish/egg collection operations on the Pamunkey and Potomac rivers; 2) intensive hatchery rearing, tagging, and stocking efforts on the James and Rappahannock rivers (efforts on this river ceased after 2013), as well as on the Pamunkey and Potomac rivers for mitigation; and 3) monitoring adult shad spring spawning runs to determine relative abundance of hatchery fish in these runs, relative run strength, and age composition. Given the results of an internal evaluation of its efforts in this regard, stocking of the Rappahannock ceased after 2013 and after 2017 DGIF brood collection and fry stocking operations will no longer occur for the James River either. DGIF will be ceasing stocking efforts in this regard until future evaluation indicates shad stocks are recovering on a broad-scale across the native range of the species. Should range-wide stock indicators warrant, DGIF will return to its broodstock collection and fry stocking operations, stocking the James River in a renewed effort to recover shad runs in that important Chesapeake Bay tributary. DGIF evaluation of returning adult shad will continue through 2023.

Should brood and stocking operations reinitiate during the grant period production goals will likely be to annually stock the James river system with a minimum of 7 million oxytetracycline (OTC) tagged shad fry, and to annually stock 1 million American shad fry into the Potomac and/or Pamunkey river systems as mitigation for using brood stock from these systems for stocking the James River. Early brood fish and egg collections efforts (1992-1993) focused on the James River; however, not enough spawning adults could be collected to support hatchery operations. VDGIF would contract with skilled watermen to collect spawning adult shad (brood fish) from the Pamunkey at Rockahock Bar (Figure 4), with watermen setting 5 ¼ - 5 ¾ inch mesh floating gillnets on a slack tide just before or following sunset. Once collected, the brood fish would be artificially spawned and fertilized eggs are sent to hatcheries; the shad fry held for about 4 to 7 days and their otoliths are marked with OTC tag to identify hatchery fish in the wild. A similar protocol would be followed for using the Potomac River as a source of brood fish for egg collection. Brood fish from the Potomac are collected off Fort Belvoir (Figure 4). Timing of brood collection is water temperature dependent, but efforts on the Pamunkey can run from late

March – May, and efforts on the Potomac would typically run from early April – May. After being tagged, the fry to be released into the James for restoration and into the Pamunkey and Potomac rivers as mitigation for brood fish losses. On average, 1,800 to 2,200 adult shad would be needed annually to achieve fry stocking goals for restoration efforts. Fry stocking locations in the James River system have primarily been above Bosher's Dam at six locations, as well as in the Appomattox, Rivanna, and Slate rivers. These locations cover a 122 RKM section of the mainstem and extend as far west as Bent Creek, 51RKM upstream from Lynchburg, Virginia. Stockings on the Rappahannock River system occur at Kelly's Ford Boat Landing near the Town of Remington and in the Hazel River. It is anticipated that should stocking commence in the future, these stocking locations would be used. The Potomac River would be stocked at Pohick Bay and in the tidal portion at of the Occoquan River.

Stocking success and population status is being evaluated by monitoring adult shad each spring during their spawning runs in the James, Rappahannock, and York (Appendix A). This effort is planned to continue through 2023. Otoliths and biological information are being collected from a sub-sample of adults during this effort as well as from a subsample of brood fish. Adult monitoring efforts on the James River and Rappahannock River are conducted using boat electrofishing in the vicinity of the fall line, on the Rappahannock this occurs in the near Fredericksburg, Virginia and on the James this occurs in Richmond, Virginia. OTC analysis of otoliths from these fish is used to determine the hatchery contribution to these spawning populations.

11.4 F-111-R Northern Snakehead Monitoring in Virginia

Following a period of intensive survey work to identify the range extent of northern snakeheads in Virginia tributaries of the Potomac River, the VDGIF developed a standard sampling regime which, since 2004, includes twice monthly sampling of tributaries known to hold reproducing adult snakeheads. On each of these twice monthly monitoring events 6,000 seconds of electrofishing effort is expended – exclusively in shallow water habitats (< 1 m water depth). This standardized sampling regime is primarily directed at tributaries from Little Hunting Creek downstream to Aquia Creek (Figure 5). To document range expansion, additional electrofishing effort has been expended periodically in fresh-mesohaline reaches in lower tributaries of the Potomac. In coming years, this effort is expected to expand to headwaters of the Great Wicomico, lower tributaries of the Rappahannock, and Dragon Run/Swamp in the Piankatank drainage.

Table 1. Summary of boat electrofishing sampling to monitor trends in fish assemblage and population parameters of important recreational species in Virginia tidal rivers and major tributaries.

Tidal River System	Year	Runs	Effort (s)	Effort (hrs)	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
Chickahominy	1994	50	73,741	20.5	0	0	0
	1995	32	54,702	15.2	0	0	0
	1996	2	4,893	1.4	0	0	0
	2000	18	32,877	9.1	0	0	0
	2001	33	55,962	15.5	0	0	0
	2002	10	12,300	3.4	0	0	0
	2003	15	18,000	5.0	0	0	0
	2004	14	17,160	4.8	0	0	0
	2005	16	16,186	4.5	0	0	0
	2006	16	15,800	4.4	0	0	0
	2007	16	16,000	4.4	0	0	0
	2008	16	15,700	4.4	0	0	0
	2009	14	14,000	3.9	0	0	0
	2010	9	9,000	2.5	0	0	0
	2011	18	17,500	4.9	0	0	0
	2012	23	23,000	6.4	0	0	0
	2013	24	24,200	6.7	0	0	0
	2014	19	18,060	5.0	0	0	0
	2015	37	18,000	5.0	0	0	0
	2016	16	15,840	4.4	0	0	0
	Total	**398**	**472,921**	**131**	**0**	**0**	**0**

James	1995	4	6,355	1.8	0	0	0
	1996	1	3,230	0.9	0	0	0
	1997	1	2,435	0.7	0	0	0
	1998	153	223,725	62.1	0	0	0
	1999	51	82,019	22.8	0	0	0
	2000	4	8,223	2.3	0	0	0
	2001	34	48,936	13.6	0	0	0
	2002	13	15,729	4.4	0	0	0
	2003	18	21,400	5.9	0	0	0
	2004	14	16,710	4.6	0	0	0
	2005	16	15,888	4.4	0	0	0
	2006	19	18,800	5.2	0	0	0
	2007	17	17,000	4.7	0	0	0
	2008	20	19,765	5.5	0	0	0
	2009	32	32,000	8.9	0	0	0
	2011	17	17,000	4.7	0	0	0
	2012	25	22,650	6.3	0	0	0
	2013	16	14,400	4.0	0	0	0
	2014	18	14,760	4.1	0	0	0
	2015	25	33,000	9.2	0	0	0
	2016	26	25,985	7.2	0	0	0
	Total	524	660,010	183	0	0	0
Piankatank	1995	3	3,885	1.1	0	0	0
	1996	5	14,404	4.0	0	0	0
	2002	3	3,655	1.0	0	0	0

	2003	3	3,600	1.0	0	0	0
	2005	12	14,272	4.0	0	0	0
	2006	15	15,254	4.2	0	0	0
	2007	8	7,356	2.0	0	0	0
	2011	4	4,000	1.1	0	0	0
	2013	7	7,000	1.9	0	0	0
	2014	27	18,244	5.1	0	0	0
	2015	4	4,000	1.1	0	0	0
	Total	91	95,670	27	0	0	0
Rappahannock	2004	8	9,600	2.7	0	0	0
	2005	20	18,224	5.1	0	0	0
	2006	16	12,188	3.4	0	0	0
	2007	9	8,680	2.4	0	0	0
	2008	4	3,800	1.1	0	0	0
	2009	19	16,900	4.7	0	0	0
	2011	20	18,000	5.0	0	0	0
	2012	21	19,800	5.5	0	0	0
	2013	33	36,173	10.0	0	0	0
	2014	27	28,080	7.8	0	0	0
	2015	16	15,000	4.2	0	0	0
	2016	2	2,000	0.6	0	0	0
	Total	195	188,445	52	0	0	0
York	1995	2	2,802	0.8	0	0	0

	1998	1	7,000	1.9	0	0	0
	1999	4	19,999	5.6	0	0	0
	2003	1	1,200	0.3	0	0	0
	2004	33	39,600	11.0	0	0	0
	2006	37	41,704	11.6	0	0	0
	2007	26	31,200	8.7	0	0	0
	2008	17	17,000	4.7	0	0	0
	2009	16	16,000	4.4	0	0	0
	2010	9	9,000	2.5	0	0	0
	2011	8	8,000	2.2	0	0	0
	2013	12	12,000	3.3	0	0	0
	2014	17	16,944	4.7	0	0	0
	2015	17	17,000	4.7	0	0	0
	Total	200	239,449	67	0	0	0
Grand Total		**1408**	**1,656,495**	**460**	**0**	**0**	**0**

Table 2. Summary of specialized, low frequency, electrofishing sampling targeting catfish species in Virginia tidal rivers and major tributaries.

Tidal River System	Year	Runs	Effort (s)	Effort (hrs)	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
Chickahominy	1994	10	16354	4.5	0	0	0
	1996	1	3436	1.0	0	0	0
	1997	4	4565	1.3	0	0	0
	2001	8	11533	3.2	0	0	0
	2006	3	1800	0.5	0	0	0
	Total	**26**	**37,688**	**10**	**0**	**0**	**0**
James	1993	1	1,280	0.4	0	0	0
	1994	2	7,515	2.1	0	0	0
	1995	11	11,993	3.3	0	0	0
	1996	15	21,561	6.0	0	0	0
	1997	11	18,424	5.1	0	0	0
	1998	6	6,366	1.8	0	0	0
	1999	8	20,951	5.8	0	0	0
	2001	21	19,758	5.5	0	0	0
	2002	13	10,423	2.9	0	0	0
	2004	7	4,200	1.2	0	0	0
	2006	12	7,200	2.0	0	0	0
	2008	15	8,100	2.3	0	0	0
	2010	13	7,800	2.2	0	0	0
	2012	17	10,980	3.1	0	0	0
	2014	12	7,120	2.0	0	0	0
	2016	13	8,950	2.5	0	0	0
	Total	**177**	**172,621**	**48**	**0**	**0**	**0**
Piankatank	2003	5	2,400	0.7	0	0	0
	2004	4	10,094	2.8	0	0	0
	2005	2	1,200	0.3	0	0	0
	2000	3	11,386	3.2	0	0	0
	2003	2	3,400	0.9	0	0	0
	2005	1	1,200	0.3	0	0	0
	2006	1	1,300	0.4	0	0	0
	2007	2	1,600	0.4	0	0	0
	2010	1	1,200	0.3	0	0	0
	2011	3	2,100	0.6	0	0	0
	2014	4	2,300	0.6	0	0	0
	2016	5	2,650	0.7	0	0	0

	Total	**33**	**40,830**	**11**	**0**	**0**	**0**
Rappahannock	2000	16	24,026	6.7	0	0	0
	2001	20	19,127	5.3	0	0	0
	2002	9	6,162	1.7	0	0	0
	2004	7	8,800	2.4	0	0	0
	2005	7	4,200	1.2	0	0	0
	2007	6	3,600	1.0	0	0	0
	2009	9	5,400	1.5	0	0	0
	2011	13	7,800	2.2	0	0	0
	2014	11	6,600	1.8	0	0	0
	2016	10	6,000	1.7	0	0	0
	Total	**108**	**91,715**	**25**	**0**	**0**	**0**
York	1999	14	15,873	4.4	0	0	0
	2000	26	34,553	9.6	0	0	0
	2003	24	16,200	4.5	0	0	0
	2004	11	8,980	2.5	0	0	0
	2005	7	4,200	1.2	0	0	0
	2006	18	10,500	2.9	0	0	0
	2008	27	15,600	4.3	0	0	0
	2010	12	7,000	1.9	0	0	0
	2011	8	4,800	1.3	0	0	0
	2014	18	11,140	3.1	0	0	0
	2016	17	10,200	2.8	0	0	0
	Total	**182**	**139,046**	**39**	**0**	**0**	**0**
Grand Total		**500**	**444,212**	**123**	**0**	**0**	**0**

Table 3. Summary of American shad brood collection activities in the tidal Pamunkey River and Potomac River through 2012.

River	Year(s)	Average Nights / Year	Estimated Nights in Time Series	Average Net Sets / Night	Average Net Sets / Year	Approximate Total Net Sets in Time Series
Pamunkey	1994 - 2008	32	480	16	512	7,680
Pamunkey	2009	20	20	6	120	120
Pamunkey	2010	17	17	8	136	136
Pamunkey	2011	14	14	8	112	112
Pamunkey	2012	22	22	8	176	176
Potomac	2003 - 2012	16	160	4	64	640

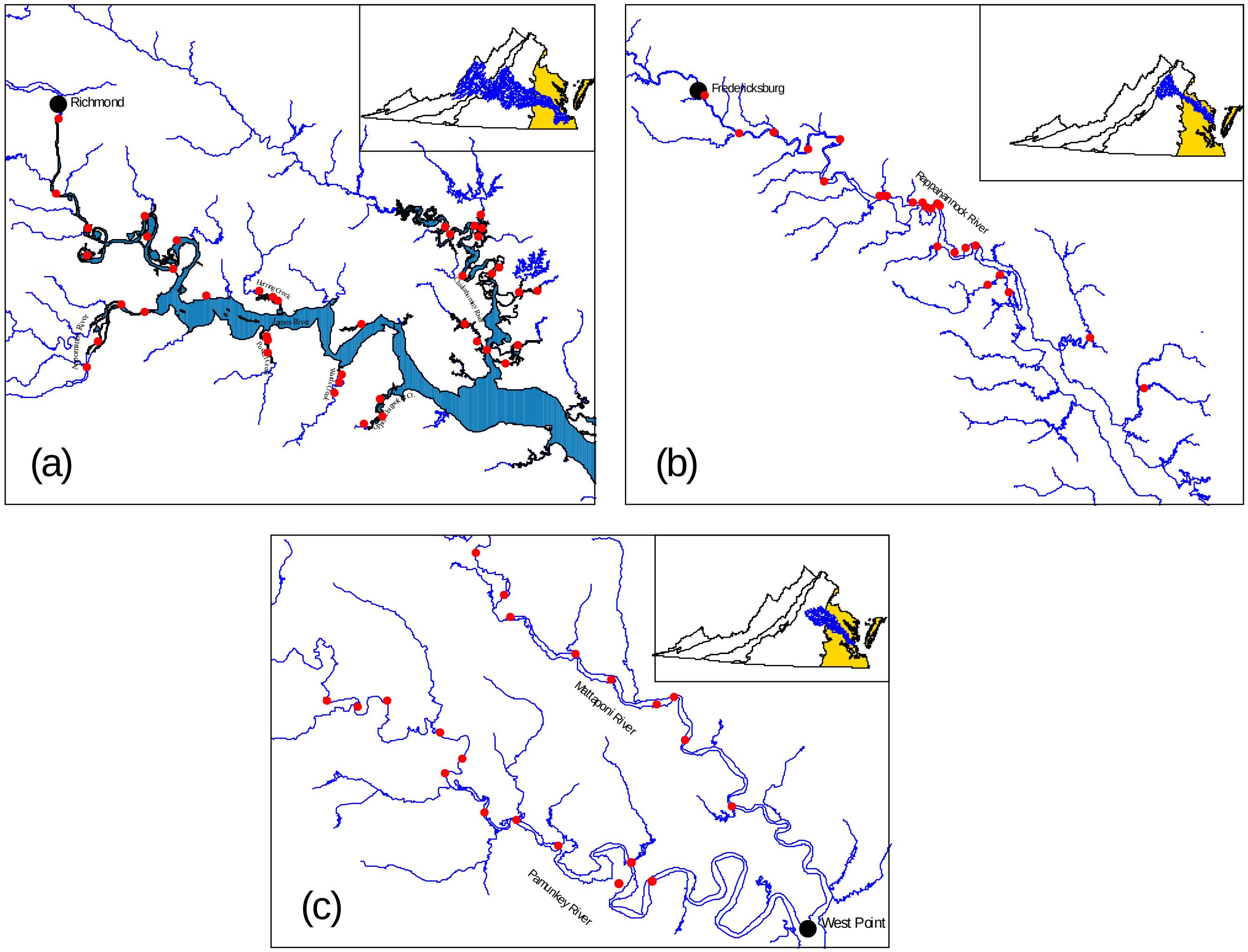


Figure 1. Fall boat electrofishing sites for monitoring fish assemblages and recreationally important species in the James River (a), Rappahannock River (b), and York River systems.

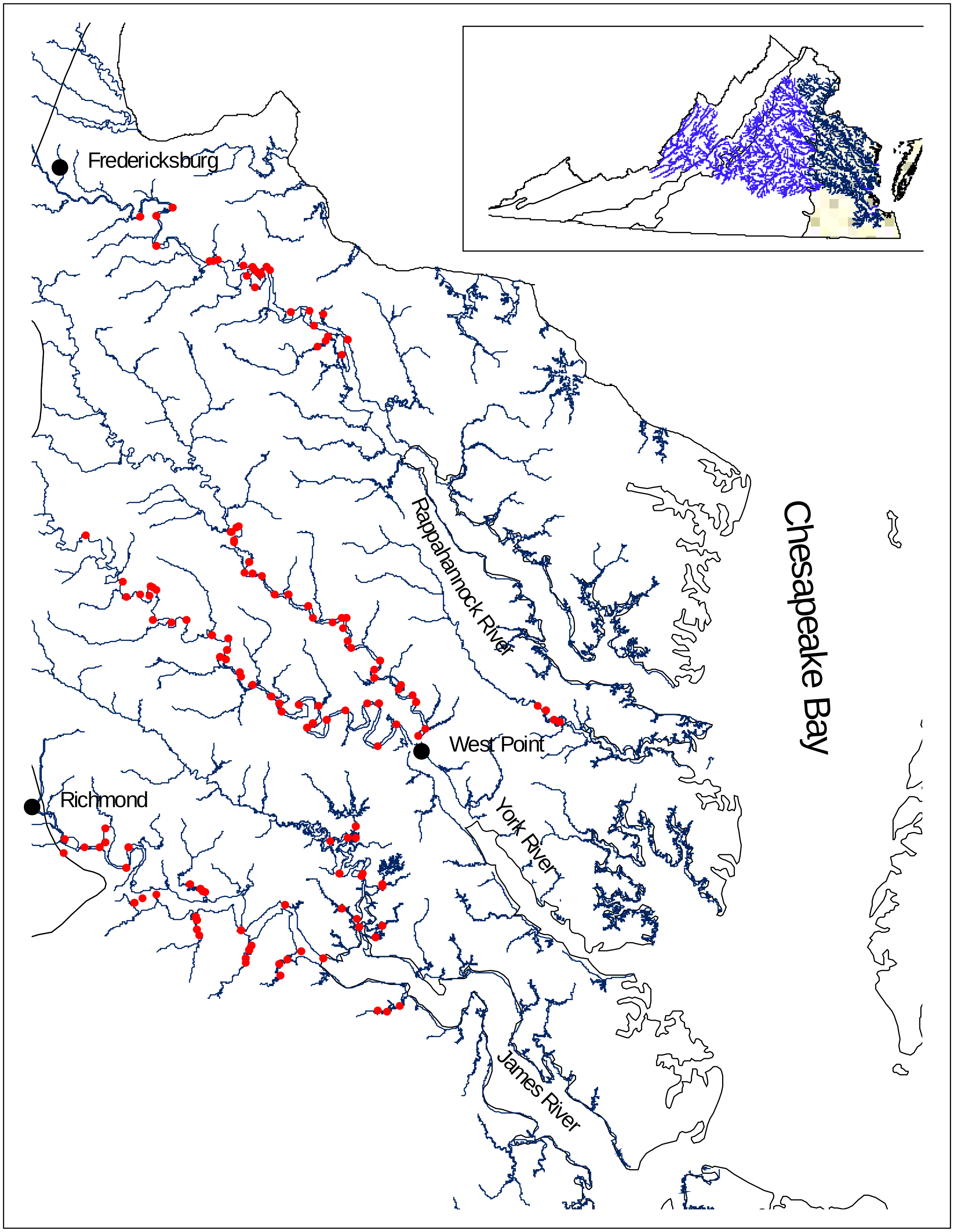


Figure 2. Map of stations sampled during low frequency (15 pulses per second) electrofishing surveys of catfish species in Virginia tidal river systems.

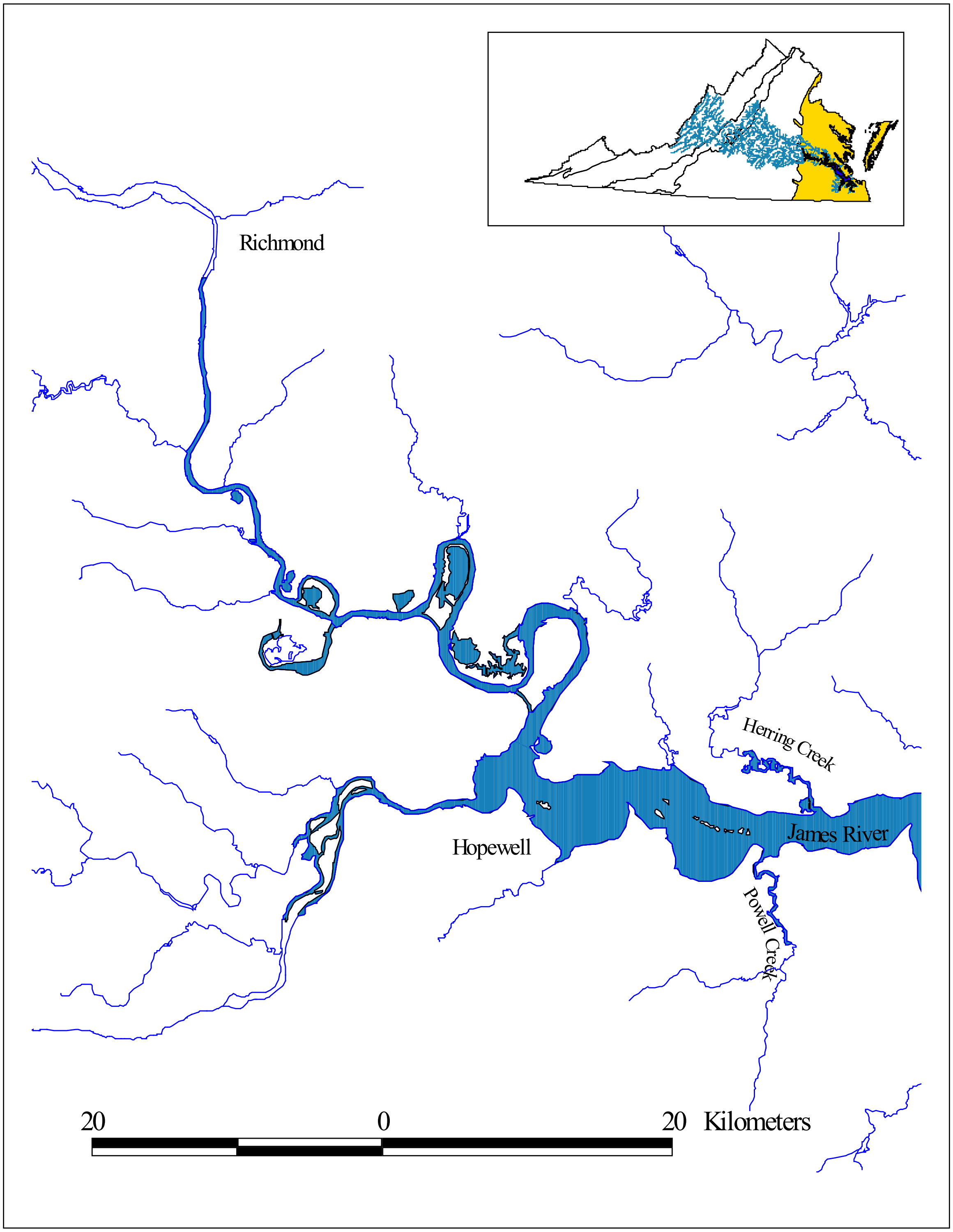
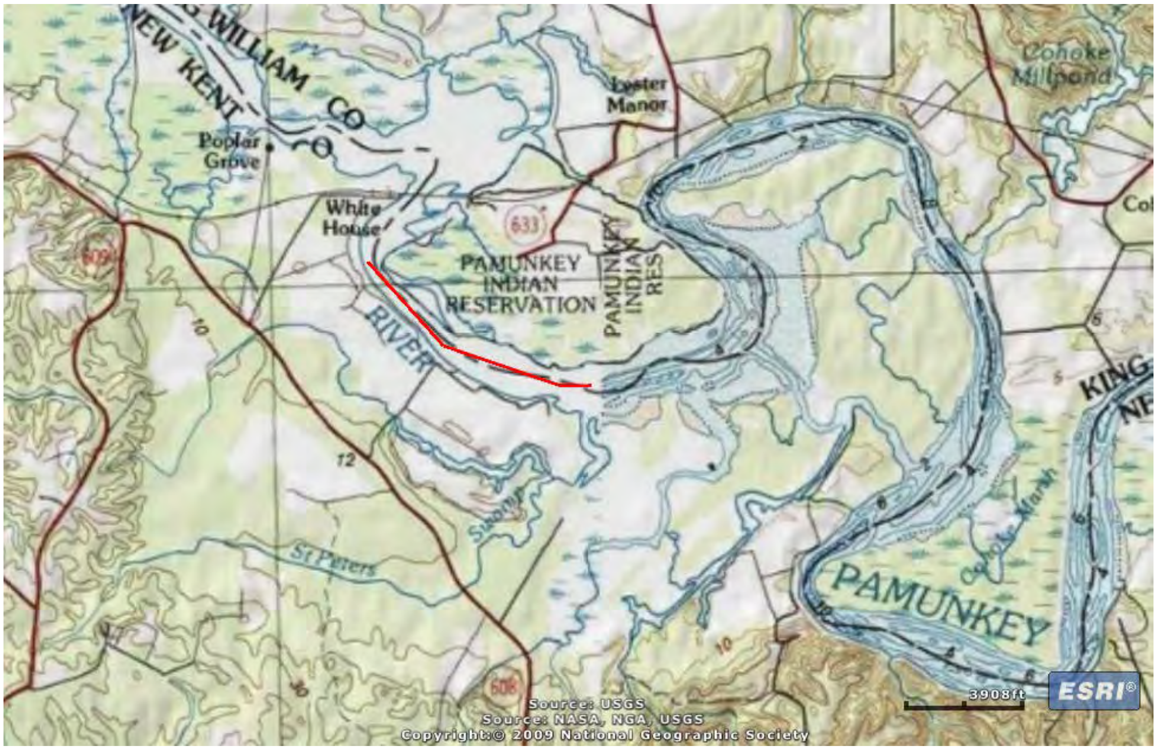


Figure 3. Map of the extent of the tidal freshwater James River where flathead catfish directed sampling has been conducted using specialized low frequency electrofishing techniques. VDGIF is in the process of selecting fixed station survey locations within this area of the tidal James system.

a.



b.

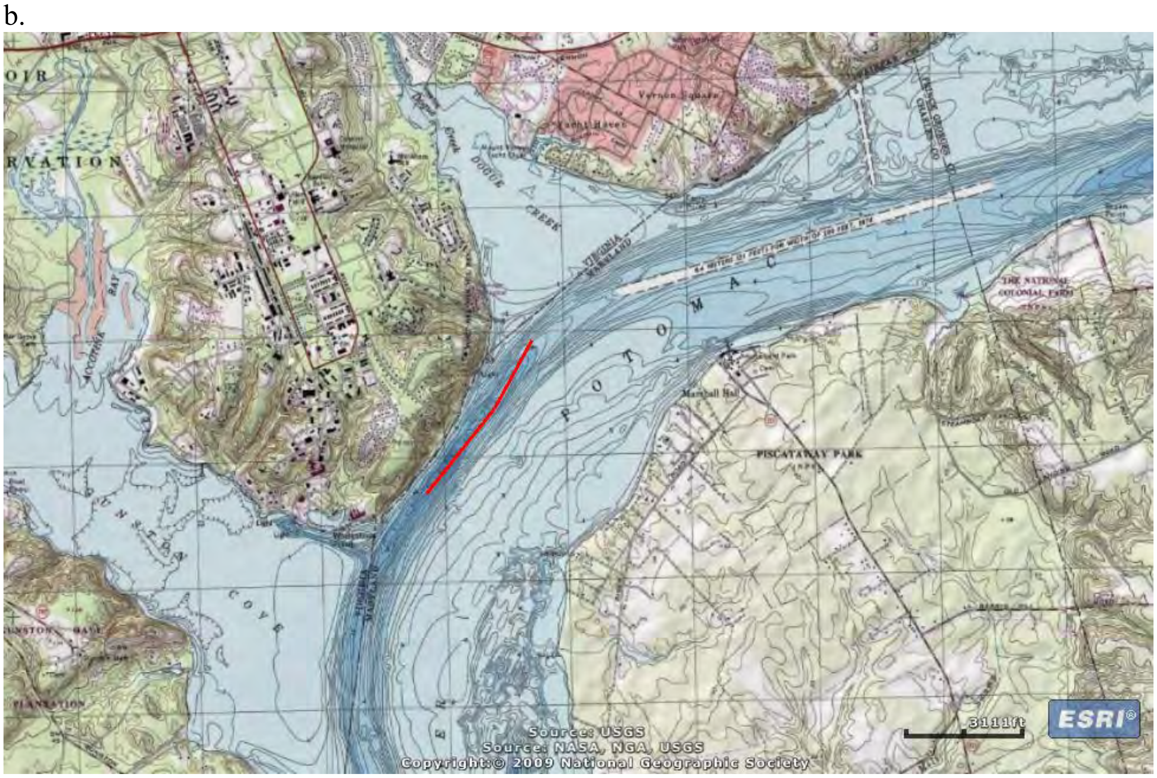


Figure 4. Collection locations for American shad brood fish from the Pamunkey (a) and the Potomac (b).

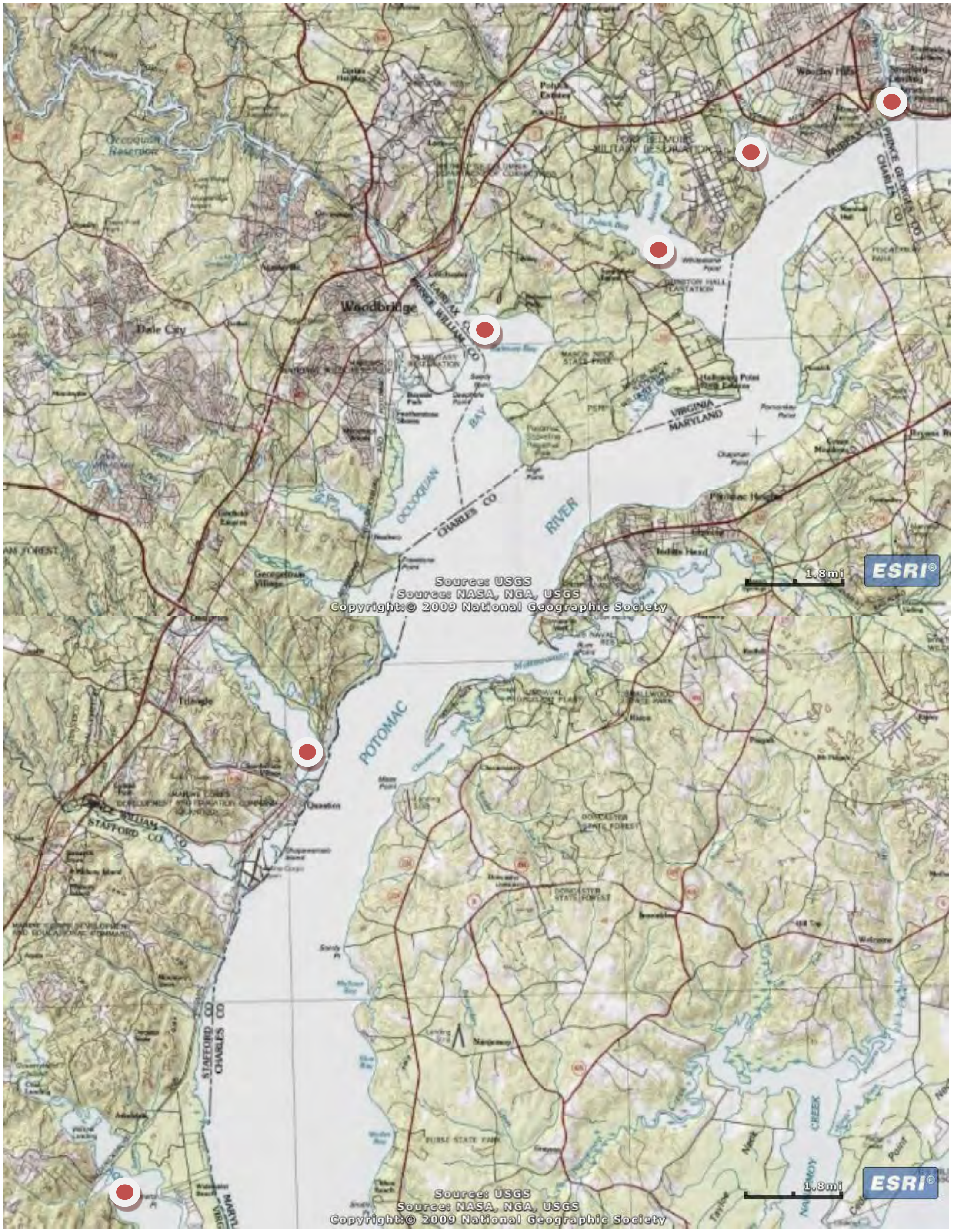


Figure 5. Map of Virginia tributaries from Little Hunting Creek downstream to Aquia Creek where boat electrofishing has been used to regularly monitor an introduced northern snakehead population.

Appendix A. Summary of spring electrofishing monitoring for adult American shad in the James River, Rappahannock River, and York River systems through 2010.

River	Year	Runs	Effort (s)	Effort (hrs)	Atlantic Sturgeon	Shortnose Sturgeon	Sea Turtles
Appomattox River	1995	4	3300	0.92	0	0	0
Appomattox River	1996	4	8472	2.35	0	0	0
Appomattox River	1997	11	7255	2.02	0	0	0
Appomattox River	1998	6	4943	1.37	0	0	0
Appomattox River	1999	5	4494	1.25	0	0	0
Appomattox River	2000	17	10970	3.05	0	0	0
Appomattox River	2001	27	20797	5.78	0	0	0
Appomattox River	2002	25	12675	3.52	0	0	0
Appomattox River	2003	3	1696	0.47	0	0	0
Appomattox River	2004	11	5680	1.58	0	0	0
Appomattox River	2005	9	6704	1.86	0	0	0
Appomattox River	2006	3	2300	0.64	0	0	0
Appomattox River	2007	10	6205	1.72	0	0	0
Appomattox River	2009	4	2550	0.71	0	0	0
Appomattox River	2010	10	7100	1.97	0	0	0
Chickahominy River	1999	1	222	0.06	0	0	0
Chickahominy River	2000	1	425	0.12	0	0	0
Chickahominy River	2001	2	1814	0.50	0	0	0
Chickahominy River	2007	2	2400	0.67	0	0	0
Chickahominy River	2008	3	2700	0.75	0	0	0
James River	1994	4	6677	1.85	0	0	0
James River	1995	18	10084	2.80	0	0	0
James River	1996	8	7181	1.99	0	0	0
James River	1997	1	500	0.14	0	0	0
James River	1999	6	3874	1.08	0	0	0
James River	2000	21	16551	4.60	0	0	0
James River	2001	9	6950	1.93	0	0	0
James River	2002	108	51050	14.18	0	0	0
James River	2002	1	600	0.17	0	0	0
James River	2003	67	42154	11.71	0	0	0
James River	2004	96	56477	15.69	0	0	0
James River	2005	98	56815	15.78	0	0	0
James River	2006	131	74477	20.69	0	0	0
James River	2007	107	59050	16.40	0	0	0
James River	2008	119	73560	20.43	0	0	0
James River	2009	102	56650	15.74	0	0	0
James River	2010	101	52650	14.63	0	0	0
Mattaponi River	2000	5	5456	1.52	0	0	0
Mattaponi River	2001	4	3600	1.00	0	0	0

Appendix A continued

Mattaponi River	2002	3	2700	0.75	0	0	0
Mattaponi River	2004	6	5400	1.50	0	0	0
Mattaponi River	2005	3	2700	0.75	0	0	0
Mattaponi River	2006	8	7200	2.00	0	0	0
Mattaponi River	2006	1	300	0.08	0	0	0
Mattaponi River	2007	9	8100	2.25	0	0	0
Mattaponi River	2008	3	2700	0.75	0	0	0
Mattaponi River	2009	3	2700	0.75	0	0	0
Mattaponi River	2010	6	5400	1.50	0	0	0
North Anna River	2001	1	1000	0.28	0	0	0
North Anna River	2004	3	1982	0.55	0	0	0
North Anna River	2005	4	3075	0.85	0	0	0
Pamunkey River	1998	1	900	0.25	0	0	0
Rapidan River	2007	3	3600	1.00	0	0	0
Rapidan River	2008	2	1725	0.48	0	0	0
Rapidan River	2009	1	900	0.25	0	0	0
Rapidan River	2010	1	800	0.22	0	0	0
Rappahannock River	1994	2	1366	0.38	0	0	0
Rappahannock River	1995	6	4379	1.22	0	0	0
Rappahannock River	1996	3	3004	0.83	0	0	0
Rappahannock River	1997	10	9392	2.61	0	0	0
Rappahannock River	1998	7	5564	1.55	0	0	0
Rappahannock River	1999	3	2577	0.72	0	0	0
Rappahannock River	2000	12	13867	3.85	0	0	0
Rappahannock River	2001	20	16769	4.66	0	0	0
Rappahannock River	2002	28	21947	6.10	0	0	0
Rappahannock River	2003	13	13400	3.72	0	0	0
Rappahannock River	2004	34	25871	7.19	0	0	0
Rappahannock River	2005	34	25851	7.18	0	0	0
Rappahannock River	2006	37	29674	8.24	0	0	0
Rappahannock River	2007	33	29300	8.14	0	0	0
Rappahannock River	2008	64	59318	16.48	0	0	0
Rappahannock River	2009	32	30034	8.34	0	0	0
Rappahannock River	2010	38	31100	8.64	0	0	0
Rivanna River	2004	1	750	0.21	0	0	0
South Anna River	1994	2	1651	0.46	0	0	0
South Anna River	1996	4	4354	1.21	0	0	0
South Anna River	1998	3	1635	0.45	0	0	0
South Anna River	1999	2	1955	0.54	0	0	0
South Anna River	2000	9	8032	2.23	0	0	0
South Anna River	2001	10	5557	1.54	0	0	0

Appendix A continued

South Anna River	2002	13	7135	1.98	0	0	0
South Anna River	2003	2	1800	0.50	0	0	0
South Anna River	2004	3	1475	0.41	0	0	0
South Anna River	2005	3	2430	0.68	0	0	0
South Anna River	2007	7	3900	1.08	0	0	0
South Anna River	2008	2	1600	0.44	0	0	0
South Anna River	2009	5	3900	1.08	0	0	0

11.5 VA F-116-R American Shad Monitoring Program

A moratorium on the taking of American shad in the Chesapeake Bay and its tributaries was established by the Virginia Marine Resources Commission (VMRC) beginning 1 January 1994. Concern about the decline in landings of American shad along the Atlantic coast generally prompted the development of an interstate fisheries management plan (FMP) under the auspices of the Atlantic States Marine Fisheries Management Program (ASMFC 1999). Legislation enables imposition of federal sanctions on fishing in those states that fail to comply with the FMP. To be in compliance, coastal states are required to implement and maintain fishery-dependent and fishery-independent monitoring programs as specified by the FMP. For Virginia, these requirements include spawning stock assessments, the collection of biological data on the spawning run (e.g., age-structure, sex ratio, and spawning history), estimation of total mortality, indices of juvenile abundance, biological characterization of permitted by-catch and evaluation of restoration programs by detection and enumeration of hatchery-released fish. The adult spawning stock monitoring program began in 1998 and consists of sampling techniques and locations that were consistent with, and directly comparable to, those that generated historical logbook data collected by VIMS during the period 1980-1992 in the York, James and Rappahannock rivers.

The primary objectives of the American shad monitoring program are: (1) to establish a time series of relative abundance indices of adult American shad during the spawning runs in the James, York and Rappahannock rivers; (2) to relate contemporary indices of abundance of American shad to historical logbook data collected during the period 1980-1992 and older data if available; (3) to assess the relative contribution of hatchery-reared and released cohorts of American shad to adult stocks; (4) to relate recruitment indices (young-of-the-year index of abundance) of American shad to relative year-class strength and age-structure of spawning adults.

One staked gillnet (SGN), 900 ft (approximately 274 m) in length, is set on the York and James rivers and one SGN, 912 ft (approximately 277 m) in length, is set on the Rappahannock River. Locations of the sets are consistent over the time series and are as follows: lower James River near the James River Bridge at river mile 10; middle York River near Clay Bank at river mile 14; and middle Rappahannock River near the Rappahannock River bridge (at Tappahannock, Virginia) at river mile 36. Each week during the spawning run (typically late February to early May), nets are fished on two succeeding days (two 24-h sets) and then hung in a non-fishing position until the next sampling episode. Surface water temperature and salinity are recorded at each sampling event. Catch data from each river are used to calculate a standardized catch index. The catch index, the duration of the run in days, the maximum daily catch rate in each year and the mean catch rate in each year were compared to summaries of historical logbook data to provide a measure of the relative size of the current shad runs. In 2011, annual fyke net sampling for juvenile American shad began on the York River. This juvenile sampling occurs between early June and late September. The sampling gear consists of five fyke nets constructed from ¼" Ace mesh. Each net includs four hoops, two throats, and one cab, with a 15.2 m leader and 7.6 m wings. Each fyke net is set for one day (24-h set) and after fishing each net was removed from the sampling site.

Adult American shad collected from the spawning stock monitoring sites are measured and weighed. Catches of all other species are recorded and enumerated on log sheets by observers on each river and released. Separate records are kept of the number of live and dead striped bass in the nets and released (if alive) or returned to the laboratory (if dead). Random subsamples of dead striped bass from each river were analyzed for sex, fork length and total weight. Sagittal otoliths are removed from samples of adult American shad, placed in numbered tissue culture trays, and stored for subsequent screening for hatchery marks. Scales for age determination are removed from a mid-lateral area on the left side posterior to the pectoral-fin base of each fish. For the juvenile sampling, all species present in the catch are identified and counted; all alosines are returned to the laboratory for further analysis. Individual juvenile alosines collected from monitoring stations are measured and weighed using the same equipment and guidelines as for adult fish. Sagittal otoliths from subsamples are removed and stored in individual collection vials for ageing and hatchery analysis. Otoliths are mounted on slides, then ground and polished by hand using wet laboratory-grade sandpaper. Daily ages are determined by counting daily incremental rings.

In 2009, VIMS American shad program personnel began tagging Atlantic sturgeons that were captured in good condition during this survey. All sturgeon are processed according to USFWS tagging protocols in the following manner: fork and total lengths (mm) are recorded, they are scanned for PIT tags. Fish without PIT tags present are tagged using T-Bar and PIT tags provided by the USFWS, fin clipped and then released alive (depending on specific circumstances, e.g., animal condition, only a subset of the above processing may take place). Note: VIMS would like to continue tagging Atlantic sturgeon during this project if possible.

11.6 VA F-116-R River Herring Monitoring

In 2014, the VMRC began working with the VIMS to fund a fishery-independent survey program for monitoring the spawning stocks of river herring in Virginia. For the first three years (2014-2016), the survey was funded with $40,000 from Marine Fishing Improvement Fund (MFIF) which includes revenue from the sale of commercial fishing licenses. By incorporating the river herring work into an existing survey for American Shad (funded by the Federal Sportfish Restoration Fund and matched with state recreational license funds), VIMS researchers were able to complete annual surveys for both species. In 2017, due to state-wide budget cuts, the river herring portion survey will be funded entirely from the federal Sportfish Restoration Program, and matched with state recreational license funds.

American shad methodology follows those employed since 1998 with the exception that effort was reduced from two to one day per week in 2015. For river herring, gear types and survey design have shifted in response to sampling success in the first years of the program. To monitor the catch rates and biological characteristics of river herring, drift gillnets deployed at the mouth of the Chickahominy River in 2014. In 2015 and 2016, anchored gill nets were incorporated downstream. Anchored gill nets were more effective in capturing river herring and produced more robust data, so for 2017, the drift gill nets will not be used. Anchored gill nets are also deployed in the Rappahannock River at Tappahannock to monitor river herring in that system.

Nighttime surface trawls are also used to capture and enumerate juvenile abundance of river herring during the summer and early fall months of the Chickahominy River, downstream of Walker's Dam.

This survey meets all of the data needs for river herring required by the ASMFC. Amendment 2 of the Interstate Fishery Management Plan for Shad and River Herring (ASMFC 2009: Table 15) mandates the following fishery-independent monitoring of river herring in Virginia (including the James, York, and Rappahannock rivers): 1) Annual spawning stock survey and representative sampling for biological data (excluding York River); 2) calculation of mortality and/or survival estimates; 3) calculation of juvenile abundance indices (JAI) as a geometric mean.

11.7 VA F-104-R Juvenile Fish Trawl Survey

The juvenile fish trawl survey conducted by VIMS is the oldest continuing monitoring program (56 years) for marine and estuarine fishes in the United States. This survey provides a monthly assessment of abundance of juvenile marine and estuarine fishes and crustaceans in the tidal rivers and main stem of Chesapeake Bay.

We use a 30' (9.14m) semi-balloon otter trawl, with 1.5" (38.1mm) stretched mesh and 0.25" (6.35mm) cod-end liner, that is towed along the bottom for 5 minutes during daylight hours. Sampling in the Bay occurs monthly except during January and March, when few target species are available. Sampling in the tributaries also occurs monthly, at both the random stratified and historical fixed (mid-channel) stations. The stratification system is based on depth and latitudinal regions in the Bay, or depth and longitudinal regions in the rivers. Each Bay region spans 15 latitudinal minutes and consists of six strata: western and eastern shore shallow (4-12 ft), western and eastern shoal (12-30 ft), central plain (30- 42 ft), and deep channel ($\geq$ 42 ft). Each tributary is partitioned into four regions of approximately ten longitudinal minutes, with four depth strata in each (4-12 ft, 12-30 ft, 30-42 ft, and $\geq$ 42 ft; Figure 1). Strata are collapsed in areas where certain depths are limited. Fixed stations were assigned to a stratum according to their location and depth.

With the exception of the fixed river stations, trawling sites within strata are selected randomly from the National Ocean Service's Chesapeake Bay bathymetric grid, a database of depth records measured or calculated at 15-cartographic-second intervals. Between two and four trawling sites are randomly selected for each Bay stratum each month, and the number varies seasonally. Exceptions include the shallow water strata where only a single station is sampled each month. For most river strata, one to two random stations are selected per month. Sampling in the York River has been altered slightly as of 1991 to make the deeper depth strata (30 ft +) similar to those in the James and Rappahannock rivers and main stem Bay. The stratification scheme for the tributaries was modified in January 1996 to create separate depth strata of 30-42 ft and ≥ 42 ft (Geer and Austin, 1996). Because tributary sampling had occurred at these depths prior to 1996, samples collected previously were reassigned to the new strata established in 1996.

Fixed stations were sampled monthly (nearly continuously) since 1980 with sites in each tributary spaced at approximately 5-mile intervals from the river mouth up to the freshwater interface. From the mid-1950's (York River) and early-1960's (James and Rappahannock rivers) to 1972, fixed stations were sampled monthly using an unlined 30' trawl (gear code 010). During 1973-79, semi-annual random stratified sampling was performed by the VIMS Ichthyology Department, while the VIMS Crustaceology Department continued monitoring the fixed tributary stations on a limited monthly basis (May - November). Area-based weightings for the tributaries were previously assigned by dividing each river into two approximately equal length 'strata' by assuming that the stations in each stratum were representative of the channel areas in those reaches (see Lowery and Geer, 2000). As of 1996, all three tributaries were sampled with a random stratified design; the fixed stations were assigned to a stratum based on location and depth. The current design (combined fixed and random stations) provides greater spatial coverage and a long-term historical reference.

At the completion of each tow, all fishes are identified to species, counted, and measured to the nearest millimeter fork length (FL), total length (TL), or total length centerline (TLC, black sea bass only). Species that have varying size ranges are measured and counted by size class and large catches of a particular species are randomly subsampled, measured, and the remaining unmeasured catch is counted. In instances of extremely large catches (e.g., bay anchovy), subsampling is performed volumetrically.

11.8 VA F-87-R Juvenile Striped Bass Beach Seine Survey

The primary objective of the Virginia Institute of Marine Science juvenile striped bass survey is to monitor the relative annual recruitment success of juvenile striped bass in the major Virginia nursery areas of lower Chesapeake Bay. The U.S. Fish and Wildlife Service initially funded the survey from 1967 to 1971. Beginning in 1980, funds were provided by the National Marine Fisheries Service under the Emergency Striped Bass Study program. Commencing with the 1989 annual survey, the work was jointly supported by Wallop-Breaux funds (Sport Fish Restoration Act), administered through the U.S. Fish and Wildlife Service, and the Virginia Marine Resources Commission.

Field sampling is conducted during five biweekly periods from mid-July through mid-September. During each round, seine hauls are conducted at 18 historical sites (index stations) and 21 auxiliary stations within the James, York and Rappahannock river systems. Auxiliary sites were added in 1989 to provide better geographic coverage, increase sample sizes within each river system, and to permit monitoring of trends in juvenile abundance within each river system. Such monitoring was desirable in light of increases in stock size and nursery ground expansion.

Collections are made by deploying a 100 ft (30.5 m) long, 4 ft (1.2 m) deep, 0.25 in (6.4 mm) mesh minnow seine perpendicular to the shoreline until either the net is fully extended or a depth of approximately 4 ft (1.2 m) is encountered and then pulling the offshore end down-current and back to the shore. During each round a single haul is made at each auxiliary station and duplicate hauls, with a 30-minute interlude, are made at each index station. Every fish collected during a haul is removed from the net and placed into water-filled buckets. All striped bass are measured to the nearest mm fork length and a sub-sample of up to 25 individuals is measured to the nearest mm fork length (or total length if appropriate) for all other species. At index stations, fish collected during the first haul are held until the second haul was completed. All captured fish, except those preserved for life history studies, are returned to the water at the conclusion of sampling.

At each sampling location sampling time, tidal stage and weather conditions are recorded for each haul. Salinity, water temperature and dissolved oxygen concentrations are measured after the first haul using a YSI water quality sampler.

11.9 VA F-130-R Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP)

The ChesMMAP survey conducts five research cruises annually (March, May, July, September, November) throughout the main stem of Chesapeake Bay. During each cruise, up to 80 sites are sampled according to a stratified random design.

Each tow is made using a 13.7m (headrope length), 4-seam, semi-balloon bottom trawl net that is constructed of 152mm stretch mesh in the wings and body and 76mm stretch mesh in the cod-end. At each sampling site, this gear is towed along the bottom for 20 minutes at approximately 3.0 knots and in the same general direction as the prevailing current. Sampling locations are selected using a stratified random design prior to each cruise and the order in which sites are sampled depends on weather, tides, and other logistical considerations.

At each sampling site, the catch is sorted by species (and size-class, where appropriate) and a subsample is taken from each for full processing. The data collected from each of these subsampled specimens include length and weight, as well as sex and maturity stage (determined macroscopically). Stomachs are removed and those containing prey items are preserved onboard for post-cruise examination at the VIMS shore-based laboratories. Otoliths or other appropriate aging structures are also removed from each subsampled specimen for age determination. Aggregate weights are recorded by species/size-class for all specimens not selected for the full processing, and either all or a representative subsample are enumerated and measured for length.

Single-species assessment models typically require information on (among others) age- and length-structure, sex ratio, and maturity stage. Quality control procedures are implemented at the conclusion of each research cruise to ensure that the data collection were accurate and complete, and these data are then be used to generate a variety of population-level information. Data are synthesized to characterize age- and length- frequency distributions across a various spatial and temporal scales (e.g., by year, season, or region of the bay) for each species. Sex ratio and maturity data are also available to support sex-specific analyses.

In addition to the population-level information described under Task 2, multispecies assessment models require information on predator-prey interactions across broad seasonal and spatial scales. Accordingly, stomachs collected in the field are processed following standard diet analysis procedures (Hyslop 1980). In general, these protocols involve identifying each prey item to the lowest possible taxonomic level; counts and weights of the various items are then recorded. Several diet indices are calculated to identify the main prey types for each species: percent by weight, percent by number, and percent frequency-of-occurrence. These indices can be coupled with the information generated from tasks above such that age-, length-, and sex-specific diet characterizations can be developed for each species. Efforts are also focused on characterizing spatial and temporal variability in these diets.

Time-series of relative abundance information can easily be generated from the basic catch data of a monitoring survey and is an integral component of both single and multispecies assessments. For each species, a variety of relative abundance trends are generated according to year, season, and location within the bay. Minimum trawlable abundance estimates can be calculated for each species by combining the catch data with estimates of the total survey area and the area swept by the trawl. Area swept by the net is calculated for each tow by multiplying tow distance (provided by GPS equipment) by average net width (provided by trawl monitoring gear). Because catch data from fishery-independent trawl surveys tend to follow log-normal distributions for most species, stratified geometric mean of catch per standard area swept indices would also be generated. Area swept would again be calculated using the procedures and variables described above. This method of calculating abundance indices was approved for use by, and currently is used by, the NEAMAP Mid-Atlantic/Southern New England Near Shore Trawl Survey, a coastal fishery-independent monitoring program that samples many of the same species in much the same way as ChesMMAP, albeit in a different geographic location (ASMFC 2009).

11.10 VA F-77-R Striped Bass Spawning Stock Assessment

The striped bass spawning stock assessment programs documents the annual size, age and sex composition of the striped bass spawning stock within defined spawning areas of the James and Rappahannock rivers of the Chesapeake Bay in Virginia. Sampling of striped bass is done from multiple mesh size gill nets in the James and Rappahannock rivers. These data are used to meet Atlantic State Marine Fishery Commission (ASMFC) compliance criteria of the Interstate Fishery Management Plan for striped bass.

The James and Rappahannock gill net surveys consist of twice-weekly samples of two 300’ gill nets (24 hr set time) in each river. Each gill net is 6’ in depth and consists of 10 30’ panels of varied mesh sizes (3, 3 ¾, 4 ½, 5 ¼, 6, 6 ½, 7, 8, 9 and 10” stretched). The order of the meshes was chosen randomly for each net. The nets are located approximately 100 m apart at mile 48 on the Rappahannock River and mile 60 on the James River. Data collected consist of lengths (fork and total, in mm), weight (in grams), sex and gonad maturity/ripeness. Scales samples are taken from each specimen and otoliths are extracted from a subsample for subsequent ageing.

12.0 District of Columbia

12.1 DC F-2-R Fish Population Surveys: Electrofishing and Seining

Electrofishing surveys are performed monthly beginning in March and running through November. Seining surveys are performed bi-monthly from June through October. The electrofishing survey specifically targets adult fish while the seining survey is aimed primarily at juvenile fish. The electrofishing surveys are conducted monthly at eight sites throughout the District of Columbia. Using a Smith-Root electrofishing vessel, DDOE biologists intermittently sample two separate lines at each site with intervals totaling ten minutes per line. As disabled fish float to the surface of the water, DDOE biologists capture as many fish as possible before the disabling effect of the shock diminishes. At each sampling site the first fifty (50) fish of each species are measured and all subsequent captures are counted and recorded. Additionally, all game fish (e.g., largemouth bass, smallmouth bass, and striped bass) are captured, measured, and weighed and a scale sample is collected and used to calculate age and growth rates. Although length and abundance data is taken for all species captured during our surveys, for the age and growth studies, weight and a scale sample are taken from each striped bass, largemouth bass, and smallmouth bass we capture.

Electrofishing takes place at four sites on the Potomac River, two on the Anacostia River, one in the Washington Channel, and one at the mouth of Rock Creek. Each monthly electrofishing sample contains two 600-second shocking repetitions. On a bimonthly basis from May through November, four additional sampling sites are added; three sites on the Potomac River, and one site on the Anacostia River. During the sampling repetition the electrofishing boat is moved parallel to the shoreline in three to six feet of water.

There are six seining sites sampled bi-monthly within District waters. Seining is a sampling technique that uses a continuous column or wall of netting to encircle fish. The top of the netting is fitted with floatation devices which keep the netting at the water's surface to keep fish from swimming over the net. The bottom of the netting is fitted with weights to keep fish from swimming under the net. Four of the sites are on the Potomac River and two sites are located on the Anacostia River. The seine survey utilizes a 100 ft x 4 ft beach seine with ¼" mesh. One end of the net is held stationary at the shoreline while the other end is pulled out into the water. A semi-circular shape is made as the entire net is pulled through the water and then back to the shoreline. Seining surveys are conducted bi-weekly from May through October at four sites on the Potomac River and at two sites on the Anacostia River. Using a one-hundred (100) foot by four (4) foot seine with a one quarter (1/4) inch mesh, DDOE biologists perform one haul of maximum allowable length, based on terrain, at each site. All fish collected are identified, measured and enumerated.

All surveys are conducted on the Potomac River, the Anacostia River, the Washington Channel, or Rock Creek.

Rock Creek is a primary freshwater tributary to the Potomac River and a secondary tributary to the Chesapeake Bay. It is approximately 33 miles in length of which 9.3 miles flow within the District of Columbia. This entire 9.3-mile stretch lies within Rock Creek Park, which is federal land that is regulated by the National Park Service. The Rock Creek watershed has a surface area of 77 square miles.

The Potomac and Anacostia rivers are two bodies of water that flow within the District of Columbia. The two rivers are tidal, freshwater (0.14ppt) and approximately 200 miles from the Atlantic Ocean. The Potomac River is the second largest tributary to the Chesapeake Bay, and one of the largest rivers in the Atlantic drainage of North America.

12.2 DC F-2-R Fish Tagging Surveys

DDOE annually tags black bass to assess the population size in certain stretches of District waters, monitor movement patterns, and examine growth rates.

Striped bass tagging in the District is a cooperative effort with the U.S. Fish and Wildlife Service (FWS). DDOE implants USFWS tags in striped bass that are encountered during routine and special sampling outings. The majority of striped bass tagged in the District are tagged during night electrofishing in the spring. Striped bass tagging takes place across several sampling regimes but the most concentrated effort is focused at special sampling events in the spring when the adult fish migrate up the river in search of spawning grounds and food. Fish are collected by electrofishing in the upper stretches of the District's portion of the Potomac River. DDOE biologists wait until after dark and begin drifting perpendicular to the shore in the fast moving river, shocking just off the bank in about 10-15 feet of water. When a striped bass is shocked it is collected in a large dip net and placed in an onboard live well. Once the live well is reasonably full but not overcrowded electrofishing is temporally halted. DDOE biologists then take a total length (mm) and weight (g) of the fish, remove a scale sample for aging and implant an external body anchor tag.

Snakehead tagging in the District began in 2009 as part of a multijurisdictional effort among neighboring agencies within the Potomac River watershed. Snakeheads are captured, generally by electrofishing, and inserted with a T-bar style Floy tag with a unique identification number and a phone number for the USFWS. In addition, biologists record the length, weight, and capture location of each fish. Once the live well is full or tagging for the day in finished the fish are released at a known location. For this study the Potomac River and its tributaries were divided into 5 sections. The upper section (Woodrow Wilson Bridge north to the District line around Chain Bridge and the Anacostia from its confluence with the Potomac up to Bladensburg, MD) is the section the District is responsible for tagging snakeheads.

Over 500 blue catfish were tagged between 2007 and 2010 with only one recapture. The survey has been conducted at five sampling locations in District waters: three on the Potomac (P1LF-Wilson Bridge, P2LF-14th Street Bridges, and P3LF- Key Bridge) and two sites on the Anacostia (A1LF- South Capitol Street Bridge and A2LF-the railroad bridge just north of Pennsylvania Avenue). All the sites were set up at bridges because of the constant structure they provide.

All catfish species are collected using a low frequency electrofishing technique which has proven to be extremely effective. A Smith-Root Inc.; Model GPP 7.5 is utilized with the following settings: pulsed DC, 0.8-1.5 A, at 7.5 pulses/second.   The survey is conducted from April through October when water temperatures are at least 18 degree Celsius and then stopped before temperatures fall below that threshold. When the water temperature falls below 18 degrees Celsius the effectiveness of the low frequency technique is greatly reduced. Each sampling site is shocked for 600 seconds or until live wells have reached capacity. Two boats are used at each site; one to apply the electricity and another as a chase boat to collect fish. Total lengths (mm) and weights (g) are taken from all blue catfish and lengths only are collected from all other catfish species at each site. All blue catfish greater than 400 mm are tagged with a Floy harpoon style tag.

12.3 DC F-2-R Push Net Survey

DDOE conducts a yearly push net survey to assess the spawning success of the various alosine species found in District waters, including American shad, hickory shad, blueback herring, and alewives. DDOE conducts push net sampling during August and September at five locations on the Potomac River. The sites are P5PN (Fletchers Boathouse), P4PN (upstream of Key bridge/adjacent to three sisters island), P3PN (adjacent to Theodore Island), P2PN (adjacent to National Airport), P1PN (upstream from the Woodrow Wilson Bridge), and A1PN (downstream of Pennsylvania Ave. Bridge). Site A1PN was added to the sampling regime in 2005. This site is located on the Anacostia River.

Samplings are done after sunset and performed eleven times a year, July through September. A 50"x 38" x8" (width x depth x length) mesh net (1/8 inch mesh) is hung on a pivoting tubular metal frame and fished from the bow of the boat for a ten minute period. A 0.83-mile long transect is covered at each station. Transects are performed at a constant speed of 5 mph. Because weather conditions vary which subsequently affects water conditions and the vessels' ability to consistently cover distances over time, the distance traveled during each push is recorded. Additionally, an in line flow meter is mounted at mouth of the push net to monitor the volume of water that passes through the net during each push. Sampling at most of the sites (P5PN, P4PN, P3PN, and P2PN) is performed starting from an upstream position and moving downstream. P1PN and A1PN are fished in the opposite direction. All alosines are collected, enumerated, measured and saved for otolith extraction.

12.4 DC F-2-R American Eel Studies

The status of American eels, *Anguilla rostrata* stocks are inadequately understood and current information suggests that populations have declined significantly. In response to the insufficient data, the Atlantic States Marine Fisheries Commission (ASMFC) has established an American Eel Fishery Management Plan to restore, protect and enhance the abundance of the American eels along the east coast. For the last several years DDOE, along with other partnering jurisdictions, have participated in the ASMFC elver surveys. The surveys are conducted to assess American eel young of year (YOY) abundance. Elvers shorter than 85 mm are considered YOY. Eels of this size represent the first year class of eels migrating back from the ocean.

In 2011, the DDOE also participated in a study that entailed the assessment of adult American eels. This survey is conducted to assess adult eel abundance. Adult eels are considered to be anything over 152 mm in length, typically a yellow or silver eel.

The YOY survey is conducted in Rock Creek. The adult eel survey is carried out on the Potomac and Anacostia rivers.

The elver survey is carried out by following a protocol provided by the ASMFC. This protocol requires sampling at minimum, one site four days per week for six weeks. The sampling gear consists of an Irish elver ramp trap. The dimensions of the wood trap are approximately 61 cm wide x 122 cm long. Each trap consists of a narrow interior ramp that is covered with enkmat, a plastic erosion control material. The ramp runs three-fourths of the length of the trap and ends in a small well at the top of the ramp. Fresh water is fed into the trap through a tube next to the well. The water fills the well and trickles down the ramp, attracting elvers. Elvers climb the ramp, fall into the well, and are carried into a mesh bag that is attached to the well. Elvers are then collected from the bag, counted, measured, and weighed. Traps are tied to trees with padlocks in case of floods and to deter theft.

Traps are set in early April and are fished until the end of May. The traps are set on Mondays and checked every day throughout the week and removed on Fridays. All traps are set in Rock Creek and are accessible by wading.

As an alternate method to capturing elvers, backpack electrofishing is also done. At selected sites a 50-meter stretch of Rock Creek was shocked at 200 to 300 volts, depending on water conditions, for just over 500 seconds. A typical crew consists of at least two biologists. A three person crew is ideal, with one person responsible for shocking and two people trailing behind on each side of the shocker netting the eels. A fine mesh (1/32 inch) dip net is used to capture the eels. The backpack shocker is started at its lowest setting (voltage, pulse rate and pulse width) and gradually increased to the point where the eels become immobilized and are netted. Settings vary according to water conditions. Biologists document basic biological information and eels are measured and weighed and their pigment stage is recorded. This method is repeated for a twenty week sampling period.

Adult eels are collected using commercial grade eel pots that are hand-made of fine mesh wire with nylon funnels sewn in them. These pots have a single entrance. Each set contains ten eel pots strung together with two weights at each end to anchor the pots and two buoys at each end so they can be easily retrieved. In 2011, four sets of eel pots were set, between the Potomac River and the Anacostia River. Pots were set on Mondays, checked and re-baited on Wednesdays and checked and retrieved on Fridays. All pots were set in ten feet or less of water. At each station collected eels are measured, weighed, and then released. Sampling is conducted during the months of May, July and September.

12.5 DC F-2-R Stock Enhancement

Adult American shad typically begin to arrive in District waters in early April as part of their annual spring spawning run. The run usually lasts from early April to mid May when water temperatures range from 12 to 20 degrees C. DDOE biologists conduct evening and night sampling in an effort to capture pre-spawn adults. The fish are captured through the use of gill nets.

In order to maximize the catch of ripe American shad, gill netting efforts have taken place outside of DDOE’s jurisdiction near the mouth of Pohick Bay. For this reason a collection permit is required and obtained from the Potomac River Fisheries Commission (PRFC). It is well known that gillnetting in this section of river for spawning American shad is very productive. Gillnetting typically consists of fishing three nets that are approximately 300ft in length and 20 – 24 feet in depth with 5 - 5 ½ inch stretch mesh. The nets are fished for roughly an hour each. The nets are set during the evening slack tide in an effort to prevent the nets from drifting too far during the soak. The nets are set parallel to the shoreline along sharp edges on the river bottom. This is done in an effort to catch spawning fish as they come up from the deeper channel at night to spawn. After an hour the nets are retrieved and all by-catch is identified, counted and released. American shad are sexed, measured, and the eggs of ripe females are stripped for incubation at the hatchery.

Effort Summary Tables

Table 1: General Electrofishing Effort Summary

Year	Number of Sites Sampled	Sampling Reps	Duration (sec)	Total Effort (sec)	Sturgeon Encountered
1990	7	108	600	64800	**0**
1991	6	120	600	72000	**0**
1992	6	114	600	68400	**0**
1993	12	138	600	82800	**0**
1994	12	178	600	106800	**0**
1995	12	152	600	91200	**0**
1996	12	176	600	105600	**0**
1997	12	179	600	107400	**0**
1998	12	184	600	110400	**0**
1999	12	203	600	121800	**0**
2000	12	176	600	105600	**0**
2001	12	176	600	105600	**0**
2002	12	176	600	105600	**0**
2003	12	176	600	105600	**0**
2004	12	143	600	85800	**0**
2005	12	176	600	105600	**0**
2006	12	176	600	105600	**0**
2007	12	176	600	105600	**0**
2008	12	176	600	105600	**0**
2009	12	176	600	105600	**0**
2010	12	176	600	105600	**0**
2011	12	176	600	105600	**0**

Table 2: Seining Summary 1990-2011

Year	Number of Sites Sampled	Reps	Net Size (Sq. Ft.)	Total Effort (Sq. Ft.)	Sturgeon Encountered
1990	6	96	400	38400	0
1991	6	108	400	43200	0
1992	6	54	400	21600	0
1993	6	54	400	21600	0
1994	6	60	400	24000	0
1995	6	54	400	21600	0
1996	6	54	400	21600	0
1997	6	60	400	24000	0
1998	6	57	400	22800	0
1999	6	58	400	23200	0
2000	6	48	400	19200	0
2001	6	54	400	21600	0
2002	6	53	400	21200	0
2003	6	40	400	16000	0
2004	5	50	400	20000	0
2005	5	45	400	18000	0
2006	5	45	400	18000	0
2007	5	45	400	18000	0
2008	5	40	400	16000	0
2009	5	40	400	16000	0
2010	6	36	400	14400	0
2011	6	30	400	12000	0

Table 3: Special Tagging Summary

Year	Number of Tagging Events (No Time Record)	Total Effort (sec)	Sturgeon Encountered
1999	6	17894	0
2000	6	13196	0
2001	6	13784	0
2002	3(5)	8196	0
2003	8	20300	0
2004	0(4)		0
2005	4(15)	6300	0
2006	0(11)		0
2007	9(7)	17016	0
2008	14	19786	0
2009	24	30789	0
2010	28	35138	0
2011	20	39451	0

Table 4: Push Net Effort Summary

Year	Number of Sites Sampled	Number of Pushes	Duration (sec)	Total Effort (sec)	Flow Meter Volume (m^3)	Sturgeon Encountered
2005	6	84	600	50400	N/A	**0**
2006	6	78	600	46800	120371	**0**
2007	6	66	600	39600	79778	**0**
2008	6	66	600	39600	88248	**0**
2009	6	54	600	32400	78129	**0**
2010	6	66	600	39600	100504	**0**
2011	6	66	600	39600	99202	**0**

Table 5: Adult Eel Pot Effort Summary

Year	Number of Sites Sampled	Pots Deployed/Day	Deployment Days	Soak Time (Hrs)	Total Effort (Hrs)	Sturgeon Encountered
2008	4	40	23	48	1104	**0**
2009	4	40	21	48	1008	**0**
2010	4	40	17	48	816	**0**
2011	4	40	18	48	864	**0**

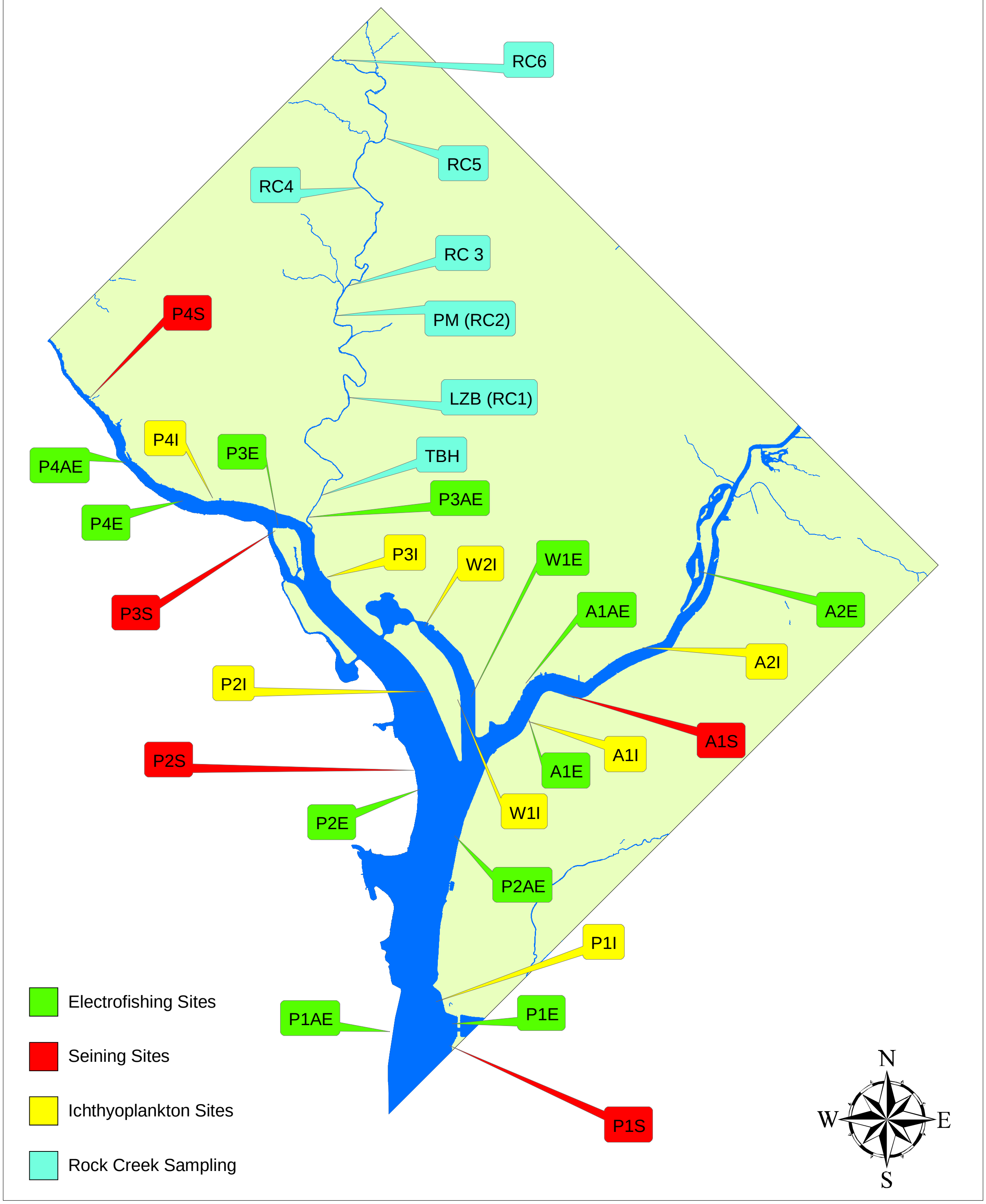
Table 6: Backpack Electrofishing Effort Summary

Year	Number of Sites Sampled	Duration (sec)	Sturgeon Encountered
2008	6	29165	**0**
2009	6	25539	**0**
2010	6	28322	**0**
2011	6	27283	**0**

Table 7: American Shad Gillnetting Effort Summary

Year	Deployment Days	Soak Time (Hrs)	Total Effort (Hrs)	Total Net Fished (Sq. Ft)	Sturgeon Encountered
2006	9	1	9	130,500	**0**
2007	11	1	11	212,400	**0**
2008	12	1	12	222,000	**0**
2009	12	1	12	295,200	**0**
2010	7	1	7	127,200	**0**
2011	0	0	0	0	**0**

District of Columbia Sampling Sites



12.6 *DC F-2-R Blue Catfish Diet Study*

This study was conducted on both the Potomac and Anacostia Rivers. The Wilson Bridge served as the southern boundary on the Potomac River and Chain Bridge served as the northern boundary. Within this stretch of river the Memorial Bridge served as a dividing line between the upper Potomac and the lower Potomac. No fish were collected within a quarter of mile of the dividing line in an attempt to prevent crossover. This distinction between the upper and lower River was made because of the very different type of habitat found in both stretches. The upper Potomac is narrower with a rocky bottom and fast moving, clear water, whereas the lower Potomac is a wide, sluggish, turbid river with a silt bottom. The Anacostia was bracketed by the South Capitol Street Bridge to the south and the New York Avenue Bridge to the north.

Blue catfish were collected from each of the three distinct sections of river. Fish were collected in conjunction with other surveys mostly by electrofishing and hook. When blue catfish were collected, lengths and weights were initially recorded then biologists killed the fish by severing their spinal columns. Next, the stomach and intestines were removed bagged, labeled, and kept on ice for examination in the laboratory. In the lab, biologists separated the stomach from the rest of the intestines at the base of the stomach. Biologists removed the intestine contents from the intestine, weighed them and recorded anything distinguishable. The stomach contents were weighted and examined separately from the intestine because stomach contents are more likely to be identifiable. The stomach and intestine content was identified as well as possible based on level of digestion.

A percent fullness was calculated by taking the total weight of the contents of the digestive tract and dividing it by the total weight of the fish. Fish were collected in five separate size ranges: stock (301-510 mm), quality (511-760 mm), preferred (761-890 mm), memorable (891-1140 mm), and trophy (1141 mm+) (Anderson and Neumann, 1996). Ideally DOEE would like to collect a minimum of 10 fish from each of the five size ranges in each of the three locations, during each of the four separate seasons: winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and fall (September, October and November).

In total, 100 blue catfish were taken for stomach analysis from the lower Potomac. Sixteen had nothing in their digestive tracts and the other 84 contained at least some matter (Table 8). Less than half of the fish from the three largest size classes had anything in their digestive tracts. The stock and quality sized fish provided plenty of digestive tract contents to examine. Their diets consisted mainly of plants (SAV) and invertebrates (corbicula) but they also consumed some fish.

Table 8: Overall description of lower Potomac blue catfish and diets, 2016.

Lower Potomac	Stock (301-510 mm)	Quality (511-760 mm)	Preferred (761-890 mm)	Memorable (891-1140 mm)	Trophy (1141 mm +)
Average length (mm) ± SE	469 ± 7	578 ± 14	788 ± 14	1058 ± 34	1168
Average weight (g) ± SE	1033 ± 59	2191 ± 208	6574 ± 943	17868 ± 4187	17700
Average stomach and intestine contents wt. (g) ± SE	54.81 ± 13.36	96.63 ± 32.35	185.00 ± 166.28	127.80 ± 248.04	0
Fullness (% body weight) ± SE	5.14 ± 1.17	4.18 ± 1.12	2.84 ± 2.51	1.00 ± 1.94	0
Sample size	36	52	6	5	1
# Males, # Females	21M, 15F	18M, 34F	2M, 4F	1M, 4F	1M
% with some digestive tract contents	94	87	50	40	0
% empty stomachs and intestines	6	13	50	60	100

A total of 21 blue catfish were taken from the upper Potomac for the diet study. Eleven of those fish came from low frequency shocking and another 10 from various other electrofishing sampling in the area. None of the fish collected in the upper Potomac had anything at all in their digestive tracts. Similar to the upper Potomac, no blue catfish were encountered during low frequency electrofishing in the upper Anacostia but DOEE was able to get two blue catfish from other surveys. Both of the Anacostia fish had fish and fish matter in their digestive tracts. One contained a small amount of fish matter while the other a 720mm female had eaten a 240mm catfish weighing about 200g. The lower Potomac site was by far the most productive low frequency electrofishing site to provide blue catfish for the diet study. The diets of the stock and quality sized fish were very similar, with plant material being the most common items found followed distantly by invertebrates and finally algae and fish. Fish were the least common prey item in both size classes. None of the memorable or trophy sized fish from the lower Potomac had anything in their digestive tracts.

The lower Potomac River site also provided DOEE biologists with plenty of quality sized blue catfish throughout the year while the low frequency electrofishing was still effective. This site gives the best insight into how their diet changes seasonally. The quality size fish rely more heavily on invertebrates in the fall and plant material in the summer (Figures 1). Only one fish from the spring sample had anything in its digestive tract (algae).

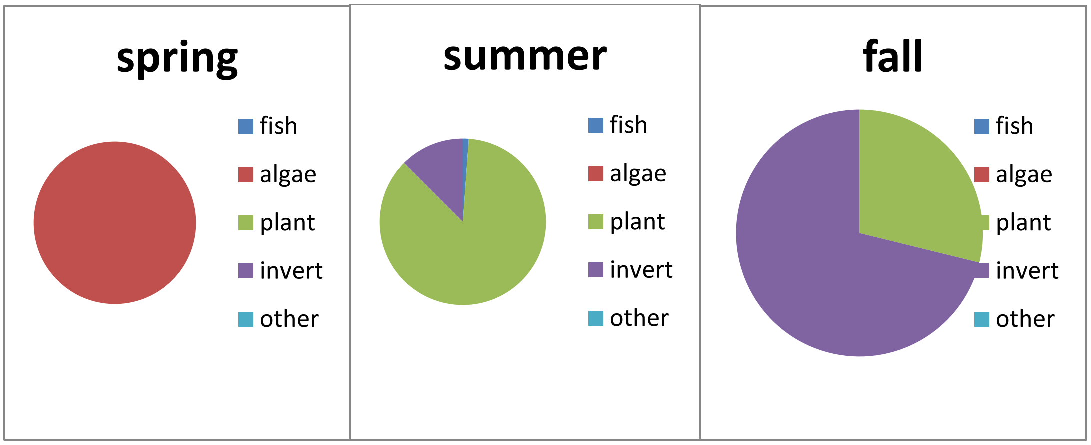


Figure 1: Seasonal diet variation of quality size blue catfish from the lower Potomac, 2016.

Blue catfish diets vary depending on size, location, and season, but some things were consistent. There is not much of a difference between the diets of the stock and quality sized fish. This suggests that the shift in diet from more diverse to nearly piscivorous is larger than the average quality sized blue catfish examined in this study. The small sample size from all of the larger (preferred, memorable, and trophy) blue catfish makes drawing concrete conclusions nearly impossible. It is clear that more large fish as well as fish from the Anacostia and upper Potomac need to be collected for this study. Overall, blue catfish appear to be extremely opportunistic feeders. They will eat what is in front of them, and that depends on the time of year and where they are located. None of the blue catfish examined in 2016 had any unusual items in their digestive tracts, but previous years have found bird legs, cigarette butts, cigar wrappers (Dutchmaster Grape), pork rib bones, and various other non-typical food items.

Alosine species do not appear to be specifically targeted by blue catfish as prey and were not found in any of the fish examined for this study in 2016. With such a small sample size in the Anacostia and upper Potomac Rivers it is difficult to draw any conclusion about blue catfish consumption of river herring. When algae and SAV are present in the environment, fish consumption in general, and consequently alosine species, is much lower. Continuing this study into the future will provide larger sample sizes so that more definite conclusions can be drawn. Further, it will provide valuable insight into how the increased blue catfish population will potentially impact other fish species.

APPENDIX B

Sea turtle handling and resuscitation measures as found at 50 CFR 223.206(d)(1).

(d) (1) (i) Any specimen taken incidentally during the course of fishing or scientific research activities must be handled with due care to prevent injury to live specimens, observed for activity, and returned to the water according to the following procedures.

(A) Sea turtles that are actively moving or determined to be dead as described in (d)(1)(i)(C) of this section must be released over the stern of the boat. In addition, they must be released only when fishing or scientific collection gear is not in use, when the engine gears are in neutral position, and in areas where they are unlikely to be recaptured or injured by vessels.

(B) Resuscitation must be attempted on sea turtles that are comatose, or inactive, as determined in paragraph (d)(1) of this section by:

(1) placing the turtle on its bottom shell (plastron) so that the turtle is right side up, and elevating its hindquarters at least 6 inches (15.2 cm) for a period of 4 up to 24 hours. The amount of the elevation depends on the size of the turtle; greater elevations are needed for larger turtles. Periodically, rock the turtle gently left to right and right to left by holding the outer edge of the shell (carapace) and lifting one side about 3 inches (7.6 cm) then alternate to the other side. Gently touch the eye and pinch the tail (reflex test) periodically to see if there is a response.

(2) sea turtles being resuscitated must be shaded and kept damp or moist but under no circumstance be placed into a container holding water. A water-soaked towel placed over the head, neck, and flippers is the most effective method in keeping a turtle moist.

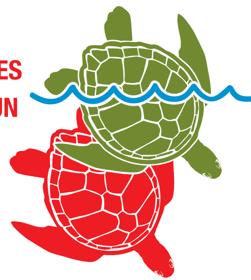
(3) sea turtles that revive and become active must be released over the stern of the boat only when fishing or scientific collection gear is not in use, when the engine gears are in neutral position, and in areas where they are unlikely to be recaptured or injured by vessels. Sea turtles that fail to respond to the reflex test or fail to move within 4 hours (up to 24, if possible) must be returned to the water in the same manner as that for actively moving turtles.

(C) A turtle is determined to be dead if the muscles are stiff (rigor mortis) and/or the flesh has begun to rot; otherwise the turtle is determined to be comatose or inactive and resuscitation attempts are necessary.

SEA TURTLE HANDLING AND RESUSCITATION REQUIREMENTS

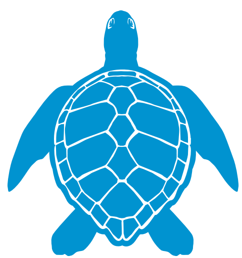
Any sea turtle taken incidentally during fishing must be handled with care to prevent injury, observed for activity, and returned to the water according to the following procedures:

Ⓐ A SEA TURTLE THAT IS ACTIVELY MOVING OR IS DEAD (THAT IS, IF MUSCLES ARE STIFF AND/OR THE FLESH HAS BEGUN TO ROT) MUST BE RELEASED OVER THE VESSEL'S STERN ONLY:



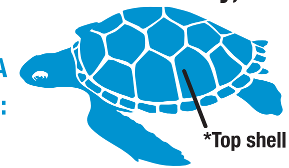
- When fishing gear is not in use,
- When the engine is in neutral, and
- In areas where the turtle is unlikely to be recaptured or injured by vessels.

OTHERWISE, YOU MUST CONSIDER THE TURTLE UNRESPONSIVE AND ATTEMPT RESUSCITATION AS DESCRIBED IN Ⓑ.



You are strongly encouraged to read the full regulation, which can be found at 50 CFR 223.206(d)(1).

Ⓑ YOU MUST ATTEMPT RESUSCITATION ON SEA TURTLES THAT ARE UNRESPONSIVE AS FOLLOWS:



❶ Place the turtle top shell up* and elevate its hindquarters at least 6” (or 15-30°) for at least 4 hours and up to 24 hours.

- The amount of elevation depends on the turtle's size; larger turtles require greater elevation.
- In warm weather (over 60 °F), keep the turtle shaded and moist, preferably by placing a damp towel over the head, shell, and flippers. You must NOT place the turtle into a container of water.

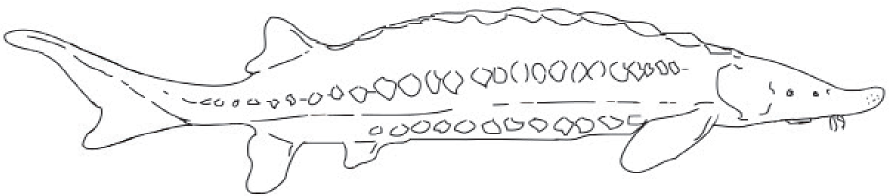
❷ Periodically rock the turtle gently side to side by holding the outer edge of the shell and lifting one side about 3”, then alternate to the other side.

❸ Periodically gently touch the eye and pinch the tail (reflex tests) to see if there is a response.

Ⓒ IF THE TURTLE REVIVES AND BECOMES ACTIVE DURING RESUSCITATION EFFORTS, you must release it over the vessel's stern as described in Ⓐ. If the turtle does not respond to the reflex test (as described in Ⓑ❸) or move within 4 hours (up to 24 hours, if possible), you must return the turtle to the water in the same manner.

Atlantic Sturgeon

ESA Listed Species



Picture Credit: picture by Tom Savoy (top), line drawing by Sarah Walsh Laporte (middle), and illustration by Duane Raver (bottom)

Atlantic Sturgeon are Protected

If you incidentally catch an Atlantic sturgeon which is responsive and lively, return the fish to the water immediately. However:

- **If the fish is nonresponsive, it is important that you try to resuscitate the fish**

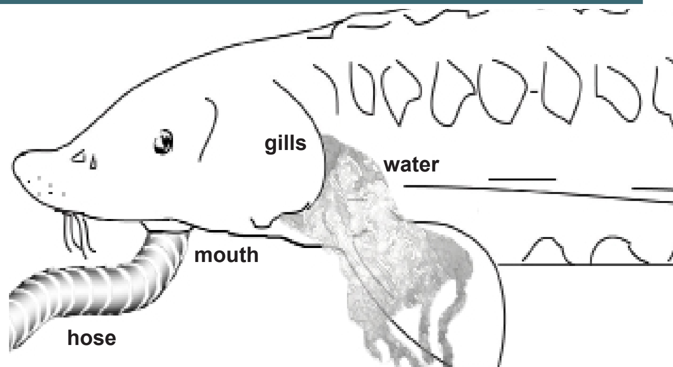
Atlantic sturgeon that have appeared nonresponsive, have been successfully resuscitated after being placed in oxygenated water or set up with a hose of water running out and over the gills for at least 30 minutes.

For a complete description of the prohibitions and exemptions for Atlantic sturgeon, call NOAA's National Marine Fisheries Service Northeast Region Protected Resources Division at 978-281-9328, or visit the Atlantic sturgeon recovery website at http://www.nero.noaa.gov/prot_res/atlsturgeon/.

Atlantic Sturgeon

ESA Listed Species

Atlantic sturgeon removed from fishing gear may be nonresponsive. It is often possible to resuscitate these fish by flushing water, over the gills until recovery is obvious. The most effective way to resuscitate fish is through the mouth, as if the fish were swimming forward.



Hose inserted up through mouth and to the side to allow water to flow over gills.

Picture Credit: Line drawing by Sarah Walsh Laporte

Resuscitation with a Hose

- Use wet hands or wet rag and support the belly when handling.
- Use a pump and hose with water (For example: 1 1/2" engine-driven wash down pump).
- Place the hose into the mouth and to the side, using a soft piece of sponge/cloth to keep the metal/hard plastic from injuring the inside of the fish's mouth.
- Use enough water pressure to gently flush water over gills. Heavy water pressure can harm the fish.
- Make sure water is running out and over the gills and NOT down the throat into the digestive tract.

Resuscitation should be attempted on all nonresponsive fish for at least 30 minutes. If the fish remains nonresponsive after 30 minutes, the fish should be considered dead and the carcass returned to the water.

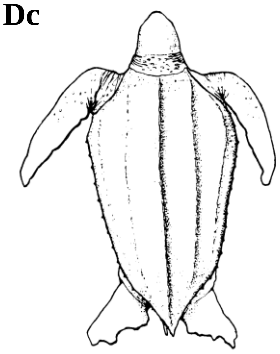
For a complete description of the prohibitions and exemptions for Atlantic sturgeon, call NOAA's National Marine Fisheries Service Northeast Region Protected Resources Division at 978-281-9328, or visit the Atlantic sturgeon recovery website at http://www.nero.noaa.gov/prot_res/atlsturgeon/.

APPENDIX E

Identification Key for Sea Turtles and Sturgeon Found in Northeast U.S. Waters

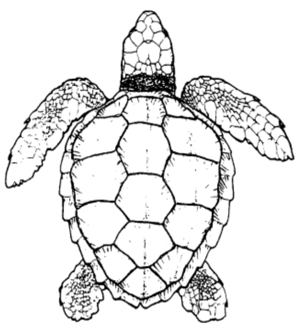
SEA TURTLES

Dc



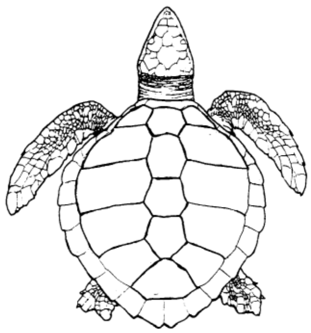
Leatherback (*Dermocheyls coriacea*)

Found in open water throughout the Northeast from spring through fall. Leathery shell with 5-7 ridges along the back. Largest sea turtle (4-6 feet). Dark green to black; may have white spots on flippers and underside.



Loggerhead (*Caretta caretta*)

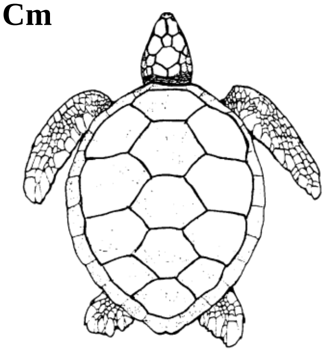
Bony shell, reddish-brown in color. Mid-sized sea turtle (2-4 feet). Commonly seen from Cape Cod to Hatteras from spring through fall, especially in southern portion of range. Head large in relation to body.



Kemp's ridley (*Lepidochelys kempi*)

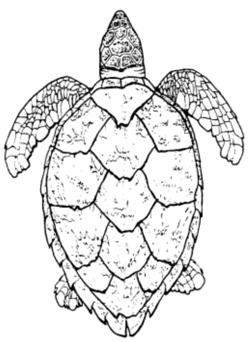
Most often found in Bays and coastal waters from Cape Cod to Hatteras from summer through fall. Offshore occurrence undetermined. Bony shell, olive green to grey in color. Smallest sea turtle in Northeast (9-24 inches). Width equal to or greater than length.

Cm



Green turtle (*Chelonia mydas*)

Uncommon in the Northeast. Occur in Bays and coastal waters from Cape Cod to Hatteras in summer. Bony shell, variably colored; usually dark brown with lighter stripes and spots. Small to mid-sized sea turtle (1-3 feet). Head small in comparison to body size.

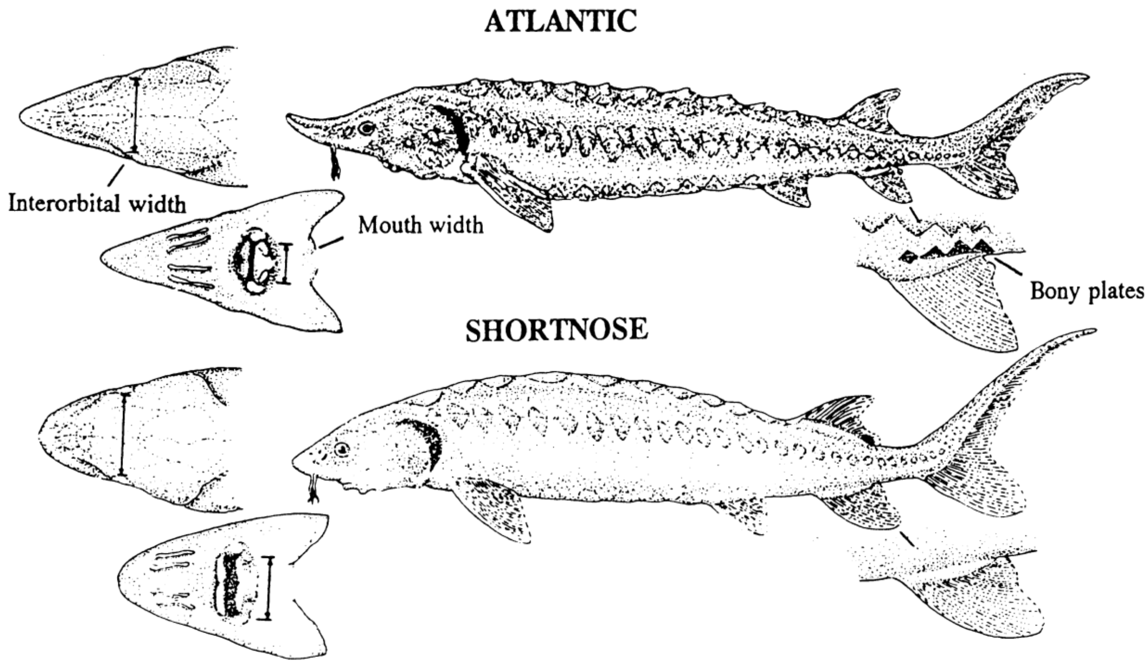


Hawksbill (*Eretmochelys imbricata*)

Rarely seen in Northeast. Elongate bony shell with overlapping scales. Color variable, usually dark brown with yellow streaks and spots (tortoise-shell). Small to mid-sized sea turtle (1-3 feet). Head relatively small, neck long.

APPENDIX E, continued

SHORTNOSE AND ATLANTIC STURGEON



Distinguishing Characteristics of Atlantic and Shortnose Sturgeon

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004

APPENDIX F

Take Report Form for ESA-Listed Species
Use one form per individual animal taken

Biological Opinion PCTS No.
NER-2018-14763

Species taken:

- ☐ **Green sea turtle**
- ☐ **Kemp's ridley sea turtle**
- ☐ **Leatherback sea turtle**
- ☐ **Loggerhead sea turtle**
- ☐ **Unknown sea turtle**
- ☐ **Atlantic sturgeon**
- ☐ **Shortnose sturgeon**
- ☐ **Unknown sturgeon**
- ☐ **Atlantic salmon**

Condition when taken (select one):

☐ Alive ☐ Fresh Dead ☐ Moderately Decomposed
☐ Severely Decomposed ☐ Dried ☐ Skeletal

Date take observed:

Animal was:

- ☐ Released alive with no visible injuries
- ☐ Released alive with visible injuries
- ☐ Released dead
- ☐ Held for Necropsy
- ☐ Transferred to rehabilitation (sea turtles only)

Date: ________________

Rehabilitation facility:

SPECIES CONDITION KEY

Fresh dead – no foul smell
Moderately decomposed – scutes and skin are intact or just beginning to peel, internal organs intact
Severely decomposed – foul smell with scutes lifting or gone, skin peeling, internal organs beginning to liquefy
Dried carcass – leathery, internal organs have decomposed
Skeletal remains - bones only

Location of the take:

Latitude and Longitude in Decimal Degrees to six places:

Latitude:

Longitude:

Sediment type in area (e.g., SAV, cobble, silt/mud, shellfish present):

Body of water where take occurred:

- ☐ Atlantic Ocean
- ☐ River (name): ________________________________
- ☐ Bay or Sound (name): ___________________________
- ☐ Creek (name): _______________________________

Take activity (select all that apply):

- ☐ Trawl (bottom, surface, mid-water, other)
- ☐ Gillnet (sink, floating, anchored, drift, other)
- ☐ Seine (beach, haul, other)
- ☐ Other net (e.g., fyke, dip, push, hoop, trap, cast, plankton, pound)
- ☐ Electrofishing (boat, backpack, barge, other)
- ☐ Pot/trap (lobster, crab, fish, eel, other)
- ☐ Hook and line (includes longline)

Tow/set duration:

Refer to your Biological Opinion for guidance on handling and resuscitating live animals

Indicate type and location of visible injuries (see diagrams). Check all that apply:

Type of Injury	Dorsal Surface	Ventral Surface -
Cuts/Gashes (not severed)	☐	☐
Severed body, limbs, or organs	☐	☐

Describe injuries and list any missing body parts:

For live animals - indicate behavior when taken:

☐ Active (alert, moving head, fins or flippers)

☐ Slow and lethargic (minimal movement and responsiveness)

☐ No movement but may or may not respond to reflex test

For dead animals, does the BiOp require necropsy:

☐ Yes ☐ No

Was resuscitation attempted:

☐ Yes, length of time ________ hours Outcome: ☐ Alive ☐ Dead

☐ No ☐ N/A, animal confirmed dead, or alive and moving when taken

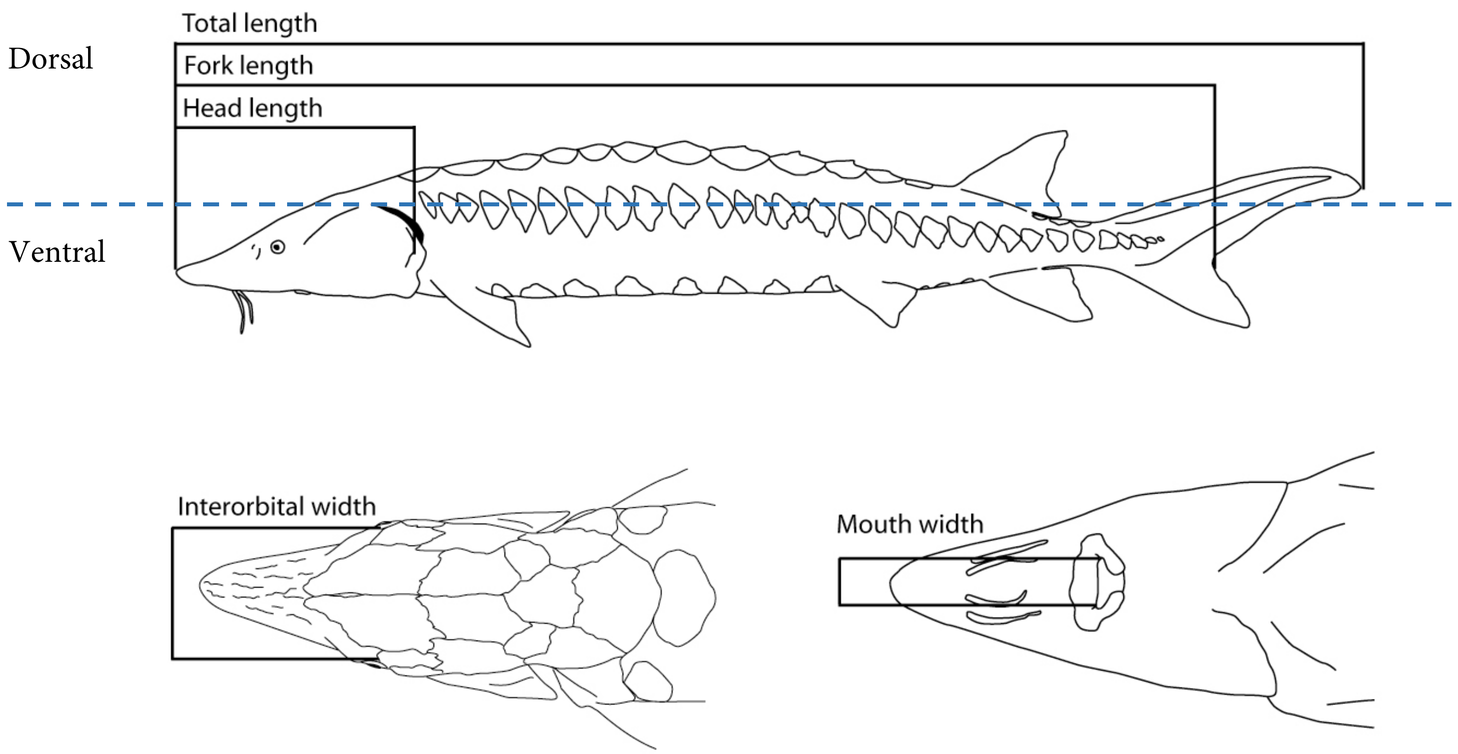
Fish measurements in centimeters – measurements should be exact.
Provide the reason for any estimated measure (e.g., tail missing)

	Exact	Estimated	Reason for Estimated Measure
Total Length: ____________ cm	☐	☐	____________________
Fork Length: ____________ cm	☐	☐	____________________
Mouth Width: ____________ cm	☐	☐	____________________
Interorbital Width: ________ cm	☐	☐	____________________

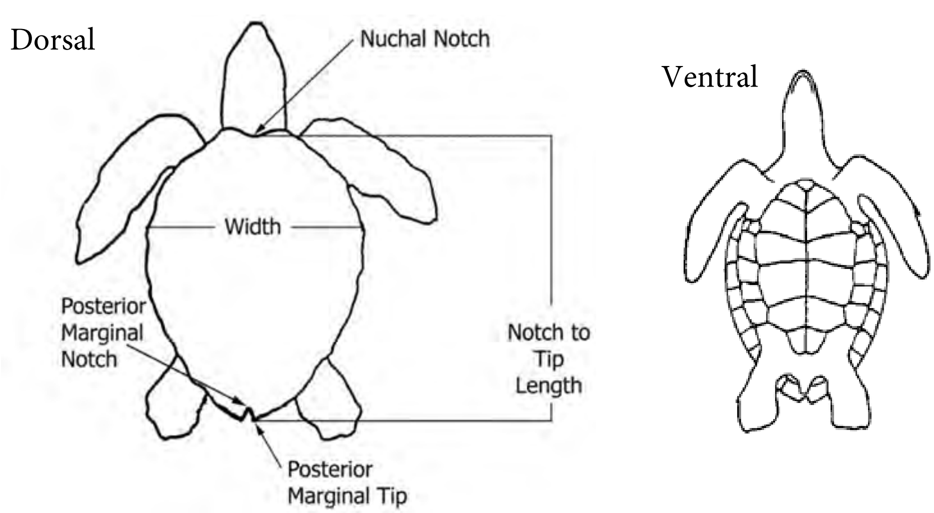
Turtle measurements in centimeters – measurements should be exact.
Provide the reason for any estimated measure (e.g., shell crushed and flattened)

	Exact	Estimated	Reason for Estimated Measure
Curved Carapace Length: ________ cm (notch to tip length with measuring tape)	☐	☐	____________________
Straight Carapace Length:________ cm (notch to tip length with calipers)	☐	☐	____________________
Straight Carapace Width: ________ cm (widest points with calipers)	☐	☐	____________________
Weight: ________ kg	☐	☐	____________________

Shortnose and Atlantic Sturgeon -



Sea Turtles -



Checklist for samples required to be collected and submitted per the BiOp's Standard Operating Procedures, RPMs, and T&Cs

Photographs and/or Video: Submit with this form to **incidental.take@noaa.gov**

Biopsy punch (sea turtles): Current Disposition (person/affiliation):

Fin Clip (fish): Current Disposition (person/affiliation):

Tags present[1]: **Type (e.g., PIT, flipper)** **Number** **Location on animal**

____

____

____

Tags inserted or applied[1]: **Type (e.g., PIT, flipper)** **Number** **Location on animal**

____

____

____

[1] **For sturgeon, also send PIT tag #, date, location, and length to Mike_mangold@fws.gov.**

Contact information for person completing this form

Name:

Email:

Phone Number:

Agency/Organization name if other than the Federal Action Agency for the BiOp:

APPENDIX G

Procedure for obtaining fin clips from sturgeon for genetic analysis

1. Wash hands and use disposable gloves. Ensure that any knife, scalpel or scissors used for sampling has been thoroughly cleaned and wiped with alcohol to minimize the risk of contamination.
2. For any sturgeon, after the specimen has been measured and photographed, take a one-cm square clip from the trailing edge of any fin (pelvic fin is recommended).
3. Place fin clips in small screw top vials (2 ml screw top plastic vials are preferred) with preservative. Avoid using glass vials.
4. Label each vial with fish's unique ID number that matches the ID number you record on the metadata sheet. This is critical for accurate tracking and record keeping .
5. RNAlater™ is the preferred preservative and is not hazardous. Ninety-five percent absolute ETOH (un-denatured) is an accepted alternative. Note that ETOH is a Class 3 Hazardous Material due to its flammable nature.
6. If non-screw top vials are used, seal individual vials with leak proof positive measure (e.g., tape).
7. Package vials together (e.g., in one box) with an absorbent material within a double-sealed container (e.g., zip lock baggie).
8. If using excepted quantities of ETOH, follow DOT and IATA packaging regulations, including affixing ETOH warning label to air package. Accepted quantities of ETOH is 30 mL per inner package and 1 L for the total package.
9. A sub-sample of the fin clip must be sent to the sturgeon genetics archive at the USGS facility in Leetown, WV.
   a. Submit sample metadata to rjohnson1@usgs.gov with a cc to incidental.take@noaa.gov. Electronic metadata must be provided in order to properly identify and archive samples. A copy of the electronic metadata was emailed to the Federal agency point of contact for this Opinion and a list of the metadata fields is included below. Retain a copy of metadata sheets for your records.
   b. Mail samples to:

Robin Johnson
U.S. Geological Survey
Leetown Science Center
Aquatic Ecology Branch
11649 Leetown Road
Kearneysville, WV 25430

10. Send a subsample and associated metadata to the NMFS-approved lab for processing to determine DPS or river of origin per the agreement you have with that facility.

APPENDIX G CONTINUED.

STURGEON GENETIC SAMPLE DATA FORM TO BE FILLED OUT ELECTRONICALLY (MS EXCEL) AND SUBMITTED BY EMAIL TO: RJOHNSON1@USGS.GOV AND INCIDENTAL.TAKE@NOAA.GOV

COPY OF EXCEL SPREADSHEET FOLLOWS FOR REFERENCE

DATA FIELDS

Collection Date	Species (ATS or SNS)	Permit or Biological Opinion Number	Action Agency, Permit Holder, Responsible Party	Unique Fish ID	PIT Tag Number	Latitude	Longitude	Fork Length (mm)	Total Length (mm)	Preservative	Tag Info	Mortality (Y or N)	Comments

FIELD DESCRIPTIONS

Field	Description
Collection Date	Date sturgeon tissue sample was collected (MM/DD/YYYY)
Species	Use "ATS" for Atlantic Sturgeon and "SNS" for Shortnose Sturgeon
Permit or Biological Opinion Number	Biological Opinion PCTS tracking number (e.g., SER-2017-12345)
Action Agency, Permit Holder, Responsible Party	Action Agency identified in the Biological Opinion as conducting/funding/carrying out the action
Unique Fish ID	Unique identification number of the fish provided by researcher, observer, handler, etc.
PIT Tag Number	PIT Tag number if detected/or applied
Latitude	Latitude of collection (decimal degrees) - If specific latitude of capture is not known, estimate midpoint of the trawl tow, dredge segment/pass, etc.
Longitude	Longitude of collection (decimal degrees) - If specific latitude of capture is not known, estimate midpoint of the trawl tow, dredge segment/pass, etc.
Fork Length (mm)	Fork length of fish measured in millimeters
Total Length (mm)	Total length of fish measured in millimeters
Preservative	Type of preservative used
Tag Info	Acoustic or other tag number (optional)
Mortality (Y or N)	Was the the take lethal?
Comments	Enter any special notes about the fish (i.e., condition) or sample

SUBMISSION INFORMATION

Please submit all tissue samples to Robin Johnson

Robin Johnson
U.S. Geological Survey
Leetown Science Center
Aquatic Ecology Branch
11649 Leetown Road
Kearneysville, WV 25430

Electronic metadata should be sent to rjohnson1@usgs.gov

- Collect tissue by removing a small 1-2 cm^2 section of fin clip from the pelvic fin using a pair of sharp scissors.
- Place the 1-2 cm^2 section of fin clip in small screw top vials (2 ml screw top plastic vials preferred; e.g., MidWest Scientific AVFS2002 and AVC100N) with preservative. Please avoid glass vials.
- Label vial with fish's unique ID number.
- RNAlater™ is the preferred preservative; RNAlater™ is a proprietary salt solution that is not a hazardous material.
- 95% absolute ETOH (un-denatured) is an accepted alternative; however, ETOH is a Class 3 Hazardous Material due to its flammable nature and RNAlater™ is strongly preferred.
- If non-screw top vials are used, seal individual vials with leak proof positive measure (e.g., tape).
- Package vials together (e.g., in one box) with an absorbent material within a double-sealed container (e.g., zip lock baggie).
- If using excepted quantities of ETOH, follow DOT and IATA packaging regulations, including affixing ETOH warning label to air package.
- Accepted quantities of ETOH is 30 mL per inner package and 1 L for the total package.

DROP DOWN OPTIONS

PIT Tag Type	Incidental Reporting Form Submitted?	Action Agency, Permit Holder, Responsible Party
New Tag Applied		BOEM
Existing Tag Detected		EPA
No Tag Detected/None Applied		FEMA
		FERC
		NMFS
		NOAA
		NOS
		NPS
		OAR
		USACE
		USCG
		USGS
		US Navy
		US Army
		US Marine
		US Air Force
		Other

APPENDIX H

STURGEON SALVAGE FORM

For use in documenting dead sturgeon in the wild under ESA permit no. 17273 (version 7-24-2015)

INVESTIGATORS'S CONTACT INFORMATION

Name: First ________________ Last ________________________

Agency Affiliation ________________ Email________________________

Address ____

____

Area code/Phone number ____

UNIQUE IDENTIFIER (Assigned by NMFS)

DATE REPORTED:
Month ☐☐ Day☐☐ Year 20☐☐

DATE EXAMINED:
Month ☐☐ Day☐☐ Year 20☐☐

SPECIES: (check one)
- ☐ shortnose sturgeon
- ☐ Atlantic sturgeon
- ☐ Unidentified *Acipenser* species

Check "Unidentified" if uncertain . See reverse side of this form for aid in identification.

LOCATION FOUND: ☐Offshore (Atlantic or Gulf beach) ☐Inshore (bay, river, sound, inlet, etc)

River/Body of Water________________ City________________________ State ____

Descriptive location (be specific)____

____

____

Latitude ______________N (Dec. Degrees) Longitude ______________ W (Dec. Degrees)

CARCASS CONDITION at time examined: (check one)
- ☐ 1 = Fresh dead
- ☐ 2 = Moderately decomposed
- ☐ 3 = Severely decomposed
- ☐ 4 = Dried carcass
- ☐ 5 = Skeletal, scutes & cartilage

SEX:
- ☐ Undetermined
- ☐ Female ☐ Male

How was sex determined?
- ☐ Necropsy
- ☐ Eggs/milt present when pressed
- ☐ Borescope

MEASUREMENTS: Circle unit

Fork length ________ cm / in

Total length ________ cm / in

Length ☐ actual ☐ estimate

Mouth width (inside lips, see reverse side) ________ cm / in

Interorbital width (see reverse side) ________ cm / in

Weight ☐ actual ☐ estimate ________ kg / lb

TAGS PRESENT? Examined for external tags including fin clips? ☐ Yes ☐ No Scanned for PIT tags? ☐ Yes ☐ No

Tag #	Tag Type	Location of tag on carcass

CARCASS DISPOSITION: (check one or more)
- ☐1 = Left where found
- ☐2 = Buried
- ☐3 = Collected for necropsy/salvage
- ☐4 = Frozen for later examination
- ☐5 = Other (describe) ________________________

Carcass Necropsied?
☐Yes ☐No

Date Necropsied:____________

Necropsy Lead:

____

PHOTODOCUMENTATION:
Photos/vide taken? ☐ Yes ☐ No

Disposition of Photos/Video:__________

____

____

SAMPLES COLLECTED? ☐ Yes ☐ No

Sample	How preserved	Disposition (person, affiliation, use)

Comments:

____

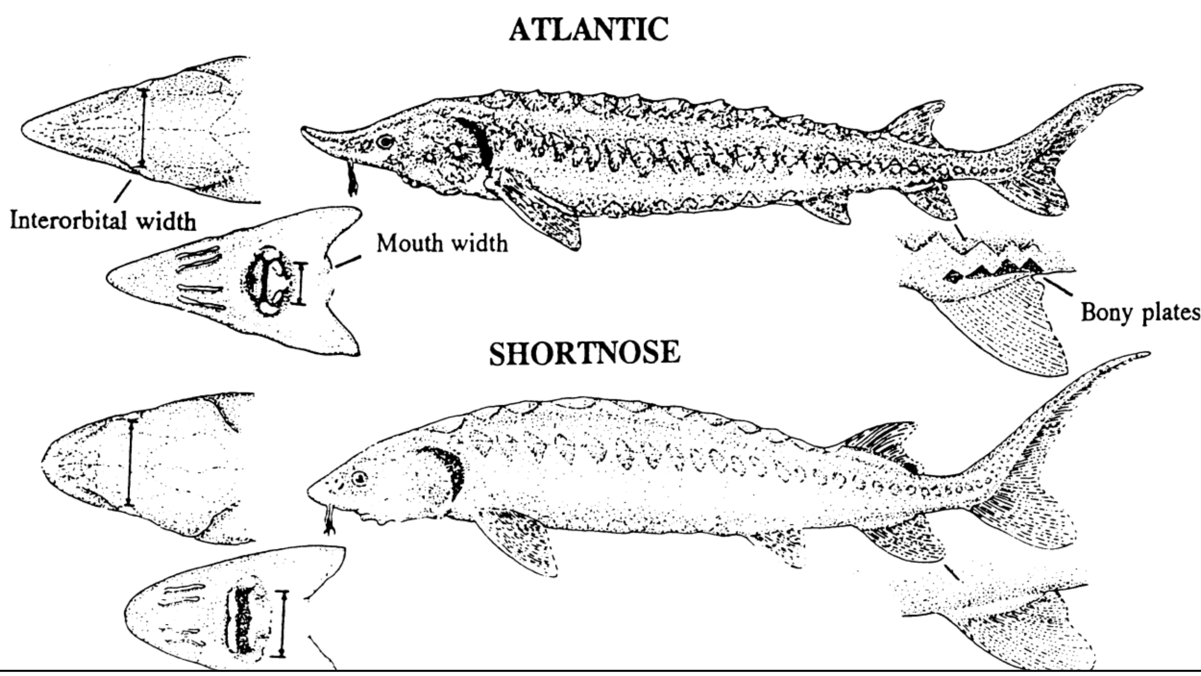
____

____

Distinguishing Characteristics of Atlantic and Shortnose Sturgeon (version 7-24-2015)

Characteristic	Atlantic Sturgeon, *Acipenser oxyrinchus*	Shortnose Sturgeon, *Acipenser brevirostrum*
Maximum length	> 9 feet/ 274 cm	4 feet/ 122 cm
Mouth	Football shaped and small. Width inside lips < 55% of bony interorbital width	Wide and oval in shape. Width inside lips > 62% of bony interorbital width
*Pre-anal plates	Paired plates posterior to the rectum & anterior to the anal fin.	1-3 pre-anal plates almost always occurring as median structures (occurring singly)
Plates along the anal fin	Rhombic, bony plates found along the lateral base of the anal fin (see diagram below)	No plates along the base of anal fin
Habitat/Range	Anadromous; spawn in freshwater but primarily lead a marine existence	Freshwater amphidromous; found primarily in fresh water but does make some coastal migrations

* From Vecsei and Peterson, 2004



Describe any wounds / abnormalities (note tar or oil, gear or debris entanglement, propeller damage, etc.). Please note if no wounds / abnormalities are found.

____

____

____

____

____

Data Access Policy: Upon written request, information submitted to National Marine Fisheries Service (NOAA Fisheries) on this form will be released to the requestor provided that the requestor credit the collector of the information and NOAA Fisheries. NOAA Fisheries will notify the collector that these data have been requested and the intent of their use.

Submit completed forms (within 30 days of date of investigation) to: **Greater Atlantic Regional Fisheries Office Contacts** – Edith Carson (Edith.Carson@noaa.gov , 978-282-8490) or Lynn Lankshear (Lynn.Lankshear@noaa.gov, 978-282-8473); **Southeast Region Contact**- Stephania Bolden (Stephania.Bolden@noaa.gov, 727-551-5768).